# PART IV

## THEORETICAL COMPUTER CALCULATION OF ALL PARAMETERS OF ELEMENTARY PARTICLES

## 16 DERIVATION OF THE CALCULATION FORMULAE

### 16.1. Formulation of the problem

Now the number of elementary particles, the principal bricks of the Universe, is over 800. The technique of experimental study of these particles is improving from year to year.

Taking into account the importance of this problem, the prominent advanced countries of the world spend many hundred millions annually to create still more perfect accelerators of the charged particles and instruments for registration of them and their parameters. It is due to the necessity to strengthen the basis of the stormy developing Scientific and Technical Revolution (STR). Our concept of the nature of matter is just this basis. Unfortunately, nowadays there is a tremendous gap between the information we obtain from the experiment and our ability to explain the obtained data. Now we can measure the mass of the particles with the accuracy up to 3—7 significant digits. Yet, before TFF, investigators could not calculate theoretically the values of masses because calculations gave infinite values. We learnt to remove this infinity by means of renormalizing, yet, we had to use in calculation the values of masses experimentally obtained. When calculating charges, the existing theories give the charges values equal to zero, which is no better than the infinity.

The well-known theories allow to calculate the values of spin and magnetic moment of the electron and the value of the magnetic moment of the muon. Yet, the investigators were not able to calculate these parameters for other particles before TFF. Even magnetic moments of such particles as the proton and neutron, which were known long ago, were not managed to be calculated. As there was no clearness as to what defines the principal EPs properties,it was impossible even to systematize EPs in a way that would allow to include all particles into this systematization.

All mentioned above does not concern the new relativistic quantum theory of the fundamental field [7, 18, 33, 34, 134]. The Periodical Law of Microparticles (PLM) follows from TFF [84]. Within the bounds of this law it is managed not only to systematize all experimentally found par-

ticles but also to find the methods of the exact theoretical calculation of principal parameters or to obtain the approximate quantitative estimations of other parameters of elementary particles. The calculations made on the basis of PLM give the parameters of bare elementary particles. The development of the theory of quark structures in TFF allows to obtain more correct parameters of real particles (see the fifth section of the book). It allows to make the methods of calculation of EP parameters more correct.

Many particles are known from the experiment. Each of them is estimated by ten independent parameters. To compare the experimental information with the results of the theoretical calculation of the parameters it is necessary to take into account many things. Firstly, it is necessary to take into account the reliability and accuracy of any parameter obtained from the experiment. Secondly, in any given case it is necessary to find the criteria for the comparison of theoretical and experimental data, which allow their one-to-one comparison. Thirdly, it is necessary to develop the logic of the comparison of all these abundant data to provide the safe solution of the identification problem by means of a computer. In part IV the way is shown in which these problems are solved in TFF. A detailed description is given of the methods of identification of experimental and theoretical data and of the procedures realizing these methods. The results of this identification performed by means of a computer are given and discussed.

The identification of the particles, whose parameters are experimentally determined with a small accuracy, is of a special difficulty. We show an example of the calculation of particles whose mass is roughly determined. The theory gives the masses spectrum which is very thin for heavy particles (the mass of the first particle in PLM [7, 84] differs from the mass of the second one approx by two times) and gradually becomes more thick with the decrease of the mass. Therefore, if the mass of the experimentally found particle is given with the accuracy less than the interval between the neighbouring particles in the theoretical spectrum of the masses, then the reliability of the identification only according to the mass decreases sharply. Moreover, as a rule, there are some elementary particles whose masses coincide within the bounds of the accuracy of the experiment. In such cases it was necessary to create the logic of comparison of some similar (according to the mass) particles with the corresponding theoretical ones, so that the comparison of other parameters of particles (such as the charge, spin, lifetime, etc.) would give the possibility to make the comparison sufficiently reliable.

Further investigations on the development of the methods of identification of theoretical and experimental data which were carried out within the bounds of this work aimed to remove the above-mentioned defects.

The calculation formulae in all modern theories are always approximate to some extent. Therefore, parallel with the development of the identification methods of theoretical and experimental data the works were carried out on making those calculation formulae more correct. Especially it concerned the determination of the parameters whose values depended to some extent on the process of interaction of elementary particles with physical vacuum, from the moment of the particle birth until the equilibrium was reached in this interaction. The theory of this relaxation

period was in embryo until recently [7, 18, 33, 34]. By now it was managed to advance substantially in understanding the physical essence of this process. This allowed to make the methods of calculation of the lifetime of particles more correct. In overwhelming majority of cases the lifetime of shortliving particles (resonances) is theoretically determined with the accuracy by far greater than the experimental one. As it was already mentioned, the accuracy of the calculation of the lifetime of the long-lived particles is still not sufficiently great.

In part IV are given and analysed the results of identification of theoretical and experimental data on the basis of the tables of the experimental data published in 1990 [108]. In recent time it was managed to find out the criterion for selection of theoretically predicted particles, which allowed to distinguish from a great variety of possible states just those which should be directly observed in the experiments carried out now. The criterion is based on the mechanism of formation of observable quark structures from unobservable, i.e. from virtual BEPs and EPVs.

## 16.2.
## The calculation formulae for the theoretical determination of elementary particle parameters

### 16.2.1. Principal notations and abbreviations

The values of the following parameters of all elementary particles predicted as well as already found out are determined theoretically.

Mass $m$ — in the masses of electron;

Charge $q$ — in $\sqrt{\alpha \hbar c}$;

Spin $J$ — in $\hbar$;

Magnetic moment $\mu$ — in the proper magnetons $\frac{e\hbar}{2mc}$;

Lifetime $\tau$ — in $s$;

Width of resonance $\Gamma$ — in MeV;

Isotopic spin $I$;
Spatial even parity $p$;
Baryon number $B$;
Lepton number $L$;
Strangeness $s$;
Charm $c$; (including the criterion of the "latent charm")
Beauty $b$;
Fascination $t$.

} in generally accepted dimensionless units.

The mentioned above values are determined as the unambiguous functions of the dimensionless integer positive "fundamental quantum number" $K$, which is the same for the group of the uniform particles included in the charge multiplet of PLM. For example, for the calculation of $m$, $q$, $J$, $\mu$ and other parameters for a proton, antiproton, neutron and antineutron $K = 133$. The numerical value of $K$ is not introduced arbitrarily but is also determined from the proper equations. Since the admissible values of $K$ constitute series of the numbers divisible by a certain value of $K_{pr}$, the parameters of the particles in accordance with this fact constitute periodically repeating series. The formulae are given in the applied tables.

The parameters related to 1SS, 2SS or 3SS have the upper index given in brackets corresponding to the relevant subspace. For example, $q_1^{(2)}$, $q_1^{(3)}$ are the values of the external fundamental charge in 2SS and 3SS, respectively.

Absence of the upper index in brackets means that the parameter corresponds to the calculation subspace $(2 \to 1)$, i.e. to the space of mapping of 2SS onto 1SS. The lower indices without brackets mean, as a rule, that this parameter relates to the *external* (the index "1") or the *internal* (the index "2") circumferences along which the subparticles in the EP structure are moving in the second and calculation subspaces.

$K_1 = 2\left[\varepsilon\left(\pi K + 1\right)\right]$ is the unambiguous function of $K$ (the integer);

$NS$ is the number of the PLM series in which the relevant EP is placed;

$N$ or $NT$ is the number of the charge multiplet of PLM in this series;

$\Delta$ is the number of the state within the given charge multiplet of PLM;

$R_1$, $R_2$ are the radii of the external and internal circumferences of the EP structure, respectively;

$R_1^{(2)}$, $R_2^{(2)}$, $R_1^{(3)}$, $R_2^{(3)}$, are the same radii in the EP model considered in 2SS and 3SS, respectively;

$R_L = \frac{m_1 R_1 + m_2 R_2}{m_1 + m_2}$ is the radius of the circumference along which the inertia center of the "transversal" (positive) masses $m_1$ and $m_2$ rotates;

$R_L^{(2)}$ is the same value for the structure in 2SS;

$n_1$, $n_2$ are the numbers of the subparticles in the calculation model on the external and internal circumferences, respectively;

$n = \frac{n_1 + n_2}{2}$ is the mean value of the total number of the subparticles, constant for a given series;

$n_1^{(2)} = n_2^{(2)} = n$ for 2SS;

$n_1^{(3)} = n_2^{(3)} = 1$ for 3SS;

$\beta_1$, $\beta_2$ are the linear velocities of motion of the subparticles on the external and internal orbits, respectively, in the units of light velocity $c$;

$\beta_L$ is the linear velocity of the mass-dipole center in the EP model at a distance $R_L$ from the center of the EP, in the units of light velocity $c$;

$\Delta\beta$ is the value characterizing the difference between the linear velocities of the subparticles and the mean value of the velocity $\beta = \frac{\beta_1 + \beta_2}{2}$, in the units of light velocity $c$;

$\beta_1^{(2)} \equiv \beta_1$; $\beta_2^{(2)} \equiv \beta_2$ are the linear velocities in 2SS;

$\beta_1^{(3)} = \beta_1 n_{1p}$; $\beta_2^{(3)} = \beta_2 n_{2p}$ are the linear velocities of the external and internal charges of the fundamenton, the basic particle of matter;

$n_{1p}$, $n_{2p}$ are $n_1$, $n_2$ for the optimal particle of the first series 1.19.1 (proton);

1.19.1 (20) is an example of the notation of the particle in PLM: 1 is the number of the series, 19 is the number of the multiplet, 1 is the number of the state in the multiplet, (20) is the quark state number (proton). 1.19.6 (21) is the particle of the first series, the 19th multiplet, the 6th state, the 21st quark state (neutron);

$Q$, $A_1$, $A_2$, $A_m$, $t_v$, $t_{vd}$ are auxiliary functions of the internal parameters of EP (the unambiguous functions of $K$);

$k_x = n_1 (1 - \beta_1^2)^{3/2}$ is the slowly changing function of $n_1$ and $\beta_1$, ($k_x \to 2^{-1/2}$ under $\beta_1 \to 1$);

$k_y = n_2 (1 - \beta_2^2)^{3/2}$ is the slowly changing function of $n_2$ and $\beta_2$, ($k_y \to 2^{-1/2}$ under $\beta_2 \to 1$);

$n_v$ is the concentration of particles in the vacuum of 1SS, in $c^{-3}$;

$\varepsilon_1$, $\varepsilon_2$, $\varepsilon_{1d}$, $\varepsilon_{2d}$ are the effective permittivities of vacuum, for the external and internal circumferences of the particle, respectively; the lower index $d$ means the same for the "double-particle" [7, 18, 33];

$\varepsilon_v$ is the proper permittivity of vacuum for separate EPs. It is equal to one of the effective $\varepsilon$ ($\varepsilon_{1,2}$ or $\varepsilon_{1d,2d}$);

$\mu_1$, $\mu_2$, $\mu_{1d}$, $\mu_{2d}$ are the magnetic permeabilities (considered just as the permittivities);

*op* or *p*, *e* are the indices of state: the optimal state, the proton ($NS = 1$, $NT = 19$) and the electron ($NS = 3$, $NT = 16009$), respectively;

$a_g = \frac{\beta_2^2 k_y^2}{\beta_1^2 k_x^2}$ is the coefficient which takes into account the metric characteristics of EP;

$\omega_1$ , $\omega_2$ are the angular frequencies of the subparticles on the external and internal orbits;

$\omega_v$ is the natural angular frequency of EPV;

$T_1$ , $T_2$ are the rotation periods of the subparticles on the external and internal circumferences;

$w_1$ , $w_2$ are the radiation intensities of the subparticles situated on the external and internal circumferences;

$\cos\alpha$ , $\cos\alpha_q$ , $\overline{\cos}\alpha_1$ , $\overline{\cos}\alpha_2$ are the cosines of the precession angles of both the charges and masses in the EP structure in different subspaces;

$q$ is the observable electric charge of EP, in $\sqrt{\alpha \hbar c}$;

$m_1$ , $m_2$ are the total "transversal" (positive) masses of the subparticles situated on the external and the internal orbits, in electron masses;

$m$ is the mass of EP observable in the first subspace, in electron masses;

$m_1^{(3)}$ , $m_2^{(3)}$ are the masses connected with the external and internal charges of fundamenton, respectively;

$m_{ef}^{(3)}$ is the effective mass of fundamenton;

$m_{ef} = m$ is the effective mass of the mass-dipole of EP in the calculation subspace;

$s$ is the total mechanical moment of the subparticles, in $\hbar$;

$J$ is the spin (the projection of $s$ on the precession axis of EP), in $\hbar$;

$\tau_{cl}$ is the "classic" time of the EP existence, in s;

$\tau_{qu}$ is the "quantum" time of the EP existence, in s;

$\alpha$ is the fine structure constant;

$R_\infty$ is the Rydberg constant, in $c^{-1}$;

$\lambda\!\!\!^{-}_p$ is the Compton wavelength of the proton, in c;

$m_p$ is the proton mass, in g;
$m_e$ is the electron mass, in g;

$G$ is the gravitational constant, in $c^3/g\ s^2$;

$\Gamma$ is the resonance width for a given EP, in MeV.

Our calculation is carried out for the model which refers to the complex subspace of mapping of the particles properties from the second subspace onto the first one, i.e. for the calculation subspace. All parameters observed directly or indirectly in 1SS have to be determined in the "calculation" subspace, surely, taking into account the mapping of properties from 2SS and 3SS onto 1SS.

### 16.2.2. Calculation of principal parameters of physical vacuum.

In TFF physical vacuum is considered as the system of elementary particles of vacuum uniformly filling up all the space. The EPVs concentration $n_V$ refers to the principal parameters of physical vacuum.

It is known [66] that the volume of the closed Riemannian space with the positive curvature is $V = 2\pi^2 a^3$, where $a$ is the radius of the space curvature. In our case the value $a = 2R_1$ is the EP curvature radius, which is the Schwarzschild sphere radius of the EP structure in 2SS, i.e.

$$V_{vol} = 2\pi^2 (2R_1)^3, \text{ more correct: } V_{vol} = 8\pi^2 R_1^3 \frac{n^3}{n_1^3} \left[1 + \frac{n_1}{2n}\left(\frac{\beta_1}{\beta_2} - 1\right)\right]^3 \qquad (16.1)$$

Only one EPV which is a system of two particles (a particle and antiparticle) is distributed in this volume. Therefore, the EPs concentration contained in an EPV turns out to be twice as great as that which would correspond to $n_V = 1 / V_{vol}$:

$$n_V = \frac{1}{\pi^2 (2R_1)^3} = \frac{1}{8\pi^2 R_1^3}. \qquad (16.2)$$

It is important to emphasize here that the notion "the most dense packing" in the non-Euclidian spaces should be introduced, according to the definition, in the following way: the most dense packing of particles is that under which the concentration $n$ is equal to $1 / v_{vol}$ where $v_{vol}$ is the volume of particles in the non-Euclidian space in question. From (16.2) it is seen that in the Riemannian space a particle with the radius $R_1$ takes the volume $2\pi^2 \{R_1^{(2)}\}^3$ which is $1.5\pi$ times greater than $\frac{4\pi R_1^3}{3}$, i.e. the volume it takes in the Euclidian space.

According to TL (the spatial metamorphosis), particles "live" simultaneously in the Euclidian as well as in the Riemannian spaces. But the Riemannian space differs from the Euclidian one by the only fact that, as the Riemannian space has the curvature, a particle placed there takes greater volume. As a matter of fact, this is the principal difference of the Riemannian space from the Euclidian one.

The permittivity and the magnetic permeability of physical vacuum are its important parameters. Due to dispersion the effective permittivity depends on the EPVs frequencies $\omega_V$ , $\omega_{1,2}$ and the natural frequency of the subparticles of which the EP in question consists and just for which we determine $\varepsilon$ and $\mu$.

We do not take into account the "background" constant components $\varepsilon$ and $\mu$ because of their small values (for detail see [84]) and the fact that physical vacuum for EP is not a stationary but moving medium. Then using the generally adopted elementary conversions [7, 18, 34] we solve the equations of the following form:

$$m_\varepsilon \frac{d^2x}{dt^2} = q\,E_0\,e^{-i\omega t}, \qquad \vec{p} = \frac{q^2 n_V}{m_\varepsilon \omega^2}\,\varepsilon\,\vec{E}_0\,e^{-i\omega t}, \tag{16.3}$$

where $m_\varepsilon$ is the effective mass in this process; $\vec{p}$ is the polarization vector. Taking into account the fact that according to the physical meaning $\omega^2 = \omega_{1ef}\omega_{2ef}$ we obtain:

$$\varepsilon_1 = \left[1 + \frac{4\pi q^2 n_V}{m_\varepsilon \omega_{1ef}^2}\right]^{-1}, \tag{16.4}$$

$$\varepsilon_2 = \left[1 + \frac{4\pi q^2 n_V}{m_\varepsilon \omega_{2ef}^2}\right]^{-1}. \tag{16.5}$$

We now introduce the notation:

$$q^2 = \alpha \hbar c, \tag{16.6}$$

where $\alpha$ is the dimensionless constant whose value will be determined below. In TFF the mass of any particle can be represented in the form (see further on and [18, 34]):

$$m = \frac{2s\hbar\beta_L}{R_1 c\,\varepsilon_V} B_m, \text{ where } B_m = \begin{cases} 8/9 \text{ when } \Delta = 1, 2; \\ 1 \text{ when } \Delta = 3, 4. \end{cases} \tag{16.7}$$

The effective mass $m_{ef}$ is determined according to the table of the calculation formulae.

For a proton (antiproton), which are the particles representing the basis of vacuum, the following equalities are valid:

$$\varepsilon_{1p} = \beta_{1p}^2 ; \varepsilon_{2p} = \beta_{2p}^2 . \tag{16.8}$$

The physical meaning of these equalities is in the fact that the velocities of the subparticles of proton, without an influence of physical vacuum as a medium, in limit would be equal to $\beta_1 = \beta_2 = 1$. In fact, the effective velocities $\beta_1$ and $\beta_2$ become not equal to one because $\varepsilon_{1,2} \neq 1$. By solving (16.3)—(16.8) we find:

$$\varepsilon_1 = \left(1 + A_1 \frac{a_g^{1/2}}{\beta_1^2 s}\right)^{-1} ; \tag{16.9}$$

$$\varepsilon_2 = \left(1 + A_2 \frac{a_g^{1/2}}{\beta_1^2 s}\right)^{-1} , \tag{16.10}$$

where

$$A_1 = \left[\frac{k_x \beta_i s}{k_y \beta_2} (1 - \beta_1^2)\right]_{p(1op.1)} ; A_2 = \left[\frac{k_x \beta_1^3 s}{k_y \beta_2^3} (1 - \beta_2^2)\right]_{p(1op.1)} ; a_g^{1/2} = \frac{\beta_2 k_y}{\beta_1 k_x} , \tag{16.11}$$

and then from (16.8), (16.9) and (16.11) we have the following expression for $\alpha$ via the internal parameters of a proton:

$$\alpha = \frac{\pi}{a_{gp}^{1/2}} (1 - \beta_1^2)_p . \tag{16.12}$$

Substituting the numerical values of $a_{gp}$ and $\beta_1$, found from the calculation of a proton, into (16.12) we obtain for $\alpha$ the following value: $\alpha = 7.297\ 20 \cdot 10^{-3}$ which differs in the sixth significant digit from the value of the fine structure constant adopted now. For the meaning of this difference see [18, 84] and Part II of this book.

The proton-antiproton vacuum makes the principal contribution to the physical vacuum properties and therefore, the effective values of $\varepsilon_V$ are

$$\varepsilon_V = \begin{cases} \varepsilon_{2p} \text{ for particles with } \Delta = 1; 2; \\ \varepsilon_{1p} \text{ for particles with } \Delta = 3; 4. \end{cases}$$

In its turn, for the magnetic permeability of vacuum we have the following formulae [113]:

$$\mu_1 = \left(1 + \frac{2\pi q_1^2 n_V l_{V\,1,2}^2}{3mc^2}\right)^{-1},$$

$$\mu_2 = \left(1 + \frac{2\pi q_2^2 n_V l_{V\,1,2}^2}{3mc^2}\right)^{-1}, \qquad (16.13)$$

where $l_{V_{1,2}}$ is the effective "average" distance between EPVs; $q_1$, $q_2$ are the charges of the fundamental field.

### 16.2.3. Determination of the ratio of the fundamental field charges $q_2/q_1$

The ratio of charges on the external and internal circular currents is determined by the amplitude condition of the radiation compensation which gives the following formula:

$$W_1 f_1(t) = W_2 f_2(t) \qquad (16.14)$$

where $W_1$ and $W_2$ are the radiation intensities of the external and internal charges of FF, respectively.

We introduce the notation $t_\nu = \frac{\Delta t^{(2\to1)}}{T^{(2\to1)}}$, where $\Delta t^{(2\to1)}$ is the time during which the radiation passes the distance $R_1^{(2)} - R_2^{(2)}$. In the calculation subspace it is necessary to take into account the radiation lag of either the internal charge (for state $\Delta = 1$) or the external one (for state $\Delta = 2$) equal to $\frac{\Delta t^{(2)}}{T^{(2)}}$.

Besides, under transition to the calculation subspace it is necessary to take into account the permittivity $\varepsilon$ for $\Delta = 1$ and the ratio of the squares of numbers of the internal and external subcharges $n_2^2/n_1^2$ for $\Delta = 2$. Finally we have:

for $\Delta = 1$ $$W_1 (1 + t_\nu)\, \varepsilon_1 = W_2\,; \qquad (16.15)$$

for $\Delta = 2$ $$W_1 = W_2 (1 + t_\nu) \frac{n_2^2}{n_1^2}. \qquad (16.16)$$

Similarly, for the double-particles we have:

for $\Delta = 3$ $$W_1 (1 + t_{\nu d})\, \varepsilon_{1d}^{-1} = W_2\,, \text{ where } t_{\nu d} = \frac{8}{9}\varepsilon_{1d}\, t_\nu\,; \qquad (16.17)$$

for $\Delta = 4$ $$W_1 = W_2 (1 + t_{rd}) \frac{n_2^2}{n_1^2}, \tag{16.18}$$

where

$$W_1 = \frac{2 q_1^2 \beta_1^4 c}{3 R_1^2 (1 + \beta_1)^2}; \tag{16.19}$$

$$W_2 = \frac{2 q_2^2 \beta_2^4 c}{3 R_2^2 (1 + \beta_2)^2}. \tag{16.20}$$

The deduction of the formulae (16.19) and (16.20) is given in detail in [7, 34, 84]. It is based on the use of the physical nature of the interaction of the field of the charge and its interpretation in TFF when solving the equations connecting the energy and momentum changes over time under radiation:

$$W_i = -\frac{dW}{dt} = \frac{2 q_i \left[\dot{\vec{v}}_i - \frac{(\dot{\vec{v}}_i \vec{v}_i)^2}{c^2}\right]}{3 c^2 (1 - \beta_i^2)^3}; \tag{16.21}$$

$$\frac{d\vec{p}_i}{dt} = \frac{\vec{v}_i}{c^2} W_i, \tag{16.22}$$

where $\vec{p}$ is the momentum vector.

Here the index $i = 1, 2$ corresponds, as usual, to the external and internal circumferences of the EP model. From (16.15) — (16.20) it is easy to obtain the ratio of the fundamental charges [7, 34, 85]:

$$\frac{q_2^2}{q_1^2} = \frac{\beta_1^2 (1 + \beta_2)^2 n_2^2}{\beta_2^2 (1 + \beta_1)^2 n_1^2} A_q(\Delta), \tag{16.23}$$

where

$$A_q(\Delta) = \begin{cases} \varepsilon_1 (1 + t_{vj}) , \Delta = 1 ; \\ \dfrac{n_1^2}{n_2^2 (1 + t_v)} , \Delta = 2 ; \\ \dfrac{(1 + t_{vd})}{\varepsilon_{1d}} , \Delta = 3 ; \\ \dfrac{n_1^2}{n_2^2 (1 + t_{vd})} , \Delta = 4 . \end{cases} \qquad (16.24)$$

When deducing (16.23) and (16.24), (besides [7, 34, 85]), we point the following: (16.23) is obtained from (16.19) and (16.20) when putting the amplitude condition in the form of

$$W_1 A_q (\Delta) = W_2 , \qquad (I)$$

where $A_q(\Delta)$ is a certain function of $\beta_1$ and $\beta_2$. The value of $A_q(\Delta)$ is determined from the following conditions.

In physical vacuum there exists the invariant

$$\frac{q_1^2 \beta_1^2 \cos\alpha_1^2}{\varepsilon_f} + \frac{q_2^2 \beta_2^2 \cos\alpha_2^2}{\varepsilon_f} = 3 \hbar c , \qquad (II)$$

where $\varepsilon_f = 1.000\,000\,351$ is the background permittivity of physical vacuum (its numerical value is determined from (II) and the following equations).

According to the physical meaning:

$$\begin{aligned} &J = S \cos\alpha = S_1 \cos\alpha_1 + S_2 \cos\alpha_2 ; \\ &S_1 = m_1 v_1 R_1 ; S_2 = m_2 v_2 R_2 ; \\ &J = J_1 + J_2 ; \\ &J_1 = S_1 \cos\alpha_1 ; J_2 = S_2 \cos\alpha_2 . \end{aligned} \qquad (III)$$

(For details on the angles $\alpha_1$ and $\alpha_2$ in these equations see section 7).

The existence of the relations (III) and the invariant (II) is possible in the only case when (16.23) is realized simultaneously with (16.24). In other words, (16.24) is the consequence of the conservation law (II) which is realized in PV.

### 16.2.4. Determination of the external fundamental charge $q_1$ and the observed electric charge $q$

The energy which the external (or internal) fundamental charges can radiate is placed in the belt of the width $(R_1 - R_2)$ in the form of the stationary wave because in the external space this energy is compensated. (Mind that ultrarelativistic rotator has directional radiation).

If the charge $q_1$ radiates with intensity $w_1$, then during the time $\Delta t = \frac{R_1 - R_2}{c}$ radiation would reach the circumference $R_2$, i.e. the energy of the stationary wave is

$$E = W_{0i}\,\Delta t, \tag{16.25}$$

where $W_{0i}$ is the radiation intensity obtained without the reaction of radiation, which was taken into account under deduction of (16.22). Since in this case we are interested in the total energy radiated by the charge, then

$$w_1 \equiv W_{01} = \frac{2q_1^2\beta_1^4 c}{3R_1^2(1-\beta_1^2)^2}. \tag{16.26}$$

Under annihilation half of the energy accumulated during the time $T$ in the belt $R_1 - R_2$ is taken away by two quanta with the frequency $\nu = 1/T$. Supposing that the total energy is $E = 4\hbar\nu$, we obtain the following formula [4] for $q_1^2$ from (16.25) and (16.26):

$$q_1^2 = \frac{3k_x^2\hbar c}{\pi K(1-\beta_1^2)\beta_1^2\cos\alpha}. \tag{16.27}$$

When introducing the notation

$$Q_1^2 = \frac{3k_x^2}{\pi K(1-\beta_1^2)\beta_1^2} \tag{16.28}$$

we may write (16.27) in the form:

$$q_1^2 = \frac{Q_1^2\hbar c}{\cos\alpha}, \tag{16.29}$$

where $\cos\alpha$ is the cosine of the precession angle of the EP radius-vector, connecting the center with the place of the charge location (see Fig. 16.1).

In the second subspace $q_1^{(2)} = q_2^{(2)}$, and consequently EP as a whole is a neutral particle. Yet, in the calculation subspace the difference $|q_1| - |q_2|$ is not equal to zero. This very difference is

perceived in ISS as the electric charge. Thus the electric charge of EP is the relativistic effect. Therefore, it is almost the same for all particles normalized in vacuum.

Thus,

$$q = q_1 \left(1 - \frac{q_2}{q_1}\right), \tag{16.30}$$

where $q_2 / q_1$ is the ratio of charges of FF according to (16.23).

If the calculation is right, and for all charged particles completely normalized in vacuum the electric charge is equal to the electron charge, then the condition $q^2 = \alpha$ is valid because we measure the charges in the units of $\sqrt{\hbar c}$.

In TFF there are also other methods of calculation of this dimensionless constant. We now consider them.

### 16.2.5. Different formulae for the fine structure constant $\alpha$ and the electric charge of EP

In TFF different approaches to the determination of $\alpha$ are possible.

1. As it was mentioned above, it is possible to express it via the observed charge of EP $q = |q_1| - |q_2|$ and thus:

$$\alpha = \frac{(|q_1| - |q_2|)^2}{\hbar c} = \frac{q_1^2 \left(1 - \left|\frac{q_2}{q_1}\right|\right)^2}{\hbar c}. \tag{16.31}$$

From calculation it is found that only the optimal particles, forming, for example, the electron-positron or proton-antiproton vacua, determine the charge dominating in vacuum, rather accurately equal to $q = \sqrt{\alpha \hbar c}$. The rest of the particles which are relatively short-living (even a muon, living $2 \cdot 10^{-6}$ s.) at birth have the charge differing from $\sqrt{\alpha \hbar c}$ by the 3rd—6th significant digit and satisfying the conditions (16.27)—(16.30). The interaction of EP and EPV results in violation of the relation between the charges of EP, which is necessary for the amplitude condition to be valid. This occurs because there is some difference between the EP charge and the charge of the EPV elements, hence the excited particles of vacuum concentrate around the given particle.

This results in the normalization of the EP charge. The normalizing factors are given in [7, 85] and in the table of the calculation formulae 16.1. They bring the charge of each particle nearer to the dominating charge in vacuum.

2. In TFF (see section 15) the following expression for the Rydberg constant $R_\infty$ for radiation of an electron is found:

$$R_\infty = \sqrt{9/8}\ \frac{\beta_{1e}\,\varepsilon_{2p}\,m_e\,c\,(1-\beta_2^2)_e^{1/2}}{\beta_{Le}\,\hbar\,2\pi}\,. \tag{16.32}$$

Since there is the generally known relation between $R_\infty$ and other global constants

$$R_\infty = \frac{2\pi^2\,m_e\,e^4}{c\,\hbar^3}\,, \tag{16.33}$$

then from (16.32) and (16.33) we obtain the following formula for $\alpha = e^2/\hbar\,c$:

$$\alpha_e\big|_{\mathrm{I}} = \left[\frac{3\,\varepsilon_{2p}\,(1-\beta_2^2)_e^{1/2}\,\beta_{1e}}{2^{1/2}\,\beta_{Le}}\right]^{1/2} = 7.29\,732\,076\,6\cdot10^{-3}\,. \tag{16.34}$$

This formula allows to determine $\alpha$ with a great accuracy because its value depends only on three parameters of two optimal particles of the first and third series (proton and electron) and corresponds to the invariant square of the charge (in $\hbar\,c$) in physical vacuum.

The invariant (16.34) corresponds, as a rule, to the particles with $\Delta = 2, 4$ in the first and second series. For $\Delta = 1, 3$ of each series there is also, as a rule, another dimensioniess invariant of the charge square:

$$\alpha_{inv}\big|_{\mathrm{II}} = s_p\,g_{00p}\,(\varepsilon_{1p} + \varepsilon_{2p})\left[\frac{3}{2^{1/2}\,(1-\beta_1^2)_p\,a_{gp}}\right]^{1/2} = 7.29\,735\,217\,7\cdot10^{-3}\,. \tag{IV}$$

For the processes of transition from one metastable state to another both invariant values of $\alpha$ may be important. Therefore, for the calculation of the parameters of such particles the ratio of these parameters is of importance:

$$k_f = \frac{\alpha_{inv}}{\alpha_e} = 1.00\,000\,430\,5\,. \tag{V}$$

The "background coefficient" $k_f$ determines either the rate of disturbance of consistency under interaction of the fundamental charges in the EP structure with the background charge ($\alpha_{inv}\big|_{\mathrm{I}}$ or $\alpha_{inv}\big|_{\mathrm{II}}$), or the contribution of one of them under the dominating influence of the other.

3. According to TFF, in physical vacuum the invariant connected with the tension in vacuum should exist. It results in constancy of a certain dimensionless value which is numerically equal to $\alpha$.

The following expression turns out to be invariant:

$$\alpha_{inv} = A_K s (\varepsilon_1^2 - \varepsilon_2^2) \varepsilon_{2p}, \tag{16.35}$$

where $A_K$ is the slowly changing function of the internal parameters of EP. The following form of this invariant is more suitable:

$$\frac{\alpha_{inv}}{\alpha_e} = \frac{(1 + \frac{\varepsilon_1}{\varepsilon_2})}{2\beta_1^2} \begin{cases} \varepsilon_{1p}^{1/2} \varepsilon_{2p}^{1/2}, & NS = 1; \\ (\varepsilon_2 / \varepsilon_1)^{1/2}, & NS \neq 1. \end{cases} \tag{16.36}$$

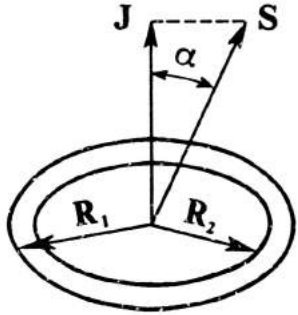
### 16.2.6. Determination of particles masses

Within the bounds of TFF different methods of the observable EP mass calculation are possible. Such mass is considered in TFF as a purely field mass, i.e. always $m = V / c^2$, where $V$ is the total energy.

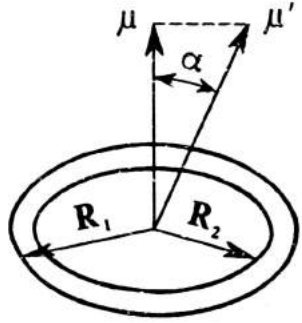
1. The EP structure can be represented according to the quasi-classical model [7, 85].

In Fig. 16.1 the great circumference corresponds to the external orbit of the subparticles considered in the second subspace. The small circumference corresponds to the motion in the calculation and third subspaces. The genuine motion occurs along the small circumference where the tachyon is situated (if to consider it in the third subspace). In the calculation subspace we observe the tachyon effect, i.e. the "splitting" of one tachyon into $n_{1,2}$ subparticles. Along the great circumference (the second subspace) the subparticles motion is of the conditional character. In fact, $n$ moments of the tachyon "appearance" arise.

All EPs are different states of a single particle which is the fundamental tachyon, called the fundamenton. It is a particle which consists of two subparticles. For the calculation of its parameters in details see [34] and section 14 of this book.




$$\begin{cases} \mathbf{S} = \mathbf{m}_1\mathbf{v}_1\mathbf{R}_1 + \mathbf{m}_2\mathbf{v}_2\mathbf{R}_2 \\ \mathbf{J} = \mathbf{S}\cos\alpha \end{cases}$$




$$\begin{cases} \mu' = \mathbf{i}_1\,\pi\mathbf{R}_1^2 - \mathbf{i}_2\,\pi\mathbf{R}_2^2 \\ \mathbf{i}_{1,2} = \dfrac{|\mathbf{q}_{1,2}|\,\nu_{\theta 1,2}}{\mathbf{c}} \\ \mu = \mu'\cos\alpha \end{cases}$$

Fig. 16. 1 Scheme of spin and magnetic moment formation in the second and calculation subspaces

The observable mass is the "transversal" one. In [7] from (16.23) and (16.24) the following formulae were obtained for the "transversal" masses in the calculation subspace:

$$m_1 = \frac{2}{3}\frac{q_1^2\beta_1^2\cos\alpha}{R_1(1+\beta_1)^2c^2}; \tag{16.37}$$

$$m_2 = \frac{2}{3}\frac{q_2^2\beta_2^2\cos\alpha}{R_2(1+\beta_2)^2c^2}. \tag{16.38}$$

In [7] under the solution of the equations (16.23) and (16.24) the character of motion of the masses $m_1$ ($m_2$) along the orbits was taken into account by means of introducing the radiation reaction, i.e.

$$|\bar{V}| = \frac{V^2}{R} - \left|\frac{d\vec{p}}{dt}\right| \frac{\cos\alpha}{m}, \tag{16.39}$$

where $\left|\frac{d\vec{p}}{dt}\right| \frac{\cos\alpha}{m}$ is the acceleration called the "radiation reaction". Since the introduction of the "transversal" masses in the second subspace is lawful, we consider that (16.38) and (16.39) retain the covariant form for $m_1^{(2)}$ and $m_2^{(2)}$. Then for $m$ we have:

$$m = \frac{\hbar}{R_1 c}\frac{2}{3}\frac{a_1^2\beta_1^2}{(1-\beta_1)^2}\frac{\cos\alpha}{\cos\alpha_q}\left\{\left[1 + \frac{n_2\beta_1}{n_1\beta_2}A_q(\Delta)\right] + F_m\left(1 + \frac{\beta_1}{\beta_2}\right)\right\}, \tag{16.40}$$

where the notation $A_q(\Delta)$ is given in [27], and $F_m = \frac{m_1^{(2)}}{m_1}\Big|_{R^{(2)}}$.

2. In the calculation space-time the following value stays invariant for all EPs without exception:

$$R_1 a_g^{-1/2}(1 - \beta_1^2)^{1/2} = \text{const}. \tag{16.41}$$

This in variant is obtained from an ordinary invariant for the planar four-dimensional space $\lambda_1(1 - \beta_2^2)^{1/2} = \text{const}$ by means of multiplying it by the coefficient coordinating the metric characteristics of these spaces:

$$\frac{\beta_1 k_x}{\beta_2 k_y}\left(\frac{(1-\beta_1^2)^{1/2}}{(1-\beta_2^2)^{1/2}}\right) \equiv a_q^{-1/2}\frac{(1-\beta_1^2)^{1/2}}{(1-\beta_2^2)^{1/2}}. \tag{16.42}$$

Since from (16.40) and (16.41) follows:

$$m = \frac{\beta_i}{\varepsilon_V \cos\alpha_q}\frac{\hbar}{R_1 c}, \text{ where } \cos\alpha_q = \begin{cases}\sqrt{9/8}\,\frac{1}{2s}, \Delta = 1, 2;\\ \frac{1}{2s_d}, \quad \Delta = 3, 4,\end{cases} \tag{16.43}$$

then taking the electron mass ($NT = 16009$, $NS = 3$ in PLM) as the unit and taking into account (16.41) and (16.43) we have the following (if we restrict ourselves with the normalized mass of a particle):

$$m = a_q^{-1/2}\frac{s(1-\beta_2^2)^{1/2}}{\varepsilon_{2\rho}}A_m, \tag{16.44}$$

where $A_m = \sqrt{8/9}\left[\frac{a_g^{1/2} f(g_{00})}{s_d(1-\beta_1^2)^{1/2}}\right]_e \varepsilon_{1\rho}$ for an electron.

3. The purely "energy" approach.

The origination of mass is due to the charges of the fundamental field, directly not revealing in the first subspace, yet contributing to the energy $U_m$ which characterizes the observable mass $m$ [7]:

$$U_m = \frac{q_1^2}{8R_1} + \frac{q_2^2}{8R_2} + \frac{\beta_1^2 q_1^2}{4R_1} + \frac{\beta_2^2 q_2^2}{4R_2} . \tag{16.45}$$

According to the known Einstein equation, we have:

$$\overline{m} = \frac{U_m}{c^2} . \tag{16.46}$$

For the on-going it is necessary to take into account that the mapping takes place from the second subspace onto the first one. In this case (16.46) turns into the following condition:

$$\overline{m} = \frac{U_m}{c^2} B_s , \tag{16.47}$$

where the coefficient

$$B_s = \frac{3}{\sqrt{2}} s \frac{k_x (1-\beta_2^2)^{1/2}}{k_y (1-\beta_1^2)^{1/2}} \begin{cases} \varepsilon_1 / \varepsilon_2^{1/2} , \Delta = 1, 2; \\ \varepsilon_{2d} , \Delta = 3, 4 \end{cases} \tag{16.48}$$

takes this mapping into consideration. The degree of coordination of $\overline{m}$ from (16.47) with $m$ from (16.44) is seen from table 4 in [7].

### 16.2.7. Determination of the mechanical moment

The total mechanical moment of the system of two circular currents in the calculation subspace, when the "basic" mass is the "external" one, is the following:

$$s = m_1 U_1 R_1 + m_2 U_2 R_2 f(\beta) , \tag{16.49}$$

where $f(\beta)$ is the factor which takes into account the chronogeometrical scale difference in the points of location of $m_1$ and $m_2$. Besides, there is a relation between $m_1$ and $m_2$ resulting in the mass defect equal to $\sqrt{8/9}$ from $m_1$ and $m_2$. Therefore, for $s$ we finally have:

$$s = \sqrt{9/8}\, m_1 U_1 R_1 \left[ 1 + \frac{m_2 U_2 R_2}{m_1 U_1 R_1} f(\beta) \right] , \tag{16.50}$$

where

$$f(\beta) = \frac{k_x (1-\beta_2^2)^{1/2}}{k_y (1-\beta_1^2)^{1/2}} . \tag{16.51}$$

$f(\beta)$ is the ratio of two coordinate conversions $\frac{k_x}{(1-\beta_1^2)^{1/2}}$ and $\frac{k_y}{(1-\beta_2^2)^{1/2}}$ which differ from the Lorentz conversions $(1-\beta_{1,2}^2)^{1/2}$ by the monotonous functions of $\beta_1$ and $\beta_2$ denoted by $k_x$ and $k_y$ [7, 34, 85] and determined from the following equalities:

$$k_x = n_1 (1-\beta_1^2)^{3/2};$$
$$k_y = n_2 (1-\beta_2^2)^{3/2}. \tag{16.52}$$

It is easy to see that

$$\lim_{\beta_1 \to 1} k_x = \lim_{\beta_2 \to 1} k_y = \frac{1}{\sqrt{2}}.$$

Taking into account (16.37) and (16.50) it is possible to obtain the following formula for $s$:

$$s = \frac{\beta_1^3 Q_1^2}{\sqrt{2}(1+\beta_1)^2}\left[1 + \frac{\beta_2 n_2 (1-\beta_1^2)(1+t_v)\varepsilon_1}{\beta_1 n_1 (1-\beta_2^2)}\right]. \tag{16.53}$$

### 16.2.8. Calculation of the magnetic moment

In TFF the internal properties of particles are mapped onto the first subspace in such a way as if the charges of the fundamental field would move along the concentric circumferences with radii $R_1$ and $R_2$ in the calculation subspace.

Therefore, it is possible to find the magnetic moment by the formulae for the determination of the magnetic moments of the circular currents.

For the particles ($\Delta = 1, 2$ and states corresponding to them)

$$\mu = \frac{|q_1|\nu_{01}\pi R_1^2}{\varepsilon_1 c} - \frac{|q_2|\nu_{02}\pi R_2^2}{\varepsilon_2 c}. \tag{16.54}$$

For the double-particles ($\Delta = 3, 4$ and states corresponding to them) which are not influenced by $\varepsilon_1$ and $\varepsilon_2$ under formation of the currents responsible for the magnetic moment

$$\mu_d = \frac{|q_1|\nu_{01}\pi R_1^2}{c} - \frac{|q_2|\nu_{02}\pi R_2^2}{c}, \tag{16.55}$$

where

$$\nu_{01} = \frac{\beta_1 c}{2\pi R_1}; \quad \nu_{02} = \frac{\beta_2 c}{2\pi R_2}.$$

For the neutral state $|q_1| = |q_2|$ from (16.54) we obtain the following:

$$\bar{\mu}_0 = \frac{|q_1|\beta_1 R_1}{2}\left[1 - \frac{\beta_2 R_2}{\beta_1 R_1}\right]. \tag{16.56}$$

Substituting the value from (16.43) for $m$ and making the elementary conversions we obtain the expressions for $\mu$ in the proper magnetons (under $J \neq 0$):

for particles

$$\bar{\mu} = \frac{q}{|q|}\frac{\beta_1\beta_2}{\varepsilon_1\varepsilon_{2p}\cos\alpha}\left(\frac{\varepsilon_1\beta_2 R_2}{\varepsilon_2\beta_1 R_1} + \frac{1 - \dfrac{\varepsilon_1\beta_2 R_2}{\varepsilon_2\beta_1 R_1}}{1 - \left|\dfrac{q_2}{q_1}\right|_n}\right); \tag{16.57}$$

for double-particles

$$\bar{\mu}_d = \frac{q}{|q|}\frac{\beta_1\beta_2}{\varepsilon_{1p}\cos\alpha}\left(\frac{\beta_2 R_2}{\beta_1 R_1} + \frac{1 - \dfrac{\beta_2 R_2}{\beta_1 R_1}}{1 - \left|\dfrac{q_2}{q_1}\right|_n}\right); \tag{16.58}$$

for neutral particles

$$\mu_0 = \frac{q}{|q|}\frac{\beta_1\beta_L\varepsilon_W}{\varepsilon^{1/2}\cos\alpha}\frac{\left(1 - \dfrac{\beta_2 R_2}{\beta_1 R_1}\right)}{\left(1 - \left|\dfrac{q_2}{q_1}\right|_n\right)}. \tag{16.59}$$

It is significant that the magnetic moment for all particles, as well as the spin, is a projection of the total magnetic moment on the precession axis, i.e. on the EP orientation axis in space, i.e. always:

$$\mu = \bar{\mu}\cos\alpha = \bar{\mu}\frac{J}{s}. \tag{16.60}$$

Therefore, in those cases when $J \neq 0$ we have for the observed magnetic moments

$$\mu = \frac{q}{|q|}\frac{\beta_1\beta_L}{\varepsilon_1\varepsilon_{2p}}\left(\frac{\varepsilon_1\beta_2 R_2}{\varepsilon_2\beta_1 R_1} + \frac{1 - \dfrac{\varepsilon_1\beta_2 R_2}{\varepsilon_2\beta_1 R_1}}{1 - \left|\dfrac{q_2}{q_1}\right|_n}\right); \tag{16.61}$$

$$\mu_d = \frac{q}{|q|}\frac{\beta_1\beta_L}{\varepsilon_{1p}}\left(\frac{\beta_2 R_2}{\beta_1 R_1} + \frac{1 - \dfrac{\beta_2 R_2}{\beta_1 R_1}}{1 - \left|\dfrac{q_2}{q_1}\right|_n}\right); \tag{16.62}$$

$$\mu_0 = \frac{q_1}{|q_1|}\frac{\beta_1\beta_L z_V}{\varepsilon^{1/2}}\frac{\left(1-\frac{\beta_2 R_2}{\beta_1 R_1}\right)}{\left(1-\left|\frac{q_2}{q_1}\right|_n\right)}; \quad \varepsilon = \begin{cases}\varepsilon_{2p}; & \Delta = 1, 2;\\ \varepsilon_{1p}; & \Delta = 3, 4,\end{cases} \tag{16.63}$$

respectively.

### 16.2.9. Deduction of the formulae for the lifetime of particles

As it was noted [84], the question about the lifetime of particles is in principle the most difficult of the entire problem of the microcosm nature. In the previuos works on TFF and, in particular, in [7, 34], the solution of this problem was only outlined. In this publication and the preceding one [84] it is solved.

In [7, p 114] it was noted that the process of normalization of particles by physical vacuum remained essentially unclear in TFF. The concept of normalization of particles discussed in [85, § 1.1] considerably assisted the progress in calculating the particles lifetime.

It was previously noted [7, 34] that only the optimal particles of PLM responsible for the physical vacuum formation, for example, a proton (antiproton), an electron (positron) can be stable. All other particles can not be completely stable in principle, because of the following. As it is shown in this subsection, the charge of particles is determined by the amplitude condition of radiation. The calculation shows (and it has been already noted in [7]) that the charge of non-optimal particles differs from the unit (as usual, the charge of the electron is taken as the unit). The difference is small, it is in the 3rd—5th significant digit, yet it exists. But it concerns the charge corresponding to the amplitude condition. This charge provides stability of the particle in relation to radiation. It is clear that any particle at the moment of its origination has just this charge. But immediately after its birth a particle begins to become normalized in physical vacuum which makes the particle change its charge up to normal,i.e. brings its charge maximally close to the unit.

Strictly speaking, the invariants of TFF characterizing the charges of the elements of EPV in the proton-antiproton and the electron-positron vacua should be considered as the normalized charges. As it was noted, these invariants are determined from (16.34) and the condition (IV):

$$\begin{aligned}\alpha_e\big|_{\mathrm{I}} &= \left[\frac{3\,\varepsilon_{2p}\,(1-\beta_2^2)_e^{1/2}\,\beta_{1e}}{2\cdot 2^{1/2}\,\beta_{Le}}\right]^{1/2} = 7.297\,320\,766\cdot 10^{-3},\\ \alpha_{\mathrm{inv}}\big|_{\mathrm{II}} &= s_p\, g_{00p}\,(\varepsilon_{1p}+\varepsilon_{2p})\left[\frac{3}{2^{1/2}\,(1-\beta_1^2)_p\, a_{gp}}\right]^{1/2} = 7.297\,352\,177\cdot 10^{-3}.\end{aligned} \tag{16.64}$$

Naturally, in the process of normalization the amplitude condition is violated and a particle loses the electrodynamic stability. It is clear that the existence of such particle is possible during the time for which it would "have radiated" the stock of energy which it has, or such quantity of energy which is necessary for a particle to pass into another state by overcoming the corresponding potential barrier.

There are reasons to suppose that for the overwhelming majority of particles this process makes the principal contribution to their lifetime. An approximate formula for the estimation of the EP lifetime was obtained in [7] on the basis of this principle (from the quasi-classical concepts on the structure of EP and EPV). Yet under the deduction of this formula the fundamental property of interaction between EP and physical vacuum (which was discussed in [7]) was not taken into account. This property is reduced to the following. An elementary particle is born as a classical object, but after a certain period, during which it has time to enter into the complete contact with physical vacuum, EP becomes a quantum object, because the quantum properties of microcosm are mostly determined by the interaction of EP with physical vacuum.

The time necessary for EP to become a quantum object from the beginning of its interaction with PV depends on many conditions. Therefore, all of them should be taken into account to calculate the lifetime of the particle in the right way. It is necessary to use the following condition when choosing between the "quantum" calculation formulae and "classical" ones.

If the potential energy $U_0$ (see formula (16.67)) is greater than the excitation energy $E$ then the calculation should be carried out by the quantum formulae, otherwise by the classical ones, i.e:

when $2\pi U_0 \geq E_0$ then the particle is a quantum object; (16.65)

when $2\pi U_0 < E_0$ then the particle is a quasi-classical object. (16.66)

The factor $2\pi$ is introduced for the coordination of the time which, as it was mentioned above, has its own scale for different $n$.

Yet, the above-mentioned conditions are necessary but not sufficient. Therefore, after making the previous selection of particles whose lifetime is determined by the quantum criteria, it is necessary to put the condition of sufficiency, which determines the possibility of existence of at least one discrete level of excitation $n_r$ in the potential pit:

$$\left(\frac{U_{0NT+1}}{E}\right)^{1/2} \geq \frac{\pi n_r - \arcsin\left(\frac{E}{U_{0NT+1}}\right)^{1/2} - \arcsin\left(\frac{E}{U_{0NT}}\right)^{1/2}}{\pi n_r - 2\arcsin\left(\frac{E}{U_{0NT}}\right)^{1/2}}, \tag{16.67}$$

where $U_{0NT} = U_0$ ; $U_{0NT+1}$ is the potential energy (the depth) of the potential pit of the particle with the number $NT+1$ in a given series; $U_{NT}$ , $U_{NT+1}$ are the depths of the potential pits of both the given state and the nearest one, respectively.

To find the lifetime in the quasi-classical case we should have the correspondence between the time of existence of a particle and the time which is required for radiating the energy equal to $mc^2$ under the corresponding conditions of violation of the amplitude condition of non-radiation. As it is easy to see, the latter is determined by the equality

$$\tau = \frac{m_{NT} c^2 (1-\beta_1^2)^{1/2}}{W_{NT} \left| 1 - \frac{\alpha}{q_{ef}^2} \right| (1-\beta_1^2)_p^{1/2}}, \tag{16.68}$$

where

$$W_{NT} \equiv W_\beta = \frac{2 q_{1ef}^2 \beta_1^4 \hbar c^2}{3 R_1^2 (1+\beta_1)^2}; \quad q_1^2 = \frac{6 k_x^2 s_q \hbar c}{\pi K (1-\beta_1^2) \beta_1^2};$$

$$q_{ef} = q + (q_n - q)\left(1 - e^{-\frac{\tau (1-\beta_1^2)^{1/2}}{T}}\right); \tag{16.69}$$

$\alpha$ is the fine structure constant which is the square of the invariant electric charge;

$\frac{(1-\beta_1^2)^{1/2}}{(1-\beta_1^2)_p^{1/2}}$ is the factor coordinating the time scales both for the given particle and the proton-antiproton vacuum.

Taking into account the relations between the parameters of particles and the fact that the particles mass changes with the change of the fundamental charge, we obtain the following expression instead of (16.68):

$$\tau = \frac{U_0 T^{(2)} (1-\beta_1^2)^{1/2} 2n}{E_0 \left(1 - \frac{m_{NT+1}}{m_{NT}}\right) (1-\beta_1^2)_p^{1/2} n_1} \left[1 + \frac{n_1}{2n}\left(\frac{\beta_1 - \beta_2}{\beta_2}\right)\right], \tag{16.70}$$

where

$$U_0 = m'_{ef} c^2 \left(1 + \frac{m_{NT+1}}{m_{NT}}\right) A_\Delta^{-1};$$

$$E_0 = W_\beta \left| 1 - \frac{\alpha_e}{q_{ef}^2} \right| T A_\Delta \frac{(1-\beta_1^2)^{1/2}}{(1-\beta_1^2)_p^{1/2}}, \quad i = 1, 2;$$

$m'_{ef} = m_{ef} m_e$ ; $m_e$ is the mass of an electron;

$$s_q = \begin{cases} s\,, & \text{if } \Delta = 1, 2; \\ s_d\,, & \text{if } \Delta = 3, 4; \end{cases}$$

$$m_{ef} = m + (m_n - m)\left(1 - e^{\frac{-\tau(1-\beta_i^2)^{1/2}}{T}}\right); \tag{16.71}$$

$$A_\Delta = \begin{cases} \sqrt{8/9}\,, & \text{if } NS = 1\,; \\ \sqrt{9/8}\,, & \text{if } NS \neq 1\,; \end{cases} \qquad i = \begin{cases} 1\,, & \text{if } NS = 3\,; \\ 2\,, & \text{if } NS \neq 3\,. \end{cases} \tag{16.72}$$

The following formulae should be used to determine the numerical values of the period $T$ and the radius:

$$T^{(2)} = \frac{2\pi R_1^{(2)}}{\beta_1 c}\,;\quad R_1 = \frac{2 s_q \hbar \beta_L}{m'_{ef} c \varepsilon_V}\,;\quad R_1^{(2)} = \frac{2n R_1}{n_1}\,, \tag{16.73}$$

where

$$\varepsilon_V = \begin{cases} \varepsilon_{2p}\,, & \text{if } \Delta = 1, 2; \\ \varepsilon_{1p}\,, & \text{if } \Delta = 3, 4. \end{cases}$$

In (16.70) it is taken into account that in the given case the period should be determined by the radius calculated for the second subspace:

$$R_1^{(2)} = \frac{2n}{n_1} R_1\,.$$

The effective fundamental charge should be found from the equation

$$q_{1ef} = q_1 + (q_{1n} - q_1)\left(1 - e^{-\frac{\tau(1-\beta_i^2)_p^{1/2}}{T}}\right). \tag{16.74}$$

If the conditions (16.65) and (16.67) hold then the lifetime should be determined for the EP considered as a quantum object. In this case we can allow the penetration through the potential barrier under $E < U_0$ and the reflection under the condition $E > U_0$. Then the lifetime should be determined by the formulae well-known from quantum mechanics (see [66], v III "Quantum mechanics", pp 86—105 ) which are of the following form, if to take into account the features of the EP structure:

$$\tau_{qu} = \frac{T^{(2)} 2n}{D n_1}\,; \tag{16.75}$$

$$D = \frac{1}{1 + \dfrac{(k_1^2 - k_2^2)^2}{4 k_1^2 k_2^2} \sin^2 a_b k_2}\,, \quad E > U_0\,; \tag{16.76}$$

$$D = \frac{1}{1 + \frac{(k_1^2 + k_2^2)^2}{4 k_1^2 k_2^2} \mathrm{sh}^2 a_b k_2}, \quad E \leq U_0, \tag{16.77}$$

where

$$k_1 = \frac{\sqrt{2 m'_{ef} E}}{\hbar}; \quad k_2 = \frac{\sqrt{2 m'_{ef} |U_0 - E|}}{\hbar}.$$

It is easy to see that for the EPs, possessing the structure and the properties described in TFF, the potential energy $U_0$ and the excitation energy $E$ should be determined by the formulae:

$$U_0 = m'_{ef} c^2 \left(1 - \frac{m_{NT+1}}{m_{NT}}\right) A_\Delta^{-1}; \tag{16.78}$$

$$E = \begin{cases} E_0 n_\tau^2, \text{ if } E_0 < U_0; \\ E_0, \text{ if } E_0 > U_0, \end{cases} \tag{16.79}$$

where

$$E_0 = W_\beta \left(1 - \frac{a_2}{q_{ef}^2}\right) T A_\Delta; \quad A_\Delta = \begin{cases} \sqrt{8/9}, \text{ if } NS = 1; \\ \sqrt{9/8}, \text{ if } NS \neq 1. \end{cases}$$

The width of the potential pit, where the particle is situated before the penetration through the barrier, is

$$a_{\text{pit}} = \begin{cases} A_{NS} \frac{\pi \hbar}{4 \sqrt{2 m E_0}} \left(1 - \frac{2 \arcsin \sqrt{E_0/U_0}}{\pi n_\tau}\right), \text{ if } E < U_0; \\ \beta_1 c \frac{(1 - \beta_1^2)^{1/2}}{(1 - \beta_1^2)^{1/2}_{op}} \tau, \text{ if } E \geq U_0. \end{cases} \tag{16.80}$$

And the barrier width $a_b$ which is taken into account in the formulae (16.76), (16.77) and (16.82) is determined via $a_{\text{pit}}$ as follows:

$$a_b = a_{\text{pit}} \begin{cases} 4, \text{ if } NS = 1 \text{ and } \Delta = 3, \text{ or } NS = 2 \text{ and } \Delta = 2; \\ 2, \text{ if } NS = 1 \text{ and } \Delta = 4; \\ 2^{1/2}, \text{ if } NS = 2, \Delta = 3 \text{ and } IS = 0; \\ 1 \text{ under all different combinations of } NS \text{ and } \Delta. \end{cases} \tag{16.81}$$

$$n_\tau = \epsilon \left[1 + \frac{2 \arcsin \sqrt{E_0/U_0}}{\pi} + \frac{k_1(E_0) a(E_0)}{\pi}\right], \tag{16.82}$$

where

$$k_1 = \frac{\sqrt{2\, m'_{at}\, E_0}}{\hbar},$$

$$q_{ef.qu} = \varepsilon\,(q_{ef}). \tag{16.83}$$

From these calculation formulae the lifetime of any particle can be determined.

The method of calculation of $\tau$ discussed here should be made more accurate for the particles with special types of the internal symmetries.

As it is well-known, the resonance width is determined via $\tau$ by the simple formula:

$$\Gamma = \frac{\hbar}{\tau}, \tag{16.84}$$

which acquires a clear and even visual physical meaning in TFF. The minimal uncertainty which exists in principle under determination of the EP parameters has the length dimension. This uncertainty corresponds to the Schwarzschild sphere radius $R_1$.

In table 16.1.2 it is shown that all possible states of the particles in the multiplet of PLM are not independent. Only the states with the state numbers $\Delta = 1, 2, 3; 4$ are completely independent. The rest values in any way are determined by these main "basic" states. For example, baryons with $\Delta = 5$, 17, 21 correspond to some versions of states with $\Delta = 1$. Therefore, many properties of these particles coincide with the properties of the particles with $\Delta = 1$ and the same goes with $\Delta = 2, 3, 4$.

### 16.2.10. Determination of principal quantum characteristics of BEPs and EPs

The quantum numbers show the place of a given particle in the systematization called the Periodical Law of Microparticles (elementary particles). They are determined by the combination of the principal characteristics of the particles in this law: the series number $NS$, the multiplet number $NT$, the state number $\Delta$, and by taking into account whether the particle $P$ or the antiparticle $A$ are in the state in question.

So, for example, only the particles of the first and second series can be baryons under certain (see the tables) states and only in the case if in the first series $NT < N_{0p}$, and in the second one $NT \leq N_{0p} \frac{(1-\beta_1^2)^{1/2}}{(1-\beta_1^2)_p^{1/2}}$. The factor $\frac{(1-\beta_1^2)^{1/2}}{(1-\beta_1^2)_p^{1/2}}$ for the second series is necessary to coordinate the units scales (see § 1.1 in [85]). Mesons can also be only in the first and second series, but in different states. Leptons are the particles of only the third series in which baryons and mesons are absent.

There is also an unambiguous relation between the place of the particle in the series of PLM and its charge. The sign of the magnetic moment is also determined unambiguously. The spatial

even parity $p$, the strangeness $s$, the charm $c$, the beauty $b$ for all charged particles are determined according to Table 16.1 based on the quarks theory.

There are internal symmetries ($IS$), whose conservation or violation can substantially influence the particle properties.

Some of these symmetries are already known in the existing theories, others are introduced and predicted in TFF. So, for example, the already found resonances $J/\psi$, $\psi$ have the "latent charm", which characterizes special properties of the particles. To take these specific quantum numbers into account the procedure $IS$ (internal symmetries) should be introduced, which takes into consideration the peculiarities in calculating the parameters of these particles.

The development of the theory of the internal symmetries of EPs on the basis of TFF is not finished yet, but now it was managed to estimate the possible increase of the accuracy of calculation of the parameters of some particles by taking $IS$ into account.

### 16.2.11. Summary table of the calculation formulae (computer calculation algorithm)

In this subsection the computer calculation algorithm of the EP parameters is discussed. The calculation is carried out by the formulae including the unambiguous functions only of the number $K$. The method of calculation of these unambiguous functions is clear from table 16.1. We now consider how the entire calculation is performed.

For the selection of permissible values of the number $K$ a computer searches through the series of natural positive numbers. This operation is written in the form of formula 1.1A, (the first two figures represent the number of the horizontal line and the letter represents the vertical line). Then two unambiguous functions of this number are found by formulae 1.1B and 1.1C: the numbers $K_1$ and $A$. The condition 1.1D at first holds only for $K = 7$. This is just the first admissible value of $K$ noted as $K_{pr}$ in a given PLM series. Since $A$ depends on the ratio $K/K_1$, then the condition 1.1D is satisfied by the values of $K$ divisible by the first value of $K$, i.e. $K = 14; 21; 28$ etc. In the condition 1.2A it is shown that the series of the first values of $K$ is given number one. The calculation shows that besides the series of values divisible by 7, $K$ can have a series of values divisible by 113. In the same way the subsequent series of $K$ is found.

The mentioned above series are just those of the fundamental quantum numbers, corresponding to the periodical law. It is of importance to note that the number $K$ and its function $K_1$ selected in the mentioned above way, turn out to be the integers known in the theory of numbers as those that give the best approximation to the number $2\pi$. So, $K = 7$ corresponds to $K_1 = 44$ and the fraction $44/7$ is the first best approximation to $2\pi$ with excess. The next best approximation, as it is known, is the fraction $710/113$ whose numerator and denominator are the first values of $K_1$ and $K$ in the second PLM series, respectively, etc. This property of the pairs of the numbers $K_1$ and $K$ which are the principal arguments in the formulae for the calculation of particle parameters, can be used to obtain the suitable values of $K$ not by means of selection from all natural numbers the

values of which satisfy the criterion 1.1D, but by means of a more simple method given in [84, p. 78].

We now consider other calculation formulae and algorithms. The condition 1.2*C* introduces the concept of the state number $\Delta$ in a given series. The condition 1.2*D* shows that each series of PLM has the restriction determined by a simple condition: the last number of a given series turns out to be equal to the first value of $K$ of the subsequent series.

Thus, the formulae of table 16.1 give the possibility to calculate the selected values of $K$ and its first functions $K_1$ and $A$. By means of the formulae from 1.3A to 1.9D the following unambiguous functions $K$ are found: the integers $n_1$, $n_2$, $n$ and the positive numbers $\Delta\beta$; $1-\beta_L$; $1-\beta$; $1-\beta_1$; $1-\beta_2$ and $R_1/R_2$; $k_x$; $k_y$; $Q_1^2$. As it is seen from the deduction of the formulae, these numbers are interpreted as the values characterizing the internal structural parameters of elementary particles. The whole set of these values is unambiguously determined from the given value $K$. Thus, only one numerical value of the mentioned above quantities corresponds to each value of $K$.

The internal parameters of all EPs of the given multiplet are the same for all $\Delta$ and for all internal symmetries (*IS*) states. The same goes with all parameters found by the formulae of table 16.1.2.

The formulae for the determination of the observed fundamental and electric charges are given in table 16.1.3. The formulae for the determination of the magnetic moments and spins of the particles are given in table 16.1.4. These formulae show that the "external" parameters of the particles are determined via their "internal" parameters which are found by the preceding formulae according to the number $K$. Yet, the determination of the external parameters by the internal ones is performed by different formulae for the following types and states of the particles included in the charge multiplet of PLM: for the charged particles, for the neutral ones and for the compound particles of all permissible states $\Delta$. Thus, from one numerical value of $K$ all parameters are obtained for all particles included in the given PLM multiplet.

Within the bounds of the discussed method of calculation of the properties and parameters of particles, besides the parameters measured experimentally, other properties of particles can be determined as well. In particular, the condition of stability of particles belonging to a given multiplet and being in a certain state is found. The number of this state, called the "optimal" state in the series, is determined by formulae 2.5 in table 16.1. It turns out that in the second and third series there is only one state, the charged one, possessing the necessary stability. The comparison of the parameters of these particles shows that the stable (optimal) state in the first series is the proton (antiproton) and that in the third series is the electron (positron). In the second series sufficiently stable states are absent at all. There is a relatively stable state corresponding to the particle with the mass of the order of 28 electron masses. This shortliving particle is not found yet. But according to the theory, it can be found, though it is difficult, because it does not take part in formation of atoms nuclei and can not be obtained in the overwhelming majority of experiments

carried out now, where the targets are the atoms nuclei and sufficiently hard particles. To find this particle it is necessary to make a specific experiment. This is the prediction of TFF.

To clear the correspondence of the external parameters of the particles calculated by the above-mentioned formulae with the experimental data it is necessary to elaborate the fundamentals of the logic of comparison of theoretical data and experimental ones.

| Nos | Parameters | *A* | *B* |
|---|---|---|---|
| 1.1 | $K, K_1, A$ | $K = 1; 2; 3 \ldots$ | $K_1 = 2\,[\varepsilon\,(\pi K + 1)]$ |
| 1.2 | $NS, NT, K_{pr}, K_{1pr}$ | *NS* (series number equals serial number *A*) | $\left.\begin{matrix} K_{pr} \\ K_{1pr} \end{matrix}\right\}$ first values of $K$ and $K_1$ in every series |
| 1.3 | $\beta_0, n_0, n, \nu$ | $(1-\beta_0^2) \approx 6A$ | $n_0 \approx \varepsilon \left\{ 0.5 + \dfrac{[1+\sqrt{1+8\,(1-\beta_0^2)}]^{3/2}}{4\,(1-\beta_0^2)^{3/2}} \right\}$ |
| 1.4 | $n_1, n_2, \beta_{1pr}, \beta_{2pr}$ | $n_1 = n + \dfrac{K_1}{2}$ | $n_2 = n - \dfrac{K_1}{2}$ |
| 1.5 | $\Delta\beta, \beta_{pr}, F(n)$ | $\Delta\beta_{pr} = \dfrac{K_{1pr}\,[(1-\beta) - A]}{2\pi}$ <br> $\Delta\beta = \Delta\beta_{pr}\,NT$ | $(1-\beta) = \dfrac{(1-\bar{\beta}_{1pr}) + (1-\bar{\beta}_{2pr})}{2}$ |
| 1.6 | $\beta_L, \beta, \beta_1, \beta_2$ | $(1-\beta_L) = (1-\beta) + \dfrac{(\Delta\beta_{pr})^2}{2\beta}$ | $\dfrac{R_2}{R_1} = \dfrac{\beta_2\, n_2}{\beta_1\, n_1}$ |
| 1.7 | $k_x, Q_1^2, k_y, \varepsilon_{1p}, \varepsilon_{2p}$ | $k_x = n_1\,(1-\beta_1^2)^{3/2}$ | $Q_1^2 = \dfrac{3k_x^2}{\pi K \beta_1^2\,(1-\beta_1^2)}$ |
| 1.8 | $g_{00}, f(g_{00}), a_g, R_{1,2}^{(2)}$ | $g_{00} = \beta_1^2 - \beta_2^2$ | $f(g_{00}) = (1-g_{00})^{1/2}\,(1-3g_{00})^{1/2}$ |
| 1.9 | $l, l^{(2)}, \dfrac{l^{(2)}}{l}$ | $l = R_1 - R_2$ | $l^{(2)} = R_1^{(2)} - R_2^{(2)}$ |
| 1.10 | $A_1, A_2, A_m, \beta_{1,2}^{(3)}$ | $A_1 = \left[ \dfrac{k_x \beta_1{}^5}{k_y \beta_2} (1-\beta_1^2) \right]_{p(1.o\,p.1)}$ | $A_2 = \left[ \dfrac{k_x \beta_1{}^3{}^5}{k_y \beta^3{}_2} (1-\beta^2{}_2) \right]_{p(1.o\,p.1)}$ |

Table 16.1

| C | D |
|---|---|
| $A = \left(1 - 2\pi \frac{K}{K_1}\right)$ | $6\sqrt{2}\, A \le K_{pr}^{-2}$ |
| $NT = \frac{K}{K_{pr}} = \frac{K_1}{K_{1pr}}$<br>$NT$ — number of multiplet in given series | $NT'_{max}\,[NS] = K_{pr}\,[NS + 1]$ |
| $n_0 + 2^{\nu} > n > n_0 - 2^{\nu}$<br>$n$, the integer | $\nu = 4 - \varepsilon \left(\frac{\log_{10} A}{\log_{10} 4}\right)$ |
| $(1 - \beta_{1pr}^2) = \frac{1}{2}\left(\frac{2}{n_1}\right)^{2/3}\left[1 + \left(\frac{2}{n_1}\right)^{2/3}\right]$ | $(1 - \beta_{2pr}^2) = \frac{1}{2}\left(\frac{2}{n_2}\right)^{2/3}\left[1 + \left(\frac{2}{n_2}\right)^{2/3}\right]$ |
| $F = \frac{n_1}{2n}\left[(1 - \overline{\beta}_1) - \left(1 - \frac{K_1}{n_1}\right)(1 - \overline{\beta}_2) - \frac{K_1 A}{n_1}\right]$ | $F(n-1) > F(n) \ge 0 > F(n+1)$ |
| $(1 - \beta_1) = (1 - \beta) - \Delta\beta$ | $(1 - \beta_2) = (1 - \beta) + \Delta\beta$ |
| $k_y = n_2 (1 - \beta_2^2)^{3/2}$ | $\varepsilon_{1p} = \beta_{1p}^2 ; \varepsilon_{2p} = \beta_{2p}^2$ |
| $a_g = \frac{k_y^2 \beta_2^2}{k_x^2 \beta_1^2}$ | $R_1^{(2)} = R_1 \frac{2n}{n_1} ; R_2^{(2)} = R_2 \frac{2n}{n_2}$ |
| $l = R_1 \frac{2\pi K}{\beta_1 n_1} = R_2 \frac{2\pi K}{\beta_2 n_2}$ | $\frac{l^{(2)}}{l} = \frac{2k_x t_v}{K}$ |
| $A_m = \sqrt{8/9}\left[\frac{\beta_2 k_y \varepsilon_{1(1.op.1)}}{\beta_1 k_x s_d (1 - \beta_2^2)^{1/2}}\right]_{p(1.op.1)}$ | $\beta_1^{(3)} = \beta_1 n_1 ; \beta_2^{(3)} = \beta_2 n_2$ |

| Nos | Parameters | Basic and coupled states of | |
|---|---|---|---|
| | | particles (antiparticles)<br>$\Delta = 1$ (1$p$ and 1$A$)<br>$\Delta = 2$ (2$p$ and 2$A$) | double-particles (antidouble-particles)<br>$\Delta = 3$ (3$p$ and 3$A$)<br>$\Delta = 4$ (4$p$ and 4$A$) |
| 1 | 2 | 3 | 4 |
| 2.1 | $t_v$<br>$t_{vd}$ | $t_v = \dfrac{nK_1[(1-\beta_1)-A]}{2\pi n_2 k_x} \equiv \dfrac{n\Delta\beta}{\pi k_x}$ | $t_{vd} = \dfrac{8}{9}\varepsilon_{1d}^2 t_v$ when $NS = 2; \varepsilon_{1d} = 1$ |
| 2.2 | $s$<br>$s_d$<br>$\bar{s}$<br>$\bar{s}_d$ | $s = \dfrac{\beta_1^3}{\sqrt{2}} \dfrac{Q_1^2}{(1+\beta_1)^2}(1 + A_s \varepsilon_1)$ | $s_d = \dfrac{\beta_1^3}{\sqrt{2}} \dfrac{Q_1^2}{(1+\beta_1)^2}(1 + A_s \varepsilon_{1d})$ |
| | | where $A_s = \dfrac{\beta_2 n_2 (1-\beta_1^2)(1+t_v)}{\beta_1 n_1 (1-\beta_2^2)}$ | |
| | | $\bar{s} = \dfrac{\sqrt{89}}{18} \dfrac{s}{s_{(1.o\,p.1)}}$ | |
| 2.3 | $\varepsilon_1$<br>$\varepsilon_{1d}$ | $\varepsilon_1 = \left(1 + A_1 \dfrac{a_g^{1/2}}{\beta_1^2 s}\right)^{-1}$ | $\varepsilon_{1d} = \left(1 + \sqrt{8/9}\, A_1 \dfrac{a_g^{1/2}}{s_d \beta_1^2}\right)^{-1}$ |
| 2.4 | $\varepsilon_2$<br>$\varepsilon_{2d}$<br>$\Delta\varepsilon$ | $\varepsilon_2 = \left(1 + A_2 \dfrac{a_g^{1/2}}{\beta_1^2 s}\right)^{-1}$ | $\varepsilon_{2d} = \left(1 + \sqrt{8/9}\, A_2 \dfrac{a_g^{1/2}}{s_d \beta_1^2}\right)^{-1}$ |
| | | $(1-\Delta\varepsilon) \approx \dfrac{1}{2\beta_1^2}\left(1 + \dfrac{\varepsilon_1}{\varepsilon_2}\right) A_c$ | $A_c = \begin{cases} (\beta_2 \beta_1)_p & , NS = 1 \\ \left(\dfrac{\varepsilon_2}{\varepsilon_1}\right)^{1/2} & , NS \neq 1 \end{cases}$ |
| 2.5 | $N_{op}$<br>$N_{dop}$ | $N_{op} = \varepsilon\left(\dfrac{A_0 n}{1 + \dfrac{A_0 K_{1pr}}{2}} + 0.5\right)$ | $N_{dop} = \varepsilon\left(\dfrac{A_{0d} n}{1 + \dfrac{A_{0d} K_{1pr}}{2}} + 0.5\right)$ |
| | | $A_0 = \dfrac{3(1-\beta_2^2)^{1/2}(1+\beta_2)}{4\pi K_{pr} \beta_2 \varepsilon_1^{1/2} \varepsilon_2^{1/2}} \times$ | $A_{0d} = \dfrac{3(1-\beta_2^2)^{1/2}(1+\beta_2)}{4\pi K_{pr} \beta_2 \varepsilon_{1(1.o\,p.1)}^{-1/2} \varepsilon_{2(1.o\,p.1)}^{-1/2}} \times$ |
| | | $\times \dfrac{\varepsilon_{2(3.o\,p.3)}}{\varepsilon_{1(1.o\,p.1)}} \varepsilon_f^{3/2}$ | $\times \dfrac{\varepsilon_{2(3.o\,p.3)}^{3/2}}{\varepsilon_{1(1.o\,p.1)}^{3/2}} \varepsilon_f$ |

internal parameters

| Compound states of particles | | Neutral states of | |
|---|---|---|---|
| first<br>$\Delta = 9-12$ (q = 1);<br>$\Delta = 17-20$ (q = 2) | second<br>$\Delta = 21-24$ | basic particles<br>$\Delta = 5-8$ | compound particles<br>$\Delta = 13-16$;<br>$\Delta = 25-32$ |
| 5 | 6 | 7 | 8 |

Values $t_\nu, s, \varepsilon_{1,2}$ for all compound states have to be taken from corresponding values of basic states from tables:

$$\text{for } \Delta = \begin{cases} 5,9,13,17,21,25,29 \\ 6,10,14,18,22,26,30 \\ 7,11,15,19,23,27,31 \\ 8,12,16,20,24,28,32 \end{cases} \text{ from } \Delta = \begin{cases} 1 \\ 2 \\ 3 \\ 4 \end{cases}$$

| 1 | 2 | 3 |
|---|---|---|
| 3.1 | $q_1$<br>$q_{1n}$<br>$q_{1d}$<br>$q_{1dn}$ | $q_1 = \left(\frac{8}{9}\right)^{1/4} (2s)^{1/2} Q_1 \; ; \Delta = 1$<br><br>$q_1 = A_{1q} \left(\frac{8}{9}\right)^{1/4} (2s)^{1/2} Q_1 \; ; \Delta = 2 \; ; A_{1q} = \begin{cases} -1 \; ; NS = 1 \\ 1 \; ; NS \neq 1 \end{cases}$<br><br>$q_{1n} = q_1 \frac{k_f}{\varepsilon_f} A_{2q} \; ; \Delta = 1 \; ; A_{2q} = \begin{cases} \left(\frac{s}{s}\right)^{1/2} \; ; NS = 1 \\ \sqrt{8/9} \; ; NS = 2 \\ \sqrt{8/9} \; ; NS \geq 3 \end{cases}$<br><br>$q_{1n} = q_1 \left[\frac{(1+t_v)\varepsilon_{1p}^{1/2}}{(1+t)_{op}\varepsilon}\right] ; \Delta = 2 ; \varepsilon = \begin{cases} \varepsilon_{2p}^{1/2} \; ; NS = 1 \\ \varepsilon_{2p} \; ; NS \neq 1 \end{cases}$ |
| 3.2 | $q_2^2/q_1^2$<br>$(q_2^2/q_1^2)_n$<br>$(q_2^2/q_1^2)_d$<br>$(q_2^2/q_1^2)_{dn}$ | $\frac{q_2^2}{q_1^2} = \frac{\beta_1^2 (1+\beta_2)^2}{\beta_2^2 (1+\beta_1)^2} \cdot \frac{n_2^2 \varepsilon_1}{n_1^2} (1+t_v) \; ; \Delta = 1$<br><br>$\frac{q_2^2}{q_1^2} = \frac{\beta_1^2 (1+\beta_2)^2}{\beta_2^2 (1+\beta_1)^2 (1+t_v)} \; ; \Delta = 2$<br><br>$\left(\frac{q_2^2}{q_1^2}\right)_n = \frac{q_2^2}{q_1^2} \; ; \Delta = 1; 2$ |

4

$$q_{1d} = (2s_d)^{1/2} \cdot Q_1 \; ; \; \Delta = 3 \; ;$$

$$q_{1d} = A_{1d} \, (2s_d)^{1/2} \cdot Q_1 \; ; \; \Delta = 4 \; ; \; A_{1d} = \begin{cases} -1 \; ; NS = 1 \\ 1 \; ; NS \neq 1 \end{cases}$$

$$q_{1dn} = q_{1d} \frac{\varepsilon_{1p}^{1/4}}{\varepsilon_{2p}^{1/4}} \varepsilon_f \, A_{2qd} \; ; \; \Delta = 3 \; ; \; A_{2qd} = \begin{cases} \sqrt[4]{8/9} ; NS = 1 \\ \sqrt{9/8} ; NS = 2 \\ 1 \; ; \; NS \geq 3 \end{cases}$$

$$q_{1dn} = q_{1d} \left[ \frac{(1 + t_{vd})}{2s_{d\,op} (1 + t_{vd})_{op} \varepsilon_{2p} \varepsilon} \right]^{1/2} A_{3qd} \; ; \; \Delta = 4; \; A_{3qd} = \begin{cases} \sqrt{9/8}, NS = 1; \\ 9/8, \; NS \neq 1. \end{cases} \varepsilon = \begin{cases} 1, NS = 2; \\ \varepsilon_{2d}^{1/2}, NS \neq 2. \end{cases}$$

$$\left( \frac{q_2^2}{q_1^2} \right)_d = \frac{\beta_1^2 (1 + \beta_2)^2}{\beta_2^2 (1 + \beta_1)^2} \cdot \frac{n_2^2}{\varepsilon_{1d} n_1^2} (1 + t_{vd}) \; ; \; \Delta = 3$$

$$\left( \frac{q_2^2}{q_1^2} \right)_d = \frac{\beta_1^2 (1 + \beta_2)^2}{\beta_2^2 (1 + \beta_1)^2 (1 + t_{vd})} \; ; \; \Delta = 4$$

$$\left( \frac{q_2^2}{q_1^2} \right)_{dn} = \left( \frac{q_2^2}{q_1^2} \right)_d \; ; \; \Delta = 3; 4$$

| 1 | 2 | 3 |
|---|---|---|
| 3.3 | $q$<br>$q_n$<br>$q_{dn}$ | $q = q_1\left(1 - \frac{q_2}{q_1}\right)$; $\Delta = 1; 2$<br><br>$q_n = q_{1n}\left(1 - \frac{q_2}{q_1}\right) B_q D_q B C_q$<br><br>For $NS = 3$: $D_q = \varepsilon_{1p}^{-1}$; $NT \neq NT_{opt}$<br><br>For $NS = 1$:<br><br>$\begin{cases} B_q = \frac{(1-\beta_1^2)^{1/2}}{(1-\beta_1^2)^{1/2}_{op}}; \Delta = 1 \wedge NT = NT_{opt} \\ B_q = \frac{(1-\beta_1^2)^{1/2}}{(1-\beta_1^2)^{1/2}_{op}} \cdot \frac{1}{\varepsilon_{2p}}; \Delta = 1 \wedge NT \neq NT_{opt} \end{cases}$<br><br>$\begin{cases} B_q = \frac{(1-\beta_1^2)^{1/2}_{op}}{(1-\beta_1^2)^{1/2}}; \Delta = 2 \wedge NT = NT_{opt} \\ B_q = \frac{(1-\beta_1^2)^{1/2}_{op}}{(1-\beta_1^2)^{1/2}} \cdot \frac{a_{gp}}{\varepsilon_{2p}^3}; \Delta = 2 \wedge NT \neq NT_{opt} \end{cases}$<br><br>$BC_q = \begin{cases} (9/8)^2 \varepsilon_{1p}^{-1/2} \varepsilon_{2p}^{-1/2}; \\ a_{gp}^{1/2} / \varepsilon_{2p}^{1/2}; \\ 1; \end{cases}$<br><br>Every index $p$ corresponds to 1.op.1, index $e$ corresponds to 3.op.3. in all other cases for $\Delta = 1; 2; 3; 4$ and corresponding to them |
| 3.4 | $q_{inv}$<br>$\varepsilon_f$<br>$k_f$ | $\varepsilon_f = \frac{q_{inv}^2}{3}$; $q_{inv}^2 = \tilde{q}_1^2 \beta_1^2 \overline{\cos}^2 a_1 + \tilde{q}_2^2 \beta_2^2 \overline{\cos}^2 a_2$;<br><br>$\overline{\cos} a_1 = \frac{3}{4} \frac{(1+\beta_1)^2}{Q_1^2 \beta_1^3} \left[1 + \frac{n_2^2 \beta_2 \overline{\cos} a_2}{n_1^2 \beta_1 \overline{\cos} a_1}\right]^{-1}$;<br><br>$k_f = \frac{\alpha_{inv}}{\alpha_e}$ |

4

$$q_d = q_{1d}\left(1-\frac{q_2}{q_1}\right)_d \; ; \Delta = 3;4$$

$$q_{dn} = q_{1dn}\left(1-\frac{q_2}{q_1}\right) B_q D_q B C_q$$

For $NS = 3$: $D_q = \varepsilon_{1p}^{-1}$ ; $NT \neq NT_{opt}$

For $NS = 1$:

$$\begin{cases} B_q = \dfrac{(1-\beta_2^2)^{1/2}}{(1-\beta_2^2)^{1/2}_{op}} \; ; \Delta = 3 \wedge NT > NT_{opt} \\ B_q = \dfrac{(1-\beta_2^2)^{1/2}_{op}}{(1-\beta_2^2)^{1/2}} \; ; \Delta = 4 \wedge NT \leq NT_{opt} \end{cases}$$

$8/9 < q \leq \sqrt{8/9}$ ; $\Delta = 1;2;3;4$
$q \leq 8/9$
$q > \sqrt{8/9}$

$D_q = 1; B_q = 1; BC_q = 1$

$$\tilde{q}_1^2 = \frac{Q_1^2}{\overline{\cos}\,\alpha_1} \; ; \; \tilde{q}_2^2 = \frac{Q_1^2}{\overline{\cos}\,\alpha_2}\frac{\beta_1^2(1+\beta_2)^2 n_2^2}{\beta_2^2(1+\beta_1)^2 n_1^2} \; ;$$

$$\frac{\overline{\cos}\,\alpha_2}{\overline{\cos}\,\alpha_1} = \frac{q_2^2}{q_1^2}\left|_{\Delta}\right. \frac{\beta_1^2(1+\beta_2)^2 n_2^2}{\beta_2^2(1+\beta_1)^2 n_1^2} \text{ for all } \Delta$$

| 1 | 2 | 3 |
|---|---|---|
| 4.1 | $\mu$<br>$\mu_d$<br>$\mu_c$ | $\mu = \frac{q}{|q|}\frac{\beta_1\beta_L}{\varepsilon_1\varepsilon_{2p}}\left(\frac{\varepsilon_1\beta_2 R_2}{\varepsilon_2\beta_1 R_1} + \frac{1-\frac{\varepsilon_1\beta_2 R_2}{\varepsilon_2\beta_1 R_1}}{1-\left\lvert\frac{q_2}{q_1}\right\rvert_n}\right)$; $\Delta = 1;2$<br>For neutral states $\mu_0 = \frac{q_1}{\lvert q_1\rvert}\frac{\beta_1\beta_L\varepsilon\left(1-\frac{\beta_2 R_2}{\beta_1 R_1}\right)}{\varepsilon_{1p}^{1/2}\left(1-\left\lvert\frac{q_2}{q_1}\right\rvert_n\right)}$; |
| 4.2 | $\mu$<br>$\mu_d$<br>$\mu_n$<br>$\mu_{nd}$ | $\mu_n = \mu_1 \varepsilon_f^2$; $\Delta = 1;2$<br>$\mu = \mu_1 \frac{\varepsilon_{2p}^{1/2}}{\varepsilon_{1p}}\bar{s}_p$<br>$\mu_{ef} = \mu + (\mu_n - \mu)(1 - e^{-\frac{\tau_c l}{T}A_\mu B_\mu})$; |
| 4.3 | $J_T$<br>$J$<br>$J_{T\max}$<br>$J_{\max}$<br>$J_{ef}$ | $J_T = S_J\left\{\frac{\sqrt{2}\beta_1^3 Q_1^2 \beta_L A_\nu}{(1+\beta_1)^2}\left[1 + \frac{k_x(1-\beta_2^2)^{1/2}}{k_y(1-\beta_1^2)^{1/2}}\cdot\frac{\beta_1^3 n_2^2(1+\beta_2)^2}{\beta_2^3 n_1^2(1+\beta_1)^2}\cdot\left(\frac{q_2}{q_1}\right)^2\right]\right\}^{-1}$;<br>$J = \begin{cases}\varepsilon(J_T);\ \Delta = 9-16\\ \varepsilon(J_T+0.5)/2;\ \Delta \neq 9-16\end{cases}$<br>$J_{T\max} = S_J A_J \frac{(1-\beta_i^2)^{1/2}}{(1-\beta_i^2)_p^{1/2}}$; $A_J = \begin{cases}2, NS = 1\\ \pi, NS \neq 1\end{cases}$<br>$i = \begin{cases}1, NS = 3\\ 2, NS \neq 3\end{cases}$<br>$J_{\max} = \begin{cases}\varepsilon(J_{T\max}) + 1,\ \Delta = 9-16\\ \varepsilon(J_{T\max}) + 0.5,\ \Delta \neq 9-16\end{cases}$<br>$J_{ef} = J_{\max} - (J_{\max} - J)(1 - e^{-\frac{\tau}{T}A})$ |

Table 16.1 continuation

| 4 |
|---|
| $\mu_d = \frac{q}{\lvert q \rvert} \frac{\beta_1 \beta_L}{\varepsilon_{1p}} \left( \frac{\beta_2 R_2}{\beta_1 R_1} + \frac{1 - \frac{\beta_2 R_2}{\beta_1 R_1}}{1 - \left\lvert \frac{q_2}{q_1} \right\rvert_n} \right) ; \Delta = 3;4$ |
| $\varepsilon = \begin{cases} \varepsilon_{2p}; \Delta = 1;2, \\ \varepsilon_{1p}; \Delta = 3;4; \end{cases}$ For all cases when $NT > NT_{opt}$ $\mu = 0; \mu_d = 0; \mu_0 = 0$ |
| $\mu_{nd} = \mu_{1d} \frac{1}{\varepsilon_f^{1/2}} ; \Delta = 3;4$ |
| $\mu_d = \mu_{1d} \left( \frac{\varepsilon_{2p}}{\varepsilon_{1p}} \right)^{1/2} k_f$ |
| $A_\mu = \begin{cases} (1-\beta_1^2)^{1/2} ; NS = 3 \\ (1-\beta_2^2)^{1/2} ; NS \neq 3 \end{cases} ; B_\mu = \begin{cases} 1/2\pi ; \Delta = 1;2 \\ 2\pi ; \Delta = 3;4 \end{cases}$ |
| $S_f = \begin{cases} s, \ \Delta = 1;2 \\ s_d, \ \Delta = 3;4 \end{cases}$ |
| $A_\nu = \begin{cases} 1 + t_\nu & \text{when } \Delta = 1, \ NS \neq 1 \\ 1 & \text{when } \Delta = 2;4, NS \neq 1 \\ 1 + t_{\nu d} & \text{when } \Delta = 3, \ NS \neq 1 \\ 1 & \text{when } NS = 1 \end{cases}$ |
| $A = \begin{cases} 2\pi \ NS = 1 \vee & (NS = 2 \vee NS = 3) \wedge \Delta = 3 \\ 4\pi & (NS = 2 \vee NS = 3) \wedge \Delta = 4 \\ \pi & (NS = 2 \vee NS = 3) \wedge \Delta = 1;2 \end{cases}$ |

| 1 | 2 | | 3 | | |
|---|---|---|---|---|---|
| 5.1 | $m_x$ | $NS = 1, 2, 3$ | $m_x = \frac{s(1-\beta_2^2)^{1/2}}{a_g^{1/2}} A_m$ ; $s = \begin{cases} s_{ef}, \Delta = 1;2 \\ s_{ef}, \Delta = 3;4 \end{cases}$ | | |
| 5.2 | $m_{(1-4)}$<br>$m$<br>$m_n$<br>$m_d$<br>$m_{dn}$ | $NS = 1, 2$ | $m_{(1)} = \frac{m_x}{a_g^{1/2} f(g_{00}) \varepsilon_2}$<br>$m_{(1)n} = \frac{m_x}{a_g^{1/2} f(g_{00}) \varepsilon_{2p}}$<br>$m = m_{(1)} A_s$<br>$m_n = m_{(1)n} C_s BC \varepsilon_f^2$ | $m_{(2)} = \frac{m_x \varepsilon_1^{1/2}}{\varepsilon_2^2}$<br>$m_{(2)n} = \frac{m_x \varepsilon_{1p}^{1/2}}{\varepsilon_{2p}^2}$<br>$\Delta = 1;$<br>$m = m_{(2)} A_s$<br>$m_n = m_{(2)n} C_s$ | $\Delta = 2$ |
| | | | $A_s = \begin{cases} 1 \\ \sqrt{9/8} \\ 9/8 \end{cases}$ $\Delta = \begin{cases} 1-16 \\ 17-20 \\ 25-28 \\ 21-24 \\ 29-32 \end{cases}$ | | |
| | | | For $NS = 1$: $IS = \begin{cases} \sqrt{8/9}\, \varepsilon_{1p}^{1/2}\ ;\ 8/9 < q < \sqrt{8/9}\ ; \\ 1 \text{ in other cases;} \end{cases}$ | | |
| 5.3 | | $NS = 3$ | $m = \frac{m_x \varepsilon_f^2}{\varepsilon_2} A_\Delta$ ; $m_n = \frac{m_x}{\varepsilon_{1p}} A_\Delta$ ; $\Delta = 1;2$ | | |
| | | | $A_\Delta = \begin{cases} \frac{1}{a_g^{1/2} f(g_{00})}\ ;\ \Delta = 1;4 \\ 1; \quad \Delta = 2;3 \end{cases}$ | | |

calculation

| 4 | | |
|---|---|---|
| $s_{ef} = s + (\bar{s} - s)(1 - e^{-\frac{r_{cl}}{T}})$<br>$s_{efd} = s_d + (\bar{s} - s_d)(1 - e^{\frac{r_{cl}}{T}})$ | | |
| $m_{(3)d} = \frac{m_x \varepsilon_{1d}^{1/2}}{\varepsilon_{2d}^2}\sqrt{9/8}$<br>$m_{(3)dn} = \frac{m_x \varepsilon_{1p}^{1/2}}{\varepsilon_{2d}^2 \varepsilon_{1d}^2}\sqrt{9/8}$<br>$m_d = m_{(3)d} A_s B_s$<br>$m_{dn} = m_d C_s$ | $m_{(4)d} = \frac{m_x}{a_g^{1/2} f(g_{00}) \varepsilon_{2d}}\sqrt{9/8}$<br>$m_{(4)dn} = \frac{m_x}{a_g^{1/2} f(g_{00}) \varepsilon_{1p}}\sqrt{9/8}$<br>$\Delta = 3;$<br>$m_d = m_{(4)d} A_s$<br>$m_{dn} = m_{(4)d} C_s$ | $\Delta = 4$ |

$$B_s = \begin{cases} \varepsilon_{1p}^{-1/2} & NS = 2 \wedge IS = 1 \\ 1 & NS \neq 2 \quad IS \neq 1 \end{cases}$$

$$C_s = \left.\begin{cases} \varepsilon_{1p}^{1/2} & \Delta = 1 \\ \varepsilon_{1p}^{-1/2} & \Delta = 2 - 4 \\ 1 & \Delta = 1 - 4 \end{cases}\right\} \begin{array}{l} NT \neq NT_{opt} \\ NT = NT_{opt} \end{array}$$

$$m_t = \frac{m_x}{\varepsilon_{2d}}\sqrt{9/8}\, A_\Delta B_\Delta \qquad \Delta = 3; 4$$

$$m_n = \frac{m_x}{\varepsilon_{1p}}\sqrt{9/8}\, A_\Delta B_\Delta$$

$$B_\Delta = \frac{\varepsilon_{2p}^{1/2}}{\varepsilon_{1p}^{3/2} a_{gp}^{1/2} f(g_{00})_p};\ NT \neq NT_{opt};\ B_\Delta = 1;\ NT = NT_{opt}$$

| 1 | 2 | 3 |
|---|---|---|
| 6.1 | $\tau_{cl}$ | $\tau_{cl} = \frac{U_0}{E_0} \frac{T(1-\beta_2^2)^{1/2}}{(1-\beta_1^2)_p^{1/2} \left\lvert 1 - \frac{m_{ef(NT+1)}}{m_{ef(NT)}} \right\rvert} \cdot \frac{2n}{n_1}$<br>$U_0 = m'_{ef(NT)} c^2 \left\lvert 1 - \frac{m_{ef(NT+1)}}{m_{ef(NT)}} \right\rvert A_U ;$<br>$q_{1ef} = q_1 + (q_{1n} - q_1)(1 - e^{-\frac{\tau}{T} 2\pi A_Q}) ;$<br>$T = \frac{2\pi R_1}{\beta_1 c} ; R_1 = \frac{2\beta_L}{m'_{ef}} \frac{\hbar}{c} A_R ; A_R = \begin{cases} s/e_{2p}; \Delta = 1;2 \\ s_d/e_{1p}; \Delta = 3;4 \end{cases}$<br>$m'_{ef} = m_{ef} m_e$<br>$m_{ef} = m + (m_n - m)(1 - e^{-\frac{\tau}{T} 2\pi A_Q})$ |
| 6.2 | $\tau_{qu}$ | $\tau_{qu} = \frac{T}{D} \cdot \frac{2n}{n_1}$<br>$D = \begin{cases} \frac{1}{1 + \frac{(k_1^2 - k_2^2)^2}{4k_1^2 k_2^2} \sin^2 a_b k_2} ; E > U_0 ; k_1 = \frac{\sqrt{2m'_{ef} E}}{\hbar} \\ \frac{1}{1 + \frac{(k_1^2 + k_2^2)^2}{4k_1^2 k_2^2} \mathrm{sh}^2 a_b k_2} ; E \le U_0 ; k_2 = \frac{\sqrt{2m'_{ef} \lvert E - U_0 \rvert}}{\hbar} \end{cases}$<br>$n_r = 1 \quad \text{If} \begin{cases} NS = 2 \text{ or} \\ NS = 3 \wedge (\Lambda = 3 \vee \Delta = 4) \end{cases}$ , then $n_r = 1 + \frac{2 \arcsin \sqrt{E/U_0}}{\pi} + \frac{k_1 a_\Delta}{\pi}$<br>$E = E_0 n_r^2$ |

Table 16.1 continuation

$$i = \begin{cases} 1; & NS = 3 \\ 2; & NS \neq 3 \end{cases}$$

$$E_0 = \frac{2}{3} \frac{\beta_1^2}{(1 \div \beta_1)^2} \frac{q_{ef}^2}{R_1^2} \hbar c^2 \left| 1 - \frac{\alpha}{q_{ef}^2} \right| \frac{(1-\beta_f^2)^{1/2}}{(1-\beta_f^2)_p^{1/2}} A_U T \qquad A_U = \begin{cases} \sqrt{978}\,; & NS = 1 \\ \sqrt{879}\,; & NS \neq 1 \end{cases}$$

$$q_{ef} = q_1 + (q_n - q)\left(1 - e^{-\frac{\tau}{T} 2\pi A_Q}\right); \quad A_Q = \begin{cases} 1 & NS = 1 \\ (1-\beta_f^2)_p^{1/2} & NS \neq 1 \end{cases}$$

$$a_{pli} = \begin{cases} \dfrac{n_r \pi}{4} \left( \dfrac{1 - 2 \arcsin \sqrt{E/U_0}}{\pi n_r} \right) \dfrac{A_N}{k_1}; & (E < U_0) \\ \beta_1 c \tau_{qu} \dfrac{(1-\beta_f^2)^{1/2}}{(1-\beta_f^2)_{op}^{1/2}}; & (E \geq U_0) \end{cases}$$

$$A_N = \begin{cases} 1; \ \Delta = 1; 2 & NS \neq 2 \\ 2; \ \Delta = 3 & NS = 2 \end{cases}$$

$$a_b = a_{pli} \begin{cases} 4, & \Delta = 2 \wedge NS = 2 \\ 2; & \Delta = 4 \wedge NS = 1 \end{cases}$$

# 17 METHODS OF COMPUTER CALCULATION AND IDENTIFICATION OF PARTICLES PREDICTED BY THEORY AND FOUND EXPERIMENTALLY

## 17.1 The fundamentals of the logic of comparison of theoretical and experimental data on elementary particles

In section 16 we discussed the mathematical algorithm and methods of calculation of all parameters of elementary particles. The theoretical values of the EP parameters obtained by means of it require comparison with the corresponding experimental data. In this subsection we discuss the main principles and methods of computer comparison of the theoretical and experimental data.

All calculated parameters of EPs are the unambiguous functions of four basic quantum numbers in the systematization of particles within the bounds of the periodical law of elementary particles (microparticles): $NS$ is the number of series; $NT$ is the number of the PLM multiplet in the series; $\Delta$ is the number of the state in the multiplet; $QS$ is the number of the quark structure.

For some particles it is necessary to take into account the quantum number characterizing the internal symmetry of EP. In its turn, $NS$, $NT$, $\Delta$, $QS$ and $IS$ are the unambiguous functions of the fundamental quantum number $K$ characterizing the multiplet in PLM. PLM allows to find the complete spectrum of possible EP states, each of them is characterized by the following parameters: the mass, the charge, the magnetic moment, the isotopic spin and its projection, the spin, the lifetime or the resonance width, the internal even parity, the baryon number, the lepton number and in some cases by previously unknown internal symmetries

For the experimentally found elementary particles (further on we shall call them "experimental particles") the data on the enumerated parameters are also given. Yet, because of the difficulties arising in the course of experimental determination of some parameters there is a far from being complete set of experimental data for each particle. Not high enough reliability of certain experimental data allows in some cases to doubt whether corresponding particles exist at all. This circumstance and inaccuracy of determination of EP parameters, due to the experimental errors, bring some uncertainty which does not allow to perform unambiguous comparison (identification) of the experimental particle and the specific state obtained by means of calculation on the basis of PLM. Thus, the identification process reasonably acquires the probabilistic character. A rather detailed statistic analysis of the identification problem is given in [84]. It is necessary to mention several important details clarifying the essence of the problem.

The methods and algorithms of identification are entirely determined by the kind of information on the experimental data, their reliability, accuracy and also by the type of the law of the errors distribution. The identification procedure is quite unambiguous when comparing theoretical

and experimental data on such parameters experimentally safe and accurate as the charge, baryon and lepton numbers, etc. Yet under identification by such inaccurately known parameters as the mass and the lifetime (the resonance width), the solution is ambiguous and not determinate but acquires a probabilistic character. The identification process discussed here includes both above-mentioned stages. At first the "rigid", determinate comparison of the data by the quantum parameters is realized. Then the theoretical particles and the experimental ones are finally identified by the mass and lifetime with the help of the statistic criteria

Before discussing the main principles of particles identification by quantum parameters we point out some general principles of PLM which determine the logic of the classification of EPs along the PLM series.

In TFF the question of the possibility of realization of a certain state of PLM is solved. The number of PLM states is finite and each state is characterized, as it was mentioned, only by the numbers $NS$, $NT$, $\Delta$ and $IS$. In TFF it is shown [7, 18, 33, 34, 85] that only the states of the first, second and third series are realized in matter, i.e. the parameter of the series number takes only the values of $NS = 1, 2, 3$. The states with the series numbers above three are not realized in matter. Besides, in each series there is a restricted number of PLM multiplets. The maximal PLM multiplets number is denoted as $NT_{max}$. It is shown that $NT_{max}$ of the given series coincides numerically with the fundamental quantum number $K_p$ of the first PLM multiplet of the next series. For example, $NT_{max}$ of the first series is numerically equal to 113, and $K_p$ of the second series is also equal to 113.

In principle, each PLM multiplet can include 32 states ($\Delta = 1 - 32$). Yet, all of them can not be simultaneously realized, which is clear from tables 16.1.1, 16.1.2 and 16.1 3. So, for example, if $NT > N_{opt}$, then the corresponding multiplet can include, in principle, only 16 states ($\Delta$ =1-16) and they are only mesons. Besides, from the tables of the calculation formulae it is seen that only a part of these states can be realized.

The quantum numbers, which characterize now EPs in PLM, show that a particle relates to a certain series $NS$, multiplet $NT$, state $\Delta$. In some cases $IS$ and $QS$ should be taken into account. Since the charge, the baryon number and the lepton number are strictly determined in PLM and the experimental data on these quantum parameters are reliably stated, it allows to determine unambiguously to which PLM series the experimental particles belong, to estimate the range of possible multiplet numbers and to define which numbers of the states $\Delta$ in the PLM multiplets they can have. Examples are presented:

1. As it is seen from table 16.1, the particles with the lepton number $L = 0$ can be related only to the first or second PLM series, and they are absent in the third series.

2. The particles with the baryon number $B \neq 0$ can be related only to the states of the first and the second series.

The particles with the lepton numbers differing from zero ($L \neq 0$) can be related only to the third PLM series. This condition for the first series means that baryons can be only in the first 19

PLM multiplets ($1 \leq NT \leq 19$). In the second series the first 72 PLM multiplets are permissible for baryons. Besides the mentioned restriction on the PLM quantum parameters $NS$ and $NT$ there is an additional restriction of the number of the state $\Delta$ in the PLM multiplet. For the baryons with the charge $|q| = 1$ the states $\Delta = 1 - 4$ and $21 - 24$ are allowed. For the baryons with the charge $|q| = 2$ the states $\Delta = 17 - 20$ are allowed. For the baryons with $q = 0$ the states $\Delta = 5 - 8$ and $\Delta = 25 - 32$ are allowed. Besides, the sign of the charge and the sign of the internal even parity put additional restrictions upon their belonging to a certain $NS$ and $\Delta$ (see [7, § 1.5]). So, for example, the baryon $B = 1$ with the charge $q = +1$ and the internal even parity $p = +$ may be in the first and the second series with $\Delta = 1; 3$ and $21; 23$.

Similarly other types of particles can be considered and the possible range of the quantum parameters $NS$; $NT$; $\Delta$; $QS$ can be stated for them.

At the next stage of identification the number of the PLM multiplet $NT$ is defined more exactly. As it is known [7], the mass of PLM state $m_t$ is the monotonously decreasing function of the multiplet number. This dependence can be represented in the form:

$$m_t \approx \frac{A(NS, NT, \Delta)}{NT}.$$

Under the fixed values of $NS$ and $\Delta$ the coefficient $A$ ($NS$, $NT$, $\Delta$) turns out to be slightly dependent on $NT$. Taking into account the fact that the experimental mass is approximately equal to the theoretical one we can find the nearest PLM state, i.e. $NS$, $NT$, $\Delta$ ($NS$ and $\Delta$ are fixed) by using the rapidly converging iteration process. Thus, the found number of the PLM multiplet $NT$ should be within the range of possible values according to table 16.1. Otherwise, the found $NS$, $NT$, $\Delta$ should be excluded from further consideration. Since the mass of the experimental particle is often determined with insufficient accuracy, the necessity arises of considering the additional PLM states with the same quantum numbers $NS$ and $\Delta$, but with the neighbouring values of $NT$ with respect to that found by the iteration scheme (the central state of $NS$, $NT$, $\Delta$).

All theoretical particles selected according to the mass and supposed to be identified with the given experimental particle are verified according to the spin. The PLM states are excluded from further consideration if the following condition does not hold:

$$J_n \leq J_{ex} \leq J_{max},$$

where $J_{ex}$ is the experimental spin of the particle; $J_n$ is the spin of the normalized PLM state; $J_{max}$ is the maximally possible spin of the normalized PLM state.

For baryons and leptons besides the mentioned condition the following is necessary:

$$NT < N_{opt}(NS),$$

where $N_{opt}(NS)$ is the optimal value of $NT$ for a given series number $NS$.

If the spin of the experimental particle is known then the above-mentioned condition is not taken into account.

Yet, after verification of all conditions and restrictions formulated above for the light experimental particles, in principle not one but some theoretical PLM states can be selected which are supposed to be identified with a given experimental particle. Further on the only state should be selected from this totality. If it is theoretically determined, this state should completely correspond to the charge and even parity and in the greatest degree to the experimental data on the mass, lifetime (the resonance width), and also on the magnetic moment for those particles whose magnetic moment is determined. For hard particles, corresponding to the first values of $NT$ in each series, there is no such necessity, because the spectrum of the theoretical values of the parameters is very thin (for example, the mass of the particle with $NT = 1$ is twice greater than the mass of the particle with $NT = 2$).

It is stated [7, § 4.1] that the logic of comparison of the theoretical and experimental data should take into account the degree of reliability and accuracy of determination of the latter. Since the accuracy and reliability of the data on EPs lifetime (the resonance width) is below those on EPs mass, at the first stage the comparison of the data on mass is performed. Then the results are corrected by taking into account the lifetime and the magnetic moment of EPs. We now consider the identification of particles according to mass and lifetime.

The necessary condition of identification of particles acording to mass is to allow the difference between theoretical values and experimental ones to be not more than $3\sigma$:

$$| m_t - m_{ex} | \leq 3 ( \Delta m_{ex} + \Delta m_t ) ,$$

where $\Delta m_{ex}$ is the error of determination of the experimental mass; $\Delta m_t$ is the error of determination of the theoretical mass.

Further on the conditions are verified on the lifetime:

for stable particles

$$\log_{10} \frac{\tau_t}{\tau_{ex}} < 1 ;$$

for resonances

$$0.02 \Delta \Gamma_{ex} < | \Gamma_t - \Gamma_{ex} | < 4 \Delta \Gamma_{ex} ,$$

where $\Delta \Gamma_{ex}$ is the error of determination of the experimental value of the lifetime (the resonance width). If $\Delta \Gamma_{ex}$ is unknown, then the following condition is verified:

$$\frac{1}{4} < \frac{\Gamma_t}{\Gamma_{ex}} < 4 .$$

The theoretical particle not satisfying the conditions of selection according to mass or lifetime does not take part in further identification.

During the identification each experimental particle is compared with a set of competing theoretical PLM states. Possible variants of identification are written into the computer main memory in the form of a series whose terms subsequently, to a different extent, satisfy the following criterion:

$$k_{ij} = \prod_{l=1}^{3} k_{ij}^{l}.$$

Here

$$k_{ij}^{1} = \frac{|m_{exj} - m_{tij}|}{m_{tij}} + \left(\frac{\Delta m_{exj}}{m_{exj}}\right)^{1/2};$$

$$k_{ij}^{2} = \begin{cases} \dfrac{|\Gamma_{exj} + \Gamma_{tij}|}{\Gamma_{tij}} - \left(\dfrac{\Delta\Gamma_{exj}}{\Gamma_{exj}}\right)^{1/2} & \text{for instable EPs;} \\ \dfrac{|\log_{10}\tau_{exi} - \log_{10}\tau_{tij}|}{3} & \text{for stable EPs;} \end{cases}$$

$$k_{ij}^{3} = \begin{cases} \dfrac{|\mu_{exi} - \mu_{tij}|}{\mu_{exj}}, \text{ if } \mu_{exij} \neq 0; \\ 1, \quad \text{if } \mu_{exj} = 0,\ \mu_{tij} \neq 0; \\ 10^{-2}, \quad \text{if } \mu_{tij} = \mu_{exj} = 0, \end{cases}$$

where $j = 1, 2,\ldots$ is the number of the experimental particle; $i = 1, 2,\ldots$ is the number of the theoretical PLM state (the candidates which are supposed to be identified with $j$ th particle); $k_{ij}^{l}$ is the value of the criterion of the correspondence of the $i$ th theoretical PLM state to the $j$ th experimental particle according to the $l$ th indication; $m_{exj}$ is the experimental mass of the $j$ th particle; $\Delta m_{exj}$ is the standard error of the experimental mass $m_{exj}$; $m_{tij}$ is the theoretical mass of the $i$ th PLM state compared with the $j$ th experimental particle; $\Gamma_{exj}$ is the resonance width of the experimental $j$ th particle; $\Delta\Gamma_{exj}$ is the standard error of the experimental resonance width; $\Gamma_{tij}$ is the theoretical resonance width of the $i$ th PLM state compared with the $j$ th experimental particle; $\tau_{exj}$, $\tau_{tij}$ are the experimental and theoretical lifetimes of the $i$ th PLM state, respectively, (they are determined only for stable particles); $\mu_{ex}$; $\mu_{tl}$ are the magnetic moments of the experimental EP and the theoretical $i$ th PLM state, respectively.

If the value $\Delta m_{ex}$ or $\Delta \Gamma_{ex}$ is known then,calculating the value of the criterion $k_{ij}^{1,2}$, instead of the corresponding ratios we take the maximal relative error of the mass or resonance width from the entire totality of the considered instable experimental particles.

As it is shown in [7, § 4.1], this criterion represents the total error of one of the possible variants of identification. Thus under comparison, the particles with minimal total error are preferable. As a result, that PLM state is identified whose value of the criterion $k_{ij}$ is the least. Under

realization of such algorithm of identification the cases are possible when the ambiguity of the solution arises, i.e. when two different experimental particles are identified with one and the same PLM state. This can occur under great errors of the experiment. To remove the probable uncertainty in identification the following rules are used:

1) The succession of identification of experimental particles is stated in regard to the reliability and completeness of experimental data. The so-called "coefficient of reliability" is introduced for the experimental particles in regard to the reliability and completeness of experimental data. This coefficient is expressed by a number of "asterisks" ranging from 4 (most reliable) to 0 (poorly studied). In accordance with this, in the first place a group of particles is identified whose coefficient of reliability is equal to four asterisks. Then groups with three, two, etc asterisks follow.

2) Within the set of particles with the same coefficient of reliability the identification is performed in the succession of the criterion $k_{ij}^{l}$ increase.

In conclusion we note that in the process of realization of the algorithms of parameters calculation and their identification with the experimental particles certain difficulties were overcome. They were connected with both the correction of physical problem formulation and the restricted possibilities of a computer. The latter includes the following: the lack of calculation accuracy because of the restricted number of decimal digits, the necessity of conversion of initial calculation formulae (for example, the formulae for the charges and magnetic moments), the lack of the main memory, the lack of capacity which, in particular, influences the calculation of lifetime of particles, when their values change within the range of some tens of the orders, etc.

## 17.2
## Method of computer comparison of calculated and esperimental data

In this subsection the results of realization of a computer program of identification of EPs with the theoretical PLM states are analysed.

Identification of EPs with the theoretical PLM states was performed for the entire totality of parameters characterizing the given EP: the charge, the mass, the spin, the isotopic spin, the projection of the isotopic spin, $p$-even parity, the lifetime (the resonance width), the magnetic moment, excluding those parameters whose experimental values are unknown. In this case the theoretical value of the parameter can be considered as prediction.

The theoretical PLM states are denoted by symbols $NS$. $NT$, $\Delta$, where $NS$ is the number of PLM series; $NT$ is the number of PLM multiplet; $\Delta$ is the number of the state in the multiplet.

The calculation of parameters characterizing the PLM state was performed with accuracy conditioned by the algorithm of the equations solution corresponding to certain parameters and with accuracy of the computer run (computing was carried out by BESM-6 and partially by the

personal computer IBM-286 (or 386)). Therefore, in most cases the accuracy of calculation of the theoretical parameter is above the accuracy of the corresponding experimental value.

From the algorithm of identification of elementary particles, discussed in the preceding subsection, it follows that the more accurate is the determination of the experimental data, the higher is the reliability of identification with the corresponding states ($NS, NT, \Delta, QS$). Therefore, it can be considered that identification is reliable, for example, for such particles as the proton, electron, muon, neutron, kaon, etc, and for particles whose basic parameters such as the mass and lifetime (the resonance width) are of lower accuracy the idenfification is the best by these parameters. The reliability of identification will rise under further correction of experimental data, development of the theory, rise of computing accuracy, improvement of the algorithm, etc.

Since identification was carried out for the entire totality of parameters characterizing EPs, then a part of those EPs for whom the computer answer was: "The possibility of existence is not verified" can be identified later on, i.e. if such set of quantum parameters is not verified, it is enough to change one of them and the identification would be possible.

We now consider the process of identification of the proper set of the experimental parameters with the theoretical PLM state for one of the best known particles.

Proton $p^+$. The experimental data give the following set of quantum parameters by means of which the identification should be carried out:

mass $m_{ex} = 1836.1527(6)$,

charge $q_{ex} = +1$,

spin $J = 1/2$,

isospin $I = 1/2$,

projection of isospin $I_3 = +1/2$,

even parity $p = +$,

magnetic moment $\mu_I = +2.7928444$,

lifetime $\tau_I$ (the particle is stable),

baryon number $B = 1$.

From PLM it is known that the state with $B = 1$ is realized only in the first or second series. Since the charge $|q_{ex}| = 1$ and $B = 1$, then from PLM it is seen that in this case only $\Delta = 1—4$ are possible.

Since $q_{ex} = +1$ and even parity $p$ is +, according to PLM, from these states the possible candidates can be the following: $NS = 1$; $\Delta = 1$ (or equivalent to $\Delta = 1$).

Further on for each candidate the number of multiplet $NT$ is chosen according to the best correspondence to the experimental mass.

For the given $NS$ and $\Delta$ the theoretical mass decreases monotonously with increase of the number of the multiplet. Therefore, for $m_{ex}$ in question, the only number of the multiplet is possible, that one when $m_t$ ($NS$, $NT$, $\Delta$) corresponds to $m_{ex}$ in the best way.

For the proton the following candidates for identification were selected: 1.19.1; 1.20.3; 1.21.21; 1.23.23. In the case when $NT > NT_{opt}$ we have $J_t = 0$ and $\mu_t = 0$. This means that only 1.19.1 is left from the possible candidates because $NT_{opt\,NS=1} = 19$.

Thus, the only state was chosen from all possible theoretical states whose quantum parameters are the following (according to the calculation):

$m_t = 1836.152$; $q_t = +1$; $J_t = 1/2$; $I = 1/2$; $I_3 = +1/2$; $\tau_t = 3.426652 \cdot 10^{39}$s; $\mu_t = +2.79284384$.

All the results of comparison are formed into a special table (a special program of print is developed for this aim) and are printed.

The results of this identification are analysed in section 20.

# 18 RESULTS OF CALCULATION OF EP !NTERNAL PARAMETERS AND THEIR ANALYSIS

All internal parameters of the elementary particles structure in all subspaces are determined on the basis of the calculation formulae deduced in section 16. To obtain the results of calculation which might be further on comparable with the results of the experiment,it is mainly necessary to obtain the parameters of the particles in the calculation subspace $(2 \to 1)$. In this book, naturally, we have no possibility to give examples of the calculation results of all internal characteristics of elementary particles. Yet, it seems necessary to give examples of the numerical values of the principal characteristics of elementary particles, so that the reader could get an idea of their values and the dynamics of their change in any series with increase of the number of the particle in that series. Such characteristics for all three series of the Periodical Law of elementary particles are given in table 18.1. For each table series the numerical values of $n$, $\left(1 - \frac{2\pi K}{K_1}\right)$, $(1 - \beta)$, $(\Delta\beta)$ are given. These values are invariable for relevant series. The characteristics of a relevant particle, i.e. the number of the series, the number of the point and the number of the state are given in the first table column. Naturally, not all possible numbers of points but only a part of them are given as an example for each series. The value of the fundamental quantum number for the multiplet of particles of relevant series with a relevant number of the point is given in the second column. This number is the same for all states characterizing a relevant point, i.e. for the entire multiplet of PLM. The number of subparticles in the structure situated on the external circumference (we remind that in concerns the structure in the subspace $(2 \to 1)$) is given in the third column. The number of subparticles situated on the internal circumference is given in the fourth column. The quantity which is the function of the internal parameters of the particles and takes an important part in the calculation of observable charges and masses, is given in the fifth column. It is calculated according to the formula given in the summary table (see table 16.1, № 2.1.3). The numerical value of the external radius of the particles structure in the calculation subspace is given in the sixth column. The distance between the external and internal charges for each structure is given in the seventh column. The value of the permittivity for a relevant structure in an average physical vacuum, when the charges are situated on the circumference with the radius $R_1$, are given in the eighth column. Each particle has its own value of permittivity due to the dispersion between the charges of the particles structure and the elementary particles of vacuum. The value of the permittivity $\varepsilon_2$ for the charges situated on the internal circumference is given in the ninth column. It differs from the value of the permittivity for the charges situated on the external circumference, due to the above-mentioned dispersion, because the velocities of the particles motion and their characteristics are different on the external and the internal circumferences. The value of the fundamental charge $q_1$ for a relevant elementary particle is given in the tenth column. This value is determined by the formulae given in the summary table of the calculation formulae 16.1, № 3.1. The numerical value of the mechanical moment of the substructure of a relevant elementary par-

ticle is given in the eleventh column. We remind the reader: we fix as a spin the projection of this mechanical moment onto the precession axis of the elementary particle structure.

It is of interest to follow the dynamics of the change of the internal characteristics of the elementary particles along the series. Most clearly it can be seen by the change of the particle parameters of the first series, because this change is more substantial. The changes of internal characteristics along the second and third series occur substantially slower.

As it was mentioned above, the mean number of the subparticles on the external and internal circumferences of the structure is preserved along the series. The amount of subparticles on the external circumference increases with the increase of the point number, while the amount of subparticles on the internal circumference decreases in the same degree. The external radius along the entire series (the sixth column) changes insignificantly, its change from the first point to the last one of the first series consists of only 17 %. At the same time the value of the internal radius substantially decreases from one point to the next one along the series. In the first series the difference between the external and internal charges, as it is seen from the seventh column, changes by two orders. The permittivities change along the series insignificantly, retaining their values near one. Yet, the difference of the permittivity from one, for the first point of the first series, is observed only in the fifth decimal place, while for the last point it is observed already in the third decimal place. The fundamental charge square also changes substantially along the series: for the first point it is equal to 23, for the last one of the first series it is equal to 0.2 only. In the second series the fundamental charge square changes more substantially: from the second point of the series to the 587th it changes approximately by three orders. The change of the external fundamental charge square is still greater for the particles of the third series: from the first point to the 16009th this change is by five orders. It is of extraordinary interest that Nature managed to provide such symmetry laws. Under immense changes of the numerical values of the fundamental field charges the difference of these charges observable in our laboratory subspace, which we call the "electric charge", is practically of the same value, differing insignificantly.

The exact values of certain internal parameters of some particles of the first, second and third series are given in table 18.2. These exact values of the principal characteristics of the internal structure of the particles are given to get an idea of the character of change of these values as well as to use these numerical values for calculation. These values have been already used in the book (section 15) for the calculation of the numerical values of the global constants.

$n = 5\,912$; $(1 - \frac{2\pi K}{k_1}) = 4.02337 \cdot 10^{-4}$; $(1 - \beta) = 1.22042 \cdot 10^{-3}$; $\Delta\beta_{pr} = 3.04428 \cdot 10^{-6}$

| State number | Internal parameters | | | | |
|---|---|---|---|---|---|
| | $K$ | $n_1$ | $n_2$ | $t_v$ | $R_i$, c. |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1.1.1(2) | 7 | 5934 | 5890 | $8.04\,335 \cdot 10^{-3}$ | $2.25\,505 \cdot 10^{-14}$ |
| 1.2.1(2) | 14 | 5956 | 5868 | $1.60\,876 \cdot 10^{-2}$ | 2.25 231 –"– |
| 1.3.1(2) | 21 | 5978 | 5864 | 2.41 332 –"– | 2.24 959 –"– |
| 1.4.1(2) | 28 | 6000 | 5824 | 3.21 807 –"– | 2.24 688 –"– |
| 1.5.1(2) | 35 | 6022 | 5802 | 4.02 308 –"– | 2.24 418 –"– |
| 1.6.1(2) | 42 | 6044 | 5780 | 4.82 840 –"– | 2.24 149 –"– |
| 1.7.1(2) | 49 | 6066 | 5758 | 5.63 408 –"– | 2.23 880 –"– |
| 1.8.1(2) | 56 | 6088 | 5736 | 6.44 017 –"– | 2.23 612 –"– |
| 1.9.1(2) | 63 | 6110 | 5714 | 7.24 674 –"– | 2.23 346 –"– |
| 1.10.1(2) | 70 | 6132 | 5692 | 8.05 383 –"– | 2.23 078 –"– |
| 1.11.1(2) | 77 | 6154 | 5670 | 8.86 151 –"– | 2.22 813 –"– |
| 1.12.1(2) | 84 | 6176 | 5648 | 9.66 982 –"– | 2.22 548 –"– |
| 1.13.1(2) | 91 | 6198 | 5626 | $1.04\,738 \cdot 10^{-1}$ | 2.22 285 –"– |
| 1.14.1(2) | 98 | 6220 | 5604 | 1.12 886 –"– | 2.22 021 –"– |
| 1.15.1(2) | 105 | 6242 | 5582 | 1.20 991 –"– | 2.21 758 –"– |
| 1.16.1(2) | 112 | 6264 | 5560 | 1.29 105 –"– | 2.21 496 –"– |
| 1.17.1(2) | 119 | 6286 | 5538 | 1.37 228 –"– | 2.21 234 –"– |
| 1.18.1(2) | 126 | 6308 | 5516 | 1.45 361 –"– | 2.20 973 –"– |
| 1.19.1(2) | 133 | 6330 | 5494 | 1.53 504 –"– | 2.20 712 –"– |
| 1.20.1(2) | 140 | 6352 | 5472 | 1.61 658 –"– | 2.20 452 –"– |
| 1.21.1(2) | 147 | 6374 | 5450 | 1.69 823 –"– | 2.20 192 –"– |
| 1.22.1(2) | 154 | 6396 | 5428 | 1.78 000 –"– | 2.19 931 –"– |
| 1.23.1(2) | 161 | 6418 | 5406 | 1.86 189 –"– | 2.19 673 –"– |
| 1.24.1(2) | 168 | 6440 | 5384 | 1.94 391 –"– | 2.19 414 –"– |
| 1.25.1(2) | 175 | 6462 | 5362 | 2.02 607 –"– | 2.19 157 –"– |
| 1.26.1(2) | 182 | 6484 | 5340 | 2.10 836 –"– | 2.18 898 –"– |
| 1.27.1(2) | 189 | 6506 | 5318 | 2.19 080 –"– | 2.18 640 –"– |
| 1.28.1(2) | 196 | 6528 | 5296 | 2.27 340 –"– | 2.18 383 –"– |
| 1.29.1(2) | 203 | 6550 | 5274 | 2.35 615 –"– | 2.18 125 –"– |
| 1.30.1(2) | 210 | 6572 | 5252 | 2.43 906 –"– | 2.17 867 –"– |
| 1.31.1(2) | 217 | 6594 | 5230 | 2.52 214 –"– | 2.17 611 –"– |
| 1.32.1(2) | 224 | 6616 | 5208 | 2.60 540 –"– | 2.17 353 –"– |
| 1.33.1(2) | 231 | 6638 | 5186 | 2.68 883 –"– | 2.17 695 –"– |
| 1.34.1(2) | 238 | 6660 | 5164 | 2.77 245 –"– | 2.16 838 –"– |
| 1.35.1(2) | 245 | 6682 | 5142 | 2.85 626 –"– | 2.16 582 –"– |
| 1.36.1(2) | 252 | 6704 | 5120 | 2.94 026 –"– | 2.16 324 –"– |
| 1.1131(2) | 791 | 8398 | 3426 | 1.05 111 –"– | 1.93 799 –"– |

of the 1st series particles

| $(R_1 - R_2)$, c | $\varepsilon_1$ | $\varepsilon_2$ | $q_1, \sqrt{\hbar c}$ | $s, \hbar$ |
|---|---|---|---|---|
| 7 | 8 | 9 | 10 | 11 |
| $0.15\,780\,0 \cdot 10^{-15}$ | 0.99 987 8 | 0.99 986 6 | 23.2 123 | 10.0 327 |
| 0.31 405 3 –"– | 0.99 975 7 | 0.99 973 2 | 11.6 154 | 5.01 685 |
| 0.46 877 7 –"– | 0.99 963 5 | 0.99 959 9 | 7.74 990 | 3.74 468 |
| 0.62 199 2 –"– | 0.99 951 4 | 0.99 946 5 | 5.81 718 | 2.50 844 |
| 0.77 371 5 –"– | 0.99 939 2 | 0.99 933 2 | 4.65 759 | 2.00 656 |
| 0.92 396 6 –"– | 0.99 927 0 | 0.99 919 8 | 3.88 456 | 1.67 158 |
| 1.07 276 –"– | 0.99 914 9 | 0.99 906 4 | 3.33 242 | 1.43 273 |
| 1.22 012 –"– | 0.99 902 7 | 0.99 893 0 | 2.91 833 | 1.25 329 |
| 1.36 605 –"– | 0.99 890 5 | 0.99 879 6 | 2.59 628 | 1.11 366 |
| 1.51 058 –"– | 0.99 878 3 | 0.99 866 2 | 2.33 865 | 1.10 190 |
| 1.65 373 –"– | 0.99 866 1 | 0.99 852 8 | 2.12 787 | 0.91 040 1 |
| 1.79 550 –"– | 0.99 850 9 | 0.99 839 3 | 1.95 223 | 0.83 410 6 |
| 1.93 591 –"– | 0.99 841 6 | 0.99 825 8 | 1.80 362 | 0.76 950 6 |
| 2.07 498 –"– | 0.99 829 3 | 0.99 812 4 | 1.67 624 | 0.71 409 5 |
| 2.21 273 –"– | 0.99 817 0 | 0.99 798 8 | 1.56 586 | 0.66 603 5 |
| 2.34 917 –"– | 0.99 804 7 | 0.99 785 3 | 1.46 927 | 0.62 394 9 |
| 2.48 431 –"– | 0.99 792 4 | 0.99 7717 | 1.38 405 | 0.58 678 2 |
| 2.61 817 –"– | 0.99 780 0 | 0.99 758 1 | 1.30 830 | 0.55 371 7 |
| 2.75 076 –"– | 0.99 767 6 | 0.99 744 5 | 1.24 052 | 0.52 410 4 |
| 2.88 210 –"– | 0.99 755 2 | 0.99 730 8 | 1.17 952 | 0.49 742 7 |
| 3.01 219 –"– | 0.99 742 7 | 0.99 717 1 | 1.12 434 | 0.47 326 7 |
| 3.14 106 –"– | 0.99 730 2 | 0.99 703 4 | 1.07 417 | 0.45 128 1 |
| 3.26 871 –"– | 0.99 717 7 | 0.99 689 6 | 1.02 836 | 0.43 118 5 |
| 3.39 516 –"– | 0.99 705 1 | 0.99 675 8 | 0.98 636 4 | 0.41 274 4 |
| 3.52 043 –"– | 0.99 692 5 | 0.99 661 9 | 0.94 772 9 | 0.39 575 9 |
| 3.64 451 –"– | 0.99 679 8 | 0.99 648 0 | 0.91 206 5 | 0.38 006 3 |
| 3.76 743 –"– | 0.99 667 1 | 0.99 634 1 | 0.87 904 0 | 0.36 551 2 |
| 3.88 920 –"– | 0.99 654 4 | 0.99 620 1 | 0.84 837 3 | 0.35 198 5 |
| 3.00 982 –"– | 0.99 641 6 | 0.99 606 0 | 0.81 981 8 | 0.33 937 5 |
| 4.12 931 –"– | 0.99 628 8 | 0.99 591 9 | 0.79 316 4 | 0.32 759 1 |
| 4.24 768 –"– | 0.99 615 9 | 0.99 577 8 | 0.76 822 8 | 0.31 655 3 |
| 4.36 495 –"– | 0.99 603 0 | 0.99 563 6 | 0.74 484 7 | 0.30 619 2 |
| 4.48 111 –"– | 0.99 590 0 | 0.99 549 3 | 0.72 288 1 | 0.29 644 6 |
| 4.59 619 –"– | 0.99 576 9 | 0.99 535 0 | 0.70 220 4 | 2.28 726 1 |
| 4.71 019 –"– | 0.99 563 8 | 0.99 520 6 | 0.68 270 5 | 0.27 858 9 |
| 4.82 312 –"– | 0.99 550 7 | 0.99 506 1 | 0.66 428 7 | 0.27 038 8 |
| 10.8 244 –"– | 0.98 274 2 | 0.98 105 4 | 0.22 003 9 | $0.67\,480\,3 \cdot 10^{-1}$ |

$n = 1.94\,442\,779\,1 \cdot 10^{9}$; $(1 - \frac{2\pi K}{K_1}) = 8.49\,137 \cdot 10^{-8}$; $(1 - \beta) = 2.54\,742\,50 \cdot 10^{-7}$; $\Delta\beta_{pr} = 3.10\,060 \cdot 10^{-14}$

| State number | Internal parameters | | | | |
|---|---|---|---|---|---|
| | $K$ | $n_1$ | $n_2$ | $t_v$ | $R_1$, c |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 2.1 (2) | 113 | $1.94\,442 \cdot 10^{9}$ | $1.94\,442 \cdot 10^{9}$ | $2.71\,395 \cdot 10^{-5}$ | $1.47\,495 \cdot 10^{-12}$ |
| 2.4.1 (2) | 452 | 1.94 442 –"– | 1.94 442 –"– | $1.08\,558 \cdot 10^{-4}$ | —"— |
| 2.7.1 (2) | 791 | 1.94 443 –"– | 1.94 442 –"– | 1.89 976 –"– | —"— |
| 2.10.1 (2) | 1130 | 1.94 443 –"– | 1.94 442 –"– | 2.71 395 –"– | —"— |
| 2.13.1 (2) | 1469 | 1.94 443 –"– | 1.94 442 –"– | 3.52 814 –"– | —"— |
| 2.16.1 (2) | 1808 | 1.94 443 –"– | 1.94 442 –"– | 4.34 232 –"– | —"— |
| 2.19.1 (2) | 2147 | 1.94 443 –"– | 1.94 442 –"– | 5.15 650 –"– | —"— |
| 2.22.1 (2) | 2486 | 1.94 443 –"– | 1.94 442 –"– | 5.97 069 –"– | —"— |
| 2.25.1 (2) | 2825 | 1.94 443 –"– | 1.94 442 –"– | 6.78 488 –"– | —"— |
| 2.28.1 (2) | 3164 | 1.94 443 –"– | 1.94 441 –"– | 7.59 906 –"– | —"— |
| 2.31.1 (2) | 3503 | 1.94 443 –"– | 1.94 441 –"– | 8.41 325 –"– | —"— |
| 2.34.1 (2) | 3842 | 1.94 444 –"– | 1.94 441 –"– | 9.22 743 –"– | —"— |
| 2.37.1 (2) | 4181 | 1.94 444 –"– | 1.94 441 –"– | $1.00\,416 \cdot 10^{-3}$ | —"— |
| 2.40.1 (2) | 4520 | 1.94 444 –"– | 1.94 441 –"– | 1.08 558 –"– | —"— |
| 2.43.1 (2) | 4859 | 1.94 444 –"– | 1.94 441 –"– | 1.16 700 –"– | —"— |
| 2.46.1 (2) | 5198 | 1.94 444 –"– | 1.94 441 –"– | 1.24 842 –"– | —"— |
| 2.49.1 (2) | 5537 | 1.94 444 –"– | 1.94 441 –"– | 1.32 984 –"– | —"— |
| 2.52.1 (2) | 5876 | 1.94 444 –"– | 1.94 440 –"– | 1.41 125 –"– | —"— |
| 2.55.1 (2) | 6215 | 1.94 444 –"– | 1.94 440 –"– | 1.49 267 –"– | —"— |
| 2.58.1 (2) | 6554 | 1.94 444 –"– | 1.94 440 –"– | 1.57 409 –"– | —"— |
| 2.61.1 (2) | 6893 | 1.94 444 –"– | 1.94 440 –"– | 1.65 551 –"– | —"— |
| 2.64.1 (2) | 7232 | 1.94 445 –"– | 1.94 440 –"– | 1.73 693 –"– | —"— |
| 2.67.1 (2) | 7571 | 1.94 445 –"– | 1.94 440 –"– | 1.81 835 –"– | —"— |
| 2.70.1 (2) | 7910 | 1.94 445 –"– | 1.94 440 –"– | 1.89 976 –"– | $1.47\,494 \cdot 10^{-12}$ |
| 2.73.1 (2) | 8249 | 1.94 445 –"– | 1.94 440 –"– | 1.98 118 –"– | —"— |
| 2.77.1 (2) | 8701 | 1.94 445 –"– | 1.94 440 –"– | $2.08\,974 \cdot 10^{-3}$ | —"— |
| 2.80.1 (2) | 9040 | 1.94 445 –"– | 1.94 450 –"– | 2.17 116 –"– | —"— |
| 2.83.1 (2) | 9379 | 1.94 445 –"– | 1.94 439 –"– | 2.25 258 –"– | —"— |
| 2.86.1 (2) | 9718 | 1.94 445 –"– | 1.94 439 –"– | 2.33 400 –"– | —"— |
| 2.89.1 (2) | 10 057 | 1.94 446 –"– | 1.94 439 –"– | 2.41 541 –"– | —"— |
| 2.92.1 (2) | 10 396 | 1.94 446 –"– | 1.94 439 –"– | 2.49 683 –"– | —"— |
| 2.95.1 (2) | 10 735 | 1.94 446 –"– | 1.94 439 –"– | 2.57 825 –"– | —"— |
| 2.98.1 (2) | 11 074 | 1.94 446 –"– | 1.94 438 –"– | 2.65 967 –"– | —"— |
| 2.101.1 (2) | 11 413 | 1.94 446 –"– | 1.94 439 –"– | 2.74 109 –"– | —"— |
| 2.104.1 (2) | 11 752 | 1.94 446 –"– | 1.94 438 –"– | 2.82 251 –"– | —"— |
| 2.107.1 (2) | 12 091 | 1.94 446 –"– | 1.94 438 –"– | 2.90 393 –"– | —"— |
| 2.110.1 (2) | 12 430 | 1.94 446 –"– | 1.94 438 –"– | 2.98 534 –"– | —"— |
| 2.113.1 (2) | 12 769 | 1.94 446 –"– | 1.94 438 –"– | 3.06 676 –"– | —"— |

| of the 2nd series particles | | | | |
|---|---|---|---|---|
| $(R_1 - R_2), c$ | $\epsilon_1$ | $\epsilon_2$ | $q_1 \cdot \sqrt{\hbar c}$ | $s, \hbar$ |
| 7 | 8 | 9 | 10 | 11 |
| $0.53\,857\,4 \cdot 10^{-18}$ | 1.00 000 | 1.00 000 | 657.512 | 293 2.21 |
| 2.15 429 –"– | 0.99 999 8 | 0.99 999 8 | 164 3.81 | 733.082 |
| 3.77 001 –"– | 0.99 999 7 | 0.99 999 7 | 939.340 | 418.920 |
| 5.38 573 –"– | 0.99 999 6 | 0.99 999 5 | 657.551 | 293.256 |
| 7.00 144 –"– | 0.99 999 4 | 0.99 999 4 | 469.622 | 209.480 |
| 8.61 715 –"– | 0.99 999 4 | 0.99 999 3 | 410.986 | 183.299 |
| $1.02\,328 \cdot 10^{-17}$ | 0.99 999 2 | 0.99 999 1 | 346.100 | 154.363 |
| 1.18 486 –"– | 0.99 999 1 | 0.99 099 0 | 298.911 | 133.319 |
| 1.34 643 –"– | 0.99 999 0 | 0.99 998 8 | 263.047 | 117.326 |
| 1.50 800 –"– | 0.99 998 8 | 0.99 998 7 | 234.868 | 104.759 |
| 1.56 957 –"– | 0.99 998 7 | 0.99 998 6 | 212.143 | 24.6 248 |
| 1.83 114 –"– | 0.99 998 6 | 0.99 998 4 | 193.428 | 86.2 790 |
| 1.99 271 –"– | 0.99 998 4 | 0.99 998 3 | 177.748 | 79.2 865 |
| 2.15 428 –"– | 0.99 998 34 | 0.99 998 2 | 164.42 | 73.3 429 |
| 2.31 584 –"– | 0.99 998 2 | 0.99 998 0 | 152.952 | 68.2 287 |
| 2.47 741 –"– | 0.99 998 1 | 0.99 997 9 | 142.930 | 63.7 815 |
| 2.63 898 –"– | 0.99 998 0 | 0.99 997 8 | 134.229 | 58.8 789 |
| 2.80 055 –"– | 0.99 997 8 | 0.99 997 6 | 126.487 | 57.4 266 |
| 2.96 212 –"– | 0.99 997 7 | 0.99 997 5 | 119.590 | 53.3 509 |
| 3.12 368 –"– | 0.99 997 6 | 0.99 997 4 | 113.407 | 50.5 933 |
| 3.28 525 –"– | 0.99 997 5 | 0.99 997 2 | 107 832 | 48.1 070 |
| 3.44 682 –"– | 0.99 997 3 | 0.99 997 1 | 102.779 | 45.8 538 |
| 3.60 839 –"– | 0.99 997 2 | 0.99 996 9 | 98.1 792 | 43.8 024 |
| 3.76 995 –"– | 0.99 997 1 | 0.99 996 8 | 93.9 734 | 41.9 268 |
| 3.93 152 –"– | 0.99 997 0 | 0.99 996 7 | 90.1 132 | 40.2 054 |
| 4.14 694 –"– | 0.99 996 8 | 0.99 996 5 | 85.4 343 | 38.1 188 |
| 4.30 851 –"– | 0.99 996 7 | 0.99 996 4 | 82.2 322 | 36.6 908 |
| 4.47 007 –"– | 0.99 996 2 | 0.99 996 6 | 79.2 615 | 35.3 660 |
| 4.63 164 –"– | 0.99 996 4 | 0.99 996 1 | 76.4 981 | 34.1 337 |
| 4.79 320 –"– | 0.99 996 3 | 0.99 995 9 | 73.9 210 | 32.9 844 |
| 4.95 477 –"– | 0.99 996 2 | 0.99 995 8 | 71.5 119 | 31.9 110 |
| 5.11 634 –"– | 0.99 996 1 | 0.99 995 7 | 69.2 550 | 30.9 036 |
| 5.27 790 –"– | 0.99 995 9 | 0.99 995 5 | 67.1 363 | 29.9 588 |
| 5.43 946 –"– | 0.99 995 8 | 0.99 995 4 | 65.7 945 | 28.9 326 |
| 5.60 103 –"– | 0.99 995 7 | 0.99 995 2 | 63.2 656 | 28.2 326 |
| 5.76 259 –"– | 0.99 995 6 | 0.99 995 1 | 61.4 930 | 27.4 421 |
| 5.92 416 –"– | 0.99 995 4 | 0.99 995 0 | 59.8 171 | 26.9 871 |
| 6.08 572 –"– | 0.99 995 3 | 0.99 994 8 | 58.2 302 | 25.9 871 |

| State number | Internal parameters | | | | |
|---|---|---|---|---|---|
| | $K$ | $n_1$ | $n_2$ | $t_v$ | $R_1$, c |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 2.116.1(2) | 13108 | $1.94\,446 \cdot 10^{9}$ | $1.94\,438 \cdot 10^{9}$ | $3.14\,818 \cdot 10^{-3}$ | $1.47\,494 \cdot 10^{-12}$ |
| 2.119.1(2) | 13447 | 1.94 447 –"– | 1.94 438 –"– | 3.22 960 –"– | —"— |
| 2.122.1(2) | 13786 | 1.94 447 –"– | 1.94 438 –"– | 3.28 388 –"– | —"— |
| 2.125.1(2) | 14125 | 1.94 447 –"– | 1.94 438 –"– | 3.39 244 –"– | —"— |
| 2.128.1(2) | 14464 | 1.94 447 –"– | 1.94 438 –"– | 3.47 386 –"– | —"— |
| 2.131.1(2) | 14803 | 1.94 447 –"– | 1.94 438 –"– | 3.55 528 –"– | —"— |
| 2.134.1(2) | 15142 | 1.94 447 –"– | 1.94 438 –"– | 3.63 669 –"– | —"— |
| 2.137.1(2) | 15481 | 1.94 447 –"– | 1.94 438 –"– | 3.71 811 –"– | —"— |
| 2.140.1(2) | 15820 | 1.94 447 –"– | 1.94 437 –"– | 3.79 953 –"– | —"— |
| 2.143.1(2) | 16159 | 1.94 447 –"– | 1.94 437 –"– | 3.88 095 –"– | —"— |
| 2.146.1(2) | 16498 | 1.94 448 –"– | 1.94 437 –"– | $3.96\,237 \cdot 10^{-3}$ | —"— |
| 2.149.1(2) | 16837 | 1.94 448 –"– | 1.94 437 –"– | 4.04 379 –"– | —"— |
| 2.152.1(2) | 17176 | 1.94 448 –"– | 1.94 437 –"– | 4.12 520 –"– | —"— |
| 2.155.1(2) | 17515 | 1.94 448 –"– | 1.94 437 –"– | 4.20 662 –"– | —"— |
| 2.587.1(2) | 663 762 | $1.94\,651 \cdot 10^{9}$ | 1.94 234 –"– | $0.15\,941\,8 \cdot 10^{2}$ | $1.47\,442 \cdot 10^{-12}$ |

$n = 4.43\,615\,212 \cdot 10^{13}$; $(1 - \frac{2\pi K}{K_1}) = 1.05\,560\,409 \cdot 10^{-10}$; $(1 - \beta) = 3.16\,681\,229 \cdot 10^{-10}$

| State number | Internal parameters | | | | |
|---|---|---|---|---|---|
| | $K$ | $n_1$ | $n_2$ | $t_v$ | $R_1$, c |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 3.1.2 | 332 15 | $4.43\,615 \cdot 10^{13}$ | $4.43\,615 \cdot 10^{13}$ | $9.91\,700 \cdot 10^{-6}$ | $4.18\,328 \cdot 10^{-11}$ |
| 3.2.2 | 664 30 | —"— | —"— | $1.98\,340 \cdot 10^{-5}$ | —"— |
| 3.3.2 | 996 45 | —"— | —"— | $2.97\,510 \cdot 10^{-5}$ | —"— |
| 3.4.2 | 132 860 | —"— | —"— | $3.96\,680 \cdot 10^{-5}$ | —"— |
| 3.5.2 | 166 075 | —"— | —"— | $4.95\,850 \cdot 10^{-5}$ | —"— |
| 3.6.2 | 199 290 | —"— | —"— | $5.90\,20 \cdot 10^{-5}$ | —"— |
| 3.7.1(2) | 232 505 | —"— | —"— | $6.94\,190 \cdot 10^{-5}$ | —"— |
| 3.72.3(4) | 239 1480 | —"— | —"— | $7.14\,024 \cdot 10^{-5}$ | —"— |
| 3.16009.3(4) | $5.31\,739 \cdot 10^{8}$ | $4.43\,632 \cdot 10^{15}$ | $4.43\,599 \cdot 10^{15}$ | $1.58\,761 \cdot 10^{-1}$ | $4.18\,323 \cdot 10^{-11}$ |

Table 18.1 continuation

| of the 2nd series particles | | | | |
|---|---|---|---|---|
| $(R_1 - R_2)$, c | $\varepsilon_1$ | $\varepsilon_2$ | $q_1, \sqrt{\hbar c}$ | $s, \hbar$ |
| 7 | 8 | 9 | 10 | 11 |
| $6.24\,728 \cdot 10^{-17}$ | 0.99 995 2 | 0.99 994 7 | 56.7 254 | 25.6 787 |
| 6.40 884 –"– | 0.99 995 1 | 0.99 994 6 | 55.2 964 | 24.6 787 |
| 6.57 041 –"– | 0.99 995 0 | 0.99 994 5 | 54.3 832 | 24.2 715 |
| 6.73 197 –"– | 0.99 994 8 | 0.99 994 3 | 52.6 443 | 23.4 960 |
| 6.89 353 –"– | 0.99 994 7 | 0.99 994 2 | 51.4 115 | 22.9 462 |
| 7.05 510 –"– | 0.99 994 6 | 0.99 994 0 | 50.2 351 | 22.4 216 |
| 7.21 666 –"– | 0.99 994 4 | 0.99 993 9 | 49.1 114 | 21.9 205 |
| 7.37 822 –"– | 0.99 994 3 | 0.99 993 8 | 48.0 370 | 21.4 414 |
| 7.53 978 –"– | 0.99 994 2 | 0.99 993 6 | 47.0 085 | 20.9 827 |
| 7.70 134 –"– | 0.99 994 1 | 0.99 993 5 | 46.0 233 | 205 433 |
| 7.86 290 –"– | 0.99 994 0 | 0.99 993 3 | 45.0 785 | 20.1 220 |
| 8.02 446 –"– | 0.99 993 8 | 0.99 993 2 | 44.1 717 | 19.7 176 |
| 8.18 602 –"– | 0.99 993 7 | 0.99 993 1 | 43.3 008 | 19.3 292 |
| 8.34 758 –"– | 0.99 993 6 | 0.99 992 9 | 42.4 637 | 18.9 559 |
| $3.15\,906 \cdot 10^{-15}$ | 0.99 774 1 | 0.99 751 6 | 1 16 212 | 0.53 766 6 |

Table 18.1 continuation

| of the 3rd series particles | | | | |
|---|---|---|---|---|
| $(R_1 - R_2)$, c | $\varepsilon_1$ | $\varepsilon_2$ | $q_1, \sqrt{\hbar c}$ | $s, \hbar$ |
| 7 | 8 | 9 | 10 | 11 |
| $1.96\,800 \cdot 10^{-19}$ | 1 | 1 | 190 85.3 | 802 4.39 |
| $3.93\,599 \cdot 10^{-19}$ | 1 | 1 | 954 2.66 | 401 2.21 |
| $5.90\,399 \cdot 10^{-19}$ | 1 | 1 | 636 1.79 | 267 4.82 |
| $7.87\,199 \cdot 10^{-19}$ | 0.99 999 9 | 0.99 999 9 | 477 1.35 | 200 6.13 |
| $9.83\,998 \cdot 10^{-19}$ | —"— | —"— | 381 7.09 | 160 4.91 |
| $1.18\,080 \cdot 10^{-18}$ | —"— | —"— | 318 0.09 | 133 7.43 |
| $1.37\,760 \cdot 10^{-18}$ | —"— | —"— | 272 6.61 | 114 6.37 |
| $1.41\,696 \cdot 10^{-18}$ | —"— | —"— | 265.119 | 111.488 |
| $3.15\,041 \cdot 10^{-15}$ | 0.99 788 0 | 0.99 767 0 | 1.23 785 | 0.51 039 0 |

Table 18.2

| Internal parameters of 1st series particles | Point number | | | | |
|---|---|---|---|---|---|
| | 113 | 36 | 19 | 15 | 1 |
| $\beta_1$ | 0.999 123 584 836 2 | 0.998 889 175 153 8 | 0.998 837 422 366 7 | 0.998 825 245 240 1 | 0.998 782 625 298 1 |
| $\beta_2$ | 0.998 435 577 196 8 | 0.998 669 986 879 2 | 0.998 721 739 656 3 | 0.998 733 916 792 6 | 0.998 776 536 734 9 |
| $\beta_1/\beta_2$ | 1.000 689 085 660 7 | 1.000 219 480 186 1 | 1.000 115 830 762 2 | 1.000 091 444 223 7 | 1.000 006 096 021 4 |
| $n_1\beta_1$ | $8.390\,539\,865\,454\,4\cdot10^{3}$ | $6.696\,553\,030\,231\,1\cdot10^{3}$ | $6.322\,640\,883\,581\,3\cdot10^{3}$ | $6.234\,667\,180\,790\,6\cdot10^{3}$ | $5.926\,776\,098\,518\,9\cdot10^{3}$ |
| $n_2\beta_2$ | $3.420\,640\,287\,476\,2\cdot10^{3}$ | $5.113\,190\,332\,821\,6\cdot10^{3}$ | $5.486\,977\,237\,726\,6\cdot10^{3}$ | $5.574\,932\,723\,536\,3\cdot10^{3}$ | $5.882\,793\,801\,368\,6\cdot10^{3}$ |
| $s$ | $6.748\,033\,073\,155\,8\cdot10^{-2}$ | 0.270 388 119 603 41 | 0.524 104 010 208 51 | 0.666 035 093 355 71 | 1.003 268 426 610 8·10 |
| $g_{00}$ | $1.374\,335\,963\,926\cdot10^{-3}$ | $4.378\,415\,460\,2981\cdot10^{-4}$ | $2.310\,830\,381\,8239\cdot10^{-4}$ | $1.824\,339\,775\,1242\cdot10^{-4}$ | $1.216\,226\,516\,7494\cdot10^{-5}$ |
| $\varepsilon_1$ | 0.982 741 537 050 1 | 0.995 507 058 147 5 | 0.997 676 196 320 2 | 0.998 170 545 074 6 | 0.999 878 374 359 4 |
| $\varepsilon_2$ | 0.981 053 529 263 0 | 0.995 061 340 039 5 | 0.997 445 113 281 9 | 0.997 988 521 815 2 | 0.999 866 250 338 5 |
| $\varepsilon_{1d}$ | 0.983 717 504 471 2 | 0.995 763 415 042 7 | 0.997 808 944 134 9 | 0.998 275 079 689 5 | 0.999 885 329 845 7 |
| $\varepsilon_{2d}$ | 0.982 123 217 224 1 | 0.995 343 009 612 0 | 0.997 591 029 893 9 | 0.998 103 437 433 5 | 0.999 873 899 082 8 |
| $(1-\beta_1^2)$ | $1.752\,062\,223\,909\,3\cdot10^{-3}$ | $2.220\,415\,760\,6110\cdot10^{-5}$ | $2.323\,803\,679\,7877\cdot10^{-3}$ | $2.348\,129\,470\,5234\cdot10^{-3}$ | $2.433\,267\,402\,6493\cdot10^{-3}$ |
| $(1-\beta_2^2)$ | $3.126\,398\,187\,836\,4\cdot10^{-3}$ | $2.658\,257\,306\,6407\cdot10^{-3}$ | $2.554\,886\,717\,9702\cdot10^{-3}$ | $2.530\,563\,448\,035\,6\cdot10^{-3}$ | $2.445\,429\,667\,8170\cdot10^{-3}$ |
| $(1-\beta_1^2)^{1/2}$ | $4.185\,764\,235\,966\cdot10^{-2}$ | $4.712\,128\,776\,4777\cdot10^{-2}$ | $4.820\,584\,694\,6067\cdot10^{-2}$ | $4.845\,750\,169\,5025\cdot10^{-2}$ | $4.932\,816\,034\,1221\cdot10^{-2}$ |
| $(1-\beta_2^2)^{1/2}$ | $5.591\,420\,381\,116\,4\cdot10^{-2}$ | $5.155\,829\,037\,7403\cdot10^{-2}$ | $5.054\,588\,725\,0796\cdot10^{-2}$ | $5.030\,470\,602\,2752\cdot10^{-2}$ | $4.945\,128\,580\,5498\cdot10^{-2}$ |

Table 18.2 continuation

| Internal parameters of 2nd series particle | Point number | | | | |
|---|---|---|---|---|---|
| | 5864 | 149 | 75 | 47 | 1 |
| $\beta_1$ | 0.999 999 745 439 6 | 0.999 999 745 263 0 | 0.999 999 745 260 8 | 0.999 999 745 259 9 | 0.999 999 745 258 4 |
| $\beta_2$ | 0.999 999 745 077 2 | 0.999 999 745 253 8 | 0.999 999 745 256 0 | 0.999 999 745 259 9 | 0.999 999 745 258 4 |
| $\beta_1/\beta_2$ | 1.000 000 000 362 4 | 1.000 000 000 009 2 | 1.000 000 000 004 8 | 1.000 000 000 003 0 | 1.000 000 000 000 0 |
| $n_1\beta_1$ | $1.946\,498\,736\,498\,4\cdot10^{9}$ | $1.944\,476\,301\,669\,8\cdot10^{9}$ | $1.944\,450\,031\,672\,3\cdot10^{9}$ | $1.944\,440\,091\,673\,1\cdot10^{9}$ | $1.944\,423\,761\,674\,3\cdot10^{9}$ |
| $n_2\beta_2$ | $1.942\,348\,076\,851\,1\cdot10^{9}$ | $9.444\,370\,511\,678\,9\cdot10^{9}$ | $1.944\,396\,781\,676\,4\cdot10^{9}$ | $1.944\,406\,721\,675\,7\cdot10^{9}$ | $1.944\,423\,051\,674\,4\cdot10^{9}$ |
| $s$ | $5.400\,579\,520\,219\,0\cdot10^{1}$ | $1.971\,764\,859\,797\,2\cdot10^{1}$ | $3.913\,427\,167\,730\,8\cdot10^{1}$ | $6.242\,528\,560\,038\,5\cdot10^{1}$ | $2.932\,210\,812\,048\,8\cdot10^{3}$ |
| $g_{00}$ | $7.250\,454\,010\,8972\cdot10^{-10}$ | $1.847\,960\,396\,2090\cdot10^{-11}$ | $9.301\,814\,0748768\cdot10^{-12}$ | $5.829\,136\,8202560\cdot10^{-12}$ | $1.240\,241\,8766503\cdot10^{-13}$ |
| $\varepsilon_1$ | $9.977\,509\,146\,049\cdot10^{-1}$ | $9.999\,938\,263\,466\,4\cdot10^{-1}$ | $9.999\,688\,933\,380\cdot10^{-1}$ | $9\,999\,804\,990\,768\cdot10^{-1}$ | $9.999\,995\,848\,272\cdot10^{-1}$ |
| $\varepsilon_2$ | $9.975\,272\,432\,659\cdot10^{-1}$ | $9.999\,321\,089\,720\cdot10^{-1}$ | $9.999\,657\,922\,208\cdot10^{-1}$ | $9.999\,785\,549\,461\cdot10^{-1}$ | $9.999\,995\,434\,361\cdot10^{-1}$ |
| $\varepsilon_{1d}$ | $9.978\,794\,150\,574\cdot10^{-1}$ | $9.999\,417\,941\,355\cdot10^{-1}$ | $9.999\,688\,933\,380\cdot10^{-1}$ | $9.999\,816\,143\,431\cdot10^{-1}$ | $9.999\,996\,085\,714\cdot10^{-1}$ |
| $\varepsilon_{2d}$ | $9.976\,684\,932\,145\cdot10^{-1}$ | $9.999\,359\,915\,897\cdot10^{-1}$ | $9.999\,657\,922\,208\cdot10^{-1}$ | $9.999\,797\,813\,953\cdot10^{-1}$ | $9.999\,995\,695\,473\cdot10^{-1}$ |
| $(1-\beta_1^2)$ | $5.091\,206\,093\,2248\cdot10^{-7}$ | $5.094\,738\,922\,2108\cdot10^{-7}$ | $5.094\,784\,811\,1604\cdot10^{-7}$ | $5.094\,802\,174\,5467\cdot10^{-7}$ | $5.094\,830\,700\,1096\cdot10^{-7}$ |
| $(1-\beta_2^2)$ | $5.098\,456\,547\,2361\cdot10^{-7}$ | $5.094\,923\,718\,2507\cdot10^{-7}$ | $5.094\,877\,829\,3009\cdot10^{-7}$ | $5.094\,860\,465\,9148\cdot10^{-7}$ | $5.094\,831\,940\,3517\cdot10^{-7}$ |
| $(1-\beta_1^2)^{1/2}$ | $7.135\,268\,805\,8858\cdot10^{-4}$ | $7.137\,743\,986\,8706\cdot10^{-4}$ | $7.137\,776\,132\,0739\cdot10^{-4}$ | $7.137\,882\,950\,860\cdot10^{-4}$ | $7.137\,808\,277\,1321\cdot10^{-4}$ |
| $(1-\beta_2^2)^{1/2}$ | $7.140\,347\,713\,6874\cdot10^{-4}$ | $7.137\,873\,435\,5903\cdot10^{-4}$ | $7.137\,841\,290\,8251\cdot10^{-4}$ | $7.137\,829\,127\,9035\cdot10^{-4}$ | $7.137\,809\,145\,9156\cdot10^{-4}$ |

Table 18.2 continuation

| Internal parameters of 3rd series particles | Point number | | |
|---|---|---|---|
| | 16009 | 72 | 1 |
| $\beta_1$ | 0.999 999 999 683 4 | 0.999 999 999 683 4 | 0.999 999 999 683 4 |
| $\beta_2$ | 0.999 999 999 683 4 | 0.999 999 999 683 4 | 0.999 999 999 683 4 |
| $\beta_1/\beta_2$ | 1.000 000 000 000 0 | 1.000 000 000 000 0 | 1.000 000 000 000 0 |
| $n_1\beta_1$ | $4.436\,320\,166\,532\,8\cdot10^{13}$ | $4.436\,153\,867\,125\,3\cdot10^{13}$ | $4.436\,153\,126\,254\,5\cdot10^{13}$ |
| $n_2\beta_2$ | $4.435\,986\,065\,106\,5\cdot10^{13}$ | $4.436\,152\,364\,514\,1\cdot10^{13}$ | $4.436\,153\,105\,584\,9\cdot10^{13}$ |
| $s$ | 0.540 353 012 485 28 | $1.114\,884\,556\,554\,7\cdot10^{2}$ | $8.024\,388\,380\,520\,5\cdot10^{3}$ |
| $g_{00}$ | $3.180\,042\,032\,763\,9\cdot10^{-14}$ | $1.430\,214\,419\,132\,8\cdot10^{-16}$ | $1.986\,408\,915\,462\,5\cdot10^{-18}$ |
| $\varepsilon_1$ | 0.997 752 141 103 8 | 0.999 989 080 837 9 | 0.999 999 848 290 8 |
| $\varepsilon_2$ | 0.997 528 591 437 8 | 0.999 987 992 249 4 | 0.999 999 833 165 8 |
| $\varepsilon_{1d}$ | 0.997 880 571 788 9 | 0.999 989 705 311 9 | 0.999 999 856 967 1 |
| $\varepsilon_{2d}$ | 0.997 669 764 730 4 | 0.999 988 678 980 0 | 0.999 999 842 707 3 |
| $(1-\beta_1^2)$ | $6.333\,465\,569\,952\,4\cdot10^{-10}$ | $6.333\,623\,856\,946\,8\cdot10^{-10}$ | $6.333\,624\,562\,122\,0\cdot10^{-10}$ |
| $(1-\beta_2^2)$ | $6.333\,783\,574\,415\,55\cdot10^{-10}$ | $6.333\,625\,287\,161\,2\cdot10^{-10}$ | $6.333\,624\,581\,986\,0\cdot10^{-10}$ |
| $(1-\beta_1^2)^{1/2}$ | $2.516\,637\,751\,038\,5\cdot10^{-5}$ | $2.516\,669\,198\,950\,6\cdot10^{-5}$ | $2.516\,669\,339\,051\,5\cdot10^{-5}$ |
| $(1-\beta_2^2)^{1/2}$ | $2.516\,700\,930\,614\,4\cdot10^{-5}$ | $2.516\,669\,483\,098\,8\cdot10^{-5}$ | $2.516\,669\,342\,998\,0\cdot10^{-5}$ |

# 19 METHOD AND PRELIMINARY RESULTS OF PREDICTION OF PARTICLES WHICH COULD BE OBSERVED IN MACROCOSM

As it was mentioned above, in microcosm there is an immense number of particles which reveal only in the fibers complementary to our laboratory subspace and do not reveal directly in the latter. We have only indirect indications of their existence via their influence upon the observed processes. The above-mentioned particles were called the "virtual particles" and their existence was predicted in the existing theories. The term "virtual particle" used in generally accepted theories is substantially narrower than the term used in this book. Here the "virtual particles" mean not the peculiar states of the known particles but the particles existing really, always, yet in another subspace. Most of them have no states forming QS. TFF determines the total number of possible virtual states in each series. The number of all possible BEPs of each series is numerically equal to $K_{pr}$ of the subsequent series. So, $K_{pr}$ of the second series is equal to 113 and therefore, the number of BEP multiplets in the first series is equal to 113. The number of all permissible (in TFF) series are shown in table 5.1. Naturally, the question arises what amount of the above-mentioned states can under certain conditions form the quark structure and be observed in our subspace? According to the physical meaning, this condition is reduced to the fact that, interacting with the nearest elementary particles of vacuum, BEP can form a sufficiently stable structure which could not be destroyed at once by the surrounding elementary particles of the corresponding physical vacuum. Mathematically this condition is reduced to the fact that a certain combination of the internal characteristics of a relevant elementary particle differs from one by the quantity which is very small and has a certain value for each series of the states. Therefore, in the most general form the condition of formation of the quark (or the pseudo-quark) structures, i.e. EP from BEP and EPV, can be written as:

$$|T_K K_0 - 1| < (A_\alpha)_{NS} . \tag{19.1}$$

The value of $T_K$ is calculated by the formula

$$T_K = 8\pi\beta\alpha \frac{nm_e}{n_{1opt}} \frac{2s_{de}}{m_{ef}\alpha_p} f_{NS}(\beta) , \tag{19.2}$$

where $f_{NS}(\beta)$ are the functions of $\beta$, different for each series. The factor $f_{NS}(\beta)$ for the third series is equal to

$$f_{NS}(\beta) = \sqrt{9/8}\,\frac{s_{d\xi}}{\varepsilon_{1p}\,\varepsilon_{2p}^{3}}\,\frac{k_x\,(1-\beta_2^2)_{\varepsilon}^{1/2}}{k_y\,(1-\beta_1^2)_p^{1/2}\,k_f\,\varepsilon_f^2}\,. \tag{19.3}$$

The coefficient $K_0$ for the particles of the third series takes one value from the three permitted:

$$1;\ \sqrt{9/8}\ \varepsilon_{2p}\,k_f^{1/2}\,\varepsilon_f;\ \left[\,\varepsilon_{1p}^{3/2}\,a_{gp}^{1/2}\,(1-g_{00})_p^{1/2}\,(1-3g_{00})_p^{1/2}\,\right]^{-1/2}. \tag{19.4}$$

One BEP or some BEPs, which are able to form EP, may correspond to each of these three values of $K_0$.

The coefficients characterizing the minimal difference of the critical values from one are of the following values for each series:

$$A_\alpha = \begin{cases} \left(\dfrac{4\alpha_p}{\pi}\right)^2, & NS = 1\ ; \\ \left(\dfrac{2\alpha_p}{\pi}\right)^2, & NS = 2\ ; \\ \left(\dfrac{\alpha_p}{2\pi}\right), & NS = 3\ . \end{cases} \tag{19.5}$$

As an example, in this section we give the result of calculation of those BEP states of the third series which can be observed in 1SS in the form of EPs. A greater amount of virtual states (they constitute many hundred thousand) may be in the third series. Only ten of these hundred thousand states can form the observable particles. By now only four particles from these ten permitted are found: the $\tau$-lepton (No 4); the muon (No 8); the electron (No 9) and the "hole" (No 10). The rest are only predicted. What is the probability of their existence, what is the reliability of predictions? Today it is difficult to estimate because of insufficient accuracy of the calculation. Most probable, not all of the six particles additionally predicted can exist, indeed. Yet, the probability of the fact that no one of them is realized, is practically equal to zero, i.e. one or two predicted particles from these six undoubtedly should be found.

The analysis of the results of selection of the particles of the second and third series, permitted for observation, is beyond the bounds of this book, and it is not given here. The parameters of those third series BEPs which can form pseudo-quark structures (see subsection 5.7) and become EPs and be directly observed in the laboratory subspace, are given in table 19.1. A computer selected the data for table 19.1 by the formulae given in this section and printed the results of the calculation.

| Nos | Particle symbols (in TFF) | Parameters of 3rd series BEP | | | | |
|---|---|---|---|---|---|---|
| | | Mass $m, m_e$ | Charge $q$, $\sqrt{\alpha \hbar c}$ | Spin $J, \hbar$ | Lifetime $\tau$, s | Magnetic moment $\mu$ (in proper magnetons) |
| 1 | 3.2.6 | 6 983.695 | 0 | 1/2 | $4.07 \cdot 10^{-14}$ | +0.00 094 735 49 |
| 2 | 3.3.2 | 4 655.819 | +1 | 1/2 | $1.08 \cdot 10^{-13}$ | +1.00 151 501 13 |
| 3 | 3.3.6 | 4 655.824 | 0 | 1/2 | $1.08 \cdot 10^{-13}$ | +0.00 094 736 20 |
| 4 | 3.4.2 | 3 491.883 | +1 | 1/2 | $1.87 \cdot 10^{-13}$ | +1.00 151 517 34 |
| 5 | 3.4.6 | 3 491.888 | 0 | 1/2 | $1.87 \cdot 10^{-13}$ | +0.00 094 736 92 |
| 6 | 3.5.2 | 2 793.522 | +1 | 1/2 | $2.68 \cdot 10^{-13}$ | +0.00 151 533 55 |
| 7 | 3.6.2 | 2 327.948 | +1 | 1/2 | $3.45 \cdot 10^{-13}$ | +1.00 151 549 77 |
| 8 | 3.72 3 | 206.768 8 | −1 | 1/2 | $2.02 \cdot 10^{-6}$ | −1.00 116 332 23 |
| 9 | 3.16009.3 | 1.00 000 0 | −1 | 1/2 | $1.43 \cdot 10^{143}$ | −1.00 115 964 28 |
| 10 | 3.16009.4 | 1.00 000 0 | +1 | 1/2 | $1.02 \cdot 10^{-9}$ | +1.00 334 974 98 |

Note: Picking out was done from 796256 states considered in theory. Non-picked out states are virtual.

# 20 RESULTS OF IDENTIFICATION OF THEORETICALLY PREDICTED PARTICLES WITH EXPERIMENTAL DATA

The results of comparison of the theoretically determined values of the parameters of elementary particles with those experimentally obtained are shown in tables 20.1, 20.2 and 20.3. The comparison was performed according to the official tables published in 1990 [108]. Totally about 700 particles were found (including the antiparticles). The comparison of such great amount of the experimental data with the theoretical ones is impossible in this book, despite its considerable volume. Therefore, we restrict ourselves to the examples of comparison of a great number of elementary particles, but not all of them. The criteria of selection of particles for identification were discussed in section 17. We shall carry out a certain analysis herein.

In the first place, it is necessary to attract the reader's attention to the fact that there is a great amount of predictions, i.e. of such theoretically found values of parameters which either have not been measured yet or have been found with substantially lower accuracy. Therefore, the theoretically determined value is a prediction. In the column "note" of the tables it is indicated which parameters are predicted in TFF for each particle.

Table 20.1

| Nos | Particle symbols and names | Information source | EP parameters | | | | Note |
|---|---|---|---|---|---|---|---|
| | | | Mass $m$ | Charge $\frac{q_1}{\sqrt{\alpha}\hbar c}$ | Spin $J$, $\hbar$ | Lifetime $\tau$, s (or resonance width $\Gamma$, GeV) | |
| | | | Field interaction quanta | | | | |
| 1. | EPV*) | Theory | $m_0 < 13 \cdot 10^{-10}$ eV | 0 | 1 | $10^{143}$ s | Excited EPV. |
| | EMF $\gamma$-quantum | Experiment | no data | — | — | Stable | |
| 2. | 2.1.1 $W$-quantum of weak interaction | Theory | 83.217 GeV | $\pm 1$ | $> 50$ | 3.955 GeV | $m$, $\tau$ are predicted in TFF. |
| | | Experiment | 81.8(1.5) GeV | $\pm 1$ | — | 6.5 GeV | |
| 3. | 2.1.14 $Z$-quantum of weak interaction | Theory | 93.030 GeV | 0 | $> 50$ | 7.840 GeV | $m$, $\tau$ are predicted in TFF. |
| | | Experiment | 92.6(1.7) GeV | 0 | — | 4.6 GeV | |
| 4. | Fundamenton*) | Theory | $2.17\,685 \cdot 10^{-5}$ g | $1/\sqrt{\alpha}$ | 1/2 | $10^{143}$ s | Particle is predicted in TFF. |
| | | Experiment | no data | | | | |

*) Virtual particle.

Table 20.2

| Nos | Particle symbols and names | Information source | EP parameters | | | | | Note |
|---|---|---|---|---|---|---|---|---|
| | | | Mass $m$ | Charge $\frac{q_e}{\sqrt{\alpha\hbar c}}$ | Spin $J, \hbar$ | Life time $\tau$, s | Magnetic moment $\mu$ (in proper magnetons) | |
| | Leptons | | | | | | | |
| 5. | 3.16009.3 | Theory | 12.86 eV | 0 | 1/2 | $>10^{143}$ | | $\mu$, $\tau$ are predicted in TFF |
| | $\nu$ - electronic neutrino | Experiment | < 46 eV | 0 | 1/2 | Stable | | |
| 6. | 3.16009.3 | Theory | 1.00 000 00(30) | ±1 | 1/2 | $1.42\,821\,3\cdot10^{143}$ | -1.00 115 964(18) | $\tau$ is predicted in TFF |
| | $e$ - electron | Experiment | 1.00 000 00(27) | ±1 | 1/2 | Stable | -1.00 115 962 209(31) | |
| 7. | 4.72.3 | Theory | $2.660\cdot10^{3}$ eV | 0 | 1/2 | $>10^{143}$ | | $m$, $\tau$ are predicted in TFF |
| | $\nu_\mu$ - muon neutrino | Experiment | < 0.25 MeV | 0 | 1/2 | Stable | | |
| 8. | 3.72.3 | Theory | 206.768 8(6) | ±1 | 1/2 | 2.19 289 252 | | -"- |
| | $\mu$ - muon | Experiment | 206.768 261(66) | ±1 | 1/2 | $2.19\,703(4)\cdot10^{6}$ | -1.00 116 332(18) | |
| 9. | 3.4.1 | Theory | $4.491\cdot10^{4}$ eV | 0 | 1/2 | $10^{143}$ | -1.00 116 592 3(9) | -"- |
| | $\nu_\tau$ – $\tau$-neutrino | Experiment | < 70 MeV | 0 | 1/2 | no data | | |
| 10. | 3.4.1 | Theory | $3.49\,188\,342\,7\cdot10^{3}$ | ±1 | 1/2 | $3.11\,381\cdot10^{-13}$ | | $m$,$\tau$ were predicted in TFF in 1975 |
| | $\tau$ – $\tau$-lepton | Experiment | $3.49\,13(70)\cdot10^{3}$ | ±1 | 1/2 | $(3.03 \pm 0.08)\cdot10^{-13}$ | | |

| Nos | Partical symbols and names | Information source | Quark composition | Mass $m$, $m_e$ | Charge $\frac{q}{\sqrt{\alpha\hbar c}}$ | Spin $J$, $\hbar$ |
|---|---|---|---|---|---|---|
| | | | | | Stable | |
| 11. | 1.112.10 | Theory | $u^2\tilde{d}^2$ | 273.126 4 | +1 | 0 |
| | $\pi^+$ pion | Experiment | $u\tilde{d}$ | 273.126 7(7) | +1 | 0 |
| 12. | 1.112.3 | Theory | $u^1u^{3(1)}(d^{3(1)}\tilde{d})$ | 264.098 2 | 0 | 0 |
| | $\pi^0$ pion | Experiment | $(u\tilde{u}-d\tilde{d})/\sqrt{2}$ | 264.137 2(10) | 0 | 0 |
| 13. | 2.135.13 | Theory | $c^1(u\tilde{u}+d\tilde{d})+c^2(s\tilde{s})$ | 107 3.28 781 7 | 0 | 0 |
| | $\eta^0$ | Experiment | $u\tilde{u}(d\tilde{d})$ | 1073.0(12) | 0 | 0 |
| 14. | 1.36.9 | Theory | $\tilde{u}^2\tilde{s}^2$ | 966.015 4 | +1 | 0 |
| | $K^+$ kaon | Experiment | $u\tilde{s}$ | 966.041(17) | +1 | 0 |
| 15. | 2.158.15 | Theory | $s^2\tilde{d}^2$ | 973.944 6 | 0 | 0 |
| | $K_g^0$ kaon | Experiment | $d\tilde{s}$ | 973.917(61) | 0 | 0 |
| 16. | 2.158.14 | Theory | $d^2\tilde{s}^2$ | 973.944 6 | 0 | 0 |
| | $K_L^0$ kaon | Experiment | $d\tilde{s}$ | 973.917(61) | 0 | 0 |
| | | | | | Stable | |
| 17. | 1.19.1 | Theory | $u^1u^2d^2(d^3)$ | 183 6.15 277 1 | +1 | 1/2 |
| | $p^+$ proton | Experiment | $u\,u\,d$ | 183 6.15 27(6) | +1 | 1/2 |
| 18. | 1.19.6 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 183 8.68 145 3 | 0 | 1/2 |
| | $n^0$ neutron | Experiment | $u\,d\,d$ | 183 8.68 36(5) | 0 | 1/2 |
| 19. | 2.70.8 | Theory | $s^2d^1u^{3(1)}$ | 218 3.00 | 0 | 1/2 |
| | $\lambda^0$ | Experiment | $u\,d\,s$ | 218 3.23(10) | 0 | 1/2 |
| 20. | 1.15.1 | Theory | $u^1u^2s^2(s^3)$ | 232 7.69 9 | +1 | 1/2 |
| | $\Sigma^+$ | Experiment | $u\,u\,s$ | 232 7.53(12) | +1 | 1/2 |
| 21. | 2.66.7 | Theory | $s^{3(1)}d^2u^{3(1)}$ | 233 3.76 1 | 0 | 1/2 |
| | $\Sigma^0$ | Experiment | $u\,d\,s$ | 233 3.76(10) | 0 | 1/2 |
| 22. | 2.74.23 | Theory | $s^2d^1d(d^3)$ | 234 3.25 6 | -1 | 1/2 |
| | $\Sigma^-$ | Experiment | $d\,d\,s$ | 234 3.31(12) | -1 | 1/2 |
| 23. | 2.67.31 | Theory | $s^{3(1)}s^2u^{3(1)}$ | 257 2.83 2 | 0 | 1/2 |
| | $\Xi^0$ | Experiment | $u\,s\,s$ | 257 3.1(10) | 0 | 1/2 |
| 24. | 2.59.4 | Theory | $s^2s^1d^2(d^3)$ | 258 6.04 1 | -1 | 1/2 |
| | $\Xi^-$ | Experiment | $d\,s\,s$ | 258 5.75(26) | -1 | 1/2 |
| 25. | 2.47.4 | Theory | $s^{3(1)}s^1s^2$ | 327 2.97 0 | -1 | 3/2 |
| | $\Omega^-$ | Experiment | $s\,s\,s$ | 327 2.86(62) | -1 | 3/2 |

| Isospin (weak isospin) $I$ | Isospin projection $I_3$ | Evenness $p$ | Baryon number $B$ | Lifetime $\tau$, s (or resonance width $\Gamma$, MeV) | Magnetic moment $\mu$ (in proper magnetons) | Note |
|---|---|---|---|---|---|---|
| mesons | | | | | | |
| 1 | +1 | - | 0 | $2.67\,262\,5 \cdot 10^{-8}$ | 0 | $m$ is predicted in TFF |
| 1 | +1 | - | 0 | $2.60\,30(23) \cdot 10^{-8}$ | no data | |
| 1 | 0 | - | 0 | $1.016711 \cdot 10^{-16}$ | 0 | $m,\tau$ are predicted in TFF |
| 1 | 0 | - | 0 | $0.87(4) \cdot 10^{-16}$ | no data | |
| 0 | 0 | - | 0 | $1.21\,752\,6 \cdot 10^{-18}$ | 0 | -"- |
| 0 | 0 | - | 0 | $6.09(19) \cdot 10^{-19}$ | no data | |
| 1/2 | +1/2 | - | 0 | $1.22\,072\,4 \cdot 10^{-8}$ | 0 | -"- |
| 1/2 | +1/2 | - | 0 | $1.2371(26) \cdot 10^{-8}$ | no data | |
| 1/2 | -1/2 | - | 0 | $8.97\,527\,110 \cdot 10^{-11}$ | 0 | $m$ is predicted in TFF |
| 1/2 | -1/2 | - | 0 | $8.92\,3(22) \cdot 10^{-11}$ | no data | |
| 1/2 | -1/2 | - | 0 | $4.54\,570\,1 \cdot 10^{-8}$ | 0 | -"- |
| 1/2 | -1/2 | - | 0 | $5.18\,3(40) \cdot 10^{-8}$ | no data | |
| baryons | | | | | | |
| 1/2 | +1/2 | + | 1 | $3.71\,352 \cdot 10^{39}$ | +2.79 284 | $\tau,\mu$ are predicted in TFF |
| 1/2 | +1/2 | + | 1 | Stable | +2.79 284 739(6) | |
| 1/2 | -1/2 | + | 1 | $8.68\,031 \cdot 10^{2}$ | -1.91 567 940 | -"- |
| 1/2 | -1/2 | + | 1 | $8.886(35) \cdot 10^{2}$ | -1.91 568 97(45) | |
| 0 | 0 | + | 1 | $2.66\,570\,4 \cdot 10^{-10}$ | -0.97 48 | -"- |
| 0 | 0 | + | 1 | $2.63\,2(20) \cdot 10^{-10}$ | -0.61 3(4) | |
| 1 | +1 | + | 1 | $7.85\,969 \cdot 10^{-11}$ | +2.85 732 | $m,\tau,\mu$ are predicted in TFF |
| 1 | +1 | + | 1 | $7.99(4) \cdot 10^{-11}$ | +2.42(5) | |
| 1 | 0 | + | 1 | $17.72 \cdot 10^{-20}$ | +0.03064439(56) | $m,\tau,\mu$ are predicted in TFF |
| 1 | 0 | + | 1 | $7.4(7) \cdot 10^{-20}$ | no data | |
| 1 | -1 | + | 1 | $1.47\,400 \cdot 10^{-10}$ | -0.97 147 949(18) | -"- |
| 1 | -1 | + | 1 | $1.479(11) \cdot 10^{-10}$ | -1 45±0.05 | |
| 1/2 | +1/2 | + | 1 | $2.86\,628\,0 \cdot 10^{-10}$ | -0.97 147 774(18) | -"- |
| 1/2 | +1/2 | + | 1 | $2.9(1)\ 10^{-10}$ | -1.75 2(20) | |
| 1/2 | -1/2 | + | 1 | $1.57\,289\,7 \cdot 10^{-10}$ | -1.03 | -"- |
| 1/2 | -1/2 | + | 1 | $1.64\,2(15) \cdot 10^{-10}$ | 0.679(31) | |
| 0 | 0 | + | 1 | $8.17\,572 \cdot 10^{-11}$ | -0.97 147 371(18) | -"- |
| 0 | 0 | + | 1 | $8.22(12) \cdot 10^{-11}$ | no data | |

| Nos | Particle symbols and names | Information source | Quark composition | Mass $m$, $m_e$ | Charge $q$, $\sqrt{\alpha\hbar c}$ | Spin $J$, $\hbar$ |
|---|---|---|---|---|---|---|
| | | | | | | Meson |
| 26. | 1.23.9 | Theory | $u^2\tilde{d}^2$ | 1516.113 | +1 | 1 |
| | $\rho^+$ (770) | Experiment | $u\tilde{d}$ | 150 3(9) | +1 | 1 |
| 27. | 2.81.17 | Theory | $s^{3(1)}\tilde{s}$ | 189 7.25 5 | 0 | 0 |
| | $f^0$ (975) | Experiment | $c^1(u\tilde{u}+d\tilde{d})+c^2(s\tilde{s})$ | 1909(6) | 0 | 0 |
| 28. | 2.25.15 | Theory | $c^1c^{3(1)}$ | 605 9.48 9 | 0 | 1 |
| | $\frac{1}{\Psi}$ (3 097) | Experiment | $c\,c$ | 606 0.4(2) | 0 | 1 |
| 29. | 1.21.29 | Theory | $u^1\tilde{u}^{3(1)}(d^{3(1)}\tilde{d}^1)$ | 192 4.07 | 0 | 0 |
| | $a_0$ (980) | Experiment | $(u\tilde{u}-d\tilde{d})/\sqrt{2}$ | 192 4(5) | 0 | 0 |
| 30. | 1.16.14 | Theory | $c^{3(1)}\tilde{d}^1$ | 229 0 | 0 | 1 |
| | $h_1$ (1170) | Experiment | $c^1(u\tilde{u}+d\tilde{d})+c^2(s\tilde{s})$ | 228 9(41) | 0 | 1 |
| 31. | 2.57.2 | Theory | $u^1\tilde{u}^{3(1)}$ | 253 4.01 | 0 | 0 |
| | $\eta$ (1 295) | Experiment | $c^1(u\tilde{u}+d\tilde{d})+c^2(s\tilde{s})$ | 253 4(7) | 0 | 0 |
| 32. | 1.11.16 | Theory | $s^{3(1)}\tilde{s}^1$ | 298 1.33 31 | 0 | 2 |
| | $f_2$ (1 525) | Experiment | $c^1(u\tilde{u}+d\tilde{d})+c^2(s\tilde{s})$ | 298 4(9) | 0 | 2 |
| 33. | 1.11.14 | Theory | $d^{3(1)}\tilde{d}^1$ | 3262.1191 | 0 | 0 |
| | $\Omega$ (1670) | Experiment | $c^1(u\tilde{u}+d\tilde{d})+c^2(s\tilde{s})$ | 326 4(9) | 0 | 0 |
| 34. | 1.11.29 | Theory | $u^1\tilde{u}^{3(1)}(d^{3(1)}\tilde{d}^1)$ | 324 9.87 32 | 0 | 2 |
| | $\pi_2$ (1670) | Experiment | $(u\tilde{u}-d\tilde{d})/\sqrt{2}$ | 325 8(39) | 0 | 2 |
| 35. | 1.9.29 | Theory | $u^{3(1)}(d^{3(1)}\tilde{d}^1)$ | 332 3.70 | 0 | 1 |
| | $P_3$ (1700) | Experiment | $(u\tilde{u}-d\tilde{d})/\sqrt{2}$ | 332 6(39) | 0 | 1 |
| 36. | 1.7.16 | Theory | $s^{3(1)}\tilde{s}^1$ | 452 8.29 | 0 | 2 |
| | $f_2$ (2 300) | Experiment | $c^1(u\tilde{u}+d\tilde{d})+c^2(s\tilde{s})$ | 449 5(54) | 0 | 2 |
| 37. | 2.15.14 | Theory | $c^1c^{3(1)}$ | 8116.16 | 0 | 1 |
| | $\Psi$ (4 160) | Experiment | $c\,c$ | 8138(39) | 0 | 1 |
| 38. | 1.4.30 | Theory | $c^1\tilde{c}^{3(1)}$ | 866 0.08 08 | 0 | 1 |
| | $\Psi$ (4 415) | Experiment | $c\,c$ | 863 9(10) | 0 | 1 |
| 39. | 2.55.16 | Theory | $u^2\tilde{s}^2$ | 280 4.95 | 0 | 0 |
| | $K_0^*$ (1 430) | Experiment | $u\tilde{s}$ | 279 6(10) | 0 | 0 |
| | | | | | | Baryon |
| 40. | 1.14.24 | Theory | $u^1u^2d^2(d^3)$ | 297 3.15 5 | +1 | 3/2 |
| | $N^+$ (1 520) | Experiment | $u\,u\,d$ | 297 4(19) | +1 | 3/2 |
| 41. | 1.14.32 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 297 3.15 5 | 0 | 3/2 |
| | $N^0$ (1 520) | Experiment | $u\,d\,d$ | 297 4(19) | 0 | 3/2 |

| Isospin (weak isospin) $I$ | Isospin projection $I_3$ | Evenness $p$ | Baryon number $B$ | Lifetime $\tau$, s (or resonance width $\Gamma$, MeV) | Magnetic moment $\mu$ (in proper magnetons) | Note |
|---|---|---|---|---|---|---|
| resonances | | | | | | |
| 1 | +1 | - | 0 | 153 | 0 | $m, \Gamma, \mu$ are predicted in TFF |
| 1 | +1 | - | 0 | 149(3) | no data | |
| 0 | 0 | + | 0 | 22.3 | 0 | -"- |
| 0 | 0 | + | 0 | 33(6) | no data | |
| 0 | 0 | - | 0 | 0.09 | 0 | -"- |
| 0 | 0 | - | 0 | 0.068(9) | no data | |
| 1 | 0 | + | 0 | 53.7 | 0 | |
| 1 | 0 | + | 0 | 57(11) | no data | -"- |
| 0 | 0 | + | 0 | 338.06 | -1.89 954 015 | -"- |
| 0 | 0 | + | 0 | 335 | no data | |
| 0 | 0 | - | 0 | 33.69 | -0.027 | -"- |
| 0 | 0 | - | 0 | 35(6) | no data | |
| 0 | 0 | + | 0 | 83.4 202 | -2.11 567 324 | -"- |
| 0 | 0 | + | 0 | 76(10) | no data | |
| 0 | 0 | + | 0 | 153.098 | -1.88 956 102 | -"- |
| 0 | 0 | + | 0 | 166(15) | no data | |
| 1 | 0 | - | 0 | 214.196 | 1.99 684 78 | -"- |
| 1 | 0 | - | 0 | 250(20) | no data | |
| 1 | 0 | - | 0 | 383.203 | 2.01 978 665 | -"- |
| 1 | 0 | - | 0 | 235(50) | no data | |
| 0 | 0 | + | 0 | 106.895 | -2.10 284 01 | -"- |
| 0 | 0 | + | 0 | 149(41) | no data | |
| 0 | 0 | - | 0 | 79.0 688 | -0.02 687 676 8 | -"- |
| 0 | 0 | - | 0 | 78(20) | no data | |
| 0 | 0 | - | 0 | 30.4 413 | -1.86 357 601 | -"- |
| 0 | 0 | - | 0 | 43(15) | no data | |
| 1/2 | +1/2 | + | 0 | 278.624 | -0.03 | -"- |
| 1/2 | +1/2 | + | 0 | 287(23) | no data | |
| resonances | | | | | | |
| 1/2 | +1/2 | - | 1 | 78.7 | -3.03 343 314 | $m, \Gamma, \mu$ are predicted in TFF |
| 1/2 | +1/2 | - | 1 | 120(20) | no data | |
| 1/2 | -1/2 | - | 1 | 78.7 | -2.12 460 295 | -"- |
| 1/2 | -1/2 | - | 1 | 120(20) | no data | |

| Nos | Particle symbols and names | Information source | Quark composition | Mass $m$, $m_e$ | Charge $q$, $\sqrt{\alpha\hbar c}$ | Spin $J$, $\hbar$ |
|---|---|---|---|---|---|---|
| 42. | 1.13.20 | Theory | $u^1u^2d^2(d^3)$ | 301 6.08 7 | +1 | 1/2 |
| | $N^+$ (1 535) | Experiment | $u\,u\,d$ | 301 4(40) | +1 | 1/2 |
| 43. | 1.12.26 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 308 1.72 0 | 0 | 1/2 |
| | $N^0$ (1 535) | Experiment | $u\,d\,d$ | 301 3(39) | 0 | 1/2 |
| 44. | 1.7.17 | Theory | $u^1u^2u^{3(1)}$ | 471 5.098 | +2 | 11/2 |
| | $\Delta^{++}$ (2 420) | Experiment | $u\,u\,u$ | 473 5(58) | +2 | 11/2 |
| 45. | 1.8.21 | Theory | $u^1u^2d^2(d^3)$ | 474 4.03 8 | +1 | 11/2 |
| | $\Delta^+$ (2 420) | Experiment | $u\,u\,d$ | 473 5(58) | +1 | 11/2 |
| 46. | 1.8.25 | Theory | $d^2d^1u^{3(1)}$ | 4591.141 | 0 | 11/2 |
| | $\Delta^0$ (2 420) | Experiment | $u\,d\,d$ | 473 5(58) | 0 | 11/2 |
| 47. | 2.34.22 | Theory | $d^{3(1)}d^2d^1$ | 479 2.23 7 | -1 | 11/2 |
| | $\Delta^-$ (2 420) | Experiment | $d\,d\,d$ | 472 6(70) | -1 | 11/2 |
| 48. | 2.56.8 | Theory | $s^2d^1u^{3(1)}$ | 274 3.45 4 | 0 | 1/2 |
| | $\Lambda^0$ (1 405) | Experiment | $u\,d\,s$ | 274 9(10) | 0 | 1/2 |
| 49. | 2.46.23 | Theory | $s^2d^1u^{3(1)}$ | 354 2.903 | 0 | 5/2 |
| | $\Lambda^0$ (1 820) | Experiment | $u\,d\,s$ | 356 1(9) | 0 | 5/2 |
| 50. | 1.11.4 | Theory | $u^1u^2s^2(s^3)$ | 335 4.125 | +1 | 3/2 |
| | $\Sigma^+$ (1 670) | Experiment | $u\,u\,s$ | 327 7(19) | +1 | 3/2 |
| 51. | 2.53.32 | Theory | $s^{3(1)}d^2u^{3(1)}$ | 326 0.97 4 | 0 | 3/2 |
| | $\Sigma^0$ (1 670) | Experiment | $u\,d\,s$ | 327 8(20) | 0 | 3/2 |
| 52. | 2.47.4 | Theory | $s^2d^1d^2(d^3)$ | 326 8.45 6 | -1 | 3/2 |
| | $\Sigma^-$ (1 670) | Experiment | $d\,d\,s$ | 327 8(20) | -1 | 3/2 |
| 53. | 2.32.3 | Theory | $c^1c^2d^2(d^3)$ | 481 6.81 07 | +1 | +1/2 |
| | $\Xi_c^+$ | Experiment | $u\,s\,c$ | 481 4(37) | +1 | 0 |
| 54. | 1.12.6 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 2821.16 | 0 | 1/2 |
| | $N$ (14 40) | Experiment | $u\,d\,d$ | 281 8(78) | 0 | 1/2 |
| 55. | 1.13.6 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 301 9.98 | 0 | 1/2 |
| | $N$ (1 535) | Experiment | $u\,d\,d$ | 301 3(39) | 0 | 1/2 |
| 56. | 1.9.6 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 323 9.42 | 0 | 1/2 |
| | $N$ (1 650)0 | Experiment | $u\,d\,d$ | 322 9(58) | 0 | 1/2 |
| 57. | 1.12.1 | Theory | $u^1u^2d^2(d^3)$ | 325 6.39 | +1 | 5/2 |
| | $N$ (1 675) | Experiment | $u\,u\,d$ | 327 8(28) | +1 | 5/2 |
| 58. | 1.10.6 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 328 2.52 | 0 | 5/2 |
| | $N$ (1 675)0 | Experiment | $u\,d\,d$ | 327 8(29) | 0 | 5/2 |

Table 20.3 continuation

| Isospin (weak isospin) $I$ | Isospin projection $I_3$ | Evenness $p$ | Baryon number $B$ | Lifetime $\tau$, s (or resonance width $\Gamma$, MeV) | Magnetic moment $\mu$ (in proper magnetons) | Note |
|---|---|---|---|---|---|---|
| 1/2 | +1/2 | - | 1 | 73.8 | -3.03 743 630 | $m,\Gamma,\mu$ are predicted in TFF |
| 1/2 | +1/2 | - | 1 | 175(75) | no data | |
| 1/2 | -1/2 | - | 1 | 287 | -1.89296241 | -"- |
| 1/2 | -1/2 | - | 1 | 175(75) | no data | |
| 3/2 | +3/2 | + | 1 | 419.945 | +2.98 377 947 | -"- |
| 3/2 | +3/2 | + | 1 | 400(100) | no data | |
| 3/2 | +1/2 | + | 1 | 481 | +2.98 377 944 7 | -"- |
| 3/2 | +1/2 | + | 1 | 400(100) | no data | |
| 3/2 | -1/2 | + | 1 | 454 | +2.03 154 931 | -"- |
| 3/2 | -1/2 | + | 1 | 400(100) | no data | |
| 3/2 | -3/2 | + | 1 | 253 | +1.02 758 950 | -"- |
| 3/2 | -3/2 | + | 1 | 400(100) | no data | |
| 0 | 0 | - | 1 | 33.6 | +0.03 022 940 | -"- |
| 0 | 0 | - | 1 | 55(10) | no data | |
| 0 | 0 | + | 1 | 77.1 | +2.02 006 221 | -"- |
| 0 | 0 | + | 1 | 80(10) | no data | |
| 1 | +1 | - | 1 | 69.4 | -3.04 560 99 | -"- |
| 1 | +1 | - | 1 | 60(20) | no data | |
| 1 | 0 | - | 1 | 40.2 | +0.03 022 776(55) | -"- |
| 1 | 0 | - | 1 | 60(20) | no data | |
| 1 | -1 | - | 1 | 40.6 | +1.03 256 504(19) | -"- |
| 1 | -1 | - | 1 | 60(20) | no data | |
| +1/2 | -1/2 | - | 1 | | -0.97 146 440 8 | -"- |
| +1/2 | -1/2 | - | 1 | $4.3 \cdot 10^{-13}$ | no data | |
| 1/2 | -1/2 | + | 1 | 254.779 | -1.89296 | -"- |
| 1/2 | -1/2 | + | 1 | 235(115) | no data | |
| 1/2 | -1/2 | - | 1 | 212.47 | -1.89628 | -"- |
| 1/2 | -1/2 | - | 1 | 175(75) | no data | |
| 1/2 | -1/2 | - | 1 | 168.979 | -1.88 253 | -"- |
| 1/2 | -1/2 | - | 1 | 150(50) | no data | |
| 1/2 | -1/2 | - | 1 | 111.202 | 2.91 060 | -"- |
| 1/2 | -1/2 | - | 1 | 150 | no data | |
| 1/2 | -1/2 | - | 1 | 123.837 | -1.88608 | -"- |
| 1/2 | -1/2 | - | 1 | 150(30) | no data | |

| Nos | Particle symbols and names | Information source | Quark composition | Mass $m$, $m_e$ | Charge $q$, $\sqrt{\alpha\hbar c}$ | Spin $J$, $\hbar$ |
|---|---|---|---|---|---|---|
| 59. | 1.11.6 | Theory | $d^{3(1)}d^2u^{3(1)}$ | 3262.11 | 0 | 5/2 |
| | N (1 680)0 | Experiment | $u\,d\,d$ | 328 8(29) | 0 | 5/2 |
| 60. | 1.12.2 | Theory | $d^{3(1)}d^2d^1$ | 3173.81 | -1 | 1/2 |
| | Δ (1 620) | Experiment | $d\,d\,d$ | 318 0(48) | -1 | 1/2 |
| 61. | 1.9.17 | Theory | $u^1u^2u^{3(1)}$ | 332 3.70 | +2 | 3/2 |
| | Δ (1700)++ | Experiment | $u\,u\,u$ | 329 7(10) | +2 | 3/2 |
| 62. | 1.9.2 | Theory | $d^{3(1)}d^2d^1$ | 333 6.22 | -1 | 3/2 |
| | Δ (1700) | Experiment | $d\,d\,d$ | 329 7(10) | -1 | 3/2 |
| 63. | 1.10.2 | Theory | $d^{3(1)}d^2d^1$ | 380 3.19 | -1 | 1/2 |
| | Δ (1 900) | Experiment | $d\,d\,d$ | 376 7(14) | -1 | 1/2 |
| 64. | 1.11.17 | Theory | $u^1u^2u^{3(1)}$ | 376 5.36 | +2 | 7/2 |
| | Δ (1950)++ | Experiment | $u\,u\,u$ | 378 7(48) | +2 | 7/2 |
| 65. | 1.11.2 | Theory | $d^{3(1)}d^2d^1$ | 377 9.55 | -1 | 7/2 |
| | Δ (1 950) | Experiment | $d\,d\,d$ | 378 7(68) | -1 | 7/2 |
| 66. | 1.7.17 | Theory | $u^1u^2u^{3(1)}$ | 465 9.74 | +2 | 1/2 |
| | Δ (2 420)++ | Experiment | $u\,u\,u$ | 473 5(58) | +2 | 1/2 |
| 67. | 2.61.8 | Theory | $s^2d^1u^{3(1)}$ | 275 0.95 | 0 | 1/2 |
| | λ (1 405) | Experiment | $u\,d\,s$ | 275 0(9) | 0 | 1/2 |
| 68. | 2.48.2. | Theory | $s^2d^1u^{3(1)}$ | 297 2.92 | 0 | 3/2 |
| | λ (1 520) | Experiment | $u\,d\,s$ | 297 3.6(19) | 0 | 3/2 |
| 69. | 2.43.8 | Theory | $s^2d^1u^{3(1)}$ | 326 9.93 | 0 | 1/2 |
| | λ (1 670) | Experiment | $u\,d\,s$ | 326 8(19) | 0 | 1/2 |
| 70. | 2.51.8 | Theory | $s^2d^1u^{3(1)}$ | 33 09.2 | 0 | 3/2 |
| | λ (1690) | Experiment | $u\,d\,s$ | 33 07(9) | 0 | 3/2 |
| 71. | 2.55.20 | Theory | $s^2d^1d^2(d^3)$ | 2711.88 | -1 | 3/2 |
| | Σ (1 385) | Experiment | $d\,d\,s$ | 270 6.7(10) | -1 | 3/2 |
| 72. | 1.13.21 | Theory | $u^1u^2s^2(s^3)$ | 319 0.22 | +1 | 1/2 |
| | Σ (1 660)+ | Experiment | $u\,u\,s$ | 324 9 | +1 | 1/2 |
| 73. | 1.11.24 | Theory | $s^{3(1)}d^2u^{3(1)}$ | 335 6.14 | 0 | 1/2 |
| | Σ (1660) | Experiment | $u\,d\,s$ | 324 9 | 0 | 1/2 |
| 74. | 1.10.24 | Theory | $s^{3(1)}d^2u^{3(1)}$ | 327 6.02 331 | 0 | 3/2 |
| | Σ (16 70)0 | Experiment | $u\,d\,s$ | 327 8(19) | 0 | 3/2 |
| 75. | 2.47.20 | Theory | $s^2d^1d^2(d^3)$ | 327 0.15 85 | -1 | 3/2 |
| | Σ 1(670) - | Experiment | $d\,d\,s$ | 327 8(19) | -1 | 3/2 |

Table 20.3 continuation

| Isospin (weak isospin) $I$ | Isospin projection $I_3$ | Evenness $p$ | Baryon number $B$ | Lifetime $\tau$, s (or resonansce width $\Gamma$, MeV) | Magnetic moment $\mu$ (in proper magnetons) | Note |
|---|---|---|---|---|---|---|
| 1/2 | -1/2 | + | 1 | 153.098 | -1.88956 | $m, \Gamma, \mu$ are predicted in TFF |
| 1/2 | -1/2 | + | 1 | 125(15) | no data | |
| 3/2 | -3/2 | - | 1 | 182.923 | -2.81 760 | -"- |
| 3/2 | -3/2 | - | 1 | 140(20) | no data | |
| 3/2 | +3/2 | - | 1 | 383.203 | 2.96 515 | -"- |
| 3/2 | +3/2 | - | 1 | 250(55) | no data | |
| 3/2 | -3/2 | - | 1 | 190.101 | -2.82 712 | -"- |
| 3/2 | -3/2 | - | 1 | 250(55) | no data | |
| 3/2 | -3/2 | - | 1 | 217.915 | 2.82 397 | -"- |
| 3/2 | -3/2 | - | 1 | 215(85) | no data | |
| 3/2 | +3/2 | + | 1 | 278.624 | 2.92 359 | -"- |
| 3/2 | +3/2 | + | 1 | 270(70) | no data | |
| 3/2 | -3/2 | + | 1 | 256.785 | -2.82 080 517 | -"- |
| 3/2 | -3/2 | + | 1 | 270(70) | no data | |
| 3/2 | +3/2 | + | 1 | 434.882 | 3.00 265 062 | -"- |
| 3/2 | +3/2 | + | 1 | 400(100) | no data | |
| 0 | 0 | - | 1 | 31.456 | -0.03 023 211 5 | -"- |
| 0 | 0 | - | 1 | 55(10) | no data | |
| 0 | 0 | - | 1 | 19.65 | -0.03 022 391 4 | -"- |
| 0 | 0 | - | 1 | 15.6(10) | no data | |
| 0 | 0 | - | 1 | 41.04 | -0.03 022 227 3 | -"- |
| 0 | 0 | - | 1 | 37(13) | no data | |
| 0 | 0 | - | 1 | 38.3 384 | -0 03 022 664 8 | -"- |
| 0 | 0 | - | 1 | 60(10) | no data | |
| +1 | -1 | + | 1 | 35.2 829 | -1.03 256 65 | -"- |
| 1 | -1 | + | 1 | 36(8) | no data | |
| 1 | +1 | + | 1 | 97.7 909 | 2.89 276 993 5 | -"- |
| 1 | +1 | + | 1 | 120 | no data | |
| 1 | 0 | + | 1 | 93.8 477 | -2.11 567 324 | -"- |
| 1 | 0 | + | 1 | 120 | no data | |
| 1 | 0 | - | 1 | 85.1 625 | -2.11 258 294 | -"- |
| 1 | 0 | - | 1 | 60 | no data | |
| 1 | -1 | - | 1 | 41.9176 | -1.03 256 505 | -"- |
| 1 | -1 | - | 1 | 60 | no data | |

| Nos | Particle symbols and names | Information source | Quark composition | Mass $m$, $m_e$ | Charge $q$, $\sqrt{\alpha\hbar c}$ | Spin $J$, $\hbar$ |
|---|---|---|---|---|---|---|
| 76. | 1.13.24 | Theory | $s^{3(1)}d^2u^{3(1)}$ | 339 2.94 88 | 0 | 1/2 |
| | $\sum$ (1 750)0 | Experiment | $uds$ | 345 4(68) | 0 | 1/2 |
| 77. | 1.12.21 | Theory | $u^1u^2s^2(s^3)$ | 345 3.92 62 | 1 | 5/2 |
| | $\sum$ (1 775)+ | Experiment | $uus$ | 347 4(9) | +1 | 5/2 |
| 78. | 1.12.24 | Theory | $s^{3(1)}d^2u^{3(1)}$ | 346 2.24 38 | 0 | 5/2 |
| | $\sum$ (1775)0 | Experiment | $uds$ | 347 4(9) | 0 | 5/2 |
| 79. | 1.9.24 | Theory | $s^{3(1)}d^2u^{3(1)}$ | 374 4.64.31 | 0 | 5/2 |
| | $\sum$ (1915)0 | Experiment | $uds$ | 375 2.5 | 0 | 5/2 |
| 80. | 1.8.24 | Teory | $s^{3(1)}d^2u^{3(1)}$ | 396 7.14 57 | 0 | 7/2 |
| | $\sum$ (20 30)0 | Experiment | $uds$ | 397 7.5(140) | 0 | 7/2 |
| 81. | 1.13.8 | Theory | $s^{3(1)}s^2u^{3(1)}$ | 329 4.49 74 | 0 | 1/2 |
| | $\Xi$ (1690)0 | Experiment | $uss$ | 330 7(19) | 0 | 1/2 |
| 82. | 2.40.4 | Theory | $s^2s^1(d^3)$ | 331 4.05 18 | -1 | 1/2 |
| | $\Xi$ (1 690) | Experiment | $dss$ | 330 7(19) | -1 | |
| 83. | 2.43.4 | Theory | $s^2s^1(d^3)$ | 356 9.65 47 | -1 | 3/2 |
| | $\Xi$ (1 820) | Experiment | $dss$ | 356 8(9) | -1 | 3/2 |
| 84. | 1.10.8 | Theory | $s^{3(1)}s^2u^{3(1)}$ | 379 5.66 29 | 0 | 1/2 |
| | $\Xi$ (1950)0 | Experiment | $uss$ | 381 6(29) | 0 | |
| 85. | 2.48 4 | Theory | $s^2s^1(d^3)$ | 381 8.39 31 | -1 | 1/2 |
| | $\Xi$ (1 950) | Experiment | $dss$ | 381 6(29) | -1 | |
| 86. | 2.45.20 | Theory | $s^2s^1(d^3)$ | 395 4.65 60 | -1 | 5/2 |
| | $\Xi$ (20 30) | Experiment | $dss$ | 396 3(9) | -1 | 5/2 |

Table 20.3 continuation

| Isospin (weak isospin) $I$ | Isospin projection $I_3$ | Evenness $p$ | Baryon number $B$ | Lifetime $\tau$, s (or resonansce width $\Gamma$, MeV) | Magnetic moment $\mu$ (in proper magnetons) | Note |
|---|---|---|---|---|---|---|
| 1 | 0 | - | 1 | 91.3 452 | -2.12 162 503 | m, $\Gamma$, $\mu$ are predicted in TFF |
| 1 | 0 | - | 1 | 110(50) | no data | |
| 1 | +1 | - | 1 | 111.202 | 2.91 060 284 | -"- |
| 1 | +1 | - | 1 | 120 | no data | |
| 1 | 0 | - | 1 | 92.3 986 | -2.1136869 | -"- |
| 1 | 0 | - | 1 | 120(15) | no data | |
| 1 | 0 | - | 1 | 98.4 453 | -2.10 941 482 | -"- |
| 1 | 0 | - | 1 | 120(40) | no data | |
| 1 | 0 | - | 1 | 102.01 | -2.10 616 764 | -"- |
| 1 | 0 | - | 1 | 175(25) | no data | |
| 1/2 | +1/2 | - | 1 | 86.1211 | -2.12 162 503 | -"- |
| 1/2 | +1/2 | - | 1 | 50 | no data | |
| 1/2 | -1/2 | - | 1 | 47.0 591 | -1.03 256 378 | -"- |
| 1/2 | -1/2 | - | 1 | 50 | no data | |
| 1/2 | -1/2 | - | 1 | 41.037 | -1.03 256 432 | -"- |
| 1/2 | -1/2 | - | 1 | 24(15) | no data | |
| 1/2 | +1/2 | - | 1 | 85.1 625 | -2.11 258 294 | -"- |
| 1/2 | +1/2 | - | 1 | 60(20) | no data | |
| 1/2 | -1/2 | - | 1 | 40.9 665 | -1.03 256 523 | -"- |
| 1/2 | -1/2 | - | 1 | 60(20) | no data | |
| 1/2 | -1/2 | - | 1 | 39.0 642 | -1.03 256 468 | -"- |
| 1/2 | -1/2 | - | 1 | 20(15) | no data | |

Unfortunately, before this publication it was not managed to discuss substantially the results of calculation of the parameters of elementary particles and to compare them with the experimental ones. Therefore, we do not think it to be rightful to enumerate here a great amount of the predictions obtained as far back as in 1983 and confirmed now, since the data of this calculation are not published. In this relation, we believe it is important to give in this publication the predictions of the new values of parameters unknown from the experiment, so that subsequent experimental confirmations could strengthen the theory positions.

The comparison of the numerical values of the masses calculated theoretically and observed experimentally shows that all theoretically determined values correspond to the experimental ones within the bounds of accuracy of the experiment. In most cases the theoretical accuracy exceeds the experimental one, and so the theoretical values are the predictions. The quantum numbers, the charges, the spins, the isotopic spins, the projections of the isotopic spins, the even parity, the baryon number are determined exactly within the bounds of the theory, mainly by using the results of the quark theory previously discussed in detail in this book.

As it was mentioned above, the lifetime of the short-living and long-living elementary particles is determined in a different way.

The lifetime of the particles living for a very short time (less than $10^{-22}$ s.) is determined by the quasi-classical method; they have no time to interact with physical vacuum and to acquire the quantum properties. The lifetime of such particles (the resonances) is determined in the theory with a satisfactory accuracy, substantially exceeding the accuracy of the experimental measurements, so these lifetimes are the predictions. The theoretically calculated resonance width corresponds very well to the experimentally observed one, up to the experiment accuracy (see tabies 20.1, 20.2 and 20.3).

The lifetime of long-living particles, i.e. the particles which have time to interact with physical vacuum and to acquire quantum properties is determined by other formulae. The method of calculation is determined in the theory and allows to calculate this time with a satisfactory accuracy. Yet, it was not managed by now to reach a very great accuracy of calculation of long-living particles lifetime. This is connected with the fact that the interaction of particles with physical vacuum, which substantially influences the lifetime of particles, is a complex process and far from being unambiguous. The ambiguity consists in the fact that particles interact with physical vacuum in different ways, depending on the series, state, number of the point they are referred to, i.e. depending on the characteristics of the internal structure of the particles. But the internal parameters do not determine the character of interaction of these particles with physical vacuum unambiguously.

The interaction of EPs and PV also depends on the degree of excitation of the particles interacting with physical vacuum, on the state of physical vacuum in those points of the space where this interaction occurs, and on many other causes, which result in a great amount of interaction channels. For each of these channels there is a certain normalizing factor in the formula of calcu-

lation of particle parameters. In other words, it is shown in the theory that the principal values determining the lifetime of the particles interacting with vacuum are unambiguously determined by the internal structure, but the normalizing coefficients depending on the character of interaction are variable. These coefficients are not great, according to their absolute values. As a rule, they are of the order of a unit or some units, and they are not of arbitrary character. There are finite, known values of the permissible normalizing factors, in other words, the permissible spectrum of the normalizing factors. Each term of this spectrum has a numerical value accurately determined by the constants of the theory. Thus, we know the permissible spectrum of the normalizing factors and their numerical values. It is important to emphasize here that the normalizing factors are always the unambiguous functions of the EP and EPV internal parameters but not arbitrary values.

In section 17 it was mentioned that the interaction character of particles with physical vacuum is determined by a certain additional symmetry connected with the behaviour of particles, so to say, the substructure of the symmetry or, better to say, the system of permissible distortions of the principal symmetries. The principal symmetries can fluctuate, be distorted under certain conditions. But it turns out that these distortions are not of random and arbitrary character, they are also regular. The greater part of these regularities is known and can be used to determine the optimal factor corresponding to the character of interaction of the particle and physical vacuum. Yet, for some particles the known today method of selection of the normalizing factros, characterizing the interaction of EP and physical vacuum, does not provide the necessary exact results. This explains the fact that for certain particles the lifetime can be calculated with a great accuracy while for other particles the lifetime can not be accurately calculated theoretically.

The mentioned above in regard to the method of determination of normalizing factors also concerns the method of calculation of the magnetic moment of particles. For certain particles it is determined unambiguously and exactly, more exactly than by the experiment. For some other particles the exact calculation of their magnetic moment is difficult. As to the rest, a great array of comparison of experimental and theoretical values does not demand special comments, because the data shown in tables 20.1, 20.2 and 20.3 speak for themselves.

To conclude the brief discussion of the essence of the problem it is necessary to remind the reader once again that for each elementary particle only one quantum number $K$ exists, and this number is the only argument whose functions are the mass, the charge, the spin, the isotopic spin and all other quantum numbers.

## RÉSUMÉ

1. The detailed theoretical calculation of all parameters of elementary particles performed by means of a computer is given herein. The result of this calculation in comparison with the experimental data is also given.

2. The well-grounded deduction of calculation formulae is given for the concentration of elementary particles in different types of vacuum, the permittivity of physical vacuum, the magnetic

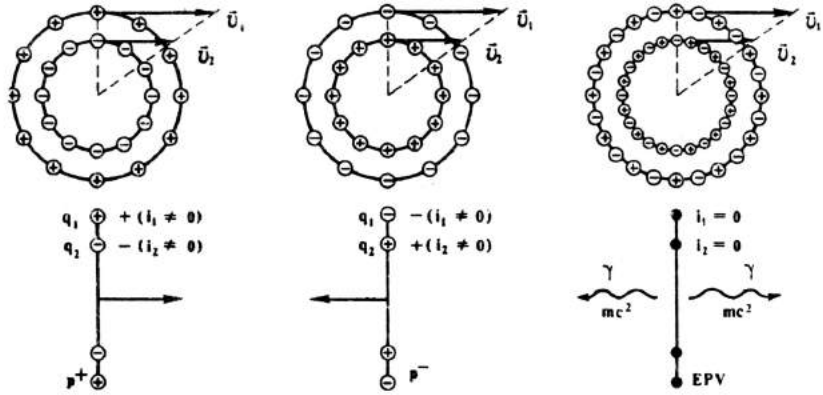



Fig. 21.1 EPV formation during particle and antiparticle annihilation process

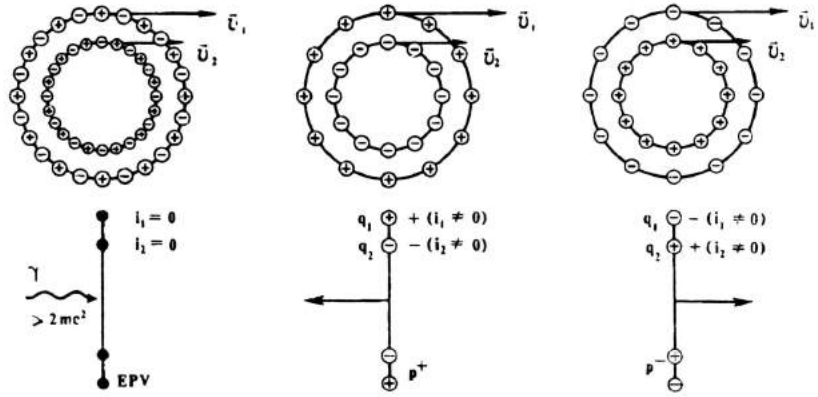



Fig. 21.2 Formation of antiparticles pair when EPV is excited by photon

which we are making now. But we are not deprived of possibility to analyse the properties of EPVs of these kinds of vacua and their part in the phenomena we investigate. So TFF calls for the existence of EPVs but the possibility of the real display of the antiparticles which form higher kinds of vacua is only assumed but not required by the theory.

In TFF there is a certain hierarchy of the points of spatial part of every manifold. Geometrical properties of these subspaces are characterized by a continuous set $P$, but the number of points, which can at the given moment characterize the material properties of the object investigated, is finite; they form a discrete subset $M$ [7].

It is clear that the energy of the unexcited EPV is equal to zero. By annihilation of antiparticles the energy $2m_v c^2$ is emitted, where $m_v$ is the mass of a particle (antiparticle) which has formed EPV (proton or electron, for example).

EPVs absorb some part of the energy of photons (the red shift) [48] and the energy of neutrino and interact between themselves (see Fig. 21.2). The result of it is the spontaneous excitation of EPV up to some energy which equals

$$E_v = \frac{2\alpha}{\pi} m_v c^2 , \tag{21.1}$$

where $\alpha$ is the fine structure constant.

The average contents of EPVs in the excited state in 1 $c^3$ of vacuum is

$$n_{exc} = \frac{\alpha}{\pi} n_v , \tag{21.2}$$

where $n_v = \frac{1}{8\pi^2 R_v^3}$ is the concentration of EPVs which have the radius $R_v$.

So the average energy in 1 $c^3$ of PV is

$$\bar{E_v} = \frac{2\alpha^2}{\pi^2} n_v m_v c^2 . \tag{21.3}$$

It is very large energy and it is in the entire Universe, in its every volume, even in the entire inter-stellar space. This energy is also in the inter-molecular spaces of any solid and in the inter-atomic spaces. Of course the concentration of the PV energy inside the condensed atomic matter (solid and liquid) differs somehow from that shown in (21.3).

Undoubtedly this energy can be used. There is some experimental information which allows to conclude that living Nature, and a man in particular, widely use PV energy. (In this connection it is not out of place to say that food is the basic building stuff but not the basic source of energy of a man. A man uses food as an emergency source of energy only in extreme cases when the expenditure of energy is above average).

Physical processes by means of which PV energy can be directly used have been studied for many years. The aim was to specify the possibilities of practical use of TFF.

These investigations show that enough information has been got by now to make the further working out possible.

All kinds of vacuum are given in Table 21.1.*)

Table 21.1

| Vacuum kind | $R_m$, c | Vacuum kind | $R_m$, c |
|---|---|---|---|
| 1 | $1.40 \cdot 10^{-13}$ | 6 | $1.07 \cdot 10^{-6}$ |
| 2 | $2.58 \cdot 10^{-10}$ | 7 | $6.32 \cdot 10^{-6}$ |
| 3 | $3.70 \cdot 10^{-10}$ | 8 | 6.370 |
| 4 | $3.70 \cdot 10^{-9}$ | 9 | $1.59 \cdot 10^{3}$ |
| 5 | $3.15 \cdot 10^{-8}$ | | |

As it was said before, the first proton-antiproton vacuum gives the basic contribution to averaged processes. The next (electron-positron) vacuum gives little conrtibution, all the less other kinds of vacuum. Resonance processes can occur in vacuum and every kind of vacuum can bring its contribution to these processes.

One of the most interesting phenomena of this kind is the process of absorbing neutrino by vacuum.

The presented table shows that the so-called relic radiation is the spontaneous radiation in vacuum 8. The wavelength that has been watched experimentally evidently proves it. And this radiation prevails, bacause there are long intervals of wavelength between the 7th and the 8th vacua, on the one hand, and between the 8th and the 9th vacua, on the other. These intervals de not conform to any vacuum.

*) For detail see table 5.1 and [7].

# 22 NATURE OF HIGH TEMPERATURE SUPERCONDUCTIVITY. THE WAYS OF USE (BRIEF INFORMATION)

The modern theory of superconductivity [126, 127] is mainly based on the L. Cooper effect which was found in 1956. As Cooper states, the electrons of conductivity in a solid, which are near the Fermy surface when their spins are directed to opposite sides, unite themselves and form the so-called Cooper pairs (CP). The energy of this pair is not great, it is near $3.5kT_c$, where $k$ is the Boltzmann constant and $T_c$ is the absolute temperature of conversion into critical state. The possibility of formation of the Cooper pairs follows from quantum physics of a solid, and an experiment corroborates the existence of such pairs. So the basic causes which lead to the phenomena of superconductivity in metals and superfluidity of liquids are firmly settled. But in spite of this fact, the mechanism of formation of CP is not found yet, and there is not yet any reliable method of theoretical calculation of critical temperature of conversion into critical state.

In this section we are going to show what opportunities to solve these problems can be opened by the unified theory of fundamental field.

In TFF the basic fundamental field is concentrated in a *string* *) which scans over the surface of the cone of anisotropy. Half of apex angle of this cone [7] is called the angle of anisotropy $\alpha_0$. Free electron and bound nucleon have $\alpha_0 = 22°$ approximately. EPVs which, in accordance with TFF, are the particle-antiparticle pairs the spins of which are directed parallel, have the angle of anisotropy $\alpha_0 = 0$, if EPVs are not excited. When the excitation is very strong the angle $\alpha_0$ differs from zero, and when EPV is being torn into the initial particle and antiparticle (the process of formation of pairs) the appeared particles have $\alpha_0$ corresponding to that of free particles.

CP consists of two electrons, the spins of which are directed to opposite sides. But both electrons, which are united into a pair, have negative charges. So the mechanism which ensures the building of a stable pair, in spite of repulsion of like charges, is not clear.

The structure of elementary particles which was found in TFF allows to explain the mechanism of formation of CP. Indeed, if two electrons are brought together so that the structure of one (in 2SS) is above the cone of anisotropy of the other (See Fig. 22.1), both electrons find themselves in a "trap" which has been created by the cones of anisotropy of the fundamental fields. The distance $l_c$ under which the unity of two electrons into the Cooper pair is possible is defined by the following conditions:

*) A concept of string in TFF is nearer to a concept of superstring which is being formed now [78,80], but in TFF it is deeper and richer (see section 5).

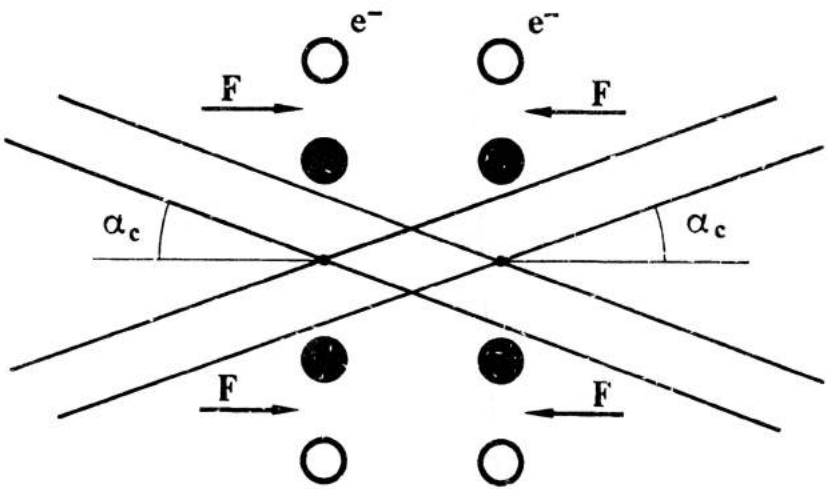



Fig. 22.1 Formation of Cooper pair from two electrons

$$l_c \leq \frac{R_c}{\sin \alpha_c}, \tag{22.1}$$

where $R_e$ is the radius of an electron substructure; $\alpha_c$ is the angle of anisotropy of the electrons which are united into the Cooper pair.

If the angle $\alpha_c$ of the electrons which are united into a pair were the same as the free particles angle, i.e. $\alpha_c = \alpha_0 = 22^0$, then

$$l_c = \frac{4.18 \cdot 10^{-11}}{0.375} = 1.12\ 10^{-10}\ \text{c}.$$

But the angle $\alpha_c$ of electrons in a pair has to be essentially less than 22°. The calculation shows, it should decrease approximately by the value which is $4\pi^2$ times more than the inverse coeffi-

cient attached to the bond energy of electrons $\frac{2\alpha^2}{\pi^2}$ (see (21.3)). Then the size of the Cooper pair is defined from the equations:

$$\alpha_c = \alpha_0 \left( \frac{2\pi^4}{\alpha_c^2} \right)^{-1} ; \tag{22.2}$$

$$l_c \leq \frac{R_e}{\sin \alpha_c} = 4.10 \cdot 10^{-4} \text{ c} , \tag{22.3}$$

that corresponds to the experimental data and theoretical notions of the Cooper effect.

Let us make the estimation of the bond energy of the electrons in the Cooper pair, and by doing this, calculate the energy of CP destruction by thermal fluctuations, and consequently, the highest temperature at which the pairs of electrons are able to exist.

From the described mechanism of formation of pairs we can inevitably conclude that the bond energy in CP can be defined by the simple formula:

$$E_c = \frac{2\alpha^2}{\pi^2} e^2 n^{1/3} , \tag{22.4}$$

where $e$ is the charge of an electron; $n$ is the total concentration of free bearers of the current which conductor has before its transition into the state of superconductivity; $\alpha \approx 7.29\ 735 \cdot 10^{-3}$ is the fine structure constant.

The best way to define the total concentration $n$ is to use the well-known condition:

$$n = \frac{1}{R_H \cdot e} , \tag{22.5}$$

where $R_H$ is the Hall constant of a superconductor before its transition to the state of superconductivity.

It is clear that CP can exist as long as the critical absolute temperature $T_c$ complies with the condition

$$k T_c \leq E_c , \tag{22.6}$$

where $k$ is the Boltzmann constant.

Hence

$$T_c \leq \frac{2\alpha^2 e^2 n^{1/3}}{\pi^2 k} = 1.81 \cdot 10^{-8} n^{1/3} \text{ K} . \tag{22.7}$$

Strictly speaking, the coefficient of efficiency of energy in (22.4) is exactly equal to $\frac{2\alpha^2}{\pi^2}$ in particular cases only. In general, the average coefficient of excitation of physical vacuum and just that coefficient which has defined the coefficient in the formula (22.4) can differ by a certain in-

teger factor. Besides, the specific features of concrete material can make a certain correction of about several units. The detailed analysis of the process is beyond the scope of this report, where we only show the possibility, in principle, of theoretical calculation of $T_c$ within the bounds of TFF.

The examples of calculation of $T_c$ for different metals by the formula (22.7) and comparison with the experiment [128] are given in table 22.1.

Table 22.1

| Metal symbol | $T_c$, K (theory) | $T_c$, K (experiment) | $n$, $c^{-3}$ (experiment) [128] |
|---|---|---|---|
| Al | 1.18 | 1.14 | $2.84 \cdot 10^{23}$ |
| Zn | 0.704 | 0.79 | $6.00 \cdot 10^{22}$ |
| Ti | 2.4 | 1.81 | $2.4 \cdot 10^{24}$ |
| Hg | 5.65 | 4.22 | $3.12 \cdot 10^{24}$ |
| In | 3.26 | 3.37 | $5.94 \cdot 10^{24}$ |
| Th | 1.45 | 1.32 | $5.2 \cdot 10^{23}$ |

If we apply the same methods to calculate the critical temperature of conversion of EPV in physical vacuum into superfluid state we obtain the following data: for the electron-positron vacuum:

$$T_c\,(e^+e^-) \approx 100\ \mathrm{K}\,,$$

and for the proton-antiproton vacuum:

$$T_c\,(p^+p^-) \approx 10^5\ \mathrm{K}\,.$$

Thus, both PVa are always in superfluid state since physical vacuum can not be heated up to 100 K. When EPVs are excited this state becomes superconductive as well.

Information discussed in this section was published [14] at the end of February 1987, i.e. earlier than the first publications about the discovery of the high temperature superconductivity (at temperature up to 100 Kelvin degrees) appeared. During recent years a lot of experiments were carried out from which it followed that the limit 100 K was really observed. Thus, the first maximum of permissible temperature of the superconductivity predicted in [14] turned out to be the prediction which was proved by the experiment.

So, high temperature superconductivity now observed is the current conductivity through the electron-positron PV. The material which is now considered to be superconductive is not, in fact, of this kind. Its role is reduced to excite EPVs of the electron-positron vacuum up to the superconductive state on numerous elements of a ramified surface (the "superconductive" ceramics is an object which has many microcells). Only such is the role of molecules in ceramics which provide high temperature superconductivity.

To excite superconductivity at temperatures above 100 K it is necessary to excite not the electron-positron vacuum but just the proton-antiproton vacuum, the maximum superconductivity limit of which is equal to $10^5$ K. Such should be the strategy of search of materials exciting high temperature superconductivity in physical vacuum.

This prediction is made on the basis of TFF.

# 23 SOME QUESTIONS OF THE THEORY OF ACTIVATION OF DIFFERENT MEDIA. THE SPHERES AND METHODS OF USE OF THIS PHENOMENON

23.1. There are different ways of activation of water solutions: mechanical, thermal, acoustic, magnetic, electric, the activation by electrohydraulic impact etc. [129—132]. There is some separate information about activation of other media, mainly of liquids and in some cases of gases and solids.

There is no theoretical interpretation of these facts that could completely explain all the aspects of these phenomena; it was repeatedly mentioned in scientific works. Moreover, some scientists declared these phenomena to be non-existing, "illegal". The reason for such opinion was the difficulty in interpreting these phenomena on the basis of generally accepted concepts.

It became possible to explain the physical nature of the theory of activation of medium on the basis of new physical theory, i.e. TFF. This explanation is based on two important consequences of TFF:

a) Surrounding space is not empty, physical vacuum consists of material physical objects which are elementary particles of vacuum. These particles are responsible for greater part of activation processes.

b) Force interactions between atoms in a molecule, between molecules in crystals, between crystals in a solid have the axial but not spherical symmetry, and change over time with very great frequency of the order of $10^{18}$ cycles per second. This feature of force interactions also influences essentially media activation.

Within the bounds of the given concept the phenomenon of media activation can be determined in the following way. There is equilibrium and set links between atoms and excited EPVs. The disturbance of these links, when there is anisotropy of force interaction, leads to metastable state which can be called the *structural activated state* of the medium.

The term activation is used in chemical kinetics and characterizes the transition of an atom or a molecule into an active state with enlarged energy which is sufficient for the proceeding of the chemical reaction. Thus, the process of activation in chemical kinetics characterizes the transmission of the so-called *energy of activation* to the molecule.

The activation we mean is a different kind of phenomenon, by its physical nature, and we call it the *structural activation*, since this phenomenon means the change of the structure of the object of activation. Under activation the energy of a molecule can remain unchanged and the active properties of the molecule are defined only by its internal structure change.

23.2. Nuclear matter and perhaps neutronic stars are the only places where, according to the theory of fundamental field, there are no EPVs (they have been forced out). Within the atom there is a great number of EPVs, between the nucleus and the electron cover. And if in a free vacuum there is approximately one spontaneously excited particle in 800 EPVs, then the number of excited particles in an atom is significantly more due to the influence of a nucleus. For example, in an atom of hydrogen there are approximately $10^7$ excited EPVs. Of course they play a great role. In particular, the continuous process of interaction of electrons on the atomic orbit and EPVs leads to the basic quantum properties of electrons in an atom, e.g. this interaction deprives an electron of its classical trajectory (see sections 7 and 8).

There is also a large number of EPVs between atoms in a molecule and inside crystals. It is connected with the fact that the concentration of EPVs in the electron-positron vacuum is approximately $10^{29}$ particles per $c^3$, and the concentration of particles in the proton-antiproton vacuum is approximately $10^{39}$ particles per $c^3$. Of course that is the concentration but not the density. EPVs in atoms, molecules and crystals almost do not increase the density of matter because unexcited EPVs have no mass. EPVs come into being as a result of interaction of particles and antiparticles, e.g. electron and positron. Thus, the defect of the mass is equal to the total mass of the initial particles. So, after interacting the whole mass of particles turns into bond energy, and the EPV which was formed by this reaction does not have any mass at all. Before the creation of TFF this reaction was called annihilation. The particles were thought to disappear, causing formation of two photons in an empty space. In accordance with TFF, these particles form EPV and cause the disturbance in the surrounding vacuum which is spread as a pair of photons.

It is clear that many properties of elementary particles and matter could not be understood without taking into account EPVs. Many properties of physical vacuum were brilliantly anticipated by Einstein, Schrödinger, Dirac and other founders of modern physics. But to know the anticipated properties only was not enough to solve all problems. It was necessary to understand the mechanism which leads to the basic laws of quantum and relativistic theories. TFF helped to do that, mainly owing to the introduction of two new concepts: structural physical vacuum and the structure of EPVs. The latter leads to the anisotropy of properties of the force field by means of which all EPVs interact between themselves.

23.3. TFF is the theory of two physical objects: EPV and EP. But the significance of this theory is not exhausted by the opportunities to apply it only to the theory of the field and elementary particles because EP and EPV reveal their individual properties not only in free state; they keep the greater part of their properties in the bound state as well. Thus, the anisotropy of the force field of elementary particles reveals not only in an atom nucleus and in an atom as a whole but also in molecules, crystals and condensed media such as liquids and solids. It is shown [84, 87] that the anisotropy of the force field of an electron causes the formation of crystals, and the same anisotropy, as well as special properties of EPV, cause many properties of solids [7] (see also section 24).

Thus, the basic "bricks" of our Universe, i. e. EPs and EPVs preserve and reveal many properties in systems which consist of a great number of these particles. This property of EPs and EPVs was initially discovered within the bounds of TFF. So, it became possible to use the results of TFF in investigating nuclei of atoms, molecules, crystals, solids and liquids. This possibility can be used even in the cases when the development of the theory of the phenomenon in question is not finished yet. The activation of media is a phenomenon that proves this fact. The use of new properties of EP and EPV, discovered by TFF, in creation of physical basis of the theory of media activation is very important and actual though the study of physical and chemical features of this phenomenon is far from being completed.

23.4. As all atomic covers consist of electrons, the force fields of the latter with the help of the excited EPVs create the gamut of forces which are considered in chemistry and physical chemistry. They are forces of chemical affinity, interatomic forces in molecules, forces that form and strengthen crystals, adhesive forces,etc.

So, it is no wonder that many investigators who came across the phenomenon of structural activation could not explain the physical nature of this phenomenon up to now.

So, further on we shall use the term of activation and activated state, meaning only the structural activation and not the usual one, considered in chemical kinetics.

The metastable states are considered in molecular physics, physical chemistry and physics of a solid. The activated state differs from them. It is connected with the equilibrium of such a great number of links and the degree of probability of formation of these links in random spontaneous processes is so small that the time of relaxation and the time of releasing from activation seems longer than that of the previously mentioned processes of formation and elimination of metastable states. Thus, the typical time of excitation and time of releasing of excitation in atomic systems is $10^{-9} - 10^{-17}$s. It should be noted that the time of relaxation in processes of activation is from one to many thousands of seconds. The essential feature of processes of activation is the following. The restoring of an activated system is often accompanied by a series of *tunnel effects*. It is a purely quantum phenomenon, and its peculiarity is in the fact that the physical system has the differing from zero probability to overcome the potential barrier or to leave the potential pit where it is, even if the energy of excitation is less than the size of the potential barrier or the depth of the potential pit. However, such processes take sometimes a lot of time for their completion.

In TFF the physical vacuum is the main quantum object of Nature. All the quantum properties of microcosm and even of macrocosm (and they do exist) are defined by the kind of link between the present physical object and physical vacuum. This fact had not been known before TFF. Therefore, it is impossible to understand many phenomena, including the phenomenon of media activation, without PV and anisotropy of force interactions.

The description of the general theory of activation is beyond this work. We shall give here the basic points of the theory of activation of liquids by the electric field. The activation of pure water is taken as an example.*)

23.5. It is known that water is a weak electrolyte and therefore, it undergoes spontaneous dissociation only in a small degree. In water solutions both the dissociation of molecules of water and dissociation of molecules of dissolved admixtures take place. The latter process is rather influenced by interaction between admixtures and dipole molecules of water. The phenomenon of hydration plays a considerable role in formation of water solutions and it should be discussed separately. In this section we shall discuss the process of dissociation of pure water without any admixtures.

The role of admixtures and the mechanism of their influence upon processes of structural activation is a separate and large problem. It is beyond the scope of this work which is merely a preliminary step. Before we start to discuss the problems of pure water activation we shall only dwell upon very general principles of influence of admixtures on the process of structural activation of liquids. Firstly, they are activated by themselves and this can strengthen or weaken general activation of solution. Secondly, admixtures have significant influence on the process of activation and as a rule decelerate it. It is so, because they are connected with the atoms, molecules, ions of the basic medium, e.g. water. Simultaneously, admixtures can influence process of relaxation of structural activation and as a rule, decelerate it, and in some cases rather significantly. The mechanism of these processes needs, as we have already said, a separate detailed analysis.

The phenomenon of activation of a pure liquid, water in particular, can be represented approximately as follows (Fig. 23.1). As it was said above, in the water (besides its molecules) there is a great number of EPVs. The average number of these particles which are in spontaneous free excited state is

$$n_{exc} = \frac{\alpha}{\pi} n_V , \tag{23.1}$$

where $n_V$ is the general number of EPVs in a unit of volume; $\alpha$ is the dimensionless constant which is called the fine structure constant; its numerical value is $7.29735 \cdot 10^{-3}$.

The average energy of excitation of EPV in a virtual electron-positron pair is equal to the following part of the annihilation energy of an electron-positron pair when EPV is formed:

$$E_{ov} = \frac{\alpha}{\pi} m_e c^2 , \tag{23.2}$$

where $E_{ov}$ is the energy of excitation; $m_e$ is the mass of electron; $c$ is the velocity of light.

*) The problem of activation of hydrocarbons, and fuel oil in particular, is considered in Appendix 8.

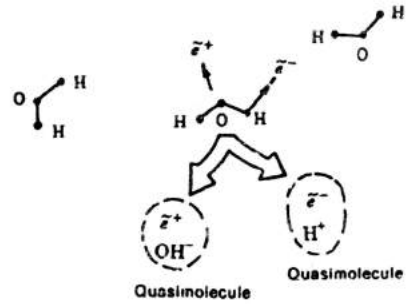



Fig. 23.1 Diagram of water dissociation

To get better understanding where the multiplier $\frac{\alpha}{\pi}$ comes from we show it for one case. We calculate the vacuum correction for the mass of an electron by means of methods of quantum electrodynamics (QED) and make it more exact by means of TFF [85].

In accordance with TFF, the energy of zero oscillations of the vacuum of an electromagnetic field (EMF) cannot be more than $2mc^2$, i.e. the energy of annihilation of a particle-antiparticle pair. To estimate these values we consider the zero oscillations of EMF as a set of free oscillations in a volume $v$ with the energy of every oscillation equal to $\hbar\omega$. The restriction of energy automatically leads to the restriction of momentum of such oscillations:

$$\hbar k \leq mc , \tag{23.3}$$

where $\hbar$ is the Plank constant; $k$ is the wave vector, and thus to restriction of zero oscillations number under the free quantizing of EMF in the volume $v$ :

$$n_0 = \int_0^{\omega_0} \rho(\omega)\, d\omega = \frac{v\omega_0^3}{3\pi^2 c^3} ,$$

where $n_0$ is the number of oscillations; $\omega$ is the frequency; $\rho$ is the density;

$$\omega_0 = \frac{mc^2}{\hbar} .$$

The value of the correction for the proper mass of an electron can be estimated as the energy of interaction of a free electron and zero oscillations of EMF. A charged particle with the inertial

mass $m$ being in an alternating electric field, the frequency of which is $\omega$ and the amplitude is $E_0$, gets some additional energy:

$$E(\omega) = \frac{m}{2}\dot{x}^2(\omega) = \frac{e^2 E_0^2}{4\omega^2 m}.$$

The total energy of the interaction of a free electron and zero oscillations can be determined by the integration over all frequencies:

$$E = \int_0^{\omega_0} E(\omega)\,\rho(\omega)\,d\omega = \frac{\alpha}{\pi} mc^2. \tag{23.4}$$

Hence

$$\Delta m = \frac{E}{c^2} = \frac{\alpha}{\pi} m. \tag{23.5}$$

Likewise, we can calculate the value of the vacuum correction for the charge. It has the same factor before the electron charge, i.e.

$$\Delta q = \frac{\alpha}{\pi} e, \tag{23.6}$$

where $e$ is the electron charge.

The average length of a dipole arm between the virtual electron and positron in an excited particle of the electron-positron vacuum can be determined from the equality

$$a_{e^+e^-} = \frac{\lambda\!\!\!^{-2}_e}{a_{\mathrm{EPV}}}, \tag{23.7}$$

where $a_{e^+e^-}$ is the length of a dipole arm between the virtual electron and positron, c; $\lambda\!\!\!^{-}_e = \frac{\hbar}{m_e c}$ is the so-called Compton wavelength of an electron; $a_{\mathrm{EPV}}$ is the dipole arm of an excited EPV inside the Schwarzschild sphere.

Making calculation by QED methods we obtain:

$$a_{\mathrm{EPV}} = \frac{\alpha}{\pi}\lambda\!\!\!^{-}_e. \tag{23.8}$$

From the formulae (23.7) and (23.8) we have:

$$a_{e^+e^-} = \frac{\pi}{\alpha}\lambda\!\!\!^{-}_e. \tag{23.9}$$

If to substitute the numerical values for symbols and to have in mind that TFF brings the coefficient approx 1.08 98 into the formula for the calculation of the Compton wavelength we shall have the numerical value of $a_{e^+e^-}$:

$$a_{\tilde{e}^+\tilde{e}^-} = 1.79 \cdot 10^{-8}\,\text{c.} = 1.79\,\text{Å}. \qquad (23.10)$$

This is an average and most often found numerical value of the dipole arm. It is interesting to note that the distance between the atoms in most materials equals (23.10) not only approximately but in some cases exactly. This coincidence cannot be considered accidental.

Now, that we have cleared up the question how numerous the excited EPVs are and what properties they have, we can state how they would interact with a molecule of water. The distance between atoms O and H in a molecule of water is equal to 0.96 Å and between H and H to 1.53 Å. It is obvious (see fig. 23.1) that a virtual pair $\tilde{e}^+\tilde{e}^-$ being apart at a distance greater than the distance between atoms in a molecule of water would have a tendency to tear the molecule into ions. This can be easily done because the force which acts from the excited EPV is constant and the bond force in the molecule has the impulsive character and changes over time.

The bond between two unlikely chagred atoms H and O undergoes the strongest influence from the dipole of EPV; therefore, the molecule of water $H_2O$ will be torn into two ions: $OH^-$ and $H^+$ by the excited EPV.

The ions of course join the virtual electron and positron and form quasimolecules $H^+e^-$ and $OH^-c^+$. These quasimolecules must have acidic $H^+e^-$ and alkaline $OH^-e^+$ properties, though they are not acid and alkali, as their chemical compound shows. If to neglect the existence of excited EPVs then the dissociated water remains the usual water $H_2O$ partly fallen into ions.

As we can see, the described mechanism of dissociation of water differs essentially from the disseminated notion of electrolytic dissociation as the process of tearing of bonds, which are the result of interaction between the dissociative substance and the molecules of the medium. The process of dissociation of pure media in chemistry is usually called the process of spontaneous decay of the matter to ions under the action of forces of solvation (interaction with the medium), as a rule without taking into account the forces which influence this process. At least for the water we have not met in literature any information about investigating the mechanism of its dissociation.

The number of acidic and alkaline quasimolecules in a volume unit of dissociated water is the same and they do not reveal their properties. The picture will be changed if the electric field is put onto dissociated water (Fig 23.2). In this case quasimolecules will start to move: the quasimolecules with the ion $OH^-$ towards the anode and the quasimolecules with the ion $H^+$ towards the cathode. Thus, if the electric field is strong enough there will be the division of quasimolecules, the acidic fraction will concentrate by the cathode and the alkaline fraction will concentrate by the anode. If in this case the electrodes are insulated, there is no current in the circuit, and the division of fractions takes place without any waste of energy.

23.6. This way of activation of water (we shall call it non-current) has not been observed and described yet. It is the prediction of the theory of activation of water which is given herein.

It is difficult to get full understanding of the process of dissociation and non-current activation of water if not to clear up the question about the charges of ions and quasimolecules. Quasielectrons and quasipositrons, which form quasimolecules with the proper ions, are the mappings of elements of EPVs onto our space. The nearer the antiparticles inside the Schwarzschild sphere are to one another, the greater is the distance between their mappings onto our space. The distances between the antiparticles which are inside the Schwarzchild sphere $r^*$ and the distances between the quasiparticles in our subspace $r$ outside it are connected by the simple equation:

$$r = \frac{R^2}{r^*}\ ;\ \left(R = \frac{\hbar}{mc}\right), \tag{23.11}$$

where $m$ is the mass of the electron in the electron-positron vacuum or the mass of the proton in the proton-antiproton vacuum.

When EPVs are not excited then $r^* \approx 0$ and $r = \infty$. Thus, by decreasing the excitation of EPVs, the quasiparticles which form the quasimolecules can be *pulled apart* for any great distance, provided they do not exceed the bounds of the given medium. Practically, if the excited particles are numerous they have associative interactions. In this case it is not possible and not necessary to know the "half" of which EPV forms a quasimolecule. In this sense to analyse the properties of quasiparticles is possible by using the well-known methods of calculation of particles which are considered as associative interactions. This method has been already worked out by the quantum theory of a solid and can be successfully used here.

If to take into account the foregoing properties of the quasiparticles which are parts of a quasimolecule it will be possible to answer the question about the charges of both the quasimolecule and its parts.

For any observer, that is outside the activated liquid, the quasimolecule has no charge and can be considered as a dipole, the arm of which is equal to the distance between the ion and the quasiparticle. It is the answer to the question which was raised by physical chemists long ago: why the ions of a liquid do not form a volumetrical charge even if they are separated by the field. For the electrodes having a direct contact with the electrolyte the ions have a charge which does give them the possibility to move under the influence of the outer field. Though the ions which are parts of the quasimolecule do not form a volumetrical charge, which could be observed from outside the electrolyte, the outer field (electric or magnetic) will influence the quasimolecule so as if it consists of one ion only. Therefore, the change of disposition of ions caused by the outer field, as well as the Hall effect, will take place in the electrolyte in spite of the fact that the ions are in a composition of quasimolecules. By the way, the Hall effect is very perspective for analysing the properties of activated electrolytes.

We hope that the foregoing conclusion gives the opportunity for better understanding the essence of non-current activation of water and its solutions.

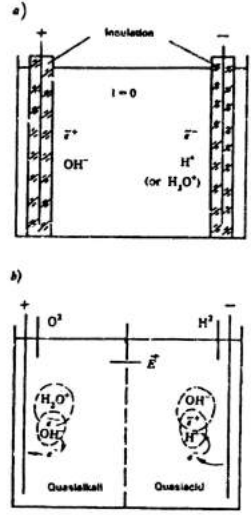



Fig. 23.2 Diagram of non-current (a) and current (b) water activation

It is important to say that the modification of the method of non-current activation, when one electrode is insulated and the other one is not, significantly changes the process of activation. There is no current in this case as well, and so the process can be called non-current. In this case the influence of the electrode, which has a direct contact with the water, on the process of activation and the activation degree of the water, which is near the *bare* electrode, is significantly greater. In this case for some time the whole water is strongly activated acquiring one property, i.e. the water becomes *quasiacid* if the bare electrode is negative and *quasialkali* if the bare electrode is positive. But, provided the water near the bare electrode is not taken away in good time, the activation will disappear for a comparatively short time, owing to diffusion.

This process of non-current activation is also a prediction which is subjected to experimental verification.

If the insulation of the electrodes which are in a vessel with water is removed and electrolysis takes place, then a new process is put over the non-current activation process described above. (See Fig. 23.2, b). This new process which as a rule is stronger is as follows: the ion $OH^-$ which has come to the anode gives away an electron, and the ion $H^+$ which has come to the cathode obtains it

from the electrode. As a result the negatively charged ions $OH^-$ practically disappear from near the surface of the anode and positively charged ions $H^+$ disappear from the surface of the cathode. This phenomenon is connected with the electrolysis and accompanies it. Therefore, the positive ions $H^+$ begin to prevail near the anode and the negative ions $OH^-$ near the cathode. They associate with the proper quasiparticles constituting EPVs and form an alkaline fraction $OH^-e^+$ near the cathode and an acidic fraction $H^+e^-$ near the anode. This process is contrary to that of the non-current activation of water.

This phenomenon has been observed experimentally by many investigators. As the possibilities of the formation of the acidic fraction near the cathode and the alkaline fraction near the anode have been already known, some scientists call the alkaline fraction the *catholyte* and the acidic fraction the *anolyte*. As it was shown above, this phenomenon is not simple, so we should better quit these terms and call the fractions by the names of their properties: *acidic* and *alkaline*.

The current and non-current processes of activation are quite different, as it can be seen.

The role of the semi-penetrable screen is reduced to decelerating the diffusion process of the formed fractions. This role can be successfully fulfilled by carefully insulated electrodes which are under large potential. They act like screens and their function is the same as that of the screens in vacuum tube triodes.

It is easy to see that the process of activation near the electrodes, when the current activation takes place, considerably increases at the first moment by quick neutralization of the ions which move to the electrodes, and the diffusion of the newly formed quasiatoms has no time to move them away from the electrodes. After some time the process of forming and moving away the quasimolecules comes to equilibrium. Then the increase of the number of the quasimolecules stops and so the activation of water stops too.

The greatest concentration of activated water for both the current and non-current types of activation appears near the very surface of the electrodes from the side nearer to the other electrode. This effect determines the demands for the design of the electrode and the methods of taking away the activated liquid. When the process of activation is continuous and is accompanied by inflow of the inactivated water and outflow of the activated water the semi-penetrable screen is not necessary.

It is of great interest to test the ionic electrostatic separator of inflowing inactivated water when the process of activation is continuous. It can be done by means of an impenetrable diclectric screen, when there is the non-current activation, and perhaps of a metal one, when there is the current activation.

Here we have considered some problems of the physical nature of the structural activation of water by considering electrochemical activation of water as an example.

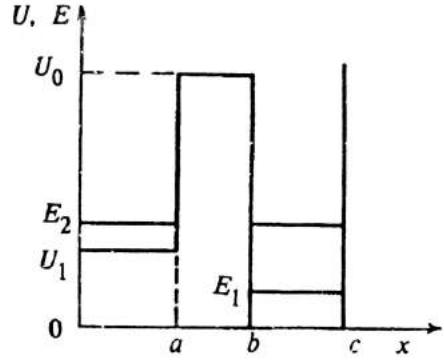



Fig. 23.3 Potential energy versus coordinate.

23.7. Let us mention some features of the physical nature of the structural activation of water when it is influenced by the magnetic field. If there is some constant magnetic field the electrons which move near the nucleus in the atomic cover start wobbling along the direction of this field. This phenomenon is known in physics as the Larmor precession. The frequency of the Larmor precession can be determined by the simple formula

$$\omega_l = \frac{eH}{2mc}. \tag{23.12}$$

where $m$ and $e$ are the mass and charge of an electron, respectively; $c$ is the velocity of light; $H$ is the intensity of the magnetic field.

Thus, the electron which is under the influence of the direct magnetic field besides the usual steady motion is performing an additional motion, the frequency of which is proportional to the intensity of the magnetic field.

If all forces, in creation of which an electron takes part, were formed by a spherically symmetric field like an electrostatic one, the Larmor precession of the electron would not have any consequences.

However, in accordance with TFF, the forces of chemical affinity and other forces which reveal in atoms and molecules are formed by the force field which has the axial and not spherical symmetry. Besides, the direction of the axis of the symmetry is the same as the direction of the spin of an electron (for details see [7] and section 16). In the latter case the appearance of the Larmor precession influences the bonds the electron got, after the system in which it exists had got into the state of the equilibrium.

The consequences of this fact can be different. Firstly, the forces of the chemical affinity, in formation of which the precessing electron takes part, have to change. Secondly, the physical properties of the whole body, which was "irradiated" by the direct magnetic field, have to change too. In this way the "magnetized" liquid appears. If to remove the direct magnetic field, the system, which has been taken out of conditions of equilibrium by magnetic field, is restored after some time only.

23.8. Let us consider the problem of the time of the process of activation, and, which is more important, the time of existence of the metastable state which appears when activation takes place.

As it was shown in the paper [7], in accordance with TFF, the elementary particles have the anisotropy that means the following. The field created by the elementary particle has the maximum on the instantaneous axis of rotation of the particle and has the minimum in the plane of its rotation. The field has the shape of a thin needle, which goes through the centre of the particle and is directed perpendicularly to the plane of rotation. The calculation given in this paper shows that the precession of the particle influences the anisotropy of the field of the particle. The intensity of the field changes from its maximum to its minimum per revolution of the precessing particle.

The presence of strong anisotropy of particles and of their precession leads to the impulse character of their interaction. Forces which act between the particles make abrupt changes all the time. But the frequency of these changes is very high and therefore, under normal conditions, that is when there are outer influences of a certain kind, these changes do not cause any visible effects. The number of particles which are in the basic state can be defined as

$$N_1(t) = N_0 - N_2(t). \tag{23.13}$$

We consider the action of an activator as an impulse one and denote the frequency of its action (the number of impulses per time unit) as $\nu$. Then the probabilities of transition from the metastable state to basic and from the basic state to metastable during the time unit are $w_1\nu$ and $w_2\nu$, respectively.

To find the change of the number of particles, which are in the metastable state, per time unit it is necessary to take in mind that the number of transitions to the metastable state is proportional to the number of particles which are in the basic state $N_1$, and the number of transitions from the metastable state to basic is proportional to the number of particles which are in the metastable state $N_2$. Thus, the change of the number of particles $N_2$ can be written as

$$\frac{dN_2}{dt} = w_2\nu N_1 - w_1\nu N_2. \tag{23.14}$$

If to put the value of $N_1$ from (23.13) we have:

$$\frac{dN_2}{dt} = -(w_1 + w_2)\nu N_2 + w_2\nu N_0. \tag{23.15}$$

If to take into account the initial condition this equation may be solved:

$$N_2 = \frac{N_0 w_2}{w_1 + w_2} \cdot \left( 1 - e^{-(w_1 + w_2)\nu t} \right) . \qquad (23.16)$$

We note that $w_1 + w_2 = 1$ because the impulse may be and may not be accompanied by the transition from one state to another. The value $\frac{N_0 w_2}{w_1 + w_2} = N_2^{max}$ corresponds to saturation. After an interval of time $\tau = 3/\nu (w_1 + w_2)$ this value can be substituted by some averaged value.

The situation may be singificantly different when there is an outer influence which causes the decrease of frequency. In this case the time, during which there are no forces which act from one particle to anoter, is sufficient to find out this effect experimentally.

Let us apply the foregoing considerations to the case when the initial state of the particle is stable and bound. It means that the particle is in the potential pit and its state is separated from the less stable (metastable) state by the potential barrier.

Under the outer influence the barrier suddenly disappears, and after some time it appears again quite instantly. As a result of this the particle has a definite probability to turn into the metastable state. This probability can be easily calculated for any model which is required by a concrete problem. Transition from the metastable to the basic state after the outer action ceases can be realized only by a tunnel effect, i.e. by penetrating through the potential barrier.

Let us assume that the system consists of $N_0$ particles, each particle can exist both in the metastable and basic states. The process of activation of this system is as follows. The particles under the influence of a certain factor change their states from basic to metastable and back. At the initial moment of time ($t = 0$) the system is not activated, i.e. the number of particles in metastable state equals zero. Later on when a certain number of particles $N_2(t)$ are in metastable state the activator will make the particles change their states from basic to metastable and from metastable to basic as well. Let us letter the probability of transition of the particle state from metastable to basic under the influence of the activator as $w_1$ and from basic to metastable as $w_2$. The second term in the brackets, the value of which is less than 0.05, is the probability of spontaneous transitions, so practically, during this time the saturation will be achieved.

To calculate the time of deactivation it is necessary to have more certain supposition about the field in which the activated particle exists. Let us assume that the basic and metastable states are separated by a rectangular barrier. The particle in both of these states is in the rectangular potential pit, but in the metastable state the pit is less deep. Let us assume that the barrier is rather large, i.e. it is sufficiently high. So the probability of penetration of particles through it can be considered quasi-classical and the levels of the particles energy in the pits can be calculated if we ignore the penetration through the barrier.

The potential energy versus coordinate is shown in fig 23.3. When $0 < x < a$ the potential energy has the value $U_1 > 0$. When $a < x < b$ it has the value $U_0 >> U_1$, and when $b < x < c$ it has the value $U = 0$. When $x < 0$ and $x > c$, $U = \infty$. The Schrödinger equation looks like:

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + U_1\psi = E_1\psi \text{ when } 0 < x < a; \tag{23.17}$$

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + U_0\psi = E_1\psi \text{ when } a < x < b; \tag{23.18}$$

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} = E_2\psi \text{ when } b < x < c. \tag{23.19}$$

As the probability of penetration of particles through the barrier is assumed to be rather small the wave functions can be assumed to be equal to zero as the first approximation, when $x = a$ and $x = b$. Besides, it is obvious that $\psi = 0$ when $x = 0$ and $x = c$. Using these assumptions we can define the energy levels and the wave functions of the particles in both pits.

For the left pit:

$$\psi_{1n} = -\sqrt{2/a}\sin\frac{n\pi}{a}x, \quad E_{1n} = \frac{\pi^2\hbar^2n^2}{2ma^2} + U_1. \tag{23.20}$$

For the right pit:

$$\psi_{2n} = \left(\frac{2}{c-b}\right)^{1/2}\sin\frac{n\pi}{c-b}(x-b); \quad E_{2n} = \frac{\pi^2\hbar^2n^2}{2m(c-b)^2}. \tag{23.21}$$

If the barrier disappears, the width of the pit becomes $c$, then the solution of the Schrödinger equations looks like:

$$\psi_n = \left(\frac{2}{c}\right)^{1/2}\sin\frac{n\pi}{c}x; \quad E_n = \frac{\pi^2\hbar^2n^2}{2mc^2}. \tag{23.22}$$

In the foregoing formulae $m$ is the mass of the particle, $\hbar$ is the quantum constant ($\hbar = h/2\pi$); $n$ is an integer: $n = 1, 2, 3, \ldots$.

To consider the tunnel effect we assume that the first level of the left pit is the same as the second level of the right pit:

$$E_{11} = E_{22} = \frac{4\pi^2\hbar^2}{2m(c-b)^2}. \tag{23.23}$$

This supposition defines the potential of the left pit:

$$U_1 = \frac{\pi^2 \hbar^2}{2m} \left( \frac{4}{(c-b)^2} - \frac{1}{d^2} \right).$$

If the barrier suddenly disappears, the particles, the initial level of stability of which was $E_{21}$, change their level to that of the barrierless wide pit $E_1$. When the barrier is restored the particles may change their level to that of the left pit, i.e. they pass into the metastable state. The probability of this change can be calculated by the formula

$$w = \left| \int_0^a \psi_{11} \psi_1 \, dx \right|^2. \tag{23.24}$$

Substituting the wave functions for $\psi_{11}$ and $\psi_1$ we get:

$$\int_0^a \psi_{11} \psi_1 \, dx = \frac{\sqrt{ac}}{\pi} \left[ \frac{\sin \pi (c-a)/c}{c-a} - \frac{\sin \pi (c+a)/c}{c+a} \right]. \tag{23.25}$$

Assuming $b - a = c - b = a$ we get the probability approximately equal to 0.1. This probability defines the number of particles in the metastable state but not the time of their formation. The time of transition of a particle into the metastable state is determined by the time during which there is no barrier and this time is very short.

The probability of the particle penetration through the potential barrier can be estimated by means of the quasi-classical formula for the transparency coefficient

$$D = \exp \left\{ -\frac{2}{\hbar} \sqrt{2m (U_0 - E_{11})} \, b \right\}. \tag{23.26}$$

To determine the time of the metastable state existence $\tau$ the following formula should be used:

$$\tau = \frac{2a}{v D}, \tag{23.27}$$

where $v$ is the particle velocity in the left pit.

Then we can determine $\tau$ by the formula

$$\tau = \frac{2ma^2}{\pi \hbar} \exp \left\{ \frac{2}{\hbar} \sqrt{2m (U_0 - E_{11})} \, b \right\}. \tag{23.28}$$

To determine the time by formula (23.28) it is necessary to find the numerical values of the parameters of the pit and the particle for any particular case.

The given calculation is mainly based on the traditional methods of quantum mechanics. But the idea of asymmetry in the processes of activation and deactivation of matter is taken from TFF.

The formula (23.28) is correct for rather long periods of existence of the metastable state $\tau$, i.e. when the exponent in (23.26) is large. If the mass of the particle is small and the barrier is not

very high,the quasi-classical approximation can not be used and it is necessary to use the exact quantum-mechanical formulae.

In accordance with TFF, it was shown that in condensed media the excited EPVs both assosiated with electrons and without them play a great role. These states are called *cresons*. It was cleared up that in the condensed state (solid, liquid) the effective mass of cresons is 10 orders less than their mass in the free state. And the mass in the free state is the mass of short-living particles observed in the experiment (these particles are called *resonances*).

The calculation of the lifetime of EP-resonances in the free state is made according to TFF [134] and is expressed in the formula:

$$\tau_{cl} = \frac{U_0 T (1-\beta_2^2)^{1/2}}{E_0 \left(1 - \frac{m_N + 1}{m_N}\right) \left(1-\beta_2^2\right)^{1/2}_{P} s_{opt}}, \tag{23.29}$$

where $U_0$ is the depth of the potential pit; $E_0$ is the energy of excitation; $T$ is the period of internal oscillations of the given EP; $\beta_2$ is the linear velocity of oscillation expressed by the light velocity units; $m_N$, $m_{N+1}$ are the masses of EPs and their "neighbours" in the periodical law of microparticles (PLM); $s$ is the mechanical moment of the optimum particle in the series of PLM in which there is the given EP.

The formula (23.29) is correct for the short-living resonances, the $\tau_{cl}$ of which is not more than $10^{-20}$ s. The lifetime of the particles which exist longer can be calculated from the formula:

$$\tau_{qu} = \frac{T}{D}, \tag{23.30}$$

where

$$D = \begin{cases} \left(1 + \left(\left(\frac{k_1}{k_2} + \frac{k_2}{k_1}\right) \frac{\operatorname{sh} a k_2}{2}\right)^2\right)^{-1}, & \text{when } E_0 < U_0; \\ \left(1 + \left(\left(\frac{k_1}{k_2} - \frac{k_2}{k_1}\right) \frac{\sin a k_2}{2}\right)^2\right)^{-1}, & \text{when } E_0 \geq U_0; \end{cases} \tag{23.31}$$

$$k_1 = \frac{\sqrt{2m_n E_0}}{\hbar}; \quad k_2 = \frac{\sqrt{2m_n (U_0 - E_0)}}{\hbar}; \tag{23.32}$$

$a \approx \frac{\pi}{4 k_1}$ is the width of the potential pit. The criterion of transition from the formula (23.29) to the formula (23.30) is found.

The researches have shown that in condensed media the cresons exist much longer and their half-life can be determined by the formula (for the particles $\tau_0$ of which is determined by the formula (23.29)):

$$\tau = \tau_0 \left( \frac{2\pi m_n}{A m_e} \right)^2 . \tag{23.33}$$

For the cresons, $\tau_0$ of which is defined by the formula (23.30), the time of retaining the activated state is determined by the formula:

$$\tau = \tau_0 \frac{2\pi m_n}{A m_e} . \tag{23.34}$$

(The coefficient by $\tau_0$ is in the first power), where $\tau_0$ is the time of existence of a free creson ($\tau_{cl}$ or $\tau_{qu}$); $m_e$ is the mass of an electron; $A = 1.66 \cdot 10^{-10}$ is the constant found from the theory of cresons.

Besides that, it was cleared up that the dimensionless mass of the creson in electron masses $m_n / m_e$ is equal numerically to the absolute critical temperature of the given matter, i.e. the temperature of melting $T_m$ or boiling $T_b$. Therefore, (23.33) can be written simply:

$$\tau \approx \tau_{0cl} \left( \frac{2\pi T_{m\,(b)}}{A} \right)^2 \tag{23.35}$$

or

$$\tau \approx \tau_{0qu} \frac{2\pi T_{m\,(b)}}{A} . \tag{23.36}$$

Since in TFF $\tau_0$ can be simply defined via $m_n / m_e$ and consequently $T_m (T_b)$, the value of $\tau$ is an unambiguous function $T_m (T_b)$ of the activated matter. For example, for the water $m_n / m_e = T_m = 273$ K and hence we have $\tau_0 = 2.6 \cdot 10^{-8}$. Then according to (23.36), $\tau = 2.7 \cdot 10^5$ s = 75 hours = 3.1 days.

Thus, for pure water the decrease of the activation level by $e$ times takes three days. The formulae (23.34) and (23.35) give the opportunity to determine the time of existence of activation for different water solutions and any other media.

It is impossible to determine the time of existence of activation for noncondensed media (e.g. gases) by the foregoing formulae. The formulae for the calculation of the time of existence of activation for gases are not obtained yet. The theory of activation of gas media is only being worked out now. The idea of physical nature of gas activation process is in the state of formation yet.

23.9. Now it is possible to give some preliminary recommendations how to define optimal conditions of current activation of water solutions.

The preliminary theoretical analysis of current activation of water solutions has shown that the interaction of water molecules with the spontaneously excited elementary particles of vacuum is the basis of this phenomenon. The addition of a virtual electron and positron to the ions $H^+$, $H_3O^+$ and $OH^-$ leads to the formation of electrically neutral quasimolecules of *quasiacid* and *quasialkali* which are relatively steady in time. Thus, they acquire new in principle physical properties. It is important to note that this process does not need any energy from the outside. This condition, as it was said before, is one of the basic principles of the whole theory of structural activation of liquids and water among them.

Theoretical investigations of changes of the isomeric properties of atoms, molecules and crystals by activation have begun recently. Experimental investigation and verification are being planned for later on. Nevertheless, it is necessary to mind that current activation is accompanied by the electrochemical processes which are connected with electrolysis and depend on the energy passing through a volume of the activated water.

The charge obtained by the electrolyte is used both for electrolysis and activation. So, the engineering design of the devices for current water activation should take into account this peculiarity of the activation process. The degree of current activation depends on the quantity of the electric energy received by the water. So, the measure or the criterion of current water activation is a certain value which can be denoted by $A$. This criterion is proportional to the quantity of the electric energy $Q$ passing through the volume unit $v$ during the period of activation $t$.

Then

$$A = k \frac{Q}{v}, \tag{23.37}$$

where $k$ is a certain dimentional coefficient of proportionality depending on the diaphragm and electrodes qualities and on the peculiarities of the activated liquid as well.

Denoting the power consumed by the activator by $W$, the coefficient of efficiency of the energy can be defined as follows:

$$\eta_{ef} = \frac{A}{W} = k \frac{Q}{v W t}. \tag{23.38}$$

If the whole electric charge participates both in the processes of electrolysis and activation, then

$$Q = It, \tag{23.39}$$

where $I$ is the working current.

Then, considering $W = IU$, we can finally define:

$$\eta_{ef} = \frac{k}{v U}. \tag{23.40}$$

where $U$ is the working voltage.

So, the efficiency of activator is defined by the coefficient $k$ which depends on the electrodes and diaphragm quality. The less is the working voltage and the volume of the activator the greater is the coefficient $\eta_{ef}$.

The result of this is the following conclusion. It is reasonable to design some activators of a small working volume and to connect them in series in the circuit. It is desirable to decrease the voltage to the utmost by making the distance between the electrodes minimal. Besides, there is one more possibility to increase $\eta_{ef}$. For this purpose it is necessary to prolong artificially the time of the stay of the activated matter in the activator.

The analysis of the numerical values of the coefficients $k$ and $\eta_{ef}$ should be the aim of special experimental and theoretical researches and is beyond the scope of this book. But the simple analysis of the efficiency dependence upon the main parameters of the cell and activation conditions makes it possible to give some specific recommendations for the design and operation of activators.

Let us express the voltage $U$ via the current and resistance, defined by the geometry of the cell, and put this voltage value into the formula (23.38). Then the formula (23.38) for the simplest case of a rectangular cell will look like:

$$\eta_{ef} = \frac{k\sigma}{I l^2}, \tag{23.41}$$

where $\sigma$ is the value of electroconductivity in the steady conditions; $I$ is the working current; $l$ is the distance between the electrodes.

From the formula (23.38) we can make the following conclusion. When the voltage and working volume are constant, the least energy consumption for the given volume of liquid activation is possible when the working voltage is minimal. If the activator operates in the conditions of direct current, to get the minimal energy consumption it is necessary to decrease the distance between the electrodes and to increase the electroconductivity of the liquid. We should once more stress the fact that it is reasonable to use activators which consist of the maximum number of cells, which are inserted in series in the circuit. Decreasing both the distance between the electrodes and the working current, we decrease the consumption of energy, but it may influence the activator capacity. To get the maximum of activated liquid it is useful to increase the working current. Thus, choosing the optimal conditions in each case we receive the maximal activator capacity and minimal energy consumption.

To save energy it is reasonable to use liquid with the maximal electroconductivity $\sigma$. But the great electroconductivity may influence the coefficient $k$ in the formulae (23.37)—(23.41). By now, it is not yet possible to give any recommendations as to the choice of the optimal value $\sigma$. Further special researches of this problem are necessary.

The electroconductivity of water solutions and other liquids depends on the dissolved components. The latter in their turn influence the time of keeping up the activation state.

23.10. The widely used and well-known method of catalysis is, to our great belief, the particular case of structural activation. From this point of view the catalysis is a way of structural activation of molecules of chemical reagent which participates in the reaction by the fields formed by the molecules of the activator (catalyzer). This approach to the catalysis nature explains all its features. It clears up the fact why the molecules of the activator participate in the reaction but the activator itself does not spend its energy on the activation process.

Nowadays a lot of different methods of structural activation are known.

1. By means of electric and magnetic fields (direct, alternating and impulsing);

2. By mechanical crushing, centrifuging or treatment by a disintegrator;

3. By electrohydraulic impact;

4. By ultrasonic waves;

5. By laser;

6. By nuclear magnetic resonance;

7. By electronic paramagnetic resonance;

8. By electrochemical forces.

Methods 1, 6, 7 of structural activation are realized in catalysis as a rule simultaneously. Besides, catalysis differs from macroscopic methods by the distances between the sources of activator fields and activated molecules. These distances are minimal in catalysis. And finally, in catalysis the active participation of the force fields caused by the atom nuclei and much more active participation of the excited EPVs are possible. Thus, catalysis is the most effective method of structural activation. The detailed analysis of this method is beyond the bounds of this book, here it is only briefly outlined.

The aforesaid in this section shows that only some parts of the discussed problem are considered more or less completely, the rest of them are only set.

# 24 NEW FACTS IN THE THEORY OF A SOLID. POSSIBILITIES OF PRACTICAL USE

Modern physics of a solid has achieved great success basing on the model which uses the following physical objects: crystal cell; free electrons, i.e. electrons of conductivity; "holes", i.e. quantum states not taken by electrons and having positive charge; phonons, i.e. quasiparticles considered as the quanta of atom framework oscillations in the crystalline lattice; exitons, i.e. quasiparticles which form something like positronium from electrons and holes; polarons which are self-consistent states of an electron and the nearest domain of local polarization and some other quasiparticles which could be considered as oscillation quanta, i.e. plasmons, magnons,etc.

Leaving alone well-known achievements of the physics of a solid let us pay attention to one of the unsolved problems, namely, strict fixing of melting temperature of crystalline solids. Some sharp resonance is responsible for this phenomenon. The objects and conditions of this resonance in melting processes are not defined completely yet. Therefore, theoretical calculation of melting temperature within the bounds of present theory of a solid is not possible. The mechanism of avalanche-like destruction of solids by a rather strong mechanical load is not clear either.

It is logical to explain the strictly fixed melting temperature and heat by existence of particles of the same kind in a solid. They are responsible for the links between crystals and have the same resonance frequency which is unambiguously connected with the melting point. The destruction or transformation of these particles changes the solid into the liquid. It is possible to show that no one of the enumerated objects of the present solid model fits for this purpose.

A new physical object, i.e. *critical resonances* (cresons) are supposed to be introduced into a more precise solid model. According to TFF, there exist EPVs. They appear as a result of annihilation of particles and antiparticles, e.g. electrons and positrons. Unexcited EPV can not be observed in macrocosm. If physical vacuum which consists of EPVs is not excited at all or very slightly,it is superfluid. Periodical excitation of EPVs by an outer field leads to formation of photons. When EPVs are being excited by a strong steady or aperiodically variable field, new physical objects appear. The origin of the term *cresons* is connected with the fact that the well-known elementary particles, i.e. resonances,from the point of view of the given here hypothesis,are nothing more than cresons which were "kicked out" from a solid or a liquid or were formed in vacuum by nuclear reactions. In a free state the cresons, i.e. particles-resonances exist for a very short period of time like a free neutron after leaving the nucleus. According to nuclear scale, if the creson is in a bound state,it lives for a long time.

When associating with electrons or "holes", cresons get a charge. Cresons are positioned in crystal symmetry nodes, e.g. in the octahedron and tetrahedron emptinesses. The cause of cresons' position mainly in the strict definite crystal points is the spatial anisotropy of the elemen-

tary particles force field. When cresons are positioned in the interatomic emptinesses of crystals, the maximum of the bond energy between cresons and atom frameworks in the crystalline lattice is achieved. It is obvious that even in polycrystalline bodies, cresons play a decisive role in inter-crystalline links and therefore, determine the strength of a solid.

According to a more precise model of a solid, melting occurs as a result of cresons leaving the symmetry nodes in which they exist, thus destroying main links between crystals, and consequently, destroying a solid and making it a liquid.

The main equation of this process should look like:

$$h \nu_{cr} f_1 (g_{00}) = k T_c , \tag{24.1}$$

where $h$ is the Plank constant; $\nu_{cr}$ is the resonance frequency of creson oscillations; $k$ is the Boltzmann constant; $T_c$ is the critical absolute temperature of melting; $f_1 (g_{00})$ is the function of the metric tensor of the physical vacuum in the domain where creson exists; its value is about one.

The equation (24.1) differs from the relation between $\nu$ and $T$, which is settled in the modern theory of a solid, only by a coefficient. This coefficient differs from one by the third decimal place. In TFF it defines the influence of excited vacuum on the process of melting.

To make further calculations easier we denote

$$A_{cr} = \frac{h \nu_{cr}}{m_{cr} c^2} , \tag{24.2}$$

where $m_{cr}$ is the creson mass (in a free state); $A_{cr}$ is some dimensionless constant, defining which part of the total creson energy a quantum of oscillation energy of this creson is; $c$ is the light velocity.

The creson mass $m_{cr}$ can be evidently expressed via the electron mass:

$$m_{cr} = \tilde{m}_{cr} m_e , \tag{24.3}$$

where $\tilde{m}_{cr} = \frac{m_{cr}}{m_e}$ is the dimensionless mass of a free creson expressed in electron masses.

Then the formula (24.2) will look like:

$$h \nu_{cr} = A_{cr} \tilde{m}_{cr} m_e c^2 . \tag{24.4}$$

As it is well known, the electron natural frequency is

$$\nu_e = m_e c^2 / \hbar . \tag{24.5}$$

In the field of the atom nucleus and surrounding electrons, considering relativistic corrections required by TFF, we can get the maximal frequency of electron free oscillations (see [7], p 81 ]):

$$\nu_{e\,max} = \sqrt{9/8}\;\; 2s_e \left(1 - \beta_2^2\right)_e^{1/2} \nu_e , \tag{24.6}$$

where $\sqrt{9/8}\;\; 2s_e \equiv \frac{3}{\sqrt{2}}\, s_e$ is the metric coefficient which takes into account the space curvature in an atom; $2s_e = \frac{M}{J}$ is the ratio of an electron mechanical moment to its projection on the precession axis, i.e. to the spin; $\beta_e = \frac{v_e}{c}$ is the linear velocity of the subparticles in the electron structure which according to TFF [7, 34] defines the scale of the space-time relations.

The natural resonance frequency, when the resonance is associated with an electron, is the creson frequency without taking into account its relativistic effects predicted by TFF. It is obviously equal to:

$$\nu_{cr\,max} = \frac{m_{cr}}{m_e} \nu_{e\,max} = \tilde{m}_{cr} \nu_{e\,max} . \tag{24.7}$$

The relativistic correction for the resonance in a crystal requires the coefficient:

$$(1 - \beta_0)^{1/2} \frac{\sqrt{2}}{\pi} f_1(g_{00}) = \frac{\sqrt{2}}{\pi} \sqrt{8/9}\;\; 2s_e (1 - \beta_2^2)_e^{1/2} . \tag{24.8}$$

From (24.7) and (24.8) we finally get:

$$\nu_{cr} = (1 - \beta_2^2)_e \tilde{m}_{cr} \frac{m_e c^2}{\hbar} \frac{\sqrt{2}}{\pi} 4s_e^2 . \tag{24.9}$$

Comparing (24.9) and (24.4) we have:

$$A_{cr} = \frac{2\sqrt{2}}{\pi} s_e^2 (1 - \beta_2^2)_e . \tag{24.10}$$

According to TFF ([7], p. 73), for the electron the numerical values which are necessary for calculation of dimensionless values are

$$2s_e = \frac{1}{\cos \alpha_e} = 0.92\,717\,269^{-1} ; \; f_1(g_{00}) = \frac{2s_e}{\sqrt{9/8}} = 1.01\,686\,46 ;$$
$$(1 - \beta_2^2)_e = 6.33\,378 \cdot 10^{-10} \;\; ([7], \text{p.112}).$$

Inserting numerical values into (24.10) we get $A_{cr} = 1.65\,83\,535 \cdot 10^{-10}$. Thus, we have: $A_{cr}$ is the universal constant which does not depend on creson mass and is the same for all cresons.

In the equations (24.1) and (24.2) we have the following values which are independent of $m_{cr}$ and $T_c$: $m_e$, $c$, $k$ and $f_1(g_{00})$. From these values it is possible to get the only combination for the constant $A_{cr}$:

$$A_{cr} = \frac{k}{m_e c^2 f_1(g_{00})} \; [\mathrm{K}] . \tag{24.11}$$

From (24.1) and (24.4) by simple substitution we can get:

$$A_{cr} = \frac{k T_c}{m_e c^2 f_1(g_{00}) \bar{m}_{cr}}.$$

This constant is independent of $T_c$ and $m_{cr}$. Thus, inserting the numerical values $m_e$ and $k$ from the table data and the given above value of $f_1(g_{00})$ into (24.11) we get $A_{cr} = 1.65\,838\,8 \cdot 10^{-10}$. This value differs from that of (24.10) only by factor 1.00 002, i.e. by two units in the sixth significant digit. This is within the limits of the accuracy of the theoretical and experimental data which are used to calculate the constants. Thus we state the complete convergence of the equations (24.10) and (24.11) for the constant $A_{cr}$.

Table 24.1

| Matter | $T_m$, K (experiment) | $T_m$, K (theory) | Resonance No in PLM |
|---|---|---|---|
| Ag | 1233.95 | 1233.16 | 1.30.9 |
| AlSb | 1353 | 1353.23 | 1.29.11 |
| Au | 1336 | 1335.20 | 2.109.6 |
| B | 2300 | 2299.66 | 2.63.1 |
| $BaCl_2$ | 2233 | 2233.0 | 1.30.3 |
| Be | 1556 | 1556.5 | 2.99.3 |
| $BiNa_3$ | 1048 | 1048.92 | 2.147.3 |
| Cd | 1120 | 1119.89 | 1.33.9 |
| $CaCl_2$ | 1055 | 1055.02 | 2.138.9 |
| $CaSiO_2$ | 1785 | 1784.61 | 1.22.11 |
| $D_2O$ | 276.89 | 276.601 | 1.113.5 |
| $FeF_2$ | 1370 | 1371.02 | 2.106.2 |
| FeS | 1468 | 1468.01 | 2.105.9 |
| $ClO_2$ | 1388 | 1388.45 | 2.111.3 |
| $Li_2O$ | 2000 | 1996.09 | 2.77.8 |
| MnO | 2053 | 2053.69 | 1.17.5 |
| $Nb_2O_5$ | 1785 | 1784.61 | 1.22.11 |
| Pt | 2042 | 2040.80 | 2.71.6 |
| $PuF_3$ | 1442 | 1441.96 | 2.107.8 |
| TaC | 4150 | 4152 | 2.37.8 |
| V | 2000 | 1996.09 | 2.77.7 |
| W | 3653 | 3657.67 | 2.42.3 |
| ZnS | 2100 | 2099.90 | 2.69.6 |
| TiO | 2293 | 2293.65 | 2.67.3 |

The Boltzmann constant $k$ can be expressed by the formulae (24.10) and (24.11) via the electron mass, light velocity and dimensionless constants of TFF:

$$k = \frac{16 s_e^3 (1-\beta_z^2)_e m_e c^2}{3\pi} = 1.38\,063\,1 \cdot 10^{-16} \frac{\text{erg}}{\text{degree}}. \qquad (24.12)$$

The experimental value of $k$ is $1.38\,066\,2(44) \cdot 10^{-16}$, i.e. it is within the limits from $1.38\,061\,8 \cdot 10^{-16}$ to $1.38\,070\,6 \cdot 10^{-16}$. The complete coincidence of the value $k$ and experimental data as well as the complete consistency of (24.10) and (24.11) proves the formulae to be true.

From the equations (24.1) and (24.4) we have the following formula for the melting temperature:

$$T_m = \frac{A_{cr}\,\tilde{m}_{cr}\,m_e\,c^2}{k} f_1(g_{00}) . \tag{24.13}$$

By substituting the coefficient from (24.11) for $A_{cr}$ we get:

$$T_m = \tilde{m}\ [\mathrm{K}] . \tag{24.14}$$

Thus, the melting temperature for all crystalline solids (of any composition) equals numerically the dimensionless mass of the corresponding creson which is expressed by electron masses. It should be noted that $m_{cr}$ and $\tilde{m}_{cr}$ are the masses of real resonances, i.e. free cresons and not virtual cresons which are in the composition of solids. Dimensionless values of these particles masses received both experimentally and by theoretical prediction are given in the tables in [7]. As the experiments have shown the particles-resonances (which are known to be more than 500) exist in a free state for as short time as any.

When comparing numerical values of the dimensionless masses obtained theoretically and the melting temperature of solids obtained experimentally, we get good coincidence (table 24.1).

Thus, the following conclusion can be drawn on the basis of this section data.

1. A great number of particles-resonances have been found recently and their number is constantly growing. A more precise model of a solid shows the processes in which they take part.

2. This new model allows to explain the reason why solids have exactly definite melting temperatures.

3. For the first time in theoretical researches this model gives the possibility to calculate the melting temperatures of the solids. The comparison of the theoretical and experimental data gives certain coincidence within the limits of accuracy of the experiment and theory.

4. The model gives theoretical definition of the resonance frequencies which correspond to the melting temperature of any solid.

# 25 RELEASE OF GRAVITY-VACUUM ENERGY (GVE) IN STELLAR AND PLANETARY ENTRAILS AND POSSIBILITIES OF ITS PRACTICAL USE ON THE EARTH

The existence of a quite new, by its physical nature, kind of energy is claimed in this section. It is the gravity-vacuum energy. The conditions of its release in stellar and planetary entrails are given as an example.

The calculation is made in the following approximation:

1. The shape of a star (planet) is taken as a sphere.

2. The star (planet) is homogeneous, i.e. it has the same density in its entire volume.

3. There are only nucleons (protons, neutrons) which take part in creation of screen effect.

4. The nucleons creating the screen effect are only in the atom nuclei which form the matter of a star (planet).

5. The possibility of nucleons to overlap one another is taken into account.

## 25.1. The complete screening radius

Considering the conditions of GVE release it is important to find the so-called complete screening radius $R_{ts}$, the value of which corresponds with the condition when the mass of a star (planet) can be a screen for its centre $O$.

According to [49], one nucleon can be considered as a screen with an angular size $\theta_p$. It can be defined by the formula

$$\theta_p = \frac{\left(R_1' - R_2'\right)_p^2}{r^2} a_g \frac{m_1 m_2}{m_V^2}, \quad \left\{ R_1' \equiv R_1^{(2)}, R_2' \equiv R_2^{(2)} \right\}, \tag{25.1}$$

where $(R_1' - R_2')_p$ is the proton size in the second subspace mapped onto the first one;

$r$ is the distance between the nucleons which are interacting;
$m_1, m_2$ are the masses of particles which are interacting;
$m_V$ is the summary mass of the particle and antiparticle;
$a_g$ is the metric coefficient of the proton-antiproton vacuum.
If $m_1 = m_2 = m_V$ and $m_V = 2m_p$, then the formula (25.1) looks like:

$$\theta_p = \frac{\left(R_1' - R_2'\right)_p^2}{r^2} a_g \frac{1}{4} \approx \frac{1}{4} \frac{\left(R_1' - R_2'\right)_p^2}{r^2}. \tag{25.2}$$

The elementary volume of a star (planet), if to use spherical coordinates, is equal to

$$dv = r^2 \sin\vartheta \, dr \, d\vartheta \, d\varphi . \tag{25.3}$$

The number of nucleons in the elementary volume $dv$ can be calculated by the formula

$$N_n(dv) = \frac{\rho_{st}}{M_{at}} A \, dv , \tag{25.4}$$

where $\rho_{st}$ is the density of the star (planet) matter; $M_{at}$ is the mass of an atom which is equal to $A$ atomic units of mass.

$$M_{at} = A \cdot 1.66 \cdot 10^{-24}, \tag{25.5}$$

where $A$ is the mass number of a nucleus.

Finally the formula (25.4) looks like:

$$N_n(dv) = \frac{\rho_{st}}{1.66 \cdot 10^{-24}} dv . \tag{25.6}$$

The total (summary) screen which was formed by an elementary volume $dv$ can be calculated by the formula

$$\theta_{dv} = N_n(dv) \, \theta_p \, K_{ov} , \tag{25.7}$$

where $K_{ov}$ is the overlaping coefficient which defines the degree of screening by every nucleon. If nucleons do not overlap one another, then $K_{ov} = 1$. If to take into account (25.2) and (25.6), then the formula (25.7) looks like:

$$\theta_{dv} = \frac{1}{4} \frac{\rho_{st} \, dv}{1.66 \cdot 10^{-24}} \frac{(R_1' - R_2')^2_p}{r^2} K_{ov} . \tag{25.8}$$

If to choose the spherical coordinates boundary limits as

$$\begin{cases} 0 \le \varphi \le \frac{\pi}{2} ; \\ 0 \le \vartheta \le \frac{\pi}{2} ; \\ 0 \le r \le R_{st} , \end{cases} \tag{25.9}$$

then it is possible to calculate the summary value of the star (planet) screen:

$$\theta_{\Sigma} = \frac{2\rho_{st} (R_1' - R_2')^2_p}{1.66 \cdot 10^{-24}} K_{ov} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_0^{R_{st}} \sin\vartheta \, dr \, d\vartheta \, d\varphi . \tag{25.10}$$

If to take into account (25.9) and to solve (25.10), we have:

$$\vartheta_{\Sigma} = \frac{2\rho_{gf}(R_1' - R_2')_p^2}{1.66 \cdot 10^{-24}} \frac{\pi R_{gf}}{2} K_{ov} . \tag{25.11}$$

On the other hand, when the centre of a star is entirely screened by its mass, then the value $\theta_{\Sigma}$ has to be equal to the total corporal angle, i.e.

$$\theta_{\Sigma} = 4\pi . \tag{25.12}$$

Making (25.11) equal to (25.12) we get the formula for the calculation of the complete screening radius:

$$R_{ts} = \frac{4 \cdot 1.66 \cdot 10^{-24}}{\rho_{gf}(R_1' - R_2')_p^2 K_{ov}} . \tag{25.13}$$

But as always $(R_1' - R_2')_p^2 = 2.0 \cdot 10^{-35}$, the equation (25.13) can be written as

$$R_{ts} = \frac{3.30 \cdot 10^{11}}{\rho_{gf} K_{ov}} . \tag{25.14}$$

The results of calculation of the complete screening radii of different stars, when $\rho_{gf} = \text{const}$ are given in table 25.1. In the particular case, when $\log_{10}\left(\frac{M_{st}}{M_s}\right) = 1.0$ and $\log_{10}\left(\frac{R_{st}}{R_s}\right) = 2.7$, where $M_s$ and $R_s$ are the mass and the radius of the Sun, we have $M_{st} = 10M_s$ and $R_{st} = 100R_s$. Table 25.1

| Star (planet) name | $R_{st}$, c | $R_{ts}$, c | $R_{st}/R_{ts}$ |
|---|---|---|---|
| Sun | $0.7 \cdot 10^{11}$ | $2.4 \cdot 10^{11}$ | 0.29 |
| Supergiant GO | $100R_s = 0.7 \cdot 10^{13}$ | $10^5 R_{ts}' = 2.4 \cdot 10^{16}$ | $0.29 \cdot 10^{-3}$ |
| Cefeids | $100R_s = 0.7 \cdot 10^{13}$ | $0.5 \cdot 10^5 R_{ts}' = 1.2 \cdot 10^{16}$ | $0.58 \cdot 10^{-3}$ |
| White dwarfs | $10^{-2}R_s = 0.7 \cdot 10^9$ | $0.2 \cdot 10^{-6} R_{ts}' = 0.5 \cdot 10^5$ | $1.4 \cdot 10^4$ |

Hence, we can make the following conclusion.

If $\rho_s = 1.4\ \text{g/c}^3$ and $K_{ov} = 1$, we have from (25.14):

$$R_{ts}^{GO} = \frac{3.30 \cdot 10^{11}}{1.4 \cdot 10^{-5}} = 2.4 \cdot 10^{16}\ \text{c} .$$

If when solving this problem we assume that the density of the matter of a star is changing according to

$$\rho = \rho_0 e^{-A\frac{r}{R}} , \tag{25.15}$$

where $r$ is the variable radius; $R$ is the radius of a star, then the equation (25.10) looks like:

$$\theta_\Sigma = \frac{2\rho_0 (R_1' - R_2')_p^2}{1.66 \cdot 10^{-24}} K_{ov} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_0^{R} e^{-4r/R} \sin\vartheta \, dr \, d\vartheta \, d\varphi . \tag{25.16}$$

By solving (25.16) we can get:

$$\theta_\Sigma = \frac{\rho_0 (R_1' - R_2')_p^2}{1.66 \cdot 10^{-24}} K_{ov} \pi \frac{R}{4} (1 - e^{-4}) . \tag{25.17}$$

And when $R = R_{ts}$, i.e. $\theta_\Sigma = 4\pi$ we have:

$$R_{ts} = \frac{16 \cdot 1.66 \cdot 10^{-24}}{\rho_0 (R_1' - R_2')_p^2 K_{ov} (1 - e^{-4})} . \tag{25.18}$$

In general, if

$$\rho = \rho_0 e^{-A\frac{r}{R}} , \tag{25.19}$$

where $A$ is a certain*) integer, it is possible to show, that

$$R_{ts} = \frac{A \cdot 3.30 \cdot 10^{11}}{\rho_0 K_{ov} (1 - e^{-A})} ; \quad R_{ts}^s = \frac{7.24 \cdot 3.30 \cdot 10^{11}}{90 (1 - e^{-7.24})} = 2.65 \cdot 10^{10} \text{ c} . \tag{25.20}$$

## 25.2.
## The radius of the complete screening domain

The problem is to define the radius of the complete screening domain, i.e. the radius when all this domain turns out to be entirely screened by the star (planet) mass which is placed in the volume $v_{st} = \frac{4}{3}\pi r_{dts}^3$ (Fig. 25.1).

The initial conditions (see subsection 25.1) are the same. We consider two cases:

$$\rho_{st} = \text{const} \text{ and } \rho_{st} = \rho_0 e^{-A\frac{r}{R}} .$$

The first case: $\rho_{st} = \text{const}$.

In accordance with (25.10), the value of the complete screen, which forms the domain $R_{st} - r_{dts}$ (see fig. 25.1) can be defined by choosing the boundary limits of the variation of the parameter $r$ as $r_{dts} \leq r \leq R_{st}$. In this case the equation (25.10) looks like:

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*) For the Sun A = 7.24 when $\rho_0 = 90$ g/c$^3$ and $\bar{\rho} = 1.4$ g/c$^3$.

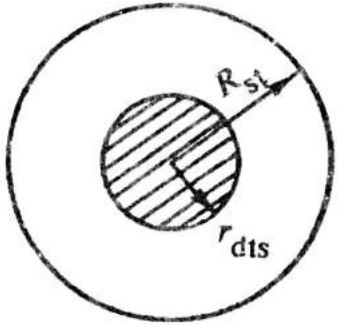


Fig. 25.1 Complete screening domain

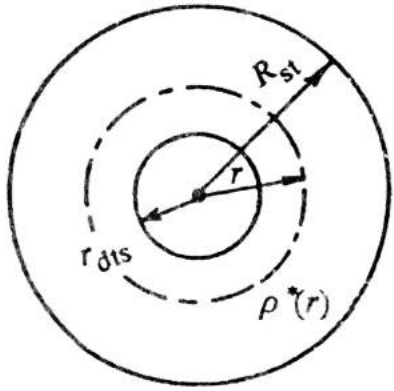


Fig. 25.2 Screening diagram

$$\theta_{\Sigma} = \frac{2\rho_{st}(R_1' - R_2')^2_{\rho}}{1.66 \cdot 10^{-24}} K_{ou} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_{r_{dts}}^{R_{st}} \sin\vartheta \, dr \, d\vartheta \, d\varphi \,. \tag{25.21}$$

Solving (25.21) and making it equal to $4\pi$ we have:

$$r_{dts} = R_{st} = \frac{4 \cdot 1.66 \cdot 10^{-24}}{\rho_{st}(R_1' - R_2')^2_{\rho} K_{ou}} \,. \tag{25.22}$$

Taking into account (25.13) the equation (25.22) can be written as:

$$r_{dts} = R_{st} - R_{ts} = R_{st} - \frac{3.30 \cdot 10^{11}}{\rho_{st} K_{ou}} \,. \tag{25.23}$$

The second case: $\rho_{st} = \rho_0 \, e^{-A\frac{r}{R}}$.

Taking into account the limits of the parameter change which are $r_{dts} \le r \le R_{st}$, we have:

$$\theta_{\Sigma} = \frac{2\rho_0(R_1' - R_2')^2_{\rho}}{1.66 \cdot 10^{-24}} K_{ou} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_{r_{dts}}^{R_{st}} e^{-A\frac{r}{R}} \sin\vartheta \, dr \, d\vartheta \, d\varphi \,. \tag{25.24}$$

Solving (25.24) we have:

$$\theta_{\Sigma} = \frac{\rho_0 (R_1' - R_2')_p^2}{A \cdot 1.66 \cdot 10^{-24}} K_{\omega} \pi R \left( e^{-A \frac{r_{dts}}{R_{st}}} - e^{-A} \right). \tag{25.25}$$

Making (25.25) equal to $4\pi$ we define the radius of the complete screening domain:

$$r_{dts} = -\frac{R_{st}}{A} \log_e \left[ \frac{4 A \cdot 1.66 \cdot 10^{-24}}{R_{st} \rho_0 (R_1' - R_2')_p^2 K_{\omega}} + e^{-A} \right]. \tag{25.26}$$

Taking into account (25.20) we finally have:

$$r_{dts} = -\frac{R_{st}}{A} \log_e \left[ \frac{R_{ts} (1 - e^{-A})}{R_{st}} + e^{-A} \right]. \tag{25.27}$$

## 25.3. The conditional loss of the mass when a star (planet) is considered to be a screen of its domain in the centre

We solve this problem by taking into account the aforesaid assumptions. The diagram of the calculation is given in Fig. 25.2. The diagram shows: $R_{st}$ is the star radius; $r_{dts}$ is the radius of the complete screening domain; $r$ is the variable radius; $\rho^*(r)$ is the conditional density which takes into account the screening effect.

It is clear from Fig. 25.2 that when $r = R_{st}$, then $\rho^*(r) \equiv \rho_{st}$, because the star surface has no screen; when $0 \le r \le r_{dts}$, then $\rho^*(r) \equiv 0$, because this domain is entirely screened.

We now consider the spherical layer, the radius of which is $r$, where $r_{dts} < r \le R_{st}$. Obviously, it is screened by the star volume which is placed in the boundary limits $[r, R_{st}]$. The angular size of this screen can be defined by analogy with (25.21):

$$\theta_r = \frac{2 \rho_{st} (R_1' - R_2')_p^2}{1.66 \cdot 10^{-24}} K_{\omega} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_r^{R_{st}} \sin \vartheta \, dr \, d\vartheta \, d\varphi. \tag{25.28}$$

Here $\theta_r = 4\pi$, when the spherical layer is entirely screened, and $\theta_r = 0$, when $r = R_{st}$.

We assume that the screening effect gives the correction to the value of the star density $\rho_{st}$ and this correction decreases the density proportionally to the screen angular size. We assume that this correction looks like:

$$\Delta = \frac{\theta_r}{4\pi} \rho_{st}. \tag{25.29}$$

Then

$$\rho^* (r) = \rho_{st} - \Delta = \rho_{st} \left( 1 - \frac{\theta_r}{4\pi} \right), \tag{25.30}$$

or

$$\rho^* (r) = \begin{cases} 0, & \text{when } r \le r_{dts}; \\ \rho_{st}, & \text{when } r = R_{st}. \end{cases} \tag{25.31}$$

When $\rho_{st} = \text{const}$, then (25.28) looks like:

$$\theta_r = \frac{2\rho_{st}(R_1' - R_2')^2_p}{1.66 \cdot 10^{-24}} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_r^{R_{st}} \sin\vartheta \, dr \, d\vartheta \, d\varphi. \tag{25.32}$$

By analogy with (25.11) we have:

$$\theta_r = \frac{\rho_{st}(R_1' - R_2')^2_p K_{ov}}{1.66 \cdot 10^{-24}} \pi (R_{st} - r). \tag{25.33}$$

By putting (25.33) into (25.30) and taking into account (25.13) we get:

$$\rho^* (r) = \begin{cases} \rho_{st} \left[ 1 - \frac{R_{st} - r}{R_{ts}} \right], & \text{when } r_{dts} < r \le R_{st}; \\ 0, & \text{when } r \le r_{dts}. \end{cases} \tag{25.34}$$

The formula for the star's mass, taking into account the screen effect, looks like:

$$M_{st}^* = \int_v \rho^* (r) \, dv, \tag{25.35}$$

and in spherical coordinates:

$$M_{st}^* = 8 \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_r^{R_{st}} \rho^* (r) r^2 \sin\vartheta \, dr \, d\vartheta \, d\varphi. \tag{25.36}$$

If to take into account (25.34), we have:

$$M_{st}^* = 8 \rho_{st} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_{r_{dts}}^{R_{st}} \left[ 1 - \frac{R_{st}}{R_{ts}} + \frac{r}{R_{ts}} \right] r^2 \sin\vartheta \, dr \, d\vartheta \, d\varphi. \tag{25.37}$$

If to consider (25.37) as the sum of integrals and to solve them, we have:

$$M_{st}^* = \pi \rho_{st} R_{st}^3 \left[ \frac{4}{3} \left( 1 - \frac{R_{st}}{R_{ts}} \right) \left( 1 - \frac{r_{dts}^3}{R_{st}^3} \right) + \frac{R_{st}}{R_{ts}} \left( 1 - \frac{r_{dts}^4}{R_{st}^4} \right) \right]. \tag{25.38}$$

When $\rho_{st} = \rho_0 e^{-A\frac{r}{R}}$, taking into account (25.24), we have:

$$\theta_r = \frac{2\rho_0 (R_1' - R_2')_p^2 K_{ou}}{1.66 \cdot 10^{-24}} \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_r^{R_{st}} e^{-A\frac{r}{R_{st}}} \sin\vartheta \, dr \, d\vartheta \, d\varphi , \tag{25.39}$$

or

$$\theta_r = \frac{\rho_0 (R_1' - R_2')_p^2 K_{ou}}{A \cdot 1.66 \cdot 10^{-24}} \pi R_{st} \left( e^{-A\frac{r}{R_{st}}} - e^{-A} \right) . \tag{25.40}$$

By putting (25.40) into (25.30) we get:

$$\rho^*(r) = \rho_{st} \left[ 1 - \frac{\rho_0 (R_1' - R_2')_p^2 K_{ou}}{4A \cdot 1.66 \cdot 10^{-24}} R_{st} \left( e^{-A\frac{r}{R_{st}}} - e^{-A} \right) \right] . \tag{25.41}$$

If to take into account (25.13) and (25.34) we have:

$$\rho^*(r) = \begin{cases} \rho_0 e^{-A\frac{r}{R_{st}}} \left[ 1 - \dfrac{R_{st}}{R_{ts}(1 - e^{-A})} \left( e^{-A\frac{r}{R_{st}}} - e^{-A} \right) \right] , \text{ when } r_{dts} < r \le R_{st} ; \\ 0 , \text{ when } 0 < r \le r_{dts} . \end{cases} \tag{25.42}$$

The formula for the conditional star mass, when the screen effect is taken into account, looks like:

$$M_{st}^* = 8 \int_0^{\frac{\pi}{2}} \int_0^{\frac{\pi}{2}} \int_{r_{dts}}^{R_{st}} \rho_0 e^{-A\frac{r}{R}} \left[ 1 - \frac{R_{st}}{R_{ts}(1 - e^{-A})} e^{-A\frac{r}{R}} + \frac{R_{st} e^{-A}}{R_{ts}(1 - e^{-A})} \right] r^2 \sin\vartheta \, dr \, d\vartheta \, d\varphi , \tag{25.43}$$

or

$$M_{st}^* = 4\pi \rho_0 \int_{r_{dts}}^{R_{st}} e^{-A\frac{r}{R}} \left[ 1 - \frac{R_{st}}{R_{ts}(1 - e^{-A})} e^{-A\frac{r}{R}} + \frac{R_{st} e^{-A}}{R_{ts}(1 - e^{-A})} \right] r^2 \, dr. \tag{25.44}$$

By solving (25.44) we can get the formula for calculation of the conditional star mass:

$$\begin{aligned} M_{st}^* = {} & 4\pi \rho_0 R_{st}^3 \left\{ \left[ 1 + \frac{R_{st} e^{-A}}{R_{ts}(1 - e^{-A})} \right] \left[ -e^{-A} \left( \frac{1}{A} + \frac{2}{A^2} + \frac{2}{A^3} \right) + \right. \right. \\ & + e^{-A\frac{r_{dts}}{R_{st}}} \left( \frac{1}{A} \frac{r_{dts}^2}{R_{st}^2} + \frac{2}{A^2} \frac{r_{dts}}{R_{st}} + \frac{2}{A^3} \right) - \\ & \left. - \frac{R_{st}}{R_{ts}(1 - e^{-A})} \cdot \left[ -e^{-2A} \left( \frac{1}{2A} + \frac{1}{2A^2} + \frac{1}{4A^3} \right) + e^{-2A\frac{r_{dts}}{R_{st}}} \left( \frac{1}{2A} \frac{r_{dts}^2}{R_{st}^2} + \frac{1}{2A^2} \frac{r_{dts}}{R_{st}} + \frac{1}{4A^3} \right) \right] \right. . \end{aligned} \tag{25.45}$$

Finally we have:

$$M_{st}^{*} = 4\pi\rho_0 \frac{R_{st}^3}{A^3}\left\{\left[1 + \frac{R_{st}e^{-A}}{R_{ts}(1-e^{-A})}\right]\times\right.$$

$$\times\left[e^{-A\frac{r_{dts}}{R_{st}}}\left(A^2\frac{r_{dts}^2}{R_{st}^2} + 2A\frac{r_{dts}}{R_{st}} + 2\right) - e^{-A}\left(A^2 + 2A + 2\right)\right] - \qquad (25.46)$$

$$\left. - \frac{R_{st}}{4R_{ts}(1-e^{-A})}\left[e^{-2A\frac{r_{dts}}{R_{st}}}\left(2A^2\frac{r_{dts}^2}{R_{st}^2} + 2A\frac{r_{dts}}{R_{st}} + 1\right) - e^{-2A}\left(2A^2 + 2A + 1\right)\right]\right\}.$$

The results of the calculation of $R_{ts}$; $r_{dts}$, $\rho_{st}^{*}$, $M_{st}^{*}$, when $\rho_{st}$ = const, and when density of the star changes in accordance with $\rho_{st} = \rho_0 e^{-A\frac{r}{R}}$, are given in tables 25.2 and 25.3.

Table 25.2

| Unknown parameter | Results of calculations of stars (planets) and Sun parameters when $\rho_{st}$ = const | |
|---|---|---|
| | Stars (planets) | Sun |
| $R_{ts}$ | $\dfrac{4\cdot 1.66\cdot 10^{-24}}{\rho_{st}(R_1' - R_2')_p^2 K_{\alpha\beta}} = \dfrac{3.30\cdot 10^{11}}{\rho_{st} K_{\alpha\beta}}$ | $2.4\cdot 10^{11}$ c |
| $r_{dts}$ | $\begin{cases} R_{st} - R_{ts}, & \text{when } R_{st} \le R_{ts} \\ 0, & \text{when } R_{ts} > R_{st} \end{cases}$ | 0 |
| $\rho_{st}^{*)}$ | $\begin{cases} \rho_{st}\left[1 - \dfrac{R_{st} - r}{R_{ts}}\right], & \text{when } r_{dts} < r \le R_{st} \\ 0, & \text{when } 0 < r \le r_{dts} \end{cases}$ | $\bar{\rho}_s\left(1 - \dfrac{R_s - r}{R_{ts}^4}\right)$ |
| $M_{st}^{*)}$ | $\pi\rho_{st}R_{st}^3\left[\dfrac{4}{3}\left(1 - \dfrac{R_{st}}{R_{ts}}\right)\left(1 - \dfrac{r_{dts}^3}{R_{st}^3}\right) + \dfrac{R_{st}}{R_{ts}}\left(1 - \dfrac{r_{dts}^4}{R_{st}^4}\right)\right]$ | $1.84\cdot 10^{33}$ g |

*) Density and mass are conditional.

Table 25.3

| Unknown parameter | Results of calculations of stars (planets) and Sun parameters when $\rho_{st} = \rho_0 e^{-A\frac{r}{R}}$ | |
|---|---|---|
| | Stars (planets) | Sun |
| $R_{ts}$ | $\frac{4A \cdot 1.66 \cdot 10^{-24}}{\rho_0 (R_1 - R_2)_p^2 K_{ov}(1 - e^{-A})} = \frac{A \cdot 3.30 \cdot 10^{11}}{\rho_0 K_{ov}(1 - e^{-A})}$ | $2.65 \cdot 10^{10}$ c |
| $r_{dts}$ | $\begin{cases} -\frac{R_{st}}{A} \log_e \left[ \frac{R_{ts}(1 - e^{-A})}{R_{st}} + e^{-A} \right], \text{ when } R_{ts} \le R_{st} \\ 0, \text{ when } R_{ts} > R_{st} \end{cases}$ | $0.93 \cdot 10^{10}$ c |
| *) $\rho_{st}$ | $\begin{cases} \rho_0 e^{-A\frac{r}{R_{st}}} \left[ 1 - \frac{R_{st}}{R_{ts}(1 - e^{-A})} \cdot \left( e^{-A\frac{r}{R_{st}}} - e^{-A} \right) \right], \text{ when } r_{dts} < r \le R_{st} \\ 0, \text{ when } 0 \le r \le r_{dts} \end{cases}$ | — |
| *) $M_{st}$ | $4\pi \rho_0 R_{st}^3 \left\{ \left[ 1 + \frac{R_{st} e^{-A}}{R_{ts}(1 - e^{-A})} \right] \left[ -e^{-A} \left( \frac{1}{A} + \frac{2}{A^2} + \frac{2}{A^3} \right) + e^{-A\frac{r}{R_{st}}} \times \right. \right.$ $\left. \left. \times \left( \frac{1}{A} \frac{r_{dts}^2}{R_{st}^2} + \frac{2}{A^2} \frac{r_{dts}}{R_{st}} + \frac{2}{A^3} \right) \right] - \frac{R_{st}}{R_{ts}(1 - e^{-A})} \left[ -e^{-2A} \left( \frac{1}{2A} + \frac{1}{2A^2} + \frac{1}{4A^3} \right) + \right.$ $\left. + e^{-2A\frac{r_{dts}}{R_{st}}} \left( \frac{1}{2A} \frac{r_{dts}^2}{R_{st}^2} + \frac{1}{2A^2} \frac{r_{dts}}{R_{st}} + \frac{1}{4A^3} \right) \right.$ | $1.43 \cdot 10^{33}$ g |

*) Density and mass are conditional.

## Résumé


Gravity-vacuum energy contributes significantly to the energetics of stars and planets.

GVE releases continuously in the internal layers of all planets as well as of the Earth. This energy releases not only in the centre of planets.

The process of GVE releasing takes place when depths are not very large. On the Earth it is possible to have a considerable release of energy when depths are about 8—12 km.

Of course it is said not only about the energy of the central parts of the Globe where it is released more intensively, but about the energy which is released directly in a certain place. This energy which is released directly in the Earth can be and should be used.

A great number of earthquakes proves the fact that if the mankind goes on not using this energy, the latter will cause only damage instead of giving benefit.

# 26 THE PHENOMENON OF GRAVITY ANISOTROPY WHICH HAS BEEN PREDICTED BY TFF. THE POSSIBILITIES OF PRACTICAL USE (BRIEF ACCOUNT)

From the vacuum theory of gravity, which has been created on the basis of TFF, we can get the following idea of the mechanism of gravitational interaction of bodies. Every elementary particle has a gravitational screen which has an axial but not spherical symmetry. The result of this fact is the dependence of the screen effective size upon EPs orientation. This orientation depends on the direction of the particle spin. The effective screen size is greater in the direction of the spin vector than in the orthogonal plane. The screen size has the maximum value when it is directed along the rotation axis of the EP substructure.

EPs are a part of atom structures and mainly of atom nuclei, because the nuclei make up the greater part of atom masses. Therefore, if EP spins are directed identically,the gravitational force is maximum in the spin direction and minimum in the perpendicular plane. This kind of effect can be easily observed in EPs accelerators,but its experimental verification is of a great technical difficulty.

The magnetized bodies also have some anisotropy of gravitational properties, but the experimental verification of this anisotropy is beyond the possible accuracy of modern experiments. Indeed, in the magnetized body only some part of the electrons of the atom cover are being oriented. The *mass* of the particles with oriented spins does not exceed several hundred thousandth parts of the *total mass* of a magnetic material. The *mass losses* of these particles in the plane perpendicular to the spin is about 20—50 %. Therefore, this effect can not be fixed even by using the modern precise methods of gravitational measurements.

The atoms orientation can be caused in gas plasma or in laser. In this case it is possible to measure the gravitational effect between the gas and some other body. Such an experiment can be performed technically but needs very precise studying. Its realization will perhaps meet with great difficulties because it is very complicated to fix the changing of gravitational forces on the background of some other interactions (the pressure of light and stationary electromagnetic waves and especially the pressure of a string of the EP fundamental field). It is especially important because the pressure which is concentrated in a string of FF can not be compensated and so this pressure can be confused with the gravitational interaction, though the latter is many times less. The influence of the aforesaid field effects on the nuclei orientation is quite possible but this fact has to be verified experimentally.

The following experiment is supposed to be most perspective. It is necessary to orientate the atom nuclei in the melting by the strong nuclear magnetic resonance (NMR),and after that to cause its quick hardening to retain a part of this orientation. This effect can be especially strong if the

fields which cause NMR do influence the process of the monocrystal growth. In this case it is possible to get the monocrystal, the atom nuclei of which are orientated.

It is important to pay attention to the fact that the materials with orientated nuclei can have unique properties. This fact by itself is of great scientific and practical interest.

# 27 BRIEF REVIEW OF SPHERES OF PRACTICAL USE OF THE THEORY IN BIOPHYSICS

The unified theory of field is a closed complete theory of matter. As it was already said, the matter is the material form possessing the mass as the measure of inertia. It can be assumed with confidence that the description of biological objects is not complete if we use matter only. It is a dead certainty that other forms of substance, apart from matter, are used to create such most complicated and important structures as the animated nature and its elements. These forms are not investigated by us yet. Therefore, it is impossible to reckon on the complete results of biology or biophysics, if the basic theory rests upon matter only.

TFF is the complete theory of matter and it contains a lot of new elements which allow to have the full comprehension of such things as physical vacuum, the structure of the elementary particles of vacuum, the interaction between macrobodies and physical vacuum, the features of the elementary particles structure. All this is new in the theory of matter, not yet practically used in modern biophysics and has bright prospects.

Preliminary thoughts of the author on the spheres and problems of use of the new information is given in this section.

The first thing which requires attention is the need to support the idea which was formulated by our eminent genetist I. A. Rapoport [166] as far back as in 1965. The principal conception of the Rapoport's monograph "The microgenetics" was formulated in the following way: "It would be more consistent to make searches in the endogene clot which produces an impression of something undisclosable, eternally intrinsic of an object, i.e. counter-matter, which is beyond the bound of modern science but is more valuable for cognition, because it can just be the source of new fundamental regularities". This statement of Rapoport can be considered as a prediction of the results obtained nowadays in TFF and, which is more, a prediction of things not obtained yet.

The modern biological science should solve one of the most important problems: where does nature store its information? There are all the grounds to assume that nature stores the information on a structure of physical vacuum and the formation of this most complicated and important informational system is realized not only by matter. Yet, by analysing matter we can understand a lot about the role of this principal informational system in Nature. Thus, the latest results of the theory of matter discussed in this book should be used for the further progress in our understanding the nature of genetic memory, the nature of memory of living beings, and man in particular.

In this connection we should like to remind the reader that the problem of human memory and mentality is far from being solved and the questions put by N. I. Kobozev [145] in his monograph as far back as in 1971 are also far from being answered. Indeed, if to suppose that the memories of living beings, both genetic and active, are recorded and stored on the atomic structural substance,

then the fact of that storing during many years contradicts the second principle of thermodynamics. It means that the memory can not be stored for long on the atomic or molecular structures. It will be erased by temperature and other fluctuations. But in reality it is stored, and it is stored for a long time. It means that there should exist some material objects on which this memory is stored. Kobozev has shown that such objects, if we want to maintain our present understanding of thermodynamics (and we have no reason why we should not), should exist under absolute zero. But what kind of objects they are, Kobozev could not explain. TFF proves that such an object does exist. This object is physical vacuum which penetrates through the entire surrounding substance, or rather through all surrounding us matter but does not take part in the trivial heat transfer, i.e. is not heated in thermodynamical meaning of heat. From the point of view of thermodynamics,it is under absolute zero. Between the elements of the physical vacuum itself, its structural elements and surrounding atomic substance there is an exchange of information and not of energy. This exchange lets the structures of atomic substance record the information on the structures of physical vacuum and store it there for an indefinitely long time. This recording can be reproduced and used. The mechanism of these procedures of recording, storing, reproduction and use should be thoroughly analysed,and the first steps in this direction can be made on the basis of TFF. But only the first steps. Science will manage to solve the entire problem only when other material forms are found and studied. The progress in this direction, based on TFF, can give the opportunity to find such forms and study them.

The next problem for the solution of which the results obtained in TFF can be used is the problem of existence of living beings which do not consist of cells. For a long time biologists considered (and some of them still consider it now) that the atom of a living being, i.e. the finest particle of a living being, is the cell. All formations that have no cells can not exist. The first doubt about this point of view appeared in works of O.P.Lepeshinskaya and her colleagues. Nowadays most scientists do not recognize these works. Yet, since the seventies more and more experimental data appear which prove the existence of such objects. In the first place we should mention the information about the discovery of some objects, which have no DNA and RNA, made by the scientists of the California University in the seventies [167]. Those microorganisms were called pryons.

There are some very interesting investigations made by L.A.Sysoeva [168]. In her experiments she showed that there exist some living creatures whose behaviour is far from being standard. For example, they multiply actively under the conditions under which microorganisms can not multiply at all; besides, they do it without any fixed external energy which is necessary for it. The investigations made by L.A.Sysoeva are rarely published and not yet recognized by the majority of scientists. But as the history of science shows it is difficult to deny facts for a long time. Therefore, the author cherishes hopes that her investigations would be not only recognized but developed and used. At any rate, we have grounds to assume that these investigations prove the hypothesis, which rather directly follows from the theory of fundamental field, that Nature stores its information not only on living beings. How can we call the inner structure of elementary particles as living beings? But information does exist there. Therefore, the problem whether the ex-

change of information is the prerogative of only the creatures which we call living requires serious consideration. We have a sufficient reason to assume the fact that Nature has the unified laws for so-called animate nature and inanimate nature, and the boundaries between them are not very distinct, as we understand it now. We can not but agree with L.A.Sysoeva that the analysis of these problems and clear understanding of their essence will play a great role in understanding the nature of cancer. This question is of greatest importance for the mankind.

Therefore, we suppose that in this direction (the direction of grounding and interpretation of experiments connected with the discovery of the non-cell living creatures and researches connected with the causes of cancer) the researches on the basis of TFF could make and will make their valuable tribute. Of cource, as it was often mentioned above, it is so only when making first steps. It is necessary to make more attempts in search of other material forms and the laws which control them, because to solve this problem it may be not enough to have only the laws of matter.

The third problem of modern biology is the problem of the energy source for living beings. TFF can make a certain tribute to the solution of this problem as well. Now the recognized opinion is the assumption that living beings take energy from what is called now food. Yet, it is reasonable to suppose that food is not the main source of energy but an emergency one. And the main energy source is the physical vacuum. This hypothesis needs thorough investigation and if it is proved or even disproved, it will be of great importance for our civilization. The question whether food is the source of energy and another question whether we have the moral right to estimate food according to its caloric value are among the most important for the existence of civilization. The ignoring of these questions may cost the humanity too much. These questions need very serious investigation. Here too, just at the very beginning of researches, the unified theory of fundamental field is supposed to make a considerable tribute.

We have enumerated here not all (that can be seen today) spheres of use of TFF in biology and biophysics but the given examples, as we consider, convincingly show that there is a considerable number of important problems for the solution of which the use of TFF is not only appropriate but rather necessary. In this section we aimed only to show the perspectives of TFF use in the solution of the above-mentioned problems, without dwelling upon the essence of investigation, because it is far beyond the scope of this book.

# 28 BASIC COMPUTER PROGRAMS FOR CORRECTING PHENOMENOLOGICAL THEORIES

It was already mentioned in the monograph that all existing physical, chemical, biological and other natural scientific theories without any exception are based upon the phenomenological principle. Some phenomenon chosen at random is taken as a ground; some prorerties, mostly imagined, are attached to it; then basing upon this phenomenon the theory is created, which cannot of course settle all problems. In many cases it gives some good positive results, but very often the result is wrong, inaccurate or incomplete. We believe that the main thing, which is emphasized in this monograph, is the fact that we have underestimated the influence of the microcosm, the microcosm itself, its direct influence but not an indirect one upon macroprocesses. We have not taken into consideration that the strings of the fundamental field are the physical objects of both micro- and macrocosms simultaneously. Thus, without considering these fundamental objects of Nature, practically all theories which we follow, happen to be incomplete or, as mathematicians say, they mostly consist of necessary but insufficient conditions. To make most of these theories sufficient,it is necessary that they should include the direct participation of objects of microcosms in the investigated processes. Such addition to different theories should make them much more resultative. This is an immense work. If to do it in a usual way (i.e. for several years to propagandize the necessity of it, then form the necessary groups of scientists of each speciality, work out hypotheses, then theories, then inculcate the results etc) it will take scores of years. But the humanity has not got these scores of years. The civilization on Earth nowadays has one foot in the grave. Only the titanic efforts of all creatively thinking people on Earth can prevent this catastrophe.

We believe that a serious practical step in the solution of this most important problem, from our point of view, might be the working out of basic computer programs.

At present there exist workings out which are called the data base. They are widely used in cybernetic calculations. Recently, attempts are being made to take the next qualitative step and create the knowledge bases. In the latter case it is meant that the amount of information written in the computer memory and its choice are made so that it makes possible to choose the necessary material from that accumulated in abundance by science as soon as possible and then use it. This direction is undoubtedly perspective and interesting but it can not help to solve the problem which we call the basic programs, to say nothing of the fact that the knowledge bases do not exist yet. Let us try and define what we mean by the term "basic programs". The basic programs are the exhaustive information about microcosm and the objects which belong both to micro- and macrocosm, i.e. they are strings of the fundamental field. Besides, and this is of great importance, the basic program contains information about where and how those objects can participate. Thus, the existing theories should consider all new objects of TFF, i.e. fundamentons, strings of the funda-

mental field, structural physical vacuum, anisotropy of the field of elementary particles. The answer to the question of how to consider the influence of those new objects in different processes is just the basic program.

Thus, if a scientist possesses a basic program he can formalize in this or that way the problem which cannot be solved by means of the existing theory and introduce it into computer. It may be, for example, the problem of cavitation, the problem which is the stumbling block of many specialists for many years. The question arises where and how the microobject ignored before should be considered. The computer either will answer what should be considered (for example, anisotropy of the fundamental field or something else) or will give the answer "do not know". Even if the computer is unable to help the researcher with concrete recommendations, this is a great positive information, because it means that we instantly see that all known properties of new objects can not be used for the solution of this problem right now. This fact immediately puts the problem for the researcher of seeking new ways for the solution. Of course, it is impossible to solve all problems and overcome all difficulties that exist in natural and technical sciences, if we take into account new physical objects. Many problems will be solved but, of course, not all. Therefore, awareness of the fact that there exist problems and difficulties which cannot be solved and overcome even if we possess the knowledge of new properties of microcosm and properties inherent both in micro- and macrocosm, is an important information as well.

We have formulated the problem of the basic programs in a general way. To make it more concrete nowadays is difficult because this is the direction of research which is not yet explored. In this connection the author thinks that some concrete considerations about the problem of formation of basic programs are not yet riped to be presented and, the more so, to be used.

So the author thinks that to finish this important section by general formulation of the problem is quite reasonable, and he emphasizes the fact that the problem of basic programs is one of the most important if not the most important direction of the practical use of the Paradigm for the Viable and Developing Systems and TFF. The question is that PVDS itself contains a lot of additional information, the use of which in the formation of different theories and the correction of already existing ones, can play a great and maybe a decisive role. But this question is quite separate; therefore, we consider it separately.

The boundaries of the practical use of PVDS are outlined. In the monograph we give the contents of the paradigm and some preliminary examples of its use beyond the bounds of TFF. The contents of the monograph, as we believe, show how the paradigm is used in the creation of the theory. The essence of PVDS penetrates through the whole TFF. As a rule, it was not mentioned and commented in the context of the monograph. We suppose that the reader will see that without any comments. A separate substantial paper should be dedicated to the problems of practical use of the paradigm. The author hopes that his colleagues and he would manage to prepare it for publishing.

## RÉSUMÉ

1. Some ways of practical use of PVDS and TFF are given briefly here.

2. The given examples evidently do not need any detailed comments. But still it is necessary to make some general remarks.

PVDS and TFF can become the basis for the creation of new kinds of aircraft and spacecraft, new energy sources, new materials and new technologies. All this will help to solve most of environmental problems of our Earth and, in contrast to present methods, solve these problems without any additional expenditure of money and material resources. So, for example, new technologies are aimed to achieve the environmental purity which can save immense expenditures of resources on liquidating sequels of ecologically dirty technologies.

3. The examples of practical use of PVDS and TFF which have been given in this paper do not exhaust of course all the opportunities that these new scientific methods offer. The detailed analysis of these methods should be a subject of special issues dedicated to these important problems.

The author hopes that in the near future his colleagues and he himself will be able to prepare and publish such papers. The author considers that these papers will be of great and even vital importance. They can help the mankind to work out urgent arrangements to save civilization from its inevitable destruction. Thus, it means not only the further progress of science but quite a new turn in the scientific and technical revolution which will bring a lot of good for the Nature and the Man, nothing but good.

# PART VI

## SPHERES OF PRACTICAL USE OF THE PARADIGM

## 29 IS IT POSSIBLE TO PREVENT THE ENVIRONMENTAL CATASTROPHE?

By now, the author of this monograph did not have any opportunity to publish openly his scientific ideas about the energy of physical vacuum. Therefore, as long ago as in 1970 he stated his ideas in the science fiction story "The message to the inhabitants of the Earth" [101], as if written by a representative of another more perfect civilization. As this publication is evidently unknown to the readers, it is expedient to quote here some extracts from this story.

It is stated in the "Message" that there exists the main energy which is to be the basis of the energetics of our civilization. Later on it is said that: "The thermonuclear energy is not the main energy. Some civilizations go through all the stages of their evolution and do not know anything of it. This fact does not prevent them from normal development because they start to master the main energy in good time. To use the nuclear energy by chain reactions is considered to be amoral. It is prohibited by the Universe Law. You are violating the Law of the Universe ethic. The nuclear explosions are harmless for anybody if they take place on the Sun and other stars. Nuclear explosions or any other kinds of artificial nuclear split are by no means admissible if they take place there where the fragments of this reaction can come into contact with any living organism.

The substance in the Universe has not only the mass and energy, as you naively think, but it has the information as well. This information is accumulated inside the interatomic spheres which are not known to you yet. It has been accumulating for many years of the evolution of the whole Universe. It is inadmissible to erase this record. This would mean to annihilate the greatest wealth of substance, the wealth which has been acquired by substance for the whole period of its evolution, for the time which in your scale of time is the Eternity.

The main energy is unknown to you but it is quite accessible".

It is evident that in the quoted story there was not any indication as to what is meant by the "main" energy. In this monograph we can say with confidence that the main energy is the physical vacuum energy. The mankind should use this sort of energy. This energy is concentrated in the whole surrounding space, as well as inside the atoms and molecules.

There are several methods to get the physical vacuum energy. The most radical method is the direct use of the energy which is being continuously released or simply exists in the whole physical vacuum space. The living nature uses this energy. There is an experimental proof of this hypothesis. The experiment was made upon plants, namely the roses. According to the hypothesis, the ability to use the physical vacuum energy is inherent to all living nature and to the plants as well, the nutrition of which is being realized by photosynthesis now. Before plants have turned to the nutrition by radiated energy in their evolution, they had the opportunity to use the physical vacuum energy. The memory of their structures must have preserved this ability.

The experiment began at the moment when the roses started forming buds and they needed some time to blossom out.

A number of roses were left as a control part on the flower bed. Several roses were used as the second control part and the rest for the experiment. The second control part was placed into the metal vessel with some water in it. The vessel was specially made to prevent not only light, but electrom agnetic waves as well from penetrating into it. The experimental part was placed into another vessel of the same kind with some water in it. These roses were influenced by some periodical impulsing to cause the nuclear magnetic resonance of the nuclei of hydrogen atoms because the hydrogen is one of the basic elements of plant structure. It was supposed that the impulsing which caused the nuclear magnetic resonance of the hydrogen would cause the molecules of the rose structure "to recollect" how to use the physical vacuum energy. And as the molecules found themselves in the situation when no other energy necessary for the photosynthesis was available they would start using the physical vacuum energy.

The experiment was going on for two days and gave the following results. The roses which were left on the flower bed went on growing but the buds did not blossom out because the time did not come yet. The roses of the second control part which had not been subjected to any influence began to droop and even to decay. The experimental roses after two days increased their biological mass, their buds blossomed out, i.e. those roses were going on to live and to develop more intensively than the roses of the first control part which were in the natural conditions in the ground.

It is a pity that engineer Pribishin, the author of that experiment, who was impressed by its positive results, instead of using theoretical workings out, decided that the development and realization of this interesting effect could be done by the inventive engineering. On the basis of theoretical elaborations it could be possible to apply the achieved results to other plants and to find the optimal method which could cause the plants "to recollect" the way to use the physical vacuum energy. In this case the plants could grow and ripen more quickly. It is very actual because now, when the situation on the Earth has changed, for many plants the photosynthesis has stopped to be the optimal way to get the energy. The plants by themselves can not turn to another way of getting energy for a short period of time (thousands of years are necessary).

Besides the direct use of the physical vacuum energy it is possible to use energy released by material structures during their usage of the physical vacuum energy. The example of such pro-

cess is the mutual orientation of atoms and molecules in the entrails of the Earth. It is a very slow process but it goes on continuously. During the process the gravitational interaction between atoms and molecules becomes less and owing to this fact the heat is released. It is the main energy that keeps high temperature in the entrails of planets, e.g. the Earth. In the paper [49] it was shown that such energy releases in the entrails of planets and stars and is the main energy because the energy of the nuclear reactions is not determinative for stars and planets energy balance. The gravitational energy is being continuously released in the entrails of the Earth. It is espesially intensively released when the depths are 5 km and more. It can be a good source of energy. This energy is released spontaneously, it is not connected with the water flows which carry heat and it is not the geothermal energy. It is supposed now that the only energy of the entrails of planets and the Earth which can be utilized is the geothermal energy. The gravitational energy which is released in the entrails of the Earth can be utilized both if there are or there are no warm water sources. There is a certain difference of the gravitational energy release in different places of the Earth. But nevertheless, it is possible in any place of the Earth to bore two boreholes which are connected between themselves at some depth. If to feed water into one borehole it is possible to obtain steam from the other. The steam can be obtained only if the depth of the boreholes is large enough to ensure the high temperature. Such way of utilizating the entrails energy is well known. But as the energy released in the Earth entrails is considered to be geothermal its deposits were falsely calculated. Thus, the gravitational energy released in planets entrails can not be identified with the geothermal energy. Therefore, the problem of the use of the gravitational energy should be considered in a different way.

We say here about the possibility to use the physical vacuum energy (by using the gravitational energy as an example), because it is the main way to solve a lot of environmental problems. The main sources of pollution of air, rivers, oceans and the earth surface are oil, coal and their combustion exhausts. The turn for the use of the physical vacuum energy, and the gravitational energy in particular, will be one of the most important steps to prevent the environmental catastrophe. The environmental situation on the Earth is highly threatening nowadays and so the working out of problems connected with the use of the physical vacuum energy as an alternative energy has to be forced intensively. The whole mankind should be mobilized to solve this problem which is perhaps the problem number one. If we do not solve this problem we shall not be able to live in peace with Nature and to prevent the environmental catastrophe.

Unfortunately, the wrong use of coal and oil (not as industrial materials but as energy resources) gave birth to the environmental catastrophe. Not less important is the problem of the ecologically pure closed circuit technologies. It is impossible to solve this problem without radical change of principal scientific approaches in analysing the essence of the processes which are used in different branches of industry.

It goes without saying that the cardinal turn from unreasonable dirty techologies to pure closed circuit processes is impossible without theoretical analysis of all basic processes used in these technologies.

At the same time in the theoretical analysis of all technologies, we mean each and every and not separate ones, there is a great drawback. The basic theories which help to analyse, to investigate and to develop the present technologies, practically in all branches of national economy, are the phenomenological theories such as hydrodynamics, gas dynamics, thermodynamics, electrodynamics, etc. These phenomenological theories have different degrees of work out, completeness and perfection, yet being phenomenological. All of them have a great drawback, the result of which is the fact that we miss a lot of properties which reveal in the processes used in these or those technologies. The fact is that all the phenomenological theories are based on the hypothesis that the main phenomenon is not only main but the only one which entirely determines the whole process. Let us take hydrodynamics as an example. Hydrodynamics is a science which deals with liquids. The liquid of hydrodynamics has no molecules and is considered as continuous material medium without any structure but with general phenomenological properties only. If so, then we have the following. The microcosm consists of elementary particles such as atoms, molecules, crystals, etc. They are always present in any liquid and influence all the processes. But hydrodynamics can not consider their influence because there is only one phenomenon in it. This phenomenon is a liquid which is considered to be continuous and consisting of nothing. As a result of this consideration modern hydrodynamics can not solve a number of problems connected with turbulence and such an important problem as cavitation. The phenomena of turbulence and cavitation are mainly influenced by the forces caused by molecular and atomic structure of a liquid which is, in its turn, directly influenced by the fundamental field. It is clear from the monograph that the fundamental field is the string which can affect other objects over very long distances. This fact is not taken into account. The average fields alone decrease inversely proportional to the distance square $r^2$ or even stronger (like average nuclear fields which decrease still stronger with the increase of distance), but all this is said only about the average fields. The instantaneous fields are concentrated in the string of the fundamental field. They have little change along this string. The string has a great extent. Therefore, all the processes, in which the fundamental field concentrated in the string participates, can have an affect at quite a long distance. This fact is not taken into account by any fenomenological theories because the phenomena on which these theories are based (heat in thermodynamics, gas in gas dynamics, liquid in hydrodynamics, average electromagnetic fields in electrodynamics, etc.) do not consider the fundamental field as it is. They do not consider its properties either, when the interactions are very quick, i.e. instant in our practice.

Thus, the fact of abstracting from direct influence of microcosm upon some processes of macrocosm leads to some difficulties.

So, if we disregard the fact that microcosm reveals its properties in macroprocesses we have no opportunity to study or simply to find out some processes. When we disregard these processes we meet with some difficulties or miss many opportunities. We think that to prevent the environmental catastrophe we should put forward the second problem. This problem is the extention of all phenomenological theories by including the microcosm properties in them, the properties which

tal catastrophe we should put forward the second problem. This problem is the extention of all phenomenological theories by including the microcosm properties in them, the properties which reveal in macroprocesses but are not taken into account by the phenomenon of the theory. It is also a very great problem.

To solve the second problem for a short period of time is obviously impossible, unless we work out the basic programs for modern computers. By the word "basic" we mean the following. The basic program should contain all the information about the microcosm which is known by the present moment, the greater part of the information which is given in this monograph, in particular. Besides, the basic program should contain the information on what kinds of macrocosm processes are influenced by microcosm (it goes without saying that we do not mean all the processes). There is a great number of processes which are determined by average fields and by those phenomena which are the bases of phenomenological theories. Therefore, it is necessary to find those kinds of processes which are directly influenced by microcosm. We should find them, study, make researches and put all the results into the basic programs. After that with the help of computers we shall be able to solve many practical problems of industrial processes and technologies rather effectively and quickly.

Thus, we think that there are three main problems that science and engineering should solve to prevent the environmental catastrophe. The first problem is to replace all the ecologically dirty kinds of energy by the physical vacuum energy. The second problem is to correct all the phenomenological theories by including those microcosm properties which reveal in macroprocesses. The third one is to speed up the working out of the basic programs for computer. These programs will help to solve the two mentioned above problems and some other not mentioned here.

# 30 WHAT SYSTEMS ARE VIABLE AND ABLE TO DEVELOP?

The unified theory of field (TFF) deals with the matter, i.e. material form which possesses the mass as the measure of inertia. The surrounding space is full of other forms of substance for which the mass as the measure of inertia is not a basic feature. Nowadays we know very little or almost nothing about these forms of substance. Does it mean that we have no right to speak about some unified properties of these still unknown for us forms of substance?

Apparently, the Paradigm for Viable and Developing Systems deals with not only matter but also with that part of substance forms which do not possess the mass as the measure of inertia. The future will verify which part it is. Nevertheless, we can say a lot about those substance forms which are beyond the bounds of TFF. We can do that if we base upon PVDS.

Some questions may arise. Is it unlawful to speak about new forms of substance now? Is to deal with the matter alone not enough? Have we exhausted all the possibilities which are offered by the theory of matter to explain the surrounding phenomena? The only answer is "no". We constantly meet a great number of facts which we can not explain. And we try to ignore them on the only ground that they can not be explained by modern science.

These facts are not only the unidentified flying objects (UFO) which apparently can be and must be explained by means of the material forms of substance, but a lot of other phenomena. These phenomena are certainly being observed, but modern science resting upon matter only can say about them very little. These phenomena are the facts of rod-guidance, telepathy, telekinesis, prophecies, the influence that living organisms undergo from unknown fields and properties created by man (e.g. the Kashpirovsky phenomenon). It is not reasonable to ignore these facts. We should look for the ways of their thorough studying and explanation.

We can get some information if we suppose that the aforesaid phenomena and facts are the result of action of some unknown systems which are viable and able to develop. If we consider obscure facts as the displaying of such systems, we get the possibility to define some unified properties of these systems, and by doing so we are nearer to understanding the essence of these phenomena. We have already said that the viable systems and those able to develop should possess the spatial metamorphosis. It means that they both reveal in our laboratory (three-dimensional Euclidian) space and possess some definite characteristics in some other fibres of our fibre bundle. These characteristics and properties are quite different in other fibres. Moreover, as we already know, there are some material objects which do not reveal directly in the laboratory space at all. These objects may be the virtual states which are intermediate between the state of matter and the states of some other forms of substance. The virtual state is that kind of state which exists in the fibres of our enclosing space and does not reveal directly in the laboratory space. In the first turn, these are the bare elementary particles (BEPs). We know that some bare elementary par-

ticles associating with elementary particles of vacuum form the quark and pseudo-quark structures which reveal in our laboratory space, and we call them "elementary particles". By now, we are already aware of a great part of properties which are necessary for BEPs to associate with EPVs and form the quark structures, i.e. elementary particles. As it has been already said, the particles of the third series do not form any pure quark structures but form pseudo-quark structures which can be observed. Leptons are the particles of the third series of the Periodical Law of Microparticles. We speak about leptons because the phenomenon of formation of pseudo-quark structures is a characteristic property of particles of the third series.

In the third series there are about 800 thousand kinds of bare elementary particles. The calculation shows that only 10 kinds of particles of this great amount can form quark structures and be observed. Some of them have been found already. They are the electron, muon, $\tau$-particle and particle which is called now the "Dirac hole". The latter is actually an analog of a positron but its lifetime has the order of $10^{-9}$ s, while a positron which is an electron antiparticle has practically an infinitely great lifetime.

If our idea of the mechanism of pseudo-quark structures formation is right, we can observe some leptons more, though very few. They are given in table 19.1. However, the remaining kinds of bare elementary particles of the third series, which are about 800 thousand in number, exist in another subspace, i.e. the fibre, as to our laboratory space. It is quite natural that they can not exist without displaying some of their properties in our space, i.e. without mapping them onto our space, without sending proper information.

In the monograph appendices there is an article named "The fundamental code". It was published long ago and it did not claim to be of any scientific importance because the author considered that the time of acknowledgement of the scientific importance of such problem has not come yet. Nowadays, we are ready to understand that the surrounding space consists not only of matter in the form of elements which possess the mass, of not only a definite structure which reveals its properties in this or that way but of a certain combination of structures which contains something that we call now information. The information is one of the most important properties of surrounding substance. In fact, this property has not been studied yet, we only start to cognize it. We are only at the entrance of understanding what the information is like, the information which is kept by the surrounding substance. We should find out where Nature is storing the information, what are the ways in which this information is being formed, recorded and passed over and, what is more, the ways in which this information is being taken for current processes and used by them both to operate and control these processes. These laws of information which Wiener has started to formulate in his cybernetics are awaiting their discoverer. We can not say yet that we have some idea of these laws nowadays. We know very little of them, in fact, we only know that they exist, play a very great role in the process of substance evolution in the Universe, control this evolution and they are the most fundamental property of the substance. We know only something about these laws, no more than something. It would be wrong to think that the slightest knowledge, we have got since Wiener has worked out cybernetics, gives us the right to say that we know and under-

stand the essence of this most important property of the material world. We should openly and fearlessly say we are only raising the cover and what is behind that is quite unknown yet.

In this section on the basis of PVDS we endeavour to formulate some ideas about the surrounding substance, that has memory and information and can use them. Our hypothesis is the existence of some fundamental code of genetic character in the surrounding space. The programs of the substance evolution in the Universe are recorded in this code. More than that, there are some records of all the processes of the Universe. We do not know yet how this recording is done, where, how and how long it is kept and what are the ways of its reproduction and use. All that is to be learned. But the time has come to put these questions from the scientific point of view, try and study them and then master them.

Now we can enumerate those already known processes and phenomena which should and could be explained. But we can obviously neither explain, nor reveal, nor create the theory of these phenomena yet. It is our aim for the future. But now we can qualitatively explain their nature and define the direction in which we should seek their main laws. For example, some people have the gift of foreseeing the future and reading the bygone. This phenomenon is quite unexplained yet. What is it like? Now we can state that it is a direct evidence of the existence of the fundamental code in the fibres of our fibre bundle. We should study the mechanism of such phenomenon when Nature endows some of its representatives with the ability to read this code and then to reproduce it. We should study this phenomenon and not outlaw it.

We ascribe a number of obscure phenomena to the so-called "biologic field" or "spinor field". The latter, from our point of view, is a wrong term. These both terms are invented to express a very great complex of phenomena which have already been fixed and which are connected with the new unknown forms of substance. We should use these terms very carefully because they are too general, not quite precise and often even false. Apparently, it would be more right to use the term "information field" though this term is disputable and we should use it with a great care until we find a better one which is more reasonable, more exact and grounded on better understanding the phenomenon. But here we shall use the terms "fundamental code" and "information fields".

Nowadays, we can say a lot about other though rather mysterious but existing phenomena. Let us begin from the one named telepathy. What is the telepathy like? It is the ability of a man to grasp what another man thinks, understands and sometimes knows. It is a kind of evidence of interchange of the information which is kept in fundamental code. It is important to study the conditions, circumstances and causes which make this or that man a generator or a receiver of telepathic information. We should state now that it is one of displays of the human organism properties, that is to be able to read, to use and to pass something that is linked with the fundamental code and the enormous memory which is inherent in this fundamental code. In the future we shall learn which part of this memory is constant, which part is temporary and what are the details. Nowadays, we do not know anything about these facts. But the telepathy testifies that such kind of memory does exist and is used.

There are some facts which testify that certain geometric forms lead to the display of this or that process, influence current processes, i.e. there exists the influence of the form of some objects on the processes which take place near this form or inside it. Some patents have been given for these observed phenomena. For example, the patent [169] "The device for intensifying the emission by the form" was given in France in 1979. In this patent it is shown that some polygonal frame with 16 sides helps to create high electric fields inside it, as the author says. As a matter of fact, they are not electric fields. The author states that with the help of this form he can influence the magnetic field of the Earth, the gravitational field of the Earth, the refraction index, the growth of plants, etc. Even if to suppose there is some kind of advertisement and some hyperbolization of facts in the claim, these facts do exist. The verification of this patent shows that much is being realized. The question arises why certain geometrical structures influence these or those processes. In literature there is a lot of indications of the fact that the Egyptian pyramids possess some properties which are connected with the influence of the geometric structures upon current processes. There are some interesting facts which are connected with the influence of the structures upon the processes which have been discovered and are studied in Bulgaria, some other countries and in the Soviet Union.

Nowadays, we should state the fact: there are some forms which influence the processes. What can we say about the nature of this phenomenon? Why do some static forms influence these or those processes? This influence is linked with the fact that any processes and phenomena which take place in Nature are connected with the viable and developing systems. These systems are almost always and mainly based upon the fundamental and cardinal property of microcosm, the property of the Universe bricks, the property which in a certain way influences everything we observe. A great role in the nature of all material structures is played by the fundamental field string which scans along the surface of the cone. As it has been already said, the fields which we observe and analyse are the average fields, while the instantaneous fields are contained in the string. The cone along which the fundamental field string scans has a definite angle. In [7] these angles are called the anisotropy angles. There are two main angles which determine the anisotropy of the structures connected with the fundamental field. The first is the proton angle which equals approx 17° and the second is the electron-meton angle which equals approx 22°. Practically, all material structures remember the fact that their basis is the fundamental field string which scans along the cone surface. These anisotropy angles, as it was shown [7], are responsible for the fact of crystal structures formation, for many properties of a solid. It appears that this memory reveals in macroprocesses as well. Therefore, when a form of a cone or a pyramid is created and its angles tend to the angles mentioned above or somehow are connected with them this fact excites some resonance in Nature. We predict now such resonance phenomena. They need to be studied and researched but they do exist. We must create their theory. These resonance phenomena appear in certain geometric forms which are connected with the anisotropy angles of the fundamental field. Some forms exciting the resonance phenomena in microcosm influence and should influence the macroprocesses. These facts are neither a fairy-tale and mystery, nor, naturally, anti-science. Many talanted persons have paid attention to these facts. We should find out, in-

vestigate and of course use them. The number of facts which are beyond the modern knowledge can be increased. Our aim is not to give an account of them. It is beyond the scope of our book. We want to pay attention to the possibilities which PVDS and TFF give us for the explanation of their nature and investigation of them.

Nowadays, we can not simply limit ourselves with general consideration resting upon PVDS and TFF to explain these or those facts whose nature is apparently connected with the material structures which are not matter alone. Both the Paradigm as it is and the Triunity Law of space-time-matter give the opportunity to extend our knowledge beyond the bounds of the matter. We now rewrite the basic equation of the Triunity Law:

$$R_{ik}^{(\zeta)} - \frac{1}{2} g_{ik}^{(\zeta)} (R_\zeta - 2\Lambda_\zeta) = \frac{8\pi\gamma_\zeta}{c^4} T_{ik}^{(\zeta)} . \tag{30.1}$$

It connects the space-time in the left part with the material structure characteristic in the right one. When we speak of matter then in the right hand side there is the energy-momentum tensor. This notion of the energy-momentum tensor for the forms which are not matter needs more precise definition. Moreover, we can not state now that this notion can be lawfully used for the material forms which do not possess the mass as the measure of inertia. But we know that the equation (30.1) is also rightful when its right part in principle equals zero. In this case there is a connection between space and time, i.e. they can not exist irrespective of each other. They are connected by the unity equation. This equation is by more extensive than the law which is inherent only in the material forms. So we can state that the equation which connects space and time

$$R_{ik}^{(\zeta)} - \frac{1}{2} g_{ik}^{(\zeta)} R_\zeta = 0 \tag{30.2}$$

is valid for many material forms. Until we meet the material forms for which this unity is not correct we should use this law of the space-time unity.

The aforesaid inevitably leads to the following conclusion. For the greatest number of material forms, even if they do not possess the mass as the measure of inertia, their space-time characteristics must obey the u n i t y Law (30.2). Therefore, when considering the phenomenon linked with new unknown material structures, we should require that space-time characteristics describing this phenomenon should obey the law (30.2). This is not simply a general consideration but the concrete relation which allows us in many cases, both discussed in this section and similar to them by nature, to make a quantitative analysis of characteristics and peculiarities of this phenomenon. We assume that this analysis is not quite exhaustive yet. But we can not only say what the fundamental nature of these or those phenomena is like or simply refer to the existence of the fundamental code, fundamental memory, to the peculiarities of these code and memory. We can try to find the real structures, which determine this process, the structures the space-time characteristics of which follow the law of the space-time unity. For the objects in question for which the notion of $\lambda$-term can be applied (as it was said in this monograph), we can write the unity equation as follows:

$$\overset{(\zeta)}{R}_{ik} - \frac{1}{2}\overset{(\zeta)}{g}_{ik}\overset{(\zeta)}{R}_{\zeta} = \overset{(\zeta)}{g}_{ik}\cdot\Lambda_{\zeta}\,. \tag{30.3}$$

Of course, it is possible to consider the aforesaid as "non-scientific" or even "anti-scientific", as it had been done before. This would allow to preserve the arrogances of modern priests of science. The author considers that we can not allow this. The mankind can use the chance to survive only when it gets rid of prejudices, which modern science has in abundance, much greater abundance than that of any religion of our modern world. It is high time to get rid of them. Until it is too late.

## APPENDIX 1
## CORRECTION OF A MISTAKE

In 1977 UFN (Soviet Physics Achievements) [124] published a review of the M.M.Protodiakonov and I. L. Gerlovin monograph which was published by the Publishing House "Nauka" [7] in 1975. The review authors consider that "... it is entirely non-scientific". The monograph [7], as the review authors have rightly mentioned, has a claim on the revision of some fundamental ideas of modern physics. During recent years it has become clear that such revision is becoming highly urgent. Besides, there have been published a lot of papers which greatly correlate with TFF created by I. L. Gerlovin and developed in the mentioned above monograph. The total number of papers correlating with TFF is about three hundred now. Therefore, it is necessary to reconsider the conclusion [124] that TFF is "non-scientific".

In the review [124] it is said: "The basis of TFF which realizes the triunity of space-time-matter is the idea that the elementary particles can be imagined as the three universes put one into another like the wooden dolls "matreshka" the bodies of which are the Schwarzschild spheres. To dispute such structure is as senseless as to dispute cosmological theories of the Middle Ages including whales and tortoises". The author of this paper is a mathematician and therefore, the emotional images like "matreshka", "whales" and "tortoises" can not convince him that the scientific position of the review [124] authors is rightful. The strict analysis of geometric design of the model of elementary particles of vacuum which was given in the TFF papers [7, 33, 34] has shown that it is a very interesting and mathematically correct version of the fibre bundle design. The authors [7] deserve reproach because instead of using generally accepted in mathematics terms "fibre" and "base of fibre bundle" they use the term "subspace" which is too general for the given case. Besides, we think they make not rightful references to TFF papers where the notions of dicomplex formalism and discrete continual geometry are not disclosed. But there is no slightest reason in the groundless statement that I. L. Gerlovin's version of a fibre bundle design is absurd. Indeed, in TFF it is proposed to use the relation between the space-time and the energy-momentum tensor, which was discovered and used only for the gravitational field by A. Einstein,

$$R_{ik} - \frac{1}{2} g_{ik} R = \frac{8\pi\gamma}{c^4} T_{ik}, \tag{1}$$

as the universal relation for all displays of the unified fundamental field:

$$R^{(\zeta)}_{ik} - \frac{1}{2} g_{ik}\, {}^{(\zeta)}R^{(\zeta)} = -\frac{8\pi\gamma_\zeta}{c^4} T^{(\zeta)}_{ik}, \tag{2}$$

where $\zeta$ is the index of subspace in which one of the elements of the fundamental field reveals. This element is responsible for the corresponding interactions.

From the whole mathematical design, which was considered in TFF papers, it is clear that the fibre bundle is meant:

$$P_\zeta : B \times G_\zeta \to B , \tag{3}$$

in which the first, i.e. the laboratory subspace, is the base of the fibre bundle $B$, and the subspace $G_\zeta$ in which the structure of particles reveals and the corresponding kinds of interaction are realized, are the fibres of this enslosing space. It is possible to dispute the degree of perspectiveness of the proposed kind of the fibre bundle and how it helps to investigate elementary particles. But there is no reason in calling the proposed mathemetically correct design "non-scientific".

In the review [124] two formulae are being cited which were selected from many hundreds given in the monograph:

$$\beta \frac{J_n'(n\beta)}{J_n(n\beta)} = m_\beta (1 - \beta^2)^{1/2} \qquad \text{(formula (77), [7])}, \tag{4}$$

where

$$m_\beta^2 = \frac{\sqrt{1+8(1-\beta^2)}-1}{2(1-\beta^2)} \qquad \text{(formula (116), [7])}, \tag{5}$$

and it is said that, firstly, these formulae are basic because they "play the role of mass formulae in the Gerlovin theory" and, secondly, they are erroneous as a whole. It is easy to see that both statements of the authors of the review are quite groundless. In the monograph there were given two formulae which were used to calculate the elementary particles mass:

$$m = \frac{2q^2\beta^2}{3R(1+\beta)^2 c^2} \cos\alpha \qquad \text{(formula (225) [7, p 56])}, \tag{6}$$

and

$$m = \frac{2s\hbar\beta_L}{R_1 c\varepsilon} \qquad \text{(formula (325) [7, p 68])}. \tag{7}$$

These formulae can not be deduced from (4) and (5). Moreover, in the monograph [7, p 47] it is shown that the value of velocity $\beta$ which was obtained from (4) and (5) is inaccurate and in calculation of the particle parameters, including the mass, another method of calculating $\beta$ is used. The verification which was made by the author of this paper has shown that only the change of the formula for calculating $\beta$ has changed the numerical value of masses in some cases up to 20—50 %. It is especially important to stress the fact that the influence of parameters, which are not connected with (4) and (5) in any way, upon the masses of the elementary particles calculated in TFF is very great. By varying these parameters we can change the numerical values of the masses by many orders. Therefore it is impossible to understand where the statement that (4) and (5) "play the role of mass formulae" was taken from.

Still greater suprise arises when we read that the equations (4) and (5) are entirely erroneous within the bounds of the theory of the Bessel functions, as the authors [124] state. It is easy to see that (4) is the direct consequence of the simplest correlation between the Bessel functions:

$$J_n'(z) = -\frac{n}{z} J_n(z) + J_{n-1}(z), \tag{8}$$

which was written by I. L. Gerlovin by means of the function $m_\beta$ introduced by him.

Found in [7] simple equation (5), where this function is expressed by means of $\beta$, is really non-trivial and was obtained for the first time. To speak ironically about this fact is at least out of place. The possibility to express exactly as an algebraical formula the ratio of two transcendental functions, namely the Bessel function of the kind $J_n(z)$ and its derivative $J_n'(z)$, is always of great mathematical interest, because in such cases, as a rule, we use the infinite series or any other asymptotic expressions. The authors of the review have apparently decided that in this case too the expression can be obtained only as an asymtotic one. The groundless reference [124] to the Eury functions is the evident proof of it.

It is easy to see that (5) is not an approximate but the exact expression, if in Bessel functions of the kind $J_n(n\beta)$ there is some connection between $n$ and $\beta$:

$$n = \frac{\left[1 + \sqrt{1 + 8(1-\beta^2)}\right]^{3/2}}{4(1-\beta^2)^{3/2}}, \tag{9}$$

and just this case is considered in [7]. Moreover, as the calculation made by the author of this paper has shown, in the given case the known error accumulation found in [135], where the recurrent relations for the Bessel functions are used, does not do away with the result of the exact character of the relation given in (4) and (5), provided (9) is valid. The detailed analysis of this purely mathematical problem is beyond the scope of this paper.

We have considered here only the mathematical aspects of the problem which was discussed in [124] and [7]. But we believe that it is the ground for the fact that the UFN editorial office and the authors [124] should admit their mistakes and apologize on the journal pages for their groundless humiliation of the dignity and the scientific authority of the authors [7]. Besides, it is of great importance for the Soviet science to defend its priority and authority.

In connection with the last question we are obliged to pay attention to the fact that the authors [124], which is surprising enough, did not take any notice of the fact that they deal with the unique potential first offered by I. L. Gerlovin [33] in 1969:

$$\varphi = q\frac{e^{-R/r}}{r} \quad (R = \text{const}), \tag{10}$$

which has no divergences in any point of the space. Neither has the field, connected with this potential:

$$\vec{E} = -\operatorname{grad}\varphi = q\frac{e^{-R/r}}{r^2}\left(1-\frac{R}{r}\right)\frac{\vec{r}}{r}, \tag{11}$$

and it is also valid for the density of the charge which is formed by the field $\vec{E}$:

$$\rho = \frac{\operatorname{div}\vec{E}}{4\pi} = \frac{q}{4\pi r^3}\cdot\frac{R}{r}e^{-R/r}\left(2-\frac{R}{r}\right). \tag{12}$$

Moreover, in the three dimensional Euclidian space the integral charge, which is spread over the whole infinite space, is not only finite but equals exaclty the charge $q$ in (10) (formula (275) [7, p 62]). Not a single potential, discussed in the scientific literature before, has such exceptional peculiarities. Nevertheless it has not drawn the due attention of the scientists yet, because, as we think, the review [124] has called upon all physicists to ignore the scientific significance of the results [7]. And this call was heard.

A. N. Sementsov

## APPENDIX 2
## ON THE POSSIBILITY TO EXPRESS THE RATIO $J'_n(n\beta) / J_n(n\beta)$ ALGEBRAICALLY IN A PARTICULAR CASE

In the theory of the ultrarelativistic rotator (multirotator) radiation [7] there is the following equation:

$$\beta \frac{J'_n(n\beta)}{J_n(n\beta)} + \frac{J_n(n\beta)}{\beta J'_n(n\beta)} = n(1 - \beta^2), \tag{1}$$

where $n$ is the number of the harmonic in which there is maximum of radiation; $\beta$ is the linear velocity of the charge movement ($\beta \leq 1$); $J_n(z)$ is the Bessel function of the order $n$.

As the existing asymptotic expressions for the Bessel functions (e.g. the Nicholson, Trikomy and Eury formulae) are not suitable when $n \to \infty$ and $\beta < 1$, to solve (1) is very difficult even with the help of a computer.

To obtain an apparent relation $n = n(\beta)$ from (1), in [7] there was used the following observation

$$\frac{J'_n(z)}{J_n(z)} - \frac{1}{2}\left(\frac{J'_{n+1}(z)}{J_{n+1}(z)} + \frac{J'_{n-1}(z)}{J_{n-1}(z)}\right) = 0\left(\frac{1}{n^2}\right), \tag{2}$$

where $z = n\beta$. When $n$ is a great number, by ignoring the terms of the order $n^{-2}$ and putting (2) into (1), we have:

$$8(1 - \beta^2) n^{1/3} - 2n^{2/3} + 1 = 0.$$

From this expression we can obtain the pairs $(n, \beta)$ which are the solutions of (1).

We now consider the question whether the assumption is correct and estimate the value of the error, but at first we consider certain properties of the function

$$B_n(z) = \frac{J'_n(z)}{J_n(z)}.$$

It obeys the following equation:

$$z^2 y' + z^2 y^2 + z y + (z^2 - n^2) = 0, \tag{3}$$

which is non-linear and has the singular points:

$z = 0$, $z = \pm n$ and $z = \infty$.

If to consider the equation (1) relative to the variable $z = n\beta$, we can obtain the following expression:

$$B_n(z) = \frac{n^2 - z^2 - \sqrt{(n^2 - z^2)^2 - 4n^2}}{2z}. \tag{4}$$

On the other hand, it is easy to see that the following recurrent relation is realized for $B_n(z)$:

$$B_n(z) + \frac{n}{z} = \frac{1}{\frac{n-1}{z} - B_{n-1}(z)}. \tag{5}$$

From this relation we can obtain the expansion $B_n(z)$ to the continued fraction:

$$B_{n+1}(z) = -\frac{n+1}{z} - \cfrac{1}{-\frac{n}{z} - \cfrac{1}{-\frac{n-1}{z} - \cfrac{1}{\frac{1}{z} - B_1(z)}}}. \tag{6}$$

Thus, we can obtain the expression for any $n$ by means of $B_n(z)$. The continued fraction (6) is stable, i.e. there is no accumulation of errors in the process of calculation. This fact differs (6) from the three-terms recurrent relations for the Bessel functions [136].

If in (2) we ignore the terms of the order $n^{-2}$, i.e. turn to the relation:

$$B_n^*(z) = \frac{1}{2}\left(B_{n+1}^*(z) + B_{n-1}^*(z)\right), \tag{7}$$

we obtain the system of functions $\{B_n(z)\}$ for which the determining relation (7) can be rewritten as

$$B_n^*(z) = n\left(B_1^*(z) - (n-1)B_0^*(z)\right). \tag{8}$$

Of course, two systems of functions $\{B_n(z)\}$ and $\{B_n^*(z)\}$ determined by relations (5) (or by continued fractions (6)) and (8), respectively, coincide only in two first terms. However, the following statements can be done.

1. If the pair $(n, z)$ fulfills the equation (1), then $B_n(z) = B_n^*(z)$. It justifies the assumption which was used in [7], namely, that the terms of the order $n^{-2}$ in (2) can be ignored. This statement can be proved by substituting the corresponding expansions and by careful comparing the items.

2. Every proper fraction

$$b_0(z) + \frac{1}{b_1(z)} + \frac{1}{b_2(z)} + \dots, \tag{9}$$

where each $b_n(z)$ is the polynomial of $\frac{1}{z}$ power, i.e.

$$b_n(z) = \sum_{k=-N_n}^{0} a_{-k}^{(n)} z^k, \quad N_0 \geq 0, N_1 \geq 1$$

corresponds to the unambiguously defined formal Laurent series of the kind

$$L_0 = \sum_{k=-N_0}^{\infty} a_{-k}^{(n)} z^k.$$

The order of correspondence of the $n$-th proper fraction $f_n(z)$ is the value

$$\nu_n = 2\sum_{k=1}^{n} N_k + N_{n+1},$$

where $n = 0, 1, 2, \ldots$.

To prove statement 1 we should make sure of the equality of the coefficients in the Laurent series which correspond to the continued fraction (6) and the terms of the recurrent relation (7) as it is required by the equation (6).

Besides the approximate method of calculation of the equation (1), discussed in [7], it is shown there that in the particular case, when between $n$ and $\beta$ there exists the relation:

$$n = \frac{\left[1 + \sqrt{1 + 8(1-\beta^2)}\right]^{3/2}}{(1-\beta^2)^{3/2}}, \tag{10}$$

(and just this relation is realized in the physical problem discussed in [7]), the equation (1) can be exactly solved as the system of algebraical equations. This result is connected with the fact that the Bessel function of the kind $J_n(z)$ when oscillating with variable $z$ according to the known law, in the points which correspond to the relation (10), gives the exact algebraical expression for the ratio of the Bessel function derivative to the function itself:

$$\frac{J_n'(n\beta)}{J_n(n\beta)} = \frac{2(1-\beta^2)^{1/2}}{\beta(1+\sqrt{1+8(1-\beta^2)})^{1/2}}. \tag{11}$$

We believe that this notice completes the discussion [7] on the possibility to express the ratio of the derivative of the Bessel function of the kind $J_n(n\beta)$ to the function itself as the exact algebraical formula (11) in a certain interval of values $n$ and $\beta$. This expression does exist and is mathematically correct.

A. N. Sementsov

## APPENDIX 3
## CRYSTAL MODEL OF NUCLEUS

As it is generally supposed, an atom nucleus consists of $Z$ protons and $N$ neutrons and their sum equals the number of nucleons in the nucleus $A$ [4]. Opposite to it, according to TFF [7], the nucleus consists of $A$ protons and $N$ negative metons which neutrolize a part of the positive charge of the nucleus. The meton is a metastable state of an electron which is inside the nucleus. Like the electron the meton is the lepton and has no quark structure, i.e. it is a bare elementary particle (Subsection 1.1). The meton can not exist in a free state. It is formed only during a certain interaction of an electron and a proton. Due to this interaction the electron is a kind of being compressed. The Compton wavelength of the meton equals three Compton lengths of the proton $3\lambda_p$. Therefore, opposite to the electron, it can become a part of the nucleus compound. Thus, the neutron is considered as a compound particle consisting of a positive proton (which defines the particle mass) and a negative light particle, i.e. meton. Hence, the nuclei of all atoms but the hydrogen nucleus, which consists of only one proton, have $A$ protons and $N$ metons. For example, in the nucleus of the beryllium isotope, the mass number of which is 9, there are $(9-4)=5$ metons. We put this number by the right inferior side of the element symbol while the charge is placed by the left inferior side and the mass number is placed by the left upper side, i.e. ${}^{9}_{4}Be_{5}$.

According to TFF, the fundamental field of elementary particles, e.g. protons and electrons, which have ultrarelativistic velocities and precession, acquires strong anisotropy [7, 34], which is the result of this movement. This field has the maximum on the instantaneous axis of the subparticles rotation and the minimum in the plane of their rotation. The precession frequency of the elements of proton and meton substructures has the order of $10^{18}$ c.p.s. Their instantaneous axis of rotation is a kind of a forming line which circumscribes the surface of the anisotropy cone in the space. The tangent of the angle between the cone forming and cone axis of symmetry for the free proton is equal to $\operatorname{tg}\alpha_p = \frac{2\sqrt{2}}{9} = 0.314\,270$, from here $\alpha_p = 17.446\,35°$, and for the free electron and meton $\operatorname{tg}\alpha_e = \frac{2\sqrt{2}}{7} = 0.404\,061$, $\alpha_e = 22.001\,71°$.

The anisotropy angle of the proton in the bound state with the meton increases and practically equals $\alpha_e$.

According to the *crystal model* of the atomic nucleus [7], in the proper coordinate frame, where the structure elements can be considered stationary, all the protons in the nucleus form the *proton* figure and all the metons form the *meton* one. Their symmetries are self-coordinated. Every figure taken separately is unstable, but as a whole they form stable nuclei. The degree of the field anisotropy (the ratio of the maximum to the minimum) for the proton is $10^7$ and for the meton is $10^{27}$, i.e. by 20 orders more. Therefore, the nucleus construction mainly depends on the number and mutual disposition of the meton anisotropy cones. The field maximum is in the points of intersection of several anisotropy cones. The field minimum is on the axis of the anisotropy cone or

in the perpendicular plane coming through the meton centre. All the protons, repelling from each other, drift to take place symmetrically in the elements of symmetry of the nucleus proton figure, where the proton interaction is minimal and in the points of intersection of the meton anisotropy cones, where the links with metons are maximal.

Let us consider, as an example, the features of the crystal models of the nuclei of two beryllium isotopes. The proton figure of ${}^{9}_{4}Be_5$ consists of 9 protons and the meton one consists of 5 metons. Therefore, the charge of the nucleus $Be$ equals $9 - 5 = 4$. The proton figure is a trigonal prism the sides of which are centred and these centres are protruding outside. In this figure the protons are arranged in three parallel layers. The whole charge of the proton figure equals $3 + 3 + 3 = 9$. The meton figure is a trigonal dipyramid, the charge equals $-2 - 3 = -5$. Two coaxial meton anisotropy cones are arranged on the triple axis of symmetry which is perpendicular to the proton layers. These cones intersect along the circumference on the level of the middle layer of the proton figure. These cones extensions pass through three upper and three lower protons which are on both sides of the nucleus centre. The axes of symmetry of three other meton anisotropy cones are arranged perpendicular to the common axis of the two first. Their axes of symmetry intersect in the nucleus centre at an angle of 120°. Therefore, the axes of these cones during precession circumsribe three anisotropy cones, each of them passing through two last protons of the trigonal prism (the first proton being on one side of the nucleus centre and the second on the other). The proton or the neutron spins in the nucleus are the projection of the moment of momentum of the substructure mass, which moves along the circumferences, upon the anisotropy cone axis. Therefore, two meton spins are directed opposite along the triple symmetry axis of the nucleus and thus compensate each other. Other meton spins are directed radially in the symmetry plane and thus also compensate each other.

The axes of three proton cones of the middle layer of the proton figure are parallel to the triple symmetry axis. Therefore, their total spin equals $+\frac{1}{2} + \frac{1}{2} + \frac{1}{2} = +\frac{3}{2}$. Other six proton spins are arranged symmetrically and directed to the nucleus centre. Therefore, their total spin equals zero. Thus, there are only three spins of the middle layer protons left. Their total spin equals 3/2, which is proved by the experiment.

The proton figure has the positive charge and the meton one has the negative charge. Hence, their link is based on the interaction of fundamental charges of the nuclear particles which have a complex field of their proton and meton anisotropy cones. In fact, the fundamental field is concentrated along the disappearingly thin string which scans along the surface of the anisotropy cone.

Each of the three protons of the outer layers gets on the intersection of two meton anisotropy cones, the axes of which are perpendicular. Each of the three protons of the middle layer gets on the plane of intersection of two meton anisotropy cones which have the common axis. Thus, the interacting forces of attraction are directed to the nucleus centre, i.e. forces of particles interac-

tion keep them in the nucleus, providing their stability, when this system is considered in proper coordinates.

For other points of intersection of the meton cones the resultant forces are directed from the nucleus centre. Therefore, the protons, which have occurred to be there, can not become a part of the stable structure.

The atomic nucleus of the other beryllium isotope ${}^{8}_{4}Be_4$ has a different structure. Four metons repelling from each other tend to be arranged in the square angles. The meton anisotropy cone axes are directed obliquely to meet each other. Thus, the meton anisotropy cones are arranged like two coaxial pairs which are intersecting along two circumferences, the axes being intersected at right angles. The protons are arranged on the meton anisotropy cones intersection.

The proton figure is a primitive tetragonal prism, 8 protons being in its angles. The size of this prism along one edge is twice longer than along the other one. The charge of the meton figure equals $-2 - 2 = -4$. The charge of the proton one equals $+4 + 4 = +8$. The total nucleus charge equals $+8 - 4 = +4$. As 8 protons are kept in the nucleus by 4 metons only, instead of 6, which are necessary for a more stable isotope of cubic syngony, the mentioned above geometry is probably the main cause of great isotope ${}^{8}_{4}Be_4$. instability. The period of its fission into two $\alpha$-particles is only 0.067 s. [138]:

$${}^{8}_{4}Be_4 = {}^{4}_{2}He_2 + {}^{4}_{2}He_2 .$$

The spins of the four protons are directed radially, passing through the nucleus centre; therefore, their total spin equals zero, which is proved by the experiment.

Thus, there are two important beryllium isotopes. The only stable one is ${}^{9}_{4}Be_5$ and the second one, the fission of which occurs right after formation, is radioactive one ${}^{8}_{4}Be_4$ . It is possible to define reasonably their masses, charges, spins and also the causes of their stability or fission by means of a crystal model of nucleus.

We have considered as an example the static structures of the crystal models of the nuclei of two berillium isotopes. These structures are rotating relatively to this or that axes of symmetry. This motion greatly contributes to the cover-model and to the rotary-model of the nucleus (the latter concerns mainly the nucleus with spherical asymmetry).

Physical vacuum plays a great role in forming the nuclei properties. An example of this is given in appendix 4.

The protons and metons can form the Cooper pairs in the nucleus, causing the phenomenon of superconductivity and superfluidity (see Section 22).

The crystal model of nucleus should not be considered as an alternative to the known models [139, 4] of atomic nuclei. We believe this model to be the missing part of the modern nucleus theory that could unite different models (which are a priori and uncoordinated frequently) in the unified theory of nucleus. We are sure that by using the crystal model of nucleus and TFF it would become possible to create the basis of the universal theory of atomic nucleus.

M. M. Protodiakonov

## APPENDIX 4
## ON THE ROLE OF PHYSICAL VACUUM IN RADIOACTIVE NUCLEI FISSION

Nuclei radioactivity is well investigated. The energy of products of fission, time of fission and other parameters are rather accurately measured. But theoretical calculation of these parameters is rather difficult. It is connected with the fact that not everything in the physical nature of this phenomenon is well known, in particular, up to now we do not have any clear understanding of the role of physical vacuum in radioactive nuclei fission. The current state of the theory of fundamental field helps to clear up this problem.

According to TFF, the formation of atom nuclei and the radioactive fission of instable nuclei are defined by interaction of protons and neutrons*) in the nucleus with elementary particles of the vacuum. The free proton and neutron, as can be seen from the formulae for theoretical determination of their parameters and from the quark structure of elementary particles, when interacting with PV during quark structure formation, increase their masses.

The minimum increase of the nucleon mass is defined by factors which are completely defined by permittivity of physical vacuum $\varepsilon_V$ which equals numerically the permittivity of vacuum for the circular current in the proton structure $\varepsilon_{1p}$ or the inner circular current in this structure $\varepsilon_{2p}$:

$$\varepsilon_{1p}^{-1/2} = 1.001\ 163\ 92\ ,\ \varepsilon_{2p}^{-1/2} = 1.001\ 279\ 90\ . \tag{1}$$

The maximum increase is defined by factor:

$$\frac{a_{gp}}{\varepsilon_{2p}^{3}\,\varepsilon_{1p}^{1/2}} = 1.009\ 77\ ,$$

where $a_{gp}$ is the dimensionless constant which equals numerically a square of ratio of relativistically contracted radii of the proton inner $R_2$ and outer $R_1$ orbits of motion of subparticles (see Sections 16 and 17):

$$a_{gp}^{1/2} = \frac{R_2(1-\beta_2^2)^{3/2}}{R_1(1-\beta_1^2)^{3/2}} = \frac{k_y\beta_2}{k_x\beta_1} = 1.000\ 889\ 02\ . \tag{2}$$

The bond energy of particles in the nucleus should be defined by gradual decreasing the physical vacuum influence upon the nucleus. Simplest nuclei have minimal decrease and most complex ones have maximal. Hence, the bond energy of one nucleon in the nucleus should not be less than

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*) See section 7 and appendix 3 as to the neutron structure, according to TFF.

$$m_n c \left( \varepsilon_{1p}^{-1/2} - 1 \right) = 1.088 \text{ MeV} , \tag{3}$$

and not more than

$$m_n c \left( \frac{a_{sp}}{\varepsilon_{2p}^{3} \varepsilon_{1p}^{1/2}} - 1 \right) = 9.17 \text{ MeV} , \tag{4}$$

where $c$ is the light velocity; $m_n$ is the nucleon mass which is assumed to be equal to 938.280 MeV.

The numerical values of the minimum and maximum bond energy of one nucleon in the nucleus obtained by experiment entirely agree with (3) and (4).

As it is shown in this monograph, physical vacuum plays a defining role in the quark structure formation of elementary particles. PV goes on to influence the nuclei structures and properties during nuclei formation from nucleons. Many consequences of this fact are described above (see Sections 7, 10 and 16). In this paper we deal only with concrete examples which prove the structural unity of the world of elementary particles, atomic nuclei, matter as a whole and physical vacuum, which is the basis of it.

We now consider the problem of energy connected with the radioactive nuclei fission.

The total energy which is carried away with products of the radioactive nuclei fission is also mainly defined by the physical vacuum properties and that helps to calculate the upper and lower boundaries of this energy.

EPVs are virtual particles, nucleons are observable particles. Whatever mechanism of interaction of nucleons and EPVs could be, each atom nucleus in all cases should have the following uncertainty relation:

$$E \frac{L}{c} \geq \hbar , \tag{5}$$

where $E$ is the energy carried away by the fission products; $L$ is the average characteristic length, along which the interaction of EPVs and nucleons of nucleus takes place.

As this interaction should take place along the geodesic of EPV structures, which are circum ferences in subspace $(2 \rightarrow 1)$, $L$ should be $2\pi$ times longer than the average distance $l_V$ between the EPVs in the given kind of vacuum.

In TFF this length for any vacuum is calculated from the condition:

$$\varepsilon_V = \mu_V ,$$

and $\mu_V$ is calculated from the equality (see table 16.1):

$$\mu_V = \left[ 1 + \frac{2 \pi e^2 n_V l_V^2}{3 m_V c^2} \right]^{-1} , \tag{6}$$

where $n_V$ is the EPVs concentration in this vacuum; $m_V$ is the sum of the absolute values of masses of the particle and antiparticle which have formed EPV (the EPV mass in the laboratory subspace equals zero; in this subspace the particle has the positive mass and the antiparticle has the negative one); $e$ is the electron (proton) charge.

As in TFF (for a single particle and not for EPV as a whole) we have:

$$n_V = (16\,\pi^2 R_V^3)^{-1}, \tag{7}$$

for $l_V$ we finally have:

$$l_V = \left(\frac{24\,\pi m_V c^2 R_V^2 (\epsilon_V^{-1} - 1)}{e^2}\right)^{-1/2}. \tag{8}$$

By inserting the numerical values we find the values of the characteristic lengths $L$ of the electron-position $e^+e^-$ and proton-antiproton $p^+p^-$ physical vacua:

$$L_{e^+e^-} = 1.343\,8 \cdot 10^{-9}\,\mathrm{c}, \tag{9}$$

$$L_{p^+p^-} = 6.971\,2 \cdot 10^{-13}\,\mathrm{c}. \tag{10}$$

Thus, we can see that the characteristic length $L_{e^+e^-}$ of the vacuum determines the sizes of atom covers, and the characteristic length $L_{p^+p^-}$ of the vacuum corresponds to the nuclei sizes.

It is clear that the minimum energy of the nuclear fission products is defined by the length $L_{e^+e^-}$ and the maximum one by the length $L_{p^+p^-}$. Hence, the energy carried away by the nuclear fission products is within the limits:

$$\frac{\hbar c}{L_{e^+e^-}} \le E \le \frac{\hbar c}{L_{p^+p^-}}. \tag{11}$$

By inserting numerical values we get:

$$14.68\ \mathrm{KeV} \le E \le 28.30\ \mathrm{MeV}, \tag{12}$$

which is also proved by the experimental data for any kind of nuclear fission.

D. I. Ivanko, I. L. Gerlovin, I. D. Dvas

## APPENDIX 5
## SOME CONSIDERATIONS CONCERNING SEVERAL PROBLEMS OF THE THEORY OF SYSTEMS IN THEORETICAL PHYSICS

Since 1960 a lot of papers on the so-called quantum logic have appeared. We believe that to speak about specific, isolated, merely quantum logic is unreasonable. It is obvious that quantum theory has many peculiar features which can not be restricted by the methods of formal logic only. Relativity has the same right to have its own logic because it is impossible to put all its principles into the Procrustean bed of formal logic.

Nowadays the attempts have been made to create some general logic where the quantum logic and the classical one could be its particular cases. Yet, the question arises: where does the logic of relativity come in? Besides, the specific logic of cybernetics (or as it is called now the theory of information systems) is being formed now. Why should we use quite different and not connected with each other logics in describing Nature?

The author of this article believes that all Nature phenomena can be described by means of the logic of the theory of systems, if extended enough. As to quantum physics logic, those of relativity and other modern physical theories, they should be particular cases of this general logic, provided they manage to keep their self-dependence.

The aim of this article is not to state the main elements of the logic of theory of systems, the more so, this logic has not been formulated yet as a complete one. We simply want to analyse some problems of relativity and make necessary conclusions. It will be done by using some existing elements of the logic of theory of systems for several concrete examples.

In the paper [142] we have shown that considering the relativistic effects as the result of mapping the information from moving bodies in the medium where the velocity of spreading of the information equals $c$, we can get some results. These results may be both agreed with the special relativity and not agreed. For example, the fact that the total body energy equals $mc^2$ entirely agrees with relativity. Likewise we get the following: the mapped signal should be changed by the Lorentz factor $(1 - \beta^2)^{1/2}$ which agrees with SR. But the question is: should this factor be used for the mass or the acceleration when acceleration takes place? The results can be quite different.

The fact that the axiomatics of SR can not be considered entirely complete is proved by the contradiction between SR and the experiment. It is known that according to SR, the electric field of the moving charge, which moves at ultrarelativistic velocity, is deformed, being increased in the plane perpendicular to the velocity by $\gamma = (1 - \beta^2)^{-1/2}$ times. The flow of the particles, which have been accelerated in the accelerator, can not be considered as a circular current, which, as it is known, does not create the electric field, but as a flow of accelerated particles. Then in the plane perpendicular to the trajectory there should be observed an electric field increased by $\gamma$ times. In the proton accelerator in Serpukhov this increase should be by about 80 times. Yet, such

effect is not observed. The question arises: what is the cause of it? In this case the theory of systems assumes that there is a flow of information, alternative to that of SR, which either leaves the field as it is, without any changes or, like the circular current, suppresses the information about it to that degree that the electric field is not observed.

Of course, the analysis of the physical phenomena based only on the logic of the theory of information in the theory of systems can be considered either as possible or as necessary, from the mathematical point of view, but not as a sufficient one.

In this sense, we consider as perspective the working out of the theory of systems which can be used in the physical theories together with the results of the new unified TFF. Apparently, it will give the possibility to find not only admissible or necessary conditions but also sufficient ones.

A. A. Denisov

## APPENDIX 6
## ON RELATION BETWEEN INERTIAL AND GRAVITATIONAL MASSES

It is known that A. Einstein has postulated the principle of equivalence of inertial and gravitational masses in the general relativity [58]. In the unified theory of fundamental field [34] as long ago as in 1973 it was shown that the principle of equivalence in the Einstein equation can not be realized because this equation expresses the triunity of space-time-matter and is not the equation of the field in a general sense.

A. A. Logunov and his colleagues [65] have shown that under certain conditions in the case of the Schwarzschild geometry the inertial mass in GR, as opposed to the gravitational one, depends on the choice of coordinate frame and therefore, the principle of equivalence is broken. We have investigated under what conversions of coordinates and in what domain the above mentioned conclusion of A. A. Logunov and his colleagues is correct. In this paper we are going to give only the main results of the research.

Let us pay attention to some inaccuracy which was made in the calculations in the paper [65]. For this, let us recalculate the inertial mass $m$ by the formula given in [65, p 33], using new coordinates $x_n^\alpha$ connected with the old ones $x_{ol}^\alpha$ by the conversion of the kind:

$$x_{ol}^\alpha = x_n^\alpha \left[ 1 + f(r_n) \right] ; \; r_n = \sqrt{x_n^2 + y_n^2 + z_n^2} .$$

Here $f(r_n)$ is some function of $r_n$ which meets the conditions formulated in detail in [65].

After simple conversion we get the following expression for the inertial mass:

$$m = \frac{c^2}{2G} \operatorname*{lim}_{r \to \infty} \left[ r_g + r^3 f'^2 + 2r^2 f' (1 + f) \right] , \qquad (1)$$

where $r_g$ is the gravitational radius; $r$ is the coordinate; $G$ is the constant of gravity; $c$ is the light velocity.

This expression for $m$ differs from that obtained in [65] (formula (4.20), p 33) by the third term in brackets which was unreasonably neglected in [65].

As the analysis has shown, all the admissible functions of coordinate conversion depend on the value $\left(\frac{R}{r}\right)^\beta$, where $R$ is the constant of the length dimension, and $\beta$ is the dimensionless parameter. By choosing, for example, the function of coordinate conversion $z$ as

$$z_1 \equiv (1 + f) = \left[ 1 + \left(\frac{R}{r}\right)^\beta \right] (1 - e^{-r/R}) ,$$

and putting the value $f'$ into (1) we get:

$$m = \lim_{r \to \infty} \left( M + C_1 r^{1-2\beta} - C_2 r^{1-\beta} \right) , \qquad (2)$$

where $M = \frac{r_g c^2}{2G}$ is the gravitational mass; $C_1 = \frac{c^2 \beta^2 R^{2\beta}}{2G}$, $C_2 = \frac{c^2}{G} \beta R^{\beta}$ are certain constants; when $r \to \infty$ they depend only on the parameters of the chosen function of the coordinates conversion. As to the expression (2) it is invariant relatively to the choice of the concrete function from the class of the admissible functions.

We now consider an example of another function $z_2(r)$:

$$z_2 = (1 + f) = \frac{1}{1 + (R/r)^{\beta}}; \; z' = f' = \frac{\beta R^{\beta}}{\left[1 + (R/r)^{\beta}\right]^2 r^{\beta+1}}.$$

By putting $f'$ into (1) we get (2) where the values of the constants are:

$$C_1 = \frac{\beta^2 R^{2\beta}}{\left[1 + (R/r)^{\beta}\right]^4}; \; C_2 = -\frac{2\beta R^{\beta}}{\left[1 + (R/r)^{\beta}\right]^2}.$$

Such examples can be continued.

From (2) it follows that the equality $m = M$ is realized only when in (2) we have:

$$\lim_{r \to \infty} (C_1 r^{1-2\beta} - C_2 r^{1-\beta}) = 0. \tag{3}$$

If $\beta$ is within the interval

$$0 \le \beta \le 1, \tag{4}$$

then (3) is not realized and the expression for $m$ diverges. In the point $\beta = 1$ we have $M = m$ if $R = 0$. Besides, from the paper [65] it follows that the equality (3) is not realized within another interval of dimensionless parameter $\beta$, namely within the interval $0 \le \beta \le 1/2$. It is the result of the unreasonable neglecting of the third item in the formula (1) which was assumed in [65]. Thus, if (4) is realized, then $m \neq M$ in any way of the coordinate conversion, corresponding to the conditions given in [65].

As the inertial mass $m$ in GR can have any value, it is possible to assume $m = 0$. Then we have:

$$M = \frac{c^2}{2G} \lim_{r \to \infty} (C_1 r^{-\beta} - C_2) r^{1-\beta}. \tag{5}$$

As $M$ is constant, the equality (5) can be realized only when $\beta = 1$. In this case from the condition (5) and the equality $M = \frac{c^2 r_g}{2G}$ for any concrete function of the coordinate conversion (i.e. for the concrete values $C_2$), it is possible to find the relation between the constant of the length $R$ and the gravitational radius $r_g$ which depends on the kind of this function. For example, if we have the exponential function of the kind

$$z_3 = (1 + f) = e^{-R/r}, \tag{6}$$

we can get the simple relation of $R$ and the gravitational radius $r_g$, when $\beta = 1$:

$$R = \frac{r_g}{2}. \tag{7}$$

It is necessary to point out that according to TFF, in the second subspace the constant of the length $R$ of the priming *bare* EPs is connected with $r_g$ (see section 16) by the same relation (7). In this case the coordinate conversion is connected with the function of the kind (6) and if to assume, in accordance with TFF, that the dimensionless constant $\beta$ equals $\frac{v}{c}$, then (4) is realized automatically. As the expression for the inertial mass $m$ in TFF is the same as in GR, it is obvious that the principle of equivalence can not be realized in TFF, and this is what takes place in this theory.

The conclusion about the violation of the principle of equivalence of the inertial and gravitational masses for the Schwarzschild metrics can be extended upon some other solutions of the Einstein equation, e.g. upon the Kerr and Reissner-Nordström geometries. The Kerr metrics is the precise solution of the Einstein equation which describes the space-time around the central rotating body [46]. When $a=0$ ($a$ is the specific moment of momentum of the central rotating body) the Kerr metrics is degenerating into the Schwartzschild metrics [46]. If we analyse the asymptotic behaviour of the metric coefficients, we can see that when $r \to \infty$ the Kerr metrics approaches the Schwarzschild metrics [46].

As the calculation of the inertial mass is connected with the integration over the infinitely remoted surface, it is obvious that when $r \to \infty$ only the specific features of the Schwarzschild metrics are left. Hence, the inference about the violation of the equality $m = M$ when the above-mentioned conditions are realized, is also correct for the Kerr solution.

The Reissner-Nordström metrics corresponds to the case when the charged central body is immovable or moves uniformly. This metrics can be written [12] as

$$ds^2 = \left(1 - \frac{r_g}{r} + \frac{Gq^2}{r^2}\right) c^2 dt^2 - \frac{dr^2}{\left(1 - \frac{r_g}{r} - \frac{Gq^2}{r^2}\right)} + r^2 \left(d\theta^2 + \sin^2\theta \, d\varphi^2\right), \tag{8}$$

where $q$ is the total charge of the central body; $r$, $\theta$, $\varphi$ are the spherical coordinates.

From the expression (8) we can see that when $r \to \infty$ the terms which have $q$ can be ignored, therefore, in this limit this metrics does not differ from the Schwarzschild metrics. Hence, the behaviour of the inertial mass (when $r \to \infty$) is defined by the Schwarzschild metrics, i.e. the principle of equivalence is violated in this case as well.

I am thankful to I.L. Gerlovin and his colleagues for the discussion.

E. V. Gnilovskoy

## APPENDIX 7
## FUNDAMENTAL CODE *)
## (WHERE DOES NATURE KEEP ITS FUNDAMENTAL INFORMATION? HYPOTHESIS)

Nowadays the symbiosis is merely a biological notion. In the Russian explanatory dictionary symbiosis is defined as "living together of two or more organisms when they do good for each other".

Is it possible to extend this notion? Could mutual connection and stipulation between other material forms of our Universe arise? We think that the endless evolution of matter in the Universe has created a lot of different kinds of "collaboration" which can not, of course, be limited to living organisms only.

We shall speak about the *fundamental symbiosis* which reveals apparently not only on the Earth but in the whole Universe as well.

If such deep and close mutual connection does exist, we need another term to define it. But for the time being we shall use the usual term "symbiosis" by extending its meaning.

When we speak about the evolution of animate Nature on the Earth, first of all we mean the ability of organisms to adapt themselves to the surrounding conditions. And what about the reverse? Can it take place? Are there any cases of "adapting" of the surrounding nature to the needs of the developing living things?

Of course, the air has not "adapted" to the animal world. But on the contrary, the animal world has adapted to the air. But the similar explanation is possible not for any case.

For example, how can the fact be explained that Nature has been "preparing" coal and oil, which are so necessary for the mankind now, for a lot of million years? In this case it is hardly suitable to state that the mankind has learned to use natural fuel during its evolution. Besides, we have reasonable arguments to think that Nature has prepared coal and oil for us by no means for combustion but for more expedient use. If to develop this idea we shall find a lot of things which can not be connected with the ability of living things to adapt to the surrounding medium.

Let us consider one more example. The rate of growth of people on the Earth is increasing quickly. But the reserves of main kinds of energy of today are decreasing. To preserve our civilization, the mankind should take possession of new kinds of energy, e.g. the thermonuclear one. But we are not going to state that the intensive growth of mankind is a sign of its getting adapted to the use of the thermonuclear energy, or the more so, of the alternative one.

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*) For the first time this hypothesis was published in 1969 [101].

Nowadays, in the epoch of the rapid scientific and technical revolution we more and more get convinced that scientific and technical progress greatly influences the future of our civilization. It is clear that if a man changes Nature and uses the results of these changes for his own needs, the evolution of the human organism can not be explained by the fatal influence of the surrounding medium only.

From this point of view the problem of the origin of life on Earth is not less important.

Nowadays we know only one life form, namely the albuminous one. It can appear only when there is water and oxygen, and the temperature interval is very narrow. The albuminous life is impossible when the temperature is higher than 100 °C. It dies away when the temperature becomes lower than −80 °C. And as to the interval of temperatures favourable for the most perfect living organisms, it is extremely small.

Nowadays it is absolutely known that the albuminous life can not appear in any other conditions. Of course, we can not deny the possibility of existence of other life forms. But we do not have any authentic knowledge of them, though practically we deal with different conditions and wide intervals of temperatures.

A question arises whether it is accidental that favourable conditions for the development of albuminous life have appeared on the Earth. Had the distance between the Earth and the Sun been different when the solar system was formed, these conditions would have been substantially different too.

It is the fact that such conditions do not exist either on Mars or Venus, which are our nearest planets in the solar system. But it is possible that such conditions once existed on Mars and will exist on Venus in many million years. If so, it is hardly reasonable to consider such complex of factors as accidental.

Indeed, there should be a lot of "accidental" coincidences on the surface of the planet that conditions for the development of the superior forms of the albuminous life might be favourable.

For example, to ensure the normal temperature interval is possible only if the average distance to the Sun, the intensity of the solar radiation, the temperature conditions inside the planet, the speed of rotation, the thermal properties of the atmosphere and a number of other factors could form a strictly definite combination. If only one of these factors changes, the conditions necessary for the existence of warm-blooded animals will disappear.

One more example. Superior albuminous life needs oxygen. The primitive forms of living organisms can exist in conditions of oxygen starvation, but the cells of human and most of warm-blooded animals need a certain oxygen conditions. A man can exist without any food for about three weeks, without any water — for some days, but without oxygen he can exist for some minutes only. And what a great many different coincidences were necessary to provide cells of superior livings by oxygen. Of course, we have already said that the air has not "adapted" to the

animal world. The surrounding medium influenced the evolution of the animal world greatly. But what would have happened if the atmosphere of Earth had contained, for example, chlorine, hydrogen sulphide, a greater percentage of carbon dioxide etc? Would the superior life appear on Earth then? We can name a score or more of gases which could have been in the atmosphere composition, but rather a small quantity of one of them would be enough to make any life impossible.

The ability of animals to use the oxygen of the air can be explained by their adaptation to the atmosphere during evolution. But why did the conditions preventing the animal world from its development not appear on the Earth? To understand this fact is more difficult. It is obvious that it would have been impossible "to adapt" beforehand to the unexpected appearance of these conditions.

There are some phenomena which could have occurred and created the conditions inadmissible for superior life. For example, a little change of ozone contents in the upper layers of the atmosphere could break the thermal conditions and greatly increase the quantity of lethal ultra-violet rays of the Sun which reach the Earth.

The recent ozone hole affair is the striking confirmation of these ideas.

The existence of mankind is accompanied by such a great number of wonderful coincidences that if they had been "accidental" all the people on the Earth could have believed that the only lottery-ticket they have, would always win the greatest sum at annual lotteries.

Generally speaking, during recent decades the mankind, amazed by the laws of great numbers in the calculus of probability and by triumphal victories of these ideas in quantum mechanics, considers the supremacy of chance in Nature phenomena as some fetish. But is it right?

Let us consider quite a banal example. An ordinary hen's egg. From the physical point of view it is a two-phase system, i.e. solution of a solid in a liquid. What will happen if we heat this system? Any physicist will answer that as the thermal velocity of molecules will increase the chaos of the system will grow. But we know that if we warm the egg, up to a certain temperature, and keep it constant for some time, the most perfect form, i.e. living organism will appear. No statistics of chances, no laws of great numbers could in the past and can in the present explain this phenomenon. Besides a well known statistics of chances, there should be the statistics of necessities of which we have had no idea up to now. PVDS and TFF have given us some opportunity to make first steps towards understanding the essence of this statistics.

Nowadays nobody has any doubts about the fact that the development of animate Nature was defined by the Darvin evolution. But the only principle of the accidental selection is absolutely insufficient to solve the problem of the origin of surrounding animate (and may be inanimate) Nature.

It is known what a great role is played by genes for the living organism development. Nowadays we also know that the main biologic code is "recorded" in the structures of complicated mole-

cules. It is, so to say, the code of the concrete biological species which is recorded by means of the most perfect and peculiar device, closely related to that which we call the cybernetical machine.

But has this device as a whole also appeared by chance? And is there any other code anywhere, which would have the ability to create such devices during evolution? If it is so, where is this code recorded?

Apparently, we can state that all material forms, we mean just all, possess not only energy but information as well. As to the information it should be kept somewhere.

A scientist from Moscow professor N. I. Kobozev has published a scientific paper [145], the significance of which can not be overestimated. He has proved that our memory, which has been preserved in our brain for scores of years, can not be "recorded" either in cells, or molecules, or even atoms. It is so, because the thermal fluctuations of molecules and atoms should "erase all the recording" rather quickly under the influence of the temperature of a man's body. But the memory is not erased. Why? What is its keeper?

If we go on considering such questions we can also meet another serious problem. The mankind on Earth can not exist for ever. Earlier or later, maybe in many hundred million years it will cease to exist on our planet. There is no doubt about the fact that some creatures similar to people once existed on other planets of our boundless Universe. So, they are sure to appear in the future and maybe they already exist somewhere in the remote worlds. A question may arise whether these events are quite accidental, separate, not connected with each other. Can it be so that mankind has not got any ancestors and will not have any descendants? Is it possible that Nature, when creating intellectual living creatures, is simply dicing?

We would not like to get positive answers to these questions. In our considerations we have touched upon only a part of such questions, which may seem not to have close connection between each other. Yet, we could propose a guess which would help if not to give answers to these questions but at least to raise slightly the cover of the mistery above them.

It would be much easier to answer these questions if we could find some structures that would possess the fundamental code of the development of matter in the Universe.

Indeed, let us suppose that there exist some hypothetic things, having some inner srtucture and retaining their properties in spite of all known cataclysms. These fundamental particles should retain their structure during most violent processes, such as explosive processes inside stars, nuclear reactions in the centres of stars accompanied by extremely high temperatures, pressures,etc.

These hypothetic objects should possess the most important ability to retain themselves while moving in the "emptiness". All the stars, planets and other bodies occupy quite insignificant part of the Universe. The "emptiness" was once called the ether, though later on this term was quitted. Nowadays the physicists use a new notion "vacuum", which is being given these or those new properties. For example, it interferes with the processes inside the atom, giving its "vacuum correc-

tions" to the experimental data (for details see sections 1.5, 5.4, parts II and III). The vacuum is the birthplace for a particle-antiparticle pair (such as an electron and a positron), which come to existence from "nothing". The vacuum by itself has no temperature, its temperature is equal to "absolute zero" (the temperature of the interstellar space differs from zero because besides the "vacuum" it contains a lot of different particles and bodies). Apparently, it is not quite easy to retain itself in such medium for a long time.

However, quite stable objects exist in the space. These are protons, for example. The protons make up the greater part of so-called primary cosmic rays. These particles roam about the whole Universe, retaining their properties. No cataclysms can destroy the protons. But to state the fact that cosmic rays, and protons in particular, store the fundamental code of matter evolution in the Universe, we should assume that they possess some inner structure on which this code could be "recorded". But as a matter of fact, our knowledge of the mechanism of "recording" the code programs is very poor (only 40 years ago we got to know that such programs can exist). It is quite possible that the "recording" of the program is done by some other way, not requiring any inner structure. But we believe that to appeal to some intellect, that can not be understood, is of no good.

In this monograph we speak about the unified structure of so-called elementary particles, i.e. microparticles. According to this structure, they consist of a very great number of "subparticles" (for example, a proton consists of 6 thousand "subparticles"). Yet, it is supposed that these "subparticles" can not exist by themselves. In this sense microparticles are elementary ones, i.e. they are indivisible. Thus, elementary particles can possess a stable structure and, hence, the fundamental code can be recorded on such structure. A great quantity of subparticles can ensure "retaining" of not only one but a lot of programs. Among them can be such programs that ensure the evolutional progress foreseing unexpectedly arising situations, i.e. "accidental" evolutionary factors.

What conclusion can follow from this supposition? As it is known, the genetic program defines physiological vital activity of simplest organisms. Apparently, even rather complicated organisms such as insects, are fully guided by a previously "recorded" program. Occasional events cause only mutations and together with them evolutional "finishing" of the program.

Something of this kind can take place in the whole Universe. If cosmic rays carry the fundamental code, the latter can contain the principles of evolutional development of animate and inanimate Nature. The principles of programming the evolution of flora and fauna on the planets can be among them.

It is not difficult to understand that this fact helps to answer the questions which were put here and the questions of the same kind.

But one should not think that if the Universe possesses such fundamental code (that provides harmony in evolutional processes and creates fundamental symbiosis), this code will fatally predetermine everything. During concrete realizations of program in evolutional process a great significance belongs to the chance. This was brilliantly proved by Darvin and became quite evi-

dent due to the progress of modern genetics. And it goes without saying that the behaviour of separate people and certain groups of human society is far from always being defined by the fundamental program. Much is defined by quite another program, which is being created during historical development of mankind and is its spiritual wealth.

I. L. Gerlovin

## APPENDIX 8
## USAGE OF PHYSICAL VACUUM ENERGY UNDER FUEL OIL ACTIVATION

The phenomenon of activation of different media, water and its systems in particular, under the influence of physical factors belongs to the problems the solution of which by means of modern physics and physical chemistry is connected with inevitable difficulties.

The great experimental data connected with the influence of mechanical impacts, magnetic field, high temperature, phase transitions upon the liquid properties have been obtained up to now. But these data have not yet got the complete theoretical explanation. The recently discovered method of electrochemical water activation lays a still stronger emphasis upon this explanation.

Taking the problem of activating water solutions and organic fuel by electric field as the primary object of investigation (section 23), we aimed to show the possibilities and advantages of the theory of fundamental field in explaining the essence of this phenomenon and also in solution of applied problems.

Here we shall dwell upon the process of fuel activation. If the fuel contains dissociated liquid, water for example, and its quantity is up to 5—10 %, the dominating process is that of water activation described in section 23. If the fuel does not contain any liquid then dissociation does not take place. Nevertheless, fuel can be activated. Then the process of activation will be as follows: under the influence of electric or electromagnetic field the excited EPVs of the electron-positron vacuum intrude into the structure of the fuel molecules. These EPVs, "intruded" into the atoms and molecules of the fuel, always have a dipole moment different from zero, i.e. they are excited and possess finite potential energy. The process of EPVs intrusion into the fuel molecules begins when the field is applied,and still goes on for some time after this field is gone away. In some optimum period of time, after the "irradiation" of the fuel caused by the field has stopped, the number of EPVs intruded into the molecules will be maximum. After a while, the EPVs excited by the external field, will be leaving the molecules and the excited metastable state will disappear. If at the moment when the intrusion of EPVs into the fuel molecules is maximum the fuel will start burning, the EPVs will not only find themselves outside the molecules (i.e. product of burning) but their excitation will decrease and the dipole moment will disappear. The simultaneous cease of excitation of great number of EPVs is accompanied by release of additional energy. This energy is released in the second subspace of the particle substructure (for details see parts I—IV). However, in some certain points, i.e. the points of bifurcation, this energy can pass into the base of fibration, i.e. the laboratory subspace.

Thus, if to burn fuel after a certain optimum period of time following the fuel activation by the field, and to create the conditions for bifurcational transition of energy from the second subspace to the first one, then during the process of burning the activated fuel we can get some quantity of

energy, due to the energy of physical vacuum. This energy will be added to the standard calorific capacity of the given fuel. This theoretical prediction made by TFF was verified and proved by the experiment.

The experimental investigation was made by means of a special device, the technological diagram of which is shown in Fig. A1. The device for the treatment of the fuel provided the measurements of fuel consumption, current intensity, voltage and oxidative-reductive potential eH. The main parts of this device are the activator (1), the feed source (4), the taring device to measure fuel consumption (2) and the transformer (3) which provides high voltage. The activator design makes it possible to pick out the fuel from the cathode and anode zones.

The object of the experiment was the fuel oils of heavy grades: motor fuel oil ДТ, ГОСТ (The State All-Union Standard) 1667—78; gas-turbine fuel oil, ГОСТ 10433—75; marine bunker oil Ф5, ГОСТ 10585—75. Besides, some experiments were made with the light fuel oil for jet propulsion ТС—1, ГОСТ 10227—62. The main characteristics (table A1) of these grades of fuel oil for the experimental investigation as a rule, met the requirements of the standard, except the flash point (all standard requirements are given in brackets).

Table A1

| Fuel grade | Characteristics | | | | | |
|---|---|---|---|---|---|---|
| | Kinematic coefficient of viscosity, $mm^2/s$ | | | Density under 20 °C, $g/c^3$ | Flash point in closed crucible, °C | Heat of combustion lowest (standard) kJ/kg |
| | 20 °C | 50 °C | 50 °C (conven - tional) | | | |
| ДТ | — | 36 | 5 | 0.93 | 88(65) | — |
| Ф5 | — | — | 5 | 0.94 | 80(80) | 41450 |
| Gas turbine | 7.18 | — | 1.6 | 0.935 | 100.4(65) | 39800 |
| ТС-1 | 1.25 | — | — | 0.775 | 30(28) | 42950 |

One of the possible means of control of the electric field influence upon the fuel oil is the comparison of the oxidative-reductive potential eH of the treated fuel and the initial untreated one. The greater is the difference in values eH of the treated and untreated fuel the stronger is the field influence upon the fuel oil. Therefore, before the beginning of the experiment the taring was done to choose the optimum fuel oil consumption, when the voltage was constant.

It should be noted that index eH is not the basic one to define the degree of the field influence upon the fuel. Nevertheless, its attraction is in the fact that it helps to do an express test and to define the presence or absence of activation quickly. As the process of fuel oil activation is very complicated, the appearance of the same experimental data often depends on those factors the influence of which is not known yet. Therefore, even the qualitative estimation of fuel activation, which is done by the comparison of eH changes, is methodically justified.

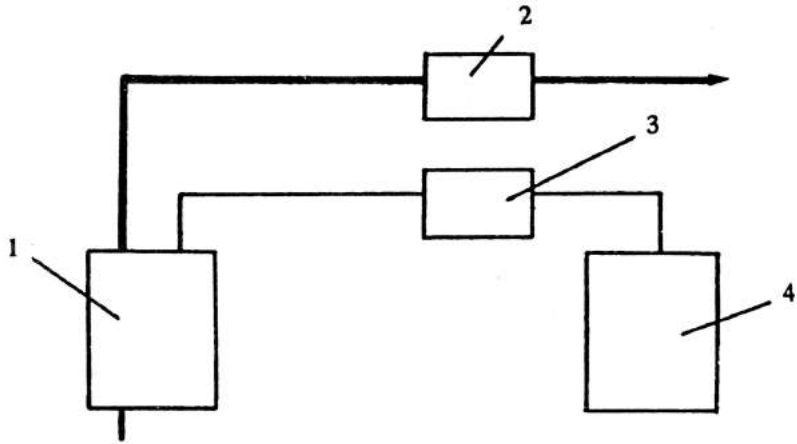


Fig. A.1 Diagram of test device

The change of eH in a great number of samples of the treated fuel oil helps to find the optimum consumption of the fuel oil passing through the activator.

Fig. A2 gives some data showing the optimum consumption of gas turbine fuel oil which is taken as an example. The abscissa scale is the fuel consumption and the ordinate one is the value eH. The dotted line shows the values eH of the untreated fuel oil; every point corresponds to eight-ten measurements. We can easily see that the optimum corresponds to a certain fuel oil consumption. Index eH decreases with the decrease of fuel consumption. This fact can be explained by the hydrodynamic changes in the activator and by their negative influence upon the process of activation.

As the change of the fuel consumption, when voltage was constant, was connected with the change of eH, it was necessary to find the optimum consumption for every fuel grade. These optimum consumptions were chosen as the basic ones and the main measurements were done in these conditions. The voltage of the electric field was changed from 6 to 50 kV.

After the treatment of the fuel oil the following characteristics were defined: the evaporativity, flash point, kinematic coefficient of viscosity and surface tension.

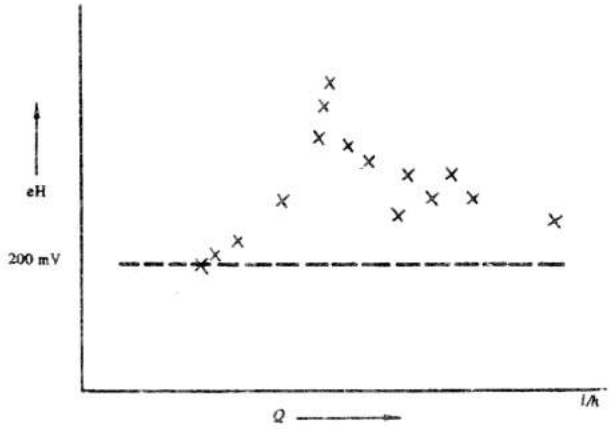


Fig. A.2 eH versus consumption $Q$ of fuel passing through activator.

Just these characteristics were chosen because, on one hand, they are important for the heat engine (or the boiler, because they influence the combustion process), and on the other hand, they are connected with each other (for example, when evaporativity increases,the flash point, viscosity and surface tension decrease).

After measuring these parameters, which gave the opportunity to show the real picture of the influence of activation upon the fuel, we made experiments to investigate the electric field influence upon the fuel heat of combustion.

The evaporativity was defined by weighing the samples of the initial and treated fuel oil. The flash point was defined in the closed crucible with the help of the ПВМ device. The kinematic coefficient of viscosity was defined with the help of the capillary viscosimeter ВПЖ—4. The surface tension was defined by the method of tearing off the ring. The heat of combustion was defined before the treatment of the fuel and after it. The measurements were done according to the ГОСТ 6712—58 for the motor fuel oil ДТ with the help of a special precision calorimeter.

Let us consider the experimental data.

As it was already mentioned, the change of the metastable state of the fuel takes place during a certain time rather intensively. The value eH proves this. Fig. A3 shows the decrease of the value eH of the treated fuel. For 20 min the value eH decreased approximately by 100 mV (the change

depends on many factors, the fuel grade is one of them). The upper curve shows the fuel pick out in the anode zone and the lower one shows that in the cathode zone.

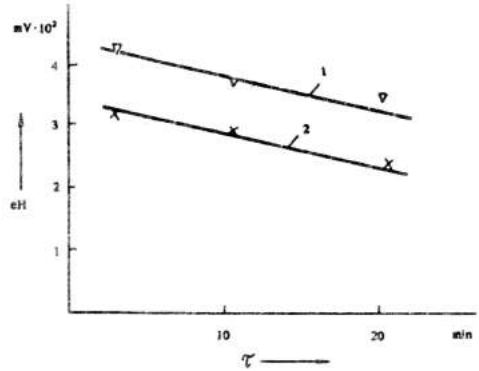


Fig. A.3 Time change of eH of treated fuel:
*1* — anode zone pick out; *2* — cathode zone pick out.

Fig. A4 shows the experimental data of the fuel evaporativity rate. The lower curve shows the untreated fuel, the middle one shows the fuel picked out in the cathode zone and the upper curve shows the fuel picked out in the anode zone. The abscissa scale is the time and the ordinate one is the percentage change of the mass of the evaporating fuel. The results of these experiments showed that the initial evaporativity of the treated fuel is higher than that of the untreated one.

Fig. A5 shows the change of the flash point when the fuel was being treated. The abscissa shows the numbers of the experiments (they were made with the gas turbine fuel oil), the ordinate shows the change of the flash point with respect to average value. The average value of the flash point was $t_{fl}^{init} = 100.4 \pm 1.5$ °C. This value was considered as the standard for comparison.

A series of measurements made during a certain time showed that the metastable state after some time disappeared and the flash point became equal to the initial one. For our experiments this time was about an hour.

After a series of experiments which were aimed to define the evaporativity and the flash point, we could see that their value corresponded with each other: the greater the evaporativity the lower the flash point.

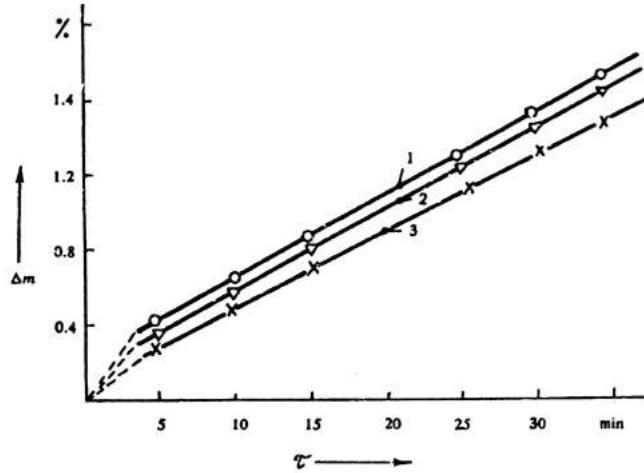


Fig. A.4 Fuel evaporativity:
1 — anode zone pick out; 2 — cathode zone pick out; 3 — untreated fuel.

The investigation of the kinematic coefficient of viscosity was made with the fuel oil grade ДТ. The experiment has shown that the viscosity change depends on the place of the fuel pick out. The cathode sample showed the increase of the viscosity by 2.6 %, in 30 min this increase was only by 0.6 % and in 170 min the viscosity became equal to the initial one. The anode sample showed the viscosity decrease by 2.7 %; then in 40 min the difference was 2 %, in an hour the difference became 0.6 % and in 190 min it became equal to the initial viscosity.

The investigation of the influence of the electric field upon the surface tension was made with the marine bunker oil Ф5. The results showed that the fuel picked out from the cathode zone had the surface tension lower by 4.8 % than the initial one. The anode zone showed the surface tension decrease by 2 %.

Thus, the potential opportunity to improve some operational characteristics of the fuel oil by treating it with the electric field was proved by the experiments. In particular, the decrease of fuel surface tension, the increase of its evaporativity and some decrease of its viscosity may have positive influence upon the process of fuel spray in the engine cylinder and upon the conditions of compiete combustion of the fuel. Consequently, it may lead to the decrease of the fuel consumption per engine. Some decrease of the flash point is not a serious negative factor from the point of view of fire safety.

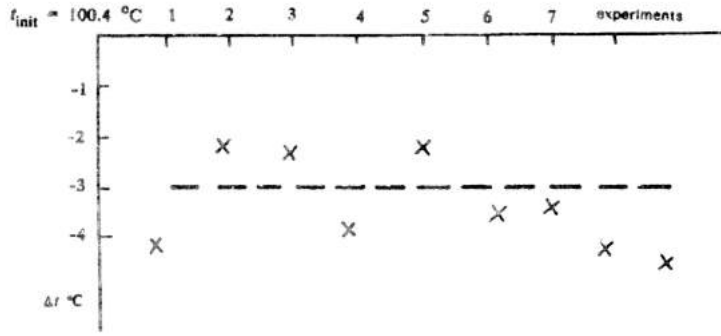


Fig. A.5 Change of fuel flash point under treatment.

The obtained results, connected with the electrical treatment influence upon the fuel qualitative characteristics, were used as the base for more detailed investigation of the influence of activation upon the change of the heat of combustion.

It was supposed that the increase of the fuel heat of combustion could be the result of, firstly, the decrease of losses connected with dissociation, which always accompanies the process of burning and consumes some part of the released energy and, secondly, the participation in the reactions of the excited elementary particles of vacuum which release some energy of excitation.

Thus, the consumed energy should be less than the energy released during the combustion. This supposition was proved by the experiments.

It should be noted that the time of fuel relaxation can be very short, therefore, the activated fuel should be used shortly after the activation. Yet, some cases of the increase of the activation degree after the electric field had stopped acting upon the fuel were observed. Therefore, it is necessary to define the optimum time of the fuel use after the end of the activation. During the analysis of the experimental data connected with the calculation of the fuel heat of combustion we defined the quadratic mean error (ГОСТ 8.213—76).

During the test measurements of the untreated fuel oil the results of only those experiments were taken into account which were within the bounds of the confidence interval of the calibration of the calorimetrical system. The increase of the fuel heat of combustion of the activated fuel was considered to be true only when its value was more than the triple confidence boundaries, which were defined for the untreated fuel.

The value $\bar{Q}$ = 42650 ± 640 kj / kg was taken as the initial average value of the heat of combustion, considering the triple confidence boundary. The value eH of the initial fuel equaled 300 mV.

Table A2 shows the value eH, the heat of combustion $Q$ and the increase of heat of combustion $\Delta Q$ for the fuel grade ДТ (ГОСТ 1667—78), which was activated in the electric field.

Table A2

| Experiment | $eH$, mV | $Q$, kj/kg | $\Delta Q = \frac{Q - \bar{Q}}{\bar{Q}} \cdot 100\%$ |
|---|---|---|---|
| 1 | — | 43900 | 3.2 |
| 2 | +1150 | 46700 | 9.5 |
| 3 | +900 | 46100 | 8.2 |
| 4 | +680 | 55300 | 29.7 |
| 5 | +550 | 49000 | 15.2 |
| 6 | +910 | 46100 | 8.2 |
| 7 | +1080 | 45700 | 7.0 |

Fig. A6 shows the increase of the heat of combustion of the fuel grade ДТ after its treatment by the electric field. It also shows the confidence interval of the heat of combustion values for the untreated fuel, which equals $3\sigma$. As it is seen from the diagram, all the obtained values of the heat of combustion are much higher than the value of the triple confidence interval. This fact is the proof of the experiments being trustworthy. The average increase of the heat of combustion is 10 %.

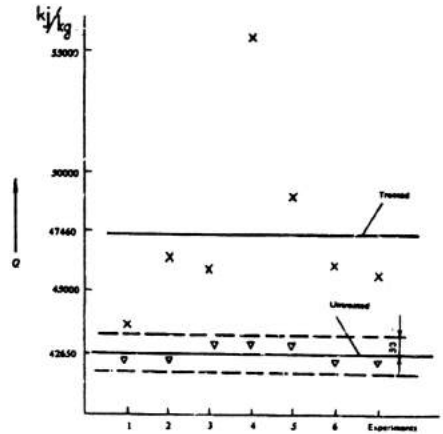


Fig. A.6 Heat of combustion increase of fuel grade ДТ.

Of great interest is the comparison of two kinds of energy: the first one is that which we spend on activating the fuel and the second is that additional energy which is released by the activated fuel during its burning.

In our experiments the power which the fuel got due to activation (with the initial voltage $U = 12V$ and the current intensity $I = 2.5A$) was $30W$. This is the power which was taken from the electric circuit. Each kilogram of fuel (with the fuel consumption 30 l/h and fuel density 0.93 g/c$^3$) received 3.85 kj/kg. Yet, in the 3rd and 6th experiments, for example, the increase of the heat of combustion was 3500 kj/kg.

It should be noted that in the given case the consumption of the electric power was connected mainly with the resistance (losses) of the activator. Thus, the energy increase due to the excitation of the elementary particles of the vacuum was approx 3500 kj/kg in these experiments.

The experiments with the fuel grade TC—1 ( ГОСТ 10227—62 ) were made by V. V. Nazarov. Their results are shown in Fig. A7.

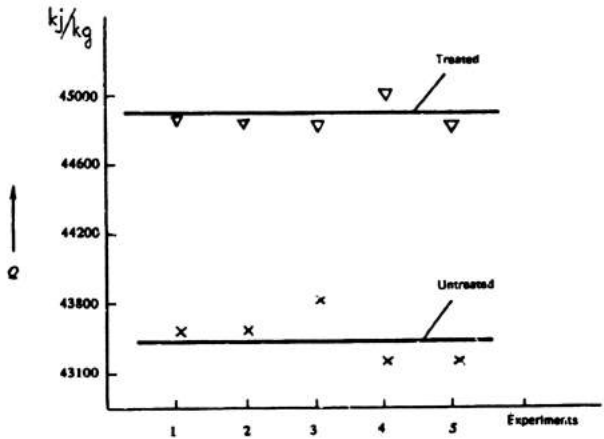


Fig. A.7 Heat of combustion increase of fuel grade TC-1.

Thus, the effect of the increase of the fuel heat of combustion due to its activation was proved.

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## APPENDIX 9
## SIGNIFICANCE AND PLACE OF THE PARADIGM FOR VIABLE AND DEVELOPING SYSTEMS IN THE RISE OF MANUFACTURE EFFICIENCY

In the paper [134 p 27 ]it is said that the Paradigm for Viable and Developing Systems (PVDS), since its appearance in the middle of the forties, has not been published for a long time and therefore, the possibility of its use in different branches of science (in economics as one of them) has not been considered. During recent years in connection with the radical improvements of national economy management, i.e. the rise of independence of enterprises, the decrease of State tasks for them, the acceleration of STP (Scientific and Technical Progress), etc, some new problems, such as the rise of uncertainty of both consumption and production of goods have arisen. At the same time it is obvious that the tendency to "become open" is observed both in economy as a whole and in separate industrial systems (IS).

The increase of the tendencies of IS to become open, on one hand, and the growth of uncertainty, on the other hand, showed that the way from the survival of IS to their viable state and further development requires quite new theoretical grounds. Thus, the main problems which require consideration are:

1. The formation of the new concept of modern manufacturing management.

2. Working out of the paradigm for management of viable and developing industrial systems (VDIS).

3. Improvement of special programs of complex development of enterprises (SPCDE).

4. Approbation of means of choice, attainment and support of effective versions of IS management.

5. Adjustment of mechanism of active interest of collective bodies of non-financed by State enterprises in the VDIS functioning.

Any concept, i.e. a certain way of interpretation of some things, phenomena, processes, which is not supported by the qualitative theoretical and methodological basis, is doomed to perish. The main block grounds of the mentioned above concept are the theory of costs, the public division of labour, economical homoerhesis and homoestasis. Just this point of view helps to estimate management measures from the positions of the expenditures (net price) and results (costs). It also helps to acquaint elementary industrial systems (each producer) with these measures and to define the main parameters of enterprises functioning and the tolerance of their errors along the whole trajectory of change when a certain IS converts from one qualitative state into another (homoerhesis) and when the functioning is stable (homoestasis).

The main methodological block grounds of the concept are both the manufacturing and output adaptation, the consideration of a phenomenon as a system and optimization of decisions. The adaptation allows to estimate the ability of an IS to reveal its adapting behaviour in complex media

and to consider the stages of adaptation process taking into account that IS should adapt to different conditions by means of the change of its structures. Thus, the realization of the triad aim-medium-structures is carried out during adaptability. The adaptation of the first kind, i.e. the conversion of a system from one state into another, due to both internal evolutional changes of the IS and the external ones, is connected with the processes of economical homoerhesis. The adaptation of the second kind, i.e. the functioning of the IS within the bounds of one state due to changes of its structures in the limits of the possibility of self-financing, is connected with the process of economical homeostasis. The approach from the point of view of a system is connected with consideration of vertical and horizontal ties in manufacturing when the decisions are taken to the elementary ISs, i.e. to each producer. The necessity to define the optimum conditions is connected with the following. It is impossible to take good decisions concerning the planning of manufacturing only on the grounds of facts. The lack of knowledge of optimal parameters may lead either to the extreme left or to the extreme right of the optimum. When the manufacturing is non-financed by State both is inadmissible.

The blocks of methodical maintenance are the following: a special program aimed at complex development of manufacturing, a system of effective management rates, a system of economical and mathematical models, a system of automatic management of manufacturing and a block of active mutual interest or of an agreement of mutual interests. The brief account of each of the above-mentioned blocks is given below.

What principles should the development of the manufacturing management meet to be able to change and remain viable and developing manufacturing system? Nowadays the system of such principles is created. The VDIS paradigm is based on PVDS. All the eight basic principles of PVDS fully agree with the VDIS paradigm. As to the IS it is reasonable to state that the pivot of the manufacturing management of the viable and developing IS is the prevalence of the negative entropy over the positive one for the second kind of adaptation. Further development, with regard to the IS conversion into a new qualitative state (the first kind of adaptation), is connected with an abrupt increase of the information flow which carries the negative entropy. All this takes place only in the "open" IS. Moreover, the growth of the degree of IS being open causes the increase of the negative entropy flow. Hence, the increase of the degree of IS being open is the necessary condition for radical changes of the IS. To reach this condition is possible only by decreasing the State tasks, extending the commercial independence and self-management and other processes connected with the modern reform of the national economy.

The informational way of approach to the functioning of the VDIS becomes defining in the formation of the conceptional scheme of perfection, or rather reconstruction, of the modern serial machine-building and instrumental manufacturing. This approach provides not only survival, but also the non-financed by State profit which is necessary in the new conditions of commercial life to reach the high level of vitality and further development.

To make the paradigm and its conception real it is necessary to have the corresponding program of activity, instrumentality and the mechanism of common and mutual interest in their realization.

The special program is being formed aiming at the development of constructions, technologies and management. Its peculiarity is the orientation on the production of all kinds of goods, well-grounded planning of final practical results and reliable methods. All this in details is given in the paper [146].

The instrumentality of the choice, achievement and keeping up of the effective versions of IS management form the methodical maintanance. The system of planned rates of output is the main link which allows to estimate and reconsider the conditions of manufacturing management, entropy value of the IS of separate shops and their parts, the expenditures on goods production and their decrease per item of lowering uncertainty in the IS. The rates of output are very important because they define the rates of the resource expenditures. The actual rates of the resource expenditures correspond to the actual rates of output, the planned ones correspond to the planned rates of output and the minimal rates of the resource expenditures correspond to the optimal rates of output.

The system of economical and mathematical models gives the opportunity to choose the best decisions, to estimate their effectiveness and the losses from the missed opportunities when the conditions of manufacturing differ from the optimal ones.

It is known that both construction and technology are worked out for a concrete article (assembly, detail). The effectiveness of this working out reveals during the process of joint manufacturing, i.e. by the management of manufacturing. There are several CAD (Computer Aided Design), namely CAD of construction, CAD of technology, CAD of control. The design of the most important part of the manufacturing, i.e. management, has no computer maintenance.

It is time to acknowledge that the CADMM (Computer Aided Design of Manufacturing Management) is the System of the same significance as any other CAD. Only having CADMM it is possible to make multialternative calculations and estimate changes in the manufacturing structure, park of technolodical equipment, management,etc, caused by dynamics of manufactured goods, i.e. to solve practical problems connected with the improvement of IS management and decrease of positive entropy. If yesterday it was too early to speak about the creation of CADMM in enterprises, because there was no proper working out, and conditions that would favour enterprises interests in computer management inculcation were not ripe yet, tomorrow it will be too late.

And finally, the last block of the methodical maintenance is the agreement of mutual interests of not financed by State policy. This is just that element of the concept the absence of which would not allow the concept to be used at all. The agreement of individual interests of each producer and common ones of the enterprises, regions, trades and the national economy is the necessary condition of the effective functioning of VDIS.

R. L. Satanovsky

## APPENDIX 10
## ON THE GENERAL LAW OF VIABLE AND DEVELOPING SOCIAL SYSTEMS IN THE SOCIETY

The analysis of PVDS (see Section 2) showed that in creating the theory of social systems the paradigm which was the basis of the unified theory of TFF can be used likewise. In appendix 9 professor R. L. Satanovsky has shown the possibility to use PVDS in the creation of a new approach to the economy of manufacturing. Here we draw the reader's attention to the possibility to use PVDS in sociology.

As it has been already stated (Section 2), any theory based on PVDS should agree with the principles which are the paradigm basis.

We consider the possibility to use the principles of PVDS in creating different theories of vitality and ability of social structures to develop as follows.

1. The method of choice of the fibre bundle is based, firstly, upon the mathematical formalism of this theory [8] and, secondly, upon the historiographical and dialectical principles, which form the basis of this science.

An example. In the system the "Human Civilization" (HC) these principles agree with the following. By the base of the set is ment the Humanity on the Earth. By the fibres are ment the states in their natural boundaries, both ethnic and sociological.

2 and 3. The method of choice of main canals of information comes to the following: the information passing from one fibre to another should promote the increase of order and decrease of chaos there.

An example. In the HC system the exchange of information between states, national groups, representatives of different religions must stabilize but not destabilize these structures. The *whole* civilization gains from this.

4. The method of choice of optimum impulses of development comes to the choice of the most useful signal and the most suitabie time to increase this signal sharply.

An example. For the HC system the STR (Scientific and Technical Revolution) can be such an impulse. The rapid growth of STR is stimulated in the proper time and in the proper direction.

5 and 6. The diagnosis of possible system diceases and the choice of methods of their cure is done by analysing the fact which kinds of information lead to the order (the negative entropy) and which ones lead to the chaos (the positive entropy).

An example. For the HC system the positive entropy is caused by:

a) The growth of the armament race and threat of war;

b) The breach of the ecological balance between a man and environment;

c) The national and religious discord and intolerance;

d) The social discord and intolerance;

e) The abuse of the STR progress.

7. To formalize the program when calculating the viable and developing systems it is necessary to consider the bearing part of the system (which in most cases is the base of fibre bundle) as being situated in the real domain and the remaining part in the imaginary one.

**An example.** In the HC system the association of people on Earth is described in real values and all the social, economical political and other fibres providing the vitality of this association are described in imaginary values.

We give a concrete example of the use of PVDS. It is our viewpoint upon the basis of the theory of structures in the system "Man and Community" (fig. A8). The channels of information between the fibres in this structure are interpreted by us as follows.

### I. The contents of channels of information in the man considered as a system

$P1$ is the talent; $P2$ is the goodwill, turn for introspection; $P3$ is the reliability of all components of the vital structure of the organism; $P4$ is the absence of hereditary psychic pathologies; $P5$ is the ability to believe in ideals; $P6$ is the ability of positive apprehension of fine arts and literature; $P7$ is the intellect that became a part of nature; $P8$ is the diligence; $P9$ is the ability to control oneself; $P10$ is the ability to see the beauty of moral principles; $P11$ is the self-control in difficult situations; $P12$ is the absence of irreversible pathologies; $P13$ is the absence of steady psychietric diseases; $P14$ is the belief in ideals which became the intrinsic habit and nature of a man; $P15$ is the love for fine arts which became nature of a man; $P16$ is the stable strong-willed character which became nature of a man.

### II. The contents of channels of information coming from the man

$f1$ is the respect for the needs of environment; $f2$ is the contribution to the level of civilization; $f3$ is the display of talent; $f4$ is the spirit of enterprise and aspiration for leadership in labour activity; $f5$ is the ability to respect other members of community, the level of aspiration for leadership in the collective body; $f6$ is the objective approach to the needs; $f7$ is the ability to appreciate cultural merits; $f8$ is the sociability, the presence and degree of sensitivity; $f9$ is the contribution to the community standard; $f10$ is the willingness to help to rise the intellectual level and level of trade skills; $f11$ is the contribution to the moral level of the whole community; $f12$ is the loyalty and devotion to community which favour the stability of the latter; $f13$ is the contribution to the

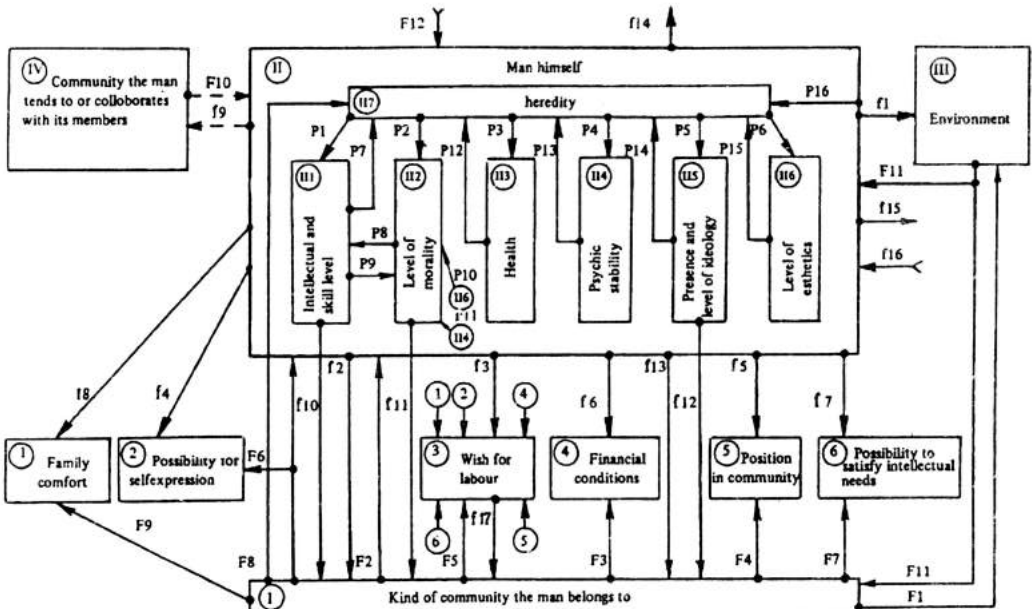


Fig. A.8 Diagram of fiber bundle in which fibers interaction provides ability for life and development of civilization on Earth: I is base of fibre bundle; II III IV are fibres (first level); 1 — 6 are fibres (second level); $P_n$, $f_n$, $F_n$ are information channels.

formation of social ideology; $f14$ is the information for space memory; $f15$ is the individual information for other members of community; $f16$ is the individual information from other members of community; $f17$ is the trade contribution of a concrete member of community to its development.

### III. The contents of channels of information coming from the community and surroundings

$F1$ is the creation of conditions for normal functioning of the environment; $F2$ is the guarantee for education, medical service, all rights for a man and necessary duties; $F3$ is the necessary level of wages and cost of living; $F4$ is the guarantee for job, rank and possibility to be a member of the proper strata of society; $F5$ is the guarantee for a proper level of comfort for a person in his private life and job, the estimation of his personal merits by prises, rewards and privileges; $F6$ is the guarantee for social justice; $F7$ is the guarantee for easy access to theatres, cinemas, books, etc, and for the opportunity to have personal contacts with other members of community; $F8$ is the requirement of a radical change of the whole nature of the person; $F9$ is the guarantee for good dwelling conditions and comfort in private life; $F10$ is the influence upon the ideology and morals; $F11$ is the guarantee for conditions to exist and function; $F12$ is the information from the space memory.

We hope that this new method of approach to the systematization and analysis of social structures which was offered by us should be of use when solving some problems connected with perestroika in our society.

The author is grateful to professor V. A. Yadov and A. N. Youschenko, Ph. D. for the discussion on this essay.

I. L. Gerlovin

## APPENDIX RÉSUMÉ

1. The appendix contains 10 essays of the author and his colleagues, which are beyond the contents of this monograph but are closely connected with the development and use of the Paradigm for Viable and Developing Systems within the bounds of the unified theory of the fundamental field.

2. The contents of most essays need no comments but the paper of professor Satanovsky. In this connection it is useful to note that the application of PVDS to the analysis of manufacturing economy, which is given in this paper, is connected with the attempt to use some additional ideas the validity of which needs verification. The author of this essay is going to do it in the near future.

# SUMMARY

The monograph contains the presentation of the original unified theory of all interactions in matter: strong, electromagnetic, weak and gravitational. The entire material is based on the new Paradigm for Viable and Developing Systems (PVDS). The book is the result of the author's work for the last fifty years. In fact, a new concept of development of science is proposed instead of the old one which caused global environmental and spiritual-moral catastrophes the mankind faced on the eve of the XXI century.

In fact, the mankind burns oil, gases, plants, i.e. things which were created by nature as the main source of raw materials, for extracting energy, and so far it is unable to use ecologically pure alternative means to get it. However, such means are available; this is the use of the gravitational energy of the Earth's interior and the physical vacuum energy. Moreover, the fact is ignored that the use of the nuclear fission or nuclear synthesis energy results in degradation of the fundamentals of life evolution on the Earth.

Up to now, the mankind has no exhaustive knowledge of how food affects a man and naively estimates its quality only by the calorie contents.

The mankind widely uses artificially produced substances in national economy, particularly in production of foodstuffs. Chemiotherapy even became the basis of medical treatment of a man. Only recently it was comprehended that all this is the self-poisoning of Mankind.

These are the main but far from being the last misfortunes of our, so to say, deformed model of civilization.

The book gives the answer to the questions, how this has happened and what should be done.

This happened because modern science could not do away with a very low level of knowledge about the world, and declared the postulates established at this level to be the truth in its complete form. Nowadays we understand the naivity of our ancestors who tried to reduce everything which exists to four elements known to them. But up to now, we had no courage to admit that the methodology based on the postulates, according to which in nature there is nothing else but matter, Euclidian space and eternally passing time, has long become obsolete. However, it is forbidden to exceed these limits. This is the main cause of the tragedy; it is really a tragedy, because the existence of civilization on the Earth is threatened.

The book contains the fundamentals of the program whose implementation is quite indispensable for the change from the Capitalist Sodom and the Communist Gomorrah to the harmo-

niously developing community of people on the Earth, the community for whom the main thing is to serve the Nature and Man, to serve the forces of Good.

## 1.
## The following starting methodological principles are defended in the book:

### a) In the field of social sciences

1.1. Construction of philosophical, political, social, economic fundamentals for the existence of communities on the Earth should follow not only the already existing developments in these sciences, but mainly the principles of the Great Logic, which should be brought to the level of a closed theory. The Great Logic has not yet been created. The monograph raises the problem of the necessity of speeding-up its development.

1.2. Scientific and theological fundamentals of spiritual life of communities on the Earth should not be opposed, they should be in harmony. Mankind should not be separated on the basis of ideological or national features. Mankind should profess one Faith, i.e. the Faith in its bright future, for which it is necessary to struggle.

1.3. It is necessary to speed up the development of the Theory of Noosphere, a unified theory of matter and spirit, a unified theory of the animate and inanimate; PVDS can serve as a basis for development of such a theory.

### b) In the field of natural sciences

1.4. Matter, i.e. material form which possesses mass as the measure of inertia, is not the only form of substance existing in nature. There must also exist other material forms; they should be found, studied and used.

It seems to be important to make the following observation. Many years ago an English scientist Occam formulated the principle called "Occam razor". According to the idea of its author, "Occam razor" has to cut off those essences disregarding which we can still explain this or that phenomenon. Nowadays this postulate without any reasons (the Occam principle is not proved, and moreover, in spite of many years elapsed, its nature and origin is still not clear; this is a volitional principle) is raised to the rank of the immutable truth and is accepted by reactionaries from science as "Occam guillotine", with the help of which it is possible to cut off all the new, that could not be laid down in the Procrustean bed of habitual schemes. Once in the USSR with the help of "Occam guillotine" the genetics and cybernetics were cut off as "superfluous conjectures"; all the progressive suggestions on the correction of the "complete" political economy of socialism were cut off; a lot of progressive ideas were left without head.

But even the most "progressive" guillotine should not be an instrument of science. It is quite the time to replace the "Occam guillotine" by another principle: everything, that completely and

for certain is not prohibited by modern science, should or could exist. In other words, if the principle of prohibition of some phenomenon, proposition, hypothesis is not given proof, then they should or could exist. Presumption of permissibility of everything that has no prohibition dominates in Nature. To prohibit something completely and for certain in serious science is not so simple as it is usually considered.

For many years in the USSR the existence of the fire-ball was rejected, all the results of observation of the so-called unidentified flying objects (UFO) were prohibited, that is why up to now we do not know what this is like. Rod guidance, telepathy, telekinesis and many other actually observable biological phenomena are volitionally prohibited only because to find the explanation of them is beyond the bounds of possibilities of modern science.

Certainly to taboo something is much easier than to give a scientific explanation of it; but then it should be admitted that modern science degenerates into dogma headed by priests, who are fully aware of what is allowed and what is not allowed and what needs prohibition. They are only "fully aware", since prohibition is not accompanied by the proof of reghtfulness of the taboo. It is impossible to consider a prohibiion of a phenomenon to be reasonable, if its existence does not correspond with yhe propositions of the theory, adopted to be complete and final without any right for an alternative approach.

1.5. The Euclidian geometry is not the only form of existence of matter. Multidimensional and imaginary spaces, fiber bundles are not an abstract invention of mathematicians but a reflection of reality.

1.6. Macroscopic time, as a continuously and similarly passing duration cannot determine all the processes taking place in the Universe. The dependence of the time scale on velocity, discovered by A. Einstein and realized by him in SR and GR, is oniy the first step on the way of disclosing the essence of time. There is a unified law, which regulates the relation of Space-Time and Matter, linking these basic essences, i.e. the Triunity Law.

1.7. All the systems realized in Nature can really exist if they satisfy the conditions which are required by the Paradigm (PVDS). The viability conditions and abilities to evolve are quite indispensable for any system which can exist in our world. The systems, which do not satisfy PVDS, are not viable.

1.8. The laws of microcosm do not have a local character. The properties of microcosm reveal on all macroscopic levels, including the entire Universe, and are a sort of universal code of its self-organization. The phenomenological principle of constructing the fundamentals of theories of modern science does not satisfy the sufficiency condition, it is only necessary. Therefore, all the theories constructed on the phenomenological principle, such as thermodynamics, gas dynamics, hydrodynamics, etc., require serious development with including into them the fundamental ideas of the universal code of self-organization of all processes in the Universe.

1.9. It took 50 years to develop PVDS and TFF up to the present state. Besides the subjective obstacles that have hindered the progress,there were objective ones.

Firstly, a great amount of work had to be carried out on the way: idea — hypothesis — theory. Secondly, the author did not think it acceptable for himself to claim the "raw", not direct ideas as a complete result, which, alas, has become a tradition for some authors.

Of course, it is possible to consider A.S.Pushkin but not P.K.Oshchepkov to be the creator of radio-location since A.S.Pushkin wrote "The golden cockerel" *) long before P.K.Oshchepkov's birth, as if it were of no importance that one created a fairy tale and the other the first locator in the world.

The author is deeply convinced that in science the result is important and not the pretensions or ambitions of authors and their worshippers, however eminent they might be. "Raw", not direct ideas, which sometimes are only a hint at something possible, cannot be called pioneer works in science. This is one of the first methodological principles always followed by the author. This principle has not allowed the author to publish a lot of what was born but has not yet become ripe.

## 2.
## The results of realization of methodological principles in science.

2.1. The idea of "Logic with a capital letter" was formulated by Lenin; nevertheless, this idea has already become obsolete in its pure form. One should work on the "Great Logic", GL, as it probably can be named, which combines the most advanced ideas. The GL should combine the dialectic, philosophical concepts, approaches from the viewpoint of theory of systems, modern achievements in the field of homoeostatics, the most important theological principles, and form a single basis for the spiritual activity of Man. In the Great Logic there are only Nature and Man; there are no alien principles, based on stereotypes, ambition and usual principles which are made a fetish of.

2.2. Paradigm for Viable and Developing Systems (PVDS) was formulated by the author as far back as in 1946. During many years of its usage and development, the author together with his colleagues and pupils not only developed the fundamentals of PVDS, but also elaborated the complete unified theory of all interactions in matter, i.e. the Theory of the Fundamental Field (TFF). TFF not only combines the Einstein special (SR) and general (GR) relativities with quantum mechanics; it enables to unify within a single approach all the known interactions: strong, electromagnetic, weak and gravitational. This is described in detail in the book.

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*) In A.S. Pushkin's fairy tale "The golden cockerel" the latter was able to determine direction of the enemy invasion.

The author expects that the publication of the monograph will mark the beginning of a detailed study, discussion and, of course, the most rapid use of PVDS and TFF.

## 3. Possibilities of a practical usage of the developed scientific fundamentals.

3.1. It is proposed to set up under the UNO the Centre on Coordination of Scientific and Theological Studies, which would combine the efforts of scientists and ministers of religion of all trends with a view to develop measures for the immediate liquidation of the existing contradictions and constantly persisting conflicts on the basis of national and religious discord and intolerance.

3.2. In the book the grounds are provided for the necessity of a direct use of PVDS, while designing a number of globally singificant technical devices and, particularly, the optimal flying apparatus for regions similar to Soviet Siberia, North, and the Far East (there are such regions in Alaska, Africa, Asia, Latin America). The author's colleagues brought to the level of the draft the development of a new flying apparatus called Flying Amphibian (FA). The production of FA would enable to solve many problems of the remote but perspective regions, among them, problem of transport, which in the nearest future should be ecologically pure.

3.3. The monograph presents grounds for the accomplishment and extensive development of works on a practical use of energy, obviously contained in large amounts in physical vacuum. From the studies, accomplished on the basis of TFF, it is clear that the animate nature has long been using this energy.

3.4. Discussion of the problem of interaction of macrobodies with physical vacuum makes it possible to raise the problem of designing a principally new flying apparatus in space, which will be not reactive (jet), but an impulse apparatus. It will be someway "pushing-off" from the physical vacuum which is a material form, but not an emptiness. The creation of this apparatus will enable to solve many problems of space flights, particularly: saving the energy, extending the time during which the apparatus can be in the space, reducing its weight and overall dimensions, cutting down the means spent to design it.

3.5. TFF allows to raise the question of studying the possibility of affecting gravitational forces for the purpose of their reduction. The best prospects are offered by the use of the gravitational anisotropy phenomenon predicted on the basis of TFF.

The vacuum gravity theory elaborated by the Corresponding Member of the USSR Academy of Sciences V. A. Krat in collaboration with I. L. Gerlovin predicts the release of the gravity energy in the interior of stars and planets. This energy, released at accessible depths in the Earth's interior, can and should be used. One cannot calmly observe that, being unused, this energy leads to disastrous earthquakes.

3.6. TFF predicts the existence of a new type of superconductivity, which ensures a high-temperature superconductivity up to 100 K with participation of the electron-positron vacuum, and up to $10^5$ K if the charges are transferred with participation of the proton-antiproton vacuum. The first type of superconductivity has already been found experimentally. The second type of superconductivity will be difficult to find by "poking method" without using TFF. It is time to add to one's armoury the results, obtained by the author, for solving this problem.

3.7. TFF predicts a new type of discharge, differing markedly from that in gas. This is a discharge in physical vacuum, which can proceed in parallel with an usual discharge in gas. This earlier unknown type of discharge is responsible for generation of ball lightnings in the cloud-Earth discharge channel and the so-called unidentified flying objects (UFO) in the cloud-cloud discharge channel. This type of discharge is rare, but the usual lightning protection does not save from it. Means have been found to struggle against this type of discharge.

3.8. On the basis of TFF it is possible to correct the directions of development of experiments in high-energy physics, using the predictions of theory for the purpose of speeding-up the work and significant saving the spent means.

3.9. It is possible to use the theoretical results to create a safe and ecologically pure energetics.

3.10. TFF enables to develop the theory of experimentally discovered phenomena whose nature remains unclear. For instance, the medium activation phenomena. The availability of theory will allow using these phenomena as the basis of new, ecologically pure technologies.

3.11. New phenomena have been predicted on the basis of TFF: the influence of atom nuclei on the process of mineral formation and the possibility of synthesizing new elements under usual conditions at shallow depths in the Earth. The predictions have been experimentally confirmed. It is necessary to develop these works for the purposes of national economy.

3.12. On the basis of TFF the possibility of developing computers of a new generation has been revealed, with atomic structures directly connected with EPV being used as the data medium.

3.13. Proceeding from FVDS and TFF, the development of basic programs started, by means of which it would be possible with the help of personal computers to solve specific problems on the development of such basic phenomenological theories (thermodynamics, gas dynamics, electrodynamics, hydrodynamics etc.), which would enable to solve important applied problems, based on fundamental ideas of the universal self-organization code of all the processes in the Universe.

3.14. A specific means of formation of the future Noosphere theory based on PVDS is shown.

This general summary of the entire monograph does not present a detailed analysis of all the problems raised therein; it is given both in the resume of each section of the book and in the text proper, with which the author expects each reader will get properly acquainted.

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## ABSTRACTS OF SOME PAPERS CORRELATING WITH TFF

The history of science shows that new theories never originate "from nothing". There have always been forerunners who have stated one or another part of basic ideas. Some part of ideas is often stated by a number of authors simultaneously. All the right physical theories, e.g. classical electrodynamics, relativity, quantum electrodynamics have originated in that way. In this respect TFF is not an exception.

The idea of A. Einstein on the possibility of creation of the unified theory of field is taken as the principle of TFF. The connection between the parameters characterizing the space-time continuum and the matter which was found by A. Einstein is used in TFF. The features of this connection are essentially revised, but the initial ideas of A. Einstein are left as the ground.

Some workings out on "geometric dynamics" which are being made by J. A. Wheeler and his numerous supporters, colleagues and disciples are referred to as the predecessors of TFF as well. In this group of workings out there was not made a necessary step to move away from considering an object in one space. Besides, the notion about the gravity as the fundamental interaction was retained, and the quantum properties of microcosm were not taken into account.

Numerous workings out of G. Hönl and A. Papapetrou should be considered as those preceding TFF as well. In these papers it was shown that there exists an apparent connection between the properties of an electron, which are described by the Dirac equations, and a certain classical model of a particle considered as an ultrarelativistic birotator, which consists of positive and negative masses. Hönl and Papapetrou have investigated the model of elementary particles similar to the model of particles in TFF in the second subspace. But in these papers the authors could not move away from the purely classical description of the particles structure, they tried to analyse it in one space only, and could not find the connection between the considered structures and the features of the space-time continuum.

There is also a certain connection between TFF and the ideas which were developed by J. A. Wheeler, M. A. Markov and K. P. Staniukovich about the "most elementary particle" (a "maximon" according to Markov and a "plankeon" according to Staniukovich). The possibility of the existence of a physical object with the mass of order $2 \cdot 10^{-5}$ g and the size of order $10^{-33}$ c follows from the Plank dimensionless system in which $\hbar = c = G = 1$. Wheeler, Markov and Staniukovich have displayed a lot of wit to show that this particle is the only main brick of the Universe. In spite of its attractiveness this intention was not finished up with any positive results. In this monograph it is shown that all elementary particles in the third subspace of TFF have such parameters that, if it were possible to map them directly onto the first subspace and fix there, (in accordance with TFF, it is impossible) we would get a particle with the parameters of a "maximon-plankeon". Thus, these particles as well as a tachyon play a certain role in the structure of particles, but they can not be experimentally found in our first subspace. So as it turned out, only one idea about the fundamentalness of a "maximon-plankeon" is not enough to form a closed and complete, in principle, theory of elementary particles.

Parallel with TFF, rather many works have been published during the last twenty five years. Their authors apparently quite independently of publications of TFF have proposed a lot of ideas that correlate in this or that degree with some results obtained in TFF (e.g. [28, 29, 35, 37—39; 53, 54, 60, 61, 74, 103, 158]). As, in our opinion, these scientific works are ideologically close to some statements of TFF, we think it will be right and quite objective to give abstracts of these papers. These essays were published in the soviet "Physics Abstracts" (Referativny Zhurnal "Fizika", further on RZF).

**Lusanna L. Lett. Nuovo cim., 1974, vol 11, N 3, pp 213—217. Expanded hadrons and Regge slope.**

The model is proposed in which hadrons are considered as the expanded quasiclassical systems, the radius of which equals the Compton wavelength. It is supposed that at least two clusters with the mass $m_f$ and the velocity of rotation of one cluster with respect to the other $v_f$ are situated inside a hadron. The motion of components inside the hadrons, which have high spins, turns out to be ultrarelativistic. It is supposed that the domain of localization of such objects coincides approximately with the dimension of a hadron. In these conditions the spin of the system increases as the hadron grows, like it is in the model of the linear Regge slope. The Regge slope turns out to be connected with the size of hadron components. (RZF, 1975, 2B299).

**Hamamoto S. Prog. Theor. Phys., 1974, vol 51, N 6, pp 1977—1978. Subluminal particles as a composite system of superluminal particles.**

The paper discusses the possibility of existence of a new class of particles (tardions) which are a composite system of superluminal particles. It is supposed that tachyons are quantizing with an irregular connection between a spin and statistics. The compound scalar particles originated from the tachyon operators have been constructed. The operators are taken with the weight function proportional to the Jordan causal commutator. It is found that the commutator of compound fields has a conventional causal type with an insufficient noncausal addition, which disappears to the limit $\delta$ of the functional spectrum of the tachyon masses. (RZF, 1975, 2B277).

**Burcev P. Czehosl. J. Phys., 1973, Bd 23, N 11, pp 1172—1175. Structural models of an electron and a nucleon in the general relativity.**

Classical phenomenological models of the structure of stable elementary particles are constructed. These models are based upon the gravitational interaction. The model of an electron is the Reissner-Nordström and De Sitter solutions of the Einstein equation outside and inside the sphere with the radius $10^{-13}$ c, respectively. Thus, the gravitational and electromagnetic properties of the substance from which an electron is constructed are taken into account. It is supposed that for a nucleon model the scalar meson field describing strong interactions is the source of the gravitational field, and an electromagnetic interaction can be ignored. (RZF, 1974, 4B198).

Sivaram C., Sinha K. P., Lett. Nuovo cim., 1974, vol 9, N 17, pp 704—706. *f*-gravity and masses of elementary particles.

To define the spectrum of masses of elementary particles it is proposed to consider the so-called *f*-gravity, i.e. the theory of a massive strongly gravitating field. The estimation is given of the bond constant between the f-meson and the hadrons $G_f \cdot 10^{38} G_N$ ($G_N$ is the Newton gravitational constant). It has been found that the *f*-gravitational radius of a hadron has the order of its Compton wavelength. The estimations of the frequencies of *f*-gravitational oscillations have been made and on this ground the spectrum of masses of mesons and baryons is calculated. It is affirmed that the introduction of *f*-gravity into the field theory eliminates UV-divergencies because all the diverged integrals are being cut off on the Schwarzschild radius. (RZF, 1974, 9B358).

Dreyfus-Graf J. A., Helv. phys. acta, 1972, vol 45, N 6, pp 966—969. The physical world as a system of self-regulated signals.

On the ground of some general principles of quantum mechanics and the communication theory (e.g. the uncertainty relation for the conic conjugate variables in quantum mechanics and the communication theory or the wave-particle dualism) it is proposed to consider all physical phenomena as those that take place in the system with feed-back. It is proposed to consider the maximum of information and the regulation with the minimum of action and time as the leading principle of the "cybernetic communication". In this kind of scheme it is supposed to construct a more consistent description of the physical process and, in particular, to describe the properties of the vacuum more completely. (RZF, 1973, 8B52).

Newman E. T., Rosadas R., Phys. Rev., 1969, vol 187, N 5, pp 1784—1787. Motion and structure of singularities in general relativity.

A new approach is proposed for the investigation of GR equations. A particle is considered as a singularity in the field of the Weil tensor. The approach is based on the study of the light cones, emanating from a singular world line. The well-known method of the spin coefficients of Neumann-Penrose is used for this aim. The Robinson-Trautman metrics of type II, according to the Petrov classification, are investigated. These metrics are interpreted as the field of the moving neutral and charged particles. It is shown by what means the information on the "intrinsic" properties of the singularity (of a particle) and its gravitational and electric multipole moments can be obtained. In the case of charged particles the Abraham radiation-reaction term appears automatically. A supposition is stated that this approach will lead to a reasonable theory of elementary particles. (RZF, 1970, 7B244).

**Brevik I. H., Flow Ark. fys. semin., Trondheim, 1971, N 1. Covariant quantum electrodynamics in terms of a possible ether flow.**

It is mentioned that in the isotropic space-time (i.e. under the absence of external factors) the Lorentz-covariant vector field $A_\mu$ complied with the Maxwell equations does not exist. A covariant formulation of quantum electrodynamics is proposed by means of introduction of the vector $v_\mu$, which has the transformative properties of the 4th velocity of the reference frame of the observer relative to some special (though arbitrary) reference frame $K$ ("ether"). There are constructed four vectors of the field polarization (two of them are orthogonal to $v_\mu$ and the momentum of the field) as well as their commutative function and the propagator. Possible interpretations of the ether as a real physical object are discussed. In particular, the author considers that the conventional objections against the ether fall away if the ether is considered as a quantum object. (RZF, 1971, 10B121).

**Israel W., Wilson G. A. Math. Phys., 1972, vol 13, N 6, pp 865—868. A class of stationary electromagnetic vacuum fields.**

It is mentioned that the well-known Papapetrou and Majumdar statistic solutions of the Einstein equations with electromagnetic sources, which generalize the statistic axial-symmetric Weil solution, represent the relativistic expression of the formal analogy between the Coulomb law and the Newton gravity law. The generalization of the class of the Papapetrou-Majumdar solutions for the arbitrary stationary fields is made. The generalized Papapetrou-Majumdar solutions represent external fields of stationary charged sources for which the mass $m$ and the charge $e$ are equal to each other numerically (in relativistic units $G = c = 1$). The Kerr-Neumann solution for a steady field of charged rotating sources and the Reissner-Nordström solution for a statistic field of a charged source under $m = e$ are given as an example. (RZF, 1972, 11B160).

**Hartle J. B., Hawking S. W., Commun. Math. Phys., 1972, vol 26, pp 48—51. Solutions of Einstein-Maxwell equations with many black holes.**

It is shown that the maximal analytical extension of the Majumdar-Papapetrou solution, describing a steady system of charged gravitating particles, allows to make a conclusion that singularities are placed under the horizon of events (black hole) only when the sources of an electric field are the point monopoles, the horizons of events in this case possessing spherical topology.

Roberts M. D., Class. and Quantum Gravity, 1985, vol 2, N 4, pp 69—70. Gravitational collapse forms a soliton.

Four properties of the solutions of the field equation are enumerated. They allow to consider the solutions to be stable localized solitons with finite energy. These properties are the following: 1) the soliton has to be asymptotically flat and allow the one-dimensional group of symmetry with time-similar trajectories; 2) the density of the energy has to be localized and the total energy has to be finite; 3) the solution has to be classically stable; 4) the solution has to be stable from the point of view of quantum mechanics. It is mentioned that the Kerr-Neumann solutions, conventionally considered as the only candidates to the role of solitons, do not comply with the enumerated requirements (at least one of them). It is supposed that such a candidate may be the static spherically symmetric Einstein scalar field. It is pointed out that if this supposition is right then the property of the soliton's stability could explain why no remnant has been detected after collapse.

Dine M., Seiberg N., Phys. Lett., 1985, Bd 162, N 4—6, pp 299—302. Is the superstring weakly coupled?

The problem of the bond constants and the mass-parameters in the superstring theory is investigated. In the theory of closed strings the loop-parameter $g$ is the vacuum average field of the dilaton. The size of compact measurement $\lambda$ (i.e. $\sqrt{\alpha}$ which is made dimensionless) is the inverse bond constant in the $\sigma$-model which considers the string spreading in the curved background. It is shown that the phenomenological restrictions lead to $g \sim 1$ and $\lambda \sim 1$. Thus, the theory has to be in the phase of a strong coupling. There is an alternative possibility. Either the vacuum average of the dilaton is equal to zero or there exists a massless scalar field coupled with the remaining substance extremely weakly.

Terletsky Y. P., Papers of the Moscow institute of radioelectronics and mining electromechanics on the field theory, 1965, issue 2, pp 16—37.

General properties of possible particles with negative and imaginary masses as well as the properties of the systems which contain joint groups of particles with positive and imaginary masses are investigated. It is shown that the particles with negative and imaginary masses can be considered as real physical objects, provided the physical principle of causality is considered as the corollary of the 2nd principle of thermodynamics (but not as a statistical law). The possibility, in principle, to register the particles with imaginary masses is cleared up. (See also RZF, 1963, 6B64).

Ne-eman Yuval, Progr. Theor. Phys. Suppl., 1986, N 86, pp 159—162. Strings and topology of space-time.

If the theory of relativistic strings is the correct quantum theory of gravity then the linear extension of string in space should be related to the structure of space-time and to space quantization. Qualitative arguments are given which explain how the quantum theory of space-time can naturally originate in the formalism of the string theory. This argumentation is the generalization of the ideas of Hawking and others (Hawking S. W., King A. R., J. Math. Phys., 1976, vol 17, N 174) on the possibility of renewal of the structure of curved space-time of GR on the ground of the Feynman trajectories of particles. In the proposed approach the fundamental conditions are the Feynman trajectories of strings given by the two-dimensional coordinates $\xi^a$, every point of which being connected with the $D$-dimensional reper $\Phi^a(\xi)$, $a = 1; 2; ...; D$ and the tetrad $e^a_\alpha = \partial a\, \Phi^a$. Lagrangian is given by the Nambu operation with the metrics on the surface $g_{\alpha,\beta} = \partial a\, \Phi^a\, \partial b\, \Phi^b\, G_{ab}(\Phi)$, where $G_{ab}$ is the $D$-dimensiona l background metrics. It is shown that the gravitational field appears naturally in this formalism.

Gutsunaev L. J., Kasachkov V. D., Terletsky Y. P., Ann. Phys. DDR, 1976, vol 33, N 1, pp 55—69. Use of relativistically moving systems in electrodynamics.

A new method of calculation of the transformation formulae from the inertial reference frame (RF) to the arbitrarily moving (so-called relativistic) RF is proposed within the bounds of GR. In particular, the formulae are obtained describing the transition to the uniformly accelerated RF and to the oscillating (along the $Z$-axis) RF. It is shown, as an example, that the obtained formulae simplify the calculation of the components of the electromagnetic field vector formed by the uniformly accelerated charge. The formulae of the radiation power and the angular distribution of the energy, radiated by the accelerated charge, are obtained. The transition to the RF rotating arbitrarily around the $Z$-axis gives the opportunity to calculate the field formed by the charge moving along the spiral trajectory and the value of the energy radiated by it. In this connection the motion of the charged particles in the rotating magnetic fields and, in particular, the problem of stability of such motion are investigated. The obtained results can be used to calculate the cyclical accelerators of the charged particles with the given magnetic fields configuration.

Stedile E., Phys. Lett., 1986, A 118, N 9, pp 439—442. Geometrical gauge approach for electromagnetism and gravitation.

The unified gauge model of electromagnetism and gravity is constructed. Its geometrical interpretation in the terms of geometry of fibre bundles is given. The group $SO(3,1) \times U(1)$ is chosen as a gauge one. The basic menifold is the Minkowski space. Two kinds of connectivity in the fibre bundle associated with the groups $SO(3,1)$ (the gravitational gauge field) and $U(1)$ (the

electromagnetic field) are introduced. The system of field equations with the sources of gravity ( the Yang type equations ) and of electromagnetism (the Maxwell equations) is obtained. The moment of momentum is the source of the gravitational field. Changes in the theory under the absence of the sources are discussed.

**Wunner G., Phys. B. L., 1989, vol 45, N 5, pp 139--145. Does chaos exist in quantum mechanics?**

It is a methodical essay. The character of correlation between quantum mechanics and classical physics under the great values of quantum numbers is discussed on the ground of experimental facts of last decades. The question in the title is open to discussion.

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Заказ 130. Типография ВВМИУ.

I. L. GERLOVIN

# TO LIVE WITHOUT DISASTERS

## PRINCIPLES OF UNIFIED THEORY OF ALL INTERACTIONS IN MATTER

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