Chapter 6. On hadrons theory

As it is known the hadron theory is based on the Yang-Mills equation.

1.0. Introduction. Dirac and Yang-Mills equations of SM

As it follows from the Standard Model theory (Pich, 2000; Peak and Varvell ; Okun, 1982). the quark family is analogue to the lepton family and the Yang-Mils equation is the generalisation of the Dirac electron equation.

The Dirac equation for the electron in the external field can be written in the form (Schiff, 1955):

$$\hat{\alpha}_\mu \left(\hat{p}_\mu + p_\mu^e\right) \psi + \hat{\beta}\ m_e c^2 \psi = 0 \qquad (1.1)$$

where $\mu = 0,1,2,3$, $\hat{p}_\mu = \left\{\hat{\varepsilon}, c\hat{\vec{p}}\right\}$, where $\hat{\varepsilon} = i\hbar \dfrac{\partial}{\partial t}$, $\hat{\vec{p}} = -i\hbar\vec{\nabla}$ are the operators of energy and momentum, respectively; $\hat{p}_\mu^e = \left\{\hat{\varepsilon}_{ex}^e, c\hat{\vec{p}}_{ex}^e\right\} = j_\mu A_\mu$, where $\varepsilon_{ex}^e = e\varphi$, $\vec{p}_{ex}^e = \dfrac{e}{c}\vec{A}$ are the electron energy and momentum in the external electromagnetic field; respectively; $\left(\varphi, \vec{A}\right)$ is 4-potential of the external field; c is the light velocity, $-e$, m are the electrical charge and mass of the electron correspondingly.

In Quantum Chromodynamics, which is described by Yang-Mills equation, we have quarks instead of electrons, and gluons instead of photons, between which there are the strong interactions instead of the electromagnetic interactions. The Yang-Mills equation for one quark may by written (Pich, 2000; Peak and Varvell ; Okun, 1982) similarly to (1.1):

$$\hat{\alpha}_\mu \left(\hat{p}_\mu + p_\mu^q\right) \psi_q + \hat{\beta}\ m_q c^2 \psi_q = 0, \qquad (1.2)$$

where ψ_q are the quark fields, $p_\mu^q \equiv icg\vec{G}_\mu$ with $\vec{G}_\mu = \dfrac{1}{2}\sum_{a=1}^{8} G_\mu^a \lambda_a$ is the potential of the gluon field, λ_a, g, m_q are the Gell-Mann matrices, strong charge and quark mass, respectively.

2.0. “One quark” theory of hadrons

Formally we can say (Peak and Varvell ; Okun, 1982), that hadron is described by two or three Dirac electron equations of (1.1) type. Thus, conditionally we can name the Dirac electron equation as the “one quark” equation.

But here we need to take into account that the Dirac equation (1.1) is not the free electron equation. On the other hand, the equation (1.2) is indeed the equation of the "free" quark. The external field terms are used in the QED for the description of the interaction between the electron and other particles. The similar terms in the Yang-Mills equation are the internal field, which describes the quark-quark interaction of the same hadron.

3.0. The derivation of Yang-Mills equation in framework of CWED

In the present chapter we will show that the CWED representation allows us to interpret the Yang-Mills equation as the *curvilinear electromagnetic waves superposition.*

Obviously, to obtain the Yang-Mills equation we must sum three "one quark" equations without mass and "turn on" the twirling of the fields.

3.1. Electromagnetic forms of "three quark" equations

As the Pauli matrices are (Ryder, 1985) the generators of the 2D rotation, for the "three quark" electromagnetic representation we must use the generators of the 3D rotation, which are the known photon spin 3x3-matrices $\hat{\vec{S}}$ of the O(3) group [3,12]:

$$\hat{S}_1 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{pmatrix}, \hat{S}_2 = \begin{pmatrix} 0 & 0 & i \\ 0 & 0 & 0 \\ i & 0 & 0 \end{pmatrix}, \hat{S}_3 = \begin{pmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \tag{3.1}$$

As the "three quark" equations for the particle and antiparticle we will use the Dirac equations (1.1) in the following form:

$$\begin{aligned} \left[\left({}^6\hat{\alpha}_o\hat{\varepsilon} - c\,{}^6\hat{\vec{\alpha}}\;\hat{\vec{p}}\right) - {}^6\hat{\beta}\, mc^2\right]\psi = 0 \\ \psi^+\left[\left({}^6\hat{\alpha}_o\hat{\varepsilon} + c\,{}^6\hat{\vec{\alpha}}\;\hat{\vec{p}}\right) + {}^6\hat{\beta}\, mc^2\right] = 0 \end{aligned}, \tag{3.2}$$

where the left upper index "6" means that these matrices are the 6x6-matrices of the following type:

$${}^6\hat{\vec{\alpha}} = \begin{pmatrix} \hat{0} & \hat{\vec{S}} \\ \hat{\vec{S}} & \hat{0} \end{pmatrix}, \; {}^6\hat{\alpha}_0 = \begin{pmatrix} \hat{S}_0 & \hat{0} \\ \hat{0} & \hat{S}_0 \end{pmatrix}, \; {}^6\hat{\alpha}_4 \equiv {}^6\hat{\beta} = \begin{pmatrix} \hat{S}_0 & \hat{0} \\ \hat{0} & -\hat{S}_0 \end{pmatrix}, \tag{3.3}$$

Here $\hat{S}_0 = \hat{1}$ and wave function ${}^6\psi = \begin{pmatrix} \vec{E} \\ i\vec{H} \end{pmatrix}$ is the 6x1 matrix.

As it is not difficult to test the above matrices give the right electromagnetic expressions of the bilinear form of the theory:

the energy: ${}^6\psi^+ \; {}^6\hat{\vec{\alpha}}_0 \, {}^6\psi = \vec{E}^2 + \vec{H}^2 = 8\pi\, U$, the Poynting vector (or momentum): $\vec{S}_P = \frac{1}{8\pi} {}^6\psi^+ \; {}^6\vec{\alpha} \; {}^6\psi$,

and the 1st scalar of the EM field: ${}^6\psi^+ \; {}^6\hat{\alpha}_4 {}^6\psi = 2\left(\vec{E}^2 - \vec{H}^2\right) = 4\pi \; F_{\mu\nu} F^{\mu\nu}$.

3.2. "Three-quarks" equation without mass-interaction terms

From the above follows that the proton equation can be represented by three "one quark" equations, i.e. three electron equations or three pairs of the scalar Maxwell equations (one pair for each co-ordinate). Obviously, there is a possibility of two directions of rotations of each quark (the left and the right quarks). Therefore, the 6+6 scalar equations for proton description must exist as well as the 6+6 equations for the antiproton description.

Let us find at first these equations without mass-interaction, putting the mass-interaction terms equal to zero. Using (3.3) from the equations (3.2) we obtain the Maxwell equation without current:

$$\begin{cases} \frac{1}{c}\frac{\partial E_x}{\partial t} - \frac{\partial H_z}{\partial y} = 0, & a \\ \frac{1}{c}\frac{\partial H_z}{\partial t} - \frac{\partial E_x}{\partial y} = 0, & a' \\ \frac{1}{c}\frac{\partial E_y}{\partial t} - \frac{\partial H_x}{\partial z} = 0, & b \\ \frac{1}{c}\frac{\partial H_x}{\partial t} - \frac{\partial E_y}{\partial z} = 0, & b' \\ \frac{1}{c}\frac{\partial E_z}{\partial t} - \frac{\partial H_y}{\partial x} = 0, & c \\ \frac{1}{c}\frac{\partial H_y}{\partial t} - \frac{\partial E_z}{\partial x} = 0, & c' \end{cases} \quad (3.4) \qquad \begin{cases} \frac{1}{c}\frac{\partial E_z}{\partial t} + \frac{\partial H_x}{\partial y} = 0, & a \\ \frac{1}{c}\frac{\partial H_x}{\partial t} + \frac{\partial E_z}{\partial y} = 0, & a' \\ \frac{1}{c}\frac{\partial E_x}{\partial t} + \frac{\partial H_y}{\partial z} = 0, & b \\ \frac{1}{c}\frac{\partial H_y}{\partial t} + \frac{\partial E_x}{\partial z} = 0, & b' \\ \frac{1}{c}\frac{\partial E_y}{\partial t} + \frac{\partial H_z}{\partial x} = 0, & c \\ \frac{1}{c}\frac{\partial H_z}{\partial t} + \frac{\partial E_y}{\partial x} = 0, & c' \end{cases} \quad (3.5)$$

As it is not difficult to see that each pair of the equations *a,b,c* describes a separate ring; the fields vectors of equations (3.4) are rolled up in the plains *XOZ*, *ZOY*, *YOX*, and similarly the fields vectors of the equations (3.5) are rolled in the plains *XOY*, *YOZ* , *ZOX*.

3.3. The compensation or gauge fields in the modern theory

The modern particle theory is also known as the gauge field theory because the interactions between the particles are introduced in the field equation via the gauge transformations. It is known (Kaempffer, 1965; Ryder, 1985) that this procedure is mathematically equivalent to the field vector transformations in the curvilinear space, which lead to the covariant derivative appearance.

It is not difficult to show (Ryder, 1985), that the electromagnetic field appears naturally as a consequence of the requirement of the Lagrangian invariance relatively to the gauge transformations of the local rotations in the internal space of the complex field ψ, when the Lagrangian has the symmetry O(2) or U(1). Mathematically this is expressed through the replacement of the simple derivatives with the covariant derivatives.

The generalization of this result on a case of 3D-space is the Yang - Mills field. The elementary generalization of this symmetry is the non-abelian group SU (2); i.e. the question is about the theory of the non-abelian gauge fields.

Let's consider (see details in (Ryder, 1985)) the rotation of some field vector $\overleftarrow{F}$ in three-dimensional space around some axis on an infinitesimal angle. Here the value $|\vec{\varphi}|$ is a rotation angle, and the vector $\vec{\varphi}/|\vec{\varphi}|$ sets the direction of the axis of rotation. The transition from the initial position of a vector to the final position will be defined by the transformation:

$$\vec{F} \to \vec{F}' = \vec{F} - \vec{\varphi} \times \vec{F} , \qquad (3.6)$$

The problem is to create independent rotations in various points of space. In order to construct correctly the covariant field derivative, we should make parallel transport of the vectors into the space, instead of on a flat curve, as in the above case of spinorial theory. The corresponding analysis (Ryder, 1985) allows us to receive an expression similar to the expression, which appears by the spinor transport on a flat curve.

It can be shown also (Kaempffer, 1965; Ryder, 1985) that this expression defines a covariant derivative of the field ψ, which is transformed according to some representation of a group:

$$\frac{D\psi}{dx^\mu} = D_\mu \psi = \left(\partial_\mu - igM^a A_\mu^a \right)\psi , \qquad (3.7)$$

where the matrixes M^a are the generators of the rotation. It is not difficult to make sure that this expression gives the same covariant derivative, as found earlier in the case of electron theory, and can give the mass-interaction terms.

In the following section we will consider the electromagnetic discription of the mass-interaction term appearance.

3.3.1. The electromagnetic description of the mass-interaction term appearance

The spinorial theory shows that the appearance of the internal mass-interaction terms is bounded with the three vectors $\vec{E}, \vec{H}, \vec{S}_P$, moving along the curvilinear trajectory. These vectors represent the moving trihedral of the Frenet-Serret (Gray, 1997). In the general case, when the electromagnetic wave field vectors of three-quark particles move along the space curvilinear trajectories, not only the additional term, defined by the curvature, appears, but also the terms that are defined by the torsion of the trajectory.

Actually, in this case we have:

$$\frac{\partial \vec{E}}{\partial t} = -\frac{\partial E}{\partial t}\vec{n} - E\frac{\partial \vec{n}}{\partial t}$$
$$\frac{\partial \vec{H}}{\partial t} = \frac{\partial \vec{H}}{\partial t}\vec{b} + H\frac{\partial \vec{b}}{\partial t}, \qquad (3.8)$$

where $\vec{b}$ is the binormal vector. According to the Frenet-Serret formulas we have:

$$\frac{\partial \vec{n}}{\partial t} = -\upsilon_p \mathrm{K}\vec{\tau} + \upsilon_p \mathrm{T}\vec{b}$$
$$\frac{\partial \vec{b}}{\partial t} = -\upsilon_p \mathrm{T}\vec{n}, \qquad (3.9)$$

where $\mathrm{T} = \frac{1}{r_{\mathrm{T}}}$ is the torsion of the trajectory and r_{T} is the torsion radius.Thus, the displacement currents can be written in the form:

$$\vec{j}^{\,e} = -\frac{1}{4\pi}\frac{\partial E}{\partial t}\vec{n} + \frac{1}{4\pi}\omega_{\mathrm{K}} E \cdot \vec{\tau} - \frac{1}{4\pi}\omega_{\mathrm{T}} E \cdot \vec{b}$$
$$\vec{j}^{\,m} = \frac{1}{4\pi}\frac{\partial H}{\partial t}\vec{b} - \frac{1}{4\pi}\omega_{\mathrm{T}} H \cdot \vec{n}, \qquad (3.10)$$

where $\omega_{\mathrm{T}} = \frac{\upsilon_p}{r_{\mathrm{T}}} \equiv c\mathrm{T}$ we name the torsion angular velocity.

Thus, we can obtain the following electromagnetic representation of the three-quarks' equations:

$$\begin{cases} \frac{1}{c}\frac{\partial E_x}{\partial t} - \frac{\partial H_z}{\partial y} = j_1^e, & a \\ \frac{1}{c}\frac{\partial H_z}{\partial t} - \frac{\partial E_x}{\partial y} = j_1^m, & a' \\ \frac{1}{c}\frac{\partial E_y}{\partial t} - \frac{\partial H_x}{\partial z} = j_2^e, & b \\ \frac{1}{c}\frac{\partial H_x}{\partial t} - \frac{\partial E_y}{\partial z} = j_2^m, & b' \\ \frac{1}{c}\frac{\partial E_z}{\partial t} - \frac{\partial H_y}{\partial x} = j_3^e, & c \\ \frac{1}{c}\frac{\partial H_y}{\partial t} - \frac{\partial E_z}{\partial x} = j_3^m, & c' \end{cases} \quad (3.11) \qquad \begin{cases} \frac{1}{c}\frac{\partial E_z}{\partial t} + \frac{\partial H_x}{\partial y} = j_1^e, & a \\ \frac{1}{c}\frac{\partial H_x}{\partial t} + \frac{\partial E_z}{\partial y} = j_1^m, & a' \\ \frac{1}{c}\frac{\partial E_x}{\partial t} + \frac{\partial H_y}{\partial z} = j_2^e, & b \\ \frac{1}{c}\frac{\partial H_y}{\partial t} + \frac{\partial E_x}{\partial z} = j_2^m, & b' \\ \frac{1}{c}\frac{\partial E_y}{\partial t} + \frac{\partial H_z}{\partial x} = j_3^e, & c \\ \frac{1}{c}\frac{\partial H_z}{\partial t} + \frac{\partial E_y}{\partial x} = j_3^m, & c' \end{cases} \quad (3.12)$$

where j_k ($k = 1,2,3$) are the currents of each quark:

$$\vec{j}_k^{\,e} = \frac{\omega_{\mathrm{K}k}}{4\pi} E\vec{\tau} + \frac{\omega_{\mathrm{T}k}}{4\pi} E\vec{b} \text{ and } \vec{j}_k^{\,m} = \frac{\omega_{\mathrm{T}k}}{4\pi} H\vec{n}, \qquad (3.13)$$

As we noted at the analysis of electromagnetic representation of the electron equation, the charge, mass and interaction between particles arise simultaneously during twirling and division of a photon. In other words, the appearance of currents at twirling a linear photon simultaneously describes the appearance of a charge, masses and electron interactions .

Since in this case we have, conditionally speaking, three electromagnetic electron equations, it is necessary to conclude, that EM masses of quarks, their charges and interactions between them are described by nine currents of the equations (3.11) or (3.12). It is possible to assume, that three from them which are tangential electric currents, define charges of quarks and partially the masses. Whether the others currents (three electric binormal and three magnetic normal) insert some amendments into these parameters, it is difficult to tell.

3.3.2. The description of *of the mass-interaction term appearance* in the framework of Rieman geometry

The appearance of additional term follows from the general theory of the vector motion along the curvilinear trajectory. This theme was studied in the vector analyse, in the differential geometry and in the hypercomplex number theory hundred years ago (Madelung, 1957; Korn and Korn, 1961) and it is well known. Below we consider some conclusions of these theories.

Any vector $\vec{F}(\vec{r},t)$ can have the following forms (Korn and Korn, 1961):

$$\vec{F}(\vec{r},t)=\vec{F}(x^0,x^1,x^2,x^3)=F^0\vec{e}_0+F^1\vec{e}_1+F^2\vec{e}_2+F^3\vec{e}_3= \\ =F_0\vec{e}^{\,0}+F_1\vec{e}^{\,1}+F_2\vec{e}^{\,2}+F_3\vec{e}^{\,3}, \quad (3.17)$$

where $F^0,F^1,F^2,F^3,F_0,F_1,F_2,F_3$ are the invariant and co-variant vector modulus and $\vec{e}^{\,i}$ and $\vec{e}_i$ are the basis vectors, which in general case are changed from point to point. When vector moves along the curvilinear trajectory the partial derivatives get the view:

$$\frac{\partial\vec{F}}{\partial x^j}=\frac{\partial F^i}{\partial x^j}\vec{e}_i+F^i\frac{\partial\vec{e}_i}{\partial x^j}=\frac{\partial F_i}{\partial x^j}\vec{e}^{\,i}+F_i\frac{\partial\vec{e}^{\,i}}{\partial x^j}, \quad (3.14)$$

where the following notations are used:

$$\frac{\partial\vec{e}_i}{\partial x^j}=\Gamma^k_{ij}\vec{e}_k=-\Gamma^i_{kj}\vec{e}^{\,k}, \quad (3.15)$$

(here $i,j,k,=0,1,2,3$)

The coefficients Γ^k_{ij} are named Christoffel symbols or bound coefficients. Thus, for the y - direction photon

$$\begin{cases}\vec{E}=E_3\vec{e}^{\,3}\\ \vec{H}=H_1\vec{e}^{\,1}\end{cases}, \quad (3.16)$$

we obtain:

$$\begin{cases}\frac{1}{c}\frac{\partial\vec{E}}{\partial t}=\frac{\partial E_3}{\partial x^0}\vec{e}^{\,3}+E_3\Gamma^3_{k0}\vec{e}^{\,k}\\ \frac{1}{c}\frac{\partial\vec{H}}{\partial t}=\frac{\partial H_1}{\partial x^0}\vec{e}^{\,1}+H_1\Gamma^1_{k0}\vec{e}^{\,k}\\ \frac{\partial\vec{E}}{\partial y}=\frac{\partial E_3}{\partial x^2}\vec{e}^{\,3}+E_3\Gamma^3_{k2}\vec{e}^{\,k}\\ \frac{\partial\vec{H}}{\partial y}=\frac{\partial H_1}{\partial x^2}\vec{e}^{\,1}+H_1\Gamma^1_{k2}\vec{e}^{\,k}\end{cases}, \quad (3.17)$$

The same we can obtain for the other directions of the photons.

Thus, in the general case, when the electromagnetic field vectors of three-knot particles move along the curvilinear trajectories, the additional terms of the same type, which we obtained in the case of Yang-Mills equation, appear.

Note: in the framework of CWED the Christoffel symbols are not the abstract mathematical values. On one hand they are the physical values; namely, they are the currents, which appeared thanks to the twirling and torsion of the electromagnetic vectors. On the other hand they have geometrical sense: they are proportional to the curvature of the trajectory K and to the torsion of the trajectory T.

4.0. The introduction of the terms of interactions of quarks

Let us examine the formation of hadrons (for example, proton) from the point of view of the reaction of photoproduction

$$\gamma + N \rightarrow p^{+} + p^{-} + N\,, \qquad (4.1)$$

where γ, p^{+}, p^{-} are a gamma-quantum (photon), proton and antiproton respectively, and N is the nuclear field, in which is accomplished the symmetry breaking of photon and as consequence tht appearance of massive particles. It should conclude from (4.1) that quarks themselves are produced simultaneously with interaction between them. Remember that we had the same in the case of the photoproduction of electron-positron pair with the only difference that in the last case the interaction was external. As the consequence of this we obtained the doubled value of mass member. Consequently, instead of (3.2) we will have

$$\begin{aligned} &\left[\left({}^{6}\hat{\alpha}_{o}\hat{\varepsilon} - c\cdot{}^{6}\hat{\vec{\alpha}}\ \hat{\vec{p}}\right) - 2\cdot{}^{6}\hat{\beta}\ m_{l}c^{2}\right]\psi = 0 \\ &\psi^{+}\left[\left({}^{6}\hat{\alpha}_{o}\hat{\varepsilon} + c\cdot{}^{6}\hat{\vec{\alpha}}\ \hat{\vec{p}}\right) + 2\cdot{}^{6}\hat{\beta}\ m_{l}c^{2}\right] = 0 \end{aligned}, \qquad (4.2)$$

where here through m_l ($l = 1,2,....9$) we conditionally designate the appropriate mass and currents, which describe both the quarks and the gluons. According to (4.2) we have 9 quark currents and 9 gluon currents, so that the summary energies each of these currents $W = \sum_{l=1}^{l=9} m_l c^2$ must be the same, or in other words summary energy of proton is divided in half between the quarks and the gluons. It is not also difficult to explain, why the inner virtual photons, called gluons, inside the hadron acquire the currents: in the strong intrinsic field of quarks they must be bent, acquiring some properties of massive particles.

These conclusions, in essence, do not contradict experimental and theoretical data, obtained within the framework of standard model.

5.0. EM hadron models

According to SM there are two sorts of hadron: barions, which contain three quarks, and mesons, which contains two quarks.

5.1. “Three quarks” model

We can suppose that in electromagnetic representation a barion is topologically the superposition of three knots and has the scheme of the trefoil knot (fig. 1):

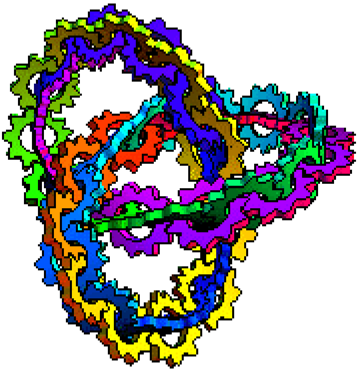

Fig.1

The figure 1 is taken from website (Möbius strip trefoil knot, MathWorld): http://mathworld.wolfram.com/TrefoilKnot.html, where the animation shows a series of gears motion along a Möbius strip trefoil knot as the electric and magnetic field vectors motion. A knot is defined as a closed, non-self-intersecting curve embedded in three dimensions. Knot theory was given its first impetus when Lord Kelvin proposed a theory that atoms of Democritus is vortex loops (Kelvin,1867). The trefoil and its mirror image are not equivalent. In other words, the trefoil knot is chiral object. It is, however, invertible.

The equation of one loop (i.e. ring) is the Dirac equation that has a harmonic solution. Therefore, it can be supposed that the EM hadrons are the 3D superposition of two or three harmonic oscillations. On other words, the EM hadrons are similar to the space wave packets. According to Schreudinger (Schreudinger, 1926) (see also (Jammer, 1967), section 6.1) the wave packets, built from harmonic waves (oscillations), don’t have a dispersion, i.e. they are stabile. Thus, we can, as a fist approximation, build the hadrons model as the space packet of the 3D superposition of three harmonics oscillations.

Here it must be noted that the superpositions of harmonic oscillations (i.e. Lissajoues figures) are not the topological figures as knots, because they are the self-intersecting curves. But we can to suppose that during the hadron formation as 3D Lissajous figures the loops will not intersect on account of the repulsion of currents.

The models were constructed by use of MathCAD-program. Probably the below models differ a lot from the real CWED particles and can not be used for calculation of the particle features. But they give some representation about them.

Thus, we suppose that the three-loops model (barion) is built from three harmonics oscillation. Let's choose the following oscillation parameters:

$$\omega_1 = 3, \quad \omega_2 = 2, \quad \omega_3 = 3, \quad ,$$

$$\phi_1 = \frac{\pi}{2}, \quad \phi_2 = \frac{\pi}{2}, \quad \phi_3 = 0,$$

$$r_1 = 2, \quad r_2 = 2, \quad r_3 = 2.$$

The argument has the view:

$t_j := j \cdot 2 \cdot \frac{\pi}{N}$, where $N := 200$, $j := 0..N$, $k := 0..N$, $v_k := k$,

The harmonic oscillations are described by functions (for each co-ordinate axis):

$$X_{k,j} := r_1 \cdot \sin(\omega_1 \cdot t_j - \phi_1)$$

$$Y_{k,j} := r_2 \cdot \sin(\omega_2 \cdot t_j - \phi_2)$$

$$Z_{k,j} := r_3 \cdot \sin(\omega_3 \cdot t_j - \phi_3)$$

As result we obtain the following three-loops figure (fig.2):

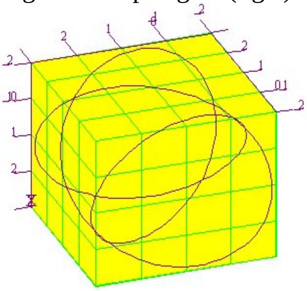

Fig. 2

To show the field plane twirling and twisting we change the parameter t_j to

$t_j := \frac{j}{2.2}$.Then we have:

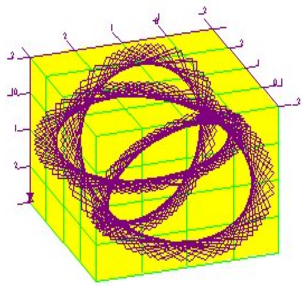

Fig. 3

5.2. "Two quarks" model

To build the two-loops model (meson) in the above proton model equations we choose: $\omega_1 = 1$ and $\phi_1 = 0$ and put $Z_{k,j} := 0$. Then we obtain the figure 4:

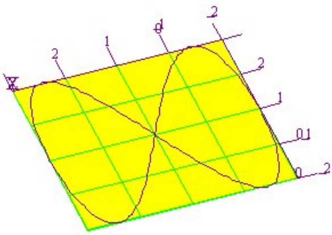

Fig. 4

It is necessary to note that depending on polarisation of the curvilinear photon (plain, circular, elliptic) the above models can have numerous different features.

We hope that the further investigations will allow us to build more realistic models, which will give us the opportunity to calculate the CWED particle features.

Discussion

The above electromagnetic representation of the Yang-Mills equations allows us to discuss some particularities of the QCD from point of view of CWED models:

1. ***The fractional charge of the quarks***: according to the above results the electric field trajectory of the quarks not only has a curvature, but also a torsion; hence, the tangential current, generated by the electrical field vector transport, alternates along the space trajectory. Consequently, the electric charge of one knot, as an integral from this current, will be less, than the electron charge. But the total charge from all knots can be equal to the charge of the electron.

2. ***Quarks confinement***: if quarks are two or three connected knots, quarks cannot exist in a free state.

3. ***The charges and masses of the quarks***: in the CWED model quarks are defined by the rotation frequencies of each knot. From three-knot model it follows that figure 2 has a steady structure only at the certain circular frequencies ratio 3 : 3 : 2. So, for barion model two of quark charges and masses must be equal among them and not equal to mass of third quarks. Analogically, two-knot figure 4 have frequencies ratio 2 to 3 and therefore the meson model has two different quarks.

4. ***Non-linearity of the Yang-Mills equation***: obviously, the Yang-Mills equation as the superposition of non-linear electromagnetic waves is the non-linear equation.

5. The *gluons and photons analogy*: according to the CWED topological models the gluons are the virtual photons, by which the knots interact between themselves.

6*.* ***The colours of quarks*:** it can be suppose that colours of quarks can identified with the quark currents since to each of the knots of the model have three different currents.

7. ***The colours of gluons*:** it can be suppose that colours of gluons can identified with two half-periods of virtual photons-gluons in respect that in the inner space of hadron these photons are bent and take the currents.

8. ***The strong interactions***: possibly as it is supposed by Denis Wilkinson (Wofson College Lectures, 1980) the strong interaction can appear analogically to the Van der Waals forces in the atoms. As a result of the interpenetration of the atoms between them appears the forces, known by the name to Van der Waals, which presents the reflection of the specific side of electric force. Analogous correspondence occurs also for the force, which acts between the quarks and that caused by gluons, from one side, and by the force, which acts between the protons and the neutrons, with another. In this sense the strong interaction between the protons with respect to the strong interaction between the quarks corresponds to the appearance of Van der Waals force.

Of course the further analysis is needed to confirm or reject the above assertions, since they don’t follow direct from the Yang-Mills equations. But as we see the CWED have the possibilities to explain many features of Standard Model.