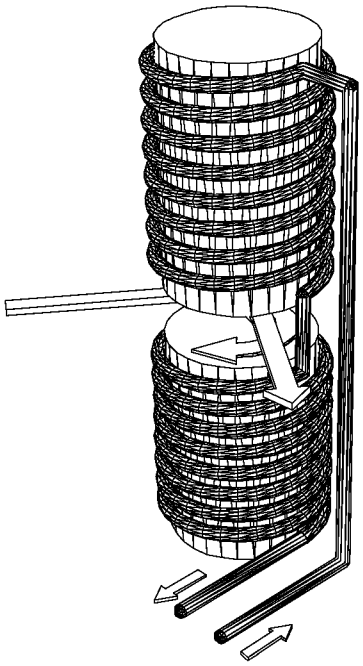
U K R A I N E ISSN 1726-4499

Spacetime & Substance

International Physical Journal



Volume 5, No. 3 (23), 2004

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U K R A I N E ISSN 1726-4499

Spacetime & Substance

International Physical Journal

Certificate of the series AB, No. 4858, issued by the State Committee for Information Policy, TV and Broadcasting of Ukraine (February 12, 2001).

The Journal is published by Research and Technological Institute of Transcription, Translation and Replication, JSC(Kharkiv, Ukraine).

It is a discussion journal on problems of theoretical and experimental physics in the field of research of space, time, substance and interactions. The Journal publishes:
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The volume of one issue is 48 pages. Format is A4. The periodicity is 5 issues per one year. The language is English. The equivalent versions: paper and electronic — ISSN 1813-9833 (*.TEX, *.PS, *.PDF).

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 97–103
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GENERATION OF BIANCHI TYPE V COSMOLOGICAL MODELS WITH VARYING Λ-TERM

Anirudh Pradhan[1] † and Sanjay Kumar Singh[2] ‡

† *Department of Mathematics, Hindu Post-graduate College (V. B. S. Purvanchal University), Zamania-232 331, Ghazipur, India*

‡ *Department of Computer Science, Post-graduate College(V. B. S. Purvanchal University), Ghazipur-233 001, India*

Received August 31, 2000

Bianchi type V bulk viscous fluid cosmological models are investigated with cosmological term Λ varying with time. Using a generation technique (Ram, 1990), it is shown that the Einstein's field equations are solvable for any arbitrary cosmic scale function. Starting from particular solutions, new classes of solutions are obtained. The cosmological constant is found to be decreasing function of time, which is supported by results from recent type Ia supernovae observations. Some physical aspects of the models are also discussed.

1. Introduction

The study of Bianchi type V cosmological models create more interest as these models contain isotropic special cases and permit arbitrary small anisotropy levels at some instant of cosmic time. This property makes them suitable as model of our universe. The homogeneous and isotropic Friedman-Robertson-Walker (FRW) cosmological models, which are used to describe standard cosmological models, are particular case of Bianchi type I, V and IX universes, according to whether the constant curvature of the physical three-space, t = constant, is zero, negative or positive. These models will be interesting to construct cosmological models of the types which are of class one. Present cosmology is based on the FRW model which is completely homogeneous and isotropic. This is in agreement with observational data about the large scale structure of the universe. However, although homogeneous but anisotropic models are more restricted than the inhomogeneous models, they explain a number of observed phenomena quite satisfactorily. This stimulates the research for obtaining exact anisotropic solution for Einstein's field equations (EFEs) as a cosmologically accepted physical models for the universe (at least in the early stages). Roy and Prasad [1] have investigated Bianchi type V universes which are locally rotationally symmetric and are of embedding class one filled with perfect fluid with heat conduction and radiation. Bianchi type V cosmological models have been studied by other researchers (Farnsworth [2], Maartens and Nel [3], Wainwright *et al.* [4], Collins [5], Meena and Bali [6], Pradhan *et al.* [7, 8]) in different context.

Models with a relic cosmological constant Λ have received considerable attention recently among researchers for various reasons (see Refs. [9]– [13] and references therein). Some of the recent discussions on the cosmological constant "problem" and on cosmology with a time-varying cosmological constant by Ratra and Peebles [14], Dolgov [15]–[17] and Sahni and Starobinsky [18] point out that in the absence of any interaction with matter or radiation, the cosmological constant remains a "constant", however, in the presence of interactions with matter or radiation, a solution of Einstein equations and the assumed equation of covariant conservation of stress-energy with a time-varying Λ can be found. For these solutions, conservation of energy requires decrease in the energy density of the vacuum component to be compensated by a corresponding increase in the energy density of matter or radiation. Earlier researchers on this topic, are contained in Zeldovich [19], Weinberg[10] and Carroll, Press and Turner [20]. Recent cosmological observations (Garnavich *et al.* [21], Perlmutter *et al.* [22], Riess *et al.* [23], Schmidt *et al.* [24]) strongly favour a significant and positive Λ with the magnitude $\Lambda(G\hbar/c^3) \approx 10^{-123}$. Their finding arise from the study of more than 50 type Ia supernovae with redshifts in the range $0.10 \leq z \leq 0.83$ and suggest Friedman models with negative pressure matter such as a cosmological constant, domain walls or cosmic strings (Vilenkin [25], Garnavich *et al* [21]. The main conclusion of these observations on magni-

[1]E-mail: acpradhan@yahoo.com, pradhan@iucaa.ernet.in
[2]E-mail: sanjaysingh10@rediffmail.com

tude and red-shift of type Ia supernova suggest that the expansion of the universe may be an accelerating one with a large function of cosmological density in the form of the cosmological Λ-term.

Several ansätz have been proposed in which the Λ term decays with time (see Refs. Gasperini [26], Freese *et al* [27], Özer and Taha [13], Peebles and Ratra [28], Chen and Hu [29], Abdussattar and Viswakarma [30], Gariel and Le Denmat [31], Pradhan *et al.* [32]). Of the special interest is the ansatz $\Lambda \propto S^{-2}$ (where S is the scale factor of the Robertson-Walker metric) by Chen and Wu [29], which has been considered/modified by several authors (Abdel-Rahaman [33], Carvalho *et al* [13], Waga [34], Silveira and Waga [35], Vishwakarma [36]).

In recent years, several authors (Hajj-Boutros [37], Hajj-Boutros and Sfeila [38], Ram [39], Mazumder [40], Pradhan and Kumar [41] and Camci *et al.* [44]) have investigated the solutions of EFEs for homogeneous but anisotropic models by using some different generation techniques. Bianchi spaces $I - IX$ are useful tools in constructing models of spatially homogeneous cosmologies (Ellis and MacCallum [42], Ryan and Shepley [43]). From these models, homogeneous Bianchi type V universes are the natural generalization of the open FRW model which eventually isotropize. Recently Ram [39] derived a new technique for generating exact solutions of EFEs with perfect fluid for Bianchi type V spacetime. In this paper, we will discuss Bianchi type V cosmological models obtained by augmenting the energy-momentum tensor of a bulk viscous fluid by a term that represents a variable cosmological constant varying with time, and later generalize the solutions of Refs. [39]. This paper is organized as follows: The metric and field equations are presented in Section 2. We have described the generation technique in Section 3. We relate three of the metric variables by solving the off-diagonal component of EFEs, and find a second integral which is used to relate the remaing two metric variables. In this section three types of new solutions are presented separately and solutions of Ram [39] are shown to be particular cases of our solutions. Kinematical and dynamical properties of model given in case (ii) are also studied in Section 3.2. In Section 4, we give the concluding remarks.

2. The Metric and Field Equations

We consider the spacetime metric of the spatially homogeneous Bianchi type V of the form

$$ds^2 = dt^2 - A^2(t)dx^2 - e^{2\alpha x}\left[B^2(t)dy^2 + C^2(t)dz^2\right], \quad (1)$$

where α is a constant. The energy-momentum tensor in the presence of bulk viscous stress has the form

$$T_{ij} = (\bar{p} + \rho)v_i v_j - \bar{p}g_{ij}, \quad (2)$$

and

$$\bar{p} = p - \xi v^i_{;i}. \quad (3)$$

Here ρ, p, $\bar{p}$ and ξ are the energy density, isotropic pressure , effective pressure and bulk viscous coefficient respectively and v_i is the fluid four-velocity such that

$$v^i v_i = 1. \quad (4)$$

Einstein's field equations (in gravitational units $c = 1$, $G = 1$) read as

$$R_{ij} - \frac{1}{2}Rg_{ij} + \Lambda g_{ij} = -8\pi T_{ij} \quad (5)$$

for the line element (1) has been set up as

$$\frac{A_{44}}{A} + \frac{B_{44}}{B} + \frac{A_4 B_4}{AB} - \frac{\alpha^2}{A^2} = -8\pi(\bar{p} + \Lambda), \quad (6)$$

$$\frac{A_{44}}{A} + \frac{C_{44}}{C} + \frac{A_4 C_4}{AC} - \frac{\alpha^2}{A^2} = -8\pi(\bar{p} + \Lambda), \quad (7)$$

$$\frac{B_{44}}{B} + \frac{C_{44}}{C} + \frac{B_4 C_4}{BC} - \frac{\alpha^2}{A^2} = -8\pi(\bar{p} + \Lambda), \quad (8)$$

$$\frac{A_4 B_4}{AB} + \frac{A_4 C_4}{AC} + \frac{B_4 C_4}{BC} - \frac{3\alpha^2}{A^2} = 8\pi(\rho - \Lambda), \quad (9)$$

$$\frac{2A_4}{A} - \frac{B_4}{B} - \frac{C_4}{C} = 0. \quad (10)$$

Here and in what follows the suffix 4 by the symbols A, B, C and ρ denote differentiation with respect to t. Elimination of p from Eqs. (6) - (8) gives the condition of isotropy of pressures

$$2\frac{B_{44}}{B} + \left(\frac{B_4}{B}\right)^2 = 2\frac{C_{44}}{C} + \left(\frac{C_4}{C}\right)^2. \quad (11)$$

The nonlinear second order differential equation (13) admits a particular solution

$$B(t) = C(t) = a(t). \quad (12)$$

In this case the metric (1) reduces to

$$ds^2 = dt^2 - A^2[dx^2 + e^{2\alpha x}(dy^2 + dz^2)]. \quad (13)$$

It is clear that when $B(t) = C(t) = K$, where K is a constant, is also a particular solution of (13), and in this case the metric (1) can be transformed into the form

$$ds^2 = dt^2 - dx^2 - e^{2\alpha x}(dy^2 + dz^2). \quad (14)$$

If we seek a solution of (13) of the form

$$B = t^m, \quad C = t^n, \quad (15)$$

then either $m = n$ or $m + n = \frac{2}{3}$. In the former case the metric (1) reduces to the form

$$ds^2 = dt^2 - t^{2m}[dx^2 + e^{2\alpha x}(dy^2 + dz^2)]. \quad (16)$$

In the latter case the metric of the solution takes the form

$$ds^2 = dt^2 - t^{2/3}dx^2 - e^{2\alpha x}(t^{2m}dy^2 + t^{2n}dz^2). \quad (17)$$

For the metric (19), the energy density and effective pressure are given by

$$8\pi(\rho - \Lambda) = \frac{2+9mn}{gt^2} + \frac{\alpha^2}{t^{2/3}}, \quad (18)$$

$$8\pi(\bar{p} + \Lambda) = \frac{2+9mn}{gt^2} - \frac{3\alpha^2}{t^{2/3}}. \quad (19)$$

For complete determinacy of the system, we consider a perfect-gas equation of state

$$p = \gamma\rho, \quad 0 \leq \gamma \leq 1. \quad (20)$$

It is worth noting here that our approach suffers from a lack of Lagrangian approach. There is no known way to present a consistent Lagrangian model satisfying the necessary conditions discussed in this paper.
Thus, given $\xi(t)$ we can solve the cosmological parameters. In most of the investigations involving bulk viscosity is assumed to be a simple power function of the energy density [45] – [47]

$$\xi(t) = \xi_0\rho^k, \quad (21)$$

where ξ_0 and k are constants. If $k = 1$, Eq. (23) may correspond to a radiative fluid. However, more realistic models [48] are based on lying in the regime $0 \leq k \leq \frac{1}{2}$.

The physical quantities expansion scalar θ and shear scalar σ^2 have the following expressions:

$$\theta = u^i_{;i} = \frac{A_4}{A} + \frac{B_4}{B} + \frac{C_4}{C} \quad (22)$$

$$\sigma^2 = \frac{1}{2}\sigma_{ij}\sigma^{ij} = \frac{1}{3}\left[\theta^2 - \frac{A_4B_4}{AB} - \frac{A_4C_4}{AC} - \frac{B_4C_4}{BC}\right]. \quad (23)$$

3. Generating Technique and New Solutions

Following Ram [39], we seek solutions of (13) of the form

$$B(t) = a(t)B_1(t), \quad C(t) = a(t)C_1(t) \quad (24)$$

Then we obtain

$$B(t) = a(t)exp\left[\frac{2}{3}\left\{\int dt\left[a^3(t)F(t)\right]^{-1} + k_2\right\}\right], \quad (25)$$

$$C(t) = a(t)exp\left[\frac{2}{3}\left\{\int dt\left[a^3(t)G(t)\right]^{-1} + k_4\right\}\right], \quad (26)$$

where

$$F(t) = \left(\int \frac{dt}{a^3(t)} + k_1\right),$$

$$G(t) = \left(\int \frac{dt}{a^3(t)} + k_3\right),$$

and the k's are constants of integration. It is remarkable to mention here that $B(t)$ and $C(t)$ obtained from (27) and (28) are different from $a(t)$. Starting from particular solutions of the field equations and using (27) and (28), we now generate some new exact solutions of EFEs. We consider the following three cases:

3.1. Case (i):

To apply (27) and (28), we first consider the metric (15) where $B(t) = C(t) = a(t) = 1$. Applying (26), we obtain

$$B(t) = (t + k_5)^{2/3}, \quad (27)$$

where k_5 is an integrating constant, and $C(t) = 1$ stays invariable. Inserting the new variables $B(t)$ and $C(t)$ in (11) and integrating, we obtain

$$A = k_6(t + k_5)^{1/3}, \quad (28)$$

where k_6 is an integrating constant. By a change of scale the metric of solution reads

$$ds^2 = dt^2 - t^{2/3}dx^2 - e^{2\alpha x}(t^{4/3}dy^2 + dz^2), \quad (29)$$

where the constants k_5 and k_6 are taken, without any loss of generality, equal to 1 and zero respectively. For this derived model (31), the pressure and energy density are given by

$$8\pi(p - \xi\theta + \Lambda) = \frac{2}{9t^2} + \frac{\alpha^2}{t^{2/3}}, \quad (30)$$

$$8\pi(\rho - \Lambda) = \frac{2}{9t^2} - \frac{3\alpha^2}{t^{2/3}}. \quad (31)$$

Here θ is the scalar of expansion calculated for the flow vector v^i as

$$\theta = \frac{1}{t} \quad (32)$$

For $\Lambda = 0$, $\xi = 0$, the metric (31) with expressions p, ρ, and θ for this model are same as that of solution (26) of Ram [39].

3.1.1. Model I : solution for $\xi = \xi_0$

When $k = 0$, Equation (23) reduces to $\xi = \xi_0$. In this case, with the use of Equations (33), (34) and (22) in (32), we obtain

$$4\pi(1+\gamma)\rho = \frac{4\pi\xi_0}{t} + \frac{2}{9t^2} - \frac{\alpha^2}{t^{2/3}}. \quad (33)$$

Eliminating $\rho(t)$ between (33) and (35), we obtain

$$8\pi(1+\gamma)\Lambda = \frac{8\pi\xi_0}{t} - \frac{2}{9t^2} + \frac{\alpha^2}{t^{2/3}}. \quad (34)$$

3.1.2. Model I : solution for $\xi = \xi_0\rho$

When $k = 1$, Equation (23) reduces to $\xi = \xi_0\rho$. In this case, with the use of Equations (33), (34) and (22) in (32), we obtain

$$4\pi\left(1+\gamma-\frac{\xi_0}{t}\right)\rho = \frac{2}{9t^2} - \frac{\alpha^2}{t^{2/3}}. \tag{35}$$

Eliminating $\rho(t)$ between (33) and (37), we obtain

$$8\pi\left(1+\gamma-\frac{\xi_0}{t}\right)\Lambda = \frac{2(1-\gamma)}{9t^2} + \frac{\alpha^2(1+3\gamma)}{t^{2/3}} + \frac{\xi_0}{t}\left(\frac{2}{9t^2} - \frac{3\alpha^2}{t^{2/3}}\right). \tag{36}$$

From Eqs. (36) and (38), we observe that the cosmological constant (Λ) in the model (31) decreases as time increases. We also observe that the value of Λ approaches a small and positive at late times which is supported by recent type Ia supernovae observations [21] – [24].

3.2. Case (ii):

In this case we apply both (27) and (28) to the metric (15), we obtain

$$B = (t+k_7)^{2/3}, \tag{37}$$

and

$$C = (t+k_8)^{2/3}, \tag{38}$$

where k_7 and k_8 are constants of integration. Inserting (39) and (40) into (11) and integrating, we obtain

$$A = k_9(t+k_7)^{1/3}(t+k_8)^{1/3}, \tag{39}$$

where k_9 is an integrating constant. The metric of solution reads

$$ds^2 = dt^2 - (t+k_7)^{2/3}(t+k_8)^{2/3}dx^2 - e^{2\alpha x}[(t+k_7)^{4/3}dy^2 + (t+k_8)^{4/3}dz^2], \tag{40}$$

For this derived model (42), the pressure and energy density are given by

$$8\pi(p - \xi\theta + \Lambda) = \frac{2(k_7-k_8)}{9t^2(t+k_7)^2(t+k_8)^2} + \frac{\alpha^2}{(t+k_7)^{2/3}(t+k_8)^{2/3}}, \tag{41}$$

$$8\pi(\rho - \Lambda) = \frac{12t^2 + 12(k_7+k_8)t + 2(k_7^2+k_8^2+4k_7k_8)}{9(t+k_7)^2(t+k_8)^2} - \frac{3\alpha^2}{(t+k_7)^{2/3}(t+k_8)^{2/3}}. \tag{42}$$

The expansion and shear are obtained as

$$\theta = \frac{2t+k_7+k_8}{(t+k_7)(t+k_8)}, \tag{43}$$

$$\sigma = \frac{[7t^2 + 7(k_7+k_8)t + 2(k_7^2+k_8^2) + 3k_7k_8]^{1/2}}{3(t+k_7)(t+k_8)}. \tag{44}$$

For $\Lambda = 0$, $\xi = 0$, the metric (42) with expressions p, ρ, θ and σ for this model are same as that of solution (32) of Ram [39]. For $k_7 = k_8$, $\alpha = 0$, $\Lambda = 0$, $\xi = 0$, we obtain the Einstein de Sitter dust-filled universe [49]. From (46), we observe that the shear scalar σ is finite for $0 < t < \infty$ and tends to zero as $t \to \infty$; the universe is then shear-free, and there is no anisotropy. It is also observed that the ratio σ/θ does not tend to zero as $t \to \infty$, which means that σ does not tend to zero faster than the expansion. For this model all of the fluids are acceleration- and rotation-free.

3.2.1. Model I : solution for $\xi = \xi_0$

When $k = 0$, Equation (23) reduces to $\xi = \xi_0$. In this case, with the use of Equations (44), (45) and (22) in (43), we obtain

$$4\pi(1+\gamma)\rho = \frac{4\pi\xi_0(2t+k_7+k_8)}{(t+k_7)(t+k_8)} + \frac{1}{9(t+k_7)^2(t+k_8)^2}\left[\frac{(k_7-k_8)}{t^2} + 6t^2 + 6(k_7+k_8)t + k_7^2 + k_8^2 + 4k_7k_8\right] - \frac{\alpha^2}{(t+k_7)^{2/3}(t+k_8)^{2/3}} \tag{45}$$

Eliminating $\rho(t)$ between (44) and (47), we get

$$8\pi(1+\gamma)\Lambda = \frac{8\pi\xi_0(2t+k_7+k_8)}{(t+k_7)(t+k_8)} + \frac{2}{9(t+k_7)^2(t+k_8)^2}\left[\frac{(k_7-k_8)}{t^2} - \left\{6t^2 + 6(k_7+k_8)t + k_7^2 + k_8^2 + 4k_7k_8\right\}\gamma\right] + \frac{\alpha^2(1+\gamma)}{(t+k_7)^{2/3}(t+k_8)^{2/3}}. \tag{46}$$

3.2.2. Model I : solution for $\xi = \xi_0\rho$

When $k = 1$, Equation (23) reduces to $\xi = \xi_0\rho$. In this case, with the use of Equations (44), (45) and (22) in (43), we obtain

$$4\pi\left[1+\gamma-\frac{(2t+k_7+k_8)\xi_0}{(t+k_7)(t+k_8)}\right]\rho = \frac{1}{9(t+k_7)^2(t+k_8)^2}\left[\frac{(k_7-k_8)}{t^2} + 6t^2 + 6(k_7+k_8)t + k_7^2 + k_8^2 + 4k_7k_8\right] - \frac{\alpha^2}{(t+k_7)^{2/3}(t+k_8)^{2/3}}. \tag{47}$$

Eliminating $\rho(t)$ between (44) and (49), we obtain

$$8\pi\left[1+\gamma-\frac{(2t+k_7+k_8)\xi_0}{(t+k_7)(t+k_8)}\right]\Lambda = = \frac{2}{9(t+k_7)^2(t+k_8)^2}\left[\frac{(k_7-k_8)}{t^2} - -\left\{6t^2+6(k_7+k_8)t+k_7^2+k_8^2+4k_7k_8\right\}\times \left\{\gamma-\frac{(2t+k_7+k_8)\xi_0}{(t+k_7)(t+k_8)}\right\}\right]+\frac{\alpha^2}{(t+k_7)^{2/3}(t+k_8)^{2/3}}\times \left[1+3\gamma-\frac{3(2t+k_7+k_8)\xi_0}{(t+k_7)(t+k_8)}\right]. \quad (48)$$

From Eqs. (48) and (50), we observe that the cosmological constant (Λ) in the model (42) is a decreasing function of time. We also observe that the value of Λ approaches a small and positive value at late times which is supported by recent type Ia supernovae observations [21] – [24].

3.3. Case (iii):

In this case we apply both (27) and (28) to the metric (16). So we can write the metric of the corresponding solution in the form

$$ds^2 = dt^2 - t^{-2m}(t+k_9t^{3m})^{2/3}(t+k_{10}t^{3m})^{2/3}dx^2 - e^{2\alpha x}\left[t^{-2m}(t+k_9t^{3m})^{4/3}dy^2 + +t^{-2m}(t+k_{10}t^{3m})^{4/3}dz^2\right]. \quad (49)$$

For isotropy of pressure $k_9 = k_{10} = \kappa$ (say), the metric (51) reduces to

$$ds^2 = dt^2 - t^{-2m}(t+\kappa t^{3m})^{4/3}[dx^2+e^{2\alpha x}(dy^2+dz^2)]. \quad (50)$$

The pressure and energy density for the derived solution (52) are given by

$$8\pi(p-\xi\theta+\Lambda) = -\frac{n(3m+2)}{t^2} - \frac{4\kappa m(3m-1)t^{3m-2}}{t+kt^{3m}} + \frac{4m(1+3\kappa m t^{3m-1})}{t(t+\kappa t^{3m})} + \frac{\alpha^2}{t^{-2m}(t+\kappa t^{3m})^{4/3}}; \quad (51)$$

$$8\pi(\rho-\Lambda) = \frac{3m^2}{t^2} - \frac{4}{3}\left(\frac{1+3\kappa m t^{3m-1}}{t+\kappa t^{3m}}\right)^2 - \frac{4m(1+3\kappa m t^{3m-1})}{t(t+\kappa t^{3m})} - \frac{3\alpha^2}{t^{-2m}(t+\kappa t^{3m})^{4/3}}. \quad (52)$$

The scalar of expansion calculated for the flow vector v^i is given by

$$\theta = \frac{2}{t+\kappa}. \quad (53)$$

For $\Lambda = 0$, $\xi = 0$, the metric (52) with expressions p, and ρ for this model are same as that of solution (38) of Ram [39].

3.3.1. Model I: solution for $\xi = \xi_0$

When $k = 0$, Equation (23) reduces to $\xi = \xi_0$. In this case, with the use of Equations (54), (55) and (22) in (53), we obtain

$$4\pi(1+\gamma)\rho = \frac{8\pi\xi_0}{(t+\kappa)} - \frac{m}{t^2} - \frac{2\kappa m(3m-1)t^{3m-2}}{(t+\kappa t^{3m})} \frac{2}{3}\left(\frac{1+3\kappa m t^{3m-1}}{t+\kappa t^{3m}}\right)^2 - \frac{\alpha^2}{t^{-2m}(t+\kappa t^{3m})^{4/3}}. \quad (54)$$

Eliminating $\rho(t)$ between (54) and (56), we get

$$8\pi(1+\gamma)\Lambda = \frac{16\pi\xi_0}{(t+\kappa)} - \frac{1}{t^2}\{2m+3(1+\gamma)m^2\} - \frac{4\kappa m(3m-1)t^{3m-2}}{(t+\kappa t^{3m})} - \frac{4}{3}\gamma\left(\frac{1+3\kappa m t^{3m-1}}{t+\kappa t^{3m}}\right)^2 + \frac{4m(1+\gamma)(1+3\kappa m t^{3m-1})}{t(t+\kappa t^{3m})} + \frac{\alpha^2(1+3\gamma)}{t^{-2m}(t+\kappa t^{3m})^{4/3}}. \quad (55)$$

3.3.2. Model I: solution for $\xi = \xi_0\rho$

When $k = 1$, Equation (23) reduces to $\xi = \xi_0\rho$. In this case, with the use of Equations (54), (55) and (22) in (53), we obtain

$$4\pi\left[1+\gamma-\frac{2\xi_0}{(t+\kappa)}\right]\rho = -\frac{m}{t^2} - \frac{2\kappa m(3m-1)t^{3m-2}}{(t+\kappa t^{3m})} + \frac{2}{3}\left(\frac{1+3\kappa m t^{3m-1}}{t+\kappa t^{3m}}\right)^2 - \frac{\alpha^2}{t^{-2m}(t+\kappa t^{3m})^{4/3}}. \quad (56)$$

Eliminating $\rho(t)$ between (54) and (58), we obtain

$$8\pi\left[1+\gamma-\frac{2\xi_0}{(t+\kappa)}\right]\Lambda = = -\frac{1}{t^2}\left[2m+3m^2\left(1+\gamma-\frac{2\xi_0}{t+\kappa}\right)\right] - \frac{4\kappa m(3m-1)t^{3m-2}}{(t+\kappa t^{3m})} - \frac{4}{3}\left(\frac{1+3\kappa m t^{3m-1}}{t+\kappa t^{3m}}\right)^2 \times \times\left\{\gamma-\frac{2\xi_0}{t+\kappa}\right\} + +\frac{\alpha^2}{t^{-2m}(t+\kappa t^{3m})^{4/3}}\left(1+3\gamma-\frac{6\xi_0}{t+\kappa}\right). \quad (57)$$

From Eqs. (57) and (59), we observe that the cosmological constant (Λ) in the model (52) is a decreasing function of time. We also observe that the value of Λ approaches a small and positive value at late times which is supported by recent type Ia supernovae observations [21] – [24].

4. Conclusion

In this paper we have described a new exact solutions of EFES for Bianchi type V spacetime with a bulk viscous fluid as the source of matter and cosmological term Λ varying with time. Using a generation technique followed by Ram [39], it is shown that the Einstein's field equations are solvable for any arbitrary cosmic scale function. Starting from particular cosmic functions, new classes of spatially homogeneous and anisotropic cosmological models have been investigated for which the fluids are acceleration and rotation free but they do have expansion and shear. It is also seen that the solutions obtained by Ram [39] are particular cases of our solutions.

The cosmological constants in all models given in Section 3 are decreasing functions of time and they all approach a small positive value at late times which are supported by the results from recent type Ia supernovae observations recently obtained by the High-z Supernova Team and Supernova Cosmological Project (Garnavich *et al.* [21], Perlmutter *et al.* [22], Riess *et al.* [23], Schmidt *et al.* [24]).

Acknowledgement

One of the authors (A. Pradhan) would like to thank the Inter-University Centre for Astronomy and Astrophysics, Pune, India for proving facility under Associateship Programme where part of this work was carried out.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 104–112
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A REEXAMINATION OF SPACETIME TRANSFORMATIONS FROM THE VIEWPOINT OF MATTER WAVES

Kazuo Ota Cottrell[1]

Science Department Lake Region Union High School 317 Lake Region Road Orleans, Vermont 05860, Italy

Received August 11, 2004

This work seeks to examine whether there is a natural way for the formalism of special relativity to embrace massless objects which move at the speed of light, by asking if the spacetime coordinates of such objects can be transformed from one inertial reference frame to another. The result of using matter waves as the embodiment of wave-particle duality in an attempt to include only the guiding principle of quantum mechanics in the derivation of the Lorentz transformation equations is presented. This allows one to incorporate the comoving velocity of an object into the transformation equations in a natural way. We call the resulting transformation equations the general forms of the Einstein-Lorentz transformations (GLT). The general forms of the Einstein-Lorentz transformations (GLT) are found to reduce to the usual forms of the Lorentz transformation equations in our spacetime, revealing that the velocity of an arbitrary object in our spacetime is equal to c, the speed of light. We find as a result of the general reformulation that mass is an apparent quantity, i.e., one that is represented by an indeterminate mathematical expression. A method for dealing with such indeterminate quantities will be presented in a subsequent work.

1.0 Preliminaries

There is a problem with interpreting special relativity if the photon has a non-zero rest mass. This is according to conventional wisdom in physics today. Indeed, the logical structure of Special Relativity leads unfailingly to the conclusion that not only is the rest mass of the photon equal to zero, but the rest mass of an arbitrary object is zero as well. This requires further clarification (V. Krasnoholovets, personal communication). The primary focus of this work is to explore whether there is a *natural* way for the formalism of special relativity to embrace massless objects which move at the speed of light. Or, in other words, can the spacetime coordinates of such objects be transformed from one inertial reference frame to another?

The relativistic transformation of space and time coordinates is embodied in the Lorentz transformation equations. These equations were put into their current form around the beginning of the 20th century, before the advent of quantum mechanics.

In our current era it is impossible to ignore the importance of quantum mechanics, primarily due to its impact on technological developments in the fields of electronics and optics. From a theoretical standpoint it has not been possible to find a completely satisfactory theory which unites special (or general) relativity with quantum mechanics. This has led some distinguished physicists to question the validity of the formal structure of quantum mechanics as a theory.

Seeking to retain only the fundamental guiding principle of quantum mechanics in order to avoid possible flaws in its formal mathematical structure, we will make use here only of the concept of wave-particle duality. In particular, we will make use of the concept of a matter wave, as formulated by Louis de Broglie. Using this idea, we will present the results of a rederivation of the Lorentz transformation equations. The goal is to recast the Lorentz transformation equations into a more general form, one in which these equations can sensibly embody transformations of the coordinates of massless objects which are traveling at the speed of light.

A fact which is usually not emphasized in descriptions of objects contained in inertial frames of reference is that there are three, not one velocities which are important for a discussion of relativistic transformations. As always recognized, there is the relative velocity V between the observer's frame O and the moving frame O'. Less often recognized are the velocity u of an object in the moving frame O' measured with respect to an observer in O and the velocity u' of an object in the moving frame O' measured with respect to an observer in O'. This last velocity, u', may be referred to as the comoving velocity, because a *proper* observer in O', i.e., one who is stationary with respect to the moving object, moves with this velocity in the frame O' along with the object. When $u' = 0$, $u = V$, and only the object's velocity, u, needs to be considered in the relativistic transformation equations.

When Einstein checked the equations of special relativity to make sure that the postulate of the constancy

[1]E-mail: kocottrell@kingcon.com

of the velocity of light was consistent with the principle of relativity, he considered an expanding sphere of light, generated when the origins of O and O' are coincident. Even after separation, observers in both O and O' saw an expanding spherical wavefront, confirming that the principle of relativity was obeyed. However, a proper observer ($u' = c$) in O' moving with the expanding spherical wavefront of light, necessarily has a relative velocity V=c with respect to an observer in O. As a direct expression of the postulate of the constancy of the velocity of light, u, must also be equal to c. So Einstein in essence checked only this special case.

Let us not underestimate what Einstein accomplished. Nature seems to be correctly described when one requires that $u = c$. In the special case when $u = c$, the general Einstein-Lorentz transformation equations which we will derive in this paper give the same results as the usual Lorentz transformation equations. *So Einstein anticipated that the postulate of the constancy of the velocity of light remains consistent with a more general expression of the transformation equations of special relativity, one which is based on matter waves.*

What happens when u is not c? Answering this question will lead us to a more general form of the Lorentz transformation equations, one which will hopefully allow us to understand the transformation of coordinates for massless objects with are traveling at the speed of light.

1.0a Introduction of the comoving velocity generalizes the Lorentz transformation equations

In the one-dimensional Galilean transformation equations, there is no loss in generality from assuming that, in a suitably chosen frame of reference, an object and a properly defined observer (i.e., one moving with the object) are at rest. Any motion of the object can be subsumed under the relative velocity which the object's frame of reference maintains with some other frame of reference with respect to which a measurement is being made. This is because velocities add in a simple way. In the relativistic treatment, however, velocity addition is not so simple. The true predictive power of the Lorentz transformation equations, as usually written, is obscured by the fact that the velocity of an object and a properly defined observer (i.e., one moving with the object) are assumed to be zero: any motion of the object is subsumed under the *relative* velocity between a moving *frame of reference* containing the object and some stationary frame of reference from within which a second observer perceives that object and first observer have zero velocity in the moving frame. This requirement is more restrictive than necessary. It is sufficient that the second observer perceives that the object and first observer have zero *relative* velocity: a properly defined observer in the moving frame can be*comoving* with an object having non-zero velocity. Thus, in general it is necessary to take explicit account of the comoving velocity when constructing the Lorentz transformation equations, as distinct from the relative velocity between the two frames of reference. The most natural way of doing this involves considering an object moving with velocity u to be a matter wave having phase velocity v, and requiring that the principle of relativity be obeyed: i.e., requiring that the form of the expanding matter wave be the same in two frames of reference that happened to be coincident at time $t = 0$. This procedure will allow us to arrive at more general forms of the original Lorentz transformation equations.

1.0b Deriving a more general form of the Lorentz transformation equations

When Einstein derived the Lorentz transformation equations in his paper, "On the Electrodynamics of Moving Bodies", which appeared in Annalen der Physik in 1905, he did so by postulating that the velocity of light c is unaffected by the relative motion between two frames of reference. Then he imagined [1] a sphere of light expanding outward from the origin of two coincident coordinate systems at time $t = 0$, with one coordinate system subsequently traveling away from the other with a relative velocity V and showed that the light wave also formed a sphere when transformed to the moving frame of reference, thus proving the compatibility of the principle of the constancy of the velocity of light with the principle of relativity, which he expressed by the statement that "the same laws of electrodynamics and optics will be valid for all coordinated systems in which the equations of mechanics hold." [2]

In relativity theory, we are interested in how the *description* of the behavior of a material object differs between one reference system and another due to the relative motion of the two systems. From quantum theory, we know that all material objects have a wavelike nature. Let us now rederive the transformation equations *starting* in a manner similar to the way in which Einstein proved the consistency of the postulate of the constancy of the velocity of light and the principle of relativity, but by considering an expanding matter wave instead of a photon sphere. The postulate of the constancy of the velocity of light is replaced by the fact that in any spacetime, the condition $uv = w^2$ must be satisified, where w^2 is a constant that characterizes the wavefront of an object's matter wave and which is proportional to the object's energy, E. Thus, strictly speaking, we need only the principle of relativity to derive the general transformation equations.

1.1 Why c?

The constancy of the velocity of light has been a long standing tenet of the laws of physics, as has the role of the velocity of light as the ultimate speed limit. In this paper, it is shown that the importance of c as a physical constant is determined by the particular spacetime in which we live, and the nature of the measurements which we are able to make in that spacetime. In particular, one finds that when the conditions of constancy of velocity and propagation with a velocity equal to c are applied to a description of the wavefronts of matter waves one arrives at a correct description of events in our spacetime manifold. However, the generalization of the usual transformation equations leads to the conclusion that while the speed of light has the role of a limiting velocity in our spacetime, it does not place an upper limit on the velocity of an object moving in a general spacetime manifold.

1.2 What is spacetime?

A spacetime manifold may be defined as the set of all matter wave wavefronts which are coevolving in space and time and which originate from sources which vibrate in phase with each other. Since energy depends on frequency, as shown by Einstein's work on the photoelectric effect, and not on amplitude of vibration, as intuition might suggest, it is apparent that the sources which define a given spacetime manifold have the same energy.

Let us define a quantity, w, to characterize the wavefronts of the matter waves

$$w = \sqrt{uv}, \tag{1}$$

in which u is the group velocity of the matter waves and v is their phase velocity. Further, let us postulate that the kinetic energy of each of the individual sources that together define a spacetime manifold is proportional to the square of the velocity, w, characterizing the wavefronts which it contains.

$$T \infty w^2. \tag{2}$$

The frequency of vibration of each source corresponds to an amount of mass which is found from the following equality

$$T = \Delta mc^2 = h\nu, \tag{3}$$

from which

$$\Delta m = \frac{h\nu}{c^2}. \tag{4}$$

Using this change in mass as the definition of a proportionality constant, one can write (2) in the form of a new equality

$$T = \frac{h\nu w^2}{c^2}. \tag{5}$$

We can replace h in (7) by use of the following relationships

$$h = \lambda p = \frac{vp}{\nu} = \frac{vmu}{\nu}. \tag{6}$$

So that

$$T = \frac{vmuw^2}{c^2}. \tag{7}$$

Finally, using (4) we find

$$\Delta mc^2 = \frac{vmuw^2}{c^2}. \tag{8}$$

Using the fact that $m_0 = 0$ leads to the relationship

$$\frac{c^4}{w^2} = vu. \tag{9}$$

Finally, using (1) we find that

$$c^2 = vu \quad (our \quad spacetime \quad manifold). \tag{10}$$

Note that equation (10) is limited to our spacetime manifold because of the use of equation (4) in the derivation of (9). In general one would have

$$T = \Delta mw^2, \tag{11}$$

which leads to

$$w^2 = vu \quad (general \quad relationship). \tag{12}$$

We can find another important result. From (8) expressed using (11) instead of (4) we have

$$\Delta mw^2 = vmu. \tag{13}$$

Expanding, grouping terms with m, and factoring yields

$$m\left(w^2 - vu\right) = m_0 w^2. \tag{14}$$

From the fact that $\gamma = m/m_0$ we find

$$\gamma = \frac{w^2}{w^2 - vu} = \frac{1}{\sqrt{1 - \frac{u^2}{w^2}}} = \frac{1}{\sqrt{1 - \frac{u}{v}}}. \tag{15}$$

Rearranging yields

$$w^2\sqrt{1 - \frac{u}{v}} = 0 \Rightarrow u = v \neq 0, or w = 0. \tag{16}$$

This resolves the conflict between Brown and Martin and MacKinnon [4], since the particle and phase velocities are indeed the same *except* when $u = 0$.

In general T is given by

$$T = \Delta mw^2 = (m - m_0)\, w^2 = muv - m_0 uv, \tag{17}$$

we have from (13) that

$$\Delta m w^2 = muv. \tag{18}$$

Thus, one finds, consistent with (16) above that

$$T = 0, (w = 0)\,, \tag{19}$$

$$T = muv, (u = v \neq 0, m_0 = 0)\,. \tag{20}$$

So an object traveling with respect to a frame of reference O with $v > u = V = 0$ is measured in O to have zero kinetic energy and an arbitrary rest mass, while an object traveling with respect to a frame of reference O with $V = u = v = c$ is measured to have kinetic energy

$$T = mc^2, \tag{21}$$

but a rest mass of zero. Thus the total relativistic energy, including the rest mass energy, is kinetic in origin.

According to Adler [5] , "Einstein states explicitly [6] that the mass of a body is nothing else than the energy possessed by the body *as judged from a coordinate system moving with the body.*" From (19) we thus see that all bodies, within the framework of Special Relativity, have zero rest mass. This would be consistent with our conventional understanding of Physics if all bodies moved at the speed of light. We will show that within the framework of special relativity, this is indeed the case.

We will be using equations (9), (10) and (12) throughout this paper. The fact that w now enters as a parameter in (12) indicates that there exists a family of spacetime manifolds, forming a space-time-energy continuum in which each spacetime is characterized by a particular value of w, or equivalently, its associated energy.

1.3 The general Einstein-Lorentz Transformation Equations (GLT)

The relationship expressed in (9) above allows us to now express the coordinate transformation equations in a more general form. Let us now show how these equations are derived. We must consider a transformation between two arbitrary reference frames in the space-time-energy continuum.

When Einstein originally derived the Lorentz transformation equations, he did so by postulating that the velocity of light c is unaffected by the relative motion between two frames of reference. Then he imagined a sphere of light expanding outward from the origin of two coincident coordinate systems at time $t = 0$, with one coordinate system subsequently traveling away from the other with a relative velocity V.

In relativity theory, we are interested in how the description of the behavior of an event differs between one reference system and another due to the relative motion of the two systems. From quantum theory, we know that all material objects have a wavelike nature. Let us now rederive the transformation equations in a manner similar to that used by Einstein, but by considering the expanding matter wave wavefronts which define all of the events in a spacetime manifold, instead of a photon sphere. The principle of the constancy of the velocity of light is replaced by the fact that, in general, condition (12) must be satisfied, and specifically for our spacetime

$$c^4 = w^2 vu = w'^2 v' u', \tag{22}$$

where the quantity c^4 transforms as a scalar.

One can now proceed to derive the transformation equations that relate two arbitrary reference frames in the space-time-energy continuum. Note that the space-time-energy continuum should not itself be thought of as an absolute frame of reference. The ability of two observers to have a *different* vantage point of *the same spacetime manifold* from within the space-time-energy continuum is an indication that there in no absolute or preferred frame of reference. This is analogous to the existence of a spectrum of frequency values for a photon: each frequency value corresponds to a possible physical representation *of the same photon.* An absolute space-time-energy continuum would be consistent with the condition of global energy conservation in a spacetime manifold. However, Einstein showed that global energy conservation was not a condition found to apply in his general theory of relativity.

The procedures used to obtain the transformation equations are readily available in such books as the mechanics text by Marion [7] and will not be provided here. The results of rederiving the transformation equations are,

$$\eta_1' = \frac{\eta_1 - Vt}{\sqrt{1-\beta^2}}, \tag{23}$$

$$\eta_2' = \eta_2, \tag{24}$$

$$\eta_3' = \eta_3, \tag{25}$$

$$\eta_4' = \frac{\frac{-iV}{\sqrt{uv}}\eta_1 + i\sqrt{uv}t}{\sqrt{1-\beta^2}}, \tag{26}$$

$$\beta = \frac{V}{\sqrt{uv}}. \tag{27}$$

It is convenient to express η_4' in terms of t'. To get the final expression starting from (26) requires some algebra, but let's do it here to obtain the correspondence between the t' derived here and the usual form of Lorentz transformation equations.

Substituting for η_4' yields

$$i\sqrt{u'v'}t' = \frac{\frac{-iV}{\sqrt{uv}}\eta_1 + i\sqrt{uv}t}{\sqrt{1-\beta^2}}. \tag{28}$$

Solving for t' yields

$$t' = \frac{\frac{-V}{\sqrt{uv}\sqrt{u'v'}}\eta_1 + \frac{\sqrt{uv}}{\sqrt{u'v'}}t}{\sqrt{1-\beta^2}}, \tag{29}$$

Using (12) we find

$$t' = \frac{\frac{-V}{ww'}\eta_1 + \frac{w}{w'}t}{\sqrt{1-\beta^2}}. \tag{30}$$

In order to use (23) and (30) it would be nice to express them in terms of x_1 rather than η_1. If we do this for our case of one-dimensional motion we find

$$x_1' = \frac{x_1 - Vt}{\sqrt{1-\beta^2}}, \tag{31}$$

$$t' = \frac{\frac{x_1}{ww'}(w-V)}{\sqrt{1-\beta^2}} = \frac{\frac{x_1}{w'} - \frac{V}{ww'}x_1}{\sqrt{1-\beta^2}}. \tag{32}$$

If one now requires that the velocity w of the matter wave wavefronts is the same [8] for all frames of reference then

$$w = w'. \tag{33}$$

We can quantify, what we have meant by "velocity w of the matter wave wavefronts" by stating the relationship

$$w = w' = (u'v')^{1/2} = (uv)^{1/2}, \tag{34}$$

which we recognize as a form of equation (12). As expressed earlier by equation (10) it now follows that $w = c$. This can be shown in the following way by using the Planck-Einstein equation and the de Broglie equation

$$E = h\nu \tag{35}$$

and

$$p = \frac{h}{\lambda}, \tag{36}$$

which we may rewrite as

$$h = \frac{E}{\nu} = \frac{mc^2}{\nu} \tag{37}$$

and

$$h = \lambda p = \frac{vp}{\nu} = \frac{vmu}{\nu}. \tag{38}$$

We find by setting (37) and (38) equal that

$$\frac{m\left(c^2 - vu\right)}{\nu} = 0, \tag{39}$$

which leads one to conclude that

$$uv = c^2. \tag{40}$$

Then it follows from (34) that

$$w = c. \tag{41}$$

This is true only for our spacetime, because of the use of (37) instead of (11). (Using (11) instead of (37), one would arrive at (35), which is thus a general relationship. Relationships (33) and (41) have the following effect on the transformation equations for x_1' and t' expressed by equations (31) and (32). From (27)

$$\beta = \frac{V}{c}, \tag{42}$$

from (31)

$$x_1' = \frac{x_1 - Vt}{\sqrt{1-\frac{V^2}{c^2}}} \tag{43}$$

and from (32)

$$t' = \frac{t - \frac{V}{c^2}x_1}{\sqrt{1-\frac{V^2}{c^2}}}. \tag{44}$$

Equations (42), (43), and (44) correspond identically to the usual form of the Lorentz transformation equations.

Thus we see one important role of c: it is the conversion factor between space and time coordinates. This emerges in a natural way in the derivation of (43) and (44) as embodied in the relation $x_1 = wt$. This leads us to a statement of condition one:

Condition One: The fact that the speed of light c is the conversion factor between space and time coordinates is an essential requirement for obtaining the Lorentz transformation equations from a treatment based on the use of matter waves.

Sachs [9] has pointed out that the essential role of c as the conversion factor between space and time in all laws of Nature follows from the principle of relativity when the language of spacetime is used to express the laws of Nature.

We also arrive at the conclusion that within a description of spacetime based on matter waves two additional conditions are required to arrive at a form of spacetime coordinate transformation equations that yield a description of events which corresponds to that obtained experimentally:

Condition Two: The velocity, w, which characterizes the matter wave wavefronts (as defined by (34)) that define a spacetime manifold must be the same for all frames of reference: i.e., $w = w'$.

Condition Three: The velocity, w, which characterizes the matter wave wavefronts is equal to the speed of light: i.e., $w = w' = c$.

These last two conditions for matter waves correspond to the principle of the constancy of the velocity of light for electromagnetic radiation in a vacuum.

1.4 Form of the general Einstein-Lorentz Transformation Equations for an arbitrary spacetime manifold

From equation (23)

$$w't' = \frac{wt - Vt}{\sqrt{1-\beta^2}}, \tag{45}$$

using the fact that $w = w'$ we may write

$$wt' = \frac{wt - Vt}{\sqrt{1-\beta^2}}, \tag{46}$$

which leads to

$$t' = \frac{1}{w}\frac{(w-V)}{\sqrt{1-\beta^2}}t, \tag{47}$$

noting that $V/w = \beta$ in the general formulation we find

$$t' = \frac{(1-\beta)}{\sqrt{1-\beta^2}}t. \tag{48}$$

Since $t' = \frac{x_1'}{w}$

$$x_1' = \frac{(1-\beta)}{\sqrt{1-\beta^2}}wt. \tag{49}$$

Now, since $wt = x_1$

$$x_1' = \frac{(1-\beta)}{\sqrt{1-\beta^2}}x_1. \tag{50}$$

From equation (32)

$$t' = \frac{\frac{x_1}{ww'}(w-V)}{\sqrt{1-\beta^2}} = \frac{\frac{x_1}{w'} - \frac{V}{ww'}x_1}{\sqrt{1-\beta^2}}, \tag{51}$$

using the fact that $w = w'$ we may write

$$t' = \frac{\frac{x_1}{w^2}(w-V)}{\sqrt{1-\beta^2}} = \frac{\frac{x_1}{w} - \frac{V}{w^2}x_1}{\sqrt{1-\beta^2}}. \tag{52}$$

Noting that $x_1/w = t$, and $V/w = \beta$ we find

$$t' = \frac{t - \frac{\beta}{w}x_1}{\sqrt{1-\beta^2}}. \tag{53}$$

Equation (47) and Equation (53) really are two forms of the same equation, but it is instructive to set them equal to each other and rearrange as shown below

$$\frac{1}{w}\frac{(w-V)}{\sqrt{1-\beta^2}}t = \frac{t - \frac{\beta}{w}x_1}{\sqrt{1-\beta^2}}, \tag{54}$$

$$(w-V)\,t = tw - \beta x_1. \tag{55}$$

Noting that $tw = x_1$ we find

$$x_1 - Vt = x_1(1-\beta), \tag{56}$$

$$x_1 - x_1(1-\beta) = Vt, \tag{57}$$

$$x_1(1-(1-\beta)) = Vt, \tag{58}$$

$$x_1\beta = Vt, \tag{59}$$

$$x_1 = \frac{Vt}{\beta}. \tag{60}$$

If one divides (50) by (48) one recovers relationship (33)

$$w = w'. \tag{61}$$

An interesting feature which the reader may have noticed is that by using (48), (50) and (60) *even if one's watch is broken* it is possible for an observer in O to determine the *time* in O' because it also corresponds to one's *spatial position* in O, and *even if one's ruler is broken* it is possible for an observer in O to determine the *location in space* in O' because it also corresponds to the *time* in O.

$$t' = \frac{(1-\beta)\,\beta}{V\sqrt{1-\beta^2}}x_1, \tag{62}$$

$$x_1' = \frac{(1-\beta)\,V}{\beta\sqrt{1-\beta^2}}t. \tag{63}$$

From an examination of (48) and (50), we can define a generalized γ, called γ_{gen} to be given by

$$\gamma_{gen} = \frac{(1-\beta)}{\sqrt{1-\beta^2}}. \tag{64}$$

(The reader may find it interesting to note that Field uses this quantity, which he calls α, to write down a "manifestly space-time exchange invariant" form of the Lorentz Transformation Equations. [10])

Then

$$t' = \frac{\gamma_{gen}\beta}{V}x_1 \tag{65}$$

and

$$x_1' = \frac{\gamma_{gen}V}{\beta}t. \tag{66}$$

Noting that β is given by (27) as

$$\beta = \frac{V}{\sqrt{uv}}, \tag{67}$$

equation (65) becomes

$$t' = \frac{\gamma_{gen}}{\sqrt{uv}}x_1 \tag{68}$$

and equation (66) becomes

$$x_1' = \gamma_{gen}\sqrt{uv}t. \tag{69}$$

By using (10) if follows that whereas $x_1 = ct$ represents the transformation between time and space coordinates within a *given frame of reference* in our spacetime manifold, the following equations represent the transformation between the space and time coordinates of *two different frames of reference* in our spacetime manifold

$$x_1 = \frac{ct'}{\gamma_{gen}}, \tag{70}$$

$$x_1' = \gamma_{gen}ct. \tag{71}$$

Alex Green points out in a Usenet post [11] that the quantity (given in the present notation)

$$t = \frac{ux}{c^2}, \tag{72}$$

is the relativistic phase. This quantity may be obtained from (44) by setting $t' = 0$. From this quantity, one can find an expression for x_1 which can be substituted into (68) above to yield

$$t' = \frac{\gamma_{gen}c^2t}{u\sqrt{uv}}. \tag{73}$$

Comparison with (48) and (64) yields

$$\frac{c^2}{u\sqrt{uv}} = 1. \tag{74}$$

Solving for u, one finds

$$u = \pm c, \tag{75}$$

where we have used the fact that

$$uv = c^2, \tag{76}$$

in our spacetime to obtain this result, and where one should select the positive root from physical considerations. The result (75) is specific to our spacetime because of the use of (44) and (76). In general, if one starts with the general expression (62) one obtains

$$u = w \neq 0, or u = 0. \tag{77}$$

Equation (75) is an important result, because it says that an arbitrary object in our spacetime is moving at the speed of light. The great physicist P.A.M. Dirac anticipated this result in his well-known book on Quantum Mechanics, stating explicitly for the case of the electron: "a measurement of a component of the velocity of a free electron is certain to lead to the result $\pm c$." [12] Dirac illustrates how this result can arise in a relativistic theory by making use of the uncertainty principle. Furthermore, he points out that there is no contradiction with experiment because "the theoretical velocity in the above conclusion is the velocity at one instant of time while observed velocities are always average velocities through appreciable time intervals. We shall find upon further examination of the equations of motion that the velocity is not at all constant, but oscillates rapidly about a mean value which agrees with the observed value." [13]

1.5 The general Einstein-Lorentz transformation equations for energy in our spacetime

The relativistic energy, T, of a particle in our spacetime may be expressed by using the following equation [14]

$$T^2 = \left(mc^2\right)^2 = p^2c^2 + m_0^2c^4. \tag{78}$$

For our spacetime manifold, equation (4) holds, and (78) becomes

$$h^2v^2 = p^2c^2 + m_0^2c^4. \tag{79}$$

We can generalize this expression by using the de Broglie equation

$$\lambda = \frac{h}{p}, \tag{80}$$

$$h^2\nu^2 - \frac{h^2}{\lambda^2}uv = m_0^2w^2uv, \tag{81}$$

where we have also used (10) and (22). The dispersion relation for a matter wave is given by

$$\nu_n = \frac{v}{2\pi}k_n. \tag{82}$$

In this expression, the subscript n indicates quantization, which results from the assumption that the particle (and consequently, its associated matter wave) is contained in a universe of finite dimension, i.e., boundary conditions apply in such a closed universe. If both "ends" of the particle's matter wave are required to be nodes, we have the boundary condition of both ends fixed, so that

$$k_n = \frac{2\pi}{\lambda_n} = \frac{n\pi}{L}, n = 1, 2, 3, ... \tag{83}$$

Thus the dispersion relation may be written

$$\nu_n = \frac{v}{\lambda_n} \rightarrow v = \lambda_n\nu_n. \tag{84}$$

By use of (84) equation (81) becomes

$$h^2\nu_n^2 - \frac{h^2}{\lambda_n}u\nu_n = m_0^2w^2vu. \tag{85}$$

Table 1: General Lorentz-Einstein Transformation Equations

General form (GLT)	Form for our spacetime ($w = u = v = c$) (LT)
$\beta = \frac{V}{\sqrt{uv}}$	$\beta = \frac{V}{c}$
$t' = \frac{(1-\beta)}{\sqrt{1-\beta^2}} t$	$t' = \frac{t - \frac{V}{c^2} x_1}{\sqrt{1-\frac{V^2}{c^2}}}$
$x_1' = \frac{(1-\beta)}{\sqrt{1-\beta^2}} x_1$	$x_1' = \frac{x_1 - Vt}{\sqrt{1-\frac{V^2}{c^2}}}$
$m = \frac{m_0}{\sqrt{1-\frac{u^2}{w^2}}}$	$m = \frac{m_0}{\sqrt{1-\frac{u^2}{c^2}}}$

Multiplying the numerator and denominator of the second term in the above equation by λ_n and ν_n yields

$$h^2\nu_n^2 - \frac{h^3\nu_n^2}{\lambda_n^2 m\nu_n} = m_0^2 w^2 vu \tag{86}$$

where we have used (80) to replace λ_n in the numerator, with p replaced by mu. One can now pull out a factor of $\left(h^2v^2\right)$ from the left side to yield

$$h^2\nu_n^2\left(1 - \frac{h}{\lambda_n mv}\right) = m_0^2 w^2 vu \tag{87}$$

where we have also used (84). Dividing both sides by the quantity in parenthesis, and taking the square root of both sides, one finds

$$h\nu_n = \frac{m_0 w\sqrt{vu}}{\sqrt{1-\frac{h}{\lambda_n mv}}} = \frac{m_0 w^2}{\sqrt{1-\frac{h}{\lambda_n mv}}} \tag{88}$$

where we have used (1). Equation (88) is the correct expression for the relativistic energy of a particle moving in an arbitrary manifold. In general, hv does not represent the same physical quantity as mc^2, but for our spacetime as described by special relativity this identification holds. In general hv represents the kinetic energy of an object. In our spacetime it follows from Condition Three that (88) becomes

$$h\nu_n = \frac{m_0 c^2}{\sqrt{1-\frac{h}{\lambda_n mv}}} \tag{89}$$

For future use, it is informative to express (89) in terms of inertial mass When we quantize the frequency in our spacetime, what we are really saying is that

$$h\nu \to h\nu_n = nh\nu_{min} = nm_{min}c^2 = m_n c^2, \tag{90}$$

so that

$$m_n = \frac{m_0}{\sqrt{1-\frac{h}{\lambda_n m_n v}}} \tag{91}$$

Recalling that λ_n is given by (80) with p replaced by mu, yields

$$m_n = \frac{m_0}{\sqrt{1-\frac{u}{v}}} \tag{92}$$

which leads to an expression which is identical to the one obtained from Einstein's Special Theory of Relativity when we use (76) and when m_n is replaced by m

$$m = \frac{m_0}{\sqrt{1-\frac{u^2}{c^2}}} \tag{93}$$

or which leads to the general expression

$$m = \frac{m_0}{\sqrt{1-\frac{u^2}{w^2}}} \tag{94}$$

when one uses (34) instead of (40).

It is now clear that from the conclusion that rest mass is zero, and the conditions that link u with v (16) and w (77), and from the fact that $u = c$ (75), along with the forms of the transformation equation for mass (92) - (94), that mass is only an apparent quantity (i.e., represented by an indeterminate mathematical expression). Now that we have understood this from our general transformation equations, we can begin to work out an interpretation of indeterminate quantities that will allow us to resolve the perplexing riddle of how to reconcile the logical need for zero rest mass with physical observations. This process is begun in another paper. Below we summarize the general Lorentz-Einstein transformation equations.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 113–115
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UNIVERSE AND LIFE ORIGINATED FROM SPACE

Amrit Sorli[1] ▲, Kusum Sorli ♦

Osho Miasto Institute, Podere San Giorgio 16, 53012 Chiusdino (SI), Italy

Received August 31, 2004

Einstein emphasises in his work (1918-1930) that space has its physical properties; gravitational force was attributed to space. He came to the conclusion that cosmic space could play a role in the formation of elementary particles. Basic organic molecules that are needed for the development of life have been discovered within the observable cosmic space. The whole universe is in a phase of chemical evolution. Some experiments show that the bodily functions of living organisms are directly related to the gravitational potential of cosmic space. Cosmic space plays an active role in the evolution of the universe and of life.

1. Introduction

Einstein says: No space or portion of space (can be conceived of) without gravitational potentials; for these give it its metrical properties without which is not thinkable at all. The existence of the gravitational field is directly bound up with the existence of the space (1).

He came to conclusion that space can be the origin of the matter. In his article "The Concept of Space" in Nature from 1930 he would say: We have now come to the conclusion that space is the primary think and matter only secondary; we may say that space, in revenge for its former inferior position, is now eating up the matter (2).

In his book "Einstein and the Ether" Ludwik Costro comments: What a fundamental change in Einstein's views! Having started from denial of the existence of space and time, he finally came to the conclusion that four-dimensional space (the space-time continuum) constitutes a reality ontologically primary even to matter. At this point, he believed that matter was born from space-time (3).

According to the first law of thermodynamics one can assume that in the universe energy cannot be created or destroyed; the sum of the energy of matter and the energy of space is always constant: $E_{matter}\,(E_m) + E_{space}\,(E_s) = E_{constant}\,(E_k)$. In the first moment after the big bang $E_m = 0$, $E_s = E_k$. In the subsequent moments of the inflation phase E_s is structured into E_m, and the transformation is over when E_s and E_m are balanced: $E_s = E_m \quad (E_s = E_k/2,\ E_m = E_k/2)$. With the formation of black holes, the transformation of E_m into E_s starts, E_m is falling towards zero $(E_m \to 0)$, E_s is rising towards $E_k\,(E_s \to E_k)$. With the disintegration of matter into space the amount of energy of space is increasing. This process increases the gravitational forces between galaxies. The speed of expansion of the universe is decreasing, at a certain point the expansion stops and the universe starts to collapse into an enormous black hole that then explodes into a new big bang. Big bangs are cyclic (4).

That big bangs are cyclic is also predicted by the cosmologic theory of Turok and Steinhardt (5). Kompanichenko came to the same conclusion by studding how stars and planetary systems have been formed (6).

Also in a "stationary model" the energy of space and matter are in dynamic equilibrium. Matter is disappearing into space through black holes and reappearing in white holes. A black hole transforms the energy of matter (E_m) into the energy of space (E_s) and creates a non-equilibrium; around the black hole the amount of E_s increases, while the amount of E_m decreases. When this non-equilibrium reaches its maximum at a certain distance from the black hole its sister "white hole" is born; E_s then begins transforming through the white hole back into E_m until the energies of E_s and E_m in the area around the "sisters" reach equilibrium. The original idea of the transportation of E_m through a kind of tunnel between a black hole and a white hole was developed by Einstein and Rosen.

In the universe the energy of matter and of space are in a dynamic equilibrium (further on only DE). DE is a basic universal law. The DE between gravitational and tangential forces make it possible for planets to orbit around the sun, the water circulation "ocean-evaporation-clouds-rain-rivers-ocean" is in DE, life chains of fauna and flora are in DE.

The universe is a self-renewing system that has no beginning and will have no end. The increase of the entropy of matter after the big bang is only temporary and does not affect the total entropy of the universe that is zero.

Gravity conserves entropy; for example, in the cosmic gravitational collapse of the "Big Crunch", the to-

[1]E-mail: spacelife@libero.it

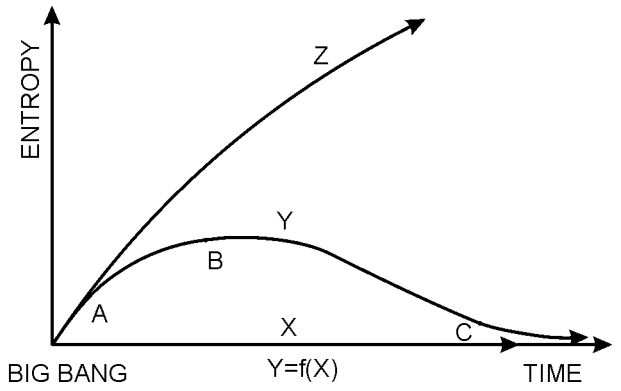

Figure 1: Entropy diagram. Y stands for evolution of life as a continuous negentropic process; X stands for a total entropy of the universe that sums to zero; Z stands for a continuous increasing of the entropy of the matter after big bang; A-B stands for chemical evolution; B-C stands for biological evolution; C- stands for the evolution of man.

tal heat loss and entropy of the Universe is reversed; in such a case, the total entropy of the Universe sums to zero. Gravity replaces positive spatial entropy with a metrically equivalent positive temporal entropy; spatial expansion is reduced because it funds the temporal component of the total entropy equation (7). In the universe the entropy of matter is continuously increasing and the entropy of life is continuously decreasing. The total entropy of the universe sums to zero.. From this point of view the evolution of life can be understood as a process that is continuously developing towards total entropy of the universe.

The relationship between life as a continuous negentropic process and the total entropy of the universe that sums to zero can be described using the following equation:

$$Y = f(X)$$

Y stands for the evolution of life

X stands for a total entropy of the universe that sums to zero

According to the understanding above the evolution of life is a consistent part of the evolution of the universe and occurs in the whole universe. Evolution on the planet Earth is a part of a wider universal process.

2. Materials and Methods

This idea is supported by the discovery of basic organic molecules necessary for the development of life in the whole of observable space. Universal space is in the phase of chemical evolution which on the earth and similar planets has continued into biological evolution (8).

Several experiments confirm that functioning of living organism is related to the gravitational field, it means to the universal space.

Spaceflight induces a cephalad redistribution of fluid volume and blood flow within the human body and space motion sickness, which has a problem during first few days of spaceflight, could be related to these changes in fluid status and in blood flow of the cerebrum and vestibular system (9).

In weightlessness there is a decreased activity of spinal ganglia neurons of the hypothalamic nuclei producing arginine, vasopressin and growth hormone releasing factor. Structural changes of the somatosensory cortex and spinal ganglia suggest a decreased afferant flow to the somatosensory cortex in microgravity. The results characterise the mechanisms of structural adaptation to a decreased afferant flow in microgravity by the neurons in the hemisphere cortex and brain stem nuclei. So, under microgravity there is a neuron hypoactivity (10).

Microgravity has a direct influence on bone fracture healing because of poor production of bone callus in microgravity: there is an increase volume of osteoid and a decrease in the number and activity of osteoblasts (11).

Experiment carried out at the University of Lubiana, Slovenia in 1987-1988 with Californian worms (Latin name is: Lumbricus Teresticus) shows that the weight of living Californian Worms greater than of the same dead ones; gravitational force of the cosmic space is stronger on the living worms than on the same dead ones (12).

Research done by Penrose and Hameroff suggest that the force of quantum gravity acting on the mass of neurones within the brain may be responsible for the emergence of consciousness. The process is fundamentally related to the influence of quantum gravity on microtubule networks within the neurones (13,14).

3. Discussion

It seems that universal space is the origin of material universe as well as of life and human consciousness. In the universe there are many solar systems with planets similar to ours. Life could also have developed there. Probably we are not alone in this vast universe.

Kompanichenko says: Approximately four billion years ago, living systems appeared on Earth and formed the superstructure over the lower organized geochemical systems. The simplest organisms were characterized by availability of unique mechanism that permitted them to transform actions from outside world and to return strengthened/expedient counteraction back into the environment. Giving an energetic profit from this exchange, living beings in fact extract free energy from the environment and accumulated it. The forms of life,

which lost the ability for the active extraction, in the long run were eliminated by natural selection. Using one more unique quality — regular self-renovation, living system step-by-step complicated and transformed the planetary medium into an environment. The extraordinary complicated human civilization is the top of this process. Both animate and inanimate natural systems of the universe are interrelated by the deepest universal processes and regularities. This shows unity of nature and allows us to support the opinion that life should be the widespread phenomenon in the cosmos (15).

Krall says: There are some hints that life could have been brought to earth from elsewhere in our solar system or even galaxy. Life tends towards more complexity but *Homo Sapiens* is not the pride of creation but rather an accident in evolution. Humans may disappear as they have come but evolution will continue. Life as such is not an accident but a function of our universe (16).

4. Conclusion

The universe is a self-renewing system in dynamic equilibrium. The increase of the entropy of matter is only temporary and does not affect the total entropy of the universe that is zero.

The evolution of life is a continuation of the evolution of the universe. It is a negentropic process that is continuously developing towards a zero entropy of the universe. All over the universe life is developing towards conscious species.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 116–120
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ABOUT THE RAPID RADIO VARIABILITY NATURE OF QUASARS AND MICROQUASARS

Yu.A. Kovalev[1] ▲, Y.Y. Kovalev[2] ♦

▲ *Astro Space Center of P.N. Lebedev Physical Institute, Profsoyuznaya 84/32, 119997 Moscow, Russia*

♦ *National Radio Astronomy Observatory, P. O. Box 2, Green Bank, WV 24944, U.S.A.; Astro Space Center of P.N. Lebedev Physical Institute, Profsoyuznaya 84/32, 119997 Moscow, Russia*

Received November 11, 2003

A hypothesis is suggested that the rapid radio variability of quasars and microquasars and the long-term radio variability of quasars are analogous in nature. A physical model of quasars, developed by the authors, is used for numerical simulation of rapid radio variability. Earlier it was successfully applied to interpret shape and structure of broadband multi-frequency spectra and long-term variability of quasars from 0.3 to 100 GHz, including instantaneous 1–22 GHz spectra, obtained recently at the RATAN–600 radio telescope. Particularly, a broadband centimeter component of an observed spectrum of a radio source reveals a long-term variability. This component was explained by a spectrum of the continuous relativistic jet, moving away from the active core of an object in a strong longitudinal magnetic field. We simulate rapid variability of the radio emission in the same model by the rapidly varying flow of relativistic particles injected from the active core. Simulated amplitude and rate of rapid radio variability is defined by amplitude, profile, and speed of rapid changes of the flow of relativistic particles, and is also dependent on effective size R of the active core. Models of microquasars suggest R to be less than that in models of quasars. The less the size R, the faster and the stronger would be a reaction (namely, the jet emission variability) to rapid changes in flow of emitting particles.

1. Introduction

Currently the variability of quasars radio emission variability is detected in a wide interval of time and frequencies: from rapid changes (round the clock, see, for example, [1–7]) up to long-term (years, see, for example, [8–13]) in millimeter, centimeter and decimeter ranges of wave lengths.

The amplitude of the registered changes of radio emission spectrum stream usually depends upon the observation occurrence and variability velocity and is from several percent to some hundred percent.

It is considered that the proper variability of radio source makes the main endowment into the observed variability at high frequencies (especially— long-term), and in decimeter (especially at short periods of time) — the distribution effects in the medium on the way to the observer (glimmering).

The problem of rapid variability nature of radio emission (on the scales of some days and less) in a centimeter range of wave length remains the most open, though in a majority of the last researches, perhaps, they inclined to the supposition about glimmering nature of such variability on interstellar medium[7].

The alternative hypothesis is analyzed numerically in the paper, according which proper source endowment into the observed rapid radio variability can be main or, at last, obvious, and the long-term variability of quasar emission have similar nature to the rapid variability so quasars as microquasars.

2. The problem setting

One of the quasar physical models is used (the model "Hedgehog"), proposed by N.S. Kardashov in 1969, developed by the authors and applied successfully earlier for the form and structure explanation of multifrequency spectra of radio emission and their long-term variability in the frequency range from 0.3 to 100 GHz ([14, 15, 16, 17]), as well as instantaneous 6-frequency emission spectra in the range of 1–22 GHz, obtained on the radio telescope RATAN–600 in 1997–2003 years as a result of mass observation about 2000 quasars and galaxies with compact RCDB components and monitoring of long-term variability 600 of them ([17, 18, 19]) — see Fig. 1.

It was shown in these papers that a majority of the measured instantaneous spectra of quasars radio emission consist of two broadband components: "decimeter" (with maximum in dm-range, reducing with the

[1]E-mail: ykovalev@adalary.asc.rssi.ru
[2]E-mail: ykovalev@nrao.edu

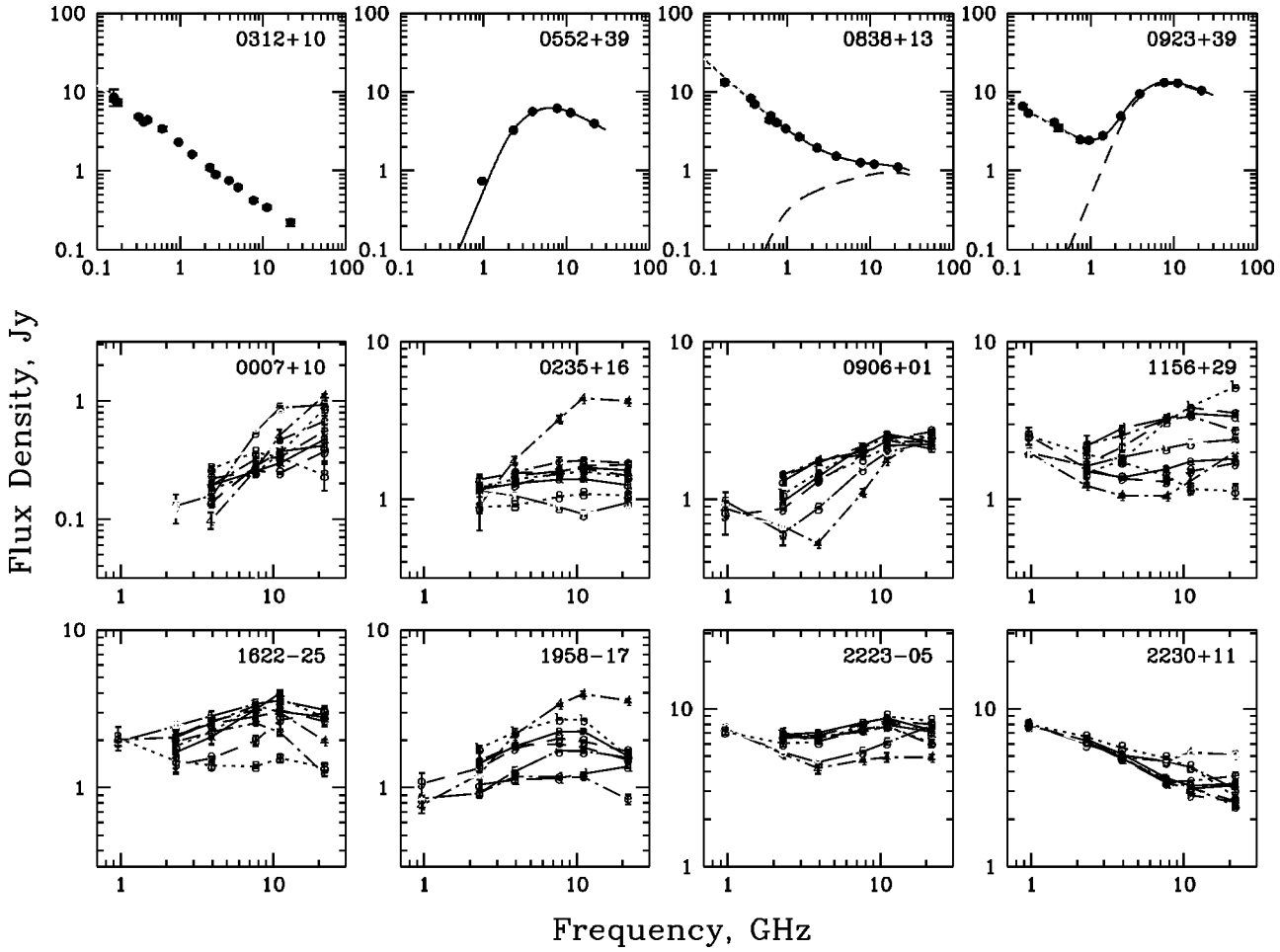

Figure 1: Some observation results at RATAN–600 and the structure modeling of radio emission instantaneous spectra of active galaxies and quasars: 1-st row: RATAN–600 spectra at 6 frequencies from 1 to 22 GHz in December 1997 (points) with LF data from the base CATS CAO RAS [22] and their modeling by the emission of compact jet (centimeter component 0552+39, 0838+13 and 0923+39 — long dotted-line, in case of 0552+39 coincides with the whole spectrum, indicated by continuous curve) and periphery lengthy cloud (decimeter component 0312+10, 0838+13 and 0923+39 — short dotted line; it coincides with the whole spectrum in the case of 0312+10, indicated by continuous direct line). 2-nd and 3-d rows: long-term spectra variability (the variability of centimeter component can be seen) RATAN–600 spectra in 1997–2002 years (15 epochs). The drawing variant of the work[19], added with new data.

frequency growth in cm-range) and "centimeter" (with maximum in cm- or mm-ranges). The centimeter component is variable in time scopes from some months to several years with variability amplitude from several units to some hundred percent (it is more than a thousand percent for some sources as well) that, according to the model, represents the emission spectrum of relativistic jet on parsec scopes, continuously flowing along strong magnetic field of the object active core.

The decimeter component is explained by quasistationary emission of compatible longitudinal periphery radio source area, accumulating the jet substance due to the link through the general structure of the magnetic field.

Let the magnetic field, having the intensity H of the quasar or microquasar active core, be dipole or quasidipole, and in the investigated vicinity of the magnetic axis at small distances r from the core center of the radius r_0 allows quasiradial approach like $H = H_0(r_0/r)^2$. Let's suppose that the relativistic particles move continuously and radiate by synchrotron mechanism from the core along the radial magnetic field, from poles outside, like narrow jet (electrons or/and protons), pitch-angles that equally distributed in the front hemispheres relating to them at the initial point r_0 ("at the margin with the core area"). Let the magnetic energy density is more lager than the density of the particles kinetic energy, the particles energetic spectrum — like $n = \mathrm{const}(E^{-\gamma})$, and changes γ, energy E of the particles and adiabatic invariant within the

considered time in the considered space area can be inessential.

Then the numerical calculation of the stream spectrum density $F_\nu(\nu, t)$ of synchrotron radio emission of the narrow relativistic jet at various frequencies (spectrum) and its variability depending upon the behavior of the whole stream in time $dN/dt \equiv dN/dt(t, r = r_0)$ of relativistic particles, injected from the active core through the jet transverse section at the margin with the core, can be executed, using the results [14], analogously to the papers[15, 17].

3. Results

If the observer is under the angle $\vartheta < \pi/2$ to the magnetic axis, only one particle jet will be observed (moving to the observer) and other stream won't be seen (moving to the opposite side). It turned out that the observer watches only the initial part of the jet in the model, the length r_0/c (c — the light speed), due to the reduction of pitch-angles radiating particles in the longitudinal magnetic field of the jet falling due to the distance increase. Let's introduce the marginal parameters of the task (at $r = r_0$) $F_0 \equiv F_0(t)$ and $\nu_0 \equiv \nu_0(t)$, making sense of the effective stream density and frequency in the emission spectrum maximum at the jet beginning accordingly. The desired emission spectrum of the jet and the whole stream of relativistic particles, injected through the margin with the active core into the jet, conveniently connected with these parameters by the ratio:

$$F_\nu(\nu, t) = \int_{\sin\vartheta}^{1} F_0(t)\, f(\nu/\nu_0(t), \vartheta, \gamma, r_0, t, x)\, dx,$$

$$\frac{dN/dt}{(dN/dt)_1} = \frac{F_0(t)}{F_{01}} \left(\frac{\nu_0(t)}{\nu_{01}}\right)^{(\gamma-1)/2},$$

where there is the function obvious view
$f(\nu/\nu_0(t), \vartheta, \gamma, r_0, t, x)$
it follows of the papers [14, 15, 17].

The results of the numerical calculation of two particular cases are given in the Table 1 and in the Fig. 2 for narrow uninterrupted jet of visible length r_0/c, observable under the angle $\vartheta = 2°$ at the background of permanent decimeter component (analogous to the modeling of two-component spectrum in the Fig. 1).

Up to some time moment $t = 0$ the marginal parameters ν_0 and F_0 and the whole stream of particles dN/dt through the transverse jet section at this margin are considered permanent within the enough long period of time, that the distribution of radiating particles along the whole visible jet part, and therefore the jet radiating spectrum became stationary (the appropriate marginal parameters, including those depending upon the time t, are designated by lower indexes "0", and initial marginal parameters (at $t = 0$) — by lower indexes "01").

Table 1: The numerical parameter values of the relativistic jet model at the parsec scales. The modeled rapid radio emission variability for Variants 1 and 2 is shown in the Fig. 2.

VARIANT	1	2
r_0/c, years	10	10
γ	2.0	2.0
ϑ, degrees	2.0	2.0
ν_{01}, GHz	30	10
F_{01}, Yan	1.0	1.0
F_0, Yan	2.0; 0.5	2.0; 0.5
ν_0, GHz	39.585; 22.736	13.195; 7.579
$(dN/dt)/(dN/dt)_{01}$	2.3; 1/2.3	2.3; 1/2.3
Δt, round a clock	36.5	36.5
T, round a clock	2.19	2.19

The emission variability is modeled by the periodic pulse changes of the whole relativistic particles stream dN/dt from the object active core, modulation between initial and final values from the moment $t = 0$ within the time Δt meandrome with the period T. Then, at $t > \Delta t$, the final stream values (in 2.3 times differing from the initial) remain unchangeable.

4. Discussion

The numerically modeled rapid radio variability is caused by rapid changes of the whole stream of relativistic particles, injected through the background of radio radiating jet area. The observed amplitude and velocity of the emission spectrum variability are determined by the amplitude of rapid changes of the whole relativistic particles stream from the object active core, velocity and changes character of these particles stream within the time. The degree of variations smoothing at the "processing" of the particles stream changes in rapidly variable radio emission, observed properties of interdaily variability depend essentially upon the rate of the particles stream change, the range of spectrum observations and, that is extremely important in this case, upon the effective dimension $R = r_0/c$ (measured in light years) of the object active core.

In its turn, this dimension should be determined by the mass and radius of the black hole in the source center — supermassive (for quasar) or littlemassive (for microquasar). The less R for microquasar in comparison with quasar, the less is the smoothing, faster and stronger is the reaction like the jet emission variability to the fastest stream changes of radiating particles.

Such rapid radio variability doesn't differ from the earlier considered long-term one as to its nature, which is caused by the analogous changes of the particle

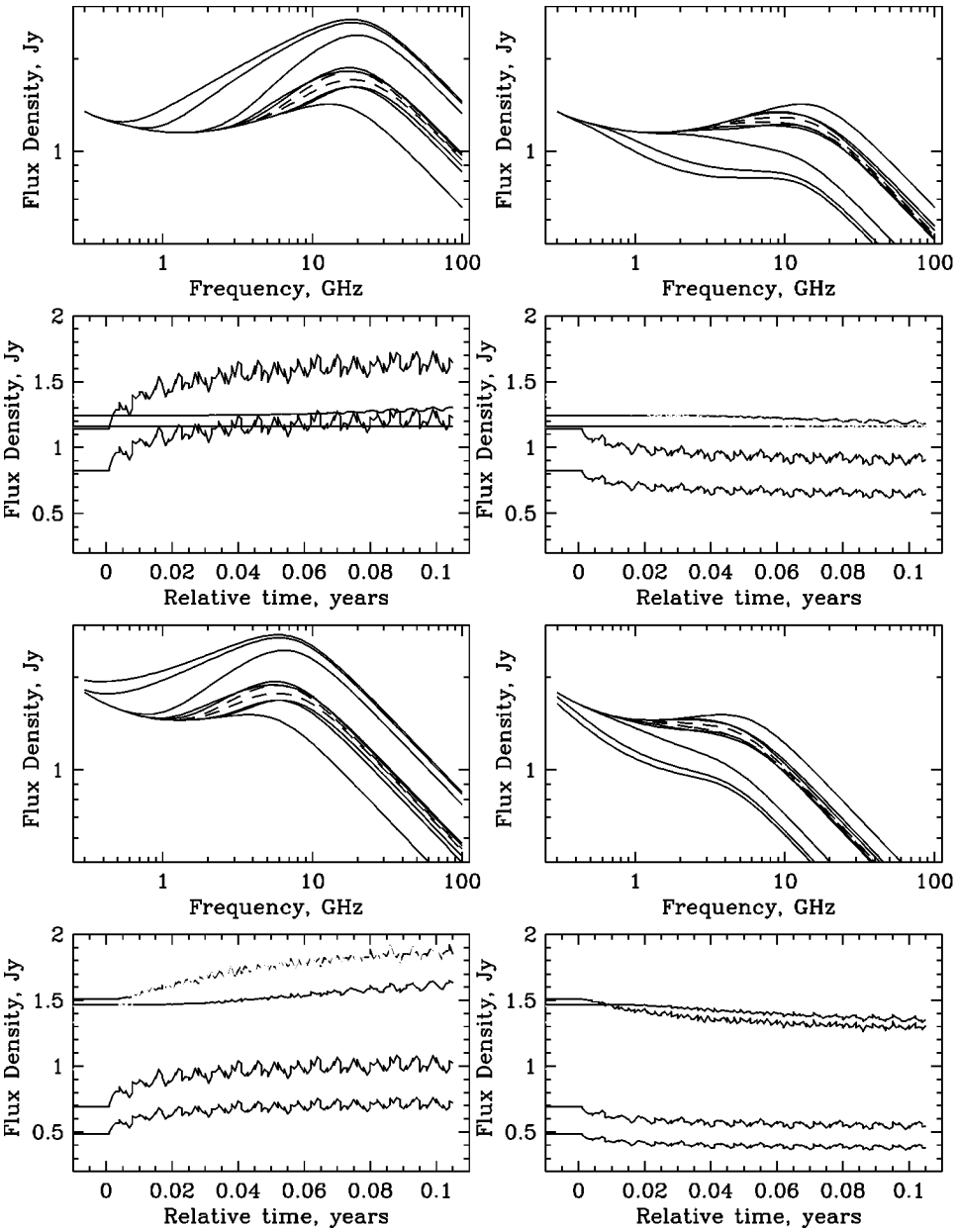

Figure 2: The rapid and long-term variability of radio emission variability of quasars and galaxies in the relativistic jet model with the parameters from the Table 1 for Variants 1 (4 upper windows) and 2 (4 lower windows). The emission variability in the time scopes from daily fractions up to 2 years is shown (at the background of permanent decimeter spectrum component, analogously to the Fig. 1), caused by the modeled pulse changes of uninterrupted stream of relativistic particles from active core with the period $T = 2.19$ round the clock within the first 36.5 round the clock. The particles stream increases (in left windows) or decreases (in right windows) in 2.3 times from the same initial value. The time interval between spectra, shown by the dotted line, is equal to 1 day, and between verge spectra — 2 years (windows in 1-st and 3-d rows from the top). The changes of the stream spectrum density within the time (windows in 2-d and 4-th rows from the top) are given in 7 frequencies: 1, 2, 4, 8, 16, 32 and 64 GHz (variability amplitude at high frequencies — more).

stream from the active core, only by less rapid (see, for example, [17]).

The first reason of rapid flowing stream changes of radio radiating relativistic electrons and protons, injected from the central area of the quasar or microquasar active core, can be the inflow non-stationarity and particles acceleration in this area due to non-stationarity of the whole substance inflow, accreationing to the black hole in the object center, — for example, due to non-stationarity, caused by the non-uniformity of the environment, involved into accreation.

In summer in 1998 we have conducted the two-months seance of radiospectra everyday observations of broadband variability 1–22 GHz for some bright com-

pact extragalactic sources[20] at the Southern sector of radio telescope RATAN–600 CAO RAS. In particular it was registered the following: at quasar 0059+581 and latsertyde 0716+714 — correlated in 2.7, 3.9, 7.7 and 13 cm the variability with approximately equal amplitude at various frequencies and specific variability time of 4–7 days and about one week accordingly; at quasar 0917+624 — rapid variability with the amplitude, increasing with wavelength enlarging, and specific period of 1 day or less than 1 day. The model, proposed in the paper, explains qualitatively the variability of the first two sources, experiencing difficulties while modeling of the last, multi-frequency properties of rapidly variable emission, which well coincides with predictions for refraction interstellar glimmering at turbulent plasma [21].

The following peculiarities of emission variability should be observed on conditions of dominating of the external (glimmering) nature of rapid variability over internal one. At first, the front delay of emission coming between signals at radiotelescopes, observing the same object simultaneously (see, for example, [5]). Secondly, the dependence of the specific glimmering period upon the season in yearly cycle (see, for example, [3, 4]) due to the Earth's rotation around the Sun. The appropriate investigation will be the critical test as for separation of external and internal physical reasons of rapid variability.

5. Conclusion

The investigated mechanism of rapid radio variability is based upon *non-stationarity* of uninterrupted jet inflow from the object active core. It follows that the availability of rapid radio emission variations can be expected in such jet sources with long-term radio variability, because strict stationarity of the jet inflow from the object active core seems less probable than permanent or temporary availability of rapid fluctuations of the jet inflow of relativistic particles. It is easier to discover the rapid proper radio variability near maximum or in high-frequency area of centimeter jet component of spectrum in the sources with minimum endowment of the "background" decimeter component.

The paper is partially supported by RFFI (projects 01–02–16812 and 02–02–16305) and the Department of Science of RF. JJK is "Jansky postdoctoral fellow" of the National Radio Astronomical Observatory of USA. The database of CATS CAO RAS was used in the paper [22].

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 121–124
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A NEW WAVE MECHANICS

S.S. Sannikov-Proskuryakov[1]

Institute for Theoretical Physics National Science Center "Kharkov Institute of Physics and Technology", Academicheskya St.1, 61108, Kharkov, Ukraine

Received August 31, 2004

In our previous papers it is demonstrated that in high energy region there is a proper quantum theory principally distinduished from the Heisenberg-Schroedinger one. It means that the usual quantum theory is not complete. Here we formulate the completeness procedure for Schroedinger wave mechanics. Hereby considering non-relativistic version naturally to use the theory of commutative functional rings. As a result we get the unique completeness procedure for the Heisenberg picture too. The new quantum scheme is based on the non-separable ring of functions (non-separable Hilbert space).

In spite of equivalence between Heisenberg picture of quantum mechanics (algebra of observables) and Schroedinger one (space of wave functions), see [1], procedures of their completeness are quite different. Enough to notice that if to begin from operator formalism of quantum mechanics so it will be seen that completeness procedure is rather non-unique (see for example [2]). May be therefore this approach did not still lead to any successes. Here we choose another approach to the problem proceeding from the wave variables of quantum mechanics. We show that in this approach closeness procedure is unique and leads to the unique extension of operator formalism of quantum mechanics. So, from the point of view of closeness problem Heisenberg and Schroedinger pictures are not equivalent: Heisenberg formulation is more closed than Schroedinger one and the reason of this circumstance is the possibility to eliminate wave variables from Heisenberg picture at all introducing instead of state vectors $|\psi\rangle$ corresponding projection operators $P_\psi = |\psi\rangle\langle\psi|$ [2.4][1]. Then the main formula of quantum mechanics is written in the form $\bar{A}_\psi = SpAP_\psi$, where A is an observable and $\bar{A}_\psi$ is its mean value in the state $|\psi\rangle$.

In [4] we have studied the topological structure of momentum and configuration spaces of new quantum theory well adopted for description of physical phenomena at very small distances[2]. Here we continue our investigation. We begin from the consideration of the well known class of wave functions used in the usual quantum (wave) mechanics and show that the class may be extended by natural way.

1. First of all we would like to notice that even in the case of non-relativistic quantum mechanics (where one does not take into account the connection between spin and statistics) field variables (wave functions) $\psi(X)$ are used not only as elements of any linear space L but also as elements of any commutative ring (algebra) A. In fact at description of field interactions products of the type $\psi(X)\varphi(X)$ where $X \in M_X$ (M_X is configuration space) and integrals $\int_{M_X} \psi(X)\varphi(X)\,dX$ (dX is the Lebesgue measure on M_X) are used.

In momentum picture connected with configuration one by the Fourier transformation

$$\psi(X) = \int_{M_p} \psi(p)\, e^{ipX} dp$$

($p \in M_p$ is momentum space, dp is the Lebesgue measure on M_p; one says that M_p is dual to the M_X in the sense of Fourier-transform) contractions $\psi * \varphi = \int_{M_p} \psi(p)\varphi(q-p)\,dp$ as else one multiplication law and integrals $\int_{M_p} \psi(p)\varphi(-p)\,dp$ appear. In connection with the latter we have to consider also usual multiplication of functions on M_p $\psi(p)\varphi(p)$.

If M_p is locally compact but non-compact manifold with Lebesgue measure $\mu_L(M_p) = \infty$ (just this case takes place in particle physics and usual quantum mechanics where a certain equilibrium between

[1]E-mail: sanpros@kipt.kharkov.ua

[1]As is well known projection operator P_ψ impossible to decompose into a *sum* $\alpha P_1 + \beta P_2$ $(\alpha + \beta = 1)$ of others projection operators P_1, P_2 (von Neumann theorem [1]). Von Neumann considered this fact to be impossibility of introducing of hidden parameters in the framework of quantum mechanics. But as it turns out P may be decomposed into (direct) *product* $Q\,Q^+$ of two other operators $Q\,Q^+$ behind which hidden parameters stand (see further).

[2]Necessity in this investigation is conditioned by the goal to construct the mathematically consequent quantum theory of particle interaction in high energy region free from ultraviolet divergences. It turned out that the simple combination of special relativity (theory of high velocities) with principles of Heisenberg-Schroedinger quantum mechanics (theory of operators in *separable* Hilbert space) is insufficient to solve this problem. The main obstacle is an inconsistency between differential topology (a priori induced in the region of small distances) and the nature of small distances, see [4].

M_X and M_p is established by Fourier-transform with Lebesgue measure) ring A may be topologized by several way. Usually one limits oneself by consideration of class of measurable absolutely integrable functions $\psi(p)$ satisfying the condition $\lim_{|p|\to\infty} \psi(p) = 0$. It forms normed (Banach) ring L_1, endowed by the norm $\|\psi\|_1 = \int |\psi(p)| dp$ obeying obviously the condition $\|\psi * \varphi\|_1 \leq \|\psi\|_1 \|\varphi\|_1$. This norm is connected with measure on M_p that is very important for physics. So the ring A (in X-picture) with usual multiplication and the ring L_1 (in p-picture) with contraction are considered to be *isomorphic* [5].

It is remarkable that L_1 ($\sim A$) is the ring without unity e: it does not contain unity function $\psi(p) = 1$[3] and therefore may be (in spite of its topological closedness) extended with conserving multiplication law $*$ and usual multiplication (but not measure on M_p and M_X, see further). More wide ring we denote A'.

2. If the set of maximal regular ideals of ring A (under usual multiplication) to denote (maximal ideal $I_p \subset A$ is collection of functions having zero in the point $p \in M_p$) so it is clear that is isomorphic to the manifold M_p [5].

Ring A may be enclosed into ring A' in the form of maximal ideal $I_\infty = A \subset A'$. All set of maximal ideals of A' is denoted '.

According to the abstract theory of commutative rings [5] manifold may be obtained from ' by means of pricking out the only one ideal $I_\infty = A$ consisting of functions obeying the condition $\psi(\infty) = 0$. In its turn manifold ' may be obtained from $\sim M_p$ by means of closeness or compactification of the latter, i.e. '$\sim \bar{M}_p$. Unlike manifold ' is closed and hence compact [5]. So, A is connected with , and A' is connected with '.

Importance of A' is in the following: as usually it contains additional (hidden from point of view of A) elements (parameters) which correspond to the more fundamental (in definite sense) objects than elementary particles standing behind the ring A. *Ring extension $A \subset A'$ is the base of our approach to the completeness problem in wave mechanics.*

3. Ring A' may be made topological one. Usually it is identified with normed (Banach) ring of limited functions L_∞ topology of which is given rise by the metric $\rho(\psi, \chi) = \|\psi - \chi\|_\infty$ where $\|\psi\|_\infty = \max_{p \in M_p} |\psi(p)|$ is the norm obeying the condition $\|\psi\varphi\|_\infty \leq \|\psi\|_\infty \|\varphi\|_\infty$. With such a topology L_∞ is *strongly non-separable* ring [5].

It is remarkable that norm $\|\bullet\|_\infty$ generally speaking by no means is connected with measure on M_p[4]. It is the reason why ring L_∞ is not used in quantum mechanics where measurement process on M_p plays very important role. In quantum mechanics L_∞ ($\sim A'$) is considered to be a dual (conjugate) space to the space L_1 of measurable (under the Lebesgue measure on M_p) functions, i.e. as a space of linear functionals over space L_1. Hereby L_∞ is endowed by weak topology in which it is *weakly separable* ring. So that in context of quantum mechanics L_∞ (as functionals) is not identical with A'. Of course further we will have to remove this *discrepancy*.

4. Further for simplicity only one-dimensional case is considered when $M_p \sim R_p =]-\infty, \infty[$ is the real number axis. In this case there are three different ways of compactification of R (see [5,6]). They are:

i) extended number axis $\bar{R} = [-\infty, \infty]$,

ii) Alexandrov compactification $\tilde{R} = R \cup \infty \sim S^1$,

iii) H.Bohr compactification bR (in this case the infinite far point of R is not added to the bR).

As is known in the case ii) completely (in i) partially) there lose linear structure and linear ordering of momentum space R_p. Dual space to the $\tilde{R}_p \sim S^1$ is the lattice Z [7]. We do not consider this case because configuration space Z does not concern the particle physics[5].

As is known usual Fourier-transform (with Lebesgue measure on M_p) is not feeling to the distinction between R_p and $\bar{R}_p$. Dual space to the R_p and $\bar{R}_p$ is one and the same R_X. Classes of functions on R_p and $\bar{R}_p$ are the same too. Hereby we may consider highly wide spectrum of normed space L_q $(1 \leq q \leq \infty)$ considered as a space of linear functionals over the normed space L_p with $p = \frac{q}{q-1}$ and also locally convex (in particular countable normed) topological vector spaces.

Quantum theory connected with $\bar{R}_p$ is quite equivalent (from pure physical point of view) to the Heisenberg-Schroedinger quantum mechanics on R_p which uses usual Lebesgue measure on R_p and separable space of functions on it. However on pure physical reasoning (exclusive importance of scalar product) quantum theory is usually connected with Hilbert space L_2 [1]. Further generalization connected with rigged Hilbert spaces including distributions of the type Dirac's δ-function as a matter of fact did nothing change but only broke the ring structure not leading to the solution of ultraviolet problem. It has to pay attention (this von Neumann emphasized [1]) that such a generalization is not desirable and not quite correct from point of view of theory of functions[6].

Especially we have to pay attention to the follow-

[3] At first sight it seems that under the contraction the Dirac's δ-function might be unity in L_1. But being a function set on manifold of zero Lebesgue measure it has norm $\|\delta\|_1 = \int \delta(p) dp = 0 \neq 1 = \|e\|_1$ that was emphasized by von Neumann [1].

[4] Although in [6] the norm $\max_{p \in M_p} |\psi(p)|$ is considered to be somehow depending on a measure on M_p.

[5] In fact increasing radius of circle S^1 (i.e. decreasing step of lattice Z) we will never come to the non-countable set of points (continuum) which consists in real configuration space R_X but will always get only some countable (may be dense in R_X) set D of points, see [4].

[6] It seems the famous argument between Dirac and von Neumann will be decided on the latter's favour.

ing circumstance: although $\bar{R}_p$ is closed (compact) its Lebesgue measure $\mu_L\left(\bar{R}_p\right) = \mu_L\left(R_p\right) = \infty$. Therefore for unity function $\psi\left(p\right) = 1 \in A'$ contraction is $\int_{\bar{R}_p} dp = \infty \ \left(= 2\pi \int \delta^2\left(X\right) dX = 2\pi\delta\left(0\right)\right)$. Namely with this infinity $\delta\left(0\right)$ ultraviolet catastrophe in usual field theory is connected. The point is in the infinity of Lebesgue measure of $\bar{R}_p$. That compact manifold $\bar{R}_p$ has infinite measure we consider to be a *discrepancy or conflict between topology and measure*[7] . We recall that *one and the same reserve of functions on R may be topologied by different ways* [1].

5. Thus the main contradiction in approach i) consists in the following: compact manifold $\bar{R}_p$ has infinite (Lebesgue) measure. To decline this contradiction we can by means of changing the measure on R_p. It turns out the compactification of R_p by means of iii) is unique remedy to solve completely this problem.

In [8] H.Bohr demonstrated in fact that the ring L_∞ with norm $\|\bullet\|_\infty$ may be enclosed into new topological ring connected with a new measure on R_p that is very important for physical theory. In Bohr's theory A' is identified with non-separable Hilbert space L_2' of almost periodical functions on R_p endowed by the scalar product

$$(\psi, \varphi)' = \lim_{P\to\infty} \frac{1}{2P} \int_{-P}^{P} \bar{\psi}\left(p\right) \varphi\left(p\right) dp$$

and norm $\|\psi\|' = \sqrt{(\psi,\psi)'}$. Hereby norm $\|\bullet\|_\infty$ majorates the Bohr-norm $\|\bullet\|'$. In fact

$$\|\psi\|' = \sqrt{\lim_{P\to\infty} \frac{1}{2P} \int_{-P}^{P} \left|\psi\left(p\right)\right|^2 dp} \leq$$

$$\leq \sqrt{\max_{p\in\bar{R}_p} \left|\psi\left(p\right)\right|^2 \lim_{P\to\infty} \frac{1}{2P} \int_{-P}^{P} dp} =$$

$$= \max_{p\in\bar{R}_p} \left|\psi\left(p\right)\right| = \|\psi\|_\infty .$$

[7] It is important to keep in mind that topology of manifold and measure on it are generally speaking not connected one with other. To set topology of manifold means to set any system of its subsets possessing definite properties, see [6]. To set the measure means to set any function on these subsets satisfying definite requirements [5]. At one and the same topology there exists some non-equivalent measures. So the Lebesgue measure μ_L is not equivalent to the Bohr measure μ_B: $\mu_L\left(R\right) = \infty$, $\mu_B\left(R\right) = 1$. But topology on a class of functions is essentially connected with measure. And we may introduce even the notion of such a topology which is connected with measure on R. Ring A' is formed by one and the same reserve of functions independently on what space $\bar{R}$ or bR is considered. But as topological rings weak separable L_∞ ($\bar{R}$) and non separable A' (bR) are principally distinct, see further and also [4].

Hence $L_\infty \subset L_2'$. In Bohr's theory contraction is defined by the formula

$$\psi * \varphi = \lim_{P\to\infty} \frac{1}{2P} \int_{-P}^{P} \psi\left(p\right) \varphi\left(q-p\right) dp.$$

R_p endowed by Bohr-measure we label bR_p. Obviously $\mu_B\left(R_p\right) = 1$. Hereby the ring A' stays non-separable because bR_p is non-Hausdorf space [4].

Factorizing A' over ideal A (carriers of functions from A are subsets in R_p of zero Bohr measure) we get the ring of Bohr's almost periodical functions on R_p denoted L_2': $A'/A = L_2'$. Properties of this ring are studied in details by H.Bohr [8].

Concretely we can say now that importance of our ring A' is in the following: *extended wave mechanics is connected with it.* Not only particles (subring A with Lebesgue measure) but particle constituents - granules (factor ring L_2' with the Bohr measure) - are described by A' , see [4]. We emphasize that non-separable ring A' is not isomorphic to the weak separable ring L_∞ used in the usual quantum theory (although they have one and the same reserve of functions, see above). Obviously operators in wave mechanics based on non-separable ring of functions (or non-separable Hilbert space) may not be represented my matrices and in such a quantum scheme there is no quantum logic (cf [2]).

Dual space to the bR_p (in Pontrjagin sense) is completely non-connected configuration space, i.e. discontinuum R_X' (R_X' like R_X consists of non-countable set of points). Topology of R_X' induced by class of almost periodical functions on R_p is the strongest or discrete one.

So new wave mechanics (field theory on discontinuum) is the theory of a new level of physical reality - particle constituents. But it is not all yet.

6. Further building of the theory is situated in the channel of works [4] where first of all it is demonstrated that the second quantized version of wave mechanics on discontinuum is trivial. Thereat it is shown that spinor granules are described by bispinors ψ_α $(\alpha = 1,2,3,4)$ obeying to the permutation relations

$$\{\psi_\alpha, \bar{\psi}_\beta\} = 0$$

which determine anti-commutative or Grassmann ring $G_8^{(*)}$ (it is important to emphasize that spinors exist in the configuration space with dimension $n \geq 3$). Grassmann's numbers $\psi_\alpha, \bar{\psi}_\beta$ are only symbols: they have not got any realization. In particular $\psi_\alpha, \bar{\psi}_\beta$ as operators dense defined on separable Hilbert space are zeros

$$\psi_\alpha = \bar{\psi}_\beta = 0,$$

see [4], that is insufficient of course for building of particle theory. At first sight it seems we swallowed the bait.

But then it turns out this Grassmann ring $G_8^{(*)}$ has complicated dynamical structure described by the Heisenberg algebra $h_8^{(*)}$, see [4]. Generators of this algebra, denoted Φ_α, $\bar{\Phi}_\beta$ $(\alpha, \beta = 1, 2, 3, 4)$, obey the commutation relations

$$\left[\Phi_\alpha, \bar{\Phi}_\beta\right] = \delta_{\alpha\beta}$$

(the rest relations are zero). They play role of canonical variables of a new dynamical system called bi-Hamiltonian. In [4] we have considered the mapping

$$\psi_\alpha \to \Phi_\alpha\,,\ \bar{\psi}_\alpha \to \bar{\Phi}_\alpha$$

(which is not homomorphism of Grassmann algebra of course) called quantization of the Dirac-Grassmann fiber. Hereby Dirac's particle fields (spin *1/2*) $\psi_\alpha, \bar{\psi}_\beta$ may be represented in the form of matrix elements

$$\psi_\alpha = \left\langle \dot{f}, \Phi_\alpha f \right\rangle, \quad \bar{\psi}_\alpha = \left\langle \dot{f}, \bar{\Phi}_\alpha f \right\rangle,$$

where f, $\dot{f}$ are states of bi-Hamiltonian dynamical system belonging to the dual pair of spaces $\left(F, \dot{F}\right)$, in which there is a non-standard (non-Fock, non-self-adjoin or non-unitary) representation of the Heisenberg algebra $h_8^{(*)}$. Field ψ of particle with arbitrary spin is represented by the formula

$$\psi = \left\langle \dot{f}, O^{(\psi)} f \right\rangle, \tag{1}$$

where $O^{(\psi)} \in U[L]$ (L is Lagrangian plane in $h_8^{(*)}$) represents particle field ψ at a new level of physical reality described by new quantum mechanics. Here f, $\dot{f}$ play the role of hidden variables in a new wave mechanics. Equations for the fields $f(x)$ and $\dot{f}(\dot{x})$ are written in [4] (x_μ and $\dot{x}_\mu$ are proper space-time coordinates of these fields). They describe a new physical substance called pre-matter (or ether).

As a result we come to definite extension of Heisenberg matrix (operator) mechanics. In fact using the expression (1) for state $|\psi\rangle$ we can write the following formula for projection operator P of usual quantum mechanics

$$P = Q(\varphi)\, Q^+(\varphi')\,, \tag{2}$$

where $Q(\varphi)$, $Q^+(\varphi')$ are other projection operators

$$Q(\varphi) = f(\varphi) >< \dot{f}(\varphi)\,,$$

and

$$Q^+(\varphi') = \dot{f}(\varphi') >< f(\varphi') \tag{3}$$

(here Q is projection onto state $f \in F$ along the state $\dot{f} \in \dot{F}$) acting on the dual non-self-adjoin pair of topological vector spaces $\left(F, \dot{F}\right)$ of ideal states f and $\dot{f}$. Concrete operator P_ψ is represented in the form

$$P_\psi = SpO^{(\psi)}Q\ SpQ^+\bar{O}^{(\psi)}, \tag{4}$$

where

$$\begin{aligned} &SpO^{(\psi)}Q =< \dot{f}, O^{(\psi)} f >= \\ &= \int \bar{\dot{f}}(\varphi)\, O^{(\psi)}(\varphi)\, f(\varphi)\, d\mu(\varphi) = |\psi\rangle\,, \end{aligned} \tag{5}$$

and $d\mu(\varphi)$ is the measure on the space of hidden parameters $\varphi_\alpha, \bar{\varphi}_\beta \in L$ $(\alpha, \beta = 1, 2)$ [4], in which canonical variables Φ, $\bar{\Phi}$ are written in the form

$$\Phi = \begin{pmatrix} \varphi_\alpha \\ \partial/\bar{\varphi}_\alpha \end{pmatrix} \&,\ \bar{\Phi} = \begin{pmatrix} -\partial/\varphi_\beta \\ \bar{\varphi}_\beta \end{pmatrix}. \tag{6}$$

Particles described by bilocal fields $\psi_\alpha(X, Y)$ (1) $\left(X = \frac{1}{2}(x + \dot{x})\,,\ Y = \frac{1}{2}(x - \dot{x})\right)$. They are smearing (not point-like) objects. Quantum theory of interaction of such objects are free from ultraviolet divergences.

So in the suggested theory pre-matter plays decided role at the construction of mathematically consequent theory of elementary particles and their interactions: from pure technical point of view it plays the role of regulating medium [4].

I am indebted to Dr. M.Konchatny for some kind of help.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 125–127
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ELECTROMAGNETIC FIELD OF THE RELATIVISTIC MAGNETIC ROTATOR

V.S. Scherbak[1]

Kuban State University, Krasnodar, Russia

Received May 12, 2004

Theory of the magnetic rotator is considered. The specific cylinder is formed around the relativistic magnetic rotator in which walls the values of magnetic and dielectric penetration of the perfect vacuum in the directions radial and parallel spin axes tend to infinity asymptotically.

A magnetic rotator (MR) is a source of magnetic field (a magnetic dipole, circulating current) that rotates on the axis located between magnetic poles and perpendicularly to the magnetic moment direction [1]. For visual imagination of the magnetic field structure originating in the MR vicinity, we shall use the magnetic flux method suggested by Faraday. If the magnetic field source is in the rotating system, so the magnetic flux seems motionless for the observer in this system. The linear velocity of magnetic flux increase proportionally to distance up to the rotation axis R. MR is the model of rotating or precessing magnetic moment of elementary particles, atom nucleuses having magnetic moment for the observer, being inside a laboratory. The particles have the high rotation frequency ω in a microcosm, therefore the linear velocity of the magnetic flux can approach to the light velocity c at the value $R_{cr} = c/\omega$. MR in which the linear velocity of a rotating system reach the values at which the relativistic effects should be taken into account, it is termed as relativistic magnetic rotator (RMR). The velocity of the magnetic flux movement cannot exceed the light speed, therefore all closed loop magnetic flux should be inside the cylindrical tube with the radius equal to R_{cr}. The magnetic flux connected to the source is absent outside this area. The cylinder radius R_{cr} should decrease proportionally to the frequency at the rotation frequency increase RMR. Let's define the values of a magnetic induction vector $\vec{B}(t)$ in any point of space around RMR by Lorentz transformation laws, and then by the General Relativity (GR) – Maxwell's equations in gravitational fields and let's compare them. The magnetic induction value $\vec{B}_0(t)$ changes both in direction and amplitude at each point of the rotating system during one rotation period MR for the observer, being inside a laboratory frame of reference. The linear velocity of any rotating system point increases proportionally to the distance R up to the rotation axis. The initial value of RMR magnetic induction $\vec{B}_0(t)$ (at low rotation frequency) grows with the relative velocity increase $v = \omega R$ transversely to the magnetic flux [2] according to Lorenz transformation laws. Taking into account that RMR has no electric field $\vec{E}_0(t) = 0$ and charges, we shall calculate the value $\vec{B}(t)$ regarding the laboratory coordinate system:

$$\vec{B}(t) = \frac{\vec{B}_0(t) - \nu \vec{E}_0(t)/C}{\sqrt{1 - \varpi^2 R^2/C^2}} = \frac{\vec{B}_0(t)}{\sqrt{1 - \varpi^2 R^2/C^2}}, \quad (1)$$

where v is the linear speed regarding the laboratory system.

The electric field $\vec{E}(t)$ appears in the rotating magnetic field, its direction is perpendicular to the direction of magnetic flux movement and the magnetic field direction:

$$\vec{E}(t) = \frac{\vec{E}_0(t) - \nu \vec{B}_0(t)/C}{\sqrt{1 - \varpi^2 R^2/C^2}}. \quad (2)$$

Lorenz transformation laws are applied only to inertial systems, therefore it is necessary to use GR for RMR - Maxwell's equations in gravitational fields. Let's define the values of the magnetic induction vector $\vec{B}(t)$ in the arbitrary point of space around RMR taking into account that the magnetic field intensity is known as $\vec{H}(t)$. It is necessary to use GR for this purpose — Maxwell's equations in gravitational fields. Let's note them for rot $\vec{H}$ and rot E in three-dimensional vector designations [3]:

$$rot\vec{H} = \frac{1}{C\sqrt{\gamma}} \frac{\partial}{\partial t}\left(\sqrt{\gamma}\vec{D}\right) + \frac{4\pi}{C}\vec{s}, \quad (3)$$

$$rot\vec{E} = -\frac{1}{C\sqrt{\gamma}} \frac{\partial}{\partial t}\left(\sqrt{\gamma}\vec{B}\right), \quad (4)$$

[1]E-mail: sherbak_w@mail.ru

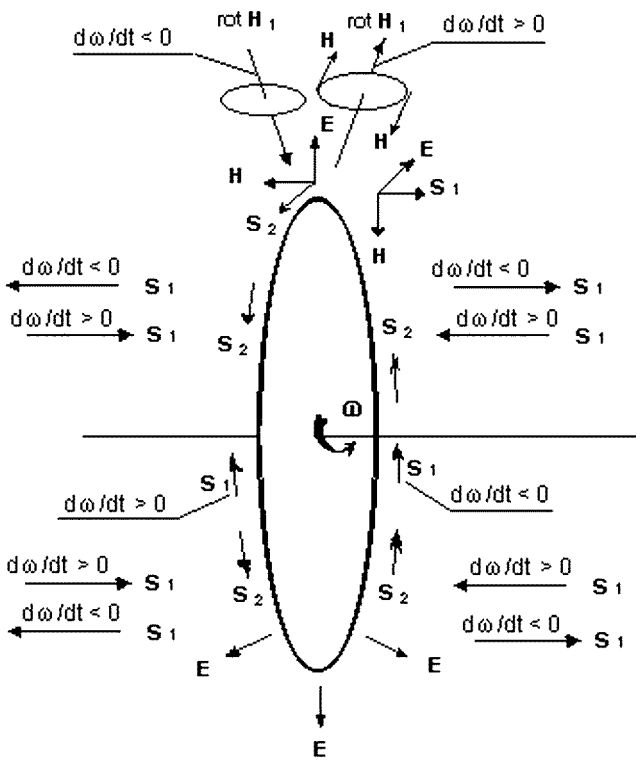

Figure 1: The energy flow of an electromagnetic field

where $\vec{s} = \rho d\vec{x}/dt$, ρ is the charge density, γ is the determinant of three-dimensional metric tensor $\gamma_{\alpha\beta}$ which is equal for the rotating system:

$$\gamma_{\alpha\beta} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \frac{r^2}{1-\frac{\omega^2 r^2}{C^2}} \end{pmatrix},$$

from which:

$$\sqrt{\gamma} = \frac{r}{\sqrt{1-\frac{\omega^2 r^2}{C^2}}}. \tag{5}$$

According to (3) rot $\vec{H}$ depends on two addends in the right-hand member. The second addend shows that the conduction current creates at motion of charges and the circulating magnetic field appears in a perpendicular plane. The first addend shows, that rot $\vec{H}$ appears at time change as electric displacement $\vec{D}$, and the additional member — the matrix determinant $\sqrt{\chi}$ (5). The gravitational field caused by acceleration varies during the angular velocity change of the rotating system or the rotation radius that the additional member $\sqrt{\chi}$ changes and results in occurrence rot $\vec{H}$ from the first addend. The first addend shows, that the change of an electric displacement $\vec{D}$ caused by its charge change (for example, around the rotating ring), and the ring acceleration change, caused by the ring radius change or its angular velocity, result in the same exterior developing process - the occurrence rot $\vec{H}$. It specifies that the physical nature of an electrical charge can be related with the acceleration occurring during rotation. The direction rot $\vec{H}$ from the first addend (3) can not coincide with a tangential direction rot $\vec{H}$ of the second addend. It results in a series of interesting phenomena. The determinant $\sqrt{\chi}$ and electric displacement $\vec{D}$ do not vary in due course at a stationary value of the rotation angular velocity of the charged ring, therefore the first addend (a current density of bias) is equal to null, and rot $\vec{H} = 4\ \mathrm{p}/\vec{s}$(the conductivity current density). The vector direction rot $\vec{H}$ coincides with the conductivity current direction. The energy flow of an electromagnetic field $\vec{S}_2 = \left[\vec{H} \times \vec{E}\right]$ is directed tangential from a second addend and constantly circulates around of a spin axis of the charged ring (Fig. 1). The circulating stream $\left[\vec{H} \times \vec{E}\right]$ does not participate in radiation according to the Heavyside's theory. The first addend (3) appears during the change of the ring rotation angular velocity $d\omega/dt$ at the constant radius r. Rot $\vec{H}$ from the first addend has both the radial and tangential directions, and the direction of it varies depending on the derivative sign dr/dt or $d\omega/dt$. Except the circulating energy flow $\vec{S}_1$ from the first addend (non-radiating and non-compensating change $\vec{S}_2$) the Pointing's vector $\vec{S}_1$ appears, which peak value is in the direction parallel to spin axes (Fig. 1). The rot $\vec{H}$ has one radial direction as the tangential acceleration lacks at the radius change dr/dt and the constant linear velocity v. Maxwell's equations in gravitational fields show that the charge stream rotating with constant velocity does not radiate and lose its energy without changing the electric displacement in space. Therefore the electron on a stationary circular orbit will not radiate the energy at rotation in case, if its charge is distributed evenly and does not cause the electric displacement changes in the environment.

The second addend lacks in Maxwell's equations (4) for rot E as the magnetic charges do not exist. Rot E appears for a rotating magnetic dipole, when $\sqrt{\chi}$, or $\vec{B}(t)$ vary in time. The physical substance of rot E is bound to varying magnetic field and has no relation to a gradient electric field, as it is impossible to create the closed-loop gradient field without an exterior radiant with an opposite direction of an electric field. MR has no Pointing's vector only in one case when the axis of its rotation coincides with a direction of a magnetic induction vector. In this case the affect of a magnetic and gravitational field, caused by acceleration at rotation, it is impossible to distinguish from each other (this assertion makes the content of the Larmor's theorem [3]), that specifies their general physical nature. We see that rotation is the cause of occurrence both a magnetic field and an electric field intensity in vacuum. Therefore it is possible to assume that all electromagnetic phenomena are the "mechani-

cal" developing processes occurring at a motion owing to the existence of special interior physical properties of vacuum. Some properties are known for us such as wave vacuum resistance, dielectric and magnetic penetration responsible for a stationary value C the velocity of electromagnetic waves distribution in vacuum. There are other interior physical properties of vacuum not understood yet by modern science, which define the values of Plank's constants, elementary charge, gravitational constant. $\sqrt{\chi}$ appears in a static gravitational field in members with time derivatives, therefore we have [3]: $\vec{D} = \vec{E}/\sqrt{\gamma}$, $\vec{B} = \vec{H}/\sqrt{\gamma}$ it is analogous to Maxwell's equations for an electromagnetic field in a material medium. We see that the gravitational field besides the affect on spatial geometry creates the same effect additionally, as the resting continuous medium with dielectric and magnetic penetration [3, 4]. The scalar gravitational potential changes the vacuum interior physical properties in SR: the dielectric e and magnetic penetration. Let's calculate their values (in the absolute system where $= \varepsilon_0 = \mu_0 = 1$), taking into account that gravitational field of RMR does not vary within time:

$$\mu = \varepsilon = \frac{1}{\sqrt{1 + 2\chi/C^2}} \quad , \tag{6}$$

where $\chi = -R^2\omega^2/2$ is the scalar gravitational potential for the rotating system [4].

The perfect vacuum changes the dielectric ε and magnetic μ penetration of the system rotating with relativistic velocity in a gravitational field according to these equations, therefore the magnetic induction vector around RMR is equal:

$$\vec{B}\,(t) = \mu\vec{H}\,(t) = \frac{\vec{H}\,(t)}{\sqrt{1 - R^2\varpi^2/C^2}}, \tag{7}$$

where $\vec{H}\,(t)$ is a magnetic-field intensity vector in a specific point of space.

Spatial distribution of magnetic induction around RMR, obtained with the help of Lorentz transformation laws and Maxwell's equations in gravitational fields, give the same pattern complementary each other. The specific cylinder is formed around RMR (Fig. 2) in which walls the values of magnetic and dielectric penetration of the perfect vacuum in the directions radial and parallel spin axes tend to infinity asymptotically. The cylinder area formed in the perfect vacuum is a cylindrical hollow waveguide for electromagnetic waves. The undamped running electromagnetic wave, polarized on a circle, spreads inside the formed waveguide. The stream of electromagnetic energy RMR circulates constantly around a spin axis and spreads along it with the light velocity. The energy E of the running electromagnetic wave in the cylindrical waveguide increases according to Planck's value $E = \hbar\omega$ with the

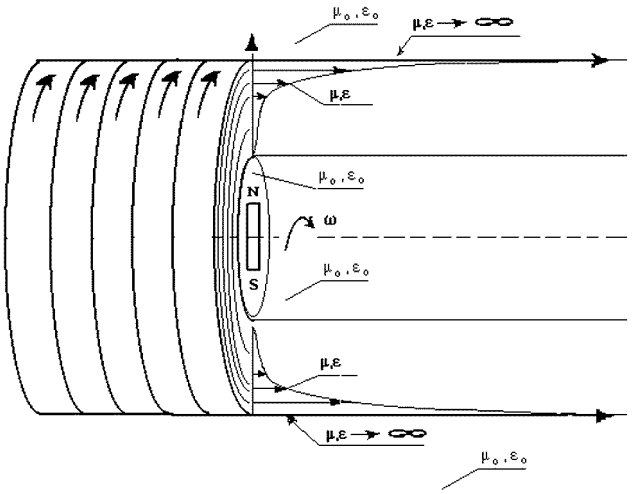

Figure 2: Spatial distribution of magnetic induction around RMR

rotation frequency increase ω, and the radius, generating the waveguide cylinder decreases. As it is shown in [5] two RMR, having close rotation frequencies form synchronously rotating pair with so-called "magnetic shaft." The length of the "magnetic shaft" is not restricted, as the reluctance in walls of the cylindrical waveguide in the direction parallel its axis tends to zero, and the energy loss (because of nuclear and molecular mediums absence in the vacuum) lacks.

The equilibrium temperature T varies according to the Tolman theorem [3] in walls of the cylindrical waveguide, at nuclear and molecular mediums available. The temperature equilibrium occurs when the value $T = T_0\sqrt{1 - 2\chi/C^2}$ becomes equal medium for all medium points. Therefore, the wall affect of the cylindrical waveguide on nuclear and molecular mediums reduces the temperature of medium T_0 up to the temperature T at which there will occur the thermal equilibrium, depending on the scalar gravitational potential value χ. The reduced medium temperature in cylindrical walls fosters the crystalline link formation and solid formations growth as tubular structures.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 128–132
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EXCHANGE INTERACTION IN A COUPLE OF RELATIVISTIC MAGNETIC ROTATORS, SYNCHRONOUSLY CONNECTED

V.S. Scherbak[1]

Kuban State University, Krasnodar, Russia

Received May 12, 2004

It is shown in the article that the relativistic magnetic rotator has a series of earlier unknown properties, which allow to explain the behavior of elementary particles in microcosm: precession of elementary particles spins, physical nature of an exchange interaction in molecular and nuclear bonds. The existence proof of earlier unknown properties at a synchronously rotated couple of relativistic magnetic rotators is given in the article.

The synchronous communication ensuring transmission of a rotation angle, synchronous gyration of power generators and operating mechanisms is widely used in industry, especially in energetic [1]. The synchronous communication is implemented by electrical communication line termed as an "electrical shaft." The rotating element of such generators (rotor) represents a magnetic rotator (MR). MR is a magnetic field source, the ring conductor with a circulating current which rotates on the axis transiting along the ring diameter. The synchronous connection between two rotating MR can be executed by magnetic communication line connected or a "magnetic shaft," but this method is not applied in technique because of high magnetic (jet) air resistance. Active, thermal losses of electrical energy in communication line wires are unavoidable at the use of synchronous communication by the "electrical shaft." The "magnetic shaft" provides power transmission without active losses, that distinguishes it significantly from the "electrical shaft."

At MR rotation rate increase up to the values, at which it is necessary to take into account the relativistic effects, MR becomes a relativistic magnetic rotator (RMR). The elementary particles, having a magnetic moment, rotate or precess with high relativistic velocities in a microcosm. They can interact among themselves, combining in synchronously connected couples by the "magnetic shaft". The investigations, executed by the author, have shown [2] that the vacuum properties change in the rotating system connected with RMR. In some distance from RMR, on the cylinder forming surface, which axis is parallel the rotator spin axis, according to the theory of relativity [3,4], the vacuum dielectric and magnetic penetration aims at perpetuity asymptotically. The peculiar cylindrical wave guide forms around RMR in space, in which walls the magnetic penetration aims at perpetuity in the direction parallel the spin axis. The diminution of the vacuum magnetic resistance allows to gain the synchronous communication and transmit the power without energy loss by so-called "magnetic shaft" connecting two and more RMR into the unified synchronously rotating system.

It is known that the magnetic moment vector is located in space along the direction of an exterior magnetic field. The potential energy MR becomes minimal at complete direction concurrence of an exterior rotating magnetic field and rotator magnetic moment. Therefore the synchronously connected rotating couple MR at the angle Q has synchronic moment equal to the magnetic energy gradient, which reduces the mismatch angle of magnetic rotators, at the mismatch of natural magnetic fields. The magnetic field energy of the synchronously connected couple MR gets the minimum value at the mismatch Q angle equal to zero. It occurs at complete coaxiality of rotating magnetic fields, MR gyration angular synchronization, and also at minimum (vanishing) distance between them. The above described properties of synchronizing magnetic fields are well described in the theory of electrical machines and widely applied in technique [1].

The relativistic synchronously rotating couple of magnetic rotators — RMR has two remarkable properties more:

1. The distance X between two RMR can only be half multiple to the wavelength λ spreading along the spin axis: $X = \lambda n/2$, where $n = 0,\ 1,\ 2,\ 3...$ are integers.

2. The magnet moments direction, their instantaneous value, RMR couples can only be parallel at $X = \lambda/2 + \lambda n$ or antiparallel at $X = \lambda n$, where $n = 0,\ 1,\ 2,\ 3...$ are integers.

Let's give the proofs of these properties. The force F, acting between magnet moments MR1 and MR2

[1]E-mail: sherbak_w@mail.ru

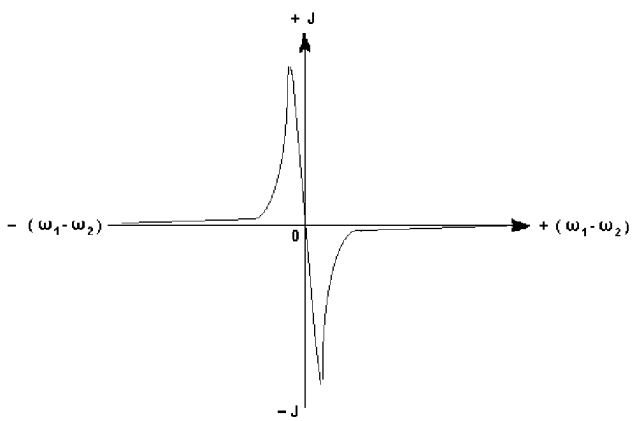

Figure 1: The moment dependence $\vec{J}$ on the frequency difference $(\omega 1 - \omega 2)$

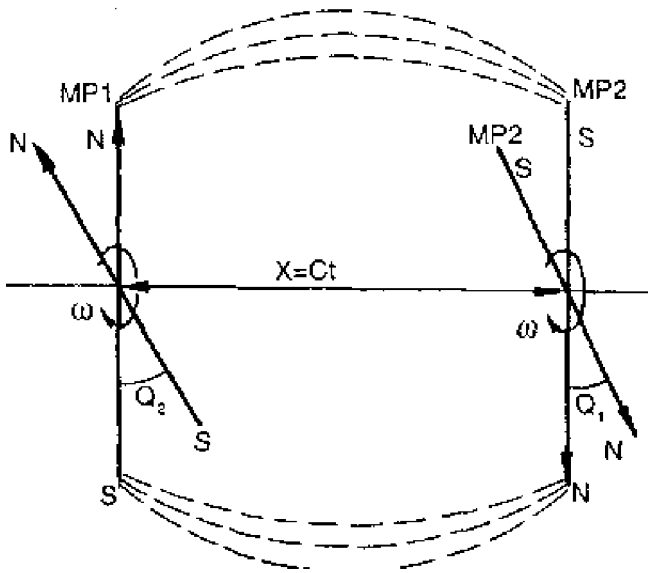

Figure 2: The rotator magnetic field

is determined as the gradient of magnetic field energy change $F = -gradEm$ at constant coupling stream. The energies of magnetic and electrical field are equal in the electromagnetic wave. The energy of a connecting electromagnetic wave is proportional to its frequency and equal $E = \omega\hbar$ for synchronically connected couple RMR. The moment $\vec{J}$, equalizing MR rotation frequencies, is equal $\vec{J} = \vec{S}/(\omega_1 - \omega_2)$, where $\vec{S}$ is the Pointing's vector of electromagnetic field. The moment dependence $\vec{J}$ on the frequency difference $(\omega 1 - \omega 2)$ is given in Fig. 1.

The potential energy of two arbitrary MR, synchronously rotating along one axis, will be minimum at the magnetic field congruence (magnetic force lines) of one magnetic rotator — MR1 with a spatial arrangement of the other magnetic rotator — MR2, i. e. at the mismatch angle Q, equal to zero. Such congruence occurs then, when the spin axes of both MR are on one line, and their magnetic moments are directed to the opposite sides. We should take into account a time delay for RMR. The rotator magnetic field MR1, spreading with the light speed c, will reach the rotator MR2 in time $t = X/c$ (Fig. 2), therefore for the concordance of the magnetic field direction from the rotator MR1 with a spatial MR2 rotator location, the last should retard the rotator MR1 in the angle $Q_1 = X\gamma/c$, where γ is RMR rotation frequency. X synchronized moment at constant distance between rotators effective on MR2, will increase with the Q mismatch angle increase.

The moment will increase also at magnification or diminution of the distance between RMR and constant Q angle. On the other hand, the last should be backward from the rotator MR2 in the angle $Q_2 = X\omega/c$ for the magnetic field congruence from the rotator MR2 with a spatial MR1 rotator location. As the values X, ω in both formulas are equal, $Q_1 = Q_2 = Q$, so both rotators should be backward in the same angle Q. It will occur then, when $Q = n$, where $n = 0, 1, 2, 3...$ We find distance between MRM from here, at which the values of a magnetic field potential energy will be minimum: $X\omega/c = n\pi$; whence $X = n\omega\pi/c = n\lambda/2$, where $n = 0, 1, 2, 3...$ Synchronously rotating on one axis, the couple RMR has a minimum potential energy at distances, multiple half of the wave length between rotators and the Q angle mismatch, equal to zero. Instantaneous directions of magnetic moments can be parallel (Fig.3), at:

$$X = \lambda/2 + \lambda n. \tag{1}$$

Or antiparallel, at:

$$X = \lambda n, \tag{2}$$

as it should be proved.

At the Q angle change or the distance between rotators in so small value ΔX the simultaneous magnetic fields congruence of both rotators is impossible. There is a synchronized moment, proportional to bias ΔX or $Q_1 - Q_2$ angles difference. There is a conservative force F, equal to the potential energy gradient, which returns RMR on the distance multiple $\lambda/2$ (Fig. 3). In this case, the electromagnetic energy stream transmits a part of the impulse moment from the rotator, advanced in an angle, to the rotator being backward. Minimum distance between two synchronously connected RMR is equal to a half of wavelength, thus the magnetic moments of both rotators should be strictly parallel. The distance change between rotators occurs in

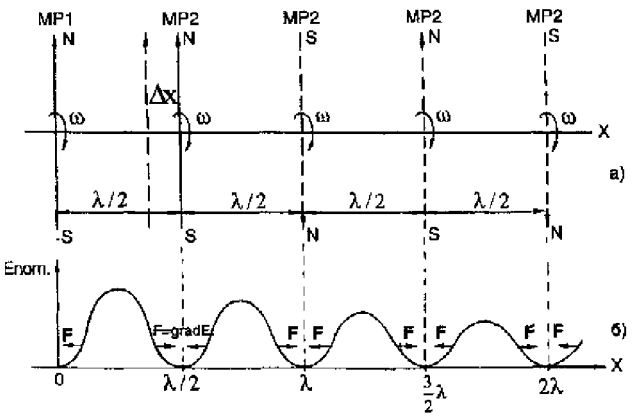

Figure 3: Instantaneous directions of magnetic moments

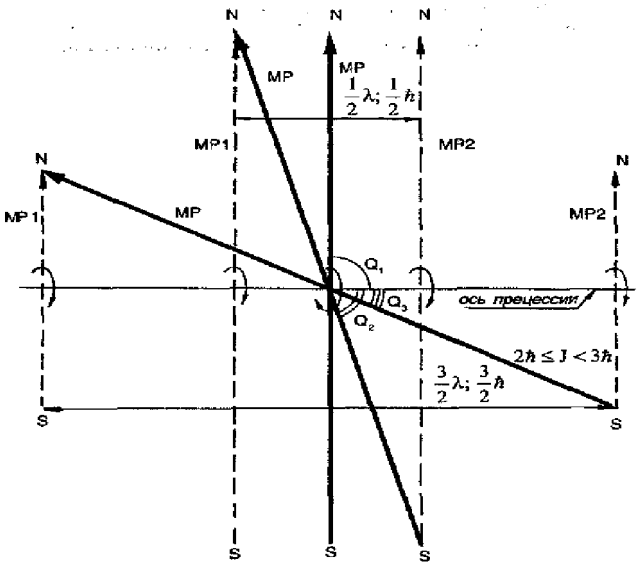

Figure 4: Magnetic moments

steps, on the wave half-length. The instantaneous direction of magnetic moments varies from parallel (at minimum distance) to antiparallel (at distances, multiple the wavelength).

It is possible to make a deduction on the basis of above-stated and as it is shown in [2]: the peculiar cylindrical wave guide is formed around RMR, inside which, the electromagnetic wave, polarized on a circle, spreads. Ponderomotive forces appear between similar objects, their frequencies and spin axes are leveled, there is a synchronous connection by the "magnetic shaft". The distance between RMR becomes multiple $\lambda/2$, and the relative direction of magnetic moments is set as parallel or antiparallel. The synchronizing moment becomes equal to zero at the complete synchronization of the RMR couple rotation, that causes the oscillatory process in inertial objects. Therefore RMR couple, synchronously connected, is dynamically steady, when it constantly makes "zero" oscillations on a rotation angle phase and connection length near the values of these parameters complete synchronization. The similar objects can form the structure like a torus in case of extraneous radial force available. The torus length, according to the requirements of RMR synchronous rotation (2), should be multiple to a wavelength. The maximal possible amount of RMR, located inside, is equal to the doubled value of wavelengths in a torus.

The experimental works, carried out by P.N. Lebedev [5], have shown, that the ponderomotive forces occurring between wave generators with various polarization and in various mediums (fluid, gas, vacuum for electromagnetic waves) are stipulated by medium properties exclusively located between generators. The vacuum properties are those that the relation is $E/\omega = \hbar$ for electromagnetic waves, photons. From here the electromagnetic wave impulse moment being in the volume, occupied by one wave length of the connected RMR couple, is equal $\hbar$, and its minimum value, at the connection length $\lambda/2$, is equal $\hbar/2$. For running electromagnetic wave, polarized on a circle excited by RMR, and spreading along the direction x in a wave-guide, we shall record the equation [6]:

$$\vec{\Psi} = \vec{y}B_m \cos(kx - \omega t) - \vec{z}B_m \sin(kx - \omega t)\,, \qquad (3)$$

where k is a wave number equal to $2\pi/\lambda$, Bm is the amplitude value of the magnetic induction.

Let's consider the relativistic gyroscope precession having parallel magnetic and mechanical moments. The precessional gyration (Fig. 4) occurs at the forces exterior moment affect on a gyroscope around its axis.

There is a field of one magnetic rotator at the precession angle *Q1* between the impulse mechanical moment of a gyroscope and forces exterior moment equal to $\pi/2$. The impulse moment projection of arbitrary quantity on a precession axis is equal to zero in this case. The $\pi/2$ magnetic poles, located on a gyroscope clips, feature a circle in space at angles Q_2, Q_3, smaller or larger, exciting a rotating magnetic field of two magnetic MR1, MR2 quazirotators. They rotate along one axis synchronously, their magnetic moments are parallel (Fig. 4). If the precessional rotation is implemented with relativistic velocities, so the distance x between two formed RMR according to (1), can obtain the values $x_n = \lambda/2 + n\pi$, where $n = 0,\ 1,\ 2,\ 3...$ Therefore, the precession angle changes in spurts at the exterior moment affect on RMR, having magnetic and mechanical moments of arbitrary value, so the distance between formed quazirotators MR1, MR2 was equal to one of the values x_n. The precessing RMR can have the distance between quazirotators only equal to: 0; $\lambda/2$; $3\lambda/2$; $5\lambda/2$ etc. As it is shown above, the

moment numerical value of the electromagnetic field impulse of synchronously connected couple RMR is proportional to the distance between rotators. So, the impulse moment of connecting electromagnetic field, is equal to λ at the distance between RMR in one wavelength $\hbar$. In consequence of it, the projection onto a precession axis of its arbitrary quantity mechanical moment can acquire only the following values during RMR precession: 0; $\hbar/2$; $3\hbar/2$; $5\hbar/2$ etc. (Fig. 4). As the quazirotators magnetic moments are always parallel, so the projection change of RMR precessing impulse moment can be only multiple to $\hbar$. The same spin projection values have elementary particles, as well as atoms nuclei having magnetic moment.

The elementary particles motion in a microcosm occurs with very high relativistic velocities. Therefore the elementary particles behavior having the magnetic moment of fermions can be explained by RMR electromagnetic fields properties. The molecular bond between two valence electrons is executed by the electromagnetic field and exchange interaction force. The Schrodinger's equation precisely describes the various sides of this phenomenon, but the physical interpretation of the molecular bond process is not clear completely. As the magnetic field energy of an electron is less in four order than its electric field energy and molecular bond energy, so it can be considered, that the molecular bond is provided with the energy of an electron electrostatic field. As it is shown above, the dynamic synchronous connection by the "magnetic shaft" has unlimited energy, as the energy of a connecting electromagnetic wave is proportional to the rotation frequency. The diameter and length of the "magnetic shaft" decrease with the connection energy increase. Therefore the synchronous electromagnetic connection by the "magnetic shaft" can represent the universal instrument, which the nature uses for the environment build-up, including both molecular and nuclear bond providing. It is possible to give the following known facts for the benefit of the above-described model of the molecular bond. It is known that mutual arrangement of valence electrons spins plays one of the important roles at chemical reactions. As the magnetic field energy of valence electrons is less in four order than the chemical bond energy, so this fact has no the reasoned physical explanation. One of the Schrodinger's equation solutions for molecular bond can be presented as:

$$\vec{\Psi} = \vec{A}\cos(kx - Et/\hbar) + i\vec{A}\sin(kx - Et/\hbar)\,. \qquad (4)$$

We shall record the equation (4) in an obvious view:

$$\vec{\Psi}_{(x,T)} = \vec{y}A\cos(kx - Et/\hbar) - \vec{z}A\sin(kx - Et/\hbar)\,. \qquad (5)$$

The physical sense of the equation (3) for a synchronously connected RMR couple is known and the matter is that the magnetic induction source $\vec{B}$ rotates in the plane y, z. It excites the electromagnetic wave polarized on a circle which spreads in the cylindrical area along the axis x with the light speed c. Reaching the other rotator, the electromagnetic wave is immersed completely and, in case of phases disparity, the ponderomotive forces level the rotation phases of both rotators. The RMR couple has the strongest bond at minimum possible connection length equal to $\lambda/2$. Thus the instantaneous directions of both rotators magnetic moments are parallel (signs of wave functions coincide), and their magnetic moments compensate each other completely. The synchronous connection of the RMR couple is provided by ponderomotive forces occurring between two generators of electromagnetic waves with circular polarization. The connection energy increases proportionally to the frequency growth, as the energy of a binding electromagnetic wave increases. Thus the connection length and its diameter decrease. The constant exchange of the impulse moment between RMR and the zero oscillations of connection length provide a dynamically stable synchronous connection. When the impulse moment value reaches the value $\hbar/2$ at the exchange, the connection length increases in $\lambda/2$, and the instantaneous directions of magnetic moments change — become antiparallel (wave functions have opposite signs). Two RMR with the same rotation frequency and direction can not exist for a long time in a limited volume, as they form the synchronously connected couple RMR, thus the rotators magnetic moments are compensated.

The equation of a wave function (5) for a connected couple of valence electrons coincides completely (taking into account that $\omega = E/\hbar$) with the equation (3), therefore it can be interpreted as follows. The vector $\vec{A}$, physical sense, which is not clear completely, describing the molecular bond electromagnetic field (the electromagnetic interaction executes molecular bond), rotates in the plane y, z. The wave function of one valence electron spreads along the axis x with the velocity c and reaches other valence electron when its spin direction coincides the vector $\vec{A}$. The molecular bond energy change occurs at the impulse moment change of the electromagnetic field equal or multiple to $\hbar$. Like RMR, two electrons can not have all identical quantum numbers, as they form synchronously connected couple with a zero magnetic moment (Pauli's principle). The singlet state arises, when the connected couple aggregate spin of valence electrons is equal to zero, and the wave functions have identical signs that corresponds to a parallel direction of the argument $\vec{A}$ vectors. The apparent contradiction for singlet connections (attraction instead of repulsion at identical signs of valence electrons wave functions) is eliminated and becomes clear by viewing in a rotating frame of reference. For a period, necessary to a wave function for distance passing between electrons, other electron, with the wave function identical sign will turn on the angle π, its wave function will change its sign into opposite one. Syn-

chronously connected RMR couple corresponds to the exchange interaction model completely as mathematically as physically. The exchange field in both connections represents an exchange of electromagnetic energy portions in the form of electromagnetic wave, polarized on a circle. The wave function quadrate of a connecting electron is equal to the electron presence probability in the area or time-average density of electron mass distribution, and the magnetic induction quadrate of the synchronously connected RMR couple is proportional to electromagnetic field energy or distribution density of electromagnetic mass. It is impossible to define the impulse direction in an arbitrary point in both cases (Heisenberg's indeterminacy), as the electromagnetic field energy stream — Pointing's vector is not dotty, but spatially distributed. It means that the physical sense has impulse direction definition only for the volume exceeding the electromagnetic field volume of synchronously connected couple RMR, in which wave half length $\lambda/2$ or the impulse moment $\hbar/2$, relevant to this length, can be placed.

The unique properties of RMR electromagnetic field allow interpreting nuclear and molecular forces as electromagnetic, caused by synchronous spin rotation of valence electrons and nucleons.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 133–136
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N OR M HIPOTHESIS?

Andrija S. Radović[1]

Nike Strugara 13a, 11030 Beograd, Serbija

Received Jule 15, 2004

The article has intention to show that M hypothesis is valid and that presently accepted one is not, i.e. that N hypothesis seriously violates Law of Momentum Conservation. It is shown on simply and comprehensive way using only basic physics laws easily understandable to everybody even with elementary physics knowledge. M hypothesis claims that magnetic field is moveable and N hypothesis claims that magnetic field is static one.

1. Homopolar Generator

Over the 180 years the question has been scarring researchers. After initial experiments done by Faraday[2] showing that $\vec{E}$ field is not moveable in his famous experiment in which Faraday's wheel (also known as homopolar or unipolar generator) was used as dynamo machine to produce electricity.

The device is consisted from the circular permanent magnet rotating over its axe of symmetry and a disk above the magnet doing the same with the angular velocity different than the magnet below just as it is shown on the picture (Fig. 1).

The device showed that induced potential depends on angular velocity $\vec{\omega}_d$ of spinning disk regardless the angular velocity of permanent magnet $\vec{\omega}_M$ as it is defined by the following formula:

$$V = \int_0^r \vec{E} \cdot d\vec{\ell} = \int_0^r \left(\vec{v} \times \vec{B}\right) \cdot d\vec{\ell} = \tag{1}$$

$$= \int_0^r \left((\vec{r} \times \vec{\omega}_d) \times \vec{B}\right) \cdot d\vec{\ell} = \frac{B \cdot r^2 \cdot \omega_d}{2}.$$

Wherein $\vec{B}$ labels field component perpendicular to te disk, and $\vec{\omega} \perp \vec{r}$ as it is shown on the previous picture. $\vec{E}$ is replaced because $\vec{E} = \vec{v} \times \vec{B}$.

Due to equation (1) that is completely independent to angular velocity of magnetic source, i.e. of permanent magnet velocity, it was concluded by 19th century scientists that magnetic field is not moveable and that potential is generating by the static magnetic field that intersect spinning disk. And this conviction is substratum of modern physics. This statements directly leads to Lorentz[3] transformation and consequently to Einstein[4] theory of relativity.

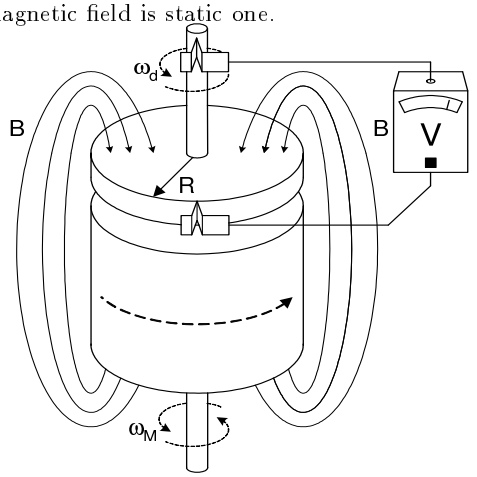

Figure 1: Construction of the device

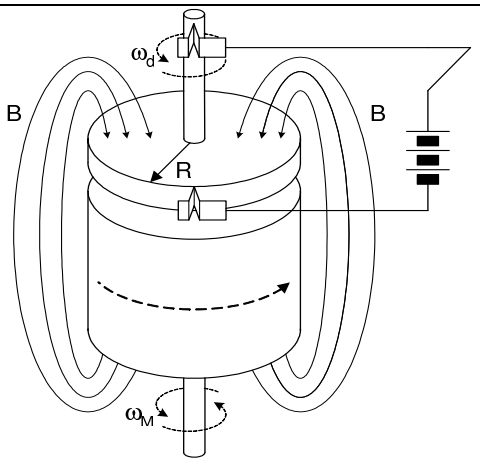

Figure 2: The plan of experiment

It really seems logically when we treat the device as generator, but situation becomes completely messy when the device is used as motor. So, let we rearrange the experiment a bit: regarding the theorem of reversibility of DC machines/generators we can conclude that the mechanism will behave as a DC motor whenever we push the current trough it as it is shown on the picture (Fig. 2).

[1] E-mail: andrijaradovic@andrijar.com
[2] Michael Faraday, 1798–1867
[3] Hendrik Antoon Lorentz, 1853 - 1928
[4] Albert Einstein, 1879 - 1955

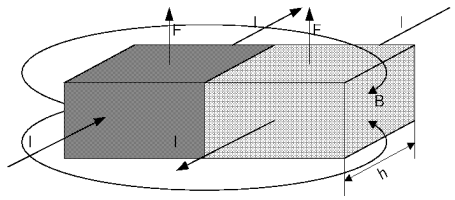

Figure 3: Linear momentum

Let we analyze both N and M cases now:

2. N Hypothesis

In case of N hypothesis current floats trough spinning disk and repeals on the static magnetic field, producing force and torque. I.e., force occurs on the path of current that floats between shaft and brash and it does not act to rotating magnet on any way. There is no stator and consequently Law of Angular Momentum Conservation is violated because there is no prop for the static magnetic field.

Also regarding the basic Newton[5] law of action and reaction we can conclude that the machine must have stator on which it will repeal.

Regarding Law of Angular Momentum Conservation the machine in case of N hypothesis could not act as motor because there is no prop for reactive forces.

This cartoon effect can be extended to the static magnet producing the force, i.e. linear momentum as it is shown on the following picture:

Let we put a current to flow trough conductive permanent magnet in contra directions in opposite parts as it is shown on the above picture and let the magnet is being separated on two parts by thin insulator that prevents current to flow between poles of magnet. But, the construction can be extended to toroidal conductive permanent magnet, etc...

Such device would produce force repealing on itself and consequently this is not possible, isn't it?

The good thing with valid N hypothesis is that modern physics stay intact including Maxwell[6] equations, Lorentz Transformations and Einstein relativity. Only Law of Momentum Conservation, a cornerstone of both claasical and quantum physics, should be rejected completely or partially. But, in the eyes of field theoreticians, the aforementioned loss is negligible regarding rejection of Lorentz Transformations or even rejection of Theory of Relativity. Acceptance of both N hypothesis and Momentum Conservation Law is really tricky and nearly impossible. It is interesting to stress

[5] Isaac Newton, 1643 - 1727

[6] James C. Maxwell, 1831 - 1879. The equation was discovered at 1865.

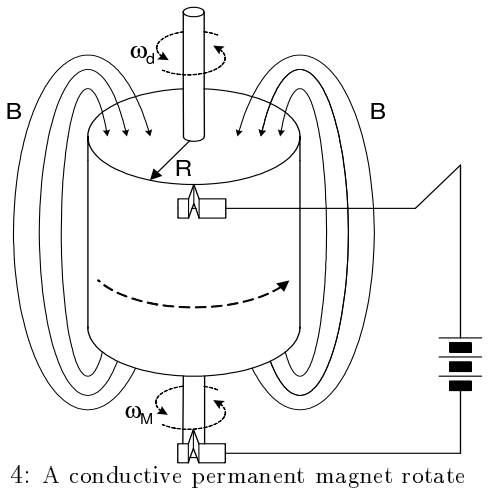

Figure 4: A conductive permanent magnet rotate

that violation of 3-rd Newton's Law as applied to rotations (angular momentum conservation) has stimulate unphysical claims on "overunity" engines, "free energy" convertes, and so.

3. M Hypothesis

For M hypothesis we can suppose that magnetic field has velocity of conductor it floats trough. For better understanding of the device let we rearrange the device a bit: let a conductive permanent magnet rotate as it is shown on the following picture:

In the case, one side of force acts to a current floating between shaft and brash and other side of the force act to the rigid part of electric circuit outside the spinning magnet, i.e. to the wires and battery. Furthermore, end of force that acts to a part of closed electrical circuit in the rotating permanent magnet has equal magnitude and opposite direction than end of force acting to a rest of the circuit outside permanent magnet.

In the case of M hypothesis Law of Angular Momentum Conservation is not violated.

It is interesting that M hypothesis obeys to Faraday's law of induction:

$$V = -\frac{d\Phi}{dt} = -\frac{d}{dt}\int_S \vec{B}\cdot d\vec{S}. \tag{2}$$

It is a special case of the law where field intensity is constant and surface $\vec{S}$ is changeable. For better understanding Lets we consider a homopolar generator consisted of permanent magnet rotating over its axe of symmetry intersected by the plane p as it is shown on the following picture:

Let we imagine additional plane that is perpendicular to plane p and intersect it on doted line thus it is tangential to rotating permanent magnet. It is obvious that amount of field are equal from both side of the additional plane supporting M hypothesis. Inner and outer part of electric circuit interacts with the same

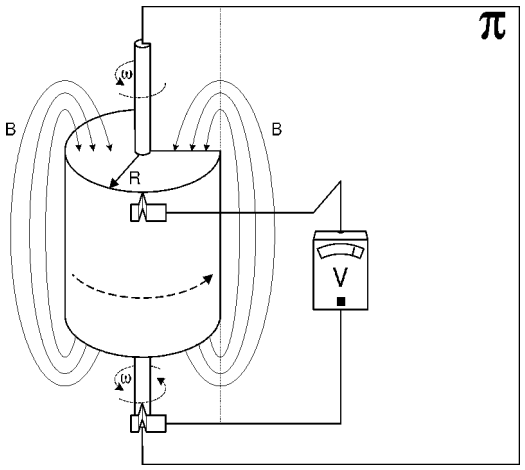

Figure 5: A homopolar generator

amount magnetic field and thus the force ends are perfectly equilibrated because the force is equal on its both ends.

The bad thing with M hypothesis is massive rearrangement of modern physics: Maxwell Equations, Pointing Theorem and Einstein Relativity are incompatible with the hypothesis because appropriate new formulas should contain velocity of $\vec{B}$ and $\vec{E}$ fields as suggested on http://www.andrijar.com/rwoteewdm/index.htm. Hooper[7] showed by his coils that electric field $\vec{E}$ can be produced by two equal and oppositely placed permanent magnets moving in opposite direction although their $\vec{B}$ fields are annulated. It is possible due to their contra magnetic directions and contra velocities producing electric field in the same direction, i.e.:

$$\vec{E} = \vec{v} \times \vec{B} + (-\vec{v}) \times \left(-\vec{B}\right) = 2 \cdot \vec{v} \times \vec{B} \neq 0. \tag{3}$$

Although:

$$\vec{B} + \left(-\vec{B}\right) = 0. \tag{4}$$

The situation is very same with magnetic induction caused by current running trough electrically neutral conductor as all ordinary conductors are. There is no outer electric field but certainly there is magnetic field in a solenoid. Present electromagnetic theory this situation exceeds dealing with currents directly avoiding usage of initial electric field.

The Hooper coils construction is shown on the following picture:

Control charge Q will be affected by electric force induced by moving annulated electric field. Electric potential will be induced in the contour too although magnetic field is annulated and thus it is zero over the plane of interaction.

[7] Hooper W. J. Hooper, U.S. Pat 3610971 & U.S. Pat 3656013, patented in 1972

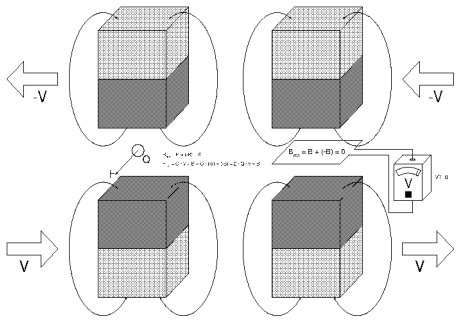

Figure 6: The Hooper coils construction

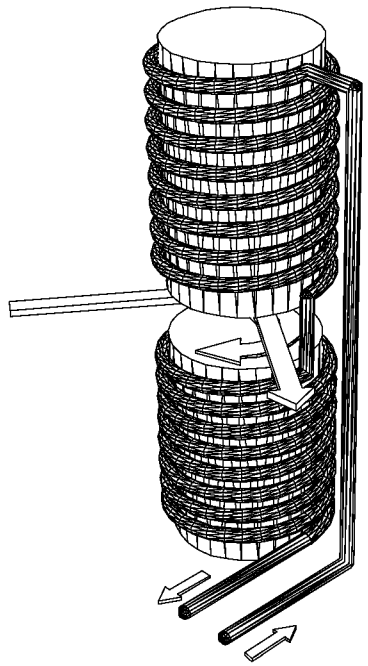

Figure 7: Case of magnetic induction

The following picture shows case of magnetic induction. The gap between two electromagnets does not contain electric field at all but it certainly contains magnetic field:

There is no significant electric field in conductors too especially in case of superconductive coils.

It is clear that charges flying trough the gap will decline in regard with rotation of electrons in solenoids. This clearly shows that electric and magnetic induction can exists regardless electric or magnetic field. If we imagine for a moment that electron is a bullet shouted in the water vertex, then the path of the bullet in the vertex and the path of the charge in the gap would be similar. But, there is no full analogy because charge in rest does not interact with the electrons in solenoid. Interaction affects only moving charges.

Regarding above picture it is obvious that magnetic field is real vertex field caused by charge movement.

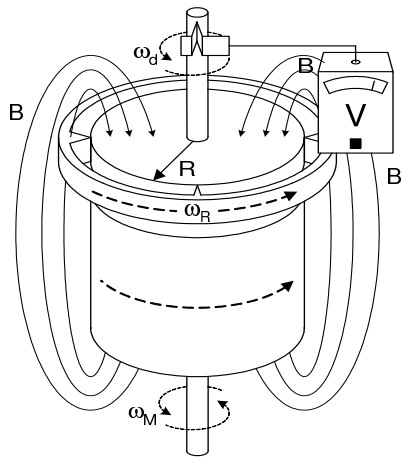

Figure 8: The project of final experiment

Consequently we cannot talk about magnetic field alone without its origin, i.e. moving charges because it is summation of effects produced by all moving electrons in solenoid.

If M hypothesis is true, than Maxwell equations are just good approximation of something more essential.

4. Experimental Verification

The final experiment should be consisted of rotating conductive disk and measuring device and wires of outer electric circuit fixated to the disk or the measuring device with wires should be fixated on the ring supplied with the brushes spinning with its own angular velocity that is independent to angular velocity of disk and velocity of magnet:

In case of valid M hypothesis voltage should be:

$$V = \frac{B \cdot r^2 \cdot (\omega_d - \omega_R)}{2}. \tag{5}$$

In case of N hypothesis equation (1) should be still valid, i.e. induced potential should stay independent to angular velocity of outer electric circuit. Formula (5) contains stator velocity and thus it is not in collision with the Law of Angular Momentum Conservation.

5. Conclusion

The question whether the N or M hypothesis is valid one is essentially important for modern physics. Proper explanation of homopolar generator would immediately leads us to much more accurate electromagnetic formulas that preserves Law of Action and Reaction, Law of Momentum Conservation and Law of Energy Conservation.

Rejection of N hypothesis would not cause complete rejection of Theory of relativity because it yields excellent experimental agreement probably due to big constant of light's speed.

In case of M hypothesis the concept of Electromagnetic Fields should be seriously revised.

The final answer should be given after series of carefully performed experiments with homopolar generator with disk of metal, graphite and semiconductor. Probably the best set of experimental work performed (and never disproved) up to day is that due to Guala-Valverde's team in Argentine [1, 2, 3, 4, 5, 6, 7]. It should be checked whether the machine in generator mode obeys to formula (1) or (5) or there is some other mechanism that produces electricity (maybe equation (2)?). Guala-Valverde et al. unassailable experiments give full credit to M hypothesis, i.e. to equ. (5), and puts the end to an old controversy on rotational electrodynamics [8,9,10,11,12,13].

Finally, if N hypothesis is true - equation (1) is valid and (5) not, Energy Conservation Law is not real law and StarDrive (StarDrive, the device from www.StarDrive.org) is possible, everything else in Physics is O.K., otherwise everything must obey to Energy Conservation Law and most of modern physics knowledge is wrong excluding classical and quantum mechanics.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 137–138
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SPIN POLARIZATION TYPE DEPENDENCE OF THE NEUTRINO MASS AND NATURE

B. S. Yuldashev[1] and R. S. Sharafiddinov[2]

Institute of Nuclear Physics, Uzbekistan Academy of Sciences, Tashkent, 702132 Ulugbek, Uzbekistan

Received August 17, 2004

The interaction with field of a nucleus of longitudinal and transversal neutrinos (antineutrinos) have been investigated at the account of their rest mass, charge, magnetic, anapole and electric dipole moments. Compound structure of these processes cross sections has sharply expressed features and generalities for any lepton as well as for a massive Majorana neutrino. A new influence of truly neutral neutrinos masses to the elastic scattering by nuclei of the electric charge have been discovered which testifies about the existence of fundamental differences both in nature and in masses of longitudinal and transversal neutrinos of Majorana.

One of highly characteristic features of all types of neutrinos is their rest mass. At the same time nature of the inertial mass itself remains thus far not finally studied. Usually it is accepted that no any connection between the mass of a particle and its fundamental structure. However, in the framework of the hypothesis of field mass based on the classical theory of an extensive electron [1], a particle all the mass has an electromagnetic behavior.

On the other hand, it is known that massless neutrinos are strictly longitudinal. In many articles the properties of longitudinal polarized Dirac neutrinos was investigated with account of their rest mass. At the availability of a non - zero mass, the neutrino can have either longitudinal or transversal polarization. In these phenomena, a sharp dependence is said between the mass of the neutrino and its spin nature [2].

The purpose of a given work is to brighter reveal the ideas of such a connection [2] and to generalize their as far as this is possible to the case of truly neutral neutrinos by studying the interaction of massive neutrinos of a different nature with field of emission in the spin polarization type dependence. At first, the processes of elastic electromagnetic scattering of longitudinal polarized Dirac ($k = D = e$) and Majorana ($k = M = 1$) neutrinos (antineutrinos) on a spinless nucleus have been considered taking into account as well as the charge $F_{1\nu_k}(q^2)$, magnetic $F_{2\nu_k}(q^2)$, anapole $G_{1\nu_k}(q^2)$ and electric dipole $G_{2\nu_k}(q^2)$ form factors of leptonic current. Next, we will reanalyze their for the transversal case of fermion polarization. Some logical implications implied from these discussions have been listed which allow to also rewatch in the nucleus field the behavior of neutrinos of both types.

[1]E-mail: yuldashev@iae.inp.uz
[2]E-mail: rasulkhozha@inp.uz, rasulkhozha@yahoo.com

The amplitude of elastic scattering of an arbitrary polarized neutrinos on the nucleus electric charge can be written in the form

$$M_{fi}^{em} = \frac{4\pi\alpha}{q^2}\overline{u}(p',s')[\gamma^{\mu_k}F_{1\nu_k}(q^2)- -i\sigma^{\mu\lambda}q_\lambda F_{2\nu_k}(q^2) + \gamma^5\gamma^\mu G_{1\nu_k}(q^2)- -i\gamma^5\sigma^{\mu\lambda}q_\lambda G_{2\nu_k}(q^2)]u(p,s)J_\mu^\gamma(q), \quad (1)$$

where $\nu_k = \nu_D = \nu_e^{L,R}$ or $\nu_M = \nu_1^{L,R}$, $q = p - p'$, $p(s)$ and $p'(s')$ imply the four - momentum (helicities) of neutrinos before and after the interaction, J_μ^γ denotes the electromagnetic current of a nucleus.

According to these data, the studied processes are at the account of longitudinal polarization of fermions described by the cross section

$$\frac{d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,s,s')}{d\Omega} = \frac{1}{2}\sigma_o^{\nu_k}(1-\eta_{\nu_k}^2)^{-1}\{(1+ss')\times \times[F_{1\nu_k} \pm 2s\sqrt{1-\eta_{\nu_k}^2}G_{1\nu_k}]F_{1\nu_k}ctg^2\frac{\theta}{2}+ +\eta_{\nu_k}^2(1-ss')[F_{1\nu_k}^2 + 4m_{\nu_k}^2(1-\eta_{\nu_k}^{-2})^2F_{2\nu_k}^2]- -8sE_{\nu_k}^2(1-ss')(1-\eta_{\nu_k}^2)^{3/2}F_{2\nu_k}G_{2\nu_k}+ +(1-\eta_{\nu_k}^2)[(1+ss')G_{1\nu_k}^2ctg^2\frac{\theta}{2}+ +4E_{\nu_k}^2(1-ss')G_{2\nu_k}^2]\}Z^2F_c^2(q^2)tg^2\frac{\theta}{2}. \quad (2)$$

Here the upper (lower) sign corresponds to the neutrino (antineutrino), θ is the scattering angle, V_{ν_k} and A_{ν_k} imply the presence both of vector and of axial - vector components of leptonic current, F_c is the charge

$(F_c(0) = 1)$ form factor of a nucleus, and Z is the number of its protons. We have also used the size

$$\sigma_o^{\nu_k} = \frac{\alpha^2 cos^2\frac{\theta}{2}}{4E_{\nu_k}^2(1-\eta_{\nu_k}^2)sin^4\frac{\theta}{2}}, \quad \eta_{\nu_k} = \frac{m_{\nu_k}}{E_{\nu_k}},$$

where E_{ν_k} and m_{ν_k} are the neutrino mass and energy.

If taken into account that the terms $(1+ss')$ and $(1-ss')$ characterize respectively the scattering with $(s'=-s)$ and without $(s'=s)$ flip of spin of incoming left $(s=-1)$ and right $(s=+1)$ polarized particles, the value of (2) one can replace to

$$d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,s) = d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,s'=s)+ \\ +d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,s'=-s), \quad (3)$$

in which $d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,s'=s)$ corresponds to the scattering with helicity conservation, $d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,s'=-s)$ is responsibile for the interconversion of longitudinal neutrinos of the different components.

Basing on (1), one can define the general structure of cross section of the discussed processes for the transversal case of the neutrino polarization:

$$\frac{d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,\varphi,s,s')}{d\Omega} = \frac{1}{2}\sigma_o^{\nu_k}(1-\eta_{\nu_k}^2)^{-1}\{((1+ss')\times \\ \times\alpha_T cos^2\frac{\varphi}{2} + (1-ss')\alpha_T^* sin^2\frac{\varphi}{2})F_{1\nu_k}^2+ \\ +\eta_{\nu_k}^2((1+ss')\gamma_T sin^2\frac{\varphi}{2}- \\ -(1-ss')\gamma_T^* cos^2\frac{\varphi}{2})[F_{1\nu_k}^2+ \\ +4m_{\nu_k}^2(1-\eta_{\nu_k}^{-2})^2F_{2\nu_k}^2]tg^2\frac{\theta}{2}\pm \\ \pm 2s\eta_{\nu_k}\sqrt{1-\eta_{\nu_k}^2}((1+ss')sin^2\frac{\varphi}{2}- \\ -(1-ss')cos^2\frac{\varphi}{2})\gamma_T^* F_{1\nu_k}G_{1\nu_k}tg\frac{\theta}{2}+ \\ +(1-\eta_{\nu_k}^2)((1+ss')\alpha_T^* sin^2\frac{\varphi}{2}+ \\ +(1-ss')\alpha_T cos^2\frac{\varphi}{2})G_{1\nu_k}^2+ \\ +4E_{\nu_k}^2(1-\eta_{\nu_k}^2)((1+ss')\gamma_T^* cos^2\frac{\varphi}{2}- \\ -(1-ss')\gamma_T sin^2\frac{\varphi}{2})G_{2\nu_k}^2 tg^2\frac{\theta}{2}\}Z^2F_c^2(q^2). \quad (4)$$

Here it has been accepted that

$$\alpha_T = 1-2(1-4sin^2\frac{\varphi}{2})sin^2\frac{\varphi}{2}, \quad (5)$$

$$\alpha_T^* = 1+2(1-4sin^2\frac{\varphi}{2})cos^2\frac{\varphi}{2}, \quad (6)$$

$$\gamma_T = 1+2cos^2\frac{\varphi}{2}, \quad \gamma_T^* = 1-2cos^2\frac{\varphi}{2}, \quad (7)$$

and φ is the azimuthal angle.

As well as (2), the presence in (4) of the multipliers $(1+ss')$ and $(1-ss')$ gives the right to present its as

$$d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,\varphi,s) = d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,\varphi,s'=s)+ \\ +d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,\varphi,s'=-s), \quad (8)$$

where $d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,\varphi,s'=s)$ answers to the scattering without flip of spin, $d\sigma_{em}^{V_{\nu_k},A_{\nu_k}}(\theta,\varphi,s'=-s)$ characterizes the change of transversal helicity.

In the case of massive Dirac neutrinos, the cross sections (3) and (8) are at the low energies $(E_{\nu_D} \to m_{\nu_D})$ not different. Unlike this, a coincidence of cross sections for the longitudinal and transversal polarized neutrinos of an arbitrary energy takes place, if the elastic scattering arises at the expense of purely vector or axial - vector components of leptonic current.

Such an order, however, may exist only in the case where the fermion mass is nohow connected with its polarization. Therefore, if it turns out that the availability of mass in neutrino transforms a longitudinal particle into a transversal ones, and vice versa, this will indicate to the existence of fundamental difference not only in masses [2] but also in nature of Dirac neutrinos of the most diverse types of polarizations.

Exactly the same one can as a completeness include in the discussion massive Majorana neutrinos. They of course have no neither an electric charge nor a magnetic moment $(F_{i\nu_M}(q^2) = 0)$, and the interaction of $G_{i\nu_M}(q^2)$ with field of emission is stronger [3] than the interaction of Dirac neutrinos axial - vector currents.

Our analysis shows that the cross sections describing the studied processes with longitudinal and transversal Majorana fermions of any energy have the same size.

It is clear, however, that the same massive neutrino possesses either longitudinal or transversal polarization. Therefore, at the availability of a non - zero mass, the longitudinal neutrino must convert into the transversal ones, and vice versa. Such a connection between the truly neutral neutrinos in their spin polarization type dependence may serve as an indication to the existence of fundamental differences both in nature and in masses of longitudinal and transversal neutrinos of Majorana.

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Spacetime & Substance, Vol. 5 (2004), No. 3 (23), pp. 139–144
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"CONFINED B-FIELD" HOMOPOLAR DYNAMOTOR

Jorge Guala-Valverde[1]▲, Pedro Mazzoni♦

▲ *Fundación Julio Palacios and Consejo Provincial de Educación, Salta 326, 8300-Neuquén, Argentina,*

♦ *Fundación Julio Palacios. Neuquen-AR*

Received May 28, 2004

Following our investigation of motional electromagnetic induction started in this journal [1], we search for torque location in *"confined **B**-field"* homopolar dynamotors. Angular momentum conservation precludes a local interaction between the magnet creating the field and a current carrying wire, as happens in the *"open **B**-field"* configurations formerly investigated. Angular momentum balance takes place now between the active current and the magnet plus the yoke as a whole.

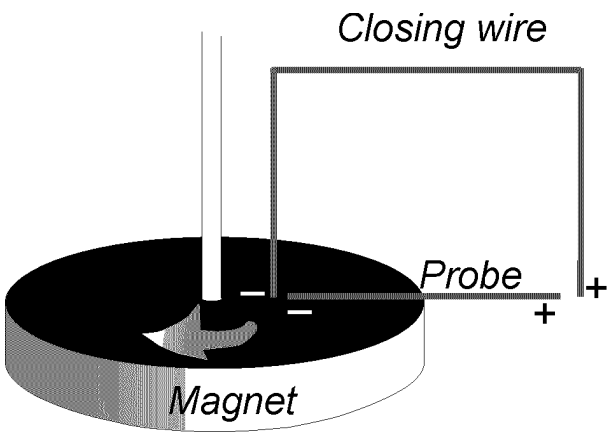

Figure 1: Homopolar Setup Magnet, Probe and Closing Wire

1. Electromotive Force due to Spinning Magnets

As advanced in 2002 in this journal [1] and widely published subsequently [2, 3, 4, 5, 6, 7, 8, 9, 10], a spinning magnet induces a Lorentz-type electric field responsible for a motional Hall effect [11] in the bulk of nearby conductors (figure 1).

The figure corresponds to a clockwise north pole magnet rotation beneath two conducting wires: a *probe* and a *closing (circuit) wire* at rest in the lab. In both the above pieces electrons move centripetally. Each wire becomes an electromotive force (emf.) source. If the ends of the wires are connected, the whole circuit behaves as two identical emf. sources connected in opposition and current cannot flow. If, enabling electrical continuity between the wires, the probe is anchored to the magnet, then direct current (DC) flows through the whole circuit [1, 2]. When the probe is at rest relative to the magnet, induction only takes place on the closing wire, which is in motion relative to the magnet. The probe plays a passive role: to provide a current path [1, 2, 3].

The above experimental discovery, in full agreement with Weber's electrodynamics [12,13], puts an end to frequent misconceptions concerning motional electromagnetic induction [14, 15, 16, 17, 18] and gives some credit to "rotating field lines" advocates [19].

1.1. Torque Acting on Magnets free to Spin

The engine sketched in figure 1 exhibits a reversible behaviour: Injecting DC through the electrically connected but mechanically decoupled wires, a motor configuration takes place.

The Laplace force, $df = IdrxB$ is that responsible for two equal and opposite torques produced by the magnet on the probe ($\tau_{M,P}$) and on the closing wire ($\tau_{M,CW}$). The probe rotates in a clockwise sense when it carries a centrifugal DC near the north pole of the magnet. Conversely, the closing wire rotates in a counter-clockwise sense. By attaching the probe to the magnet, both co-rotate in the clockwise sense. Now the magnet itself is acted on by the closing wire via the reaction torque $\tau_{CW,M} = -\tau_{M,CW} = \tau_{M,P}$. All happens as if the magnet were dragged by the probe, when it is in fact the magnet which drags the probe.

Obviously, if the probe is soldered to the closing wire giving rise to a closed loop, torque cancellation precludes both magnet and loop rotation.

Concluding, two active plus to reactive torques govern the rotational dynamics in "open-field" homopolar motors. Total angular momentum remains null:

[1]E-mail: fundacionjuliopalacios@usa.net

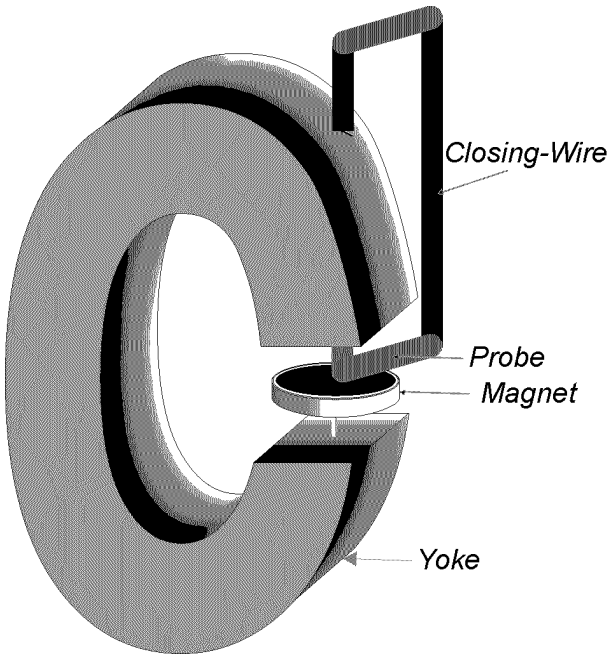

Figure 2: Confined B-field machine

$L = L_M + L_P + L_{CW} = 0$, which means that $(I\omega)_P = -(I\omega)_{CW}$ and $\omega_M = 0$ when both the probe and the closing wire are free to rotate, and $(I\omega)_{M+P} = -(I\omega)_{CW}$ when the probe is attached to the magnet. Here ω means angular rotational velocity, as measured in the lab, and I means moment of inertia.

1.2. "Confined B-field" Homopolar Motor

A slight variation of our former experiments [1] was developed in order to study the behaviour of homopolar motors when the magnetic field remains confined in an iron core.

Figure 2 sketches an iron core, the "yoke" from here on, availableto confine the ***B**-field* generated by a uniform cylindrical permanentmagnet able to rotate about its symmetry axis.

Traversing the yoke, collinearly aligned with the magnet shaft, is the left branch of a carrying DC wire loop. Laplace force acts on this left wire but is inefficient for developing rotational torque. Both the upper horizontal branch and the right vertical one are located in a region free of ***B**-field* actions (neglecting leakage). The lower horizontal branch, the **probe** from here on, lies in the intense ***B**-field* region (air gap). The loop itself can be considered as consisting of a probe connected to a closing wire.

According to standard electrodynamics, the probe would be the active region for torque generation on the coil and rotation will take place for current sufficient to overcome frictional torque

That fact suggested us, in order to enhance the effects, to replace the single loop by a coil of *N-loops*. In our actual setup the probe "active length" reaches some 4 cm, $N = 20$, and the *B- field* on the probe amounts to some 0,1 T.

Whilst coil dynamical behaviour is trivially predicted, the same cannot be said when referring to the magnet. From theoretical considerations we cannot expect continuous magnet rotation, since it would imply angular momentum creation. Due to spatial constraints imposed by the yoke, the coil is unable to describe a full rotation and, after a limited angular excursion, it will collide with the yoke remaining at rest. A continuous magnet rotation would imply the generation of an unbalanced angular momentum, without any identifiable source. Moreover, if we admit the coincidence between kinematical and dynamical rotations [20], we would expect a force interaction between the coil and the magnet plus the core as a whole magnetised bulk. In order to check the above rationale, we have performed the following experiments.

2. EXPERIMENTAL-1

2.1. 1-a Both coil and magnet free to rotate in the lab

A (centrifugal on the lower branch) DC ranging from 1 to 20 A is injected in the coil located on the north pole of the magnet. The relevant rotational effects must appear on the probe, which would suffer a clockwise torque amounting to $\int_0^R r \otimes df = \int_0^R r \otimes (Nidr \otimes B)$ (newton times meter).

In our actual setup the above integral at least amounts to some

$$NIR^2B/2 = 20\,(1)\left[(4x10^{-2})\right]^2(0.1)/2 > 10^{-3}N.m.$$

The predicted torque is observed when DC reaches some 2 A, which suffices to overcome friction on the coil-bearings. As expected, rotation reverses when centripetal DC is injected in the circuit.

Magnet rotation never was detected albeit in our experiments frictional torque on the magnet never exceeded $3x10^{-3}$ $N.m.$

2.2. 1-b Coil attached to the magnet

With the coil attached to the magnet, both co-rotate in the clockwise sense when centrifugal (on the active branch) DC exceeds some 4 A. Motion reverses when centripetal DC is injected. Due to action-reaction cancellation, this experiment rules out a local interaction magnet/coil. The behaviour of the above engine exhibits a strong departure from the equivalent *"open-field"* configuration, and is the first indication that the

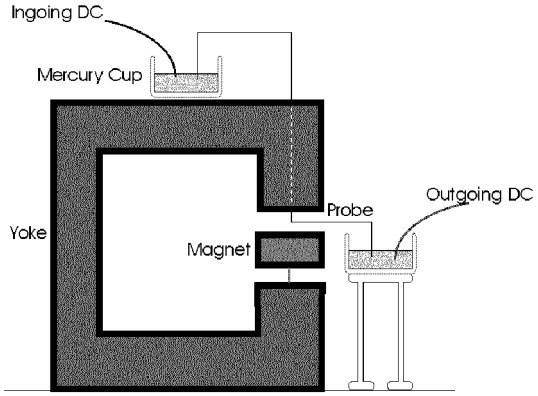

Figure 3: Setup employed in section 2 - experiments

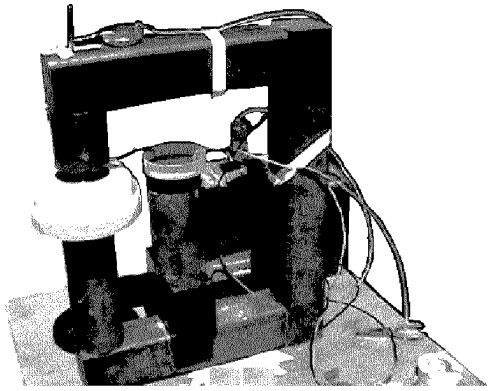

Figure 4: Photo 1 Corresponding to Fig. 3

interaction would take place between the (magnet + yoke) as a whole and the active branch of the coil. With the aim of throw light on that issue we designed and performed two independent sets of experiments.

3. EXPERIMENTAL-2

3.1. 2-a Probe and closing wire mechanically decoupled

A L-shaped wire is adopted as probe. Both probe and closing wire are electrically connected via mercury beds [1, 3] but mechanically decoupled (figure 3 + photo 1).

The probe is free to rotate in the air gap, whereas the closing wire remains anchored to the bench. When the probe carries a centrifugal DC amounting to some 4 A, then a net probe clockwise rotation is detected. Rotation becomes counter-clockwise when centripetal DC is injected. When DC is raised up to 50 A, no magnet rotation is observed.

3.2. 2-b Probe attached to the magnet

Probe attached to the magnet, both free to rotate in the air gap. A net clockwise rotation is observed when centrifugal DC reaches some 10 A. Rotation reverses when centripetal DC is injected.

The closing wire, responsible for a magnet rotation in the *"open field"* equivalent configuration, lies now in a field-less region, becoming a passive element for torque generation.

On the other hand, a magnetised body (the yoke in our actual case) is unable to put in rotation another magnetised body (the magnet itself in our actual case). A dragging of the magnet by the probe appears to be the most plausible explanation for the observed phenomenon. In order to give additional credit to the latter hypothesis, we replace the uniform cylindrical magnet by a piece in which a circular sector amounting to some 15 was removed (photo 2). This modification introduces a *short range singularity* in which ***B**-field* locally reverses [1, 2, 3, 4].

3.3. 2-c Probe free to rotate in the magnet's singularity

As expected, and due to field reversal, when the probe carries a centrifugal DC amounting to some 4 A, it itself rotates in the counter-clockwise sense, whereas the magnet rotates in the clockwise sense. Clearly, a local interaction in full agreement with Newton's third law takes place in this arrangement.

3.4. 2-d Probe attached to the magnet in the singularity

No rotation is observed with the probe attached to the magnet when DC as high as 100 A is injected in the circuit, despite the frictional torque being the same as in **2-b**. Action-reaction cancellation in the singularity destroys rotational mutual actions between the probe and the magnet. Consequently, this experiment rules out the hypothesis of a "hidden" torque acting on the magnet.

Conclusively, **the active branch of the current carrying loop is the only piece able to drag the magnet**. Our experiments prove that the magnet can no more be the seat of reactive torques, as in the *"open-field"* configuration. In *"confined-field"* arrangements, it only plays a passive electro-mechanical role: to provide a magnetic field source. Force interaction is now between the current and the whole magnetised bulk.

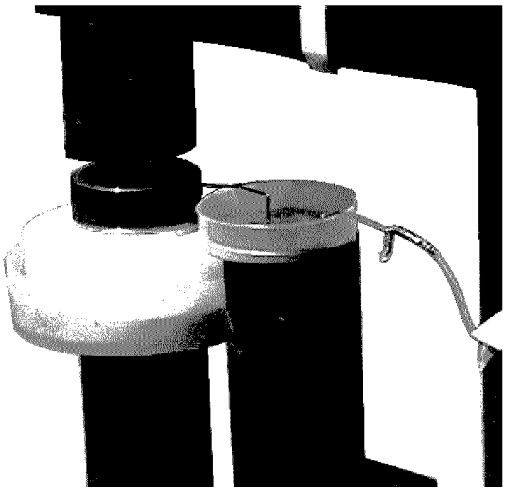

Figure 5: Photo 2 Corresponding to experiments 2- c + 2-d

4. EXPERIMENTAL-3

4.1. 3-a Symmetric counterpart of 1-a

With the aid of two 4 meter steel wires anchored to the ends of its upper branch, the yoke (*ca.* 80 kg weight) itself was suspended from the ceiling. Fixing the (20 turns) coil in the lab, a counter-clockwise yoke rotation amounting to *ca.* 1 degree is detected when centrifugal (on the active branch) DC reaches some 50A. Constrained rotation takes place about the line in which lies the magnet axle. This minute effect is easily amplified by optical means. Rotation becomes clockwise when DC reverses.

By attaching the coil to the yoke no angular deviation is detected even for DC as high as 100 A.

4.2. "Confined B-field"

Homopolar Generator

If the homopolar dynamotor is a reversible engine [1, 2] the conclusions drawn for the motor configuration can be applied, *mutatis mutandis* to a generator configuration:

4.2.1. 1. Oscillating Coil

Spatially constrained rotation of the coil delivers a $N\omega BR^2/2$ emf which changes sign when rotation is reversed. The measured output remains unchanged when the coil is attached to the magnet. These qualitative experiments were performed with the aid of a *1000 turns* coil manually moved. The output signal was amplified with the aid of a linear amplifier. When, with the coil at rest in the lab, the magnet is spun up to some 5 rps no electrical signal is detected in the coil.

4.2.2. 2. Decoupled circuit

We have not performed experiments on generation with the probe mechanically decoupled from the closing wire. Nevertheless, and due to the full reversibility exhibited by electromechanical conversion [1, 2], it is easy to infer the behaviour of each component in an actual engine. We apply, step-by-step, to generation the protocol formerly developed for the motor:

If the probe is spun, then it will generate an emf which changes sign when rotation is reversed. Magnet rotation is unable to generate emf.

If the probe rotates anchored to the magnet, the same output as in 2-a will be displayed. When dealing with *"confined-field"* arrangements, magnet rotation doesn't play any active role in emf generation. The above finding gives partial credit to old statements due to Panofsky [16] and Feynman [17], although they were wrong for *"open-field"* configurations.

Probe in motion relative to the magnet will develop an emf. No emf can be expected when the magnet is spun with the probe attached in the singularity.

5. FINAL CONSIDERATIONS

Homopolar phenomena have been a troublesome issue for the theory of electrodynamics for almost two centuries [21]. The whole set of experiments performed on both *"open"* and *"confined"* configurations exhibits a common feature: **angular momentum conservation**. Reactive forces, which have their seat on the magnet in *"open"* configurations, "shift" to the whole magnetised bulk when *"confined"* arrangements are employed. The above findings are fully consistent with the Amperian surface-currents responsible for magnetic effects [22]. The source of magnetic field (the magnet itself) **induces** Amperian surface currents on the **whole yoke**, and each of them interacts with the ohmic current traversing the circuit.

A few words on the (in archaic language) "rotating"/"fixed" field-lines controversy can be said in the light of our experiments:

For *"open"* configurations all happens as if ***B**-lines* rotate anchored to the magnet, whereas the above lines appear to be attached to the whole magnetised bulk, when dealing with *"confined"* arrangements.

Unlike the *"open"* configuration, in the *"confined"* one, only an active torque $\tau_{(M+Y),C}$ exists due to the (magnet + yoke) body, acting on the active (ohmic) current C. The active current reacts on the (magnet + yoke) body with the equal but opposite torque $\tau_{C,(M+Y)}$. Total angular momentum remains null: $L = L_{M+Y} + L_C = 0$, which means that $(I\omega)_{M+Y} = -(I\omega)_C$.

Our experiments confirm Müller's measurements concerning homopolar motional induction, as applied to emf generation [23, 24]. Unfortunately, Müller (as

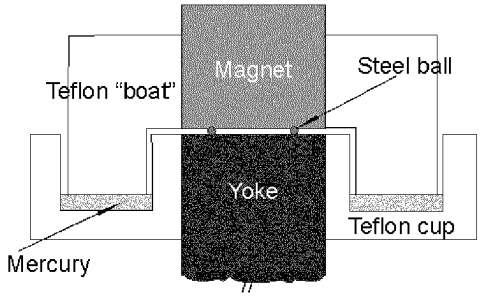

Figure 6: Contrivance employed to diminish frictional torque on the bearings

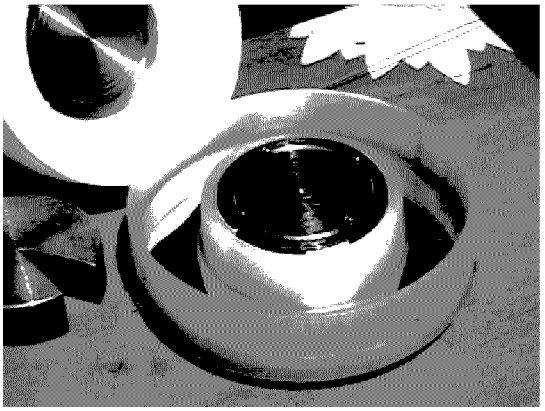

Figure 7: Photo 3 Corresponds to Fig. 4

well as Wesley [25]) failed when attempting to rationalize the observed facts. The above due to a misconception about the relevant parts involved in the whole interaction. Müller centered his analysis in the magnet/wire pair, rather than in the (magnet + yoke)/wire one which is, in fact, the physically relevant pair. The Müller/Wesley rationale entails doubts about angular momentum conservation.

Concerning the motivations that triggered the present investigation, we only wish to stress the growing interest in the search for the location of forces and torques in actual electrodynamical systems [26, 27, 28].

6. APPENDIX. Experimental details

In order to diminish frictional torque on the magnet's bearings, we developed the contrivance shown in figure 4 and photo 3.

The magnet itself is embedded in a teflon "boat" able to float in a mercury bed. Archimedes push diminishes the apparent weight of the whole piece. Mechanical contact between the magnet and the yoke is achieved with the aid of 4 steel balls "sandwiched" between two circular paths, respectively inscribed in both the contacting faces of the yoke and the magnet. Mercury is added until the magnet smoothly slides on the yoke.

Acknowledgements

To Roberto Blas for the design of the "floating boat" bearings..

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