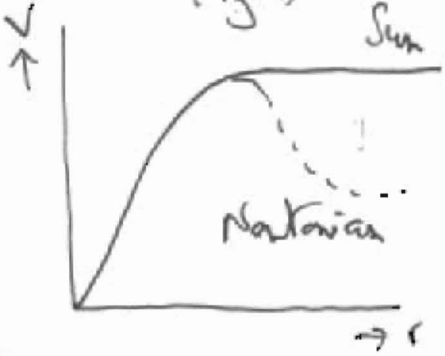
1) <u>119(8)</u>: <u>Sun's Position and Orbit in the Milky Way</u>

The sun's orbit is 10% off from circular, and it is falling slowly into the centre of the galaxy. It is an outer star situated between the third and fourth arms of the galaxy, about 20 light years above the galactic plane, and 28,000 light years from the centre. It orbits at a nearly constant linear velocity of

$$v = 210 \text{ km s}^{-1} \quad -(1)$$

Fig (1)



and this is in the non-Newtonian region of the velocity curve (Fig (1)). So

$$L = mrv = \text{constant} \quad -(2)$$

where m is the mass of the sun, r is its distance from the galactic centre, and v is given by eq. (1). The gravitomagnetic equation:

$$\Omega = \frac{vg}{c^2}\sin\theta \quad -(3)$$

gives for

$$v \sin\theta = 70.4 \text{ km s}^{-1} \quad -(4)$$

$$\Omega = 50.28 \text{ arcseconds a year}$$

(the equinoctial precession angle). Therefore from eqs (1) and (4):

$$\sin\theta = \frac{70.4}{210.0} = 0.335$$

$$\theta = 19.6^\circ \quad -(5)$$

This is the angle between $\underline{v}$ and $\underline{g}$, the direction of the latter depending on the position.

2) a the surface of the earth at which Ω is observed. The vector $\underline{g}$ is directed from this position to the centre of the earth, and the vector $\underline{v}$ is the present direction of the sun's orbit around the galactic centre. This orbit takes 220 million years to complete. The equatorial precession is that of the entire solar system with respect to the reference point (e.g. a far distant star).

<u>Galactic Dynamics</u>

These are explained by the generally covariant equation:

$$\underline{\nabla} \cdot \underline{g} = 4\pi G \rho \quad -(6)$$

$$= c^2 (R - \omega T). \quad -(7)$$

Here:

$$g = c^2 T. \quad -(8)$$

Here R is shorthand for curvature, ω is shorthand for spin connection, and T is shorthand for torsion. In the Newtonian limit:

$$\omega \rightarrow 0 \quad -(9)$$

and this is the Newtonian curve of Fig (1).

For constant velocity v and angular momentum L, the torsion is constant, so g is constant, and

$$\underline{\nabla} \cdot \underline{g} = 0 \quad -(10)$$

So:

$$R = \omega T. \quad -(11)$$

From previous work it is known that eq. (11) describes pure rotation. Therefore eq. (6) describes the main feature of Fig (1). Also previous work has shown that the canonical angular momentum / energy density is proportional to the torsion tensor:

$$J^{\kappa\mu\nu} = \left(\frac{\hbar}{Ar}\right) T^{\kappa\mu\nu} \quad -(12)$$

$$= -\frac{1}{2}\left(E^{\kappa\mu}x^{\nu} - E^{\kappa\nu}x^{\mu}\right).$$

Here:

$$E^{\kappa\mu} = E^{\mu\kappa}. \quad -(13)$$

is the canonical energy / momentum density. In eq. (12) Ar denotes area. The angular momentum is an integral over the $J^{\kappa\mu\nu}$ tensor:

$$J^{\mu\nu} = \int J^{\kappa\mu\nu} \, d^3x_{\kappa} \quad -(14)$$

In eq. (12) $\hbar$ / Ar is the quantum of action or angular momentum area density. In paper (98), eq. (62), Ar is defined as κ^2, so

$$J^{\kappa\mu\nu} = \hbar \kappa^2 T^{\kappa\mu\nu} \quad -(15)$$

4) In paper 103, eq. (16), it was inferred that:

$$T^{\kappa\mu\nu} = \frac{k}{c} J^{\kappa\mu\nu} \quad \text{— (16)}$$

where k is Einstein's constant

<u>Units</u> <u>Check</u>

$$T^{\kappa\mu\nu} = m^{-1}, \quad k = \frac{8\pi G}{c^2} = 1.86595 \times 10^{-26} \; m \, kgm^{-1}$$

$$\text{RHS of (16)} = m \, kgm^{-1} \, s \, m^{-1} \, kgm \, m^2 \, s^{-1} / m^3 = m^{-1} \checkmark$$

Compare (15) and (16):

$$\frac{1}{\hbar \kappa^2} = \frac{k}{c} \quad \text{— (17)}$$

so is

$$\boxed{\kappa^2 = \frac{c}{\hbar k}} \quad \text{— (18)}$$

Eq. (15) shows that the torsion tensor of <u>spacetime</u> is <u>the canonical</u> angular energy momentum density tensor within k/c.

The angular momentum is obtained by integration over $J^{\kappa\mu\nu}$ as in eq. (14). As in general relativity the <u>densities</u> of

5) dynamical quantities are important, i.e. quantities divided by volume. The latter must always be identically non-zero, so there is no "Big Bang" because the initial volume would be zero.

The quantity that defines $\underline{g}$ in eq. (6) is known from previous work to be:

$$\underset{\sim}{T} = T^{010}\,\underline{i} + T^{020}\,\underline{j} + T^{030}\,\underline{k} \quad -(19)$$

so:

$$\boxed{\underline{g} = c^2\,\underline{T} = c\kappa\,\underline{J}} \quad -(20)$$

where

$$\underline{J} = J^{010}\,\underline{i} + J^{020}\,\underline{j} + J^{030}\,\underline{k}. \quad -(21)$$

So the acceleration due to quantity g is an orbital angular momentum energy density.

From review paper 100, eq. (116), the orbital angular momentum associated with g is:

$$J^{\lambda\mu} = \int J^{0\lambda\mu}\, d^3x \quad -(22)$$

i.e.

$$J^{01} = \int J^{010}\, d^3x \quad -(23)$$

$$J^{02} = \int J^{020}\, d^3x \quad -(24)$$

$$J^{03} = \int J^{030}\, d^3x \quad -(25)$$

6) In the galactic region where the sun is located, J^{01}, J^{02} and J^{03} are constant:

$$\underline{J} = J^{01}\,\underline{i} + J^{02}\,\underline{j} + J^{03}\,\underline{k} \quad -(26)$$

$$|\underline{J}| = m r v \quad -(27)$$

$$= \text{constant},$$

and therefore the curve of Fig (1) in this region is indicated by a constant spacetime torsion.

In the Newtonian region of Fig (1), the torsion is not constant, because $\underline{\nabla} \cdot \underline{g}$ is not zero.

These are all new insights of ECE theory.