# Macro-Analogies and Gravitation in the Micro-World: Further Elaboration of Wheeler's Model of Geometrodynamics

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The proposed model is based on Wheeler's geometrodynamics of fluctuating topology and its further elaboration based on new macro-analogies. Micro-particles are considered here as particular oscillating deformations or turbulent structures in non-unitaty coherent two-dimensional surfaces. The model uses analogies of the macro-world, includes into consideration gravitational forces and surmises the existence of closed structures, based on the equilibrium of magnetic and gravitational forces, thereby supplementing the Standard Model. This model has perfect inner logic. The following phenomena and notions are thus explained or interpreted: the existence of three generations of elementary particles, quark-confinement,"Zitterbewegung", and supersymmetry. Masses of leptons and quarks are expressed through fundamental constants and calculated in the first approximation. The other parameters — such as the ratio among masses of the proton, neutron and electron, size of the proton, its magnetic moment, the gravitational constant, the semi-decay time of the neutron, the boundary energy of the beta-decay — are determined with enough precision.

The world ... is created from nothing,
provided the structure ...

*P. Davies*

## 1 Introduction

The Standard Model of fundamental interactions (SM) is a result of the attempts of thousands of researches in the course of decades. This model thus bears rather complicated mathematical techniques which hide the physical meaning of the phenomena.

Is this process inevitable? And also: can further mathematical details make the Standard Model able to explain virtually everything that takes place in the micro-world? May it be necessary to add SM by the concept proceding not from electrodynamics? This problem statement is grounded, because another adequate model allows us to consider microphenomena from another side, and so it remains accessible for more number researchers.

According to contemporary statements, objects of the micro-world cannot be adequately described by means of images and analogies of the surrounding macro-world. But certain analogies successfully interpreting phenomena of the micro-world and explaining their physical essence exist. It will be shown further in the present exposition.

This work uses conceptualization of another class of physical phenomena, and its possibilities are demonstrated. This model has the inner logic which does not contradict confirmed aspects of SM. Besides, it explains some problems which are not solved at the present time.

It is necessary to outline a survey illustration of our model worked out in the spirit of Wheeler's geometrodynamics. The logic of the model, and its adequacy, is justified by many examples. Thus another approach towards understanding micro-phenomena is proposed. Herein, straightforward numerical results are obtained only on the basis of the laws of conservation of energy, charge and spin, and evident relations between fundamental constants, without any additional coefficients. These results, being the basic points of this model, justify the model's correctness.

The geometrization of the physics assumes the interpretation of micro-phenomena by topological images. Many such works have been outlined now: for example, the original elements of the micro-world, from which particles are constructed according to Yershov's model [1], are preons, which are, generally speaking, local singularities.

Wheeler's idea of fluctuating topology is used here as an original model of a micro-element of matter: in particular, electric charges are considered therein as singular points located at a surface and connected to each other through "wormholes" or vortex current tubes of the input-output kind in an additional direction, thus forming a closed contour.

A surface can be two-dimensional, but fractal, topologically non-unitaty coherent at that time. It can consist of vortex tubes linkage which form the three-dimensional structure as a whole.

This paper follows [3], where numerical values of the electric charge and radiation constants were obtained. It is shown in [3] that from the purely mechanistic point of view the so-called *charge* only manifests the degree of the non-equilibrium state of physical vacuum; it is proportional to the momentum of physical vacuum in its motion along the contour of the vortical current tube. Respectively, the spin is proportional to the angular momentum of the physical vacuum with respect to the longitudinal axis of the contour, while the magnetic interaction of the conductors is analogous to the forces acting among the current tubes.

The electric constant in the framework of the model is a linear density of the vortex tube:

$$\varepsilon_0 = \frac{m_e}{r_e} = 3.233 \times 10^{-16} \text{ kg/m}, \tag{1}$$

and the value of *inverse magnetic constant* is associated with a centrifugal force:

$$\frac{1}{\mu_0} = c^2 \varepsilon_0 = 29.06 \text{ n} \tag{2}$$

appearing by the rotation of a vortex tube of the mass $m_e$ and of the radius $r_e$ with the light velocity $c$. This force is equivalent to the force acting between two elementary charges by the given radius. Note that Daywitt has obtained analogous results in [4].

One must not be surprised that the electrical charge has dimension of impulse. Moreover, only the number of electric charges $z$ is meaningful for the force of electrical and magnetic interaction, but not the dimension of a unit charge. So, for example, the Coulomb formula takes the form:

$$F_e = \frac{z_1 z_2}{\mu_0 r^2} \tag{3}$$

where $r$ is the relative distance between the charges expressed in the units of $r_e$.

The co-called standard proton-electron contour intersecting the surface at the points $p^+$ and $p^-$ is considered in [3] and in further papers. The total kinetic energy of this contour equals the energy limit of the electron. Possibilities of the model explaining different phenomena of the micro-world are considered with the help of this standard contour.

## 2 On the connection between the electric and the weak interactions

The electric and weak interactions are united in the uniform contour. The form of our model continuum in a neighborhood of a particle is similar to the surface of a hyperboloid. It is conditionally possible to separate the contour into two regions: the proper surface of the region (the region $X$) and the "branches", or vortex tubes (the region $Y$), as shown Fig. 1. A perturbation between charged particles along the surface $X$ is transmitted at light velocity in the form of a transverse surface wave, i.e. the electromagnetic wave. The perturbation along vortex tubes by $Y$ spreads in the form of a longitudinal wave with the same velocity of transmission, as it will be shown.

Express the light velocity from (1) as:

$$c = \sqrt{\frac{s}{\varepsilon_0}} \sqrt{\frac{1}{s\mu_0}} \tag{4}$$

where $s$ is some section, for instance, the section of the vortex tube. Upon dimensional analysis, the first factor is a specific volume, the second — a pressure. In other words, this formula coincides with the expression of the local velocity of sound inside continuous medium. It is interpreted in this case as the velocity of the longitudinal wave along the tube of the contour. The longitudinal wave transforms into the transverse surface wave from the viewpoint of an outer observer at the boundary of the $X$- and $Y$-regions.

According to [3], the mass of the contour is given by $M = c_0^{2/3} m_e = 4.48 \times 10^5 m_e$. This value equals approximately the *summary mass of $W$, $Z$-bosons* (the dimensionless light velocity $c_0 = \frac{c}{[\text{m/sec}]}$ is introduced here). One can state therefore that the vortex current tube is formed by three vortex threads rotating around the principal longitudinal axis. These threads are finite structures. They possess, by necessity, the right and left rotation; the last thread (it is evidently double one) possesses summary null rotation. These threads can be associated with vector bosons $W^+$, $W^-$, $Z^0$ which are considered as true elementary particles as well as the photon, electron and neutrino.

This structure is confirmed by three-jet processes observed by high energies — the appearance of three hadron streams by the heavy $Y$-particle decay and by the electron and positron annihilation. The dates about detection of three-zone structure of really electron exist [5].

Other parameters of the weak interaction correspond to the given model. So, the projective angle is an addition to the *Weinberg angle of mixing* $q_w$ of the weak interaction. The projective angle is determined in [3] as $\arcsin \frac{c_0^{1/6}}{\sqrt{2\pi a}} = 61.8°$, where $a$ is inverse to the fine structure constant. The value $\sin^2 q_w = 0.231$ is determined experimentally, i.e. $q_w = 28.7°$ and $\frac{\pi}{2} - q_w = 61.3°$. Based exactly on the value of this angle the electric charge is calculated precisely, the numerical value of which has the form [3]:

$$e_0 = m_e c_0^{4/3} \cos q_w \times [\text{m/sec}] = 1.603 \times 10^{-19} \text{ kg m/sec}. \tag{5}$$

## 3 Fermions and bosons

It is necessary to note that vortex structures are stable in this case if they are leaned on the boundary of phase division, i.e. on the two-dimensional surface.

The most close analogy to this model, in the scale of our world, could be *surfaces of ideal liquid*, vortical structures in it and subsequent interaction between them, forming both relief of the surface and sub-surface structures.

Vortex formations in the liquid can stay in two extreme forms — the vortex *at the surface* of radius $r_x$ along the $X$-axis (let it be the analog of a fermion of the mass $m_x$) and the vortical current tube *under the surface* of the angular velocity $v$, the radius $r_y$ and the length $l_y$ along the $Y$-axis (let it be the analog of a boson of the mass $m_y$). These structures oscillate inside a real medium, passing through one another (forming an oscillation of oscillations). Probably, fermions conserve their boson counterpart with half spin, thereby determining their magnetic and spin properties, but the spin is regenerated up to the whole value while fermions passing through boson form. The vortex field, twisting into a spiral, is able to form subsequent structures (current tubes).

The possibility of reciprocal transformations of fermions and bosons forms does not mean that a micro-particle can stay simultaneously in two states, but it shows that a mass (an energy) can have two states and *pass from one form to another*.

It is easy to note that this model of micro-particles gives an overall original interpretation of the employed notions: *mass defect* and *supersymmetry*. At the same time, our model does not require us to introduce additional particles (superplayers) which have remained undetected until now by experiments and, evidently, will not be discovered.

## 4 The determination of the relation of the masses proton/electron

In order to compare masses of fermions, it is necessary to consider them as objects possessing inner structure. Let us introduce the analog where the vortex tube is similar to a jet crossing the surface of liquid inside a bounded region and originating ring waves, or contours of the second order (which originate, in turn, contours of the third order, etc.). Let this region of intersection correspond to a micro-particle. Then it is considered now as a proper contour and can be characterized by parameters of the contour: a quantum number $n$, the radius of the vortex thread $r$, the circuit velocity $v$ and the mass of the contour $M$.

Let us proceed to determine the quantum numbers for micro-particles. We express the typical spin of fermions through parameters of their characteristic contour, being restricted to self-evident cases, namely:

1) the spin of the particle equals the momentum of the contour as a whole:

$$\frac{h}{4\pi} = Mvr\,, \tag{6}$$

2) the spin of the particle equals the momentum of the contour, related to the unity element of the contour structure (the photon):

$$\frac{h}{4\pi} = \frac{Mvr}{z}\,, \tag{7}$$

where $h = 2\pi a m_e c r_e$ is the Planck constant.

The parameters of $M$, $v$, $r$ following from the charge conservation condition are determined as [3]:

$$M = (an)^2 m_e, \tag{8}$$

$$v = c_0^{1/3}\frac{c}{(an)^2}, \tag{9}$$

$$r = c_0^{2/3}\frac{r_e}{(an)^4}, \tag{10}$$

and the number of photons $z$ in the contour for the case of the decay of the contour (ionization) is

$$z \approx n^4. \tag{11}$$

The following evident relation ensues from the expression of the linear density $\varepsilon_0$ (1):

$$\frac{l_y}{r_e} = \frac{m_y}{m_e} = \frac{M}{m_e} = (an)^2. \tag{12}$$

In other words, the relative length of the current tube expressed through the units $r_e$ equals the boson mass M expressed through the units $m_e$.

Using the parameters obtained in (8), (9), (10), (11) from (6) and (7), we find:

1) for the first particle, assuming that it is a proton

$$n = n_p = \left(\frac{2\,c_0}{a^5}\right)^{1/4} = 0.3338, \tag{13}$$

2) for the second particle, assuming that it is an electron

$$n = n_e = \left(\frac{2\,c_0}{a^5}\right)^{1/8} = 0.5777. \tag{14}$$

Taking into account properties of fermions and bosons in our model, we conjecture that the boson thread is able to pack extremely compactly into the *fermion form* by a process of oscillation along the $Y$-axis. This packing is possible along all four coordinates (degrees of freedom), because this structure can form subsequent structures. Using (10) and (12), we find that the relative linear dimension of a fermion along the $X$-axis is proportional to the radius of the vortex thread. It can be expressed by the formula:

$$\frac{r}{r_e} = \left(\frac{r}{r_e}\right)\left(\frac{l_y}{r_e}\right)^{1/4} = \frac{(c_0)^{2/3}}{(an)^{7/2}}. \tag{15}$$

For instance, substituting into the above-obtained formulas $n = n_p$, we find the characteristic dimensions of the proton structure expressed through the units $r_e$: the radius of the vortex thread $r = 0.103$, the linear dimension along the $X$-axis $r_x = 0.692$ and the length of the vortex thread $l_y = 2092$. For the electron, by the substitution $n = n_e$, we have, respectively: 0.0114, 0.1014 and 6266.

Of course, the expression (15) has only qualitative character, but it can be used for the calculation of the *mass relation* of arbitrary fermions, assuming that the respective masses are proportional to their four-dimensional volumes:

$$\frac{m_{xp}}{m_{xe}} = \left(\frac{r_{xp}}{r_{xe}}\right)^4 = \left(\frac{n_e}{n_p}\right)^{14}. \tag{16}$$

For the given couple of particles, we have the relation $\left(\frac{0.5777}{0.3338}\right)^{14} = 2160$, therefore it is evident that this couple is

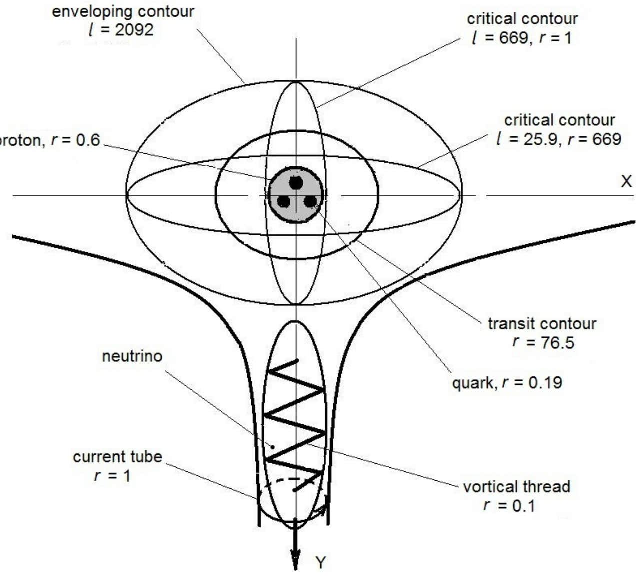


Fig. 1: The contours: scheme of the contours of the proton, and their sizes (in the units of $r_e$).

really *proton* and *electron*. Thus the given relation is equal to the mass of the proton expressed by the units of the electron mass. It is more evident, because the boson mass of a particle $m_{yp}$ is almost equal to the fermion mass $m_{xp}$ , and it is non-randomly so. Let these masses be equal, then the more precise value is the boson mass according to (12), because it does not depend on the photon number $z$, which is determined by means of the approximated formula. Then we can correct also the value $n_e$ using the relation (16), and accept that its value is equal to 0.5763. It is necessary to correct the proton mass and electron charge by the cosine of the Weinberg angle. We obtain, as the final result, an almost exact value of the observed proton mass:

$$\frac{m_p}{m_e} = (an_p)^2 \cos q_{\mathrm{w}} = 1835. \qquad (17)$$

The Weinberg angle has also a geometric interpretation as $\cos q_{\mathrm{w}} = \left(\frac{1}{2\pi}\right)^{1/14}$, which confirms indirectly the correctness of the expression (16) also.

The masses of other particles expressed through the units of the electron mass are calculated: for the fermion — according to (16), assuming that $n_p$ is the quantum number for an arbitrary fermion, and for the boson — according to (12).

The quantum numbers for the electron $n_e$ and the proton $n_p$ are their inner determinant parameters, emerging into the influence zone of these particles. The parameter $n_e$ determines the length of the enveloping contour of the electron as a circle of the length $l_y = (an_e)^2 r_e$, corresponding to three inscribed circles of the diameter $d_y$. The vortex threads rotate inside these circles. This diameter equals the Compton wavelength, i.e. the amplitude of electron oscillations, which follows from the Dirac equation (the phenomena "*Zitterbewegung*"). Evindently, it follows from geometric reasons:

$$d_y = \frac{(an_e)^2 r_e \sin(60^\circ)}{2\pi} = 2.423 \times 10^{-12}\mathrm{m}, \qquad (18)$$

which coincides with the Compton wavelength, where "*Zitterbewegung*" is confirmed by experiments [6].

Analogously, the parameter $n_p$ determines the length of the contour of the proton of the diameter $d_y = \frac{(an_p)^2 r_e}{\pi}$ enveloping the extremely contracted $p^+ - e^-$-contour, parameters of which reach critical values with $v = c$, Fig. 1. It follows in this case from (9):

$$n_p = n_{min} = \frac{c_0^{1/6}}{a} = 0.1889 \qquad (19)$$

and using (12) we find further $l_y = c_0^{1/3} r_e = 669 r_e \approx d_y$.

The excitation of elementary particles gives a set of their non-stable forms. So, fermions can have more porous and voluminous packing of boson threads, forming hyperons, etc. Apparently, some preferred configurations of packing exist, but the most compact is a proton, for which the volume and the mass of the particle are *minimal* for baryons.

## 5 Three generations of elementary particles

A micro-particle is considered in our model as an actual contour, therefore any contour connecting charged particles can be compared with a particle included in a greater contour; i.e. the mass of a relatively lesser contour is assumed to be the mass of a hypothetical fermion (e.g. a baryon as the analog of a proton for greater one), as shown in Fig. 2. Thus, there can exist correlated contours of the first and following orders forming several generation of elementary particles. It is clear that two quantum numbers correspond to every particle depending on its classification: 1) the particle is considered as a fermion (the analog of the proton being part of the greater contour of the following class); 2) the particle is considered as a boson (the mass of the contour of the previous class of particles). Fermion and boson masses are equal only for a proton, besides they have the same quantum number $n = 0.3338$.

The analog of a proton for the $\mu$-contour is the mass of the standard contour $M = c_0^{2/3} m_e$. We find from (16) its quantum number $n_\mu = 0.228$. The analog of a proton for the $\tau$-contour is the mass of the $\mu$-contour, and $n_\tau$ is determined from extreme conditions, i.e. when $v \to 1$, $r \to 1$ and $n_\tau = n_{min} = 0.1889$. Then we find from (16) the mass of the $\mu$-contour or the $\tau$-analog of a proton which equals $6.05 \times 10^6 m_e$.

It is logical to assume that by analogy with the second class that this mass also consists of three bosons (the middle mass of every boson $2.02 \times 10^6 m_e$, i.e. 1030 GeV), which corresponds to the upper bound of the mass of the unknown Higgs boson. Thus, in reality, the *$\tau$-contour is the largest and the last one in the row*.

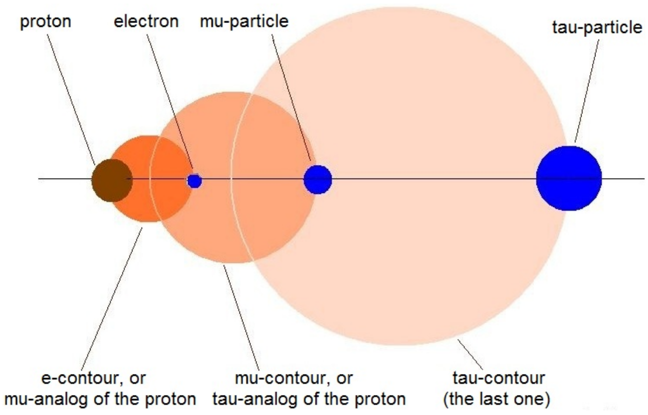


Fig. 2: Scheme of the families of the elementary particles.

Assume that the relation between the masses of baryons and their leptons in the following classes of particles, i.e. between masses of the $\mu$-analog of the proton and a muon, and the $\tau$-analog of a proton and a taon, is the same as for a proton-electron contour: it equals 2092. Then, using the obtained value, we can estimate the masses of other leptons. The mass of a *muon* equals $\frac{4.48\times10^5}{2092} = 214\,m_e$, whereas the mass of a *taon* equals $\frac{6.05\times10^6}{2092} = 2892\,m_e$.

The $\mu$- and the $\tau$-analogs of protons as baryons do not actually exist, but their boson masses $(an_\mu)^2 m_e$ and $(an_\tau)^2 me$ are close to the masses of lightest mesons — kaon and a couple of pions.

## 6 On the proton's structure

Continuing a hydrodynamic analogy, we assume that any charged particle included in a contour of circulation is the region where a flow of the medium intersects the boundary between $X$- and $Y$-regions: the phase transformation is realized in this boundary and the parameters attain *critical values*.

Let us now introduce the notion the density of a fermion and a boson mass: $\rho_x = \frac{m_x}{w_x}$ and $\rho_y = \frac{m_y}{w_y}$. Neglecting their exact forms, assume three-dimensional volumes of fermions and bosons in the simplest form: a fermion — as a sphere $w_x = r_x^3$, a boson thread — as a cylinder $w_y = r^2 l_y$.

Using (10), (12), (15), (16), we obtain, after transformations, their respective densities:

$$\rho_x = \frac{\rho_e\, n_e^{14}\, a^{10.5}}{n^{3.5}\, c_0^2}, \tag{20}$$

$$\rho_y = \frac{\rho_e\,(an)^8}{c_0^{4/3}}, \tag{21}$$

where $\rho_e$ is the density of the electron for a classical volume $\frac{m_e}{r_e^3} = 4.071\times10^{13}$ kg/m$^3$.

Of course, the densities of fermion and boson masses by the critical section are equal. Then we find by $\rho_x = \rho_y$ the critical quantum number and the density:

$$n_k = \frac{n_e^{1.217}\, a^{0.217}}{c^{0.058}} = 0.480, \tag{22}$$

$$\rho_k = \frac{\rho_0\,(a\,n_e)^{9.74}}{c_0^{1.797}} = 7.65\times10^{16}\ \text{kg/m}^3, \tag{23}$$

It is possible to ascribe these averaged parameters to some particle — a *quark*, existing only inside the phase transfer region. At once note that a quark by this interpretation is not a specific particle but only a part of the mass of a proton, obtaining critical parameters. The value of the mass can be determined from the formula (16): $m_k = 12.9\,m_e$. It is easy to calculate further other parameters of an electronic quark. It is possible to verify that the density of a quark is between the fermion and boson densities of a proton, and its size goes in to the size of a nucleon.

The critical velocity of a vortex current is determined from the known hydrodynamic equation:

$$v_k = \left(\frac{p_k}{\rho_k}\right)^{1/2}, \tag{24}$$

where in this case: $v_k$ is the critical velocity, $\rho_k = \frac{m_k}{w_k}$ is the critical density, $w_k$ is the volume of the quark, $p_k$ is the pressure in the critical section, or the energy related to a corresponding volume. The energy of the standard contour equals $m_e c^2$ [3], and the critical volume is determined as $z_k w_k$, where $z_k$ is the number of quarks.

Substituting the indicated values and expressing also $v_k$ through (9), we find from (24) the number of quarks as

$$z_k = \frac{(a\,n_k)^4 m_e}{c_0^{2/3}\, m_k} = 3.2. \tag{25}$$

This result shows that the flow of the general contour must split into *three parts* in the region of the proton so as to satisfy the conditions of critical density and velocity. The relation of boson masses of an electron and a proton equals the same value. In fact, using (12), we obtain $\frac{M_e}{M_p} = \left(\frac{n_e}{n_p}\right)^2 = 3.0$.

It means that in order that the conditions of current continuity and charge steadiness in any section of the contour are realized, *inverse circulation currents* must arise in a neighborhood of a proton. It can be interpreted as a whole that zones with different signs of charge exist in a proton. Using a *minimal* number of *non-recurrent force current lines*, we can express schematically current lines in a proton in a unique way, as shown in the Fig. 3

As seen, there exist two critical sections with a conditionally plus current (up in the scheme) and one section with a conditionally minus current (down in the scheme), where three current lines correspond to a general current in the scheme. Therefore, the fermion surface of a proton is constructed: the regions where force lines intersect the critical sections on the line 0 – 0 inside a proton will be projected on this surface in the form +2/3, +2/3, −1/3 from the total charge according to the number and direction of the force lines intersecting this surface.

Therefore, it is more correct to associate quarks not with critical sections but with *steady ring currents*, containing one or two closed single contours intersecting the critical section, as follows from the scheme. Therefore the masses of quarks can be determined as 1/3 or 2/3 from the summary-calculated $12.9\,m_e$, i.e. they must be equal, respectively, to $4.3\,m_e$ and $8.6\,m_e$ , which coincides in fact with the masses of light quarks determined at the present time.

Parameters of quarks of $\mu$- and $\tau$-classes are calculated analogously by substitution of muon and taon quantum numbers in place of $n_e$, respectively, (Table 1).

Of course, the proposed structure of the proton is a hypothesis of the author only. Nevertheless, the definite numbers and masses of quarks here do not contradict the ones obtained by other methods earlier. Concerning the *confinement* or non-flying of quarks: this phenomenon is self-evident, because a proton in the presently given model has no combined parts, but it has only local features in its structure. The density of a proton in critical-value regions is considerable less than its fermion density: they are, probably "holes" and, of course, they cannot be distinguished as individual particles. On the other hand, only regions of critical sections, being of advanced frontal velocity pressure (dynamical pressure), are observed by experiments as *partons*.

We can deduce one more reason on behalf of the stated model: the Georgi-Glashow hypothesis of a linear potential exists. According to this hypothesis, between infinitely heavy quarks there must act, independently from a distance, a force of attraction (approximately 14 tons). Current tubes are just linear objects in our model.

Concerning the force: its limiting value can be expressed here as the sum of electrical forces' projections relative to the center of the right triangle. The forces act in pairs between critical sections carrying an elementary charge by the condition that the distance between them is minimal (according to (10), for a quark $r = 0.0239\,r_e$). Then, taking into account (3), we find $F_e = \frac{3\cos 30^\circ}{\mu_0\, r^2} = 1.33\times 10^5$ N or 13.3 tons.

## 7 The weak interaction and the neutrino

The stated scheme of a proton allows us to give a native illustration to the proton-neutron transitions in the weak interactions. For example, in the case of the so-called hunting phenomenon (*e-capture*) if a proton and an electron bring together up to $n \leqslant 1$) an intermediate contour is formed, connecting the particles temporarily. The boson mass of the contour, in addition, must be more than the sum of the combined boson masses of the proton and the electron, precisely:

$$M = (an)^2 m_e + m_{yp} + m_{ye}. \qquad (26)$$

Let $n$ =1, then $M = 27108\,m_e$. Using the general relation

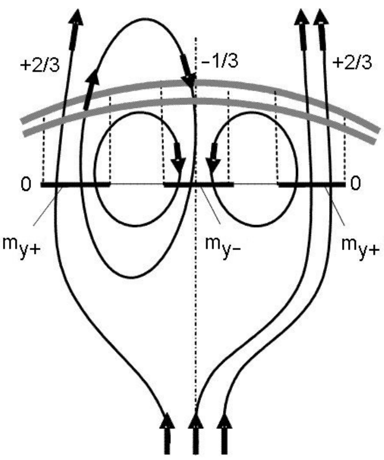


Fig. 3: Scheme of the proton: distribution of the current lines inside the proton.

between the boson mass of a contour and a lepton, we find the mass of the fermion for this contour: $m_x = \frac{27137}{2092} = 12.9\,m_e$.

This result turns out to be independent. The obtained value $M$ coincides with a total mass of the quark and confirms that in the process of *e*-capture the temporal contour is actually formed, which is analogous to earlier considered contours (section 5) where one of the critical sections of a proton as a lepton is present.

Recall that our model contour has the properties of ideal liquid, therefore closed ring formations as parts of this continuum are absolutely inelastic and absolutely deforming at the same time. The contour connecting the particles, by their further coming together, transmits a share of energy-momentum to the inner structure of the proton, deforms and orients itself to the $Y$-region; then it is extracted as a *neutrino* which takes the momentum (spin) of the electron (Fig. 1). In other words, this process is similar to a separation of charge and spin — the phenomenon, fixed in hyperfine conductors [7], which vortex tubes are supposedly similar to.

A similar contour is formed by every act of the weak interaction, and it corresponds to the exchange of intermediate bosons. The relative slowness of this process is connected with the *time constant t*. The typical value of $t$, taking into account a spiral derived structure, determined by the time during which a circulating current passes with the velocity $v$ through all line of the "stretched" counter (the size of $W$-, $Z$-particles). For the standard contour we have

$$t = (4.884)^2\, \frac{R_b\,(r_e/r)}{v} = 1.25\times 10^{-9}\ \text{sec}, \qquad (27)$$

where 4.884 is the quantum number for a standard contour [3], $r$ and $v$ are determined by (9) and (10) by the given $n$, $R_b$ is the Bohr first radius.

It follows from the logic of the model, that a neutrino is a particle analogous to a photon, but it spreads in the $Y$-region, i.e. it transfers energy along the vortex tube of the contour. As known, two kinds of these particles: a neutrino — with a left spiral and an anti-neutrino — with a right spiral, corresponding to two poles of a general contour. Because a neutrino is a closed structure and exists only in the $Y$-region, it has no considerable charge and the mass in a fermion form ( i.e. in form of the $X$-surface objects). Probably, a neutrino has a spiral-toroidal structure and thus it inherits or reproduces (depending on the type of the weak interaction) the structure of the vortex tube of the contour.

## 8 On the magnetic-gravitational interaction

Consider a possibility of existence of the mentioned closed contours at the express of an equilibrium between magnetic forces of repulsion and electrical forces of attraction. Let us formally write this equality for tubes with oppositely directed currents, neglecting the form of the contour and its possible completeness, and expressing the magnetic forces through the Ampere formula in the "Coulomb-less" form:

$$\frac{z_{g1} z_{g2} \gamma m_e^2}{r_i^2} = \frac{z_{e1} z_{e2}\, \mu_0\, m_e^2\, c^2\, l_i}{2\pi r_i \times [\mathrm{sec}^2]}, \tag{28}$$

where $z_{g1}$, $z_{g2}$ , $z_{e1}$, $z_{e2}$, $r_i$, $l_i$ are gravitational masses and charges expressed through masses and charges of an electron, a distance between current tubes and theirs length.

Substituting $\mu_0$ from (2), we derive from (28) the characteristic size of the contour as the *mean-geometric* of two linear values:

$$l_k = \sqrt{l_i r_i} = \sqrt{\frac{z_{g1} z_{g2}}{z_{e1} z_{e2}}}\, \sqrt{2\pi\gamma\varepsilon_0} \times [\mathrm{sec}]. \tag{29}$$

The parameter $l_k$ is composite. Using the formulas (10), (12), (29), we obtain for a contour with a unit charge the values $l_i$ and $r_i$ , where the lengths are expressed by the units of $r_e$:

$$l_i = \frac{c_0^{2/3}}{l_k^2}, \tag{30}$$

$$r_i = \frac{l_k^4}{c_0^{2/3}}. \tag{31}$$

The contour can be placed both in the $X$-region (for example, a contour $p^+ - e^-$) and in the $Y$-region (inside an atomic nucleus). A deformation of the contour, for example, its contraction by the e-capture, takes place by means of the $\beta$-decay energy. When a proton and an electron come together, energy and fermion-mass increase of the contour occurs, while the boson mass decreases, but the impulse (charge) is conserved.

Consider some characteristic cases of a contour contraction and of a further transition of the nucleon from a proton form into a neutron one.

a) Write the equality (29) for $p^+ - e^-$-contour, where $z_{g1} = \frac{m_p}{m_e \cos q_\mathrm{w}}$ is the relative mass of the proton, where the cosine of the Weinberg angle is considered, and $z_{g2} = 1$. In this case $l_k = 5977.4\, r_e$, which corresponds to the value $\frac{R_b}{\pi}$ exactly. In other words, for the contour $p^+ - e^-$:

$$l_k = \sqrt{\frac{m_p}{m_e \cos q_\mathrm{w}}}\, \sqrt{2\pi\gamma\varepsilon_0} \times [\mathrm{sec}] = \frac{R_b}{\pi}. \tag{32}$$

The extension of the contour is now impossible, because all the mass of the proton is involved in the contour of circulation. Thus the parameters $l_i$ and $r_i$ are limited and equal to 0.0125 and $2.850 \times 10^9\, r_e$, respectively, i.e. the length of contour tubes equals the radius of the vortex thread of an electron, approximately (section 4), and the distance between them equals the limiting size of the hydrogen atom ($390^2 R_b$). The last result is confirmed by the fact that the maximal level of energizing of hydrogen atoms in the cosmos, registered at the present time by means of radio astronomy, does not exceed $n = 301$ [8].

b) Let $l_k$ be equal to the Compton wavelength $\lambda_k = 2\pi a r_e$. In this case, $l_i$ and $r_i$ are equal to 0.604 and $1.227 \times 10^6\, r_e$, respectively, i.e. the length of contour tubes corresponds to the diameter of a nucleon, and the distance between them — to the size of the most atomic size ($8^2 R_b$). Thus, taking into account (30) and the expression for $\lambda_k$, we can express the proton radius in the form:

$$r_p = \frac{c_0^{2/3}}{8\pi^2 a^2} = 0.302\, r_e = 851\ \mathrm{fm}, \tag{33}$$

which corresponds to the size of the proton, determined by the last experiments (842 fm) [9].

The equality (29) of $l_k = \lambda_k$ is observed, if the relation $\frac{z_{g1} z_{g2}}{z_{e1} z_{e2}} = 43.4$. This value can be interpreted as the product of the masses of two quarks $z_{g1} z_{g2}$, included in the contour of a nucleon or an atomic nucleus.

c) The critical contour of $v = c$. Here $l_i = c_0^{1/6}$, $r_i = c_0^{1/3}$, $l_k = c_0^{1/4}$ by the units of $r_e$. The equality (29) is fulfilled provided that the relation $\frac{z_{g1} z_{g2}}{z_{e1} z_{e2}} \approx 1$. A fraction of the impulse is transmitted to its own current (quark) contour of the proton by a further contraction of the contour, because the velocity of circulation cannot exceed the light velocity.

d) The contour is axially symmetric and is placed at the intersection of regions $X$ and $Y$, which corresponds to a transient state between a proton and a neutron. It is logical to assume that the mass of the contour is situated in a critical state which is intermediate between fermion and boson forms. It is possible to suppose, according to the considered model, that a boson thread is contracted already into a contour by the length $l_k$, but it is not packed yet into a fermion form.

In this case $l_i = r_i = l_k = c_0^{2/9} r_e$, and the equality (29) is fulfilled provided that the relation $\frac{z_{g1} z_{g2}}{z_{e1} z_{e2}} \approx 1/3$. The limit impulse of this contour $I = \pi\varepsilon_0\, l_k\, c \approx \frac{e_0}{3\cos q_\mathrm{w}}$, consequently it could correspond to one excited quark contour.

The size of the magnetic-gravitational contour is correlated with the size of an atom depending on the value of gravitational masses involved in its structure; the product of these masses is in the limits $(5.4\ldots43)\,m_e^2$ in the intervals of the main quantum numbers $n = 1,\ldots,8$. Moreover, in the region $X$ the relation $\frac{z_{g1}z_{g2}}{z_{e1}z_{e2}}$ is proportional to the degree of deformation of the contour, i.e. to the relation of the size of the symmetric contour $l_k$ with respect to the small axis of the deforming one; the coefficient of proportionality is *constant* and equal to $0.34 \approx 1/3$.

The contour is reoriented into the region $Y$ by the proton-neutron transition. However in this case, in the region $Y$, there is a *sole solution*, which determines the critical contour by $v = c$. Here $l_i = c_0^{1/3}$, $r_i = 1$, $l_k = c_0^{1/6}$ by the units $r_e$. The contour is inserted in the current tube with the size $r_e$ and the inverse relation is realized exactly for this contour:

$$\frac{z_{e1}z_{e2}}{z_{g1}z_{g2}} = \frac{l_k}{3r_i}. \tag{34}$$

Taking into account that for the symmetric contour $l_k = c_0^{2/9} r_e$ and using the formula (29), we have, after transformations,

$$\frac{c_0^{5/9} r_e^2}{2\pi\gamma\varepsilon_0 \times [\mathrm{sec}^2]} = 3. \tag{35}$$

The uniqueness of the solution indicates that, by the transition of a proton into a neutron, the contour is isolated into the region $Y$, namely with the corresponding critical parameters, and corresponds to a neutrino.

The expressions (32) and (35) are exact, as the values $\pi$ and 3 reflect the geometry of the space and its three-dimensionality. It is possible to deduce from them the formula of the *gravitational constant* using the least quantity of values possessing dimensions, and to obtain also the more exact expression for the Weinberg angle. So, removing the expression for $\varepsilon_0$, we find from (35), after transformations,

$$\gamma = \frac{c_0^{5/9}}{6\pi\rho_e \times [\mathrm{sec}^2]} = 6.6733 \times 10^{-11}\ \mathrm{m^3/sec^2\,kg}, \tag{36}$$

from (32) and (35):

$$\cos q_{\mathrm{w}} = \frac{\pi^2 c_0^{5/9}}{3a^4}\frac{m_p}{m_e} = 0.8772. \tag{37}$$

Note that the expression for $\gamma$ shows that the gravitational constant is an acceleration, i.e. the velocity at which the specific volume of matter in the Universe changes, in view of its expansion.

Thus, the analysis of a magnetic-gravitational equilibrium, additionally and independently, confirms the existence of three zones in the proton structure and the correspondence to the masses of light quarks of the active parts of the proton mass, included in the circulation. The conditions stated in sections 4, 6, 8 reflect different aspects of the unit structure of a proton as a whole.

## 9 The determination of the mass and lifetime of the neutron

A neutron is somewhat heavier than a proton, which is due to the excited condition of its own current (quark) contours. But in SM, only one quark from among the three undergoes a transformation by the proton-neutron jump. Let us assume that this quark contour obtains in addition the energy of a symmetric contour (which is considered in this situation as the own contour of a particle of the mass $\varepsilon_0 l_k$), which leads to its size extension and, respectively, to the increase of the nucleon mass.

Let us equate a total-energy differential, obtained by a nucleon, to the rotational energy of a symmetric contour except the initial rotational energy of a quark contour:

$$\frac{(m_n - m_p)\,c^2}{\cos q_{\mathrm{w}}} = \varepsilon_0\, l_k\, v_i^2 - \frac{m_k v_k^2}{2}, \tag{38}$$

where $v_i$ is the peripheral velocity of a symmetric contour, $v_k$ is the peripheral velocity of a quark contour, $\frac{1}{2}\,m_k$ is the averaged mass of a quark contour (section 6). Starting from the masses $c_0^{2/9} m_e$ and $12.9\,m_e$, theirs quantum numbers are determined from the formula (16), the rotational velocities — from (9). Substituting these values we obtain after transformations the expression (by the unites of $m_e$ and $r_e$):

$$m_n - m_p = r_{ie}\left(c_0^{2/7} - \frac{m_k^{9/7}}{2}\right)\cos q_{\mathrm{w}} = 2.53\,m_e, \tag{39}$$

where $r_{ie}$ is the radius of the vortical thread of the electron determined from (10).

After discharge of a neutrino and deletion of three enclosed current lines, there remains one summary contour in the neutron. This contour consists of three closed force lines. Its size can maximally reach the size of a symmetric contour by means of the obtained energy. This contour forms three vortex threads by the length $l_y$ with co-directed currents. These threads rotate relative to the longitudinal axis and have the boson masses $m_y$. The equality of magnetic and inertial (centrifugal) forces for vortex threads must follow from the equilibrium condition. By analogy with (28), we have:

$$\frac{m_y v_0^2}{r_i} = \frac{z_{e1}z_{e2}\,\mu_0\, m_e^2\, c^2\, l_y}{2\pi r_i \times [\mathrm{sec}^2]}, \tag{40}$$

where $v_0$ is the *peripheral velocity* of vortex threads. Taking into account (1), (2), (12), we find from (40):

$$v_0 = \frac{\sqrt{z_{e1}z_{e2}}\, r_e}{\sqrt{2\pi} \times [\mathrm{sec}]}, \tag{41}$$

where the velocity does not depend on the length of the vortex threads and the distance between them.

A spontaneous, without action of outer forces, neutron-decay is realized just owing to the own rotation of vortex threads, causing a variation of its inner structure. In other words, the excited contour deforms and is turned into another configuration with less energy, which corresponds to the initial energy of the proton. This process must characterize itself by the *constant of time* which can be determined as a quotient from a division of the characteristic linear size in terms of the peripheral velocity $v_0$. As the diameter of the tube is not determined, $r_i$ is not determined, then it is expediently to consider the length of a symmetric transient contour $\pi l_k$ as a characteristic size. In this case, the constant of time takes the form for unit charges:

$$\tau = \frac{\pi l_k}{v_0} = \sqrt{2\pi^3}\, c_0^{2/9} \times [\text{sec}] = 603 \text{ sec.} \tag{42}$$

On the other hand, the constant of time can be determined also from energetic reasons, taking into account the difference of the masses of nucleons.

Let a neutron lose step-by-step the transmitted total energy $(m_n - m_p)c^2$ by portions which are proportional to the energy of an electron $m_e v_e^2$, where $v_e$ is the electron's own-contour rotational velocity during the time equal to the period of vortex threads rotation inside the current tube. Determine this characteristic time as $\frac{r_e}{v_0} = 2.51$ sec, then, taking into account (9), (39), (41), we obtain the period of the total dispersion of the energy by a neutron:

$$\tau = \frac{\sqrt{2\pi}\,(m_n - m_p) \times [\text{sec}]}{r_{ie} \cos q_{\text{w}}} = 628 \text{ sec,} \tag{43}$$

The obtained constants of time correspond to the half-life of a neutron $\tau_{1/2}$. By definition, $\tau_{1/2} = \ln 2 \times \tau_n$, where $\tau_n$ is the lifetime of a neutron; its value which is obtained by one of the recent studies is 878.5 sec [10], then $\tau_{1/2} = 609$ sec.

Note that the contour of a neutrino also consists of three different vortex fields and probably undergoes periodically small variations of time when forming three configurations relative to a chosen direction. This result, probably, can explain the problem of solar neutrinos and their possible variations.

## 10 On the $\beta$-decay energy

The energy of the excited contour of a neutron by its decay is transmitted to an electron and an anti-neutrino extracted by this process. Taking into account (1), (9), (16), we can express, in relative units, the additional impulse $I_\beta = \pi \varepsilon_0 l_k v_i$ transmitted to a nucleon from the symmetric contour:

$$I_\beta = \frac{\pi c_0^{37/63}}{(a n_e)^2} = 47.92\, m_e c. \tag{44}$$

This impulse is distributed between the contours of a neutrino and an electron with the total mass $M_\beta$, and these contours are present in any process of the weak interaction.

In addition, the mass of a neutrino contour is $c_0^{1/3} m_e$, and the mass of an electron contour also cannot be smaller than the critical value $c_0^{1/3} m_e$. The velocity of rotation of the contour by the impulse transmission will be $\frac{I_\beta}{M_\beta}$, and the $\beta$-decay energy is $E_\beta = \frac{I_\beta^2}{M_\beta}$; then its maximal value, transmitted additionally to the electron and neutron contours, and, consequently, to the electron and the neutrino, occurs at $M_\beta = 2c_0^{1/3} m_e$. Substituting the values, we obtain the boundary value of energy: $E_{\beta 0} = 1.72$ (in the units of $m_e c^2$) or 0.88 MeV.

The same result can be obtained by means of another, independent way, if we assume that the transient contour is symmetric from an energetic viewpoint (but not from a geometric one). Assume that the limit energy of the mass of a fermion contour equals the energy of rotation of this mass in a boson form, i.e. $m_x c^2 = m_y v^2$. Introduce also into the expression of the impulse the value of the spin of the contour: it allows us to characterize the process of the $\beta$-decay more objectively. Correct to this end the quantum number $n_e$ for the unit relative mass (the mass of an electron) in the case of arbitrary spin. It is evident that, taking into account of (7) and (14), $n_{ei} = \frac{n_e}{k^{1/8}}$, where $k$ is the relation between an arbitrary spin value and the spin 1/2.

Taking into account the aforesaid equalities and using the formulas (9), (12), (16), we obtain as a result the expression for the impulse of the contour which is analogous to (44), in the units of $m_e c$:

$$I_\beta = \frac{k^{7/12} c_0^{11/9}}{(a n_e)^{14/3}}. \tag{45}$$

It gives, for $k = 2$, the value of the impulse 47.96 $m_e c$, coinciding with the result of the formula (44).

Thus we have showed that, by the transient condition of a nucleon, the symmetric contour obtains temporarily the spin 1 (joining the spin of an electron 1/2, which then takes a neutrino).

This energy of the $\beta$-decay for isotopes can be higher, and its maximal value can be determined. According to our model, a symmetric contour can transfer the limit impulse which equals one third of a charge (section 8, d). Then, taking into account (5), assuming $M_\beta = 2c_0^{1/3} m_e$ and introducing the Weinberg angle, we obtain as a result the simple expression of the $\beta$-decay limit energy in the units of $m_e c^2$:

$$E_{\beta lim} = \frac{c_0^{1/3} \cos q_{\text{w}}}{18} = 32.6 \tag{46}$$

or 16.7 MeV.

In fact, the maximal value of the $\beta$-decay energy among different isotopes is registered for the transition $N^{12} \rightarrow C^{12}$ (16.6 MeV), which coincides with the calculated value. The value of the impulse which corresponds to the given energy follows from the formula (45) by $k = 28$. In other words, the obtained spin is proportional to the number of nucleons in the nucleus (for a nitrogen, 28/2 = 14).

In the case of $e$-capture only a neutrino is extracted, then $M_\beta = c_0^{1/3} m_e$, and the typical energy of the neutrino must be

1.75 MeV.

Namely, such contours, possessing symmetric forms and balanced energies (quarks), are the base of the microstructure of particles: *three* quarks for baryons and *two* — for mesons. Partially, for $k = 1$, the contour, possessing the spin 1/2, has the mass 146.4 $m_e$. Consequently, two such contours, depending on their properties of combination, can form mesons more easily — pions, and their excited states — , i.e. heavier micro-particles.

Thus, the results obtained in sections 8, 9, 10 in the framework of our model correspond to well-known parameters and admissible limits. Various coincidences of the calculated values with reality (e.g. the number of quarks, the sizes of the axes of characteristic contours, the size of the proton, the gravitational constant, the difference of the masses of nucleons, the half-life of the neutron, the $\beta$-decay energy) cannot have accidental nature: they prove that the structure satisfying the magnetic-gravitational equilibrium condition really exists in the micro-world.

## 11 The magnetic moments of the proton and the neutron

The anomalous magnetic moment of the proton $\mu_p$ in the given model can be calculated as follows. The value $\mu_p$ depends on the boson configuration of a proton and is determined relative to the $Y$-axis where $\mu_p$ is the product (charge×velocity ×path). We thus have, for a vortex thread, a peripheral velocity $v$ and a circumference $\pi r$. Substituting $v$ and $r$ from (9) and (10), we obtain as a result:

$$\mu = \frac{\pi c_0 c e_0 r_e}{(a n_p)^6} = 1.393 \times 10^{-26} \text{ am}^2, \qquad (47)$$

which differs insignificantly from the experimental value.

The magnetic moment of the neutron equals two thirds of the proton's magnetic moment, i.e. proportional to the reduction of the number of intersections of the critical sections by current lines for a proton (six instead of nine, existing in a proton, see Fig. 3). Naturally, the sign of the moment changes in addition, because three positive enclosed currents are removed.

The calculated values of some parameters with respect to reality, or obtained earlier by other methods, are given in Table 1.

| Particles* | Calculated data | Actual data |
|---|---|---|
| *Family 1* | | |
| Proton | 1835 | 1836 |
| Electron | 1 | 1 |
| Quark | 12.9 (4.3; 8.6) | 3.93; 9.37 |
| *Family 2* | | |
| $\mu$-analog of the proton, $m_{x\mu}$ | $4.48 \times 10^5$ | $4.92 \times 10^5$ † |
| Muon | 214 | 206.8 |
| $\mu$-quark | 8780 | 3230; 276 |
| *Family 3* | | |
| $\tau$-analog of the proton, $m_{x\tau}$ | $6.31 \times 10^6$ | ? |
| $\tau$-lepton | 2892 | 3480 |
| $\tau$-quark | 233000 | 348000; 8260 |
| *Other parameters* | | |
| Charge of the electron, kg m/s | $1.603 \times 10^{-19}$ | $1.602 \times 10^{-19}$ |
| Number of the quarks (on the basis of the phase transit condition) | 3.2 | 3 |
| Number of the quarks (on the basis of the magnetic-gravitational equilibrium) | 3 | 3 |
| Interacting force among the quarks, N | $1.33 \times 10^5$ | $1.4 \times 10^5$ |
| Weinberg angle | 28.2° | 28.7° |
| Compton wavelength, m | $2.423 \times 10^{-12}$ | $2.426 \times 10^{-12}$ |
| The gravitational constant, m$^3$/kg sec$^2$ | $6.673 \times 10^{-11}$ | $6.673 \times 10^{-11}$ |
| Radius of the proton, fm | 851 | 842 |
| Difference between the mass of the proton and the mass of the neutron, $m_e$ | 2.53 | 2.53 |
| Semi-decay of the neutron (kinematic estimation), sec | 603 | 609 |
| Semi-decay of the neutron (energetic estimation), sec | 628 | 609 |
| Ultimate high energy of the $\beta$-decay, MeV | 16.7 | 16.6 |
| Magnetic moment of the proton, am$^2$ | $1.39 \times 10^{-26}$ | $1.41 \times 10^{-26}$ |
| Magnetic moment of the neutron, am$^2$ | $-0.92 \times 10^{-26}$ | $-0.97 \times 10^{-26}$ |

*Masses of the particles are given in the mass of the electron.
†The summary mass of the W, Z-bosons.

Table 1: The actual numerical parameters, and those calculated according to the model suggested by the author.

## 12 Conclusion

This work is an attempt to add a physically descriptive interpretation to some phenomena of the micro-world using both topological images of Wheeler's geometrodynamic idea and further macro-world analogies. This approach allows us to include into consideration inertial and gravitational forces.

This model has a logical demonstrative character and determines a scheme for the construction of a possible theory adding up the Standard Model (SM) of particle physics. The new theory must use such mathematical apparatus, in the framework of which vortex structures and their interactions could be described. As often mentioned by the author, the contours will be mapped out by singular configurations of force lines of some field.

Nevertheless, the present model gives a correct interpretation even in the initial, elementary form where only laws of conservation are used. It explains some phenomena misunderstood in the framework of SM and allows us to obtain qualitative and, sometimes, quantitative results by calculation of important parameters of the micro-world.

In part, this model predicts that it is impossible by means of experiments conducted at the BAC to obtain new particles — dubbed "super-partners": rather, it is necessary to seek new massive vector bosons in the region of energies approximating 1000 GeV.

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