Unified Theory of Bivacuum, Particles Duality, 
Fields & Time. 
Virtual Replicas of Material Objects and Possible Mechanism of Nonlocality  

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ABSTRACT

A new Bivacuum model is a consequence of new interpretation and development of
Dirac theory, pointing to equal probability of positive and negative energy. Bivacuum is
introduced as the infinitive dynamic superfluid matrix of virtual dipoles, named Bivacuum
fermions (BVF\(^i\)) and Bivacuum bosons (BVB\(^i\)), formed by correlated torus (V\(^+\)) and
antitorus (V\(^-\)) - as a collective excitations of subquantum particles and antiparticles of
opposite energy, charge and magnetic moments, is developed. The spatial and energetic
parameters of torus and antitorus of primordial Bivacuum, i.e. in the absence of matter and
fields influence, correspond to three generation of leptons: electrons, muons and tauons
\((i = e, \mu, \tau)\). The positive and negative Virtual Pressure Waves (VPW\(^\pm\)) and Virtual Spin
Waves (VirSW\(^S\pm_{1/2}\)) are the result of emission and absorption of positive and negative
Virtual Clouds (VC\(^\pm\)), resulting from transitions of V\(^+\) and V\(^-\) between different state of
excitation. It is demonstrated, that symmetry shift between V\(^+\) \(\uparrow\) V\(^-\) parameters to the left
or right, dependent on their external rotational-translational velocity and relativistic effects,
is accompanied by the virtual and real sub-elementary fermions and antifermions
formation. The formation of real sub-elementary fermions and their fusion to stable triplets
of elementary fermions, corresponding to the rest mass and charge origination, became
possible at the velocity of angular rotation of pairs of [BVF\(^i\) \(\uparrow\) BFV\(^i\)] around common
axis, been determined by Golden Mean condition: \((v/c)^2 = \phi = 0.618\). The photon in such
approach is a result of fusion (annihilation) of two triplets of particle and antiparticle:
(electron + positron) or (proton + antiproton). It represent a sextet of sub-elementary
fermions and antifermions with axial structural symmetry.
The fundamental physical roots of Golden Mean condition: \((v/c)^2 = \frac{v_{ex}^{|+|}}{v_{ph}^{|+|}} = \phi\) are revealed in form of equality of internal and external group and phase velocities of torus and antitorus of sub-elementary fermions, correspondingly: \(v_{gr}^{|+|} = v_{ex}^{|+|}, \; v_{ph}^{|+|} = v_{ph}^{|+|}.\) These equalities are named ‘Hidden Harmony Conditions’.

The new expressions for total, potential and kinetic energies of de Broglie waves of elementary particles were obtained:

\[
E_{tot} = V_{tot} + T_{tot} = \frac{1}{2}(m\hat{v}^{|+|} + m\hat{v}^{|-|})c^2 + \frac{1}{2}(m\hat{v}^{|+|} - m\hat{v}^{|-|})c^2
\]

or \(E_{tot} = m\hat{v}^{|+|}c^2 = \sqrt{1 - (v/c)^2} (m_0c^2)^{in} + \left[\frac{\hbar}{m\hat{v}^{|+|}}\lambda^2_0\right]^{ext}\)

where: \(\lambda_B = \hbar/m\hat{v}\) is a de Broglie wave length; the \(m\hat{v}^{|+|}\) and \(m\hat{v}^{|-|}\) are the actual (inertial) and complementary (inertialess) mass of torus \((V^+)|\) and antitorus \((V^-)\) of asymmetric sub-elementary fermions. Their product is the rest mass squared: \(|m\hat{v}|^2 = m^2_0\).

The new formulas subdivide the total energy to potential and kinetic energy and to internal and external contributions. The shift of symmetry between the mass and other parameters of torus and antitorus of sub-elementary fermions are dependent on their internal rotational-translational dynamics in triplets and the external translational velocity of the whole triplets.

The dynamic mechanism of \([\text{corpuscle} (C) \equiv \text{wave} (W)]\) duality is proposed. It involves the modulation of the internal (hidden) quantum beats frequency between the asymmetric ‘actual’ (torus) and ‘complementary’ (antitorus) states of sub-elementary fermions or antifermions by the external - empirical de Broglie wave frequency of the whole particles. It is demonstrated, that the different kind of Bivacuum matrix excitations, accompanied \([\text{Corpuscle} \equiv \text{Wave}]\) pulsations of sub-elementary fermions in triplets of fermions and their fact rotation are responsible for electric, magnetic and gravitational fields origination. The zero-point vibrations of particle and evaluated zero-point velocity of these vibrations are also a result of \([\text{recoil} \equiv \text{antirecoil}]\) effects, accompanied \([C \equiv W]\) pulsations.

The Maxwell’s displacement current and the additional to that instant current, increasing the refraction index of Bivacuum and light velocity near strongly gravitating and charged objects, are also the consequences of Bivacuum virtual dipoles \((\text{BVF}^0 \text{ and } \text{BVB}^\pm)\) excitations and vibrations. The nonzero contribution of the rest mass of photons and neutrino in this perturbed secondary Bivacuum is a consequence of its elevated refraction index.

It is shown, that the Principle of least action and realization of 2nd and 3d laws of thermodynamics for closed systems - can be a result of slowing down particles dynamics and the kinetic energy decreasing, under the influence of the basic - lower frequency Virtual Pressure Waves \((\text{VPW}_{q=1}^{\pm})\) with minimum quantum \(q = j - k = 1.\) This is a consequence of induced combinational resonance between \([C \equiv W]\) pulsation of particles and basic \(\text{VPW}_{q=1}^{\pm}\) of Bivacuum. The new notion of Bivacuum Tuning Energy (TE), responsible for driving a particles to resonance conditions, is introduced. It is demonstrated, that the dimensionless ‘pace of time’ \((dt/t = -dT/k)\) and time itself \((t)\) for each closed system are determined by the change of this system kinetic energy. They are positive, if the particles of system are slowing down under the influence of \(\text{VPW}_{q=1}^{\pm}\) and Tuning energy of Bivacuum. The \((dt/t)\) and \((t)\) are negative in the opposite case.

The concept of Virtual Replica (VR) or virtual hologram of any material object is developed. The VR or virtual hologram is a result of interference of Virtual Pressure Waves \((\text{VPW}_{q}^+ \text{ and } \text{VPW}_{q}^-)\) and Virtual Spin waves \((\text{VirSW}_{q}^{|+|-1/2})\) of the Bivacuum, representing “reference waves”, with “object waves” \(\text{VPW}_{m}^{\pm}\) and \(\text{VirSW}_{m}^{|+|-1/2},\) modulated
by de Broglie waves of molecules.

Possible Mechanism of Quantum entanglement between remote elementary particles via Virtual Guides of spin, momentum and energy \((\text{VirG}_{S,\text{M,E}})\) is proposed. It is demonstrated, that the consequences Unified theory (UT) of Bivacuum, matter and fields are in good accordance with known experimental data. The two slit experiment also get its explanation even in single particles case, as a consequence of interference of particle in wave phase with its own virtual replica.

Introduction

The Dirac theory points to equal probability of positive and negative energy (Dirac, 1947). In asymmetric Dirac vacuum its realm of negative energy is saturated with infinitive number of electrons. However, it was assumed that these electrons, following Pauli principle, have not any gravitational or viscosity effects. Positrons and electron in his model represent the 'holes', originated as a result of the electrons jumps in realm of positive energy over the energetic gap: \(\Delta = 2m_0c^2\). Currently it becomes clear, that the Dirac type model of vacuum is not general enough to explain all known experimental data, for example, the bosons emergency. The model of Bivacuum (Kaivarainen, 1995; 2004; 2005) looks to be more advanced. However, it use the same starting point of equal probability of positive and negative energy, confined in each of Bivacuum cell-dipole in the absence of these dipoles symmetry shift.

All numerous experimental attempts to reveal the monopoles, as analogs of electric charges has failed. The proposed Unified theory explains the absence of magnetic monopoles by the absence of symmetry shift between the internal opposite actual |\(\Omega^+\)| and complementary |\(\Omega^-\)| magnetic moments of virtual torus and antitorus, forming Bivacuum fermions in contrast to mass and charge symmetry shifts (Kaivarainen, 2005).

In book, written by D. Bohm and B. Hiley (1993): "THE UNDIVIDED UNIVERSE. An ontological interpretation of quantum theory” the electron is considered, as a particle with well- defined position and momentum which are, however, under influence of special wave (quantum potential). Elementary particle, in accordance with these authors, is a sequence of incoming and outgoing waves, which are very close to each other. However, particle itself does not have a wave nature. Interference pattern in double slit experiment after Bohm is a result of periodically ”bunched” character of quantum potential.

It is a basic difference with our model of duality (Kaivarainen, 2005a,b), assuming that the wave and corpuscle phases are realized alternatively with high Compton frequency. This frequency is modulated by the empirical de Broglie wave frequency of particles, making possible their interference, mediated by modulated Bivacuum Virtual Pressure Waves (VPW\(^\pm\)).

Some common features with our and Bohm-Hiley models has a Unitary Quantum Theory (UQT), proposed by Sapogin (1982). In the UQT any elementary particle is not a point and source of field like in the ordinary quantum mechanics, but represents a wave packet of a certain unified field (Sapogin and Boichenko, 1991). The dispersion equation of such a nonlinear field turned out to be such, that the wave packet (particle) during its movement periodically appears and disappears, and the envelope of this process coincides with the de Broglie wave. Numerous particles during their periodic disappearance (spreading in the Universe) and repeated appearance represent vacuum fluctuations. The square of wave packet describes the oscillating charged particle (Sapogin, et.al., 2002), following the conventional Newton equations. The essential in UQT is the absence of the energy and the momentum conservation laws for single particles.

In 1950 John Wheeler and Charles Misner published Geometrodynamics, a new
description of space-time properties, based on topology. Wheeler (1968) supposed that elementary particles and antiparticles, their spins, positive and negative charges can be presented as interconnected black and white holes. The connecting tube exist in another space-time than holes itself. Such a tube is undetectable in normal space and the process of energy transmission looks as instantaneous. In conventional space-time two ends of tube, termed 'wormholes' can be a vast distant apart. It is one of explanation of quantum nonlocality. This ‘wormhole’ idea has common with our model of entanglement between coherent remote elementary particles via Virtual Guides of spin, momentum and energy (VirG\textit{SME}), representing quasi one-dimensional Bose condensate of Bivacuum dipoles.

Sidharth (1998, 1999) considered \textit{elementary particle as a relativistic vortex of Compton radius, from which he recovered its mass and quantized spin}. He pictured a particle as a fluid vortex steadily circulating with light velocity along a 2D ring or spherical 3D shell with radius: \( L = h/(2mc) \). Inside such vortex the notions of negative energy, superluminal velocities and nonlocality are acceptable without contradiction with conventional theory. This view have some common features with recent model of sub-elementary particles and antiparticles (Kaivarainen, 2005). If measurements are averaged over time \( t \sim mc^2/h \) and over space \( L \sim h/mc \), the imaginary part of particle’s position disappears and we are back in usual Physics (Sidharth, 1998).

Aspden (2003) introduced in his aether theory the basic unit, named Quon, as a pair of virtual muons of opposite charges, i.e. [muon + antimuon]. This idea is close to model of Bivacuum dipoles of torus + antitorus of opposite energy/mass, charge and magnetic moments with Compton radiuses, corresponding to electron, muon and tauon (Kaivarainen, 2004, 2005). In the book: "The physics of creation", Aspden (2003) used the Thompson model of the electron, as a sphere with radius (a), charge (e) and energy: \( 2e^2/3a = mc^2 \). This model strongly differs from that, presented in Unified theory (see section 3) of this paper.

Barut and Bracken (1981) considered \textit{zitterbewegung} - rapidly oscillating imaginary part of particle position, leading from Dirac theory (1947), as a harmonic oscillator in the Compton wavelength region of particle. The Einstein (1971, 1982) and Shrödinger (1930) also spoke about oscillation of the electron with frequency: \( \nu = mc^2/h \) and the amplitude: \( \zeta_{\text{max}} = h/(2mc) \). It was demonstrated by Shrödinger, that position of free electron can be presented as: \( x = \bar{x} + \zeta \), where \( \bar{x} \) characterize the average position of the free electron, and \( \zeta \) its instant position, related to its oscillations. Hestness (1990) proposed, that \textit{zitterbewegung} arises from self-interaction, resulting from wave-particle duality.

This ideas are close to our explanation of elementary particles zero-point oscillations, as a consequence of their recoil \( \sim \) antirecoil vibrations, accompanied corpuscle \( \sim \) wave pulsations. Corresponding oscillations of each particle kinetic energy, in accordance to our theory of time (Kaivarainen, 2005), is related with oscillations of \textit{instant} time for this closed system. We came here to concept of space-time-energy discreet trinity, generated by corpuscle – wave duality.

Puthoff (2001) developed the notion of 'vacuum engineering', using hypothesis of polarizable vacuum (PV). The electric permittivity \( (\varepsilon_0) \) and magnetic permeability \( (\mu_0) \) is interrelated in 'primordial' symmetric vacuum, as: \( \varepsilon_0\mu_0 = 1/c^2 \). It is shown that changing of vacuum refraction index: \( n = c/\nu = \varepsilon^{1/2} \), for example in gravitational or electric potentials, is accompanied by variation of lot of space-time parameters. Earlier, Fock (1964), explained the bending of light beam, induced by gravitation near massive bodies, also by vacuum refraction change, i.e. in another way, than General theory of relativity. However, the mechanism of vacuum polarization and corresponding refraction index changes in electric and gravitational fields remains obscure. Our Unified theory (Kaivarainen, 2005) propose such mechanism.
The transformation of neutron after scattering on neutrino, to proton and electron, in accordance to Electro-Weak (EW) theory, developed by Glashow (1961), Weinberg (1967) and Salam (1968), is mediated by negative $W^-$ particle. The reverse reaction in EW theory: proton $\rightarrow$ neutron is mediated by positive massless $W^+$ boson. Scattering of the electron on neutrino, not accompanied by charge transferring, is mediated by third massless neutral boson $Z^0$.

In EW theory for explanation of spontaneous symmetry violation of intermediate vector bosons: charged $W^\pm$ and neutral $Z^0$ with spin 1, accompanied by big mass of these exchange particles origination, the Higgs field was introduced. The EW theory needs also the quantum of Higgs field, named Higgs bosons with big mass, zero charge and integer spin. The fusion of Higgs bosons with $W^\pm$ and $Z^0$ particles is accompanied by increasing of their mass up to 90 mass of protons. The experimental discovery of heavy $W^\pm$ and $Z^0$ particles in 1983 was considered as a confirmation of EW theory. However, the Higgs field and Higgs bosons are still not found.

The spontaneous symmetry violation of vacuum, in accordance to Goldstone theorem, turns two virtual particles with imaginary masses ($im$) to one real particle with mass:

$$M_1 = \sqrt{2} \, m$$

and one real particle with zero mass:

$$M_2 = 0.$$

Thompson, Heaviside and Searl supposed that mass is an electrical phenomena. In theory of Haish, Rueda and Puthoff (1994), Rueda and Haish (1998) it was proposed, that the inertia is a reaction force, originating in a course of dynamic interaction between the electromagnetic zero-point field (ZPF) of vacuum and charge of elementary particles. However, it’s not clear from their theory, how the charge itself originates.

In EW theory the charge and mass of $W^\pm$ bosons are considered, as independent. The Unified theory of Bivacuum, matter and fields tries to unify these parameters with magnetic moment, spin and Bivacuum dipoles symmetry shift (Kaivarainen, 2004; 2005).

1. The new concept of Bivacuum

1.1. Properties of Bivacuum dipoles - Bivacuum fermions and Bivacuum bosons

Our Unified Theory (UT) is a result of long-term efforts for unification of vacuum, matter and fields from few ground postulates (Kaivarainen, 1995-2005). The Bivacuum concept is a result of new interpretation and development of Dirac theory (Dirac, 1958), pointing to equal probability of positive and negative energy in Nature.

The Bivacuum is introduced, as a dynamic superfluid matrix of the Universe, composed from non-mixing subquantum particles of opposite polarization, separated by an energy gap. The hypothetical microscopic subquantum particles and antiparticles have a dimensions less than the Plank length ($10^{-33}$ cm), zero mass and charge. They form the infinite number of mesoscopic paired vortices - Bivacuum dipoles of three generations with Compton radii, corresponding to electrons ($e$), muons ($\mu$) and tauons ($\tau$). Only such mesoscopic collective excitations of subquantum particles in form of pairs of rotating fast torus and antitorus are quantized. In turn, these Bivacuum ‘molecules’ compose the macroscopic superfluid ideal liquid, representing the infinitive Bivacuum matrix.

Each of two strongly correlated ‘donuts’ of Bivacuum dipoles acquire the opposite mass and magnetic moments, compensating each other in the absence of symmetry shift between them. The latter condition is valid only for symmetric primordial Bivacuum, where the influence of matter and fields on Bivacuum is negligible. The sub-elementary fermion and antifermion origination is a result of the Bivacuum dipole symmetry shift toward the torus or antitorus, correspondingly. The correlation between paired vortical structures in a liquid medium was theoretically proved by Kiehn (1998).

The infinite number of paired vortical structures: $[\text{torus (} V^+ \text{)} + \text{antitorus (} V^- \text{)}]$ with the in-phase clockwise or anticlockwise rotation are named Bivacuum fermions.
\( \text{(BVF}^i = \text{V}^+ \uparrow \downarrow \text{V}^-) \) and Bivacuum antifermions (\( \text{BVF}^\dagger = \text{V}^+ \downarrow \downarrow \text{V}^- \)), correspondingly. Their intermediate - transition states are named Bivacuum bosons of two possible polarizations: (\( \text{BVB}^+ = \text{V}^+ \uparrow \prime \downarrow \text{V}^- \prime \)) and (\( \text{BVB}^- = \text{V}^+ \downarrow \prime \uparrow \text{V}^- \prime \)). The positive and negative energies of torus and antitorus (\( \pm \text{E}_{\text{V} \pm} \)) of three lepton generations \( (i = e, \mu, \tau) \), interrelated with their radiiuses (\( \text{L}_{\text{V} \pm}^i \)), are quantized as quantum harmonic oscillators of opposite energies:

\[
\text{[E}_{\text{V} \pm}^i = \pm \text{m}_0 \text{c}^2 (\frac{1}{2} + n) = \pm \text{h} \omega_0 (\frac{1}{2} + n)]^i \quad \text{n} = 0, 1, 2, 3 \ldots
\]

1.1

or:

\[
\text{[E}_{\text{V} \pm}^i = \pm \frac{\text{h} \text{c}}{\text{L}_{\text{V} \pm}^i}]^i \quad \text{where:} \quad \text{[L}_{\text{V} \pm}^i = \frac{\pm \text{h}}{\text{m}_0 \text{c}(\frac{1}{2} + n)} = \frac{\text{L}_0}{\frac{1}{2} + n}]^i
\]

1.1a

where: \( \text{[L}_0 = \text{h/m}_0 \text{c}] \) is a Compton radii of the electron of corresponding lepton generation \( i = e, \mu, \tau \) and \( \text{L}_0^\prime > \text{L}_0^\prime > \text{L}_0^\prime \). The Bivacuum fermions (\( \text{BVF}^i \)) with smaller Compton radiiuses can be located inside the bigger ones (\( \text{BVF}^\dagger \)).

The absolute values of increments of torus and antitorus energies (\( \Delta \text{E}_{\text{V} \pm}^i \)), interrelated with increments of their radii (\( \Delta \text{L}_{\text{V} \pm}^i \)) in primordial Bivacuum (i.e. in the absence of matter and field influence), resulting from in-phase symmetric fluctuations are equal:

\[
\Delta \text{E}_{\text{V} \pm}^i = -\frac{\text{h} \text{c}}{(\text{L}_{\text{V} \pm}^i)^2} \Delta \text{L}_{\text{V} \pm}^i = -\text{E}_{\text{V} \pm}^i \frac{\Delta \text{L}_{\text{V} \pm}^i}{\text{L}_{\text{V} \pm}^i} \quad \text{or :}
\]

1.2

\[
-\Delta \text{L}_{\text{V} \pm}^i = \frac{\pi}{\pi \text{h} \text{c}} \Delta \text{E}_{\text{V} \pm}^i = \frac{\text{S}_{\text{BVF}^i}}{2 \text{h} \text{c}} \Delta \text{E}_{\text{V} \pm}^i = \text{L}_{\text{V} \pm}^i \frac{\Delta \text{E}_{\text{V} \pm}^i}{\text{E}_{\text{V} \pm}^i}
\]

1.2a

where: \( \text{S}_{\text{BVF}^i} = \pi \left( \frac{\text{L}_{\text{V} \pm}^i}{\pi \text{h} \text{c}} \right)^2 \) is a square of the cross-section of torus and antitorus, forming Bivacuum fermions (\( \text{BVF}^i \)) and Bivacuum bosons (\( \text{BVB}^\pm \)).

The virtual mass, charge and magnetic moments of torus and antitorus of \( \text{BVF}^i \) and \( \text{BVB}^\pm \) are opposite and in symmetric primordial Bivacuum compensate each other in their basic \( (\text{n} = 0) \) and excited \( (\text{n} = 1, 2, 3 \ldots) \) states.

The Bivacuum atoms': \( \text{BVF}^i = \text{[V}^+ \uparrow \downarrow \text{V}^-] \) and \( \text{BVB}^\pm = \text{[V}^+ \downarrow \uparrow \text{V}^-] \) represent dipoles of three different poles - the mass \( (\text{m}_0 = |\text{m}_0|) \), electric \((e_+ \text{ and } e_-) \) and magnetic \((\mu_+ \text{ and } \mu_-) \) dipoles.

The torus and antitorus \( \text{[V}^+ \downarrow \downarrow \text{V}^-] \) of Bivacuum fermions of opposite spins \( \text{BVF}^i \) and \( \text{BVF}^\dagger \) are both rotating in the same direction: clockwise or anticlockwise. This determines the positive and negative spins \( (\text{S} = \pm 1/2 \text{h}) \) of Bivacuum fermions. Their opposite spins may compensate each other, forming virtual Cooper pairs: \( \text{BVF}^i \propto \text{BVF}^\dagger \) with neutral boson properties. The rotation of adjacent \( \text{BVF}^i \) and \( \text{BVF}^\dagger \) in Cooper pairs is side- by- side in opposite directions, providing zero resulting spin of such pairs and ability to virtual Bose condensation. The torus and antitorus of Bivacuum bosons \( \text{BVB}^\pm = \text{[V}^+ \downarrow \downarrow \text{V}^-] \) with spin, equal to zero, are rotating in opposite directions.

The energy gap between the torus and antitorus of symmetric \( \text{BVF}^i \) or \( \text{BVF}^\dagger \) is:

\[
[\text{A}_{\text{BVF}} = \text{E}_{\text{V}^+} - (-\text{E}_{\text{V}^-}) = \text{h} \omega_0 (1 + 2\text{n})] = \text{m}_0^i \text{c}^2 (1 + 2\text{n}) = \frac{\text{h} \text{c}}{[\text{d}_{\text{V}^+\text{V}^-}]_\text{h}}
\]

1.3

where the characteristic distance between torus \( \text{(V}^+ \) \) and antitorus \( \text{(V}^- \) of Bivacuum dipoles (gap dimension) is a quantized parameter:

\[
[\text{d}_{\text{V}^+\text{V}^-}]_\text{h} = \frac{\text{h}}{\text{m}_0^i \text{c}(1 + 2\text{n})}
\]

1.4

From (1.2) and (1.2a) we can see, that at \( \text{n} \rightarrow 0 \), the energy gap \( \text{A}_{\text{BVF}} \) is decreasing till \( \text{h} \omega_0 = \text{m}_0^i \text{c}^2 \) and the spatial gap dimension \( [\text{d}_{\text{V}^+\text{V}^-}]_\text{h} \) is increasing up to the Compton
oscillation of virtual pressure (negative energy) considered as 'drops' of virtual Bose condensation of subquantum particles of positive and particles and antiparticles of opposite energies, correspondingly. They can be subquantum length $\lambda_0 = h/m_0 c$. On the contrary, the infinitive symmetric excitation of torus and antitorus is followed by tending the spatial gap between them to zero: $|d_{\text{VPW}}|_n \to 0$ at $n \to \infty$. This means that the quantization of space and energy of Bivacuum are interrelated and discreet.

1.2 The basic (carrying) Virtual Pressure Waves (VPW$^\pm$) and Virtual spin waves (VirSW$^{\pm1/2}$) of Bivacuum

The emission and absorption of Virtual clouds ($\text{VC}_{j,k}^+$) and anticlouds ($\text{VC}_{j,k}^-$) in primordial Bivacuum, i.e. in the absence of matter and fields or where their influence on symmetry of Bivacuum is negligible, are the result of correlated transitions between different excitation states $(j,k)$ of torus ($V_{j,k}^+$) and antitorus ($V_{j,k}^-$), forming symmetric $[\text{BVF}]^+$ and $[\text{BVB}]^-$, corresponding to three lepton generations $(i = e, \mu, \tau)$:

\[
(\text{VC}_{j,k}^+) = [V^+_j - V^+_k] - \text{virtual cloud}
\]

\[
(\text{VC}_{j,k}^-) = [V^-_j - V^-_k] - \text{virtual anticloud}
\]

where: $j > k$ are the integer quantum numbers of torus and antitorus excitation states.

The virtual clouds: ($\text{VC}_{j,k}^+$) and ($\text{VC}_{j,k}^-$) exist in form of collective excitation of subquantum particles and antiparticles of opposite energies, correspondingly. They can be considered as 'drops' of virtual Bose condensation of subquantum particles of positive and negative energy.

The process of [emission $\Rightarrow$ absorption] of virtual clouds should be accompanied by oscillation of virtual pressure ($\text{VirP}^\pm$) and excitation of positive and negative virtual pressure waves ($\text{VPW}^+$ and $\text{VPW}^-$)$_{j,k}$. In primordial Bivacuum the virtual pressure waves of opposite energies totally compensate each other. However, in asymmetric secondary Bivacuum, in presence of matter and fields, the total compensation is absent and the resulting virtual pressure is nonzero (Kaivarainen, 2005):

\[
(\Delta \text{VirP}^\pm = |\text{VirP}^+| - |\text{VirP}^-|) > 0.
\]

In accordance with our model of Bivacuum, virtual particles and antiparticles represent the asymmetric Bivacuum dipoles ($\text{BVF}^\pm$) of three electron generations $(i = e, \mu, \tau)$ in unstable state, not corresponding to Golden mean conditions (see section 2.1). Virtual particles and antiparticles are the result of correlated and opposite Bivacuum dipole symmetry fluctuations. Virtual particles, like the real sub-elementary particles, may exist in Corpuscular and Wave phases (see section 5). The Corpuscular [C] - phase, represents strongly correlated pairs of asymmetric torus ($V^+$) and antitorus ($V^-$) of two different by absolute values energies. The Wave [W] - phase, results from quantum beats between these states, which are accompanied by emission or absorption of Cumulative Virtual Cloud (CVC$^+$ or CVC$^-$), formed by subquantum particles.

Virtual particles have a mass, charge, spin, etc., but they differs from real sub-elementary ones by their lower stability (short life-time) and inability for fusion to stable triplets (see section 3). They are a singlets or very unstable triplets or other clusters of Bivacuum dipoles ($\text{BVF}^\pm$) in contrast to real fermions-triplets.

For Virtual Clouds ($\text{VC}^\pm$) and virtual pressure waves ($\text{VPW}^\pm$) excited by them, the relativistic mechanics is not valid. Consequently, the causality principle also does not work in a system (interference pattern) of $\text{VPW}^\pm$.

The quantized energies of positive and negative $\text{VPW}^+$ and $\text{VPW}^-$ and corresponding virtual clouds and anticlouds, emitted $\Rightarrow$ absorbed by ($\text{BVF}$)$^j$ and ($\text{BVB}$)$^j$, as a result of their transitions between $j$ and $k$ states can be presented as:
The quantized fundamental Compton frequency of VPW$^\pm$:

$$q \omega_0 = q \frac{m_0 c^2}{\hbar}$$

where: $q = (j - k) = 1, 2, 3, \ldots$ is the quantization number of VPW$^{\pm}_j$ energy.

In symmetric primordial Bivacuum the total compensation of positive and negative Virtual Pressure Waves is possible:

$$q E_{VPW}^{\pm} = -q E_{VPW}^{\mp} = q \hbar \omega_0$$

The density oscillation of VC$^{\pm}_j$ and VC$^{\mp}_j$ and virtual particles and antiparticles represent positive and negative basic virtual pressure waves (VPW$^{\pm}_j$ and VPW$^{\mp}_j$).

The correlated *virtual Cooper pairs* of adjacent Bivacuum fermions (BVF$^{\pm}_{S=\pm 1/2}$), rotating in opposite direction with resulting spin, equal to zero and Boson properties, can be presented as:

$$[\text{BVF}^{\pm}_{S=1/2}] \cong [\text{BVF}^{\pm}_{S=-1/2}]_{S=0} = [(V^+ \uparrow \uparrow V^-) \cong (V^+ \downarrow \downarrow V^-)]_{S=0}$$

Such a pairs, as well as Bivacuum bosons (BVB$^{\pm}$) in conditions of ideal equilibrium, like the Goldstone bosons, have zero mass and spin: $S = 0$. The virtual clouds (VC$^{\pm}_j$), emitted and absorbed in a course of correlated transitions of $[\text{BVF}^{\pm}_{S=1/2}]_{S=0}$ between $(j)$ and $(k)$ sublevels, excite the virtual pressure waves VPW$^+$ and VPW$^-$. They compensate the energy of each other totally in primordial Bivacuum and partly in *secondary Bivacuum* - in presence of matter and fields.

*The nonlocal virtual spin waves* (VirSW$^{\pm 1/2,j,k}$), with properties of massless collective Nambu-Goldstone modes, represent oscillation of equilibrium of Bivacuum fermions with opposite spins, accompanied by origination of intermediate states - Bivacuum bosons (BVB$^{\pm}$):

$$\text{VirSW}^{\pm 1/2,j,k} \sim \left[ \text{BVF}^{\pm}_{S=1/2}(V^+ \uparrow \uparrow V^-) \cong \text{BVB}^{\pm}(V^+ \uparrow \uparrow V^-) = \text{BVF}^{\pm}_1(V^+ \downarrow \downarrow V^-) \right]$$

The VirSW$^{1/2,j,k}$ and VirSW$^{-1/2,j,k}$ are excited by (VC$^{\pm}_j$)$_{S=1/2}$ and (VC$^{\mp}_j$)$_{S=-1/2}$ of opposite angular momentums: $S_{\pm 1/2} = \pm \frac{1}{2} \hbar = \pm \frac{1}{2} L_0 m_0 c$ and frequency, equal to VPW$^{\pm}_j$ (1.7):

$$q \omega^{\prime}_{\text{VirSW}^{\pm 1/2,j,k}} = q \omega^{\prime}_{\text{VPW}^{\pm}_j} = q m_0 c^2/\hbar = q \omega_0$$

The most probable basic virtual pressure waves VPW$^{\pm}_0$ and virtual spin waves VirSW$^{\pm 1/2}_0$ correspond to minimum quantum number $q = (j - k) = 1$.

The VirSW$^{\pm 1/2}_0$, like so-called torsion field, can serve as a carrier of the phase/spin (angular momentum) and information - *qubits*, but not the energy.

The Bivacuum bosons (BVB$^{\pm}$), may have two polarizations ($\pm$), determined by spin state of their actual torus (V$^*$):

$$\text{BVB}^{+} = (V^+ \uparrow \uparrow V^-), \quad \text{when} \quad \text{BVF}^{\pm} \rightarrow \text{BVF}^{\pm}$$

$$\text{BVB}^{-} = (V^+ \downarrow \downarrow V^-), \quad \text{when} \quad \text{BVF}^{\pm} \rightarrow \text{BVF}^{\pm}$$

The Bose-Einstein statistics of energy distribution, valid for system of weakly interacting bosons (ideal gas), do not work for Bivacuum due to strong coupling of pairs [BVF$^{\pm}_{S=0}$] and (BVB$^{\pm}$), forming virtual Bose condensate (VirBC) with nonlocal properties. The Bivacuum nonlocal properties can be proved, using the Virial theorem (Kaivarainen, 2004, 2005).
1.3 Virtual Bose condensation (VirBC), as a base of Bivacuum nonlocality

It follows from our model of Bivacuum, that the infinite number of Cooper pairs of Bivacuum fermions \( [\text{BVF}^\dagger]_{\mathcal{S} = 0} \) and their intermediate states - Bivacuum bosons \((\text{BVB}^\pm)\), as elements of Bivacuum, have zero or very small (in presence of fields and matter) translational momentum: 
\[
p_{\text{BVF}^\dagger} = p_{\text{BVB}} \rightarrow 0
\]
and corresponding de Broglie wave length tending to infinity: 
\[
\lambda_{\text{VirBC}} = \frac{h}{p_{\text{BVF}^\dagger}} = \frac{h}{p_{\text{BVB}}} \rightarrow \infty.
\]
It leads to origination of 3D net of virtual adjacent pairs of virtual microtubules from Cooper pairs \( [\text{BVF}^\dagger]_{\mathcal{S} = 0} \), rotating in opposite direction and \((\text{BVB}^\pm)_{\mathcal{S} = 0}\), which may form single microtubules, with resulting angular momentum, equal to zero. These twin and single microtubules, termed Virtual Guides \( \text{VirG}^\dagger_{\text{BVF}} \) and \( \text{VirG}^{\dagger}_{\text{BVB}} \), represent a quasi one-dimensional Bose condensate with nonlocal properties close to that of 'wormholes' (see section 9). Their radiuses are determined by the Compton radiuses of the electrons, muons and tauons. Their length is limited only by decoherence effects. In symmetric Bivacuum, unperturbed by matter and fields, the length of \( \text{VirG} \) may have the order of stars and galactics separation.

Nonlocality, as the independence of potential on the distance from its source in the volume or filaments of virtual or real Bose condensate, follows from application of the Virial theorem to systems of Cooper pairs of Bivacuum fermions \( [\text{BVF}^\dagger]_{\mathcal{S} = 0} \) and Bivacuum bosons \((\text{BVB}^\pm)\) (Kaivarainen, 1995; 2004; 2005).

The Virial theorem in general form is correct not only for classical, but also for quantum systems. It relates the averaged kinetic \( T_k(\mathbf{v}) = \sum_i m_i v_i^2/2 \) and potential \( V(r) \) energies of particles, composing these systems:
\[
2T_k(\mathbf{v}) = \sum_i m_i v_i^2 = \sum_i \mathbf{v}_i \cdot \nabla \mathbf{v}_i/\nabla r_i^2
\]
1.12

If the potential energy \( V(r) \) is a homogeneous \( \mathbf{a} - order \) function like:
\[
V(r) \sim r^\mathbf{a}, \text{ then } \mathbf{a} = \frac{2T_k}{V(r)}
\]
1.12a

For example, for a harmonic oscillator, when \( T_k = V \), we have \( \mathbf{a} = 2 \). For Coulomb interaction: \( \mathbf{a} = -1 \) and \( T_k = -V/2 \).

The important consequence of the Virial theorem is that, if the average kinetic energy and momentum \( (\mathbf{p}) \) of particles in a certain volume of a Bose condensate (BC) tends to zero:
\[
T_k = \mathbf{p}^2/2m \rightarrow 0
\]
1.13

the interaction between particles in the volume of BC, characterized by the radius:
\[
L_{BC} = \left( \frac{h}{\mathbf{p}} \right) \rightarrow 0,
\]
becomes nonlocal, as independent on distance between them:
\[
V(r) \sim r^\mathbf{a} = 1 = \text{const at } \mathbf{a} = 2T_k/V(r) = 0
\]
1.14

Consequently, it is shown, that nonlocality, as independence of potential on the distance from potential source, is the inherent property of macroscopic Bose condensate. The individual particles (real, virtual or subquantum) in a state of Bose condensation are spatially indistinguishable due to the uncertainty principle. The Bivacuum dipoles \( [\text{BVF}^\dagger]_{\mathcal{S} = 0} \) and \((\text{BVB}^\pm)_{\mathcal{S} = 0}\) due to quasi one-dimensional Bose condensation are tending to self-assembly by 'head-to-tail’ principle. They compose very long virtual microtubules - Virtual Guides with wormhole properties. The 3D net of these two kind of Virtual Guides \( (\text{VirG}^\dagger_{\text{BVF}} \text{ and VirG}^{\dagger}_{\text{BVB}}) \) represent the nonlocal fraction of superfluid Bivacuum.
2. Basic postulates of Unified Theory and their consequences

There are three basic postulates in our theory, interrelated with each other:

I. The absolute values of internal rotational kinetic energies of torus and antitorus are equal to each other and to the half of the rest mass energy of the electrons of corresponding lepton generation, independently on the external group velocity (v), turning the symmetric Bivacuum fermions (BVF\textsuperscript{\pm}) to asymmetric ones:

\[ [I] : \left( \frac{1}{2} m_+^i |v_{gr}^i|^2 = \frac{1}{2} m_-^i |v_{ph}^i|^2 = \frac{1}{2} m_0 c^2 = \text{const} \right) \]

where: \( m_+^i \) and \( m_-^i \) are the ’actual’ - inertial and ’complementary’ - inertialess masses of torus (V\textsuperscript{+}) and antitorus (V\textsuperscript{-}); the \( v_{gr}^i \) and \( v_{ph}^i \) are the internal angular group and phase velocities of subquantum particles and antiparticles, forming torus and antitorus, correspondingly. In symmetric conditions of primordial Bivacuum and its virtual dipoles, when the influence of matter and fields is absent: \( v_{gr}^i = v_{ph}^i = c \) and \( m_+^i = m_-^i = m_0 \).

It will be proved in section (7.1) of this paper, that the above condition means the infinitive life-time of torus and antitorus of BVF\textsuperscript{\pm} and BVB\textsuperscript{\pm}.

II. The internal magnetic moments of torus (V\textsuperscript{+}) and antitorus (V\textsuperscript{-}) of asymmetric Bivacuum fermions BVF\textsuperscript{\pm} = [V\textsuperscript{\pm} \uparrow \downarrow V\textsuperscript{\pm}] and antifermions: BVF\textsuperscript{\pm\pm} = [V\textsuperscript{\pm} \downarrow \downarrow V\textsuperscript{-}], when \( v_{gr}^i \neq v_{ph}^i \), \( m_+^i \neq |m_-^i| \) and \( |e_+| \neq |e_-| \), are equal to each other and to that of Bohr magneton:

\[ [II] : \left( |\pm \mu_+| = \frac{1}{2} |e_+| e_{gr}^{\pm} |v_{gr}^i|_{rot}^{\pm} = |\pm \mu_-| = \frac{1}{2} |e_-| |v_{ph}^i|_{rot}^{\pm} = \mu_0 = \frac{1}{2} |e_0| \frac{h}{m_0 c} = \text{const} \right) \]

This postulate reflects the condition of the invariance of the spin value, with respect to the external velocity of Bivacuum fermions.

III. The equality of Coulomb interaction between torus and antitorus V\textsuperscript{\pm} \uparrow \downarrow V\textsuperscript{\pm} of primordial Bivacuum dipoles of all three generations \( i = e, \mu, \tau \) (electrons, muons and tauns), providing uniform electric energy density distribution in Bivacuum:

\[ [III] : F_0^i = \left( \frac{e^2}{|d_{\text{V\textsuperscript{\pm}V\textsuperscript{\pm}}}|_n} \right)^{\pm} = \left( \frac{e^2}{|d_{\text{V\textsuperscript{\pm}V\textsuperscript{-}}}|_n} \right)^{\mu} = \left( \frac{e^2}{|d_{\text{V\textsuperscript{\pm}V\textsuperscript{\pm}}}|_n} \right)^{e} \]

where: \( |d_{\text{V\textsuperscript{\pm}V\textsuperscript{-}}}|_n = \frac{h}{m_i c (1 + 2a)} \) is the separation between torus and antitorus of Bivacuum three pole dipoles (1.4) at the same state of excitation (n). A similar condition is valid as well for opposite magnetic poles interaction; \( |e_+| e_- = e_0^2 \).

The important consequences of postulate III are the following equalities:

\[ (e_0 m_0)^\epsilon = (e_0 m_0)^\mu = (e_0 m_0)^\tau = \sqrt{|e_-| |m_+^i| |v_{gr}^i|} = \text{const} \]

It means that the toruses and antitoruses of symmetric Bivacuum dipoles of generations with bigger mass: \( m_0^\mu = 206,7 m_0^\epsilon; \quad m_0^\tau = 3487.28 m_0^\epsilon \) have correspondingly smaller charges:

\[ e_0^\mu = e_0^\epsilon (m_0^\mu / m_0^\epsilon); \quad e_0^\tau = e_0^\epsilon (m_0^\tau / m_0^\epsilon) \]

As is shown in the next section, just these conditions provide the same charge symmetry shift of Bivacuum fermions of three generations (\( i = e, \mu \)) at the different mass symmetry shift between corresponding torus and antitorus, determined by Golden mean.
It follows from second postulate, that the resulting magnetic moment of sub-elementary fermion or antifermion \((\mu^\pm)\), equal to the Bohr’s magneton, is interrelated with the actual spin of Bivacuum fermion or antifermion as:

\[
\mu^\pm = (\pm \mu_+ \pm \mu_-)^{1/2} = \mu_B = \pm \frac{1}{2} \hbar \frac{e_0}{m_0 c} = S \frac{e_0}{m_0 c}
\]

where: \(e_0/m_0 c\) is gyromagnetic ratio of Bivacuum fermion, equal to that of the electron.

One may see from (2.3), that the spin of the actual torus, equal to that of the resulting spin of Bivacuum fermion (symmetric or asymmetric), is:

\[
S = \pm \frac{1}{2} \hbar
\]

Consequently, the permanent absolute value of spin of torus and antitorus is a consequence of 2nd postulate.

The dependence of the actual inertial mass \((m^+_V)\) of torus \(V^+\) of asymmetric Bivacuum fermions \((BVF_{as} = V^+\uparrow\uparrow V^-)\) on the external translational group velocity \((v)\) follows relativistic mechanics:

\[
m^+_V = m_0 / \sqrt{1 - (v/c)^2} = m
\]

while the complementary inertaless mass \((m^-_V)\) of antitorus \(V^-\) has the reverse velocity dependence:

\[
-m^-_V = i^2 m^-_V = -m_0 \sqrt{1 - (v/c)^2}
\]

where \(i^2 = -1\); \(i = \sqrt{-1}\) and complementary mass in terms of mathematics is the imaginary parameter.

For Bivacuum antifermions \(BVF_{as} = V^+\downarrow\downarrow V^-\) the relativistic dependences of positive and negative mass are opposite to those described by (2.5) and (2.6) and the notions of actual and complementary parameters change place.

The product of actual (inertial) and complementary (inertialess) mass is a constant, equal to the rest mass of particle squared and reflect the mass compensation principle. It means, that increasing of mass/energy of the torus is compensated by in-phase decreasing of absolute values of these parameters for antitorus and vice versa:

\[
|m^+_V| - |m^-_V| = m_0^2
\]

Taking (2.7) and (2.1) into account, we get for the product of the internal group and phase velocities of positive and negative subquantum particles, forming torus and antitorus, correspondingly:

\[
v^{in}_{gr} v^{ph}_{in} = e^2
\]

A similar symmetric relation is reflecting the charge compensation principle:

\[
|e_+| |e_-| = e_0^2
\]

For Bivacuum antifermions \(BVF_{as} = V^+\downarrow\downarrow V^-\) the relativistic dependences of positive and negative charge, like the positive and negative masses of torus and antitorus are opposite to that of Bivacuum fermions \(BVF_{as} = V^+\uparrow\uparrow V^-\) (see eqs.2.13 and 2.13a). The symmetry of Bivacuum bosons \((BVB^\pm = V^+\downarrow\downarrow V^-)\) of each electron’s generation \((i = e, \mu, \tau)\) can be ideal and independent on external velocity, due to opposite relativistic effects of their torus and antitorus, compensating each other.

The product of actual (inertial) and complementary (inertialess) mass is a constant, equal to the rest mass of particle squared and reflect the mass compensation principle. It means, that increasing of mass/energy of the torus is compensated by in-phase decreasing of absolute values of these parameters for antitorus and vice versa.

The difference between absolute values of total actual and the complementary energies
(2.5 and 2.6) is equal to doubled kinetic energy of asymmetric \( \text{BVF} \):

\[
|\text{m}_\uparrow c^2 - |\text{m}_\downarrow c^2| = (\text{m}_\uparrow - \text{m}_\downarrow) c^2 = \text{m}_\uparrow v^2 = 2T_k = \frac{m_0v^2}{\sqrt{1 - (v/c)^2}}
\]

The fundamental Einstein equation for total energy of particle can be reformed and extended, using 2.10 and 2.7:

\[
E_{\text{tot}} = \text{m}_\uparrow c^2 = mc^2 = \frac{m_0^2}{m_\uparrow} c^2 + m_\uparrow v^2
\]

or:

\[
E_{\text{tot}} = \text{m}_\downarrow c^2 = \sqrt{1 - (v/c)^2} m_0 c^2 + 2T_k
\]

The ratio of (2.6) to (2.5), taking into account (2.7), is:

\[
\frac{|-m_\downarrow|}{m_\uparrow} = \frac{m_0^2}{(m_\uparrow)^2} = 1 - \left(\frac{v}{c}\right)^2
\]

It can easily be transformed to the important formula (2.10).

2.1 The relation between the external and internal parameters of Bivacuum fermions & quantum roots of Golden mean.

The rest mass and charge origination

The important formula, unifying a lot of internal and external (translational-rotational) parameters of \( \text{BVF} \), taking into account that the product of internal and external phase and group velocities is equal to light velocity squared:

\[
\text{v}_{\text{ph}}^{\text{in}} \text{v}_{\text{gr}}^{\text{ext}} = \text{v}_{\text{ph}}^{\text{ext}} \text{v}_{\text{gr}}^{\text{in}} = c^2
\]

can be derived from eqs. (2.1 - 2.11):

\[
\left(\frac{m_\uparrow}{m_\downarrow}\right)^{\frac{1}{2}} = \frac{m_\downarrow}{m_0} = \frac{\text{v}_{\text{ph}}^{\text{in}}}{\text{v}_{\text{gr}}^{\text{ext}}} = \left(\frac{c}{\text{v}_{\text{gr}}^{\text{in}}}\right)^2 = \frac{L^-}{L^+} = \frac{\text{e}_+}{\text{e}_0} = \left(\frac{\text{e}_+}{\text{e}_0}\right)^2 = \frac{1}{[1 - (v^2/c^2)^{\text{ext}}]^{\frac{1}{2}}}
\]

where:

\[
L_\uparrow = h/(m_\uparrow \text{v}_{\text{ph}}^{\text{in}}) \quad \text{and} \quad L_\downarrow = h/(m_\downarrow \text{v}_{\text{gr}}^{\text{in}})
\]

are the radii of torus (\( \text{V}^+ \)), antitorus (\( \text{V}^- \)) and the resulting radius of \( \text{BVF} = [\text{V}^+ \emptyset \text{V}^-] \), equal to Compton radius, correspondingly.

The relativistic dependence of the actual charge \( \text{e}_+ \) on velocity of Bivacuum dipole, following from (2.13a), is:

\[
\text{e}_+ = \frac{e_0}{[1 - (v^2/c^2)^{\text{ext}}]^{\frac{1}{4}}}
\]

The influence of relativistic dependence of real particles charge on the resulting charge and electric field density of Bivacuum, which is known to be electrically quasi neutral vacuum/bivacuum, is negligible for two reasons:

1. Densities of positive and negative real charges (i.e. particles and antiparticles) are very small and approximately equal, as it follows from Bo Lehnert approach (see Chapter III). This quasi-equilibrium of opposite charges is Lorentz invariant;

2. The remnant uncompensated by real antiparticles charges density at any velocities can be compensated totally by virtual antiparticles and asymmetric Bivacuum fermions
The ratio of the actual charge to the actual inertial mass, as it follows from (2.13 and 2.13a), has also the relativistic dependence:

$$\frac{e_\pm}{m_\pm} = \frac{e_0}{m_0}[1 - (v^2/c^2)]^{1/4}$$

2.16

The decreasing of this ratio with velocity increasing is weaker, than what follows from the generally accepted statement, that charge has no relativistic dependence in contrast to the actual mass $m_\pm$. The direct experimental study of relativistic dependence of this ratio on the external velocity ($v$) may confirm the validity of our formula (2.16) and general approach.

From eqs. (2.10); (2.13) and (2.13a) we find for mass and charge symmetry shift:

$$\Delta m_\pm = m_\pm - m_{\pm} = m_\pm \left(\frac{v}{c}\right)^2$$

2.17

$$\Delta e_\pm = e_+ - e_- = \frac{e_0^2}{e_+ + e_-} \left(\frac{v}{c}\right)^2$$

2.17a

The ratio of charge to mass symmetry shifts is:

$$\frac{\Delta e_\pm}{\Delta m_\pm} = \frac{e_0^2}{m_\pm (e_+ + e_-)}$$

2.18

The mass symmetry shift can be expressed via the squared charges symmetry shift also in the following manner:

$$\Delta m_\pm = m_\pm - m_{\pm} = m_\pm \frac{e_0^2}{e_\pm^2}$$

2.18a

or using (2.11) this formula turns to:

$$\frac{e_\pm^2 - e_-^2}{e_\pm^2} = \frac{v^2}{c^2}$$

2.18b

When the mass and charge symmetry shifts of Bivacuum dipoles are small and $|e_+| + |e_-| = 2e_+ \approx 2e_0$, we get from 2.17a for variation of charge shift:

$$\Delta e_\pm = e_+ - e_- = \frac{1}{2} e_0 v^2 c^{-2}$$

2.18c

The formula, unifying the internal and external group and phase velocities of asymmetric Bivacuum fermions ($\text{BVF}_{as}$), derived from (2.13) and (2.13a), is:

$$\left(\frac{v_{gr\text{in}}}{c}\right)^4 = 1 - \left(\frac{v}{c}\right)^2$$

2.19

where: ($v_{gr\text{in}}$) = $v$ is the external translational-rotational group velocity of $\text{BVF}_{as}$.

At the conditions of "Hidden Harmony", meaning the equality of the internal and external rotational group and phase velocities of asymmetric Bivacuum fermions $\text{BVF}_{as}$:

$$\left(v_{gr\text{in}}\right)_{V^+}^{\text{rot}} = \left(v_{gr\text{in}}\right)_{V^-}^{\text{rot}} = v$$

2.20

$$\left(v_{ph\text{in}}\right)_{V^+}^{\text{rot}} = \left(v_{ph\text{in}}\right)_{V^-}^{\text{rot}}$$

2.20a

and introducing the notation:

$$\left(\frac{v_{gr\text{in}}}{c}\right)^2 = \left(\frac{v}{c}\right)^2 = \left(\frac{v_{in\text{in}}}{v_{ph\text{in}}}ight) = \left(\frac{v_{gr\text{in}}}{v_{ph\text{in}}}ight) = \phi$$

2.21

formula (2.19) turns to a simple quadratic equation:
\[ \phi^2 + \phi - 1 = 0, \]
which has a few modes: \( \phi = \frac{1}{\phi} - 1 \) or \( \phi = \frac{1}{(1 - \phi)^{1/2}} = 1 \)

The solution of (2.22), is equal to **Golden mean**: \((v/e)^2 = \phi = 0.618\). *It is remarkable, that the Golden Mean, which plays so important role on different Hierarchic levels of matter organization: from elementary particles to galactics and even in our perception of beauty (i.e. our mentality), has so deep physical roots, corresponding to Hidden Harmony conditions (2.20 and 2.20a). Our theory is the first one, elucidating these roots (Kaivarainen, 1995; 2000; 2005). This important fact points, that we are on the right track.*

The overall shape of asymmetric \( \text{BVF}^{\frac{i}{2s}} = [\text{V}^+ \uparrow \downarrow \text{V}^-] \) is a truncated cone (Fig.3.1) with plane, parallel to the base with radiuses of torus \((L^+\) and antitorus \((L^-)\), defined by eq. (2.14).

Using Golden Mean equation in the form (2.22b), we can see, that all the ratios (2.13 and 2.13a) at Golden Mean conditions turn to:

\[
\left[ \left( \frac{m^+}{m^-} \right)^{1/2} = \frac{m^+}{m_0} = \frac{V^{in}_{\mu\bar{\nu}}}{V^{out}_{\mu\bar{\nu}}} = \frac{L}{L_0} = \frac{|e|}{e_0} = \left( \frac{e_0}{e_0} \right)^2 \right] = \frac{1}{\phi} \]

where the actual \((e_+)\) and complementary \((e_-)\) charges and corresponding mass at GM conditions are:

\[ e_0^\phi = e_0^{1/2}, \quad e_0^\phi = e_0^{1/2} \]

(2.25)

using (2.25 and 2.22a) it is easy to see, that the difference between the actual and complementary mass at GM conditions is equal to the rest mass:

\[
|\Delta m_0| = \frac{1}{\phi} = \left( \frac{m}{m_0} \right)^{1/2} - m_0 = m_0 (1/\phi - \phi) = m_0 \]

2.26

This is an important result, pointing that just a symmetry shift, determined by the *Golden mean conditions, is responsible for origination of the rest mass of sub-elementary particles of each of three generation (i.e. e, \(\mu\), \(\tau\)).

The same is true for charge origination. The GM difference between actual and complementary charges, using relation \( \phi = (1/\phi - 1) \), determines corresponding minimum charge of sub-elementary fermions or antifermions (at \( V_{ext}^{\text{ext}} \rightarrow 0 \)):

\[ \phi^{3/2} e_0 = |\Delta e_+|^\phi = |e_+ - e_-|^\phi = |e|^\phi \]

where: \((|e_+| |e_-|) = e_0^3 \)

2.27a

The absolute values of charge symmetry shifts for electron, muon and tauon at GM conditions are the same. This result determines the equal absolute values of empirical rest charges of the electron, positron, proton and antiproton. However, the mass symmetry shifts at GM conditions, equal to the rest mass of electrons, muons and tauons are very different.

The ratio of charge to mass symmetry shifts at Golden mean (GM) conditions \((V_{ext}^{\text{ext}} = 0)\) is a permanent value for all three electron generations \((e, \mu, \tau)\). The different values of their rest mass are taken into account by postulate III and it consequences of their rest mass and charge relations: \( e^\mu_0 = e_0^\phi (m_0^\mu/m_0^\phi) \), \( e^\tau_0 = e_0^\phi (m_0^\tau/m_0^\phi) \) (see 2.2c):

\[
\left[ \left( \frac{|\Delta e_+|^\phi}{m_0^\phi} = \left( \frac{|e|^\phi}{m_0^\phi} = \frac{|e_+|^\phi}{m_0^\phi} = \frac{e_0^\phi}{m_0^\phi} \right)^{3/2} \right) \right] \]

2.28
where: \((m^\phi)^{\parallel} = m_0/\phi\) is the actual mass of unpaired sub-elementary fermion in \([C]\) phase at Golden mean conditions (see next section); \(e_0 = e_0^0;\) \(m^c = m_0\).

Formula (2.28) can be considered as a background of permanent value of gyromagnetic ratio, equal to ratio of magnetic moment of particle to its angular momentum (spin). For the electron it is:

\[
\Gamma = \frac{e_0}{2m_e c}
\]

When searching for elementary magnetic charges \((g^-\text{ and } g^+)\) being symmetric in respect to the electric ones \((e^-\text{ and } e^+)\) and named monopoles, the Dirac theory leads to the relation \(ge = \frac{1}{2}n\hbar c\) between the magnetic monopole and the electric charge of the same signs, where \(n = 1, 2, 3\) is an integer. It follows from this definition that the minimal magnetic charge (at \(n = 1\)) is as big as \(g = 67.7e\). The mass of the monopole should then be huge, about \(10^{16}\text{ GeV}\). All numerous attempts to reveal such particles experimentally have failed. But the postulate II of our theory (eq.2.2) explains the absence of magnetic monopoles, through the absence of a symmetry shift between the internal opposite actual quantities \(\mu^\parallel\) and the complementary \(\mu^\parallel\) magnetic moments of the virtual torus and antitorus, which form Bivacuum fermions. This is in contrast to the mass and charge symmetry shifts.

The absence of magnetic monopole - spatially localized magnetic charge, is one of the important consequences of our model of elementary particles, as far:

\[
\Delta\mu^\parallel = \mu^\parallel - \mu^\parallel = 0
\]

i.e. the magnetic moments of torus \((\mathbf{V}^+)\) and antitorus \((\mathbf{V}^-)\) symmetry shift are always zero, independently on the external group velocity of elementary particles. This consequence of our theory is in line with a lot of unsuccessful attempts to reveal monopole experimentally.

3. Fusion of triplets of elementary particles from sub-elementary fermions and antifermions at Golden mean conditions

The fusion of asymmetric sub-elementary fermions and antifermions of \(\mu\) and \(\tau\) generations to triplets \(<F^+_x F^+_y F^+_z e^p\rangle\), corresponding to electrons/positrons, protons/antiprotons and neutrons/antineutrons becomes possible also at the Golden mean (GM) conditions (Fig.3.1). It is accompanied by energy release and electronic and hadronic \(e, h\) -gluons origination, equal in sum to the mass defect. It was demonstrated theoretically, that the vortical structures at certain conditions self-organizes into vortex crystals (Jin and Dubin, 2000).
1. **Fig. 3.1** Model of the electron, as a triple of rotating sub-elementary fermions: \[ \langle [F^+_1 \otimes F^-_1] + F^-_1 \rangle \]

![Diagram of electron model as a triple of fermions](image)

The total energy of each sub-elementary fermion:

\[ E_{SBF} - mc^2 - \sqrt{1 - (v/c)^2} (m_0 c^2 L^2) + \left( \frac{\hbar}{m_c} \right)^2 \]

or:

\[ E_{SBF} = \sqrt{1 - (v/c)^2} h \alpha c + \hbar \omega c, \quad \lambda_S = h/m_v \]

The asymmetry of rotation velocity of torus and antitorus of \((\text{BVF}^+_\alpha = V^+ \otimes V^-)\), is a result of participation of pairs of \((\text{BVF}^+_\alpha = \text{BVF}^1 \otimes \text{BVF}^1)'_{\ell=0}\) in Bivacuum vorticity. This motion can be described, as a rolling of pairs of \((\text{BVF}^+_\alpha = [V^+ \otimes V^-])\) and \((\text{BVF}^-_{\alpha} = [V^+ \otimes V^-])\) with their internal radii:

\[ L_{\text{BVF}}^{in} = h/|m^+_V + m^-_V|_{\text{BVF}} c \]

around the inside of a larger external circle with radius of vorticity:

\[ L_{\text{BVF}}^{ext} = h/|m^+_V - m^-_V|_{\text{BVF}} c = \frac{h c}{m_v^2 v_{\text{BVF}}^{\text{BVF}}_{\text{BVF}}^{\text{BVF}} c} \]

The increasing of velocity of vorticity \(v_{\text{vor}}\) decreases both dimensions: \(L_{\text{in}}\) and \(L_{\text{ext}}\) till minimum vorticity radius, including pair of adjacent Bivacuum fermions \([\text{BVF}^+_\alpha, \text{BVF}^-_{\alpha}']_{\ell=0}\) with shape of **two identical truncated cones** of the opposite orientation of planes with common rotation axis (see Fig.3.1). The corresponding asymmetry of torus \(V^+\) and \(V^-\) is responsible for resulting mass and charge of \(\text{BVF}^+_\alpha\). The trajectory of a fixed point on each of two \(\text{BVF}^+_\alpha\), participating in such dual rotation, is **hypocycloid**.

The ratio of internal and external radii: (3.1) and (3.1a) is equal to the ratio of potential \(V_p\) and kinetic \(T_k\) energy of the de Broglie wave, related with its phase \(v_{\text{ph}}\) and group \(v_{\text{gr}}\) velocities, as demonstrated in next section (see eqs. 4.1 and 4.3):
At Golden mean conditions, when \( v \rightarrow \frac{\phi}{2} \), \( \| m_{\gamma} - m_{\gamma}' \|_{\text{BVF}_i} \rightarrow m_0 \); 
\( (m_{\gamma})^\phi = m_0 \phi \) and \( (m_{\gamma}')^\phi = m_0 \phi \), we get for internal (3.1) and external (3.1a) radiiuses:

\[
\text{L}_{\text{BVF}_i}^{in} = \frac{|m_{\gamma} + m_{\gamma}'|_{\text{BVF}_i}}{|m_{\gamma} - m_{\gamma}'|_{\text{BVF}_i}} = \frac{V_p}{V_{gr}} = 2 \frac{\nu_{ph}}{\nu_{gr}}
\]

The performed analysis can be considered, as a strong evidence, pointing to important role of Golden mean in the process of elementary particle fusion from sub-elementary constituents.

The model of a photon (boson), resulting from fusion (annihilation) of pairs of triplets (electron + positron), are presented by Fig.3.2. Such a structure can originate also, as a result of six Bivacuum dipoles opposite symmetry shift, accompanied by the transitions of the excited atoms and molecules, i.e. systems: [electrons + nuclears] to the ground state.

There are two possible ways to make the rotation of adjacent sub-elementary fermion and sub-elementary antifermion compatible.

One of them is interaction 'side-by-side', like in the 1st and 3d pairs on Fig.3.2. In such a case they are rotating in opposite directions and their angular momenta (spins) compensate each other and the resulting spin of such a pair is zero. The resulting energy of such a pair of sub-elementary particle and antiparticle is also zero, because their asymmetry with respect to Bivacuum is exactly opposite, compensating each other.

The other way of compatibility is interaction 'head-to-tail', like in a central pair of sub-elementary fermions on Fig.3.2. In this configuration they rotate in the same direction and the sum of their spins is: \( s = \pm I \hbar \). The energy of this pair is a sum of the absolute values of the energies of sub-elementary fermion and antifermion, as far their resulting symmetry shift is a sum of the symmetry shifts of each of them. From formula (4.8b) of the next section we can see, that if the velocity of de Broglie wave is equal to the light velocity or very close to it, the contribution of the rest mass to its total energy is zero or almost zero. In such a case, pertinent for photon, its total energy is interrelated with photon frequency (\( \nu_{ph} \)) and length like:

\[
E_{ph} = m_{ph}c^2 = \hbar\nu_{ph} = \hbar^2/(m_{ph}\lambda_{ph}^2)
\]

where: \( m_{ph} \) is the effective mass of photon and \( \lambda_{ph} = c/\nu_{ph} \) is the photon wave length.

It follows from our model, that the minimum value of the photon effective mass and energy is equal to the sum of absolute values of minimum mass/energy of central sub-elementary fermion and antifermion: \( E_{ph}^{min} = m_{ph}^{min}c^2 = 2m_0c^2 \), i.e. the sum of the rest energy of an electron - positron pair. This consequence of our model is in accordance with available experimental data.

The law of energy conservation for elementary particles can be reformulated, as a law of resulting Bivacuum symmetry conservation. The additivity of different forms of energy, as a consequence of the energy conservation law, means the additivity of Bivacuum dipoles torus and antitorus energy difference (i.e. forms of kinetic energy) and sum of their absolute values (forms of potential energy). These energy conservation roots are illustrated for one particle case by eqs.(4.1 and 4.1a).
Fig. 3.2 Model of photon $< 2[F^+ \propto F^+]_{s=0} + (F^+_\uparrow + F^+_\uparrow)_{s\neq \pm 1} >$, as result of fusion of electron and positron-like triplets $< [F^+_\uparrow \propto F^+] + F^+_\uparrow >$ of sub-elementary fermions, presented on Fig. 3.1. The resulting symmetry shift of such structure is equal to zero, providing the absence or very close to zero rest mass of photon and its propagation in primordial Bivacuum with light velocity or very close to it in the asymmetric secondary Bivacuum.

We may see, that it has axially symmetric configurations in respect to the directions of rotation and propagation, which are normal to each other. These configurations periodically change in the process of sub-elementary fermions and antifermions correlated [Corpuscle $\approx$ Wave] pulsations in composition of photon (Fig. 3.2). The clockwise and counter clockwise rotation of photons around the z-axes stands for two possible polarizations of photon. More detailed description of photon properties is presented in sections 6.6 and 10.4.

3.1 Correlation between new model of hadrons and conventional quark model of protons, neutrons and mesons

The proton ($Z = +1; \ S = \pm 1/2$) is constructed by the same principle as the electron (Fig. 3.1). It is a result of fusion of pair of sub-elementary fermion and antifermion $< [F^+_\uparrow \propto F^+]_{r=0} >$ and one unpaired $[\tau]$ sub-elementary fermion $(F^+_\tau)_{S=\pm 1/2}$ - tauons. These three components of proton have some similarity with quarks: $(F^+_\tau)_{S=\pm 1/2} \sim q^-\tau^+$ and antiquarks $(F^-_\tau)_{S=\pm 1/2} \sim q^+\tau^-$. The difference with conventional quark model of protons and neutrons is that we do not need to use the notion of fractional charge in our proton model:

$$ p = < [F^+_\uparrow \propto F^+]_{S=0} + (F^+_\uparrow + F^+_\uparrow)_{S=\pm 1/2} >^r $$

or:

$$ p \sim \langle [q^-\propto q^+]_{S=0} + (q^+)_{S=\pm 1/2} \rangle $$

$$ or: \quad p \sim \langle [\tau^-\propto \tau^+]_{S=0} + (\tau^+)_{S=\pm 1/2} \rangle $$

The charges, spins and mass/energy of sub-elementary particles and antiparticles in pairs $[F^+_\uparrow \propto F^+]_{r}$ compensate each other. The resulting properties of protons ($p$) are determined by unpaired/uncompensated sub-elementary particle $F^+_\uparrow_{S=\pm 1/2}$ of heavy $\tau$-electrons generation (tauons).

The neutron ($Z = 0; \ S = \pm 1/2$) can be presented as:
where: the neutral quark \((q_i^0)_{0=\pm 1/2}\) is introduced, as a metastable complex of positive sub-elementary \(\tau\) – fermion \((F_\tau^+)\) with negative sub-elementary fermion of opposite charge \([F_\tau^-]\):

\[
(q_i^0)_{0=\pm 1/2} = \left(\left[q_i^+ \equiv [F_\tau^+]\right]_{0=\pm 1/2}\right)
\] (3.3c)

This means that the positive charge of unpaired heavy sub-elementary particle \((F_\tau^+)\) in neutron \((n)\) is compensated by the charge of the light sub-elementary fermion \((F_\tau^+)\). In contrast to charge, the spin of unpaired \((F_\tau^+)\) is not compensated (totally) by spin of \((F_\tau^-)\) in neutrons, because of strong mass and angular momentum difference in conditions of the \((F_\tau^-)\) confinement. The mass of \(\tau\)- electron, equal to that of \(\tau\)-positron is: \(m_{\tau^\pm} = 1782(3)\) MeV, the mass of the regular electron is: \(m_{\mu^{-}} = 0.511003(1)\) MeV and the mass of \(\mu^{-}\) electron is: \(m_{\mu^{-}} = 105.6595(2)\) MeV.

On the other hand, the mass of proton and neutron are correspondingly: \(m_p = 938.280(3)\) MeV and \(m_n = 939.573 (3)\) MeV. They are about two times less than the mass of \(\tau\)- electron and equal in accordance to our model to the mass of its unpaired sub-elementary fermion \((F_\tau^+)\). This difference characterizes the energy of neutral massless gluons (exchange bosons), stabilizing the triplets of protons and neutrons. In the case of neutrons this difference is a bit less (taking into account the mass of \([F_\tau^-]\)), providing much shorter life-time of isolated neutrons (918 sec.) than that of protons (>10\(^{31}\) years).

In accordance with our hadron (baryon) models, each of three quarks (sub-elementary fermions of \(\tau\) – generation) in protons and neutrons can exist in 3 states (red, green and blue), but not simultaneously:

1. The red state of quark/antiquark means that it is in corpuscular [C] phase;
2. The green state of quark/antiquark means that it is in wave [W] phase;
3. The blue state means that quark/antiquark \((F_\tau^+)\) is in the transition [C] ↔ [W] state.

The 8 different combinations of the above defined states of 3 quarks of protons and neutrons correspond to 8 gluons colors, stabilizing these hadrons (Okun’, 1998). The gluons with boson properties are represented by pairs of Cumulative Virtual Clouds \((CVC^+ \equiv CVC^-)\), emitted \(\neq\) absorbed in the process of the in-phase and counterphase \([C \neq W]\) pulsation of paired quarks + antiquark or tauon + antitaun. These 8 gluons, responsible for strong interaction, can be presented as a different combinations of transition states of \(q^-\) and \(q^+\), corresponding to two spin states of proton \((S = \pm 1/2)\), equal to that of unpaired quark - tauon (Kaivarainen, 2005).

The known experimental values of life-times of \(\mu\) and \(\tau\) electrons, corresponding in accordance to our model, to monomeric asymmetric sub-elementary fermions \((BV_{\mu,\tau})\), are equal only to \(2.19 \times 10^{-6} s\) and \(3.4 \times 10^{-13} s\), respectively. We assume here, that stability of monomeric sub-elementary particles/antiparticles of \(e, \mu\) and \(\tau\) generations, strongly increases as a result of their fusion in triplets, which became possible at Golden mean conditions.

The well known example of weak interaction, like \(\beta\) – decay of the neutron to proton, electron and \(\bar{e}\) – antineutrino:
\[ \mathbf{n} \rightarrow \mathbf{p} + e^- + \bar{\nu}_e \]

or: \[ \left( [q^+ \rightarrow \bar{q}^-] + \left( q_0^0 \right)_{\text{te}} \right) \rightarrow (q^+ \rightarrow \bar{q}^-) + q^- + e^- + \bar{\nu}_e \]

is in accordance with our model of elementary particles, neutrino and antineutrino, as a packet of virtual pressure waves \([\text{VPW}^+ \approx \text{VPW}^-]\) of two possible polarization (see section 6.3).

The reduced sub-elementary fermion of \(\tau\) – generation in composition of a proton or neutron can be considered, as a quark and the sub-elementary antifermion, as an antiquark:

\[ (F_\tau^+)^+ \text{ and } (F_\tau^-)^- \approx \bar{q}^- \]

In the process of \(\beta\) – decay of the neutron (3.4; 3.4a) the unpaired negative sub-elementary fermion \([F_\tau^-]_{\text{te}}\) in the neutral quark \(\left( q_0^0 \right)_{S=\pm 1/2}\) (see 3.3c) fuses with asymmetric virtual pair \([F_\tau^- \approx F_\tau^+]\) \(S=0\), which emerged from the vicinal to neutron polarized Cooper pair of Bivacuum fermion and antifermion. The result of this fusion is a release of the real electron and electronic antineutrino:

\[ [F_\tau^+]_{S=0} + [F_\tau^-]_{S=0} \rightarrow e^- + \bar{\nu}_e \]

The antineutrino \(\bar{\nu}_e\) is a consequence of inelastic recoil effect in Bivacuum matrix, accompanied the electron fusion and its separation from hadron. The neutrino and antineutrino of three generation can be considered as the asymmetric superposition of positive and negative virtual pressure waves: \([\text{VPW}^+ \approx \text{VPW}^-]_{e,\mu,\tau}\) with clockwise or counterclockwise rotation of their plane, which determines spirality/spin of neutrino \((\pm 1/2)\).

The energy of 8 gluons, corresponding to different superposition of \([\text{CVC}^+ \approx \text{CVC}^-]_{S=0,1}\), emitted and absorbed with the in-phase \([\mathbf{C} = \mathbf{W}]\) pulsation of pair [quark + antiquark] in the baryons triplets:

\[ [F_\tau^+ \approx F_\tau^-]_{S=0,1} = [q^+ + \bar{q}^-]_{S=0,1} \]

is about 50% of energy/mass of quarks. This explains, why the mass of isolated unstable tauon and antitauon is about 2 times bigger, than their mass in composition of proton or neutron.

It looks, that our model of elementary particles is compatible with existing data and avoid the strong assumption of fractional charge. We anticipate that future experiments, like deep inelastic scattering inside the hadrons, will be able to choose between models of fractal and integer charge of the quarks.

One of the versions of elementary particle fusion have some similarity with thermonuclear fusion and can be as follows. The rest mass of isolated sub-elementary fermion/antifermion before fusion of the electron or proton, is equal to the rest mass of unstable muon or tauon, correspondingly. The 200 times decrease of muons mass is a result of mass defect, equal to the binding energy of triplets: electrons or positrons. It is provided by origination of electronic \(e\)-gluons and release of the huge amount of excessive kinetic (thermal) energy, for example in form of high energy photons or \(e\)-neutrino beams.

In protons, as a result of fusion of three \(\tau\) –electrons/positrons, the contribution of hadron \(h\)-gluon energy to mass defect is only about 50% of their mass. However, the absolute hadron fusion energy yield is higher, than that of the electrons and positrons.

Our hypothesis of stable electron/positron and hadron fusion from short-living \(\mu\) and \(\tau\) - electrons, as a precursor of electronic and hadronic quarks, correspondingly, can be verified using special collider (Kaivarainen, 2005a).

In accordance to our Unified Theory, there are two different mechanisms of stabilization of the electron and proton structures in form of triplets of sub-elementary

\[ \text{CVC}^+ \approx \text{CVC}^- \]

and

\[ \text{VPW}^+ \approx \text{VPW}^- \]
fermions/antifermions of the reduced $\mu$ and $\tau$ generations, correspondingly, preventing them from exploding under the action of self-charge:

1. Each of sub-elementary fermion/antifermion, representing asymmetric pair of torus ($V^+$) and antitorus ($V^-$), as a charge, magnetic and mass dipole, is stabilized by the Coulomb, magnetic and gravitational attraction between torus and antitorus;

2. The stability of triplet, as a whole, is provided by the exchange of Cumulative Virtual Clouds (CVC$^+$ and CVC$^-$) between three sub-elementary fermions/antifermions in the process of their $[C \neq W]$ pulsation. In the case of proton and neutron, the 8 transition states corresponds to 8 $h$-gluons of hadrons, responsible for strong interaction. In the case of the electron or positron, the stabilization of triplets is realized by 8 lighter $e$-gluons [23]. The process of internal exchange of pairs $[F_1 \cong F_1]^c_{\varepsilon_{\alpha}}$ with unpaired sub-elementary fermion in triplets is accompanied by the external energy exchange with Bivacuum dipoles, modulating positive and negative virtual pressure waves $[VPW^+\cong VPW^-]$. The feedback reaction between Bivacuum and elementary particles is also existing (Kaivarainen, 2005a).

### 4. Total, potential and kinetic energies of elementary de Broglie waves

The total energy of sub-elementary particles of triplets of the electrons or protons $< [F^+_1 \cong F^-_1]_{S=0,1} >$ we can present in three modes, as a sum of total potential $V_{tot}$ and kinetic $T_{tot}$ energies, including the internal and external contributions:

$$E_{tot} = V_{tot} + T_{tot} = \frac{1}{2}(m^+_v + m^-_v)v^2 + \frac{1}{2}(m^+_v - m^-_v)c^2$$  \hspace{1cm} 4.1

$$E_{tot} = m^+_v c^2 = \frac{1}{2}m^+_v (2c^2 - v^2) + \frac{1}{2}m^+_v v^2$$  \hspace{1cm} 4.1a

$$E_{tot} = 2T_{tot}(v/c)^2 = \frac{1}{2}m^+_v c^2 [1 + R^2] + \frac{1}{2}m^+_v v^2$$  \hspace{1cm} 4.1b

where: $R = m_0/m^+_v = \sqrt{1 - (v/c)^2}$ is the dimensionless relativistic factor; $v$ is external translational - rotational velocity of particle. One may see, that $E_{tot} \to m_0 c^2$ at $v \to 0$ and $m^+_v \to m_0$.

Taking into account that $\frac{1}{2}(m^+_v - m^-_v)c^2 = \frac{1}{2}m^+_v v^2$ and $c^2 = v_{gr}v_{ph}$, where $v_{gr} = v$, then dividing the left and right parts of (4.1 and 4.1a) by $\frac{1}{2}m^+_v v^2$, we get:

$$2 \frac{c^2}{v^2} - 1 = 2 \frac{v_{ph}}{v_{gr}} - 1 = \frac{(m^+_v + m^-_v)c^2}{m^+_v v^2} = \frac{m^+_v + m^-_v}{m^+_v - m^-_v}$$  \hspace{1cm} 4.2

Comparing formula (4.2) with known relation for relativistic de Broglie wave for ratio of its potential and kinetic energy (Grawford, 1973), we get the confirmation of our definitions of potential and kinetic energies of elementary particle in (4.1):

$$2 \frac{v_{ph}}{v_{gr}} - 1 = \frac{V_{tot}}{T_{tot}} = \frac{m^+_v + m^-_v}{m^+_v - m^-_v}$$  \hspace{1cm} 4.3

In Golden mean conditions, necessary for triplet fusion, the ratio $(V_{tot}/T_{tot})^\theta = (1/\phi + \phi) = 2.236$.

Consequently, the total potential ($V_{tot}$) and kinetic ($T_{tot}$) energies of sub-elementary fermions and their increments can be presented as:

$$V_{tot} = \frac{1}{2}(m^+_v + m^-_v)c^2 = \frac{1}{2}m^+_v (2c^2 - v^2) = \frac{1}{2} \frac{hc}{L_{Vtot}} \geq V^\theta_{tot}$$  \hspace{1cm} 4.4

$$\Delta V_{tot} = \frac{\Delta m^+_v c^2 - \Delta T_{tot}}{2} = -\frac{1}{2} \frac{hc}{L_{Vtot}} \frac{\Delta L_{Vtot}}{L_{Vtot}} = -v^p \frac{\Delta L_{Vtot}}{L_{Vtot}}$$  \hspace{1cm} 4.4a

where: the characteristic velocity of potential energy, squared, is related to the group velocity of particle ($v$), as $v^2 = c^2(2 - v^2/c^2)$ and the characteristic curvature of potential
energy of elementary particles is:

\[ L_{V_{tot}} = \frac{\hbar}{(m_0v + m \vec{v})c} \leq L_0^\phi \quad \text{at} \quad \left( \frac{v_{tot}}{c} \right)^2 > \phi \quad 4.4b \]

The total kinetic energy of unpaired sub-elementary fermion of triplets includes the internal vortical dynamics and external translational one, which determines their de Broglie wave length, \((\lambda_B = 2\pi L_{Tr,at})\):

\[ T_{tot} = \frac{1}{2} |m_0^+ - m \vec{v}|c^2 = \frac{1}{2} m \vec{v}^2 = \frac{1}{2} \frac{\hbar c}{L_{Tr,at}} \geq T_0^\phi; \quad 4.5 \]

\[ \Delta T_{tot} = T_{tot} \frac{1 + R^2}{R^2} \frac{\Delta v}{\nu} = - T_0^\phi \frac{\Delta L_{Tr,at}}{L_{Tr,at}} \quad 4.5a \]

where the characteristic curvature of kinetic energy of sub-elementary particles in triplets is:

\[ L_{Tr,at} = \frac{\hbar}{(m_0v + m \vec{v})c} \leq L_0^\phi \quad \text{at} \quad \left( \frac{v_{tot}}{c} \right)^2 > \phi \quad 4.5b \]

It is important to note, that in compositions of triplets < \([F_1^+ \propto F_1^-]_{S=0} + (F_1^+)^{S=\pm1/2}_{S=\mp1/2}\) the minimum values of total potential and kinetic energies and the maximum values of their characteristic curvatures correspond to that, determined by Golden mean conditions (see eqs. 3.1b and 3.1c). In our formulas above it is reflected by corresponding inequalities. In accordance to our theory, the Golden mean conditions determine a threshold for triplets fusion from sub-elementary fermions.

The increment of total energy of elementary particle is a sum of total potential and kinetic energies increments:

\[ \Delta E_{tot} = \Delta V_{tot} + \Delta T_{tot} = - V_{tot} \frac{\Delta L_{V_{tot}}}{L_{V_{tot}}} - T_{tot} \frac{\Delta L_{Tr,at}}{L_{Tr,at}} \quad 4.6 \]

The well known Dirac equation for energy of a free relativistic particle, following also from Einstein relativistic formula (2.5), can be easily derived from (4.1a), multiplying its left and right part on \(m_0^+c^2\) and using introduced mass compensation principle (2.7):

\[ E_{tot}^2 = (m_0^+c^2)^2 = (m_0c^2)^2 + (m_0^+v^2)^2 \quad 4.6a \]

where: \(m_0^2 = |m_0^+ m \vec{v}|\) and the actual inertial mass of torus of unpaired sub-elementary fermion in triplets is equal to regular mass of particle: \(m_0 = m_0^+\).

Dividing the left and right parts of (4.6a) to \(m_0^+c^2\), we may present the total energy of an elementary de Broglie wave, as a sum of internal and external energy contributions, in contrast to previous sum of total potential and kinetic energies (4.1):

\[ E_{tot} = \frac{m_0^+c^2}{m_0} = E^{in} + E^{ext} = \]

\[ = \frac{m_0}{m_0^+} (m_0c^2)_{rot}^{in} + (m_0^+v^2)_{tr}^{ext} \quad 4.7a \]

\[ E_{tot} = R(m_0c^2)_{rot}^{in} + (m_0^+v^2)_{tr}^{ext} \quad 4.8 \]

or:

\[ E_{tot} = m_0^+c^2 = (m_0^+ - m_0^+\vec{v})c^2/v^2 \quad 4.8a \]

\[ E_{tot} = \hbar \nu_{C\approx W} = R(m_0c^2)_{rot}^{in} + \left[ \frac{\hbar^2}{m_0^+\lambda_B^2} \right]^{ext}_{tr} \quad 4.8b \]

where: \(R = \sqrt{1 - (v/c)^2}\) is relativistic factor, dependent on the external translational velocity (\(v\)) of particle; \(m_0^+ = m_0/R = m\) is the actual inertial mass of sub-elementary fermion; the external translational de Broglie wave length is: \(\lambda_B = \frac{\hbar}{m_0^+\vec{v}}\) and \(\nu_{C\approx W}\) is the resulting frequency of corpuscle - wave pulsation (see next section).

We can easily transform formula (4.8) to a mode, including the internal rotational
parameters of sub-elementary fermion, necessary for the rest mass and charge origination:

$$E_{tot} = R (m_0 \omega_0^2 L_0^2 \omega_0^2)_{rot} + [ (m^+ \nu - m^- \nu) c^2 ]_{rot}$$  

where: $L_0 = \hbar / m_0 c$ is the Compton radius of sub-elementary particle; $\omega_0 = m_0 c^2 / \hbar$ is the angular Compton frequency of sub-elementary fermion rotation around the common axis in a triplet (Fig.3.1).

For potential energy of a sub-elementary fermion, we get from (4.7b), assuming, that $(m^+_\nu v^2) = 2T_{tot}$ and $E_{tot} = V_{tot} + T_{tot}$:

$$V_{tot} = E_{tot} - \frac{1}{2} (m^+_\nu v^2) = R^0 (m_0 c^2)_{rot} + \frac{1}{2} (m^+_\nu v^2)$$  

The difference between potential and kinetic energies, as analog of Lagrangian, from (4.9) is:

$$\mathcal{L} = V_p - \frac{1}{2} (m^+_\nu v^2)_{rot}^2 = R (m_0 c^2)_{rot}^2$$  

It follows from (4.9 - 4.9b), that at $v \to c$, the total relativistic factor, involving both the external and internal translational - rotational dynamics of sub-elementary fermions in triplets: $R_{tot} = \sqrt{1 - (v_{tot}/c)^2} \to 0$ and the rest mass contribution to total energy of sub-elementary particle also tends to zero: $R^0 (m_0 c^2)_{rot} \to 0$. Consequently, the total potential and kinetic energies tend to equality $V_{tot} \to T_{tot}$, and the Lagrangian to zero. This is a conditions for harmonic oscillations of the photon, propagating in unperturbed Bivacuum.

The important formula for doubled external kinetic energy can be derived from (4.8), taking into account that the relativistic relation between the actual and rest mass is $m^+_\nu = m_0 / R$:

$$2T_k = m^+_\nu v^2 = m^+_\nu c^2 - R m_0 c^2 = \frac{m_0 c^2}{R} (1^2 - R^2) \quad \text{or}$$

$$2T_k = \frac{m_0 c^2}{R} (1 - R)(1 + R) = (1 + R)[m^+_\nu c^2 - m_0 c^2]$$

This formula is a background of the introduced in section (III: 7) notion of Tuning energy of Bivacuum Virtual Pressure Waves (VPW$^\pm$).

Our expressions (4.1 - 4.10a) are more general, than the well known (4.6a), as far they take into account the properties of both poles (actual and complementary) of Bivacuum dipoles and subdivide the total energy of particle to the internal and external or to kinetic and potential ones.

5. The dynamic mechanism of corpuscle-wave duality

It is generally accepted, that the manifestation of corpuscle - wave duality of a particle is dependent on the way in which the observer interacts with a system. However, the mechanism of duality, as a background of quantum physics, is still obscure.

It follows from our theory, that the [corpuscle (C) = wave (W)] duality represents modulation of the internal (hidden) quantum beats frequency between the asymmetric 'actual' (torus) and 'complementary' (antitorus) states of sub-elementary fermions or antifermions by the external - empirical de Broglie wave frequency of these particles (Kaivarainen, 2005). The [C] phase of each sub-elementary fermions of triplets $< [F^+_\nu \otimes F^-_\nu] + F^0_\nu >^j$ of elementary particles, like electrons and protons, exists as a mass and an electric and magnetic asymmetric dipole.

The [C $\to$ W] transition is a result of two stages superposition:

The 1st stage of transition is a reversible dissociation of charged sub-elementary fermion in [C] phase $(F^+_\nu)_C$ to charged Cumulative Virtual Cloud (CVC$^\pm$)$_{F^+_\nu}$ of
subquantum particles and the 'anchor' Bivacuum fermion in C phase \((\text{BVF}^\uparrow_{\text{anc}})^{\text{anc}}_C\):

\[
(\text{I}) : \left( (F^\pm)^{e\pm}_{\text{anc}} \right)^{\text{anc}}_C \xrightarrow{\text{Recoll/Antirecoil}} \left( \text{BVF}^\uparrow_{\text{anc}} \right)^{\text{anc}}_C + (\text{CVC}^{\pm})^{\text{anc}}_{\text{BVF}^\uparrow_{\text{anc}}} \right)
\]

5.1

where notations \(e^\pm, e^\pm_{\text{anc}}\) and \(e^\pm - e^\pm_{\text{anc}}\) mean, correspondingly, the total charge, the anchor charge and their difference, pertinent to CVC\(^\pm\).

The 2nd stage of \([C \rightarrow W]\) transition is a reversible dissociation of the anchor Bivacuum fermion \((\text{BVF}^\uparrow_{\text{anc}})^i = [V^+ \otimes V^-]_{\text{anc}}^i\) to symmetric \((\text{BVF}^i)^i\) and the anchor cumulative virtual cloud \((\text{CVC}^{\pm})_{\text{BVF}^\uparrow_{\text{anc}}}\), with frequency, equal to the empirical frequency of de Broglie wave of particle:

\[
(\text{II}) : \left( (\text{BVF}^\uparrow_{\text{anc}})^{\text{anc}}_C \right) \xrightarrow{\text{Recoll/Antirecoil}} \left[ (\text{BVF}^i)^0 + (\text{CVC}^{\pm})^{\text{anc}}_{\text{BVF}^\uparrow_{\text{anc}}} \right]^i
\]

5.2

The 2nd stage takes a place if \((\text{BVF}^\uparrow_{\text{anc}})^i\) is asymmetric, i.e. in the case of nonzero external translational - rotational velocity of particle, when the magnetic field originates. The beat frequency of \((\text{BVF}^{\text{anc}})^{\text{ep}}\) is equal to that of the empirical de Broglie wave frequency: \(\omega_B = h/(mL^2_B)\). The higher is the external kinetic energy of fermion, the higher is frequency \(\omega_b\) and stronger magnetic field, generated by the anchor Bivacuum fermion. The frequency of the stage (II) oscillations modulates the internal frequency of \([C = W]\) pulsation: \(\left[ R \omega_0 = R m_0 c^2/h \right]^{\text{ep}}\), related to contribution of the rest mass energy to the total energy of the de Broglie wave (Kaivarainen, 2005; 2005a and http://arxiv.org/abs/physics/0103031).

The \([C = W]\) pulsations of unpaired sub-elementary fermion \(F^\pm_\uparrow >\), of triplets of the electrons or protons \(< F^+_\uparrow \otimes F^-_\uparrow >^{\text{ep}}\) are in counterphase with the in-phase pulsation of paired sub-elementary fermion and antifermion, modulating Bivacuum virtual pressure waves \((\text{VPW}^{\pm})\):

\[
[F^+_\uparrow \otimes F^-_\uparrow]^{\text{ep}}_W \xrightarrow{\text{CVC UAVC}} [F^+\uparrow \otimes F^-_\uparrow]^{\text{ep}}_C
\]

5.3

The basic frequency of \([C = W]\) pulsation, corresponding to Golden mean conditions, \((v/c)^2 = 0.618 = \phi\), is equal to that of the 1st stage frequency (5.1) at zero external translational velocity \(v^{\text{ext}} = 0\); \(R = 1\). This frequency is the same as the basic Bivacuum virtual pressure waves \((\text{VPW}^{\pm})_{\text{ext}}\) and virtual spin waves \((\text{VirSW}^{S=\pm1/2})\) frequency (1.7 and 1.10a): \(\omega_q = m_0 c^2/h\).

The empirical parameters of de Broglie wave of elementary particle are determined by asymmetry of the torus and antitorus of the anchor Bivacuum fermion \((\text{BVF}^{\text{anc}})^{\text{ep}} = [V^+ \otimes V^-]_{\text{anc}}^{\text{ep}}\) (Fig.3.1) and the frequency of its reversible dissociation to symmetric \((\text{BVF}^i)^i\) and the anchor cumulative virtual cloud \((\text{CVC}^{\pm})_{\text{BVF}^\uparrow_{\text{anc}}}\) – stage (II) of duality mechanism (5.2).

The total energy, charge and spin of triplets - fermions, moving in space with velocity \(v\) is determined by the unpaired sub-elementary fermion \((F^\pm_\uparrow)\), as far the paired ones in \([F^+\uparrow \otimes F^-_\uparrow]_{\text{ext}}\), of triplets compensate each other. From (4.9 and 4.9a) it is easy to get:

\[
E_{\text{tot}} = m^0 c^2 = h\omega_C = R \left( (h\omega_B)_{\text{rot}}^{\text{in}} + (h\omega_B)_{\text{rot}}^{\text{ext}} \right) = R \left( (m_0 c^2)_{\text{rot}}^{\text{in}} + (m_0 c^2)_{\text{rot}}^{\text{ext}} \right)
\]

5.4

\[
E_{\text{tot}} = m^0 c^2 = E_{\text{rot}}^{\text{in}} + E_{\text{rot}}^{\text{ext}} = R \left( m_0 \omega_0^2 L^2_B \right)_{\text{rot}}^{\text{in}} + \left( \frac{h^2}{m_0 \lambda_B^2} \right)_{\text{rot}}^{\text{ext}}
\]

5.4a

where: \(R = \sqrt{1 - (v/c)^2}\) is the relativistic factor; \(v = v_{\text{ext}}^{\text{ext}}\) is the external translational group velocity; \(\lambda_B = h/m_0 c\) is the external translational de Broglie wave length; the actual inertial mass is \(m^0 = m = m_0/R\); \(L^2_B = h/m_0 c\) is a Compton radius of the
It follows from our approach, that the fundamental phenomenon of corpuscle-wave duality (Fig. 3.3) is a result of modulation of the primary-carrying frequency of the internal $[C \Rightarrow W]_{\text{in}}$ pulsation of individual sub-elementary fermions (1st stage): $(\omega_{\text{in}})^i = R\omega_0^i = Rm_0^i c^2/\hbar = Rc/L_0^i$, by the frequency of the external empirical de Broglie wave of triplet: $\omega_B^{\text{ext}} = m_1^i v_{\text{ext}}^i / \hbar = 2\pi v_{\text{ext}}^i / L_B$, equal to angular frequency of $[C \Rightarrow W]_{\text{anc}}$ pulsation of the anchor Bivacuum fermion (BVF$_{\text{anc}}^i$) (2nd stage).

The contribution of this external dynamics modulation of the internal one, determined by asymmetry of the anchor (BVF$_{\text{anc}}^i$) = $[V^+ \uparrow V^-]^i_{\text{anc}}$ to the total energy of particle, is determined by second terms in (5.4) and (5.4a):

$$E_B^{\text{ext}} = \langle h\omega_B^{\text{ext}} \rangle_{\text{tr}} = \left( \frac{\hbar^2}{m_1^i \lambda_B^2} \right)_{\text{tr}} = \left( m_1^i - m_1^- \right) c^2_{\text{tr}}^{\text{ext}}$$  \hspace{1cm} (5.5)

$$= \left( m_1^i v^2_{\text{ext}} \right)_{\text{tr}} = \left( m_1^i \omega_B^2 \lambda_B^2 \right)_{\text{rot}}^{\text{ext}}$$  \hspace{1cm} (5.5a)

This external contribution is increasing with particle acceleration and tending to light velocity. At $v \rightarrow c$, $(m_1^i v^2_{\text{ext}})_{\text{tr}} \rightarrow m_1^i c^2 = E_{\text{tot}}$.

In contrast to external translational contribution of triplets, the internal rotational contribution of individual unpaired sub-elementary fermions inside the triplets is tending to zero at the same conditions:

$$E_{\text{rot}}^{\text{in}} = R\langle h\omega_{0}^{\text{in}} \rangle_{\text{rot}} = R\langle m_0^i \omega_0 \lambda_0^2 \rangle_{\text{rot}}^{\text{in}} = R\langle m_0^i c^2 \rangle_{\text{rot}}^{\text{in}} \rightarrow 0 \hspace{1cm} \text{at} \hspace{0.5cm} v \rightarrow c$$  \hspace{1cm} (5.6)

as far as $\omega_{\text{in}} = R\omega_0^i \sim 10^{21} \text{s}^{-1} >> \omega_B^{\text{ext}}$. However, for relativistic case at $v \rightarrow c$, the situation is opposite: $\omega_B^{\text{ext}} >> \omega_{\text{in}}$ at $\omega_{\text{in}} \rightarrow 0$.

**Fig. 3.3.** Dynamic model of $[C \Rightarrow W]$ pulsation of triplets of sub-elementary fermions/antifermions (the reduced by fusion to triplets $\mu$ and $\tau$ electrons) composing, correspondingly, electron and proton $< [F^+_1 \Rightarrow F^-_1] + F^+_1 >^{e\phi}$. The
pulsation of the pair \([F^+ \cong F^-]\), modulating virtual pressure waves of Bivacuum (VPW+ and VPW-), is counterphase to pulsation of unpaired sub-elementary fermion/antifermion \(F^\pm \rightarrow \). The properties of the anchor Bivacuum fermion \(\text{BV}F^\dagger_{anc}\) where analyzed (Kaivarainen, 2005), at three conditions:

1. The external translational velocity (v) is zero;
2. The external translational velocity corresponds to Golden mean (v = cφ1/2);
3. The relativistic case, when v ~ c.

Under nonrelativistic conditions (v << c), the de Broglie wave (modulation) frequency is low: \(2\pi v_B < (\omega_{\text{in}} = R\omega_0)\). However, in relativistic case (v ~ c), the modulation frequency of the 'anchor' \(\text{BV}F^\dagger_{anc}\), equal to that of de Broglie wave, can be higher, than the internal one: \(2\pi v_B \geq \omega_{\text{in}}\).

The paired sub-elementary fermion and antifermion of \([F^+ \cong F^-]\) also have the 'anchor' Bivacuum fermion and antifermion \(\text{BV}F^\dagger_{anc}\), similar to that of unpaired. However, the opposite energies of their pulsation compensate each other in accordance with proposed model.

6. The nature of electrostatic, magnetic and gravitational potentials, based on Unified theory

6.1 Electromagnetic dipole radiation as a consequence of charge oscillation

The [emission ⇔ absorption] of photons in a course of elementary fermions - triplets \(< [F^+ \cong F^-]_{S=0} + (F^\dagger)_{S=\pm1/2}>\) vibrations can be described by known mechanism of the electric dipole radiation \(\varepsilon_{EH}\), induced by charge acceleration (a), following from Maxwell equations (Berestetsky, et. al., 1989):

\[
\varepsilon_{EH} = \frac{2e^2}{3c^3} a^2
\]

The resulting frequency of \([C ⇔ W]\) pulsation of each of three sub-elementary fermions in triplets is a sum of internal frequency contribution \((R\omega_0^n)\) and the external frequency \((\omega_B)\) of de Broglie wave from (5.4):

\[
[\omega_{C\Rightarrow W} = R\omega_0^n + \omega_B]_i
\]

where: \(R = \sqrt{1 - (v/c)^2}\) is relativistic factor.

The acceleration can be related only with external translational dynamics which determines the empirical de Broglie wave parameters of particles. Acceleration is a result of alternating change of the charge deviation from the position of equilibrium:

\[
\Delta \lambda_B(t) = (\lambda_B - \lambda_0) \sin \omega_B t
\]

with de Broglie wave frequency of triplets: \(\omega_B = \hbar/(m\lambda_B^2)\), where \(L_B = \hbar/m\lambda_B^2\). It is accompanied by oscillation of the instant de Broglie wave length \(\lambda_B^i\).

The acceleration of charge in the process of \(C ⇔ W\) pulsation of the anchor \(\text{BV}F^\dagger_{anc}\) can be expressed as:

\[
a = \omega_B^2 \Delta \lambda_B(t)
\]

where: \(\lambda_B^i = 2\pi L_B\) is the instant de Broglie wave length of the particle and \(\lambda_0 = \hbar/m_0c\) is the Compton length of triplet.

The intensity of dipole radiation of pulsing \(\text{BV}F^\dagger_{anc}\) from 6.2 and 6.4 is:
\[ \varepsilon_{EM} = \frac{2}{3} e^2 \omega^4 (d_E)^2 \]

where the oscillating electric dipole moment is: \( d_E' = e(\lambda - \lambda_0) \).

Consequently, in accordance with our model of duality, the EM dipole radiation is due to modulation of the anchor Bivacuum fermion BVF\(^{inc} \) frequency of \( C \Rightarrow W \) pulsation of unpaired sub-elementary fermion by thermal vibrations of triplets.

6.2 The different kind of Bivacuum dipoles perturbation, induced by dynamics of elementary particles

In the process of \([ C \leftrightarrow W ] \) pulsation of sub-elementary particles in triplets
\(< [ F^+_t \propto F^-_t ] + F^+_t >^\text{c.p.} \) the [local (internal) \( \leftrightarrow \) distant (external)] compensation effects stand for the energy conservation law. The local effects are pertinent for the \([ C ] \) phase of particles. They are confined in the volume of sub-elementary fermions and are determined by gravitational interaction between opposite actual and complementary mass, Coulomb attraction between opposite electric charges and magnetic attraction between magnetic moments of asymmetric torus and antitorus of sub - elementary fermions. These potential attraction forces are balanced by the energy gap between torus \(( V^+ ) \) and antitorus \(( V^- ) \) and centripetal force of the axial rotation of triplets. The axis of triplet rotation is strictly related, in accordance with our model, with the direction of its translational propagation. It is supposed, that like magnetic field force lines, this rotation follows the right hand screw rule and is responsible for magnetic field origination. The total energy of triplet, the angular frequency of its rotation and the velocity of its translational propagation are interrelated.

The distant (external) effects, related with certain polarization and alignment of Bivacuum dipoles (circular and linear) are related with \([ C \rightarrow W ] \) transition of unpaired \( F^+_t >^\text{c.p.} \). It is accompanied by the recoil effect and and the distant elastic deformation of Bivacuum superfluid matrix, shifting correspondingly a symmetry of Bivacuum dipoles. The reverse \([ W \rightarrow C ] \) transition represents the antirecoil effect. The latter is accompanied by giving back the delocalized recoil energy and restoration of the unpaired sub-elementary fermion and the whole triplet properties.

The recoil - antirecoil and polarization effects on surrounding Bivacuum dipoles (BVF\(^t \) and BVF\(^\text{BVB} \)) in form of spherical elastic waves, excited by \([ C \Rightarrow W ] \) pulsations of unpaired sub-elementary fermions \( F^+_t >^\text{c.p.} \) and antifermions \( F^-_t >^\text{c.p.} \) of triplets \(< [ F^+_t \propto F^-_t ] + F^+_t >^\text{c.p.} \), are opposite. This determines the opposite effects of positive and negative charged \( F^+_t >^\text{c.p.} \) on symmetry of Bivacuum torus \(( V^+ ) \) and antitorus \(( V^- ) \) of Bivacuum dipoles BVF\(^t \), accompanied by their mass and charge polarization and acquiring the external momentum. Corresponding energy shift between torus and antitorus is dependent on distance \(( R ) \) from charge as \(( \theta/R ) \). The induced by such mechanism linear alignment of Bivacuum bosons (BVBF\(^\text{BVB} \)) or Cooper pairs [BVF\(^t \epsilon BVF\(^\text{BVB} \)] with opposite direction of BVF\(^t \) and BVF\(^\text{BVB} \) rotation between remote \( F^+_t >^\text{c.p.} \) and \( F^-_t >^\text{c.p.} \) of different triplets, like bundles of virtual microtubules stands for electrostatic field and its force lines origination.

On the other hand, pulsations of each of paired sub-elementary fermions \([ F^+_t \propto F^-_t ] \) have similar and symmetric effect on excitation of \(( V^+ ) \) and \(( V^- ) \) of BVF\(^t \) = \([ V^+ ] \cup \cup V^- \), independently on the charge of unpaired fermion and direction of triplets motion. Corresponding excitation of positive and negative virtual pressure waves (VPW\(^+ \) and VPW\(^- \)) is a background of gravitational attraction between different triplets, like between pulsing spheres in liquid medium. The influence of the in-phase recoil effect of pulsing \([ F^+_t \propto F^-_t ] \) on the external momentum and energy of torus \(( V^+ ) \) and antitorus \(( V^- ) \) of Bivacuum dipoles BVF\(^t \) = \([ V^+ ] \cup \cup V^- \)] should be symmetric and equal by absolute value to increment of energy of unpaired \( F^+_t >^\text{c.p.} \).
The fast rotation of pairs of sub-elementary fermion and antifermion \([F^+_1 \propto F^-_1]\) of triplets with opposite charges and actual magnetic moments should induce a polarization of Bivacuum dipoles around the vector of triplets propagation, shifting the spin equilibrium \([BVF^\pm \approx BVB^\pm \Rightarrow BVF^1]\) to the left or right and stimulate their ‘head-to-tail’ circular structures assembly in form of closed virtual microtubules. Our conjecture is that corresponding circular/axial ‘polymerization’ of polarized Bivacuum dipoles around direction of current, coinciding with that of triplets propagation, stands for curled magnetic field origination. The fast chaotic thermal motion of conducting electrons in metals or charged particles in plasma became more ordered in electric current, increasing correspondingly the magnetic cumulative effects due to triplet fast rotation in the same plane.

It is possible to present the above explanation of field nature and origination in more formal way. The total energies of \([C \rightarrow W]\) and \([W \rightarrow C]\) transitions of particles we present using general formula (4.1). However, here we take into account the corresponding recoil \(\approx\) antirecoil effects and the reversible conversion of the internal - local \((L)\) gravitational, Coulomb and magnetic potentials to the external - distant \((D)\) Bivacuum matrix perturbation, stimulated by these transitions. The \([C \rightarrow W]\) transition, accompanied by three kinds of recoil effects, can be described as:

\[
E^{C \rightarrow W} = m_c^2 c^2 = V_{tot} + [(E_G)_{Loc}^{Re} - (E_G)_{Dist}^{Re}] +
\]

\[
+ T_{tot} + [(E_E)_{Loc}^{Re} - (E_E)_{Dist}^{Re}]_{tr} +
\]

\[
+ [(E_H)_{Loc}^{Re} - (E_H)_{Dist}^{Re}]_{rot}
\]

6.6

In the process of the reverse \([W \rightarrow C]\) transition the unpaired sub-elementary fermion \(F^+_1\) of triplet \(\langle [F^+_1 \propto F^-_1]_{S=0} \pm (F^+_2)_{S=1/2} \rangle\) gets back the antirecoil \((ARe)\) energy in form of relaxation of Bivacuum matrix, transforming back the Bivacuum matrix elastic deformation and VPW \(^+\) excitation:

\[
E^{W \rightarrow C} = m_c^2 c^2 = V_{tot} + [-(E_G)_{ARe}^{Loc} + (E_G)_{ARe}^{Dist}] +
\]

\[
+ T_{tot} + [-(E_E)_{ARe}^{Loc} + (E_E)_{ARe}^{Dist}]_{tr} +
\]

\[
+ [-(E_H)_{ARe}^{Loc} + (E_H)_{ARe}^{Dist}]_{rot}
\]

6.7

where: \(V_{tot} = \frac{1}{2} (m_\Psi + m_\overline{\Psi}) c^2 = \frac{1}{2} m_\Psi (2c^2 - v^2)\) is a total potential energy of triplet (4.4), equal to that of unpaired sub-elementary fermion, and \(T_{tot} = \frac{1}{2} (m_\Psi - m_\overline{\Psi}) c^2\) is its total kinetic energy (4.5).

The reversible conversions of the local gravitational potential \(\pm (V_G)_{Loc,ARe}^{Re}\) to the distant one \(\pm (V_G)_{Dist,ARe}^{Re}\), accompanied the \([C \approx W]\) pulsation of unpaired sub-elementary fermions of triplets, interrelated with paired ones \([F^+_1 \propto F^-_1]\). The latter excite the positive VPW\(^+\) and negative VPW\(^-\) spherical virtual pressure waves, propagating in space with light velocity. They are a consequence of transitions of torus \(V^+\) and antitorus \(V^-\) of surrounding Bivacuum dipoles \(BVF^1 = [V^+ \parallel V^-]\) between the excited and ground states.

The \(\pm (E_E)_{Loc,ARe}^{Re}\) and \(\pm (E_E)_{Dist,ARe}^{Re}\) are the local and distant electrostatic potential oscillations; the \(\pm (E_H)_{Loc,ARe}^{Re}\) and \(\pm (E_H)_{Dist,ARe}^{Re}\) are the local and distant magnetic potentials oscillations, accompanied \([C \approx W]\) pulsations and rotation of triplets.

Let us consider in more detail the interconversions of the internal - local and the external - distant gravitational, Coulomb and magnetic potentials of charged elementary particles, like electron or proton.

6.3 The new approach to quantum gravity and antigravity.
The equality of gravitational and inertial mass of particles. Possible nature of neutrino and antineutrino.

The unified right parts of eqs. (6.6) and (6.7), describing the excitation of gravitational waves, which represent superposition of positive and negative virtual pressure waves (VPW+ and VPW−), are:

\[
\vec{V}_{tot}^{C=W} = \vec{V}_{tot} \pm \left[ (E_G)_{loc}^{Re} - (E_G)_{Re}^{Dist} \right] \sim V_{tot} \pm \left[ \Delta VPW^+ + \Delta VPW^- \right] \tag{6.8}
\]

This formula reflects the fluctuations of potential energy of triplets, induced by [C = W] pulsation of unpaired sub-elementary fermions (5.1 and 5.2), interrelated with and paired ones (5.3), which are responsible for gravitational field.

The more detailed presentation of 6.8 is:

\[
\vec{V}_{tot}^{C=W} = \frac{1}{2} (m_+^+ + m_0^-) c^2 \pm \left\{ \left[ G \left( \frac{m_0^+ m_0^-}{L_G} \right) \right]_{loc}^{Re} - \left[ \left( \frac{m_0}{M_{Pl}} \right)^2 (m_+^+ + m_0^-) c^2 \right]_{Re}^{Dist} \right\} \tag{6.9}
\]

The local internal gravitational interaction between the opposite mass poles of the mass-dipoles of unpaired sub-elementary fermions (antifermions) \( \langle F_+^\pm \rangle_{S=\pm 1/2} \) turns reversibly to the external distant one:

\[
\left[ G \left( \frac{m_0^+ m_0^-}{L_G} \right) \right]_{loc}^{C=W} \left[ \left( \frac{m_0}{M_{Pl}} \right)^2 (m_+^+ + m_0^-) c^2 = \left( \frac{m_0}{M_{Pl}} \right)^2 m_0^- (2c^2 - v^2) \right]^{Dis} \tag{6.10}
\]

where: \( L_G = \hbar (m_0^+ + m_0^-) c \) is a characteristic curvature of potential energy (4.4b); \( M_{Pl}^2 = \hbar c / G \) is a Plank mass; \( m_0^2 = |m_0^+ m_0^-| \) is a rest mass squared; \( \beta^i = \left( \frac{m_0^i}{M_{Pl}} \right)^2 \) is the introduced earlier dimensionless gravitational fine structure constant (Kaivarainen, 1995-2005). For the electron \( \beta^e = 1.739 \times 10^{-45} \) and \( \sqrt{\beta^e} = \frac{m_0^e}{M_{Pl}} = 0.41 \times 10^{-22} \).

The excitation of the external - distant spherical virtual pressure waves of positive and negative energy: VPW+ and VPW− is a result of torus and antitorus energy fluctuations, accompanied [C = W] pulsation of paired sub-elementary fermions \[ F_+^\pm \approx F_+^\pm \] strictly equal by absolute values to fluctuation energy of the unpaired \( \langle F_+^\pm \rangle_{S=\pm 1/2} \) one. It is important to note, that the introduced gravitational field does not depend on charge of triplet, determined by unpaired sub-elementary fermion < \[ F_+^\pm \approx F_+^\pm \] , in contrast to electrostatic and magnetic field.

The possible mechanism of relativistic increasing of the mass of triplets with their translational velocity is a consequence of higher excitation of torus and antitorus of Bivacuum dipoles \[ V_++ V^- \] - see eqs.1.5 and 1.5a. This excitation is a result of Bivacuum fermions and antifermions opposite symmetry shifts, induced by moving particle. These shifts are accompanied by activation of VPW+ and VPW− of higher frequency (eqs. 1.6 and 1.6a). In turn, due to feedback reaction, these virtual waves induces the increasing of frequency of paired sub-elementary fermions \[ F_+^\pm \approx F_+^\pm \] pulsation in triplets (Fig. 1). Because of strict correlation between symmetry shift of paired and unpaired sub-elementary fermions in triplets, the frequency of unpaired \( \langle F_+^\pm \rangle_{S=\pm 1/2} \) increases equally to that of paired. In accordance to (5.4), this increases the mass of unpaired \( \langle F_+^\pm \rangle_{S=\pm 1/2} \), which in accordance to our model of elementary particles determines the mass and charge of whole triplet.

The increments of particle mass increasing with acceleration are the same, if this happens in gravitational field or under the pure mechanical action. Consequently, the
proposed mechanism of relativistic effect explain also the equality of gravitational and inertial mass. The inertia itself is a consequence of particles system mass relativistic increasing with acceleration. Consequently, inertia is proportional to the number of particles in this system and their rest mass (i.e. total rest mass of the system).

In accordance to our hypothesis (Kaivarainen, 1995; 2000; 2005), the mechanism of gravitational attraction is similar to Bjerknes attraction between pulsing spheres in liquid medium - Bivacuum. The dependence of Bjerknes force on distance between centers of pulsing objects is quadratic: $F_{Bj} \sim 1/r^2$:

$$F_G = F_{Bj} = \frac{1}{r^2} \pi \rho_G R_1^2 R_2^2 v^2 \cos \beta$$  \hspace{1cm} 6.10a

where $\rho_G$ is density of liquid, i.e. virtual density of secondary Bivacuum. It is determined by Bivacuum dipoles (BVF⁺ and BVB⁻) symmetry shift; $R_1$ and $R_2$ radiuses of pulsing/gravitating spheres; $v$ is velocity of spheres surface oscillation (i.e. velocity of VPW², excited by $[C=W]$ pulsation of elementary particles, which can be assumed to be equal to light velocity: $v = c$); $\beta$ is a phase shift between pulsation of spheres.

It is important to note, that on the big enough distances the attraction may turn to repulsion. The latter effect, depending on the phase shift of $[C=W]$ pulsation of interacting remote triplets ($\beta$), can explain the revealed acceleration of the Universe expansion. The possibility of artificial phase shift of $[C=W]$ pulsation of coherent elementary particles of any object may (for example by magnetic field) may change its gravitational attraction to repulsion. The volume and radius of pulsing spheres ($R_1$ and $R_2$) in such approach is determined by sum of volume of hadrons, composing gravitating systems in solid, liquid, gas or plasma state. The gravitational attraction or repulsion is a result of increasing or decreasing of virtual pressure of subquantum particles between interacting systems as respect to its value outside them. This model can serve as a background for new quantum gravity theory.

The effective radiuses of gravitating objects $R_1$ and $R_2$ can be calculated from the effective volumes of the objects:

$$V_{1,2} = \frac{4}{3} \pi R_{1,2}^3 = \frac{4}{3} \pi L_{p,n}^3$$

where $N_{1,2} = M_{1,2}/m_{p,n}$ is the number of protons and neutrons in gravitating bodies with mass $M_{1,2}$; $m_{p,n}$ is the mass of proton and neutron; $L_{p,n} = \hbar/m_{p,n}c$ is the Compton radius of proton and neutron.

From (3.91a) we get for effective radiuses:

$$R_{1,2} = \left( \frac{M_{1,2}}{m_{p,n}} \right)^{1/3} L_{p,n} = \left( \frac{M_{1,2}}{m_{p,n}} \right)^{1/3} \frac{\hbar}{m_{p,n}c}$$

Putting this to (6.10a) we get for gravitational interaction between two macroscopic objects, each of them formed by atoms with coherently pulsing protons and neutrons:

$$F_G = \frac{1}{r^2} \pi \rho_{Bv} \left( \frac{M_1 M_2}{m_{p,n}^4} \right)^{2/3} \left( \frac{\hbar}{m_{p,n}} \right)^{4/3} \frac{1}{c^2}$$  \hspace{1cm} 6.10b

Equalizing this formula with Newton’s one: $F_G^N = \frac{1}{r^2} G(M_1 M_2)$, we get the expression for gravitational constant:

$$G = \frac{\pi \rho_G}{\sqrt{M_1 M_2}} \frac{h^2/c^2}{\sqrt{m_{p,n}^4}}$$  \hspace{1cm} 6.10c

The condition of gravitational constant permanency from (6.10c), is the anticipated from our theory interrelation between the mass of gravitating bodies $\sqrt{M_1 M_2}$ and the virtual density $\rho_G$ of secondary Bivacuum, determined by Bivacuum fermions symmetry.
shift and excitation in gravitational field:
\[ G = \text{const}, \quad \text{if} \quad \frac{\rho_G}{\sqrt{M_1 M_2}} = \text{const} \quad 6.10d \]

where, taking into account (6.10):
\[ \sqrt{M_1 M_2} \sim \rho_G = \frac{1}{3} \left( \frac{m_a}{M_{Pl}} \right)^2 (m_V^+ + m_V^-) \]

assuming, that the radius of characteristic volume of asymmetry of Bivacuum fermion, responsible for gravitation is:
\[ L_G = \frac{\hbar}{(m_V^- - m_V^+)c} \]

we get for reduced gravitational density:
\[ \rho_G = \frac{2}{3} \frac{1}{\pi h^3} \left( \frac{m_a}{M_{Pl}} \right)^2 (m_V^+ + m_V^-)(m_V^+ - m_V^-)^3 c^3 \quad 6.10e \]

or:
\[ \rho_G = \frac{2}{3} \frac{1}{\pi h^3} \left( \frac{m_a}{M_{Pl}} \right)^2 (m_V^+ + m_V^-)(m_V^- v^2/h)^3 \quad 6.10f \]

we may see from (6.10e) that at conditions of ideal symmetry of primordial Bivacuum, i.e. in the absence of matter and fields the virtual density of Bivacuum and gravitational interaction is equal to zero (\( \rho_G = 0 \)), as far (\( m_V^- - m_V^+ \)) = 0. The (6.10f) was derived from (6.10e), taking into account (2.10): (\( m_V^- - m_V^+ \))^2 = \( m_V^- v^2 \).

The ratio: \( m_V^- v^2/h = \omega_B \) represents the de Broglie wave frequency of asymmetric Bivacuum dipoles.

**Possible nature of neutrino and antineutrino**

We put forward a conjecture, that neutrinos or antineutrinos represent a stable nonelastic Bivacuum excitations in form of packet of positive and negative virtual pressure waves, slightly uncompensated each other:
\[ \nu, \bar{\nu} \sim [\text{VPW}^+ \propto \text{VPW}^-] \sim \text{VirP}^+ \sim \text{VirP}^- \]

However, their nonlocal asymmetry is compensating the local asymmetry in Bivacuum, accompanied origination of positrons or electrons. This asymmetry can be described as a small difference in energy of paired sub-elementary fermion and antifermion [\( F^\uparrow \propto F^\uparrow \), \( S = 0 \) in triplets \( < F^\uparrow \propto F^\uparrow + F\downarrow > \)]. It can be positive for electrons and negative for positrons and expressed as energy increment of elementary de Broglie wave:
\[ E_{\nu,\bar{\nu}}^i = \pm \left[ (m_V^- c^2)_{[F^\uparrow}] - (m_V^+ c^2)_{[F^\uparrow]} \right] \]

or:
\[ \left[ \Delta m_V^+ c^2 = \Delta(R m_0 c^2) + \Delta m_V^- v^2 \right] \]

We suppose that this increment of opposite sign, corresponding to neutrino and antineutrino, can be defined by gravitational fine structure constant \( \beta^i = \left( \frac{m_0}{M_{Pl}} \right)^2 \) different for each lepton generation:
\[ E_{\nu,\bar{\nu}}^i = \pm \beta^i (m_V^+ c^2) = \pm \beta^i [(R m_0 c^2) + (m_V^- v^2)] \]

Such Bivacuum resulting local symmetry shift compensation by nonlocal one in different possible ways looks to be a general phenomena in any other reaction. In formal way this idea can be expressed as a postulate:
The total symmetry shift in the Universe is zero:

\[
\frac{1}{Z} \sum P_k (m_\uparrow - m_\downarrow) k c^2 = 0
\]

where \( Z = \sum P_k \) is the total partition function, i.e. sum of probabilities of all reactions in the Universe.

This Bivacuum symmetry compensation principle can be a background for the energy conservation law.

6.4 The Bivacuum dipoles linear and circular ordering, as a background of electrostatic and magnetic fields origination

Let us consider now the origination of electrostatic and magnetic fields, as a consequence of proposed models of elementary particles and their duality. The unified right parts of eqs. (6.6) and (6.6a) can be subdivided to translational (electrostatic) and rotational (magnetic) contributions, determined by corresponding degrees of freedom of Cumulative Virtual Cloud \((CVC)_{tr,rot}\):

\[
T_{tot}^{C=W} = T_{tot} \pm [(\mathbf{E}_E)_{Rec} - (\mathbf{E}_E)_{Rec}^{Dist}]_{tr} \pm \\
\pm [(\mathbf{E}_H)_{Rec} - (\mathbf{E}_H)_{Rec}^{Dist}]_{rot}
\]

where the most probable total kinetic energy of particle can be expressed only via its actual inertial mass \((m_\uparrow - m_\downarrow)c^2\) and external velocity \((v)\):

\[
T_{tot} = \frac{1}{2} (m_\uparrow - m_\downarrow) c^2 = \frac{1}{2} m_\uparrow v^2
\]

The comparison of (6.11b) with (6.10) prove that the inertial and gravitational mass are equal.

Formula (6.11-6.11a) reflects the fluctuations of the most probable total kinetic energy, accompanied pulsation of unpaired sub-elementary fermion, responsible for linear - electrostatic and curled - magnetic fields origination. The more detailed form of (6.11) is:

\[
T_{tot}^{C=W} = \frac{1}{2} (m_\uparrow - m_\downarrow) c^2 \pm \left\{ \left[ \frac{|e_+ e_-|}{L_T^{Loc}} \right] - \left[ \frac{e_+^2}{\hbar c} (m_\uparrow - m_\downarrow) c^2 \right]_{Dist} \right\} \\
\pm \left\{ \left[ K_{HE} \frac{|\mu_+ \mu_-|}{L_T} \right]_{Loc} - \left[ K_{HE} \frac{\mu_0^2}{\hbar c} (m_\uparrow - m_\downarrow) c^2 \right]_{rot} \right\}
\]

The oscillation of electrostatic translational contribution, taking into account the obtained relation between mass and charge symmetry shifts (2.18a): \( m_\uparrow - m_\downarrow = m_\uparrow \frac{c^2 - e_+^2}{e_+^2} \),

can be expressed as:

\[
\left[ \frac{|e_+ e_-|}{L_T^{Loc}} \right]_{C=W}^{C=W} \left[ a \left( \frac{m_\uparrow c^2 e_+^2 - e_-^2}{e_+^2} \right) \right]_{Dist}
\]

where: \( L_T = \hbar / (m_\uparrow - m_\downarrow) c \) is a characteristic curvature of kinetic energy (4.5b); \( |e_+ e_-| = e_0^2 \) is a rest charge squared; \( a = e^2 / \hbar c \) is the well known dimensionless electromagnetic fine structure constant (Kaivarainen, 1995-2005).

The right part of (6.13) taking into account that: \( e_+^2 - e_-^2 = (e_+ - e_-)(e_+ + e_-) \)

characterizes the electric dipole moment of triplet, equal to that of unpaired sub-elementary fermion \( (F_+^\pm) \).

Like in the case of gravitational potential, it is assumed, that the local internal Coulomb potential between opposite charges of torus and antitorus of unpaired sub-elementary fermions (antifermions) \( (F_+^\pm)_{s=\pm 1/2} \) turn reversibly to the external distant one due to elastic
recoil=antirecoil effects, induced by \( C \Rightarrow W \) pulsation of \( (F^\pm_{\ell})_{S=\pm 1/2} \).

The electrostatic Coulomb attraction between opposite electric charges (unpaired sub-elementary fermions of triplets) can be a result of Bivacuum bosons \( \text{BVB}^\pm = [V^+ \uparrow \downarrow V^-] \) or Cooper pairs of Bivacuum dipoles:

\[
\text{BVF}^\uparrow = [V^+ \uparrow \uparrow V^-] \Rightarrow (\text{BVF}^\downarrow = [V^+ \downarrow \downarrow V^-])
\]

linear assembly, their "head to tail" polymerization between \( (F^\pm_{\ell})_{S=\pm 1/2} \) of two opposite charges (i.e. electron and proton).

These quasi one-dimensional single \( \Sigma \text{BVB}^\pm \) and twin \( \Sigma(\text{BVF}^\uparrow \Rightarrow \text{BVF}^\downarrow) \) virtual microtubules, like 'springs', are responsible for the 'force lines' origination, connecting the opposite charges. The energy of attraction has the following dependence on the length \( R \) of virtual 'springs':

\[
\frac{r}{R}, \text{where } r \text{ is the unitary radius-vector.}
\]

On the other hand, the repulsion between similar charges by sign is a result of the opposite phenomena - chaotization of Bivacuum dipoles orientation between such charges and decoupling of virtual Cooper pairs \( [V^+ \uparrow \uparrow V^-] \Rightarrow [V^+ \downarrow \downarrow V^-] \), accompanied by Pauli repulsion (Kaivarainen, 2005) and the repulsion between similar charges.

The oscillation of magnetic dipole radiation contribution in the process of \([C \Rightarrow W]\) pulsations of sub-elementary fermions between local and distant modes is not accompanied by magnetic moments symmetry shift, but only by the oscillation of separation between torus and antitorus of \( \text{BVF}^\pm \). It can be described as:

\[
K_{HE}^i |\vec{\mu} \cdot \mu_\perp \rangle \frac{L_T}{\ell} [\text{Loc}] \begin{bmatrix}
\text{c-w} \\
\text{w-c}
\end{bmatrix}
\begin{bmatrix}
K_{HE}^i \mu_0^2 \left( m_\text{\nu} - m_\text{\bar{\nu}} \right) c^2 \\
K_{HE}^i \mu_0^2 \left( m_\text{\nu} \omega_\text{T}^2 L_T^2 \right)
\end{bmatrix}
\]

or:

\[
K_{HE}^i |\vec{\mu} \cdot \mu_\perp \rangle \frac{L_T}{\ell} [\text{Loc}] \begin{bmatrix}
\text{c-w} \\
\text{w-c}
\end{bmatrix}
\begin{bmatrix}
K_{HE}^i \mu_0^2 \left( m_\text{\nu} - m_\text{\bar{\nu}} \right) c^2 \\
K_{HE}^i \mu_0^2 \left( m_\text{\bar{\nu}} \omega_\text{T}^2 L_T^2 \right)
\end{bmatrix}
\]

where: \( \frac{\mu_0^2}{h} = \gamma \) is the magnetic fine structure constant, introduced in our theory. The magneto - electric conversion coefficient \( K_{HE} \) we find from the equality of the electrostatic and magnetic contributions:

\[
E_H = E_E = T_{rec} = \frac{1}{2} \frac{e^2}{hc} (m_\text{\nu} - m_\text{\bar{\nu}}) c^2 = \frac{1}{2} K_{HE} \mu_0^2 \frac{m_\text{\nu} \omega_\text{T}^2 L_T^2}{hc}
\]

These equality is a consequence of equiprobable energy distribution between translational (electrostatic) and rotational (magnetic) independent degrees of freedom of an unpaired sub-elementary fermion and its cumulative virtual cloud (CVC\( ^\pm \)). This becomes evident for the limiting case of photon in vacuum. The sum of these two contributions is equal to

\[
E_H + E_E = \alpha m_\text{\nu} v_{\text{res}}^2
\]

where \( v_{\text{res}} \) is a resulting translational - rotational recoil velocity.

From the above conditions it follows, that:

\[
K_{HE} \mu_0^2 \frac{h e^2}{4 m_0^2 c^3} = \frac{e_0^2}{hc}
\]

where \( \mu_0^2 = |\mu_\perp| = \left( \frac{e_0}{m_0} \frac{h}{4\pi c} \right)^2 \) is the Bohr magneton.

Consequently, the introduced magneto-electric conversion coefficient is:

\[
K_{HE}^{\epsilon_0} = \left( \frac{m_0^2 \epsilon_0 c}{h/2} \right)^2 = \left( \frac{2}{L_0^{\epsilon_0}} \right)^2
\]

where \( L_0^{\epsilon_0} = h/m_0^{\epsilon_0} c \) is the Compton radius of the electron or proton.

**Origination of magnetic field** is assumed to be a result of dynamic equilibrium
\[ \text{[BVF}^{\dagger}_{S=+1/2} \rightleftharpoons \text{BVF}^{\dagger}_{S=-1/2}] \text{ shift between Bivacuum fermions and Bivacuum antifermions to the left or right and their circulation around the direction of triplet propagation in the current. It should be related to asymmetric properties of the 'anchor' BVF}^{\dagger}_{\text{unc}} \text{ of unpaired sub-elementary fermion (F}^+_1)_{S=\pm 1/2} \text{ of triplets < [F}^+_1 \approx F}^+_1_{,S=0} + (F}^+_1)_{S=\pm 1/2} \text{ > and fast rotation of pairs of charge and magnetic dipoles [F}^+_1 \approx F}^+_1_{,S=0} \text{ in plane, normal to directed motion of triplets, i.e. current. This statement is a consequence of the empirical fact, that the magnetic field can be exited only by the electric current: } \mathbf{j} = n \mathbf{e} \mathbf{v}, \text{ i.e. directed motion of the charged particles. The cumulative effect of rotation of many of the electrons in current in plane, normal to current and direction of rotation is determined by the \textit{hand screw rule} and induce the circular structure formation around } \mathbf{j} \text{ in Bivacuum. These axisymmetric structures are the result of 'head-to-tail' \textit{vortical \textit{assembly of Bivacuum dipoles, i.e. by the same principle as between opposite charges. The vortex - like motion of these axial circled structures along the force lines of the magnetic field occur due to a small symmetry shift between mass and charge of torus and antitorus of BVF}^{\dagger} \text{ in accordance with (2.11) and (2.13a). This asymmetry is produced by perturbation of Bivacuum dipoles, induced by the unpaired sub-elementary fermions of triplets. The unpaired sub-elementary fermions and antifermions have the opposite influence on symmetry shift between torus and antitorus, interrelated with their opposite influence on the direction of the \textit{BVF}^{\dagger}_{S=+1/2} \rightleftharpoons \text{BVB}^{\pm} \rightleftharpoons \text{BVF}^{\dagger}_{S=-1/2}] \text{ equilibrium shift.}

The equilibrium constant between Bivacuum fermions of opposite spins, characterizing their uncompensated magnetic moment, we introduce, using (2.11), as function of the external translational velocity of BVF\(^{\dagger}\):

\[
K_{\text{BVF}^{\dagger}} = \frac{\text{BVF}^{\dagger}_{S=+1/2}}{\text{BVF}^{\dagger}_{S=-1/2}} = \exp\left[-\frac{\alpha(m_j^+ - m_j^-)}{m_j}ight]
\]

The similar values of \(K_{\text{BVF}^{\dagger}}\) have the axial distribution with respect to the current vector (\(\mathbf{j}\)) of charges. The conversion of Bivacuum fermions or Bivacuum antifermions to Bivacuum bosons (\(\text{BVB}^{\pm} = \text{V}^+ \rightleftarrows \text{V}^-\)) with different probability, also may provide an increasing or decreasing of the equilibrium constant \(K_{\text{BVF}^{\dagger}}\). The corresponding probability difference is dependent on the direction of current related, in-turn, with direction of unpaired sub-elementary fermion circulation, affecting in opposite way on the angular momentum and stability of \(\text{BVF}^{\dagger}_{S=+1/2}\) and \(\text{BVF}^{\dagger}_{S=-1/2}\).

The magnetic field tension can be presented as a gradient of the constant of equilibrium:

\[
H = \text{grad}(K_{\text{BVF}^{\dagger}}) = (\mathbf{\hat{r}}/R)K_{\text{BVF}^{\dagger}}
\]

The chaotic thermal velocity of the 'free' conductivity electrons in metals and ions at room temperature is very high even in the absence of current, as determined by Maxwell-Boltzmann distribution:

\[
v_T = \sqrt{\frac{kT}{m_V}} \approx 10^7 \text{ cm/s}
\]

It proves, that not the acceleration, but the ordering of the electron translational and rotational dynamics in space, provided by current, is a main reason of the curled magnetic field excitation. In contrast to conventional view, the electric current itself is not a \textit{primary}, but only a \textit{secondary} reason of magnetic field origination, as the charges translational and rotational dynamics 'vectorization factor'.
6.5 Interpretation of the Maxwell displacement current, based on Bivacuum model

The magnetic field origination in Bivacuum can be analyzed also from more conventional point of view.

Let us analyze the 1st Maxwell equation, interrelating the circulation of vector of magnetic field tension $\mathbf{H}$ along the closed contour $\mathbf{L}$ with the conduction current ($\mathbf{j}$) and displacement current $j_d = \frac{1}{4\pi} \frac{\partial \mathbf{E}}{\partial t}$ through the surface, limited by $\mathbf{L}$:

$$\oint_{\mathbf{L}} \mathbf{H} \, dl = \frac{4\pi}{c} \int_{\mathcal{S}} \left( \mathbf{j} + \frac{1}{4\pi} \frac{\partial \mathbf{E}}{\partial t} \right) \, ds$$

6.18

where $(s)$ is the element of surface, limited with contour $(l)$.

The existence of the displacement current $j_d = \frac{1}{4\pi} \frac{\partial \mathbf{E}}{\partial t}$ is in accordance with our model of Bivacuum, as the oscillating virtual dipoles (BVF$^\pm$ and BVB$^\mp$) continuum.

In condition of primordial Bivacuum of the ideal virtual dipoles symmetry (i.e. in the absence of matter and fields) these charges totally compensate each other.

However, even in primordial symmetric Bivacuum the oscillations of distance and energy gap between torus and antitorus of Bivacuum dipoles is responsible for displacement current. This alternating current generates corresponding displacement magnetic field.

Corresponding virtual dipole oscillations are the consequence of the in-phase transitions of $V^+$ and $V^-$ between the excited and ground states, compensating each other. These transitions are accompanied by spontaneous emission and absorption of positive and negative virtual pressure waves: $\text{VPW}^+$ and $\text{VPW}^-$. The primordial displacement current and corresponding displacement magnetic field can be enhanced by presence of matter. It is a consequence of fluctuations of potential energy of sub-elementary fermions of triplets, accompanied by excitation of positive and negative virtual pressure waves, which in accordance to our approach, is interrelated with gravitational field of particles (see 6.8 - 6.10).

6.6 New kind of current in secondary Bivacuum, additional to displacement and conducting ones

This additional current is a consequence of vibrations of BVF$^\pm$, induced by recoil-antirecoil effects, accompanied $[C \approx W]$ transitions of unpaired sub-elementary fermion of triplets $< [F^+_\uparrow \cong F^+_\uparrow]_{S=0}^+ (F^+_\uparrow)_{S=\pm 1/2}^+ >$ It can be also a consequence of Bivacuum dipoles perturbations, induced by relativistic translational propagation of particles in Bivacuum.

The corresponding elastic deformations of Bivacuum fermions $(\text{BVF}^\pm) = [V^+ \dagger \dagger V^-]$ are followed by small charge-dipole symmetry zero-point oscillations ($v_{ext} = 0$) with amplitude, determined by the most probable resulting translational - rotational recoil velocity ($v_{rec}$). At conditions $e_+ \approx e_- \approx e_0$ and $|e_+ - e_-| << e_0$, i.e. at small perturbations of torus and antitorus: $V^+$ and $V^-$ we have for the charge symmetry shift oscillation amplitude:

$$\Delta e_{\pm} = e_+ - e_- = \frac{1}{2} e_0 \frac{v_{rec}^2}{c^2}$$

6.19

The resulting most probable recoil velocity using (6.15) can be defined from two expressions of recoil momentum, standing for electromagnetism:

$$T_{rec} = \frac{1}{2} \alpha (m_V - m_V) c^2 = \frac{1}{2} \alpha m_V v_{res}^2$$

6.20

$$v_{rec}^2 = \alpha v_{res}^2$$

6.20a
The minimum value of recoil velocity, corresponding to zero external translational velocity of triplets and internal velocity, determined by Golden mean conditions 
\((v_{rec}/c)^2 = \phi = 0.61803398\), can be considered as the velocity of zero-point oscillations:

\[
(v_{rec})_{min}^2 = (v_{0})_{HE}^2 = \alpha \phi \ c^2
\]

where: \(\alpha = e^2/\hbar c = 0.0072973506\); \(\alpha \phi = (v_{rec})_{min}/c^2 = 4.51 \cdot 10^{-3}\).

The alternating recoil current \((j_{rec}^{EH})\), additional to that of Maxwell displacement current \((j_d)\) existing in presence of charged particles even in the absence of conducting current \((j = 0)\) is equal to product of (6.19) and square root of (6.21). At Golden mean conditions \((v/c)^2 = \phi\) this recoil current is:

\[
(j_{rec}^{EH}) = (\Delta e_z)^{\phi}(v_{rec})_{min} = \frac{1}{2} \alpha^{1/2} \phi^{3/2} e_0 c
\]

Corresponding gravitational contribution of recoil velocity, related to vibration of potential energy of particle (6.10) is much smaller, as far \(\beta << \alpha\):

\[
V_{rec} = \frac{1}{2} \beta (m^2 + m) c^2 = \frac{1}{2} \beta \ m c^2 (2 - v^2/c^2)
\]

The zero-point characteristic potential recoil velocity squared at GM conditions \((v^2/c^2)^{\phi} = \phi\) is:

\[
(v_0)^2_{G} = \beta c^2 (2 - \phi);
\]

\[
(v_0)^2_{G}/c^2 = \beta (2 - \phi)
\]

Consequently, the Maxwell equation (6.18) can be modified, taking into account the EH recoil current, as

\[
\oint_L H \ dl = \frac{4 \pi}{c} \int_S (j + \frac{1}{2} \frac{\partial E}{\partial t} + j_{rec}^{EH}) \ ds = I_{tot}
\]

where: \(I_{tot}\) is total current via surface \((S)\).

We have to note, that \(j_{rec}^{EH}\) is nonzero not only in the vicinity of particles, but as well in any remote space regions of Bivacuum, perturbed by electric and magnetic potentials. This consequence of our theory coincides with the extended electromagnetic theory of Bo Lehnert (2004, 2004a), also considering current in vacuum, additional to displacement one.

In accordance with the known Helmholtz theorem, each kind of vector field \((F)\), tending to zero at infinity, can be presented, as a sum of the gradient of some scalar potential \((\phi)\) and a rotor of vector potential \((A)\):

\[
F = \nabla \phi + \nabla \times A
\]

The scalar and vector potentials are convenient to use for description of electromagnetic field, i.e. photon properties. They are characterized by the interrelated translational and rotational degrees of freedom, indeed (Fig.3.2).

To explain the ability of secondary Bivacuum to keep the average (macroscopic) mass and charge equal to zero, we have to postulate, that the mass and charge symmetry shifts oscillations of Bivacuum fermions and antifermions, forming virtual Cooper pairs:

\[
(BVF^*)_{S = 1/2}^{\pm} = [V^+ \uparrow V^-]^\pm \cong [V^+ \downarrow V^-]^\pm = (BVF^1)_{S = 1/2}^{\pm}
\]

are opposite by sign, but equal by the absolute value. Consequently, the polarized secondary Bivacuum (i.e. perturbed by matter and field) can be considered, as a plasma of the in-phase oscillating virtual dipoles \((BVF)\) of opposite resulting charge and mass/energy.

6.7 The mechanism, increasing the refraction index of Bivacuum

By definition, the torus is a figure, formed by rotation of a circle with maximum radius, corresponding to minimum quantum number \((n = 0,\ \text{see} \ 1.1a)\):

\[
I_{LS}^{\phi} = \frac{\beta h}{m_i c}, \ \text{around} \ \text{the} \ \text{axis},
\]
shifted from the center of the circle at the distance \( \pm \Delta L_{EHG} \). The electromagnetic (EH) and gravitational (G) vibrations of positions (\( \pm \Delta L_{EHG} \)) of the big number of recoiled BVF$_{rec}$, induced by the elastic recoil\(-\)antirecoil deformations of Bivacuum matrix, are accompanied by vibrations of square and volume of torus (\( V^+ \)) and antitorus (\( V^- \)) of perturbed Bivacuum dipoles: (BVF$_{rec}$)$_i^\pm = [V^+ \pm V^-]_{rec}^\pm$. The electromagnetic and gravitational increments of square (\( \Delta S_{EHG}^{\pm} \)) and volume (\( \Delta V_{EHG}^{\pm} \)) of toruses and antitoruses of (BVF$_{rec}$)$_i^\pm$, as a consequence of their center vibrations can be presented, correspondingly, as:

\[
\Delta S_{V^\pm}^{EHG} = 4\pi^2 |\Delta L_{EHG}|_{V^\pm}^{EHG} \cdot L_{V^\pm} \quad 6.25
\]
\[
\Delta V_{V^\pm}^{EHG} = 4\pi^2 |\Delta L_{EHG}|_{V^\pm}^{EHG} \cdot L_{V^\pm}^2 \quad 6.25a
\]

At conditions of zero-point oscillations, corresponding to Golden Mean (GM), when the ratio (\( v_0/c \))$^2 = \Phi$ and external translational velocity (\( v \)) is zero, the maximum shifts of center of secondary Bivacuum dipoles in vicinity of pulsing elementary particles due to electromagnetic and gravitational recoil-antirecoil (zero-point) vibrations are, correspondingly:

\[
(\Delta L_{EH}^{\Phi})_{V^\pm} = (\tau_{C=W}^{\Phi} \cdot v_{EH}^{\Phi})_i^\pm = \frac{h}{m_c^\Phi c} (\alpha\Phi)^{1/2} = 0.067 (L_{V^\pm}) \quad 6.26
\]
\[
(\Delta L_{G}^{\Phi})_{V^\pm} = (\tau_{C=W}^{\Phi} \cdot v_{G}^{\Phi})_i^\pm = \frac{h}{m_c^\Phi \beta^{1/2} (2 - \Phi)^{1/2} = 3.27 \cdot 10^{-23} (L_{V^\pm}) \quad 6.26a
\]

where: the recoil\( \approx \) antirecoil oscillation period is \([\tau_{C-W}^{\Phi} = 1/\omega_{C-W} = h/m_c^\Phi c^2] \); the recoil\( \approx \)antirecoil most probable velocity of zero-point oscillations, which determines the electrostatic and magnetic fields is: \( v_{EH}^{\Phi} = c (\alpha\Phi)^{1/2} = 0.201330447 \times 10^8 \text{ m s}^{-1} \) and \( (\alpha\Phi)^{1/2} = 0.067 \) the corresponding zero-point velocity, which determines gravitational field is: \( v_{G}^{\Phi} = c \beta^{1/2} (2 - \Phi)^{1/2} = 1,446 \cdot 10^{-12} \text{ m s}^{-1} \) and \( \beta^{1/2} (2 - \Phi)^{1/2} = 0.48 \cdot 10^{-22} \).

The dielectric permittivity of Bivacuum and corresponding refraction index, using our theory of refraction index of matter (Kaivarainen, 1995; 2001), can be presented as a ratio of volume of Bivacuum fermions and bosons in symmetric primordial Bivacuum (V$_{pr}$) to their volume in secondary Bivacuum: V$_{sec} = V_{BVF} - (r/r)\Delta V_{BVF,rec}$, perturbed by matter and fields. The secondary Bivacuum is optically more dense, if we assume that the volume, occupied by Bivacuum fermion torus and antitorus, is excluded for photons. The Coulomb and gravitational potentials and the related excluded volumes of perturbed Bivacuum fermions/antifermions decline with distance (\( r \)) as:

\[
(\vec{r} / r)\Delta V_{BVF,rec}^{EH} \quad \text{and} \quad (\vec{r} / r)\Delta V_{BVF,rec}^{G}
\]

where: (\( r \)) is a distance from the charged and/or gravitating particle and \( \vec{r} \) is the unitary radius vector. Taking all this into account, we get for permittivity of secondary Bivacuum:

\[
\varepsilon = n^2 = \left( \frac{V_{EHG}}{V_{BVF}} \right)^2 = \frac{V_{pr}}{V_{sec}} = \frac{V_{BVF}}{V_{BVF} - (r/r)\Delta V_{BVF,rec}^{EHG}} = \frac{1}{1 - (r/r)\Delta V_{BVF,rec}^{EHG}} = \frac{1}{1 - (r/r) 3\pi |\Delta L_{EHG}^{\Phi}|_{V^\pm} \cdot L_{V^\pm}} \quad 6.27
\]
\[
n^2 = 1 - (r/r) 3\pi |\Delta L_{EHG}^{\Phi}|_{V^\pm} \cdot L_{V^\pm} \quad 6.27a
\]

where: the velocity of light propagation in asymmetric secondary Bivacuum of higher virtual density, than in primordial one, is noted as: \( v_{EHG} = c_{EHG} \); the volume of primordial Bivacuum fermion is \( V_{BVF} = (4/3)\pi L_{V^\pm}^3 \) and its increment in secondary Bivacuum: \( \Delta V_{BVF,rec}^{EHG} = \Delta V_{V^\pm}^{EHG} \) (6.25a).
(r/r) is a ratio of unitary radius-vector to distance between the source of [C \sim \mathbf{W}]
pulsations (elementary particle) and perturbed by the electrostatic, magnetic and
gravitational potential BVF_{REC}^{EH,G}.

Putting (6.26) into formula (6.27a) we get for the refraction index of Bivacuum and
relativistic factor (R_E) in the vicinity of charged elementary particle (electron, positron or
proton, antiproton) the following expression:

\[ n^2 = \left( \frac{c_{EH}}{c} \right)^2 \]

where: \( 1 \leq n^2 \leq 2.71 \) is tending to 1 at \( r \rightarrow \infty \).

The Coulomb relativistic factor:

\[ R_{EH} = \sqrt{1 - \frac{c_{EH}^2}{c^2}} = \sqrt{\frac{1}{1 - \left( \frac{r}{r} \right)^2}} \approx 0.687 \]

0 \leq R_E \leq 0.794 is tending to zero at \( r \rightarrow \infty \).

In similar way, using (6.26a) and (6.27a), for the refraction index of Bivacuum and the
corresponding relativistic factor (R_G) of gravitational vibrations of Bivacuum fermions
(BVF) in the vicinity of pulsing elementary particles at zero-point conditions, we get:

\[ n^2 = \left( \frac{c_G}{c} \right)^2 \]

where (\( \beta^* \))_{1/2}(2 - \phi)_{1/2} = 0.48 \times 10^{-22}.

The gravitational relativistic factor:

\[ R_G = \sqrt{1 - \frac{c_G^2}{c^2}} = \sqrt{\frac{1}{1 - \left( \frac{r}{r} \right)^2}} \approx 0.69 \times 10^{-11} \]

Like in previous case, the Bivacuum refraction index, increased by gravitational
potential, is tending to its minimum value: \( n^2 \rightarrow 1 \) at the increasing distance from the
source: \( r \rightarrow \infty \).

The charge - induced refraction index increasing of secondary Bivacuum, in contrast to
the mass - induced one, is independent of lepton generations of Bivacuum dipoles (e, \( \mu \), \( \tau \)).

The formulas (6.28) and (6.30) for Bivacuum dielectric permittivity and refraction
index near elementary particles, perturbed by their Coulomb and gravitational potentials,
point out that bending and scattering probability of photons on charged particles is much
higher, than that on neutral particles with similar mass.

We have to point out, that the light velocity in conditions:

\[ n^2_{EH,G} = c/\nu_{EH,G} = c/c_{EH,G} \] > 1 is not longer a scalar, but a vector, determined by the
gradient of Bivacuum fermion symmetry shift:

\[ \text{grad} \Delta |\mathbf{m}_+ - \mathbf{m}_-|_{EH,G} c^2 = \text{grad} \Delta (\mathbf{m}_+ \nu^2) \]

and corresponding gradient of torus and antitorus equilibrium constant increment:

\[ \Delta K_{\nu^+ \nu^-} = 1 - \mathbf{m}_+ / \mathbf{m}_- = \left( c_{EH,G} / \nu \right)^2 \]

\[ \text{grad} \Delta K_{\nu^+ \nu^-} = 1 - \mathbf{m}_+ / \mathbf{m}_- \]

\[ = \text{grad} \left( \frac{c_{EH,G}}{c} \right)^2 = \text{grad} \frac{1}{n^2} \]

The other important consequence of: \( n^2_{EH,G} > 1 \) is that the contributions of the rest
mass energy of photons and neutrino (Kaivarainen, 2005) to their total energy is not zero,
as far the electromagnetic and gravitational relativistic factors (R_{EH,G}) are greater than zero.
It follows from the basic formula for the total energy of de Broglie wave (the photon in our
case):
\[ E_{\text{tot}} = m \gamma c^2 = h \omega_{\text{C} \Rightarrow \text{W}} = R(m_0 c^2)^{\text{in}}_{\text{rot}} + (h \omega_{\text{ext}})^{\text{tr}}_{\text{rot}} \]

where the gravitational relativistic factor of electrically neutral objects:

\[ R_G = \sqrt{(r/r_0)^3} \cdot 10^{-22} \leq (r/r_0)^{3/2} \cdot 1.75 \times 10^{-11}. \]

This consequence is also consistent with a theory of the photon and neutrino, developed by Bo Lehner (2004a).

We can see, that in conditions of primordial Bivacuum, when \( r \rightarrow \infty \), the \( n_{EH,G} \rightarrow 1 \), \( R_{EH,G} \rightarrow 0 \) and the contribution of the rest mass energy \( R(m_0 c^2)^{\text{in}}_{\text{rot}} \) tends to zero. At these limiting conditions the frequency of photon [\textit{Corpuscle} \Rightarrow \textit{Wave}] pulsation is equal to the frequency of the photon as a wave:

\[ E_{ph} = h \omega_{C \Rightarrow W} = h \omega_{ph} = h \cdot \frac{c}{\lambda_{ph}} \]

The results of our analysis explain the bending of light beams, under the influence of strong gravitational potential in another way, than by Einstein’s general theory of relativity. A similar idea of polarizable vacuum and its permittivity variations has been developed by Dicke (1957), Fock (1964) and Puthoff (2001), as a background of 'vacuum engineering'.

For the spherically symmetric star or planet it was shown using Dicke model (Dicke, 1957), that the dielectric constant \( K \) of polarizable vacuum is given by the exponential form:

\[ K = \exp(2GM/rc^2) \]

where \( G \) is the gravitational constant, \( M \) is the mass, and \( r \) is the distance from the mass center.

For comparison with expressions derived by conventional General Relativity techniques, it is sufficient a following approximation of the formula above (Puthoff, 2001):

\[ K \approx 1 + \frac{2GM}{rc^2} + \frac{1}{2} \left( \frac{2GM}{rc^2} \right)^2 \]

Our approach propose the concrete mechanism of Bivacuum optical density increasing near charged and gravitating particles, inducing light beams bending.

7. The Principle of least action, as a consequence of Bivacuum basic Virtual Pressure Waves (VPW\textsuperscript{\pm}_{q=1}) action on particles dynamics

Let us analyze the formula of action in Maupertuis-Lagrange form:

\[ S_{\text{ext}} = \int_{t_0}^{t_1} 2T^\text{ext}_{k} \cdot dt \]

The principle of Least action, choosing one of few possible trajectories of system changes from one configuration to another at the permanent total energy of a system of elementary particles: \( E_{\text{tot}} = m \gamma c^2 = \text{const} \) has a form:

\[ \Delta S_{\text{ext}} = 0 \]

This means, that the optimal trajectory of particle corresponds to minimum variations of the external energy of it wave B.

The time interval: \( t = t_1 - t_2 = nt_B \) is equal or bigger than the period of the external (modulation) frequency of wave B (\( t_B = 1/\nu_B \)):

\[ t = t_1 - t_2 = nt_B = n/\nu_B \]

Using eqs.(7.1 and 4.10; 410a), we get for the action:
\[ S_{ext} = 2T_\xi \cdot t = m_\xi v^2 \cdot t = (1 + R)[m_\xi c^2 - m_0 c^2] \cdot t = \]

**7.4**

or:

\[ S_{ext} = m_\xi v^2 \cdot t = (1 + R)TE \cdot t \]

**7.4a**

where relativistic factor: \[ R = \sqrt{1 - (v/c)^2} \]

**7.4b**

(v) is the resulting external translational velocity.

We introduce here the important notions of Tuning energy of Bivacuum and corresponding frequency difference, as:

\[ \text{TE} = E_{tot} - E^{in}_{rot} = [m_\xi c^2 - q m_0 c^2] = h \omega_{TE} = h[\omega_{c=w} - q \omega_0] = \frac{m_\xi v^2}{1 + R} \]

**7.5**

where: \[ q = j - k \] is a quantum number characterizing excitation of Bivacuum virtual pressure waves (VPW) and spin (VirSW) waves (see section 1.1 and eq.1.8a).

The frequency (\(\omega_{TE}\)) of Bivacuum Tuning energy is defined as:

\[ \omega_{TE} = (m_\xi - q m_0)c^2/h = [\omega_{c=w} - q \omega_0] \]

**7.6**

The influence of Tuning energy of Bivacuum on matter is a result of forced combinational resonance between virtual pressure waves (VPW) of Bivacuum with quantized frequency

\[ \omega_{VPW} = q \omega_0 = q m_0 c^2/h \]

and \([C \neq W]\) pulsation of elementary particles \(\omega_{c=w}\).

The condition of combinational resonance is:

\[ \omega_{VPW} = q \omega_0 = \omega_{c=w} \]

**7.8**

or:

\[ E_{VPW} = q m_0 c^2 = m_\xi v^2 \]

**7.8a**

The energy exchange between VPW or VPW and real particles in the process of \([C \neq W]\) pulsation of pairs \([F^+_\xi \otimes F^-_\xi]_{x,y}\) of real fermions - triplets \(<(F^+_\xi \otimes F^-_\xi)_{x,y} + F^+_\xi >\) at pull-in-range state accelerate them, i.e. bigger than 1, driving to resonant conditions (7.8 and 7.8a). On the other hand, at the minimum energy of VPW, when \(q = j - k = 1\), their interaction with triplets slow the translational velocity of particles down, i.e. deceleration (cooling) effect takes a place.

In accordance to rules of combinational resonance of Bivacuum virtual pressure waves with elementary particles, we have the following relation between quantized energy and frequency of VPW and energy/frequency of triplets \([C \neq W]\) pulsation in resonance conditions:

\[ E_{VPW} = h \omega_{VPW} = q \omega_0 = h \omega_{c=w} = R \omega_0 + h \omega_B \]

**7.9**

\[ E_{VPW} = q m_0 c^2 = R m_0 c^2 + m_\xi v^2 \]

**7.9a**

or:

\[ E_{VPW} = R m_0 c^2 + \frac{m_0 c^2(v/c)^2}{R} \]

**7.9b**

where the VPW quantum number: \(q = j - k = 1,2,3...\) (integer numbers)

The angle frequency of de Broglie waves of particles \((\omega_B)_{1,2,3}\), is dependent on the external translational velocity \((v)_{1,2,3}\):

\[ (\omega_B = h/2m_\xi L_B^2 = m_\xi v^2/2h)_{1,2,3} \]

**7.10**

The important relation between the translational most probable velocity of particle \((v)\) and quantization number \((q)\), corresponding to resonant interaction of Bivacuum VPW
with pulsing particles, derived from (7.9b) is:

\[ v = c \left( \frac{q^2 - 1}{q^2} \right)^{1/2} \]  

At the conditions of triplets fusion, when \( q = 1 \), the resonant conditions correspond to translational velocity of particle equal to zero: \( v_{n=1} = 0 \).

When the quantized energy of \( E_{VPW_n^=} = q m c^2 \) corresponds to \( q = 2 \), the resonant translational velocity of particle from (7.11) should be: \( v_{q=2} = c \times 0.866 = 2.6 \times 10^{10}\text{cm/s} \).

At \( q = 3 \), we have from (7.11) for resonant velocity:

\[ v_{q=3} = c \times 0.942 = 2.83 \times 10^{10}\text{cm/s}. \]

It is natural to assume, that if the velocity of particles (v), corresponds to \( q < 1.5 \), the interaction of these pulsating particles with basic \( VPW_{n=1} \) should slow down their velocity, driving it to resonant conditions: \( q = 1 \), \( v \rightarrow 0 \). The 2nd and 3d laws of thermodynamics for the closed systems, reflecting the 'spontaneous' cooling of matter and tending the entropy to zero (Glansdorf and Prigogine, 1971), can be a consequence of just this condition.

On the other hand, if velocity of particles is high enough and corresponds to \( q > 1.5 \) in (7.11), their pull-in range interaction with excited \( VPW_{n=2} \) can accelerate them up to conditions: \( q = 2 \), \( v \rightarrow 2.6 \times 10^{10}\text{cm/s} \). If the starting particles velocity corresponds to \( q > 2.5 \), their forced resonance with even more excited \( VPW_{n=3} \) should accelerate them up to conditions: \( q = 3 \), corresponding to \( v = 2.83 \times 10^{10}\text{cm/s} \). The described mechanism of Bivacuum - Matter interaction, can be a general physical background of all kinds of overunity devices (Kaivarainen, 2004; http://arxiv.org/abs/physics/0207027; see also Naudin’s web site "The Quest For Overunity"). The coherent electrons and protons of hot enough plasma in stars and in artificial conditions also may get the additional energy from high-frequency virtual pressure waves of Bivacuum \( VPW_{n=2,3} \), excited by strong gravitational and/or magnetic fields.

We can see from the formulas above, that the action of Bivacuum Tuning energy due to interaction of Bivacuum low frequency \( VPW_{n=1} \) with particles, is responsible for realization of fundamental principle of Least action: \( \Delta S_{ext} \rightarrow 0 \) at \( TE \rightarrow 0 \), corresponding to minimization of translational kinetic energy of particles \( v_{ext} \rightarrow 0 \) at \( q \rightarrow 1 \).

The action of TE on virtual Cooper pairs of sub-elementary fermions is to slow down the velocity and kinetic energy of virtual particles and finally may turn them to real ones. Such a mechanism of real particles (like photon) origination may work in the process of photons emission by excited atoms, molecules and accelerated charges.

The second law of thermodynamics, formulated as a spontaneous irreversible transferring of the heat energy from the warm body to the cooler body or surrounding medium, also means slowing down the kinetic energy of particles, composing this body. Consequently, the 2nd law of thermodynamics, as well as Principle of least action, can be a consequence of Tuning energy (TE) minimization, slowing down particles thermal translational dynamics at pull-in range synchronization conditions:

\[ TE = h (\omega_{C} \rightarrow \omega_{0})^{\rightarrow 0} \]  

at \( (1.5 < q)^{\rightarrow 0} \rightarrow (q = 1) \)

The third law of thermodynamics states, that the entropy of equilibrium system is tending to zero at the absolute temperature close to zero. Again, this may be a consequence of forced combinational resonance between basic \( VPW_{n=1} \) and particles \( [C \equiv W] \) pulsation, when translational velocity of particles \( v \rightarrow 0 \) and \( TE = h (\omega_{C} \rightarrow \omega_{0})^{\rightarrow 0} \)
at \((q < 1,5) \to 0\) \((q = 1)\). At these conditions in accordance with our Hierarchic theory of condensed matter \([63, 64]\) the de Broglie wave length of atoms is tending to infinity and state of macroscopic Bose condensation of ultimate coherence and order, i.e. minimum entropy.

This result of our Unified theory could explain the energy conservation law, independently of the Universe cooling. Decreasing of thermal kinetic energy in the process of cooling is compensated by increasing of potential energy of the matter particle-particle interaction, accompanied Bose condensation. The energy of resonant interaction of matter with Bivacuum virtual pressure waves of basic energy: \(E_{VPW} = n\hbar\omega_0 = n m_0 c^2\) at \(n = 1\) is also increasing at \(v \to 0\), keeping the total energy of the Universe permanent.

### 7.1 The new approach to problem of Time

It follows from the section above, that the Principle of least action is a consequence of basic Tuning energy \((TE_{q=1})\) of Bivacuum influence on particles, driving the properties of matter on all hierarchical levels to Golden mean condition. It is shown, using the formula for action \((7.4)\), that the introduced dimensionless internal pace of time for any closed coherent system is determined by the pace of its kinetic energy change (anisotropic in general case), related to changes of Tuning energy (eq.7.5):

\[
\frac{dt}{d\ln t} = -d\ln (T_k)_{x,y,z} = -d\ln [(1 + R)TE]_{x,y,z}
\]

Using relations (7.13 and 7.5), the pace of the internal time and time itself for any closed system of particles can be presented via their acceleration and velocity:

\[
\left[\frac{dt}{t} = d\ln t = -\frac{dV}{v} \frac{2 - (v/c)^2}{1 - (v/c)^2}\right]_{x,y,z}
\]

\[
\left[\frac{t}{dV/dt} = \frac{1 - (v/c)^2}{2 - (v/c)^2} = \frac{[(1 + R)TE]}{d[(1 + R)TE]/dt}\right]_{x,y,z}
\]

The pace of time and time itself are positive \((t > 0)\), if the particle motion is slowing down \((dV/dt < 0)\) and negative, if particles are accelerating. For example, at temperature decreasing the time and its pace are positive. At temperature increasing they are negative. Oscillations of atoms and molecules in condensed matter, like pendulums, are accompanied by alternation the sign of acceleration and, consequently, sign of time. In the absence of acceleration \((dV/dt = 0\) and \(dv = 0\)), the time is infinitive and its pace zero:

\[
t \to \infty \quad \text{and} \quad \frac{dt}{t} \to 0
\]

\(\text{at} \quad dV/dt \to 0 \quad \text{and} \quad v = \text{const}\)

The postulated principle \([I]\) of conservation of internal kinetic energy of torus \((V^+)\) and antitorus \((V^-)\) of symmetric and asymmetric Bivacuum fermions/antifermions: \((BVF_{as}^+)\) \((eq.2.1)\) in fact reflects the condition of infinitive life-time of Bivacuum dipoles in symmetric and asymmetric states. The latter means a stability of sub-elementary fermions and elementary particles, formed by them.

In scale of the Universe, the decreasing of all-pervading Tuning energy \((TE)\) in \((7.12b)\):

\[
\{d[(1 + R)TE]/dt\} < 0 \quad (t > 0)
\]

means positive direction of "TIME ARROW" \(t > 0\). This corresponds to tending of the actual energy of particles to the energy of rest mass: \(m_0 c^2 \to q m_0 c^2\) \(at v \to 0\), meaning cooling of the Universe, if quantization number of virtual pressure waves \((VPW^+)\) is minimum: \(q = 1\).

The presented approach to the TIME problem differs from the conventional one,
following from relativistic theory, however, they do not contradict each other. For example, from (7.14) we can see, that in relativistic conditions, when as a result of acceleration \( (d\vec{v}/dt) > 0 \) and \( v \rightarrow c \) the negative internal time of closed system is tending to zero, like it follows from Lorentz relations for the 'own' time of system.

The internal time (7.14) turns to infinity and its pace (7.13a) to zero in the absence of acceleration and deceleration in a closed system \( (d\vec{v}/dt) = 0 \). The permanent \( (t \rightarrow \infty) \) collective motion of the electrons and atoms of \(^4\text{He}\) in superconductors and superfluid liquids, correspondingly, with constant velocity \( (v = \text{const}) \) in the absence of collisions and accelerations are good examples.

In Bivacuum with superfluid properties the existence of stable excitations, like quantized toruses/antitoruses of Bivacuum dipoles and vortical filaments - virtual guides (VirG), described in section 9, are also in-line with out time theory.

Each closed real system of elementary particles and macroscopic objects, rotating around common center on stable orbits, like in atoms, planetary systems, galactics, etc. is characterized by different centripetal acceleration \((-d\vec{v}/dt = \vec{v}^2/R = \omega^2R\) and velocity \((\vec{v})\). Corresponding characteristic times of such systems is equal to periods of their cycles: \( t = T = 2\pi/\omega \). The closed systems of virtual particles and virtual waves in Bivacuum do not follow the causality principle and the notion of time for such a systems is uncertain. In conditions of primordial symmetric Bivacuum, when the real and virtual particles are absent, the time is absent also.

At conditions: \([v = c = \text{const}]\), valid for the case of photons, we get from (7.14) the uncertainty for time, like: \( t = 0/0 \). The similar result we get for state of virtual Bose condensate (VirBC) in Bivacuum, when the external translational velocity of Bivacuum fermions (BVF\(^i\)) and Bivacuum bosons (BVB\(^\pm\)) is equal to zero \((v = 0 = \text{const})\). The latter condition corresponds to totally symmetric BVF\(^i\) and BVB\(^\pm\), of primordial Bivacuum, when their torus (V\(^+\)) and antitorus (V\(^-\)) mass, charge and magnetic moments compensate each other (Kaivarainen, 2005). It follows from (7.14) that the internal time for each selected closed system of particles is a parameter, characterizing the average velocity and acceleration of these particles, i.e. this system internal dynamics.

8. Virtual Replicas (VR) of material objects in Bivacuum

The basically new concept of Virtual replica (VR) or virtual hologram of any material object in Bivacuum, is introduced in our Unified theory (Kaivarainen, 2004, 2005). The VR is result of interference of primary all-pervading quantized Virtual Pressure Waves (VPW\(_q^+\)) and Virtual Spin waves (VirSW\(_q^{±\pm}\)) of Bivacuum, working as the "reference waves" in hologram formation and the same waves, modulated by de Broglie waves of atoms and molecules, representing the "object waves" VPW\(_m^±\) and VirSW\(_m^{±\pm}\). The frequencies of basic reference virtual pressure waves (VPW\(_q^+\) = VPW\(_q^-\)) and virtual spin waves (VirSW\(_q^{±\pm}\)) of Bivacuum are equal to Compton frequencies, like the carrying frequencies of \([C = W]\) pulsation of sub-elementary fermions of triplets at zero external translational velocity of particles \((v = 0)\) (Fig.3.1):

\[
[\omega_{\text{VPW}_q} = \omega_{\text{VirSW}_q} = \omega_0 = \omega_{C=W} = \text{qm_c^2/h}]
\]

Two kinds of primary wave modulation (VPW\(_m^±\) and VirSW\(_m^{±\pm}\)) are realized by cumulative virtual clouds (CVC\(_{±}^\pm\)), emitted/absorbed in the process of \([C = W]\) pulsation of pairs: \([F^+\}_C^{\pm}\) and \([F^+\}_W^{\pm}\) of elementary triplets (electrons, protons, neutrons) \(<[F^\pm_i] \simeq [F^\pm_i] >^i\), and the recoil angular momentum, generated by CVC\(_{±}^\pm\) of unpaired sub-elementary fermion \(F^+_i >^i\), correspondingly:
\[
[(F_+^{T} \approx F_{-}^{T})_C + (F_+^{T})_{W}] \xleftarrow{\text{+CVC}^{+} \rightarrow \text{Recoil}} [F_+^{T} \approx F_{-}^{T}]_W + (F_+^{T})_C \quad 8.1
\]

The in-phase \([C \Rightarrow W]\) pulsation of a sub-elementary fermion \(F_+^{T}\) and antifermion \(F_{-}^{T}\) of pair \([F_+^{T} \approx F_{-}^{T}]\), accompanied by reversible [emission \(\Rightarrow\) absorption] of cumulative virtual clouds CVC\(^{+}\) and CVC\(^{-}\) and the ‘object’ virtual pressure wave (VPW\(_m^\pm\) and VPW\(_m^{-}\)) excitation. However, the recoil energy and the angular momenta of CVC\(^{+}\) and CVC\(^{-}\) of \(F_{-}^{T}\) and \(F_+^{T}\) of pairs compensate each other and the resulting recoil energy of \([F_+^{T} \approx F_{-}^{T}]\) is zero.

Superposition of VPW\(_m^+\) and VPW\(_m^{-}\), excited by cumulative virtual clouds: CVC\(^{+}\) and CVC\(^{-}\), emitted and absorbed in the process of the in-phase \([C \Rightarrow W]\) pulsation of pairs \([F_+^{T} \approx F_{-}^{T}]\) of rotating triplets (Fig.3.1), activate quantized whirls in Bivacuum. The stability of VR of object, as a hierarchical system of quantized metastable torus-like vortex filaments structures formed by VPW\(_m^\pm\) and by VirSW\(_m^{\pm 1/2}\) excited by paired and unpaired sub-elementary fermions, correspondingly, in superfluid Bivacuum, could be responsible for so-called "phantom effect" of object after its removing to another distant place.

8.1 Bivacuum perturbations, induced by the oscillation of the total energy of de Broglie waves, accompanied by their thermal vibrations and recoil \(\Rightarrow\) antirecoil effects

In contrast to the situation with unpaired sub-elementary fermion \((F_+^{T})\) in triplets, the recoil/antirecoil momenta and energy, accompanying the in-phase emission/absorption of CVC\(_{S=1/2}^+\) and CVC\(_{S=1/2}^{-}\) by \(F_{+}^{T}\) and \(F_{-}^{T}\) of pair \([F_+^{T} \approx F_{-}^{T}]\), totally compensate each other in the process of their \([C \Rightarrow W]\) pulsation. Such pairs display the properties of neutral particles with zero spin and zero rest mass:

\[
[F_+^{T} \approx F_{-}^{T}]_C \xleftarrow{[E_{CVC}^{+} + E_{CVC}^{-}] + \Delta VP_{F+}^{T} \approx \Delta VP_{F-}^{T}} [F_+^{T} \approx F_{-}^{T}]_W \quad 8.2
\]

The total energy increment of elementary particle, equal to that of each of sub-elementary fermions of triplet, generated in nonequilibrium processes, accompanied by entropy change, like melting, boiling, etc., can be presented in a few manners:

\[
\Delta E_{\text{tot}} = \Delta(m_+^c e^2) = \Delta \left( \frac{m_0 c^2}{\sqrt{1 - (v/c)^2}^{1/2}} \right) = 8.3
\]

\[
= \frac{m_0 \Delta v}{R^2} = \frac{p}{R^2} \Delta v = \frac{h}{\lambda_B R^2} \Delta v
\]

or : \(\Delta E_{\text{tot}} = \Delta[(m_+^c - m_{-}^c) e^2 (c/v)^2] = \frac{2 T_k}{R^2} \Delta v \quad 8.4 \]

or : \(\Delta E_{\text{tot}} = \frac{2 T_k}{R^2} \Delta v = \Delta[R(m_0 e^2)^{\text{in}_{rot}}] + \Delta(m_+^c v^2)^{\text{rot}} \quad 8.4a\)

where: \(R = \sqrt{1 - (v/c)^2}\) is the relativistic factor; \(\Delta v\) is the increment of the external translational velocity of particle; the actual inertial mass of sub-elementary particle is: \(m_+^c = m_0 / R; \ p = m_+^c v = h / \lambda_B\) is the external translational momentum of unpaired sub-elementary particle \(F_+^{T} >^t\), equal to that of whole triplet \([F_+^{T} \approx F_{-}^{T}] + F_+^{T} >^t\); \(\lambda_B = h / p\) is the de Broglie wavelength of particle; \(2 T_k = m_+^c v^2\) is a doubled kinetic energy; \(\Delta \ln v = \Delta v / v\).

The increments of internal rotational and external translational contributions to total energy of the de Broglie wave (see eq. 8.4a) are, correspondingly:
\[ \Delta [R(m_0c^2)^{in}_{rot}] = -2T_k(\Delta v/v) \]

\[ \Delta (m_j^2v^2)_{rot}^{ext} = \Delta (2T_k)_{rot}^{ext} = 2T_k \frac{1+R^2}{R^2} \frac{\Delta v}{v} \]

The time derivative of total energy of elementary de Broglie wave, following from 4.1 - 4.1b is:

\[ \frac{dE_{tot}}{dt} = 2T_k \frac{dv}{R^2} - 2T_k \frac{d\ln v}{dt} \]

Between the increments of energy of triplets, equal to that of unpaired \( \Delta E_{tot}^{F_+F_-} = \Delta E_{F_+}^{F_-} \) and increments of modulated CVC\(_m^+\) and CVC\(_m^-\), emitted by pair \([F_+ \gg F_-]\) in the process of \([C \rightarrow W]\) transition, the direct correlation is existing.

These cumulative virtual clouds modulated by particle’s de Broglie wave \((\lambda_B = h/m_0v)\): CVC\(_m^+\) and CVC\(_m^-\), of paired sub-elementary fermions, superimposed with basic virtual pressure waves (VPW\(_0\)) of Bivacuum, turn them to the object waves (VPW\(_m^\pm\)), necessary for virtual hologram of the object formation:

\[ \Delta E_{F_+}^{F_-} = \frac{h}{\lambda_B R^2} \Delta v = \frac{2T_k}{R^2} \Delta \ln v \rightarrow \Delta \text{(VPW}^n_{m}) \]

\[ - \Delta E_{F_+}^{F_-} \rightarrow \Delta \text{(VPW}^n_{m}) \]

The virtual pressure waves represent oscillations of corresponding virtual pressure (VirP\(_m^\pm\)).

The increment of total energy of fermion or antifermion, equal to increment of its unpaired sub-elementary fermion can be presented via increments of paired sub-elementary fermions (8.5 and 8.5a), like:

\[ \Delta E_{tot} = \Delta E_{F_+} = \frac{1}{2} \left( \Delta E_{F_+}^{F_-} - \Delta E_{F_+}^{F_-} \right) + \frac{1}{2} \left( \Delta E_{F_+}^{F_-} + \Delta E_{F_+}^{F_-} \right) = \Delta T_k + \Delta V^+ \]

where, the contributions of the kinetic and potential energy increments to the total energy increment, interrelated with increments of positive and negative virtual pressures (\(\Delta \text{VirP}^\pm\)), are, correspondingly:

\[ \Delta T_k = \frac{1}{2} \left( \Delta E_{F_+}^{F_-} - \Delta E_{F_+}^{F_-} \right) \sim \frac{1}{2} (\Delta \text{VirP}^+ - \Delta \text{VirP}^-) \sim \alpha \Delta (m_v^2v^2)_{F_+} \]

\[ \Delta V = \frac{1}{2} \left( \Delta E_{F_+}^{F_-} + \Delta E_{F_+}^{F_-} \right) \sim \frac{1}{2} (\Delta \text{VirP}^+ + \Delta \text{VirP}^-) \sim \beta \Delta (m_v^2 + m_v^-) c_{F_+}^2 \]

The specific information of any object is imprinted in its Virtual Replica (VR), because cumulative virtual clouds (CVC\(_m^\pm\)) of the object’s elementary particles and their superposition with Bivacuum pressure waves and Virtual spin waves: VPW\(_m^\pm\) and VirSW\(_m^{1/2}\) are modulated by frequency, phase and amplitude of de Broglie waves of molecules, composing this object. Comparing eqs. 8.8a and 6.9 we may see, that the modulated gravitational virtual pressure waves form a part of VR.

### 8.2 Modulation of the basic Virtual Pressure Waves (VPW\(_0\)) and Virtual Spin Waves (VirSW\(_q^{1/2}\)) of Bivacuum by molecular translations and librations

The external translational/librational kinetic energy of particle \((T_k)_{tr, lb}\) is directly related to its de Broglie wave length \((\lambda_B)\), the group \((v)\), phase velocity \((v_{ph})\) and frequency \((v_B = \omega_B/2\pi)\):

\[ \left( \lambda_B = \frac{h}{m_0v} = \frac{h}{2m_0vT_k} = \frac{v_{ph}}{v_B} = 2\pi \frac{v_{ph}}{\omega_B} \right)_{tr, lb} \]

where the de Broglie wave frequency is related to its length and kinetic energy of
It follows from our model, that zero-point frequency of \([C \approx W]\) pulsation \((\omega_0)^i\) of sub-elementary fermions and antifermions, forming triplets of elementary particles
\(< [F^+_i \approx F^-_i] + F^+_j \approx F^-_j>^i\), accompanied by \([\text{emission} \approx \text{absorption}]\) of cumulative virtual clouds \(CVC^\pm\) has has the same value, as a basic (reference) frequency
\((\omega_{q=1} = \omega_0 = m_0 c^2/h)^i\) of Bivacuum.

The total energy of de Broglie wave and resulting frequency of pulsation \((\omega_{C=W})\) (see eq. 4.3) is a result of modulation of the internal frequency, related to the rest mass of particle, by the empirical most probable frequency of de Broglie wave of the whole particle \((\omega_B)\), determined by its most probable external momentum: \( p = m_i v\).

In a composition of condensed matter this value is different for thermal librations and translation of molecules. The corresponding most probable modulation frequencies of translational and librational de Broglie waves are possible to calculate, using new Hierarchic theory of condensed matter and based on this theory computer program (Kaivarainen, 2001; 2003; 2004; 2005).

The interference between the basic \((q = j - k = 1)\) reference virtual spin waves \((\text{VirSW}_{q=1}^{1/2})\) and virtual pressure waves \((\text{VPW}_{q=1}^z)\) of Bivacuum with virtual ‘object waves’, modulated by the librational and translational de Broglie waves \((\lambda_{tr,lb} = h/m_i v)\) of molecules, produce the holographic-like image or Virtual Replicas (VR) of the object.

The frequencies of virtual pressure waves \((\text{VPW}_{m}^z)\) and virtual spin waves \((\text{VirSW}_{m}^{1/2})\) are modulated by de Broglie waves of the object particles. Corresponding modulation frequencies are related to frequencies of librational \((\omega_{lb})\) and translational \((\omega_{tr})\) de Broglie waves of molecules of matter (8.10) in accordance to rules of combinational resonance:

\[
\omega_i^l = R \omega_0^l + g \omega_{tr}^l + r \omega_{lb}^l \equiv [R \omega_0^l + g \omega_{tr}^l]
\]

\[
\omega_i^l = R \omega_0^l + r \omega_{lb}^l + g \omega_{tr}^l \equiv R \omega_0^l + r \omega_{lb}^l
\]

\[
R = \sqrt{1 - (v/c)^2}; \quad g, r = 1, 2, 3\ldots (\text{integer numbers})
\]

Each of 24 collective excitations of condensed matter, introduced in our Hierarchic theory (Kaivarainen, 1995; 2001, 2004), has its own characteristic frequency and can be imprinted in Virtual Replica of the object, as a corresponding pattern.

Three kinds of modulations: \(\text{frequency, amplitude and phase}\) of the object \((\text{VPW}_{m}^z)\) and \((\text{VirSW}_{m}^{1/2})\) by de Broglie waves of the object’s molecules may be described by known relations (Prochorov, 1999):

1. \(\text{The frequencies of virtual pressure waves} \((\omega_{VPW}^M)\) and spin waves \((\omega_{VPW}^M)\), modulated by translational and librational de Broglie waves of the object’s molecules, can be presented as:

\[
\omega_{\text{VPW}}^M = R \omega_0^M + \Delta \omega_{tr}^M \cos \omega_{tr}^M t
\]

\[
\omega_{\text{VPW}}^M = R \omega_0^M + \Delta \omega_{lb}^M \cos \omega_{lb}^M t
\]

The Compton pulsation frequency of elementary particles (section 1.4; 1.5) is equal to basic frequency of Bivacuum virtual waves at \(q = j - k = 1:\)

\[
\omega_0^l = m_i c^2/h = \omega_{\text{VPW}_{q=1}^z, \text{VirSW}_{q=1}^*}
\]

8.12

Such kind of modulation is accompanied by two satellites with frequencies: \((\omega_0^l + \omega_{tr,lb}^*)\) and \((\omega_0^l - \omega_{tr,lb}^*)\), \(\Delta \omega_{tr,lb}^l\). The latter is named frequency deviation. In our case:
\( \omega_0^s \sim 10^{21} s^{-1} >> \omega_B^{r,lb} \sim 10^{12} s^{-1} \) and \( \Delta \omega_{r,lb} >> \omega_B^{r,lb} \).

The temperature of condensed matter and phase transitions may influence the modulation frequencies of de Broglie waves of its molecules.

2. The amplitudes of virtual pressure waves (VPW\(_m^\pm\)) and virtual spin waves VirSW\(_m^{\pm 1/2}\) (informational waves) modulated by the object are dependent on translational and librational de Broglie waves frequencies as:

\[ A_{\text{VPW}} = A_0 (\sin R \omega_0^s t + \gamma \omega_B^s \sin t \cdot \cos \omega_B^s t) \]

\[ I_{\text{VirSW}} = I_0 (\sin R \omega_0^s t + \gamma \omega_B^s \sin t \cdot \cos \omega_B^s t) \]

where: the informational/spin field amplitude is determined by the amplitude of Bivacuum fermions \([BVF^\dagger = BVF^\dagger]\) equilibrium constant oscillation:

\[ I_s = I_{\text{VirSW}} \sim K_{BVF^\dagger = BVF^\dagger} (t) \]

The index of frequency modulation is defined as: \( \gamma = (\Delta \omega_{r,lb}/\omega_B^{r,lb}) \). The carrying zero-point pulsation frequency of particles is equal to the basic frequency of Bivacuum virtual waves: \( \omega_{\text{VPW}} = \omega_0^s \). Such kind of modulation is accompanied by two satellites with frequencies: \( (\omega_0^s + \omega_B^{r,lb}) \) and \( (\omega_0^s - \omega_B^{r,lb}) = \Delta \omega_{r,lb} \). In our case:

\( \omega_0^s \sim 10^{21} s^{-1} >> \omega_B^{r,lb} \sim 10^{12} s^{-1} \) and \( \gamma >> 1 \).

The fraction of molecules in state of mesoscopic molecular Bose condensation (mBC), representing, coherent clusters (Kaivarainen, 2001a,b; 2004) is a factor, influencing the amplitude \( A_0 \) and such kind of modulation of Virtual replica of the object.

3. The phase modulated VPW\(_m^\pm\) and VirSW\(_m^{\pm 1/2}\) by de Broglie waves of molecules, related to their translations and librations, can be described like:

\[ A_{\text{VPW}}^M = A_0 \sin (R \omega_0^s t + \Delta \phi_{r,lb} \sin \omega_B^s t) \]

\[ I_{\text{VirSW}}^M = I_0 \sin (R \omega_0^s t + \Delta \phi_{r,lb} \sin \omega_B^s t) \]

The value of phase increment \( \Delta \phi_{r,lb} \) of modulated virtual waves of Bivacuum \( (VPW_m^\pm\) and \( VirSW_m^{\pm 1/2} \)), contains the information about geometrical properties of the object.

The phase modulation takes place, if the phase increment \( \Delta \phi_{r,lb} \) is independent on the modulation frequency \( \omega_B^{r,lb} \).

The virtual holographic image, resulting from interference pattern of the virtual object waves: \( VPW_m^\pm\) and \( VirSW_m^{\pm 1/2} \), modulated (scattered) by translations and librations of molecules, with similar reference waves of Bivacuum \( (VPW_q^\pm\) and \( VirSW_q^{\pm 1/2} \)) contains full information about the object’s internal dynamic and spatial properties and may be named “Virtual Replica (VR)” of the object.

9 Possible mechanism of entanglement between remote elementary particles via Virtual Guides of spin, momentum and energy (VirGS,M,E)

In accordance to our theory, the instant nonlocal quantum entanglement between two or more distant similar elementary particles (electrons, protons, neutrons, photons), named [Sender (S)] and [Receiver (R)], revealed in a lot of experiments, started by Aspect and Granger (1983), involves a few stages:

1. Superposition of their nonlocal and distant components of Virtual replicas (VR) or Virtual hologram, formed by interference of modulated by de Broglie waves of object Virtual spin waves: \([VirSW_m^{\pm 1/2}(S) \leftrightarrow VirSW_m^{\pm 1/2}(R)]\) and Virtual pressure waves: \([VPW_m^\pm(S) \leftrightarrow VPW_m^\pm(R)]\) with corresponding reference waves of Bivacuum VirSW\(_q^{\pm 1/2}\) and VPW\(_q^\pm\), described in Section 8.2;

2. Tuning (frequency and phase synchronization) of de Broglie waves of remote interacting identical particles (like electrons, protons) and their complexes in form of atoms
forms
Virtual Guide
opposite Bivacuum fermions: BVF
for two synchronized photons (bosons) of opposite spins.

- proton) with similar frequency of their own axes in opposite directions. The resulting angular moment (spin) of such pair is zero.

Two remote coherent triplets - elementary particles, like (electron - electron) or (proton - proton) with similar frequency of their own axes in opposite directions. The resulting angular moment (spin) of such pair is also zero.

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The double VirG^{BV\cdot BV\cdot BVF}_{SME} can be transformed to single VirG^{BV\cdot BV\cdot BVF}_{SME} by conversion of opposite Bivacuum fermions: BVF^\dagger = [V^+ \uparrow V^-] and BVF^\dagger = [V^+ \downarrow V^-] to the pair of Bivacuum bosons of two possible alternatives of polarization:

\[ \text{BVB}^+ = [V^+ \uparrow V^-] \quad \text{or} \quad \text{BVB}^- = [V^+ \downarrow V^-] \]

Superposition of two nonlocal virtual spin waves excited by similar elementary particles (electrons or protons) of Sender (VirSW_{m=1/2}^S) and Receiver (VirSW_{m=1/2}^R) of the same pulsation frequency and opposite spins, i.e. opposite phase of [C = W] pulsation, forms Virtual Guide of spin, momentum and energy (VirG_{SME}^i) (Fig.3.4):.

\[ \left[ < F^\dagger_c \approx F^\dagger_s >_S \right]_{BVF}^{VirSW^s_{SME}} = \left[ < F^\dagger_s \approx F^\dagger_r >_R \right]_{BVF}^{VirSW^r_{SME}} \]

9.1

9.1a

The spin exchange via VirG_{SME} is accompanied either by the instant change of Bivacuum boson polarization: [BVB^+ = BVB^-] or by instant spin state change of both Bivacuum fermions, forming virtual Cooper pairs in the double virtual microtubule:

\[ [BVF^\dagger \approx BVF^\dagger]_{SME} \]

9.2

The radius of virtual microtubules of VirG_{SME} is dependent on generation of torus and antitorus \((i = e, \mu, \tau)\), forming them:

\[ L^e_V = h/m^e_O c \gg L^\mu_V = h/m^\mu_O c \gg L^\tau_V = h/m^\tau_O c \]

The radius of VirG^e_{SME}, connecting two remote electrons, is the biggest one (L^e). The radius of VirG^\mu_{SME}, connecting two protons or neutrons (L^\mu) is about \(3.5 \times 10^3\) times smaller. The entanglement between similar atoms in pairs, like hydrogen, oxygen, carbon or nitrogen can be realized via complex virtual guides of atoms (VirG_{SME}^a), representing multishell constructions.

The increments of momentum \(\Delta p = \Delta (m^v c)_{tr,ib}\) and kinetic \((\Delta T^k)_{tr,ib}\) energy transmission from [S] to [R] of selected generation of elementary particles is determined by the translational and librational velocity variation (\(\Delta v\)) of nuclei of (S). This means, that energy/momentum transition from [S] to [R] is possible, if they are in nonequilibrium state.
The variation of kinetic energy of atomic nuclei under external force application, induces nonequilibrium in a system \((S + R)\) and decoherence of \([C \leftrightarrow W]\) pulsation of protons and neutrons of \([S]\) and \([R]\). The nonlocal energy transmission from \([S]\) to \([R]\) is possible, if the decoherence is not big enough for disassembly of the virtual microtubules and their systems in the case of atoms. The electronic \(\text{VirG}_{SME}^\text{VirG}\), as more coherent (not so dependent on thermal vibrations), can be responsible for stabilization of the complex atomic Virtual Guides \(\sum \text{VirG}_{SME}^\text{VirG}\).

The values of the energy and velocity increments of free elementary particles are interrelated by (8.3).

The instantaneous energy flux via \((\text{VirG}_{SME})^i\), is mediated by pulsation of energy and radii of torus \((V^+)\) and antitorus \((V^-)\) of Bivacuum bosons: \(\text{BVB}^+ = [V^+ \downarrow V^-]\). Corresponding energy increments of the actual torus and complementary antitorus of \(\text{BVB}^\pm\), forming \((\text{VirG}_{SME})^i\), are directly related to increments of Sender particle external velocity \((\Delta v)\):

\[
\Delta E_{V^+} = +\Delta m^+ c^2 = \left(\frac{p^+}{R^2} (\Delta v)_{F_i}^{[F^+ \leftrightarrow F^-]} \right) = m^+ c^2 \left(\frac{\Delta L_{V^+}}{L_{V^+}}\right)_{N,S} \quad \text{actual} \quad 9.3
\]

\[
\Delta E_{V^-} = -\Delta m^- c^2 = \left(\frac{-p^-}{R^2} (\Delta v)_{F_i}^{[F^+ \leftrightarrow F^-]} \right) = -m^- c^2 \left(\frac{\Delta L_{V^-}}{L_{V^-}}\right)_{N,S} \quad \text{complementary} \quad 9.4
\]

where: \(p^+ = m^+ \vec{v}\); \(p^- = m^- \vec{v}\) are the actual and complementary momenta; \(L_{V^+} = h/m^+ c\) and \(L_{V^-} = h/m^- c\) are the radii of torus and antitorus of \(\text{BVB}^\pm = [V^+ \uparrow V^-]\), forming \(\text{VirG}_{SME}^\text{VirG}\).

The nonlocal energy exchange between \([S]\) and \([R]\) is accompanied by the instant pulsation of radii of tori \((V^+)\) and antitori \((V^-)\) of BVF and \(\text{BVB}^\pm\), accompanied by corresponding pulsation \(\left|\Delta L_{V^\pm}/L_{V^\pm}\right|\) of the whole virtual microtubule \(\text{VirG}_{SME}\) (Fig.3.4).

Most effectively the proposed mechanism of spin (information), momentum and energy exchange can work between Sender and Receiver, containing coherent molecular clusters - mesoscopic Bose condensate (mBC) (Kaivarainen, 2001, 2005).

The instantaneous angular momentum (spin) exchange between \([S]\) and \([R]\) does not need the radius pulsation, but only the instantaneous polarization change of Bivacuum dipoles \((\text{BVB}^+ \rightleftharpoons \text{BVB}^-)^i\) or Cooper pairs \([\text{BVF}^\dagger \rightleftharpoons \text{BVF}^\dagger]\) \(\rightleftharpoons [\text{BVF}^\dagger \rightleftharpoons \text{BVF}^\dagger]\), forming \(\text{VirG}_{SME}\).
The mechanism of nonlocal Bivacuum mediated interaction (entanglement) between two distant unpaired sub-elementary fermions of 'tuned' elementary triplets (particles) of the opposite spins \( \sigma \) and \( \sigma' \), with close frequency of \( \omega_0 = m_0 c^2 / \hbar \) of particles. The tunnelling of momentum and energy increments: \( \Delta \mathbf{p} = \Delta \mathbf{E} \approx \mathbf{p} \approx \mathbf{E} \) from Sender to Receiver and vice-verse via Virtual spin-momentum-energy Guide [VirG\(_{\text{SME}}\)] is accompanied by instantaneous pulsation of diameter \( \lambda_B = \alpha / \sqrt{\omega_0} \) of this virtual microtubule, formed by Bivacuum bosons \( \text{BVB}^\pm \) or double microtubule, formed by Cooper pairs of Bivacuum fermions: \( \text{BVF}^\dagger \approx \text{BVF} \). The spin state exchange between \( [S] \) and \( [R] \) can be realized by the instantaneous change polarization of Cooper pairs: \( \text{BVF}^\dagger \approx \text{BVF} \) and Bivacuum bosons: \( \text{BVB}^+ \approx \text{BVB}^- \).

In virtual microtubules \( \text{VirG}_{\text{SME}} \) the time and its 'pace' are uncertain: \( t = 0 \), as far the external velocities \( \mathbf{v} \) and accelerations \( \mathbf{a} = \mathbf{dv} / \mathbf{dt} \) of Bivacuum dipoles, composing such virtual Bose condensate, are zero (see eqs. 7.13a and 7.14).

9.1 The role of tuning force \( (F_{VPW^\pm}) \) of virtual pressure waves \( VPW_{\omega}^\pm \) of Bivacuum in entanglement

The tuning between two similar elementary particles: 'sender (S)' and 'receiver (R)' via \( \text{VirG}_{\text{SME}} \) may be qualitatively described, using well known model of damped harmonic oscillators, interacting with all-pervading virtual pressure waves \( (VPW^\pm) \) of Bivacuum with fundamental frequency \( \omega_0 = m_0 c^2 / \hbar \). The criteria of tuning - synchronization of [S] and [R] is the equality of the amplitude probability of resonant energy exchange of Sender and Receiver with virtual pressure waves \( (VPW_{\omega}^\pm) \): \( A_\omega^S = A_\omega^R \), resulting from minimization of frequency difference \( (\omega_S - \omega_0) \to 0 \) and \( (\omega_R - \omega_0) \to 0 \):
where the frequencies of \( C \mapsto W \) pulsation of particles of Sender (\( \omega_S \)) and Receiver (\( \omega_R \)) are:

\[
\omega_R = \omega_{C=W} = R \omega_0 + (\omega_0^{\text{alt}})_R
\]

\[
\omega_S = \omega_{C=W} = R \omega_0 + (\omega_0^{\text{alt}})_S
\]

\( \gamma \) is a damping coefficient due to decoherence effects, generated by local fluctuations of Bivacuum deteriorating the phase/spin transmission via \( \text{VirG}_{\text{SME}} \). (\( m_J^{\tau} \))_{S,R} are the actual mass of (S) and (R); \([F_{VPW}]\) is a tuning force of virtual pressure waves \( VPW^{\pm} \) of Bivacuum with tuning energy \( E_{VPW} = q m_0 c^2 \) and wave length \( L_{VPW} = h/m_0 c \)

\[
F_{VPW^{\pm}} = \frac{E_{VPW}}{L_{VPW}} = \frac{q}{\hbar} m_0^2 c^3
\]

The most probable Tuning Force (TF) has a minimum energy, corresponding to \( q = j - k = 1 \).

The influence of virtual pressure force \( (F_{VPW}) \) stimulates the synchronization of \([S]\) and \([R]\) pulsations, i.e. \( \omega_R \mapsto \omega_S \mapsto \omega_0 \). This fundamental frequency \( \omega_0 = m_0 c^2/h \) is the same in any space volume, including those of Sender and Receiver.

The VirG_{SME} represent quasi 1D macroscopic virtual Bose condensate with a configuration of single microtubules, formed by Bivacuum bosons \( (BVB^{\pm}) \) or with configuration of double microtubules, composed from Cooper pairs as described in previous section.

The effectiveness of entanglement between two or more similar elementary particles is dependent on synchronization of their \([C \mapsto W]\) pulsation frequency and 'tuning' the phase of these pulsations via nonlocal virtual guide \( \text{VirG}_{\text{SME}}^{S,R} \) between Sender and Receiver under the action of the virtual pressure waves \( VPW^{\pm}_{q=1} \) and Tuning energy of Bivacuum.

The mechanism proposed may explain the experimentally confirmed nonlocal interaction between coherent elementary particles (Aspect and Gragier, 1983), atoms and between remote coherent clusters of molecules.

Our theory predicts that the same mechanism, involving a nonlocal net of VirG_{SME}, may provide the entanglement even between macroscopic systems, including biological ones. It is possible, if the frequency and phase of \([C \mapsto W]\) pulsations of clusters of their particles in state of mesoscopic Bose condensation (Kaivarainen, 2001; 2004) are 'tuned' to each other.

### 10. Experimental data, confirming Unified theory (UT)

#### 10.1 The electromagnetic radiation of nonuniformly accelerating charges

It follows from our theory, that the charged particle, nonuniformly accelerating in cyclotron, synchrotron or in undulator, can be a source of photons. The same is true for dipole radiation.

From eqs. (4.10, 4.10a and 6.15a) we get general expression for electromagnetic radiation, dependent on the doubled kinetic energy \( \Delta(2T) = \Delta(m_J^2, v^2) \) of alternately accelerated charged particle and related inelastic recoil effects, accompanied its \([C \mapsto W]\) pulsation:
\[ h\omega_{EH} + \Delta 2T_k = \Delta \langle (1 + R)[m_i c^2 - m_0 c^2] \rangle = \Delta [ (1 + R) TE ] = \]

\[ \text{or : } h\omega_{EH} + \Delta 2T_k = \Delta [(\alpha m_i v^2)_{rec} + m_i v^2]^{ext} \]

where \( R = \sqrt{1 - (v/c)^2} \) is relativistic factor

We can see from this formula, that the alternation of kinetic energy of charged particle, resulting from its alternating acceleration, can be accompanied by electromagnetic radiation. This effect occurs, if the jump of kinetic energy \( \Delta 2T_k \) and corresponding inelastic recoil energy jump: \( \Delta (\alpha m_i v^2)_{rec} \) exceed the energetic threshold necessary for photon origination. The \( [C \Rightarrow W] \) pulsations of all three sub-elementary fermions of triplets of charged elementary particles: \( \langle [F_i^1 \Rightarrow F_i^1]_W + (F_i^1)_C \rangle_{p,e} \Rightarrow \langle (F_i^1 \Rightarrow F_i^1)_C + (F_i^1)_W \rangle_{p,e} \), modulated by external translational dynamics, participate in photon creation. In accordance with our model (Fig.3.2) photons are the result of fusion of the electron and positron like triplets. They can be a result of correlated asymmetric excitation of three pairs of Bivacuum Cooper pairs \( 3[BVF^1 \Rightarrow BVF^1] \) by accelerated electrons or positrons, like in the case of excited atoms and molecules.

It is the Tuning energy (TE) of Bivacuum: \( TE = [m_i c^2 - q m_0 c^2] \), that induces the transitions of the excited state of particle to its ground state, corresponding to the rest mass energy:

\[ m_i c^2 \xrightarrow{TE} m_0 c^2 \text{ at } v_{ext}^{\text{kin}} \to 0, \quad \text{if } q = 1 \]

There are huge numbers of experimental data confirming this consequence of our theory for electromagnetic radiation. The gravitational radiation in form of Virtual Pressure Waves (VPW) in similar conditions is also predictable.

At the permanent (uniform) acceleration of the charged elementary particle, moving along the hyperbolic trajectory, the radiation is absent. This nontrivial experimental fact also can be explained by our Unified theory. In accordance to UT, the recoil energy, following radiation of CVC at \( [C \Rightarrow W] \) transitions, equal to deceleration of particle in \( [C] \) phase, activate the elastic longitudinal spherical waves in superfluid Bivacuum matrix. If the energy of this activation energy is smaller than threshold of inelastic recoil energy, necessary for photons origination, there are no EM radiation of moving particle. The uniform acceleration, in contrast to alternative one, do not provide the fulfilment of condition of overcoming of corresponding activation barrier and the EM radiation is absent. Consequently, the real photon radiation by charged particles and other dissipation inelastic process in Bivacuum matrix, are possible only in the conditions of nonuniform and big enough jumps of particles acceleration.

Some similarity is existing between the mechanisms of inelastic phonons excitation in solids, detected by \( \gamma \) –resonance spectroscopy, and photons excitation in Bivacuum by alternatively accelerated particle.

The one more consequence of UT is that the radiation of photons, induced by accelerations of charged elementary particle, should be strongly asymmetric and coincide with direction of charged particle propagation in space. This is also well confirmed result by analysis of synchrotron and ondulator radiation.

Most of energy, emitted by relativistic particle is located in direction, close to its instant velocity \( (v = v_{ext} \to c) \) in narrow angles range, determined by semiempirical expression (Ginsburg, 1987):

\[ \Delta \theta \approx [1 - (v/c)^2]^{1/2} = \frac{m_0 c^2}{E} \to 0 \]

where: \( E = mc^2 = m_i c^2 \) is a total relativistic energy of the charged particle.
Our theory leads to the same result. Formula (2.11) for relativistic condition \( v \to c \), can be easily transformed to:

\[
[1 - (v/c)^2]^{1/2} = \left| \frac{-m_p}{m_{1/2}} \right|^{1/2} = \frac{m_0c^2}{m'_0c^2} = \frac{L_{1/2}^+}{L_0} \approx \Delta \theta \to 0 \tag{10.2b}
\]

where, the radius of the actual torus, taking into account (4.3), is:

\[
L_{1/2}^+ = \left( \frac{h}{m_0 c} v_{in}^{\nu} \right) \to 0 \quad \text{at} \quad v \to c
\]
as far:

\[
\mathbf{m}_1^+ = m = \frac{m_0}{\sqrt{1 - (v/c)^2}} \to \infty \quad \text{at} \quad v \to c \tag{10.2c}
\]

and the Compton radius of sub-elementary particle is \( L_0 = (h/m_0 c) = \text{const} \).

Their ratio determines the angle range of radiation of accelerating particle. As far, in accordance to our approach, the actual energy of particle is determined by the inertial mass:

\[
E = m_1^+ c^2 = mc^2
\]

we can see that eq. 10.2a coincides with eq.10.2b.

10.2 The double turn (720°), as a condition of the fermions spin state reversibility

It is known fact, that the total rotating cycle for spin of the electrons or positrons is not 360°, but 720°, i.e. double turn by external magnetic field of special configuration, is necessary to return elementary fermions to starting state (Davies, 1985). The correctness of our model of elementary particles was testified by its ability to explain this nontrivial fact (Kaivarainen, 2004a,b) on example of the electron or proton:

\[
< [F_{1/2}^+ \otimes F_{1/2}^-]_{x,y} + (F_{1/2}^-)_z >^{180°}\tag{10.3}
\]

The external rotating \( \mathbf{H} \) field interact with sub-elementary fermions/antifermions of triplets in two stage manner \((2 \cdot 360°)\), changing their spins. The angle of spin rotation of sub-elementary particle and antiparticles of neutral pairs \([F_{1/2}^+ \otimes F_{1/2}^-]\) are the additive parameters. It means that turn of resulting spin of pair on 360° includes reorientation spins of each \(F_{1/2}^+\) and \(F_{1/2}^-\) only on 180°. Consequently, the full spin turn of pair \([F_{1/2}^+ \otimes F_{1/2}^-]\) resembles that of Möbius transformation.

The spin of unpaired sub-elementary fermion \( F_{1/2}^- >\), in contrast to paired ones, makes a full turn each 360°, i.e. twice in 720° cycle:

\[
< [(F_{1/2}^-)_x \otimes (F_{1/2}^-)_y] + (F_{1/2}^-)_z >^{360°} \to \to < [(F_{1/2}^-)_x \otimes (F_{1/2}^-)_y] + (F_{1/2}^-)_z >^{360°} \tag{10.4}
\]

The difference between the intermediate - 2nd stage and the original one in (10.4) is in opposite spin states of paired sub-elementary particle and antiparticle:

\[
[(F_{1/2}^-)_x \otimes (F_{1/2}^-)_y]^{360°} \to [(F_{1/2}^-)_x \otimes (F_{1/2}^-)_y]^{180°+180°} \tag{10.5}
\]

It follows from our consideration, that the 3D spatial organization of the electron (positron) is asymmetric, and some difference \((F_{1/2}^-)_x \neq (F_{1/2}^-)_y\) and \((F_{1/2}^-)_y \neq (F_{1/2}^-)_y\) is existing. The \([C \neq W]\) pulsation of unpaired sub-elementary fermion \((F_{1/2}^-)_y\) is counterphase and spatially compatible in basic state of the electron triplet with \((F_{1/2}^-)_y\) and in the intermediate state - with its partner \((F_{1/2}^-)_y\) in triplets (10.4).

One more known “strange” experimental result can be explained by our dynamic model of triplets of elementary particles. The existence of two paired in-phase pulsating sub-elementary fermions (10.5) with opposite parameters, exchanging by spin, charge and energy in the process of their \([C \neq W]\) pulsation, can be responsible for the two times stronger magnetic field, generated by electron, as compared with those, generated by
rotating sphere with charge $|e^-|$.

10.3. Michelson-Morley experiment, as a possible evidence for the Virtual Replica of the Earth existing

The experiments, performed in 1887 by Michelson-Morley and similar later experiments of higher precision, where based on checking the difference of light velocity in the direction of Earth motion on its orbit around the Sun and in the direction normal or opposite to the this one. In the case of fixed aether (vacuum), independent of the Earth motion, one may anticipate that the difference in these two light velocities should exist. The absence of any difference was interpreted, as the absence of the Earth - independent fixed aether. This conclusion was used by Einstein in his postulate of permanency of light velocity in any inertial systems.

The conjecture of virtual replica (VR), following from our particles duality and Bivacuum models, allows another interpretation of Michelson-Morley experiments. The VR of the Earth represents Bivacuum, modulated by collective effect of the planet’s particles corpuscle - wave pulsation (see section III-H).

In accordance with properties of distant component of VR, it has at least as big diameter, as the Earth atmosphere and moves in space together with planet. It is obvious, that in such 'virtual shell' of the Earth the light velocity, dependent on Bivacuum properties, should be the same in any directions.

I propose the experiment, which may confirm the existence of both: the VR and the Aether/Bivacuum, as a certain medium, assuming, that perturbation of Bivacuum of VR on the distance of about few hundred kilometers from the planet surface is smaller than on the surface.

If we perform one series of the Michelson-Morley like experiments on the satellite, rotating with the same angle velocity as the Earth, i.e. fixed as respect to the Earth surface and another series of experiments on the surface, the difference in results will confirm our Virtual Replica theory. The absence of difference will confirm the absence of aether and equality of light velocity in any inertial system.

10.4 Interaction of particles with their Virtual Replicas, as a background of two slit experiments explanation

In accordance with our model, the electron and proton (Fig.3.1) are the triplets $\langle [F^- \cong F^+] + F^- e^\tau, \rangle$ formed by two negatively charged sub-elementary fermions of opposite spins ($F^- \text{ and } F^+$) and one uncompensated sub-elementary antifermion ($F^\tau$) of $\mu$ and $\tau$ generation. The symmetric pair of sub-elementary fermion and antifermion: $[F^- \cong F^+]$ are pulsing between Corpuscular [C] and Wave [W] states in-phase, compensating the influence of energy, spin and charge of each other.

It follows from our model, that the charge, spin, energy and momentum of the electron and positron are determined just by uncompensated/unpaired sub-elementary fermion ($F^\tau$). The parameters of ($F^\tau$) are correlated strictly with similar parameters of pair $[F^- \cong F^+]$ due to conservation of symmetry of properties of sub-elementary fermions and antifermions in triplets. It means that energy/momentum and, consequently, de Broglie wave length and frequency of uncompensated sub-elementary fermion ($F^\tau$) determine the empirical de Broglie wave properties of the whole particle (electron, positron).

The frequency of de Broglie wave and its length can be expressed from eq.5.4 as:
where: $v_0 = m_0c^2/h = \omega_0/2\pi$; $\lambda_B = h/mc$

In a nonrelativistic case, when $v \ll c$ and the relativistic factor $R = \sqrt{1 - (v/c)^2} \approx 1$, the energy of de Broglie wave is close to Tuning energy $(TE)$ of Bivacuum $(7.5)$:

$$E_B = hv_B \approx m \gamma c^2 - m_0c^2 = TE$$

1. In each triplet of elementary particle $\langle [F^+ \approx F^+] + F^\pm \rangle \approx \gamma (\pm \gamma)$ (Fig.3.1) or boson, like the photon (Fig.3.2).

2. In the absence of particle accelerations, meaning its permanent kinetic energy, the
internal time of \([C]\) and \([W]\) phases is the same. Consequently, in the internal reference system, both phase of unpaired or paired sub-elementary fermions in different de Broglie wave semiperiods can be considered as simultaneous.

This statement follows from our notion of time and its pace for closed system (see section 7.1).

The formula for \textit{pace of time} for any closed coherent system or free particle is determined by the pace of its kinetic energy: 
\[
\left( m v \frac{\mathbf{v} \cdot \mathbf{v}}{2} \right)_{x,y,z} = \frac{m_0 v^2}{\left(2 \sqrt{1 - (v/c)^2}\right)}
\]

change, which is anisotropic in a general case:
\[
\begin{align*}
\frac{dt}{d} &= -dT_{k/k} \frac{T_k}{T_k} x,y,z \\
\text{For the internal time itself it follows from (10.8):} \\
\begin{bmatrix}
\begin{array}{l}
t = -\frac{v}{dv/dt} \left( \frac{1 - (v/c)^2}{2 - (v/c)^2} \right)
\end{array}
\end{bmatrix}
\end{align*}
\]

We can see, that in the absence of acceleration (\(dv/dt = 0\) \textbf{and} \(dv = 0\)), i.e. permanent kinetic energy, momentum and, consequently, permanent de Broglie wave frequency and length, the time for such particle is infinitive and pace of time is zero:
\[
t \to \infty \quad \text{and} \quad \frac{dt}{d} \to 0
\]

These conditions mean that the \([C]\) and \([W]\) phases of triplets - elementary particles, moving with permanent velocity, may be considered, as simultaneous. The oscillation of kinetic energy and velocity of triplets occur only in transition states \([C \rightarrow W]\) or \([W \rightarrow C]\), accompanied by \textit{recoil \& antirecoil} effects.

We can see from the above analysis, that our model does not need the Bohmian "quantum potential" (Bohm and Hiley, 1993) or de Broglie’s "pilot wave" for explanation of wave-like behavior of elementary particles.

Scattering of the photon on a free electron will affect its velocity, momentum, mass, wave B frequency, length, its virtual replica (VR) and its feedback influence on the electron, following by change of the interference picture.

Our theory predicts that, applying of the EM field to \textit{singe electrons} with frequency resonant to their de Broglie frequency, should be accompanied by alternative acceleration of the electrons, modulation of their internal time and Virtual Replica with the same frequency, accompanied by 'washing out' the interference pattern in two-slit experiment. This consequence of our explanation of two-slit experiment can be easily verified.

\section*{11. The main Conclusions of Unified Theory}

1. A new Bivacuum model, as the infinite dynamic superfluid matrix of virtual dipoles, named Bivacuum fermions (BVF)\(^{\dagger}\) and Bivacuum bosons (BVB\(^{\pm}\)), formed by correlated torus (V\(^{+}\)) and antitorus (V\(^{-}\)), as collective excitations of subquantum particles and antiparticles of opposite energy, charge and magnetic moments and separated by energy gap, is developed. In primordial non polarized Bivacuum, i.e. in the absence of matter and fields, these parameters of torus and antitorus totally compensate each other. Their spatial and energetic properties correspond to three generations: electrons, muons and tauons \((i = e, \mu, \tau)\). The positive and negative Virtual Pressure Waves (VPW\(^{\pm}\)) and Virtual Spin Waves (VirSW\(^{S=\pm 1/2}\)) are the result of emission and absorption of positive and negative Virtual Clouds (VC\(^{\pm}\)), resulting from transitions of V\(^{+}\) and V\(^{-}\) between different state of excitation.

2. It is demonstrated that symmetry shift between V\(^{+}\) and V\(^{-}\) parameters to the left or right, opposite for Bivacuum fermions BFV\(^{\dagger}\) and antifermions BFV\(^{\dagger}\) with relativistic
dependence on their external rotational-translational velocity, is accompanied by sub-elementary fermion and antifermion formation. The formation of sub-elementary fermions and their fusion to stable triplets of elementary fermions, like electrons and protons \( \langle \text{VPW}^+ \rangle \), corresponding to the rest mass and charge origination, become possible at the certain velocity of angular rotation of Cooper pairs of \( \text{BVF}^{\pm} \) around a common axis. It is shown, that this rotational-translational velocity is determined by Golden Mean condition: \( (v/c)^2 = \phi = 0.618 \). The photon is a result of fusion (annihilation) of two triplets of particle and antiparticle: [electron + positron] or [proton + antiproton]. It represents a rotating sextet of sub-elementary fermions and antifermions with axial structural symmetry and minimum energy \( 2m_0c^2 \).

3. The fundamental physical roots of Golden Mean condition: \( (v/c)^2 = \frac{v_{\text{ext}}}{v_{\text{ph}}} = \phi \) are revealed as the equality of internal and external group and phase velocities of torus and antitorus of sub-elementary fermions, correspondingly: \( v_{\text{in}} = v_{\text{ext}} \), \( v_{\text{ph}} = \frac{v_{\text{ext}}}{\phi} \). These equalities are named 'Hidden Harmony Conditions’.

4. The new expressions for total, potential and kinetic energies of de Broglie waves of elementary particles were obtained. The former represents the extended basic Einstein and Dirac formula for free particle: \( E_{\text{tot}} = m c^2 = \sqrt{1 - \left(\frac{v}{c}\right)^2} m c^2 + h^2 / 2m \lambda^2 \). The new formulas take into account the contributions of the actual mass/energy of torus \( (V^+) \) and those of complementary antitorus \( (V^-) \), correspondingly, of asymmetric sub-elementary fermions to the total ones. The shift of symmetry between the mass and other parameters of torus and antitorus of sub-elementary fermions are dependent on their internal rotational-translational dynamics in triplets and the external translational velocity of the whole triplets.

5. A dynamic mechanism of [corpuscle \( (C) \approx \text{wave} \ (W) \)] duality is proposed. It involves the modulation of the internal (hidden) quantum beats frequency between the asymmetric 'actual’ (torus) and 'complementary’ (antitorus) states of sub-elementary fermions or antifermions by the external - empirical de Broglie wave frequency of the whole particles (triplets).

6. It is demonstrated, that the elastic deformations and collective excitations of Bivacuum matrix, providing field origination, are a consequence of reversible \( \text{[recoil} \approx \text{antirecoil]} \) effects, generated by correlated \( \text{[Corpuscle} \approx \text{Wave]} \) pulsation of sub-elementary fermions/antifermions of triplets and their fast rotation. The linear and circular alignment of Bivacuum dipoles are responsible for electrostatic and magnetic field origination. The gravitational waves and field are the result of positive and negative virtual pressure waves excitation \( \text{(VPW}^+ \text{ and VPW}^- \text{)} \) by the in-phase \( [C \approx W] \) pulsation of pairs \( \langle \text{VPW}_1 \rangle \) of triplets \( \langle F_t \approx F_t' \rangle \), counterphase to that of unpaired \( F_t \). Such virtual waves provide the attraction or repulsion between pulsing remote particles, depending on phase shift of pulsations, as in the case of hydrodynamic Bjerknes force action. The zero-point vibrations of particle and evaluated zero-point velocity of these vibrations are also the result of \( \text{[recoil} \approx \text{antirecoil]} \) effects, accompanied by \( [C \approx W] \) pulsation of triplets.

7. Maxwell’s displacement current and the additional instant currents are the consequences of Bivacuum virtual dipoles \( \text{(BVF}_0^{\pm} \text{ and BVB}_0^{\pm}) \) excitations and vibrations, correspondingly. Their vibrations are accompanied by the elastic deformations of secondary Bivacuum matrix, induced by presence of matter and fields. The increasing of the excluded for photons volume of toruses and antitoruses, enhance the refraction index of Bivacuum and decrease the light velocity near strongly gravitating and charged objects. The nonzero contribution of the rest mass energy to photons and neutrino energy is a consequence of the enhanced refraction index of secondary Bivacuum.
8. It is shown that the Principle of least action and realization of 2nd and 3d laws of thermodynamics for closed systems - can be a result of slowing down the dynamics of particles and their kinetic energy decreasing, under the influence of the basic - lower frequency Virtual Pressure Waves (VPW$^{±}_{q=1}$) with minimum quantum number $q = j - k = 1$. This is a consequence of induced combinational resonance between $[C \cong W]$ pulsation of particles and basic VPW$^{±}_{q=1}$ of Bivacuum. The new notion of Bivacuum Tuning Energy (TE), responsible for forcing of particles pulsation frequency to resonance conditions with VPW$^{±}_{q=1}$, is introduced.

9. It is demonstrated, that the dimensionless 'pace of time' $(dt/t = -dT/T)$ and time itself for each closed system are determined by the change of this system kinetic energy. They are positive, if the particles of the system are slowing down under the influence of VPW$^{±}_{q=1}$ and Tuning energy of Bivacuum. The $(dt/t)$ and $(t)$ are negative in the opposite case. This new concept of time does not contradict the relativistic theory.

10. The notion of Virtual Replica (VR) or virtual hologram of any material object is developed. The VR is a result of interference of all-pervading quantized Virtual Pressure Waves (VPW$^{+}_{q}$ and VPW$^{-}_{q}$) and Virtual Spin waves (VirSW$^{q=±1/2}_{q}$) of Bivacuum, working as "reference waves" in holograms formation, with modulated by de Broglie waves of matter atoms and molecules - "object waves" VPW$^{±}_{m}$ and VirSW$^{±1/2}_{m}$. In our Unified theory the virtual pressure waves are identified with gravitational waves. The mechanism of gravitation may have common features with the hydrodynamic Bjerknes force between pulsating spheres. Their attraction or repulsion is dependent on the phase shift between pulsating spheres.

11. A possible Mechanism of Quantum entanglement between remote elementary particles via Virtual Guides of spin, momentum and energy (VirGS$^{M,E}$) is proposed. The VirGS$^{M,E}$, connecting similar and coherent electrons and nuclei of atoms of Sender(S) and Receiver(R). The single VirGS$^{BVB}_{S,M,E}$ can be assembled from Bivacuum bosons (BVB$^{±}$) from adjacent microtubules, rotating in opposite directions, are formed by Cooper pairs of Bivacuum fermions (BVF$^{±}$). The spin/information transmission via Virtual Guides is accompanied by reorientation of spins of tori and antitori of conjugated Bivacuum dipoles. The momentum and energy transmission from S to R is realized by the instant pulsation of diameter of such virtual microtubule. The Virtual Guides of both kinds represent the quasi 1D virtual Bose condensate with nonlocal properties, similar to that of "wormholes".

12. It is demonstrated that the consequences of Unified theory (UT) of Bivacuum, matter and fields are in good accordance with known experimental data. Among them: electromagnetic radiation of nonuniformly accelerating charges; the double turn $(2 \times 360 = 720)$ of the electron’s spin in external magnetic field, necessary for total reversibility of spin state of fermion. The two slit experiment also get its explanation even in a single particles case, as a consequence of interference of particle in the wave phase with its own virtual replica (VR).

REFERENCES

Klein, Martin J., A.J. Kox, Jürgen Renn, and Robert Schulmann (eds.): The

Lamb (1945). Hydrodynamics.


Naudin J–L. website "The Quest For Overunity": http://members.aol.com/jnaudin509/


