New Effect of General Relativity: Thomson Dispersion of Light in Stars as a Machine Producing Stellar Energy

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Given a non-holonomic space, time lines are non-orthogonal to the spatial section therein, which manifests as the three-dimensional space rotation. It is shown herein that a global non-holonomity of the background space is an experimentally verifiable fact revealing itself by two fundamental fields: a field of linear drift at 348 km/sec, and a field of rotation at 2,188 km/sec. Any local rotation or oscillation perturbs the background non-holonomity. In such a case the equations of motion show additional energy flow and force, produced by the non-holonomic background, in order to compensate the perturbation in it. Given the radiant transportation of energy in stars, an additional factor is expected in relation to Thomson dispersion of light in free electrons, and provides the same energy radiated in the wide range of physical conditions from dwarfs to super-giants. It works like a machine where the production of stellar energy is regulated by radiation from the surface. This result, from General Relativity, accounts for stellar energy by processes different to thermonuclear reactions, and coincides with data of observational astrophysics. The theory leads to practical applications of new energy sources working much more effectively and safely than nuclear energy.

1 Introduction. The mathematical basis

We aim to study the effects produced on a particle, if the space is non-holonomic. We then apply the result to the particles of the gaseous constitution of stars.

To do this we shall study the equations of motion. To obtain a result applicable to real experiment, we express the equations in terms of physically observable quantities. Mathematical methods for calculating observable quantities in General Relativity were invented by A. Zelmanov, in the 1940's [1, 2, 3]. We now present a brief account thereof.

A regular observer perceives four-dimensional space as the three-dimensional spatial section $x^0 = \text{const}$, pierced at each point by time lines $x^i = \text{const}$.* Therefore, physical quantities perceived by an observer are actually *projections* of four-dimensional quantities onto his own time line and spatial section. The spatial section is determined by a three-dimensional coordinate net spanning a real reference body. Time lines are determined by clocks at those points where the clocks are located. If time lines are everywhere orthogonal to the spatial section, the space is known as *holonomic*. If not, there is a field of the space non-holonomity — the non-orthogonality of time lines to the spatial section, manifest as a three-dimensional rotation of the reference body's space. Such a space is said to be *non-holonomic*.

By mathematical means, four-dimensional quantities can be projected onto an observer's time line and spatial section by the projecting operators: $b^\alpha = \frac{dx^\alpha}{ds}$, the observer's four-dimensional velocity vector tangential to his world-line, and $h_{\alpha\beta} = -g_{\alpha\beta} + b_\alpha b_\beta$. For a real observer at rest with respect to his reference body ($b^i = 0$), the projections of a vector Q^α are $b^\alpha Q_\alpha = \frac{Q_0}{\sqrt{g_{00}}}$ and $h^i_\alpha Q^\alpha = Q^i$, while for a tensor of the 2nd rank $Q^{\alpha\beta}$ we have the projections $b^\alpha b^\beta Q_{\alpha\beta} = \frac{Q_{00}}{g_{00}}$, $h^{i\alpha} b^\beta Q_{\alpha\beta} = \frac{Q^i_0}{\sqrt{g_{00}}}$, $h^i_\alpha h^k_\beta Q^{\alpha\beta} = Q^{ik}$. Such projections are invariant with respect to the transformation of time in the spatial section: they are *chronometrically invariant quantities*.

In the observer's spatial section the chr.inv.-tensor

$$h_{ik} = -g_{ik} + b_i b_k = -g_{ik} + \frac{g_{0i}\, g_{0k}}{g_{00}}\,, \tag{1}$$

possesses all the properties of the fundamental metric tensor $g_{\alpha\beta}$. Furthermore, the spatial projection of it is $h^\alpha_i h^\beta_k g_{\alpha\beta} = -h_{ik}$. Therefore h_{ik} is the *observable metric tensor*.

The chr.inv.-differential operators

$$\frac{^*\partial}{\partial t} = \frac{1}{\sqrt{g_{00}}}\frac{\partial}{\partial t}\,, \qquad \frac{^*\partial}{\partial x^i} = \frac{\partial}{\partial x^i} - \frac{g_{0i}}{g_{00}}\frac{\partial}{\partial x^0}\,, \tag{2}$$

are different to the usual differential operators, and are non-commutative: $\frac{^*\partial^2}{\partial x^i \partial t} - \frac{^*\partial^2}{\partial t\, \partial x^i} = \frac{1}{c^2} F_i \frac{^*\partial}{\partial t}$ and $\frac{^*\partial^2}{\partial x^i \partial x^k} - \frac{^*\partial^2}{\partial x^k \partial x^i} = \frac{2}{c^2} A_{ik} \frac{^*\partial}{\partial t}$. The non-commutativity determines the chr.inv.-vector for the gravitational inertial force F_i and the chr.inv.-tensor of angular velocities of the space rotation A_{ik}

$$F_i = \frac{1}{\sqrt{g_{00}}}\left(\frac{\partial \mathrm{w}}{\partial x^i} - \frac{\partial v_i}{\partial t}\right), \qquad \sqrt{g_{00}} = 1 - \frac{\mathrm{w}}{c^2}\,, \tag{3}$$

$$A_{ik} = \frac{1}{2}\left(\frac{\partial v_k}{\partial x^i} - \frac{\partial v_i}{\partial x^k}\right) + \frac{1}{2c^2}\left(F_i v_k - F_k v_i\right), \tag{4}$$

where w is the gravitational potential, and $v_i = -c\frac{g_{0i}}{\sqrt{g_{00}}}$ is the linear velocity of the space rotation†. Other observable

*Greek suffixes are the space-time indices $0, 1, 2, 3$, Latin ones are the spatial indices $1, 2, 3$. So the space-time interval is $ds^2 = g_{\alpha\beta}\, dx^\alpha dx^\beta$.

†Its contravariant component is $v^i = -c\, g^{0i}\sqrt{g_{00}}$, so $v^2 = h_{ik} v^i v^k$.

properties of the reference space are presented with the chr. inv.-tensor of the rates of the space deformations

$$D_{ik} = \frac{1}{2\sqrt{g_{00}}}\frac{\partial h_{ik}}{\partial t} = \frac{1}{2}\frac{{}^*\partial h_{ik}}{\partial t} \qquad (5)$$

and the chr.inv.-Christoffel symbols

$$\Delta^i_{jk} = h^{im}\Delta_{jk,m} = \frac{1}{2}\,h^{im}\left(\frac{{}^*\partial h_{jm}}{\partial x^k} + \frac{{}^*\partial h_{km}}{\partial x^j} - \frac{{}^*\partial h_{jk}}{\partial x^m}\right) \qquad (6)$$

built just like Christoffel's usual symbols $\Gamma^\alpha_{\mu\nu} = g^{\alpha\sigma}\Gamma_{\mu\nu,\sigma}$ using h_{ik} instead of $g_{\alpha\beta}$.

Within infinitesimal vicinities of any point in a Riemannian space the fundamental metric tensor can be represented as the scalar product $g_{\alpha\beta} = \vec{e}_{(\alpha)}\vec{e}_{(\beta)}$ of the basis vectors, tangential to curves and non-orthogonal to each coordinate line of the space. Hence $g_{\alpha\beta} = e_{(\alpha)}e_{(\beta)}\cos(x^\alpha; x^\beta)$. Therefore the linear velocity of the space rotation

$$v_i = -c\,\frac{g_{0i}}{\sqrt{g_{00}}} = -c\,e_{(i)}\cos(x^0; x^i) \qquad (7)$$

shows how much the time line inclines to the spatial section, and is the actual value of the space non-holonomity.

The observable time interval $d\tau$ and spatial displacements are the projections of the world-displacement dx^α:

$$d\tau = \frac{1}{c}\,b_\alpha\,dx^\alpha = \sqrt{g_{00}}\,dt - \frac{1}{c^2}\,v_k dx^k, \qquad (8)$$

while the observable spatial displacements coincide with the coordinate ones $h^i_\alpha dx^\alpha = dx^i$. The observable spatial interval is $d\sigma^2 = h_{ik}\,dx^i dx^k$, while $ds^2 = c^2 d\tau^2 - d\sigma^2$.

Using these techniques, we can calculate the physically observable projections of any world-quantity, then express them through the observable properties of the space.

2 A global non-holonomity of the background space — an experimentally verifiable fact

Can such a case exist, where, given a non-holonomic space, the linear velocity of its rotation is $v_i \neq 0$, while the angular velocity is $A_{ik} = 0$? Yes, it is possible. If v_i has the same numerical value $v_i = \bar{v}_i = \text{const}$ at each point of a space, we have $A_{ik} = 0$ everywhere therein. In such a case, by formula (7), there is a stationary homogeneous *background field of the space non-holonomity*: all time lines, piercing the spatial section, have the same inclination $\cos(x^0; x^i) = -\frac{\bar{v}_i}{c e_{(i)}}$ to the spatial section at each its points.

Is such a background truly present in our real space? If yes, what is the "primordial" value $\bar{v}_i = \text{const}$? These questions can be answered using research of the 1960's, carried out by Roberto di Bartini [4, 5].

In his research di Bartini used topological methods. He considered "a predicative unbounded and hence unique specimen A. [...] A coincidence group of points, drawing elements of the set of images of the object A, is a finite symmetric system, which can be considered as a topological spread mapped into the spherical space R^n" [5].

Given the spread R^n, di Bartini studied "sequences of stochastic transitions between different dimension spreads as stochastic vector quantities, i. e. as fields. Then, given a distribution function for frequencies of the stochastic transitions dependent on n, we can find the most probable number of the dimension of the ensemble" [5]. He found extrema of the distribution function at $n = \pm 6$, "hence the most probable and most improbable extremal distributions of primary images of the object A are presented in the 6-dimensional closed configuration: the existence of the total specimen A we are considering is 6-dimensional. [...] a spherical layer of R^n, homogeneously and everywhere densely filled by doublets of the elementary formations A, is equivalent to a vortical torus, concentric with the spherical layer. The mirror image of the layer is another concentric homogeneous double layer, which, in turn, is equivalent to a vortical torus coaxial with the first one. Such formations were studied by Lewis and Larmore for the $(3+1)$-dimensional case" [5].

For the $(3+1)$-dimensional image, di Bartini calculated the ratio between the torus diameter D and the radius of the circulation r which satisfies the condition of stationary vortical motion (the current lines coincide with the trajectory of the vortex core). He obtained $E = \frac{D}{r} = 274.074\,996$, i. e.

$$\frac{R}{r} = 137.037\,498. \qquad (9)$$

Applying this bizarre result to General Relativity, we see that if our real space satisfies the most probable topological shape, we should observe two fundamental drift-fields:

1. A field of the constant rotating velocity 2,187.671 km/sec — a field of the background space non-holonomity.

This comes with the fact that the frequency distribution Φ_n of the stochastic transitions between different dimensions "is isomorphic to the function of the surface's value $S_{(n+1)}$ of a unit radius hypersphere located in an $(n+1)$-dimensional space (this value is equal to the volume of an n-dimensional hypertorus). This isomorphism is adequate for the ergodic concept, according to which the spatial and time spreads are equivalent aspects of a manifold" [5].

In such a case the radius of the circulation r (the spatial spread's function) is expressed through a velocity v just like the torus' radius R (the time spread's function) is expressed through the velocity of light $c = 2.997\,930 \times 10^{10}$ cm/sec. Thus, we obtain the analytical value of the velocity $\bar{v}_i$:

$$\bar{v} = \frac{2c}{E} = \frac{cr}{R} = 2.187\,671 \times 10^8 \text{ cm/sec}, \qquad (10)$$

Because the vortical motion is stationary, the linear velocity $\bar{v}_i$ of the circulation r is constant everywhere within it. In other words, $\bar{v}_i = 2{,}187.671$ km/sec is the linear velocity of the space rotation characterizing a stationary homogeneous field of the background space non-holonomity: there in the space all time lines have the same inclination to the spatial section at each of its points

$$\cos\left(x^0; x^i\right) = -\frac{\bar{v}}{c} = -\frac{1}{137.037498} = -0.0072972728. \quad (11)$$

The background non-holonomity should produce an effect in v_i-dependent phenomena. Hence the non-holonomic background should be an experimentally verifiable fact.

In such an experiment we should take into account the fact that all v_i-dependent physical factors should initially contain the background space rotation $\bar{v}_i = 2{,}187.671$ km/sec. Therefore, the background cannot itself be isolated; it can be shown only by the changes of the quantities expected to be affected by local perturbations of the background.

2. A field of constant linear velocity 348.1787 km/sec — a field of the background drift-velocity.

This comes from the fact that the background becomes polarized while "the shift of the field vector at $\frac{\pi}{2}$ in its parallel transfer along closed arcs of radii R and r in the affine coherence space R^n" [5]. Hence, we find that the unpolarized component of the field $\bar{v}_i = 2{,}187.671$ km/sec is a field of a constant dipole-fit velocity

$$\bar{\mathrm{v}} = \frac{\bar{v}}{2\pi} = 3.481787\times10^7 \text{ cm/sec}. \quad (12)$$

In other words, it should be a global-drift field of the constant dipole-fit linear velocity $\bar{\mathrm{v}} = 348.1787$ km/sec, represented in the circulation r (three-dimensional spread).

Our analytically obtained value 348.1787 km/sec is in close agreement with the linear drift-velocity 365 ± 18 km/sec extracted from the recently discovered anisotropy of the Cosmic Microwave Background.

The Cosmic Microwave Background Radiation was discovered in 1965 by Penzias and Wilson at Bell Telephone Lab. In 1977, Smoot, Gorenstein, and Muller working with a twin antenna Dicke radiometer at Lawrence Berkeley Lab, discovered an anisotropy in the Background as the dipole-fit linear velocity 390 ± 60 km/sec [9]. Launched by NASA, in 1989, the Cosmic Background Explorer (COBE) satellite produced observations from which the dipole-fit velocity was extracted more precisely at 365 ± 18 km/sec. The Wilkinson Microwave Anisotropy Probe (WMAP) satellite by NASA, launched in 2001, verified the COBE data [10].

As already shown by Zelmanov, in the 1940's [1], General Relativity permits absolute reference frames connected to the anisotropy of the fields of the space non-holonomity or deformation — the globally polarized fields similar to a global gyro. Therefore the drift-fields analytically obtained above provide a theoretical basis for an absolute reference frame in General Relativity, connected to the anisotropy of the Cosmic Microwave Background.

In the next Section we study the effects we expect on a test-particle due to the background space non-holonomity.

3 A test-particle in a non-holonomic space. Effects produced by the background space non-holonomity

Free particles move along the shortest (geodesic) lines. The equations of free motion are derived from the fact that any tangential vector remains parallel to itself when transferred along a geodesic, so the general covariant derivative of the vector is zero along the line. A particle's four-dimensional impulse vector is $P^\alpha = m_0 \frac{dx^\alpha}{ds}$, so the general covariant equations of free motion are

$$\frac{dP^\alpha}{ds} + \Gamma^\alpha_{\mu\nu} P^\mu \frac{dx^\nu}{ds} = 0; \quad (13)$$

their observable chr.inv.-projections, by Zelmanov [1], are

$$\left.\begin{aligned} &\frac{dE}{d\tau} - mF_i \mathrm{v}^i + mD_{ik}\mathrm{v}^i\mathrm{v}^k = 0, \\ &\frac{dp^i}{d\tau} - mF^i + 2m\left(D^i_k + A^{\cdot i}_{k\cdot}\right)\mathrm{v}^k + m\Delta^i_{nk}\mathrm{v}^n\mathrm{v}^k = 0, \end{aligned}\right\} \quad (14)$$

where $\mathrm{v}^i = \frac{dx^i}{d\tau}$ and $p^i = m\mathrm{v}^i$ are the observable velocity and impulse of the particle, m and $E = mc^2$ are its relativistic mass and energy. Each term in the equations is an observable chr.inv.-quantity*. The scalar equation is the chr.inv.-energy law. The vector equations are the three-dimensional chr.inv.-equations of motion, setting up the 2nd Newtonian law.

In non-free motion, a particle deviates from a geodesic line, so the right sides of the equations of motion become non-zero, expressing a deviating force.

We will now fit the chr.inv.-equations of motion according to the most probable topological configuration of the space, as propounded by di Bartini. In such a case we can represent dx^i as $dx^i = v^i dt$ while the time interval is $dx^0 = cdt$. Such a representation coincides with the ergodic concept, where the spatial and time spreads are equivalent elements of a manifold; so the transformation $dx^i = v^i dt$ should be understood to be "ergodic".

Applying the "ergodic transformation", after some algebra we find that in such a space the metric ds^2 takes the form†

$$ds^2 = g_{00}\, c^2 dt^2 \left\{ \left(1 + \frac{v^2}{c^2\sqrt{g_{00}}}\right)^2 - \frac{v^2}{c^2 g_{00}} \right\}, \quad (15)$$

while the physically observable time interval is

$$d\tau = \left(\sqrt{g_{00}} - \frac{v^2}{c^2}\right) dt = \left\{1 - \frac{1}{c^2}\left(\mathrm{w} + v^2\right)\right\} dt, \quad (16)$$

where $v^2 = v_i v^i = h_{ik} v^i v^k$. Looking at the resultant metric from the geometric viewpoint, we note an obvious feature:

> In such a metric space the flow of time is equivalent to a *turn of the spatial section*.

*Given a chr.inv.-quantity, we can raise/lower its indices by the chr.inv.-metric tensor h_{ik}: $h_{ik} = -g_{ik} + \frac{1}{c^2} v_i v_k$, $h^{ik} = -g^{ik}$, and $h^i_k = \delta^i_k$.

†Because $v_i = -c\,\frac{g_{0i}}{\sqrt{g_{00}}}$, $v^i = -c\,g^{0i}\sqrt{g_{00}}$, $h_{ik} = -g_{ik} + \frac{1}{c^2} v_i v_k$.

In the (3+1)-dimensional vortical torus, the ratio between its diameter D and the radius of the circulation r is the fundamental constant $E=\frac{D}{r}=274.074\,996$ [4, 5]. Hence the circulation velocity $\bar{v}=\frac{2c}{E}=2{,}187.671$ km/sec (the linear velocity of the background space rotation) is covariantly constant. On the other hand, locally in the spatial section, the components of the vector $v_i=-c\,\frac{g_{0i}}{\sqrt{g_{00}}}$ can be different from 2,187.671 km/sec due to the locally non-holonomic perturbations in the background*. In other words, the field v_i is built on two factors: (1) the background remaining constant and uniform $\bar{v}_i=2{,}187.671$ km/sec at any point or direction in the space, and (2) a local perturbation $\tilde{v}_i$ in the background produced by rotating bodies located nearby.

As a result, within an area in which the non-holonomic background $\bar{v}_i$ is perturbed by a local rotation $\tilde{v}_i$,

$$dx^i = v^i dt = \left(\bar{v}^i + \tilde{v}^i\right) dt\,. \tag{17}$$

That is, with the same displacement dx^i the turn dt can be different depending on how much the non-holonomic background is perturbed by a local rotation.

The non-holonomic background remaining constant does not produce an effect in the differentiated quantities. An effect is expected to be due only from the expansion of the differential operator $\frac{\partial}{\partial t}$ where we represent dt, according to the metric (15), as a turn of the spatial section. As such, dt should be expressed through the ergodic transformation $dx^i=v^i dt=(\bar{v}^i+\tilde{v}^i)\,dt$. Expanding $\frac{\partial}{\partial t}$ in such a way, after algebra, we obtain the corrected formulae for the main physically observable chr.inv.-characteristics of the space that take the background space non-holonomity into account†

$$F_i = \frac{1}{\sqrt{g_{00}}}\left\{\frac{\partial \mathrm{w}}{\partial x^i} - \left(1+\delta_n^m\,\frac{\tilde{v}^n}{\bar{v}^m}\right)\frac{\partial \tilde{v}_i}{\partial \bar{t}}\right\}, \tag{18}$$

$$A_{ik} = \frac{1}{2}\left(\frac{\partial \tilde{v}_k}{\partial x^i} - \frac{\partial \tilde{v}_i}{\partial x^k}\right) + \frac{1}{2c^2}\left(F_i\tilde{v}_k - F_k\tilde{v}_i\right), \tag{19}$$

$$D_{ik} = \frac{1}{2\sqrt{g_{00}}}\left(1+\delta_n^m\,\frac{\tilde{v}^n}{\bar{v}^m}\right)\frac{\partial h_{ik}}{\partial \bar{t}}\,, \tag{20}$$

$$\begin{aligned}\Delta^i_{jk} &= \frac{1}{2}\,h^{im}\left(\frac{\partial h_{jm}}{\partial x^k} + \frac{\partial h_{km}}{\partial x^j} - \frac{\partial h_{jk}}{\partial x^m}\right) + \\ &+ \frac{1}{c^2}\,h^{im}\left(1+\delta_n^m\,\frac{\tilde{v}^n}{\bar{v}^m}\right)\left(v_k D_{jm} + v_j D_{km} + v_m D_{jk}\right),\end{aligned} \tag{21}$$

where the differential operator $\frac{\partial}{\partial \bar{t}}$ is determined in the unperturbed background $\bar{v}_i$, while the additional multiplier sets up a correction for a local perturbation $\tilde{v}_i$ in it.

*Note that Minkowski space of Special Relativity is free of gravitational fields ($g_{00}=1$) and rotations ($g_{0i}=0$). So all the effects we are considering are attributed only to General Relativity's space.

†Here $\delta_n^m=\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$ is the unit three-dimensional tensor, the spatial part of the four-dimensional Kronecker unit tensor δ^α_β used for replacing the indices. So δ_n^m replaces the indices in three-dimensional tensors.

If there is no non-holonomic background, but only locally non-holonomic fields due to rotating small bodies, the above formulae revert to their original shape through $\bar{v}^i=0$ in the transformation $dx^i=v^i dt=\left(\bar{v}^i+\tilde{v}^i\right)dt$. The above transformation is impossible in a holonomic space since therein the spatial coordinates aren't functions of the time coordinate; $x^i\neq f(x^0)$. So the foregoing is true only if the space is non-holonomic, and the spatial and time spreads are equivalent elements of the manifold.

From the formulae obtained, we conclude that:

> The main physically observable chr.inv.-properties of the reference space, such as the gravitational inertial force F_i, the angular velocity of the space rotation A_{ik}, the rate of the space deformation D_{ik}, and the space non-uniformity (set up by the chr.inv.-Christoffel symbols Δ^i_{jk}) are dependent on the ratio between the value of the local non-holonomity $\tilde{v}_i$ (due to nearby rotating bodies) and the background space non-holonomity $\bar{v}_i=2{,}187.671$ km/sec.

What effect does this have on the motion of a particle? Let's recall the chr.inv.-equations of motion (14). While a particle is moved along dx^i by an external force (or several forces), the acceleration gained by the particle is determined by the fact that its spatial impulse vector p^i, being transferred along dx^i, undergoes a space-time turn dt expressed by the ergodic transformation (17).

The entire motion of a particle is expressed by the term with $\frac{d}{d\tau}$ in the scalar and chr.inv.-vector equations of motion (14). The remaining terms in the scalar equation express the work spent on the motion by external forces, while the remaining terms in the vector equation account for the forces themselves. Therefore, for the entire motion of a particle, we have no need of expanding $\frac{\partial}{\partial t}$ by the ergodic transformation, for each force acting thereon. We simply need to apply the expansion to the chr.inv.-derivative with respect to the observable time $\frac{d}{d\tau}$ in the equations of motion (14).

By definition (8), $d\tau=\sqrt{g_{00}}\,dt-\frac{1}{c^2}\,v_k dx^k$, so we have $dt=\frac{1}{\sqrt{g_{00}}}\left(1+\frac{1}{c^2}\,v_k\mathrm{v}^k\right)d\tau$. The differential is $d=\frac{\partial}{\partial x^\alpha}\,dx^\alpha$, so $d=\frac{1}{\sqrt{g_{00}}}\left(1+\frac{1}{c^2}\,v_k\mathrm{v}^k\right)\frac{\partial}{\partial t}\,d\tau+\frac{\partial}{\partial x^k}\,dx^k$ and, finally

$$\frac{d}{d\tau} = \frac{1}{\sqrt{g_{00}}}\left(1+\frac{1}{c^2}\,v_k\mathrm{v}^k\right)\frac{\partial}{\partial t} + \mathrm{v}^k\,\frac{\partial}{\partial x^k}\,. \tag{22}$$

Expanding this formula with the ergodic transformation $dx^i=v^i dt=(\bar{v}^i+\tilde{v}^i)\,dt$, we obtain it in the form

$$\begin{aligned}\frac{d}{d\tau} &= \left(1+\delta_n^m\,\frac{\tilde{v}^n}{\bar{v}^m}\right)\frac{d}{d\bar{\tau}} + \delta_n^m\,\frac{\tilde{v}^n}{\bar{v}^m}\,\mathrm{v}^k\,\frac{\partial}{\partial x^k} + \\ &+ \frac{1}{c^2\sqrt{g_{00}}}\left(1+\delta_n^m\,\frac{\tilde{v}^n}{\bar{v}^m}\right)\tilde{v}_k\mathrm{v}^k\,\frac{\partial}{\partial \bar{t}}\end{aligned} \tag{23}$$

where the non-holonomic background $\bar{v}_i=2{,}187.671$ km/sec is taken into account. Here $\frac{\partial}{\partial\bar{\tau}}$ and $\frac{\partial}{\partial\bar{t}}$ are also determined in the unperturbed background $\bar{v}_i$.

In particular, if a moving particle is slow with respect to light and the differentiated quantity is distributed uniformly in the spatial section, we have $\frac{1}{c^2}\tilde{v}_k \mathrm{v}^k = 0$ and $\frac{\partial}{\partial x^k} = 0$ in the above formula, so we obtain

$$\frac{d}{d\tau} \simeq \frac{1}{\sqrt{g_{00}}}\frac{\partial}{\partial t} = \frac{1}{\sqrt{g_{00}}}\left(\bar{v}^k + \tilde{v}^k\right)\frac{\partial}{\partial x^k} = \\ = \left(1 + \delta^m_n \frac{\tilde{v}^n}{\bar{v}^m}\right)\frac{d}{d\bar{\tau}}\,. \tag{24}$$

In such a case, by the chr.inv.-equations of motion (14), the total force moving the particle $\Phi^i = \frac{dp^i}{d\tau}$ and the total energy flow $W = \frac{dE}{d\tau}$ expended on the motion are

$$W = \frac{dE}{d\tau} = \left(1 + \delta^m_n \frac{\tilde{v}^n}{\bar{v}^m}\right) W_{(0)} = W_{(0)} + \delta^m_n \frac{\tilde{v}^n}{\bar{v}^m} W_{(0)} \tag{25}$$

$$\Phi^i = \frac{dp^i}{d\tau} = \left(1 + \delta^m_n \frac{\tilde{v}^n}{\bar{v}^m}\right)\Phi^i_{(0)} = \Phi^i_{(0)} + \delta^m_n \frac{\tilde{v}^n}{\bar{v}^m}\Phi^i_{(0)} \tag{26}$$

where $\Phi^i_{(0)}$ and $W_{(0)}$ are the acting force and energy flow in the unperturbed non-holonomic background (before a local rotation $\tilde{v}^i$ was started). The additional force $\delta^m_n \frac{\tilde{v}^n}{\bar{v}^m}\Phi^i_{(0)}$ and energy flow $\delta^m_n \frac{\tilde{v}^n}{\bar{v}^m} W_{(0)}$ are produced by the stationary homogeneous field of the background space non-holonomity $\bar{v}_i$ in order to compensate for a perturbation in it caused by a local rotation $\tilde{v}_i$. As a result we conclude that:

> The presence of a background space non-holonomity manifests in a particle as an addition to its acceleration, gained from an external force (or forces) moving it. This additional force appears only if the non-holonomic background is perturbed by a local rotation in the area where the particle moves. (Being unperturbed, the non-holonomic background does not produce any forces.) The force appears independently of the origin of the forces moving the particle, and is proportional to the ratio between the linear velocity of the local rotation $\tilde{v}_i$ and that of the background space rotation $\bar{v}_i = 2{,}187.671$ km/sec.

Such an additional force should appear on any particle accelerated near a rotating body. On the other hand, because the space background rotates rapidly, at 2,187.671 km/sec, such a force is expected only near rapid rotations, comparable with 2,187.671 km/sec.

For instance, consider a high speed gyro as used in aviation navigation technology: 250 g rotor of 1.65″ diameter, rotating at 24,000 rpm. With current technology, the latter is almost the ultimate speed for such a mechanically rotating system. In such a case the non-holonomic background near the gyro is perturbed as $\tilde{v} = 5.3\times10^3$ cm/sec, i. e. 53 m/sec*. So near the gyro, by our formula (26), we expect to have an additional factor of 2.4×10^{-5} of any force accelerating a particle near the gyro. In other words, the expected effect is very small near such mechanically rotating systems.

The terrestrial globe rotates at 465 m/sec at its equator, so the non-holonomic space background is perturbed there by Earth's rotation by the factor 2.2×10^{-4}. Hence, given a specific experiment performed at the equator, an additional force produced by the non-holonomic background in order to compensate the perturbation in it should be 2.2×10^{-4} of the force acting in the experiment. This effect decreases with latitude owing to concomitant reduction of the linear velocity of the Earth's rotation, and completely vanishes at the poles.

However, the additional force can be much larger if the non-holonomic background is perturbed by particles rotated or oscillated by electromagnetic fields. In such a case a local rotation velocity can even reach that of the background, i. e. 2,187.671 km/sec, in which case the main force accelerating the particle is doubled. In the next Section we consider a particular example of such a doubled force, expected in relation to Thomson dispersion of light in free electrons within stars.

In forthcoming research we show how such an additional force can be detected in experiment, and applied to the development on a device whose motion is based on principles, completely different from those employed in aviation and space technology today. Such a device should revolutionize aviation and space travel.

It is interesting to note that a similar conclusion on the time flow as a turn and additional forces produced by it were drawn by the famous astronomer and experimental physicist, N. A. Kozyrev, within the framework of his "non-symmetrical mechanics" [8]. Kozyrev proceeded from his research on the insufficiency of Classical Mechanics and thermodynamics in order to explain some effects in rotating bodies and also the specific physical conditions in stars. He didn't construct an exact theory, limiting himself to phenomenological conclusions and general speculations. On the other hand, his phenomenologically deduced formula for a force additional to Classical Mechanics is almost the same as our purely theoretical result $\delta^m_n \frac{\tilde{v}^n}{\bar{v}^m}\Phi^i_{(0)}$ obtained by means of General Relativity in the non-holonomic four-dimensional space of General Relativity, in the low velocity approximation. Therefore this coincidence can be viewed as an auxiliary verification of our theory.

We see that there is no need to change the basic physics as Kozyrev did. Naturally, all the results we have obtained are derived from the background non-holonomity of the four-dimensional space of General Relativity. Classical Mechanics uses a three-dimensional flat Euclidean space that does not contain the time spread and, hence, the non-holonomic property. Classical Mechanics is therefore insufficient for explaining the effects of the background space non-holonomity predicted herein by means of General Relativity. So the additional force and energy flow are new effects predicted within the framework of Einstein's theory.

*Mechanical gyros used in aviation and submarine navigation systems have rotations at speeds in the range 6,000 – 30,000 rpm. The upper speed is limited by problems derived from friction in such a mechanical system.

4 Thomson dispersion of light in stars as a machine producing stellar energy due to the background space non-holonomity

Here we apply the foregoing results to the particles of the gaseous constitution of stars.

The physical conditions in stars result from the comparison of well-known correlations of observational astrophysics and two main equations of equilibrium in stars (mechanical and thermal equilibrium). Such a comparison is made in the extensive research started in the 1940's by Kozyrev. The final version was printed in 2005 [6].

In brief, a star is a gaseous ball in a stable state, because mechanical and thermal equilibrium therein are expressed by two equations: (1) the mechanical equilibrium equation — gravity pushing each cm^3 of the gas to the centre of a star is balanced by the gaseous pressure from within; (2) the thermal equilibrium equation — the energy flow produced within one cm^3 of the gas equals the energy loss by radiation. The comparison of the equilibrium equations with the mass–luminosity relation and the period — average density of Cepheids, a well verified correlation of observational astrophysics, resulted in the stellar energy diagram wherein the isoergs show the productivity of stellar energy sources per second [6]. The diagram is reproduced below. The energy output of thermonuclear reactions gives a surface, whose intersection with the diagram is the dashed arc. Because stars have a completely different distribution in the diagram, it is concluded that thermonuclear synthesis can be the source of stellar energy in only a minority of stars, located along the dashed arc. Naturally, stars in the diagram are distributed along a straight line that runs from the right upper region to the left lower region, with a ball-like concentration at the centre of the diagram. The equation of the main direction is

$$\frac{B}{n_e} = \text{const} = 1.4\times10^{-11}\,\text{erg}\,, \qquad (27)$$

and is the relation between the radiant energy density B and the concentration of free electrons in stars. In other words, this is the energy produced per free electron in stars, and it is constant throughout the widest range of the physical conditions in stars: from dwarfs to super-giants. This is the actual physical condition under which the mechanism that generates stellar energy works, even in the low-temperature stars such as red super-giants like the infrared satellite of ε Aurigae, wherein the temperature is about 200,000° and the pressure about one atmosphere. In other words, the relation characterizes the source of stellar energy. According to the stellar energy relation (27), constant in any kind of star, Kozyrev concluded that "the energy productivity in stars is determined by the energy drainage (radiation) only. [. . .] In contrast to reaction, such a mechanism should be called a machine. [. . .] In other words, stars are *machines* which generate radiant energy. The heat drainage is the power regulation mechanism in the machines" [6].

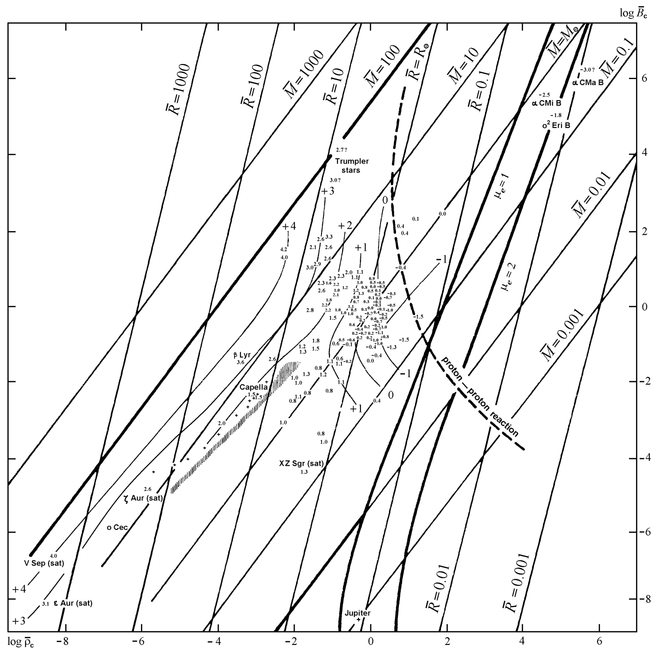

Fig. 1: Diagram of stellar energy: the productivity of stellar energy sources. The abscissa is the logarithm of the density of matter, the ordinate is the logarithm of the radiant energy density (both are taken at the centre of stars in multiples of the corresponding values at the centre of the Sun). Reproduced from [6].

I note that the stellar energy relation (27) — the result of comparing the two main equilibrium equations and observational data — is pure phenomenology, independent of our theoretical views on the origin of stellar energy.

Let's consider the stellar energy relation (27) by means of our theory developed in Section 3 herein. By this relation we have $\frac{B}{n_e} = \text{const} = 1.4\times10^{-11}$erg: the energy produced per electron is constant in any kind of star, under any temperature or pressure therein. So the mechanism producing stellar energy works by a process related to electrons in stars. There is just one process of such a kind — Thomson dispersion of light in free electrons in the radiant transportation of energy from the centre to the surface.

We therefore consider the Thomson process. When a light wave having the average density of energy q encounters a free electron, the flow of the wave energy $\sigma c q$ is stopped in the electron's "square" $\sigma = 6.65\times10^{-25}$ cm^2 (the square of Thomson dispersion). As a result the electron gains an acceleration σq, directed orthogonally to the wave front. In other words, the electron is propelled by a force produced by the wave energy flow stopped in its square, and in the direction of the wave propagation.

We will determine the force by means of electrodynamics in the terms of physically observable chr.inv.-quantities*. The

*The basics of electrodynamics such as the theory of an electromagnetic field and a charged particle moving in it, expressed in terms of chronometric invariants, was developed in the 1990's [11, Chapter 3].

chr. inv.-energy density q and chr.inv.-impulse density J^i are the chr.inv.-projections $q = \frac{T_{00}}{g_{00}}$ and $J^i = \frac{cT_0^i}{\sqrt{g_{00}}}$ of the energy-momentum tensor $T^{\alpha\beta}$ of an electromagnetic field

$$q = \frac{1}{8\pi}\left(E_i E^i + H_{ik}H^{ik}\right), \qquad J^i = \frac{c}{4\pi}\,E_k H^{ik}, \quad (28)$$

where $E^i = \frac{F_{0\cdot}^{\cdot i}}{\sqrt{g_{00}}}$ and $H^{ik} = F^{ik}$ are the chr.inv.-projections of the electromagnetic field tensor $F_{\alpha\beta}$ — the physically observable electric and magnetic strengths of the field [11]. We consider radiation within stars to be isotropic. In an isotropic electromagnetic field $E_i E^i = H_{ik}H^{ik}$ [11], so

$$q = \frac{1}{4\pi}\,E_i E^i, \qquad J^2 = h_{ik}\,J^i J^k = q^2 c^2,. \quad (29)$$

Hence, the wave impulse flow along the x^1 direction the wave travels is

$$J^1 = \frac{qc}{\sqrt{h_{11}}}\,, \quad (30)$$

while the flow of the wave energy stopped in an electron's surface σ, i. e. the force pushing the electron in the x^1 direction, orthogonal to the wave front, is

$$\Phi^1 = \frac{\sigma q}{\sqrt{h_{11}}} = \frac{\sigma q}{\sqrt{1 + \frac{1}{c^2}\,v_1 v_1}}\,. \quad (31)$$

On the other hand, according to our theory, developed in Section 3, the total force Φ^1 acting on an electron and the energy flow W expended on it via the Thomson process should be

$$W = \frac{dE}{d\tau} = W_{(0)} + \delta_n^m \frac{\tilde{v}^n}{\bar{v}^m}\,W_{(0)}\,, \quad (32)$$

$$\Phi^1 = \frac{dp^1}{d\tau} = \Phi^1_{(0)} + \delta_n^m \frac{\tilde{v}^n}{\bar{v}^m}\,\Phi^1_{(0)}\,, \quad (33)$$

depending on a local perturbation $\tilde{v}^i$ in the background space non-holonomity $\bar{v}_i = 2{,}187.671$ km/sec.

What is the real value of the local perturbation $\tilde{v}^i$ in Thomson dispersion of light in stars? We calculate the value of $\tilde{v}^i$, proceeding from the self-evident geometrical truth that the origin of a non-holonomity of a space is any motion along a closed path in it, such as rotations or oscillations.

When a light wave falls upon an electron, the electron oscillates in the plane of the wave because of the oscillations of the electric field strength E^i in the plane. The spatial equation of motion of such an electron is the equation of forced oscillations. For oscillations in the x^2 direction, in a homogeneous non-deformed space, the equation of motion is

$$\ddot{x}^2 + \omega_0^2 x^2 = \frac{e}{m_e}\,E_0^2 \cos\omega t\,, \quad (34)$$

where ω is the frequency of the wave and ω_0 is the proper frequency of the electron. This equation has the solution

$$x^2 = \frac{eE_0^2\cos\omega t}{m_e\left(\omega_0^2 - \omega^2\right)} \simeq \frac{eE_0^2\cos\omega t}{m_e\,\omega^2} \quad (35)$$

so the components of the linear velocity $\tilde{v}^i$ of the local space rotation, approximated by the oscillation, are

$$\tilde{v}^2 = \frac{eE_0^2}{m_e\,\omega}\,, \qquad \tilde{v}^1 = 0\,, \qquad \tilde{v}^3 = 0\,. \quad (36)$$

The electric field strength E in a light wave, according to (29), is $E = \sqrt{4\pi q} = \sqrt{4\pi B}$ where B is the radiant energy density. Therefore the value of $\tilde{v}^2$ is

$$\tilde{v} = \frac{e\sqrt{4\pi}}{m_e}\frac{\sqrt{B}}{\omega} = \frac{e\sqrt{4\pi\alpha}}{m_e}\frac{T^2}{\omega}\,, \quad (37)$$

where $\alpha = 7.59\times10^{-15}$ erg/cm³ × degree⁴ is Stefan's constant, T is temperature. Therefore the total energy flow $W = W_{(0)} + \frac{\tilde{v}^2}{\bar{v}^2}\,W_{(0)} = W_{(0)} + \frac{\tilde{v}}{\bar{v}}\,W_{(0)}$ and force $\Phi^1 = \Phi^1_{(0)} + \frac{\tilde{v}^2}{\bar{v}^2}\,\Phi^1_{(0)}$ acting on an electron orthogonally to the wave plane in the Thomson process should be

$$W = W_{(0)} + \frac{e\sqrt{4\pi}}{m_e\,\bar{v}}\frac{\sqrt{B}}{\omega}\,W_{(0)}\,, \quad (38)$$

$$\Phi^1 = \Phi^1_{(0)} + \frac{e\sqrt{4\pi}}{m_e\,\bar{v}}\frac{\sqrt{B}}{\omega}\,\Phi^1_{(0)}\,, \quad (39)$$

where $\bar{v} = 2{,}187.671$ km/sec. So the additional energy flow $\Delta W = \frac{\tilde{v}}{\bar{v}}\,W_{(0)}$ and force $\Delta\Phi^1 = \frac{\tilde{v}}{\bar{v}}\,\Phi^1_{(0)}$ are twice the initial acting factors W and Φ if the multiplier

$$\frac{\tilde{v}}{\bar{v}} = \frac{e\sqrt{4\pi}}{m_e\,\bar{v}}\frac{\sqrt{B}}{\omega} \quad (40)$$

becomes close to unity ($\tilde{v}$ becomes close to $\bar{v}$). In such a case the background non-holonomic field produces the same energy and forces as those acting in the system, so the energy flow and forces acting in the process are doubled.

Given the frequency $\nu = \frac{\omega}{2\pi} \approx 5\times10^{14}$ Hz, close to the spectral class of the Sun†, we deduce by formula (37) that there in the Sun $\tilde{v}$ reaches the linear velocity of the background space rotation $\bar{v} \simeq 2.2\times10^{8}$ cm/sec, if the radiant energy density is $B = 1.4\times10^{11}$ erg/cm³, which is close to the average value of B in the Sun. From phenomenological data [6], in the central region of the Sun $B \simeq 10^{13}$ erg/cm³ so $\tilde{v} \simeq 2\times10^{9}$ cm/sec there, i. e. ten times larger than the average in the Sun. In the surface layer where $T \simeq 6\times10^{3}$, we obtain the much smaller value $\tilde{v} \simeq 2\times10^{3}$ cm/sec.

This calculation verifies the phenomenological conclusion [6] that the sources of energy aren't located exclusively in the central region of a star (as would be the case for thermonuclear reactions), but are distributed throughout the whole volume of a star, with some concentration at the centre. With the above mechanism generating energy by the background space non-holonomity field, the sources of stellar energy should be working in even the surface layer of the

†A light wave doesn't change its proper frequency in the Thomson process, so the frequency remains the same while light travels from the inner region of a star to the surface where it determines the spectral class (visible colour) of the star.

Sun, but with much less power.

Because the productivity of such an energy generator is determined by the multiplier $\frac{\tilde{v}}{\bar{v}} = \frac{e\sqrt{4\pi}}{m_e \bar{v}} \frac{\sqrt{B}}{\omega}$ (40), in the additional energy flow $\Delta W = \frac{\tilde{v}}{\bar{v}} W_{(0)}$ and the force $\Delta \Phi^1 = \frac{\tilde{v}}{\bar{v}} \Phi^1_{(0)}$. So the energy output ε of the mechanism is determined mainly by the radiant energy density B in stars, i.e. the drainage of energy by radiation*. Therefore, given the above mechanism of energy production by the background space non-holonomity, stars are *machines* producing radiation, the power of which (the energy output) is regulated by their luminosity.

By the stellar energy relation (27) determined from observations, the radiant energy density per electron is constant $\frac{B}{n_e} = 1.4\times10^{-11}$erg in any kind of star. Even such different stars as white dwarfs, having the highest temperatures and pressures (the right upper region in the stellar energy diagram), and low-temperature and pressure infrared super-giants (the left lower region therein) satisfy the stellar energy relation. We therefore conclude that:

> Stellar energy is generated in Thomson dispersion of light while light travels from the inner region of a star to the surface. When a light wave is dispersed by a free electron, the electron oscillates in the electric field of the wave. The oscillation causes a local perturbation of the non-holonomic background space of the Universe, so the background non-holonomic field produces an additional energy flow and force in the Thomson process in order to compensate for the local perturbation in itself. Given the physical conditions in stars, the additional energy and forces are the same as those radiated throughout the wide range of physical conditions in stars — from dwarfs to super-giants. Such energy sources work in the whole volume of a star, even in the surface layer, but with some concentration at the centre. Moreover, the power of the mechanism is regulated by the energy drainage (the radiation from the surface). This is a self-regulating machine, actuated by the background space non-holonomity, and is independent of thermonuclear reactions.

This theoretical result, from General Relativity, verifies the conclusion drawn by Kozyrev from his analysis of well-known phenomenological correlations of observational astrophysics [6]. But having no exact theory of stellar energy sources, Kozyrev had no possibility of calculating similar effects under the physical conditions different than those in stars whose temperatures and pressures are hardly reproducible in a laboratory.

With the theory of the phenomenon established, we can simulate similar effects in a laboratory for low temperature and pressure conditions (with less energy output). We can as well discover, in a laboratory, similar additional energy flow and force in processes much more simply realizable than Thomson dispersion of light. So the theoretical results of Sections 3 and 4 can be used as a basis for forthcoming developments of new energy sources.

As is well known, current employment of nuclear energy produces ecological problems because of radioactive waste. Besides that, events of recent years testify that such energy sources are dangerous if atomic power stations are destroyed by natural or human-made causes: the nuclear fuel, even without atomic explosion, produces many heavy particles and other deadly radiations.

We therefore conclude that new energy sources similar to stellar energy sources described herein, being governed by the energy output, and producing no hard radiation, can work in a laboratory conditions much more effectively and safely than nuclear energy, and replace atomic power stations in the near future.

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*The frequency ω determining the spectral class of a star undergoes a much smaller change, within 1 order, along the whole range of stars.