About the polarization nature of confinement

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The polarization nature of confinement is discussed by the example of mesons. A new polarization approach is used, which allows establishing that in the gravitating matter mesons consist of two structures: a nucleus of octets of quarks and antiquarks, and a quark-antiquark shell that is treated as meson in the quantum chromodynamics (QCD). Polarization mechanisms and associated new interactions give an interaction potential agreeing with the fitted potential for $c-\bar{c}$ - and $b-\bar{b}$ -mesons that describes their spectra well. The paper also provides a polarization substantiation of the Regge trajectory (linear relationship between the adron moment and its square mass) that uses a new notion of the spin nature.

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1. Introduction.

Color confinement is a central hypothesis of the modern strong-interaction theory that is based on the QCD. It assumes that quarks and gluons can only exist in a bound state inside hadrons, and that their absence in free form shall follow from the QCD.

Various assumptions about the color confinement mechanism are being considered at present, but it is difficult to check them since the QCD is the strong-interaction theory [1].

The suggested mechanisms can be divided into two groups conventionally called “color shielding” and “linear potential”.

The color shielding hypothesis presumes that the Yang-Mills gluon field produced by an individual quark polarizes the physical vacuum to an extent that it gives birth to an antiquark that shields the test quark charge.

An analog of supercritical Coulomb interaction studied in quantum electrodynamics (QED) could be one of the color shielding mechanisms (V.N. Gribov, 1985). It is assumed that at large distances the critical charge value is achieved due to the increase of the effective color charge, and the birth of a quark-antiquark pair becomes beneficial in terms of energy (by analogy of the QED). The antiquark of the pair localizes near the initial quark, and the born quark goes to infinity. This is possible at the effective charge of the quarks of the order of unity, when virtual gluons and quark-antiquark pairs are likely to be born, which makes the analogy with QED dubious.

Color confinement is also attributed to interaction of Yang-Mills gluon fields rather than quarks. This simplification of QCD received the name quantum gluon dynamics.

Another possible mechanism of confinement is initiation of a linear potential describing interaction of quarks with force independent of distance. An associated field theory model of the Georgi-Glashow type is studied in [2].

According to one of the hypotheses [3], in gluon dynamics confinement is accomplished by means of a so called dual Meissner effect. In this case hypothetical magnetic monopoles (that are possible in the Yang-Mills theory) act as electric monopoles. At their condensation, color-electric lines of force corresponding to electric components of the color field should not enter the medium. Otherwise the introduced color charges would be connected by a tube of electric lines of force with the monopole condensate destroyed inside the tube. As a result, a linear potential would develop between the charges. The problem with this mechanism is that the long-standing search for the magnetic monopole has not given any result.

Even though the linear potential is possible in a purely gluonic world, it cannot exist in the real world with light quarks because the birth of quark-antiquark pairs forming normal mesons is energy beneficial at a large quark-antiquark separation. Thus the linearly growing potential is “shielded” by light quarks [1].

Numerical methods [4] also provide a linear potential, but on relatively small scales.

Though the confinement mechanism is not understood, in certain cases hadron spectra can be quantitatively described on the basis of model notions of intra-hadronic interactions of quarks. In particular, a good agreement with spectra of families of $c-\bar{c}$ -mesons ($\eta_c, \Psi, \eta_c', \Psi'$ etc.) and $b-\bar{b}$ -mesons (Υ, Υ' etc.) is achieved when using a specially fitted potential of the form:

$$U_{q_1,q_2} = -\frac{A}{r} + Br; A, B > 0 \tag{1}$$

where *r* is the inter-quark spacing. This potential is shown in Fig. 1 taken from [5]. It describes observed spectra of low-frequency excitations of mesons mentioned above, and the calculated level separations agree with the measured mass spectrum.

The linear growth of the potential at large values of *r* means that there exists some unknown force that keeps the quarks and antiquarks in a bound (confined) state. The same potential is responsible for the experimentally observed Regge trajectory: the linear dependency between the hadron moment *J* and the square of its mass *m*:

$$m^2 = m^{*2}(J - j) \tag{2}$$

For example, for a ρ-meson having spin S=1, according to [5], j=1/2, and m^*=1.07 GeV/s^2.

The polarization substantiation of (1) and (2) is provided below.

2. Polarization meson structure.

We see that the color confinement mechanism cannot be consistently substantiated in the context of the QCD. Hence the possibility that understanding of the confinement nature lies beyond the QCD cannot be ruled out. This work makes an attempt to find its mechanism using the polarization approach developed in [6] with a view to compare results obtained with (1) and (2). Here the color confinement mechanism is discussed in greater detail than in [6].

In the polarization theory (PT), a meson represents a double-structure particle with a nucleus and a quark-antiquark shell that is treated as meson in the QCD. This difference is essential in deriving (1). The nature of forces that confine color at large distances also proves to be different.

Let us start discussing the confinement problem with substantiation of the structure of a meson and its nucleus.

According to [6], hadrons are formed at interaction between fermion 16-plets of the non-gravitation world, which consist of lepton pairs (electrons and neutrino) and their antileptons, and sextets of color quarks and their antiquarks. When gravitation appears, a massive particle creates a centrally symmetric gravitation field. This space symmetry of the gravitation world allows for the existence of a dodecahedron-icosahedral system (DIS) which symmetry defines the structure of hadrons and multiplets of fields implementing the inter-quark interaction. The number of apices, edges and faces of a dodecahedron equals to 30, 20 and 12, respectively, and for an icosahedron their numbers are 30, 12 and 20. It is assumed that multiplets of fields and quarks of a gravitating meson shall be determined by reduced multiplets of some or other DIS elements, and the number of angles (or sides) of the icosahedron faces (three) or dodecahedron faces (five) corresponds to numbers of non-electric charges of quarks and the number of field spin projections. This means that along with three color charges of quarks and gluons with spin S=1 there shall exist a field multiplet with spin S=2 that implements the interaction between the quintet of the new quark charges called *taste* charges (according to the number of tastes) and their anti-charges. Possibly, the taste charges are QCD flavors [6].

According to the PT, everything that exists in the Universe (including space-time and physical vacuum) is produced from zero vacuum – Void that represents some ex-natural substance. This is implemented via polarization processes similar to polarization of physical vacuum that produces an electron-positron pair with a zero electric charge. The world where matter is born (and disappears) is called polarization world. It is invisible to us: no one physics scientist has observed a process of origination of particles and their properties. In our world particles come as “ready” ones.

The birth and destruction of physical quantities is described by simple polarization relationships of the following type:

$$a+b=0; \quad a^2+b^2=0; \quad ab+cd=0; \quad \vec{a}+\vec{b}=0; \quad \vec{a}^{\,2}+\vec{b}^{\,2}=0. \tag{3}$$

An example is balance of forces that characterizes a steady state of physical systems. From (3) it follows that in the general case all physical quantities, including space-time coordinates, are complex, and along with particles having positive mass there are born particles with the same but negative mass. Such particles are called *counterparticles** in [6]. As will be further demonstrated, one of the counterparticle types plays a defining role in color confinement.

It is assumed in [6] that a meson-antimeson pair appears from the zero vacuum at interaction between of three initial fermion 16-plets. Similarly, a pair with negative mass that compensates the mass of the former pair is produced. These pairs are formed in different subspaces.

The initial number of fermions in a meson-antimeson pair is 48 which corresponds to the dimensionality of irreducible representation of group SU(7). Special unitary groups SU(d) characterize interactions and structure in the polarization world, while unitary groups U(d) – characterize the same in the 4-dimensial space of our world. In the gravitation world, the maximum value that corresponds to the DIS is d=5, because dimensionalities of the first three irreducible representations equal to 1, 5 and 24, add up to 30. This means that group SU(7) characterizes an unsteady state that breaks down into two orthogonal subsystems with the symmetry of group SU(5). In the QCD color-charged gluon fields are described by group SU(3). Dimensionalities of its first three irreducible representations equal 1, 3 and 8, and add up to the number of dodecahedron faces and icosahedron apices. Hence, three types of vector interactions of gravitating matter are implemented. The QCD only uses an octet of color-charged gluon fields. And the first two representations (with dimensionalities 1 and 3) describe neutral vector fields: the singlet – electromagnetic field, and the triplet – three new and non-charged gluon fields. They transfer interaction between the same color charges (and their anticharges). In this respect they are similar to electromagnetic field, and implement the Coulomb type of interaction. Non-charged fields determine formation of stationary structures where particles retain their charges throughout their life, and define the first term of potential (1).

Group SU(5) produces a new charge type – a quintet of taste charges, and a new field type with spin S=2 that are called *gravionic* in [6]. The 24-plet of fields are taste-charged gravionic Yang-Mills fields. Apart from them, there exists a quintet of non-charged fields, each transferring interaction between the same taste charges and their anticharges. The singlet represents a gravitation field.

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* Counterparticles are particles that only differ in the sign of mass. A particle with negative mass is called negaparticle.

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Thus in steady states of hadrons, which are important for understanding of the color confinement mechanism, quarks and antiquarks interact by Coulomb type forces produced by uncharged gluon and gravionic fields, as well as electromagnetic and gravitation fields, with uncharged gluon fields playing the key role. Charged gluon fields of the QCD are important for analysis of transient processes. Uncharged gluon fields, without which a quantitative hadron theory cannot be developed, are missing in the QCD.

Let us consider a possible meson structure assuming that initial fermion 16-plets lose their lepton component when a meson is born, thus leading to formation of quark-antiquark 12-plets that correspond to the DIS structure. It would appear reasonable to assume that neutrino and antineutrino do not take part in meson structuring, and charged leptons and antileptons draw together due to mutual attraction and annihilate. Quarks have an imaginary (or complex) color charge (see below) that prevents them from going to the Minkowski space where free real (electrical) charges are implemented. In the polarization world subspace, quarks of one color are mutually attracted and repel from their antiparticles, which prevents annihilation (see section 3). A meson-antimeson pair accounts for 36 quarks and antiquarks, i.e. each meson or antimeson contains 9 quarks. A quark-antiquark 18-plet includes a scalar and neutral 16-plet comprised of an octet of quarks and antiquarks that forms a nucleus of a meson which shell contains a quark and an antiquark. In the case of $c-\bar{c}$ - and $b-\bar{b}$ -mesons of interest to us, the shell is also scalar and neutral.

Hence, as distinct from the QCD, in the PT a meson is a double-structure particle. The meson structure described is used to build a confinement model agreeing with (1) and (2).

3. Confinement model.

It is assumed in the PT that unlike an atom, a meson emits massive counterparticles produced by polarization rather than massless photons. Radiation from counterparticle pairs produces a reaction force that does not allow quarks and antiquarks passing into our world and becoming free particles. Since reaction forces are independent of space coordinates, their potential will linearly depend on the interparticle distance (no matter how large it is), thus defining the addend in (1). This polarization-reaction mechanism of confinement is discussed below for mesons.

Experiments have not discovered any massive particles emitted by hadrons or associated energy effects. This may be associated with the neutral and scalar nature of emitted counterparticles, as well as with the fact that they are born with the same outwards-directed radial velocity. In this case the confining reaction force develops without changing the counter particle pulse, moment or energy, which deprives us of the opportunity to note their birth by known methods. The counterparticles are formed in the imaginary subspace of the polarization world, hence the counterparticle velocity and reaction force are imaginary (and non-observable) quantities. However, the force potential is a real quantity that manifests itself in our world. Considering the decisive role of counterparticles in the color confinement mechanism described above, these counterparticles are called plenons and negaplenons in [6].

Let us discuss in greater detail, how this confinement mechanism works, and to what extent it agrees with potential (1) that is shown in Fig. 1 and describes the spectrum of $c-\bar{c}$ - and $b-\bar{b}$ -mesons.

Let us consider that the reaction force acts on the shell that, in its turn, confines the meson core. In the shell, the quark and antiquark counter-rotate with the real azimuthal velocity u_{φ} .

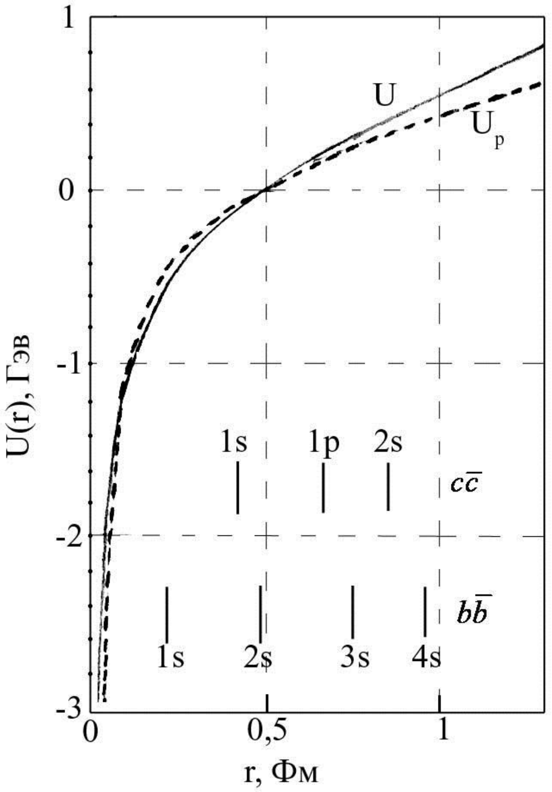

Fig. 1. Potential U(*r)* that describes interaction of heavy quark-antiquark pairs, in particular $c-\bar{c}$ and $b-\bar{b}$ [5]; $U_p(r)$ is the potential of mesons containing a heavy quark-antiquark pair with polarization confinement of quarks and antiquarks.

Due to its polarization origination, the radial velocity of counterparticles shall satisfy the last relation (3), i.e.

$$u_r = \pm i u_\varphi . \tag{4}$$

Let us now determine the magnitude of the reaction force acting on a meson when a plenon and a negaplenon are emitted. With the polarization mechanism of emission, the change in meson action ($\delta\Sigma$) and counterparticle action $(\delta\Sigma_p)$ satisfy the first polarization relation (3)

$$\delta\Sigma + \delta\Sigma_p = 0.$$

The value of $\delta\Sigma_p$ is defined by the mass of the produced counterparticle $\delta m = \pm m_0$ acquired during time $\delta\tau$, and equals $\delta mc^2 \delta\tau$, i.e.

$$\delta\Sigma + \delta mc^2 \delta\tau = 0. \tag{5}$$

Relation (5) above is analogous to the well-known mechanics formula

$$\frac{\partial\Sigma}{\partial\tau} = -E, \quad E = \delta mc^2 .$$

In the elementary polarization process under consideration, the meson action reduces by quant $\hbar$ ($\delta\Sigma = -\hbar$). The reaction force produced by the counterparticle recoil moment -δmu acquired during time $\delta\tau$ in view of (5) equals

$$f_p = -\frac{\delta m}{\delta\tau} u_r = \frac{(\delta m)^2 c^2 u_r}{\delta\Sigma} = -\frac{m_0^2 c^2 u_r}{\hbar} . \tag{6}$$

Since f_p is independent of the mass sign, the polarization reaction force that develops at emission of counterparticles is equal to

$$f = 2 f_p. \tag{7}$$

The considered polarization-reaction mechanism of confinement is implemented by an imaginary reaction force that cannot be measured by existing instruments. Its potential Φ, however, is a real quantity that should be present in the meson (1). Since the imaginary space coordinates of the polarization world ($\vec{r}\,'$) and real coordinates of our world ($\vec{r}$) satisfy condition (3), we have

$$\vec{r}\,'^2 + \vec{r}^{\,2} = 0. \tag{8}$$

In view of (4) and (8), the potential Φ can be expressed in terms of real physical quantities of our world as follows:

$$\Phi = \pm \frac{2 m_0^2 c^3 \beta}{\hbar} r, \tag{9}$$

where $\beta = |u_\varphi| / c$. The potential of the reaction force confining quarks has sign “+”. Since the basic interaction between particles in hadrons is a gluon one, it should be assumed that the value of β is defined by the Cabibbo polarization angle θ_c. The value of $\sin\theta_c$ calculated in [6] equals

$$\sin\theta_c = 1/3\sqrt{2} = 0.2357. \tag{10}$$

This value agrees with the experimental value $\sin\theta_c = 0.226(9)$ given in [7]. From this value it follows that the motion of the shell quarks and antiquarks is non-relativistic. This does not contradict to experimental data.

It remains for us to determine the main plenon parameter -- its mass m_0. As masses of other fundamental particles (leptons, quarks, intermediate vector bosons), in the PT this mass is defined by Planck mass

$$m_P = \sqrt{\hbar c / G}. \tag{11}$$

A scalar and neutral Planck particle gives birth to a plenon in the 5-demensioanl polarization world (the fifth coordinate is time τ, characterizing the particle birth process), that has

$$k_d = 2^{(2^d)} \tag{12}$$

of space-time states that differ in direction of at least one real or imaginary coordinate. In the problem being considered, $d = 5$. The paired birth of counterparticles increases the dimensionality of the space-time state multiplet to the $k_5^2 = k_6$. To each of them there corresponds the mass of $\pm m_P / k_6$. The plenon and negaplenon state vectors are orthogonal (Fig. 2) and form polarization angle $\theta_p = \pi / 4$. Hence

$$m_0^2 = (\frac{m_p}{k_6})^2 \cos^2\theta_p = \frac{\hbar c}{2 k_7} G;\ m_0 = 0.468 GeV. \tag{13}$$

The value of the potential of force f that confines quarks in the polarization world subspace follows from (9) and (13):

$$\Phi = \frac{c^4 \sin\theta_p}{k_7 G} r. \tag{14}$$

As could be expected, the reaction force proves to be independent of the Planck's constant and meson structure.

The condition of long-distance confinement of a shell quark (antiquark) with mass m rotating at a rate of $\pm u_\varphi$,

$$\frac{mu_\varphi^2}{r'} + \frac{2m_0^2 c^2 u_r}{\hbar} = 0 \tag{15}$$

allows determining the real equilibrium angular rotation rate

$$\omega = \frac{u_\varphi}{r} = \pm \frac{2\hbar c^3}{k_7 G m}. \tag{16}$$

This rotational speed depends on the mass of rotating meson particles does not depend on the meson size.

4. Hydrogen-like mesons.

Polarization reaction confinement is implemented at long distances. On small scales, binding of meson quarks and antiquarks by means of uncharged gluon fields, which existence is substantiated above, becomes prevailing. It is described by the first summand in (1) which constant for $c-\bar{c}$ - and $b-\bar{b}$ -mesons we have to find.

In the two-component meson structure, its nucleus and shell may contain quarks and antiquarks of different generations. To have a hydrogen-like model of $c-\bar{c}$ - and $b-\bar{b}$ - mesons, the meson nucleus shall consist of the first generation quarks and antiquarks which total mass of about 100 GeV/s^2 is much less than the shell mass. This makes the shell kinematics governing, and the approximation of the two-particle hydrogen-like model proves to be acceptable for such mesons. For $s-\bar{s}$ -mesons with comparable masses of the nucleus and the shell this model becomes ineffective.

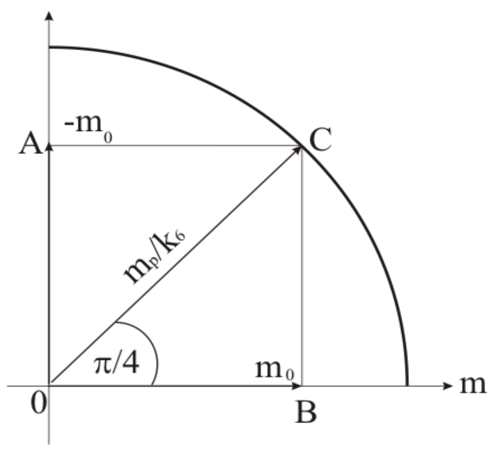

Fig. 2. Polarization of the plenon mass (m_0) and negaplenon mass $(-m_0)$.

When a lepton-quark octet is formed, the electric and color charges are polarized separately. Joint polarization of these two charge type is possible at the birth of a quark-antiquark pair with the total electric charge $\pm e$. Their color charge $(\pm c)$ satisfies the second polarization condition (3)

$$e^2 + c^2 = 0$$

that defines the color charge and anticharge:

$$c = ie; \quad \bar{c} = -ie. \tag{17}$$

Hadrons produced by means of polarization contain an equal number of quarks and antiquarks, it is i.e. the color-anticolor polarization that is implemented. In mesons it takes place both in the shell and in the nucleus. By virtue of (17), an attraction force acts between quarks (antiquarks) in the polarization subspace $\vec{r}\,'$, while between quarks and antiquarks there acts a repulsive force. This results in a separate spatial grouping of quarks (antiquarks) and their repulsion with force

$$f_{q\bar{q}} = \frac{c\bar{c}N_q N_{\bar{q}}}{r'^{\,2}_{q\bar{q}}}; \quad N_q = N_{\bar{q}} = 9. \tag{18}$$

Here $r'_{q\bar{q}}$ is an imaginary distance between the quark and antiquark groups that is close to the distance between the massive quark and antiquark of the shell. In view of (8), in the real subspace force (18) is attractive and equals

$$f_{q\bar{q}} = -\frac{e^2 N_q^{\;2}}{r^2}, \tag{19}$$

where r designates the distance between the massive quark and antiquark of the meson shell.

Hence the potential energy of hydrogen-like mesons takes the form (1):

$$U_p = -\frac{e^2 N_q^2}{r} + \frac{c^4 \sin\theta_C}{k_7} r; \qquad N_q = 9. \tag{20}$$

Now we can numerically determine the constants of potential (1) and make a comparison (20) with the potential shown in Fig. 1:

$$A = U_p r(r \to 0) = N_q^2 e^2 \approx 0.117 GeVFm;$$

$$B = \frac{dU_p}{dr}(r \to \infty) = \frac{c^4 \sin\theta_C}{k_7 G} \approx 0.52 GeV / Fm; \tag{21}$$

$$r(U_p = 0) = \frac{N_q k_6 e}{c^2}\sqrt{\frac{G}{\sin\theta_C}} = 0.472 Fm.$$

These values give potential $U_p\,(r)$ close to potential $U(r)$ presented in Fig. 1 that describes well meson spectra. Some values of $U_p(r)$ are listed in Table 1 below.

Table 1. Polarization potential of a hydrogen-like meson.

r (Fm)	0.04	0.05	0.1	0.2	0.5	1	1.3
U_p (GeV)	-2.98	-2.37	-1.15	-0.5	0.02	0.4	0.58

The agreement obtained confirms relevance of the considered 18-quark meson model for description of spectral properties of $c-\bar{c}$ and $b-\bar{b}$-mesons which mass differs by a factor of 3. In agreement with the experimental data, $U_p(r)$ does not depend on the meson mass. Hence color confinement is quantitatively described by the polarization reaction force rather than by QCD fields.

5. Rotationally excited meson states.

Here an attempt will be made to provide a polarization substantiation of experimental relation (2) for rotationally excited states of mesons with moment J≠0. Unlike the case of a scalar meson discussed above, this will allow us to understand how moment and spin are formed due to polarization, to clear up the spin mystery.

The two-component quadratic velocity polarization equation (4) describes two types of rotational excitation that exist at the same time independently of one another. One of them has imaginary radial velocity and real azimuthal one, and the other, conversely, has imaginary azimuthal velocity and real radial one. Hence there also exist two types of real moments: the rotational moment has real azimuthal velocity, while the spin has imaginary one, therefore we cannot observe it. Moment and spin represent different polarization states of the movement of mass that is held together by polarization reaction forces.

In the case of the scalar hydrogen-like meson discussed above, rotational moments of quark and antiquark nonets should compensate each other. At rotational excitation of a meson, it is expected that the 16-plet remains scalar, while forming a spherically symmetric meson core, and the quark and antiquark singlets located on the core surface will obtain rotational moment. They form the meson shell with axially symmetric eigenspace where the meson moment and spin are born. In the PT, meson mass (*m*) is a parameter of the meson surface that separates the internal and external subspaces. For mesons under consideration, their mass is concentrated in two massive shell particles. Let us designate the surface radius as *R*, and the shell singlet rotation velocity as V'_φ. The following relation follows from the equilibrium condition (15) for a singlet with mass *m*/2, and polarization conditions (4) and (8):

$$m^2\frac{V_\varphi'^2}{c^2}=4m_0^2L_Z\,,L_Z=-\frac{mV_r'R'}{\hbar}=\frac{mV_\varphi'R}{\hbar}\,, \tag{22}$$

where L_Z is the value of the projection of the both singlet moment onto the rotation axis.

Let us now consider the spin rotation at imaginary rate u_φ. It develops at real radial velocity $u_r=\pm iu_\varphi$, i.e. while the radius of the meson with mass m increases to its equilibrium value *R* where the meson acquires its moment *L*. As the particle expands, its angular rotation rate ω, according to (16), remains constant, i.e.

$$u_\varphi'=\omega r' \tag{23}$$

The meson expansion is controlled by reaction force of plenons:

$$m\frac{du_r}{dt}=\frac{2m_0^2c^2}{\hbar}u_r(r);u_r=\frac{dr}{dt} \tag{24}$$

Following integration, equation (24) can be brought to the following form:

$$m^2\frac{u_r^2}{c^2}=2m_0^2S_Z\,;S_Z=\frac{2m}{\hbar}\int_0^R u_r dr \tag{25}$$

In view of (4) and (23), $u_r=\omega r$, hence,

$$S_Z=\left.\frac{mu_\varphi r'}{\hbar}\right|_{r'=R'=iR}\,, \tag{26}$$

i.e. S_Z represents a spin projection on the meson symmetry axis, and the spin itself – a moment of rotation in an imaginary subspace with an imaginary speed. The spin is a real quantity that manifests itself in the real subspace, but rotation in the latter associated with the spin cannot be observed by currently available means. This is a new interpretation of spin that follows from polarization properties of matter and space. From formulae (22) and (25) it follows

$$m^2 \cos\theta_P = 4m_0^2(L_Z + S_Z/2) = 4m_0^2(J - S/2), \qquad (27)$$

where $\cos^2\theta_P = \frac{V_\varphi^2 + u_r^2}{c^2}$, and meson moment $J=L_Z+S_Z=J_Z$. This relation reduces to (2):

$$m^2 = m^{*2}(J - S/2); m^* = \frac{2m_0}{\cos\theta_P}. \qquad (28)$$

In case of a ρ-meson, S=1. If we take $\theta_p = \theta_W$, where θ_W is the Weinberg polarization angle calculated in [6] and equal to $\sin\theta_W = \sqrt{2}/3$, then m*=1.0615 GeV, which agrees well with the experimental value m*(ρ)=1.07 GeV. This is another quantitative proof of the meson model being discussed and of existence of plenons. Note that a close value m*=1.15 GeV is derived from the Regge trajectory in case of baryon Δ(1232) [5], i.e. polarization of plenons defines the baryon mass, holding together the rotating triplet of its shell quarks. This suggests that the polarization approach can be used for baryons as well (see [6]).

6. Conclusion.

By the example of mesons, the polarization nature of color confinement is demonstrated: the confinement is implemented in imaginary subspace by means of reaction effect that develops at polarization formation of masses of plenons and negaplenons – neutral scalar particles. It is hardly possible that they can be detected by known methods since their polarization does not cause changes in meson pulse, moment, energy or mass in the Minkowski space. In this space quarks and antiquarks can only exist in bound colorless state. And the quark plasma is a substance of the polarization world.

Color confinement is a main puzzle for the QCD, but, as we see, it possible solution lies outside the QCD. The polarization approach allows gaining an insight into the nature of the confinement, Regge trajectory and spin (as a moment of a shell rotating in an imaginary subspace with an imaginary velocity).

In the examples considered above, a satisfactory agreement with experimental data is achieved through the use of a simple double-structure meson model. In this work this is demonstrated for mesons with mass greater than 1 GeV/s^2. The agreement obtained counts in favor of the model used, which comprised a nucleus of octets of quarks and antiquarks, and a quark-antiquark shell that is nowadays perceived as a meson. This meson model follows from the symmetry of the gravitating matter space [6] producing uncharged gluon fields that do not change color charges of meson quarks and antiquarks. The two-quark meson model adopted in the QCD, which does not take into account the gravitating matter symmetry and, most importantly, the polarization-reaction mechanism of confinement, fails to adequately describe the confinement phenomenon and meson spectra.

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