Laboratory Instrument for Detecting the Earth's Time-Retarded Transverse Vector Potential

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This article provides the basic design for a laboratory instrument that may detect the Earth's time-retarded transverse vector potential [Hafele J.C. *Zelm. Jour.*, 2012, v.5, 134]. The instrument is based on the compound pendulum used by N.A. Kozyrev to measure the change in weight of a suspended aircraft navigation gyroscope [Kozyrev N.A. *Zelm. Jour.*, 2012, v.5, 188]. If such an instrument is developed to measure the strength of the Earth's vector potential with a precision of about 1 part in 1000, the neoclassical causal theory can be worked backwards to calculate the speed of the Earth's gravitational field.

Introduction

A new causal version for Newtonian gravitational theory has been shown to explain exactly the six Earth flyby anomalies reported by NASA in 2008, and also explain exactly an overlooked lunar orbit anomaly [1, 2]. The new causal theory, which retains the traditional acausal radial component, requires in addition a small time-retarded transverse component for the Earth's gravitational field. The new transverse component is orthogonal to the traditional radial component and is directed along the east-west direction. It is well-known that the traditional radial component can be derived from the gradient of a scalar potential. However, the time-retarded transverse component can be derived only from the curl of a vector potential. The formula for the vector potential will be found by using Stoke's theorem. The resulting vector potential is directed along the north-south direction. The north-south component of the gravitational field is given by the time-derivative of the vector potential. By using an analogous Lorentz force law, it will be shown that a small time-dependent radial component is created by induction from the north-south gravitational field. This small induced radial component can slightly change the weight of a suspended gyroscope. By measuring the change in weight, the neoclassical causal theory can be worked backwards to deduce the strength of the vector potential, and thereby indirectly measure the speed of the Earth's gravitational field.

More than 60 years ago [3], N.A. Kozyrev used the causality principle to predict the need for a second universal velocity, one that is to be associated with rotational motion [4]. He designates c_2 as the speed for this second universal velocity. He developed a theory that suggests that the numerical value for c_2 should be related to the fine structure constant [5]. In electrostatic cgs units, the unit of electric charge is the statcoulomb.

The formula for the fine-structure constant, designated by α, in cgs electrostatic units, becomes [5]

$$\alpha = \frac{2\pi}{c}\frac{e^2}{h} \cong \frac{1}{137}, \tag{1}$$

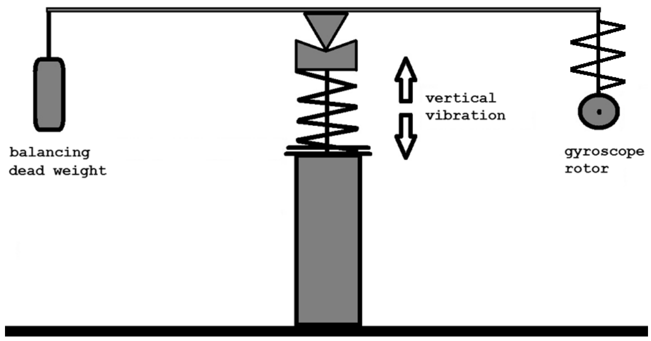

Fig. 1: Schematic of the compound pendulum developed by N.A. Kozyrev to measure a change in the weight of a gyroscope suspended from a balanced cross beam [6]. The preferred orientation of the cross beam appears to have been along the north/south direction, and that for the rotational axis of the gyroscope's rotor along the east/west direction. In some cases a weight change was detected by a small steady imbalance in the cross beam.

where c is the well-known speed of light in vacuum, e is the electronic charge in statcoulombs, and h is Plank's constant. The numerical value for the ratio e^2/h is 350 km/s. Kozyrev found by experiment that $c_2 \cong 700\,\text{km/s} = 2e^2/h = c/430 = \alpha c/\pi$.

A schematic for the compound pendulum developed by N.A. Kozyrev to measure c_2 is shown in Fig. 1 [6]. Kozyrev found that the weight of the gyroscope under certain conditions would change when there is a vertical vibration of the cross arm. Sometimes he observed a relative weight change on the order of 10^{-5}.

The objective of *this article* is to derive the effects of the neoclassical causal theory on a suspended gyroscope. We will find that the weight changes observed by N.A. Kozyrev may have been caused by the causal version of Newton's theory.

Parameter values and basis vectors

Numerical values for various parameters will be needed. Let m be the mass of the gyroscope's rotor, let R be its radius, let ω_{rot} be its angular speed, let P_{rot} be the rotational period, let I_{rot} be the moment of inertia, let $\boldsymbol{J}_{rot}$ be the angular momentum vector, and let E_{rot} be the rotational energy. Typical numerical values for the parameters of an aircraft navigation gyroscope are [4]

$$\begin{aligned} m &= 0.1 \text{ kg}, \\ R &= 2\times10^{-2} \text{ m}, \\ \omega_{rot} &= 2\pi 500 \text{ rad/s} = 3.14\times10^{3} \text{ rad/s}, \\ P_{rot} &= 2\pi/\omega_{rot} = 2\times10^{-3} \text{ s}, \\ I_{rot} &= mR^2 = 4\times10^{-5} \text{ kg}\times\text{m}^2, \\ J_{rot} &= I_{rot}\omega_{rot} = 0.126 \text{ kg}\times\text{m}^2/s, \\ E_{rot} &= \frac{1}{2} I_{rot}\omega_{rot}^2 = 197 \text{ kg}\times m^2/s^2. \end{aligned} \tag{2}$$

Let the Earth be simulated by a spinning isotropic sphere of radius r_E, mass M_E, sidereal spin angular speed Ω_E, equatorial surface speed v_{eq}, moment of inertia I_E, surface gravitational scalar potential φ_E, surface gravitational field g_E, spin energy E_E, and spin angular momentum $\boldsymbol{J}_E$. Numerical values for the Earth's parameters are [1]

$$\begin{aligned} G &= 6.6732\times10^{-11} \text{ N}\times\text{m}^2/\text{kg}^2, \\ r_E &= 6.37\times10^{6} \text{ m}, \\ M_E &= 5.98\times10^{24} \text{ kg}, \\ \Omega_E &= 7.29\times10^{-5} \text{ rad/s}, \\ \mathrm{v}_{eq} &= r_E\Omega_E = 4.65\times10^{2} \text{ m/s}, \\ I_E &= 8.02\times10^{37} \text{ kg}\times\text{m}^2, \\ \varphi_E &= \frac{GM_E}{r_E} = 6.26\times10^{7} \text{ m}^2/\text{s}^2, \\ g_E &= \frac{GM_E}{r_E^2} = 9.83 \text{ m/s}^2, \\ E_E &= \frac{1}{2} I_E\Omega_E^2 = 2.13\times10^{29} \text{ kg}\times\text{m}^2/\text{s}^2, \\ J_E &= I_E\Omega_E = 5.85\times10^{33} \text{ kg}\times\text{m}^2/\text{s}. \end{aligned} \tag{3}$$

Let (X, Y, Z) be the rectangular coordinates for an inertial frame-of-reference, let the Earth's center be at the origin, let the (X, Y) plane coincide with the equatorial plane, and let the axis of rotation coincide with the Z-axis. Let $\mathbf{e}_X$ be a unit vector directed outwardly along the X-axis, let $\mathbf{e}_Y$ be a unit vector directed outwardly along the Y-axis, and let $\mathbf{e}_Z$ be a unit vector directed outwardly along the Z-axis.

Let the spherical coordinates for an exterior field-point be (r,ϕ,λ), where r is the geocentric radial distance, ϕ is the azimuthal angle, and λ is the geocentric latitude. Let $\mathbf{e}_r$ be a unit vector directed upward along $\boldsymbol{r}$, let $\mathbf{e}_\phi$ be a unit vector directed towards the east, and let $\mathbf{e}_\lambda$ be a unit vector directed towards the north. The triad $(\mathbf{e}_r, \mathbf{e}_\phi, \mathbf{e}_\lambda)$ forms the basis for a right-handed system of orthogonal spherical coordinates.

Effects of a vertical vibration of a suspended gyroscope

Let the field-point be at the center of the rotor of an aircraft navigation gyroscope. Let λ be the geocentric latitude for the gyroscope. Let h be the rotor's height above the Earth's surface, let h_0 be a constant altitude, let h_1 be the vibration amplitude, and let ω_h be the angular speed for a vertical vibration. Then

$$h = h_0 + h_1 \cos\omega_h t. \tag{4}$$

The time dependent geocentric radial distance becomes

$$r = r_E\left(1 + \frac{h_0}{r_E} + \frac{h_1}{r_E}\cos(\omega_h t)\right). \tag{5}$$

Let r_ϕ be the rotor's geocentric radius of gyration

$$r_\phi = r_E\cos\lambda\left(1 + \frac{h_0}{r_E} + \frac{h_1}{r_E}\cos(\omega_h t)\right). \tag{6}$$

Let $\mathbf{v}$ be the rotor's vector inertial velocity

$$\mathbf{v} = \mathbf{e}_r\mathrm{v}_r + \mathbf{e}_\phi\mathrm{v}_\phi + \mathbf{e}_\lambda\mathrm{v}_\lambda. \tag{7}$$

The formulas for v_r and v_ϕ are

$$\begin{aligned} \mathrm{v}_r &= \frac{dr}{dt} = -h_1\omega_h\sin(\omega_h t), \\ \mathrm{v}_\phi &= r_\phi\Omega_\phi = r_E\Omega_E\cos\lambda\left(1 + \frac{h_0}{r_E} + \frac{h_1}{r_E}\cos(\omega_h t)\right). \end{aligned} \tag{8}$$

Let E_r be the radial energy. If the radial energy is *constant*, then

$$\begin{aligned} constant = E_r &= \frac{1}{2} mv_r^2 - mg_E h = \\ &= \frac{1}{2} mh_1^2\omega_h^2\sin^2(\omega_h t) - mg_E(h_0 + h_1\cos(\omega_h t)). \end{aligned} \tag{9}$$

By using a trig identity for $\sin^2(\omega_h t)$, the time independent part of (9) becomes

$$constant = \frac{1}{4} mh_1^2\omega_h^2 - mg_E h_0. \tag{10}$$

Suppose a gyroscope is suspended by a spring of unstretched length ℓ_0 and spring constant k, as depicted in Fig. 2. Suppose the upper end of the spring is connected to a vibrator which can produce a time-dependent supporting force.

$$F_{up} = W + mh_{vib}\omega_{vib}^2\cos(\omega_{vib}t), \tag{11}$$

where W is the weight of the gyroscope. If the vibrator is turned off, $h_{vib} = 0$. In this case, the upper end of the spring is attached to a fixed solid point, and the system becomes a simple undriven harmonic oscillator.

Let $\delta\ell_0$ be the stretch of the spring when the gyroscope is attached. Then $k = W/\delta\ell_0 \cong mg_E/\delta\ell_0$, where g_E is the Earth's radial gravitational field at the surface. Let $\delta\ell_0 = h_0$. Then

$$k = \frac{mg_E}{h_0}. \tag{12}$$

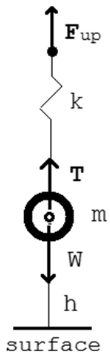

Fig. 2: Schematic for a forced harmonic oscillator; a rotor of mass m suspended by a spring of spring constant k with an upward supporting force F_{up}. Here T is the spring tension pulling up on the rotor, the weight W is the downward force of gravity on the rotor, and h is the height of the center of the rotor above the surface. Assume that the mass of the spring is negligible, and that the mass of the gyroscope approximately equals the mass of the rotor.

If the system is enclosed in a glass box, the damping of small amplitude free oscillations would be weak. The equation for an undamped harmonic oscillator is [7]

$$\frac{d^2h}{dt^2} + \omega_k^2 h = 0, \tag{13}$$

where

$$\omega_k^2 = \frac{k}{m} = \frac{g_E}{h_0}. \tag{14}$$

If $h_0 \cong 10^{-4}$ m, then $\omega_k \cong 313$ rad/s or 50 Hz. If $\omega_h = \omega_k$ and the constant of (10) is zero, the connection between h_1 and h_0 becomes

$$h_1 = 2h_0. \tag{15}$$

This shows that the constant h_0 is comparable with the amplitude h_1.

Now consider the forced harmonic oscillator. Suppose the vibrator is turned on and adjusted to an amplitude h_{vib} and angular speed ω_{vib}. In this case,

$$F_{up} = mg_E + mh_{vib}\omega_{vib}^2 \cos(\omega_{vib}t). \tag{16}$$

If $\omega_{vib} \cong \omega_k$, the system is at or near resonance [7]. At resonance, if the damping is small, the speed dh/dt is in phase with the driving force F_{up}, the average kinetic energy in the system is at a maximum, and the amplitude at the rotor h_1 can be many times greater than the driver amplitude h_{vib}.

The effects of vibration alone apply to any dead weight, because vibration alone does not depend on the rotation of the gyroscope's rotor. Gyroscopic forces do depend on the rotation of the rotor. Therefore, for a complete analysis, gyroscopic forces must be included.

Effects of gyroscopic forces

Gyroscopic forces cause precession and nutation [7, 8]. Precession is a steady revolution of the rotor around a vertical

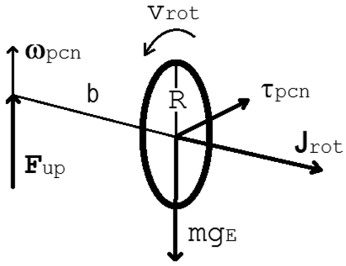

Fig. 3: Depiction of the gyroscopic forces acting on a rotor of mass m, radius R, and angular momentum vector $\mathbf{J}_{rot}$, which is supported by an upward force $\mathbf{F}_{up}$ at a distance b along the axel from the rotor's center to the support. Assume $\mathbf{J}_{rot}$ is in the horizontal plane. If $F_{up} = mg_E$, the precessional torque on the rotor $\tau_{pcn} = bmg_E$. In this case, the rotor precesses around the support with an angular speed $\omega_{pcn} = bmg_E/mR^2\omega_{rot}$.

axis, and nutation is an up-down nodding motion of the rotor. The general problem for motions of a spinning rigid body can be quite complicated, but the problem is simplified for certain special cases. The case for "THE HEAVY SYMMETRICAL TOP WITH ONE POINT FIXED" is described in great detail by H. Goldstein [8, p. 213].

Suppose the axel for a rotor is supported at a distance b from the center with an upward supporting force $\mathbf{F}_{up}$ and with the angular momentum vector $\mathbf{J}_{rot}$ released in the horizontal plane, as depicted in Fig. 3.

For a first case, suppose the supporting force is constant and equal to the weight, $F_{up} = mg_E$. Consider the case for slow precession without nutation.

Let ω_{pcn} be the precessional angular speed, and let v_{pcn} be the linear speed. Then the torque $\tau_{pcn} = bmg_E = J_{rot}\omega_{pcn}$. Solving for the angular speed gives $\omega_{pcn} = bg_E/R^2\omega_{rot}$.

If the distance $b = 0.1$ m, $R = 2 \times 10^{-2}$ m, and $\omega_{rot} = 3.14 \times 10^3$ rad/s, numerical values for ω_{pcn} and v_{pcn} are

$$\begin{aligned} \omega_{pcn} &= \frac{bg_E}{R^2\omega_{rot}} = 0.782 \quad \text{rad/s}, \\ v_{pcn} &= b\omega_{pcn} = 7.82 \times 10^{-2} \quad \text{m/s}. \end{aligned} \tag{17}$$

Thus we find that the precessional speed for this case would be slow and constant at about 8 cm/s. Notice that this gyroscopic force supports the entire weight of the rotor.

Suppose the system is started with $\boldsymbol{J}_{rot}$ at a small initial angle $\delta\theta_0$ above the horizontal plane. Let h_{ntn} be the amplitude for nutation, which is the initial height above the horizontal plane. Then

$$h_{ntn} = b \tan \delta\theta_0. \tag{18}$$

When released, the rotor will precess with the angular speed ω_{pcn} of (17) and oscillate up and down with an upper maximum angle $\delta\theta_0$ and a lower minimum angle $\delta\theta_1$. Let ω_{ntn} be the angular speed for nutation. The formula for ω_{ntn} can be found in [8, p. 221].

$$\omega_{ntn} = \frac{bg_E}{R^2\omega_{pcn}} = \omega_{rot} = 3.1 \times 10^3 \quad \text{rad/s}. \tag{19}$$

Thus we find that the frequency for nutation is the same as the frequency for the rotor, 500 Hz.

The formula for the difference $\sin\delta\theta_0 - \sin\delta\theta_1$ can be found in [7, p. 312].

$$\sin\delta\theta_0 - \sin\delta\theta_1 = \frac{2g_E b^3}{R^4\omega_{rot}^2}.$$

If $b = 0.1$ m, $R = 2\times10^{-2}$ m, and $\omega_{rot} = 3.14 \times 10^3$ rad/s, the numerical value for the difference becomes

$$\sin\delta\theta_0 - \sin\delta\theta_1 = 1.24 \times 10^{-2}, \tag{20}$$

the amplitude

$$h_{ntn} = 6.2 \times 10^{-4} \quad \text{m}, \tag{21}$$

and the linear speed for nutation becomes

$$\mathrm{v}_{ntn} = h_{ntn}\omega_{ntn} \sin(\omega_{ntn}t) \cong (1.9 \text{ m/s}) \sin(\omega_{ntn}t). \tag{22}$$

Now let's change the length of the axel. Suppose the rotor's axel is extended on the other side of the support by the same distance b, and a dead weight that balances the cross beam is attached. If $\boldsymbol{J}_{rot}$ is directed outward from the supporting point, the dead weight would produce a torque equal in magnitude but opposite to the direction for τ_{pcn}, which would cancel the precessional motion. But such a balance would not cause any change in the nutational motion.

With the cross beam balanced in this manner, suppose the vibrator that supports the cross beam is turned on and adjusted to have an amplitude of h_{ntn} and an angular speed ω_{ntn}. This would induce an artificial nutation, but only if the gyroscope's rotor is spinning with an angular speed ω_{rot}. If the radial gravitational field contains a small time-dependent component with an angular speed near ω_{ntn}, there would be interesting interference effects and beat frequencies that could become visible in the balance of the cross beam.

The Earth's time-retarded transverse gravitational field

To satisfy the causality principle, the neoclassical causal theory postulates a new time-retarded transverse component for the Earth's gravitational field [1]. Let $\boldsymbol{g}_\phi$ be the Earth's time-retarded transverse component. The formula for the magnitude is [1]

$$g_\phi = C_\phi\left(1 - \frac{\Omega_\phi}{\Omega_E}\right) PS(r)\cos^2\lambda, \tag{23}$$

where the definition for the coefficient is

$$C_\phi = G\bar{\rho} r_E \frac{v_{eq}}{c_g}. \tag{24}$$

Here G is the gravity constant, r_E is the Earth's spherical radius, Ω_E is the Earth's sidereal angular speed, $\bar{\rho}$ is the Earth's mean mass density, c_g is the speed of propagation of the Earth's gravitational field, r is the geocentric radial distance to the field point, λ is the geocentric latitude for the field point, Ω_ϕ is the angular speed of the projection of the field point onto the equatorial plane, and $PS(r)$ is a power series representation for a triple integral over the Earth's volume.

The numerical value for C_ϕ with $c_g = c$ is

$$C_\phi = G\bar{\rho} r_E \frac{\mathrm{v}_{eq}}{c} = 3.635 \times 10^{-6} \quad \text{m/s}^2. \tag{25}$$

The formula for the power series is

$$PS(r) = \left(\frac{r_E}{r}\right)^3 \left(C_0 + C_2\left(\frac{r_E}{r}\right)^2 + C_4\left(\frac{r_E}{r}\right)^4 + C_6\left(\frac{r_E}{r}\right)^6\right), \tag{26}$$

where the values for the coefficients are

$$\begin{aligned} C_0 &= 0.50889, \quad C_2 = 0.13931, \\ C_4 &= 0.01013, \quad C_6 = 0.14671. \end{aligned} \tag{27}$$

Let CPS_0 be the value for $PS(r_E)$. The definition and numerical value are

$$CPS_0 = C_0 + C_2 + C_4 + C_6 = 0.805. \tag{28}$$

Let $\boldsymbol{J}_Z$ be the geocentric angular momentum for the rotor, defined as

$$J_Z = m r_\phi^2 \Omega_\phi \tag{29}$$

By conservation of angular momentum,

$$constant = \frac{J_z}{m} = r_\phi^2\Omega_\phi = r_E^2\Omega_E\cos^2\lambda \tag{30}$$

Solving (30) for Ω_ϕ gives

$$\Omega_\phi \cong \Omega_E\left(1 - 2\frac{h_0}{r_E} - 2\frac{h_1}{r_E}\cos(\omega_h t)\right) \tag{31}$$

Then the difference

$$1 - \frac{\Omega_\phi}{\Omega_E} = 2\frac{h_0}{r_E} + 2\frac{h_1}{r_E}\cos(\omega_h t). \tag{32}$$

Substituting (32) into (23) produces

$$g_\phi = C_\phi\left(2\frac{h_0}{r_E} + 2\frac{h_1}{r_E}\cos(\omega_h t)\right) PS(r)\cos^2\lambda. \tag{33}$$

The numerical value for g_ϕ with $c_g = c$, $r = r_E$, $h_0 = h_1 = 10^{-4}$ m, and λ = 60°, is

$$g_\phi = \left(2.3 \times 10^{-17} \text{ m/s}^2\right)\left(1 + \cos(\omega_h t)\right). \tag{34}$$

This result shows that the time-retarded transverse gravitational field for a suspended gyroscope is totally negligible.

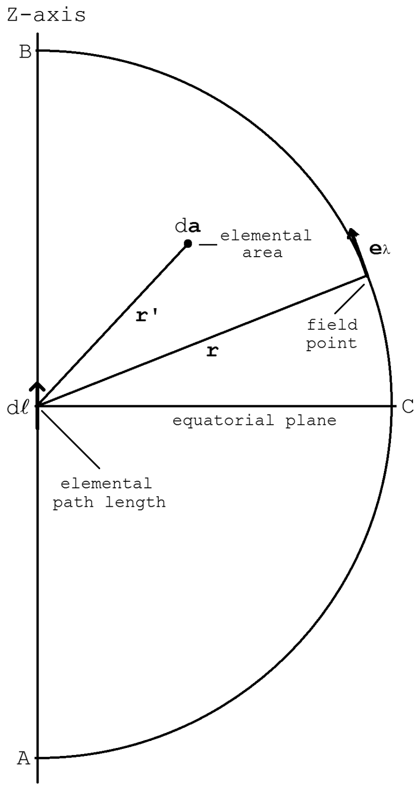

Fig. 4: Depiction of the semicircular area to be used for Stoke's theorem. The contour for the line integral is $A \to B \to C \to A$. Here $d\boldsymbol{\ell}$ is an elemental path length vector, d**a** is an elemental area vector, and $\mathbf{e}_\lambda$ is a unit vector for λ. The field-point is at **r** and the elemental area d**a** is at **r**′.

The Earth's time-retarded transverse vector potential

Let $\boldsymbol{A}$ be the vector potential for $\boldsymbol{g}_\phi$. Then by definition

$$\boldsymbol{g}_\phi = \boldsymbol{\nabla} \times \boldsymbol{A}. \tag{35}$$

Units for A are m^2/s^2, the same as the units for the scalar potential. Because the divergence of $\boldsymbol{g}_\phi$ is zero, the divergence of $\boldsymbol{A}$ must also be zero, which means that $\boldsymbol{A}$ cannot have a component directed along $\boldsymbol{e}_r$. Consequently, $\boldsymbol{A}$ must be directed along $\boldsymbol{e}_\lambda$.

The needed elemental vectors $d\boldsymbol{\ell}$ and d**a** for integration using Stoke's theorem are depicted in Fig. 4. Stoke's theorem states that the line integral of $\boldsymbol{A} \bullet d\boldsymbol{\ell}$ around a closed contour equals the surface integral of $\boldsymbol{\nabla} \times \boldsymbol{A} \bullet d\boldsymbol{a}$ over the surface bounded by the contour. It is symbolically written as

$$\oint \boldsymbol{A} \bullet \mathrm{d}\boldsymbol{\ell} = \iint \boldsymbol{\nabla} \times \boldsymbol{A} \bullet \mathrm{d}\mathbf{a}. \tag{36}$$

Consider the closed contour depicted in Fig. 4: $A \to B \to C \to A$. The left side of (36) becomes

$$\oint_{A \to B} \boldsymbol{A} \bullet d\boldsymbol{\ell} = 0, \qquad \oint_{B \to C \to A} \boldsymbol{A} \bullet d\boldsymbol{\ell} = A_\lambda \pi r. \tag{37}$$

The right side of (36) becomes

$$\iint \boldsymbol{\nabla} \times \boldsymbol{A} \bullet \mathrm{d}\mathbf{a} = g_\phi \iint r' dr' d\lambda' = g_\phi \frac{\pi}{2} r^2. \tag{38}$$

Next comes the solution

$$A_\lambda = \frac{1}{2} r g_\phi = A_0 \cos^2\lambda \, PS'(r) \left(2\frac{h_0}{r_E} + 2\frac{h_1}{r_E} \cos(\omega_h t) \right) \tag{39}$$

where the definition for A_0 and its numerical value with $c_g = c$ and the definition for the power series for A_λ are

$$\begin{aligned} A_0 &= \frac{C_\phi r_E}{2} = 11.6 \quad \mathrm{m^2/s^2}, \\ PS'(r) &= \frac{r}{r_E} PS(r) = \\ &= C_0 \left(\frac{r_E}{r}\right)^2 + C_2 \left(\frac{r_E}{r}\right)^4 + C_4 \left(\frac{r_E}{r}\right)^6 + C_6 \left(\frac{r_E}{r}\right)^8. \end{aligned} \tag{40}$$

The formula that connects $\boldsymbol{g}_\lambda$ to the time-dependence of $\boldsymbol{A}_\lambda$ is [9, p. 219].

$$\begin{aligned} g_\lambda &= -\frac{1}{\mathrm{v}_k} \frac{dA_\lambda}{dt} = \\ &= 2\frac{A_0}{\mathrm{v}_k} \cos^2\lambda \left(\frac{h_1 \omega_h}{r_E} PS'(r_E) \sin(\omega_h t) - \right. \\ &\left. - \frac{dPS'}{dt} \left(\frac{h_0}{r_E} + \frac{h_1}{r_E} \cos(\omega_h t) \right) \right), \end{aligned} \tag{41}$$

where v_k is the "induction speed" for the neoclassical causal theory.

The numerical value for the average induction speed has been found to be [1]

$$\bar{\mathrm{v}}_k \cong 5 \times 10^3 \ \ \mathrm{m/s}. \tag{42}$$

The coefficient A_0 is inversely proportional to c_g. It is interesting to notice that A_0/v_k with $c_g = c$ is inversely proportional to $c\mathrm{v}_k$, and that

$$\sqrt{c\mathrm{v}_k} \cong 11 \times 10^5 \ \mathrm{m/s} = 1.7 c_2, \tag{43}$$

where c_2 is Kozyrev's secondary universal speed, the one that is to be associated with rotational motion [4].

Let CPS'_0 be the value for PS' at $r = r_E$.

$$CPS'_0 = PS'(r_E) = C_0 + C_2 + C_4 + C_6 = 0.805. \tag{44}$$

The value for dPS'/dt evaluated at $r = r_E$ is

$$\begin{aligned} \left.\frac{dPS'}{dt}\right|_{r=r_E} &= (2C_0 + 4C_2 + 6C_4 + 8C_6) \frac{h_1 \omega_h}{r_E} \sin(\omega_h t) = \\ &= 2.81 \frac{h_1 \omega_h}{r_E} \sin(\omega_h t). \end{aligned} \tag{45}$$

The formula for g_λ to first order in h_1/r_E reduces to

$$g_\lambda \cong C_\lambda \cos^2\lambda \frac{h_1 \omega_h}{\mathrm{v}_k} \sin(\omega_h t), \tag{46}$$

where the definition and numerical value with $c_g = c$ for C_λ are

$$C_\lambda = 0.805 \times 2\frac{A_0}{r_E} = 0.805 C_\phi = 2.926 \times 10^{-6} \ \ \text{m/s}^2, \quad (47)$$

and C_ϕ is given by (24).

If $h_1 = 10^{-4}$ m, $\omega_h = \omega_{rot}$, $v_k = 5$ km/s, and $\lambda = 60°$, the numerical value for g_λ reduces to

$$g_\lambda = (4.6 \times 10^{-11}\,\text{m/s}^2)\sin(\omega_h t) \quad (48)$$

This result shows that the vector potential can produce a relatively large value for the north/south transverse gravitational field. The ratio for g_λ / g_ϕ, with g_ϕ from (34), is on the order of

$$\frac{g_\lambda}{g_\phi} \sim 2 \times 10^6. \quad (49)$$

Secondary radial induction field

The analogous Lorentz force law for gravity [1, 2] states that a north/south transverse gravitational field can induce a radial gravitational field. Let $\boldsymbol{g}_{ind}$ be the induced gravitational field. Then

$$\boldsymbol{g}_{ind} = \frac{\mathbf{v}}{v_k} \times \boldsymbol{g} = \frac{1}{v_k}\begin{vmatrix} \mathbf{e}_r & \mathbf{e}_\phi & \mathbf{e}_\lambda \\ v_r & v_\phi & v_\lambda \\ g_r & g_\phi & g_\lambda \end{vmatrix}. \quad (50)$$

The induced gravitational field along $\mathbf{e}_r$ is the only one of the components that can change the weight of the rotor.

$$\mathbf{e}_r g_{ind} = \mathbf{e}_r\left(\frac{v_\phi}{v_k} g_\lambda - \frac{v_\lambda}{v_k} g_\phi\right) \cong \mathbf{e}_r \frac{v_\phi}{v_k} g_\lambda. \quad (51)$$

Substituting (8) and (42) into (51) gives

$$g_{ind} \cong C_{ind}\sin(\omega_h t), \quad (52)$$

where

$$C_{ind} = C_\lambda \frac{h_1 \omega_h}{v_k}\frac{v_{eq}}{v_k}\cos^3\lambda \quad (53)$$

If $\lambda = 60°$, $h_1 = 10^{-4}$ m, $\omega_h = \omega_{rot}$, and $v_k = 5$ km/s, the numerical value for C_{ind} reduces to

$$C_{ind} = 2.1 \times 10^{-12} \quad \text{m/s}^2. \quad (54)$$

This result predicts a very small value for g_{ind}, but it is close to the order of magnitude for g_λ, which is predicted to be about 10^6 times g_ϕ. There may be some hidden effect that enhances g_{ind} by 10^6, in particular the nutation effects of (21) and (22). This question can be resolved only by experiment.

Conclusions and recommendations

It seems plausible but not proven that the weight changes observed by N.A. Kozyrev may have been caused by the neoclassical causal theory. Modern experimental techniques using digital electronics, sensitive strain gauges, sensitive accelerometers, and computer controls, can greatly increase the sensitivity and reliability of laboratory instruments. If an instrument that can detect the Earth's time-retarded transverse vector potential is developed with a precision of about 1 part in 1000, the theory can be worked backwards to provide a measured value for the speed of the Earth's gravitational field. To accomplish this end, a dedicated effort to develop an instrument, and comprehensive systematic studies using such an instrument, are highly recommended.

Acknowledgements

I thank Patrick L. Ivers for reviewing the manuscript for this article and suggesting improvements. I also thank Dr. Dmitri Rabounski for providing the schematic drawing for N. A. Kozyrev's compound pendulum.

Submitted on August 18, 2013 / Accepted on August 25, 2013
Updated with corrections on October 10, 2013

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