119(4): A Suggested Explanation of the Equinox Precession in terms of Gravitomagnetism.

If we consider a point on the surface of the earth an equatorial precession is observed of about fifty arcseconds a year. It is difficult to explain this with Newtonian mechanics or with developments of such mechanics due for example to d'Alembert. From observation it is seen that this precession is one of the whole solar system. This precession cannot be explained by the spinning top dynamics because there is no fixed point. As first shown by Lagrange, the spinning top type wobbling requires the point of the top to be in contact with a surface. Such is not the case for the earth.

In this note we approach this well known problem with the simplest type of gravitomagnetic equation:

$$\boxed{\Omega = \left(\frac{GM}{c^2 r^2}\right) v} \quad -(1)$$

where Ω is in radians per second (or arcseconds). In eq. (1), G is Newton's constant, M is the mass of the earth, c is the vacuum speed of light, r is the radius of the earth, and v is the linear velocity of the point on the earth's

2) surface with respect to the origin of a frame of reference. The earth spins every day, so there is a velocity of the point due to this spin. The earth orbits the sun every year, so the point also has a linear velocity due to this orbit. The net velocity is:

$$\underline{v} = \underline{v_1} + \underline{v_2} \quad -(2)$$

where $\underline{v}_1$ is the spin velocity and $\underline{v}_2$ is the orbital velocity. By observation of the Pleiades, the whole solar system seems to be moving at a velocity $\underline{v}_3$ with respect to the Milky Way galaxy. So:

$$\underline{v} = \underline{v_1} + \underline{v_2} + \underline{v_3} \quad -(3)$$

Finally, the Milky Way galaxy may be moving with respect to a distant object such as a reference star used to measure the equinoctial precession. We denote this by $\underline{v}_4$. So:

$$\underline{v} = \underline{v_1} + \underline{v_2} + \underline{v_3} + \underline{v_4} \quad -(4)$$

and:

$$v = |\underline{v}| = \left((\underline{v}_1 + \underline{v}_2 + \underline{v}_3 + \underline{v}_4) \cdot (\underline{v}_1 + \underline{v}_2 + \underline{v}_3 + \underline{v}_4) \right)^{1/2} \quad -(5)$$

so there are sixteen terms.

Eq. (1) comes from the basic relation:

$$\underline{\Omega} = -\frac{1}{c^2} \underline{v} \times \underline{g} \quad -(6)$$

3)

where $\underline{g}$ is the acceleration due to gravity of the earth, because the observer (a telescope) is on the surface of the earth. Eq. (6) is precisely analogous to:

$$\underline{B} = -\frac{1}{c^2}\,\underline{v}\times\underline{E} \quad -(7)$$

in ECE electrodynamics.

So eq. (1) assumes that the equinoctial precession is due to the gravitomagnetic angular frequency:

$$\Omega = |\underline{\Omega}| \quad -(8)$$

The data are:

$$M = 5.98\times 10^{24}\ \text{kgm}$$

$$r = 6.37\times 10^{6}\ \text{metres}$$

$$G = 6.67\times 10^{-11}\ m^3\ \text{kgm}^{-1}\ s^{-2}$$

$$c = 3\times 10^{8}\ m\ s^{-1}$$

<u>Units</u> <u>check</u>

$$\Omega = \frac{m^3\ \text{kgm}^{-1}\ s^{-2}\ \text{kgm}\ m\ s^{-1}}{m^2\ s^{-2}\ m^2} = s^{-1}$$

Therefore:

$$\Omega = 1.09\times 10^{-15}\ v\ \text{rad}\ s^{-1}$$

$$= 7.10\times 10^{-3}\ v\ \text{arcseconds per year}$$

4)

So, in the simplest theory:

$$\boxed{\Omega = 7.10 \times 10^{-3} v} \text{ arcseconds per year} \quad -(9)$$

The experimental result for the equinox precession is:

$$\Omega \,(\text{exptl.}) = 50 \text{ arcseconds per year} \quad -(10)$$

Therefore the velocity v is:

$$v = \frac{50}{7.10} \times 10^{3} \; m\,s^{-1}$$

$$\boxed{v = 7{,}042 \; m\,s^{-1}} \quad -(11)$$

The orbital velocity of the earth around the sun is:

$$v_2 = 2{,}980 \; m\,s^{-1} \quad -(12)$$

and the daily spin velocity is:

$$v_1 = 512 \; m\,s^{-1} \quad -(13)$$

The velocity of the solar system with respect to the Milky Way, v_3, must therefore make up part of the difference, and the velocity of the Milky Way galaxy with respect to the reference stars is v_4.

As can be seen from eq. (5) the net velocity v is a vector sum, so the relative direction of $\underline{v}_1$, $\underline{v}_2$, $\underline{v}_3$ and $\underline{v}_4$ must be taken into account, as well as their magnitudes.

Considering the complexity of the problem, the gravitomagnetic explanation is satisfactory, at the least it may be claimed to contribute to the Earth's equinoctial precession. If eq. (9) is accepted as a first approximation, then the Earthbound observer moves with respect to the origin of a reference frame by $7{,}042\ ms^{-1}$.