# 76(4) The Balance Condition in Spiral Galaxies

In note 76(3) it was shown that there exists a constant torque:

$$\underline{Tq} = -mcv_x \underline{k} \quad -(1)$$

whose modulus is

$$Tq = -mcv_x . \quad -(2)$$

This torque comes from the existence of spinning spacetime described by the Cartan torsion:

$$T^a = d \wedge q^a + \omega^a{}_b \wedge q^b \quad -(3)$$

in the notation of previous work. Eq. (3) is the first Cartan structure equation of standard differential geometry. The latter's first Bianchi identity is:

$$d \wedge T^a + \omega^a{}_b \wedge T^b := R^a{}_b \wedge q^b \quad -(4)$$

and its second Bianchi identity is:

$$D \wedge R^a{}_b := 0. \quad -(5)$$

The first Bianchi identity (4) is:

$$d \wedge T^a = R^a{}_b \wedge q^b - \omega^a{}_b \wedge T^b . \quad -(6)$$

If the torsion is independent of time and distance:

$$\boxed{\begin{array}{ll} d \wedge T^a = 0 & -(7) \\ T^a = \text{constant.} & -(8) \end{array}}$$

Therefore for this type of torsion:

$$\boxed{R^a{}_b \wedge q^b = \omega^a{}_b \wedge T^b} \quad - (9)$$

which is the balance condition.

Under this condition the "gravitational pull" represented by the LHS of eq. (9) is balanced by the effect of spinning spacetime (RHS of eq. (9)). The outer stars in a galaxy remain fixed as observed experimentally.

The torque (1) is derived from this type of constant torsion, a type of spinning spacetime.

Einstein Hilbert Theory (EH)

In this theory:

$$\omega^a{}_b \wedge T^b = 0 \quad - (10)$$

and

$$R^a{}_b \wedge q^b = 0 \quad - (11)$$

but

$$R^a{}_b \neq 0. \quad - (12)$$

Therefore in EH:

$$T^a = 0 \quad - (13)$$

and

$$\boxed{Tq = 0} \quad - (14)$$

The Newtonian theory of orbits is the weak field limit of the EH theory.

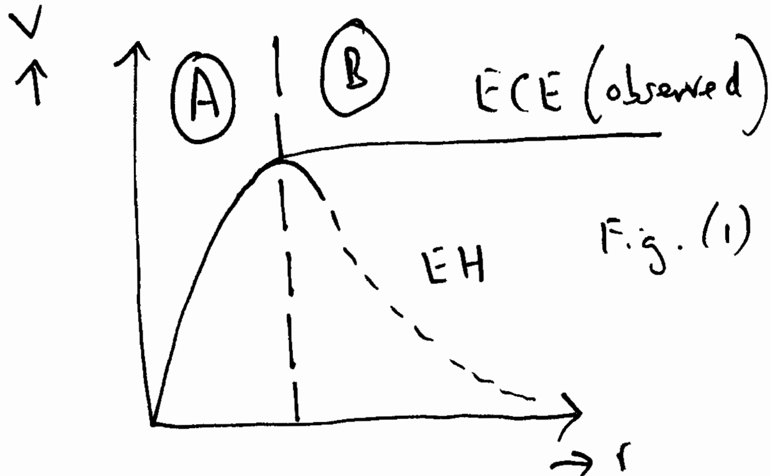


Fig. (1)

For spiral galaxies the EH and ECE theories are compared in Fig. (1). It is clear that the ECE theory is preferred experimentally over the EH theory.

Central Bulge Region of a Spiral Galaxy

In this region:

$$D \wedge R^a{}_b := 0 \quad -(15)$$

$$R^a{}_b = D \wedge \omega^a{}_b \quad -(16)$$

but:

$$\boxed{R^a{}_b \gg T^a} \quad -(17)$$

so EH theory (eqs. (15) and (16)) can be applied without much influence from torsion. This gives region (A) of Fig. (1).

Spiral Arms

In this region:

4)

$$\boxed{R^a{}_b \wedge q^b = \omega^a{}_b \wedge T^b \neq 0} \quad -(18)$$

and there is a constant version that obeys the torque (1) and the equation (7). This gives the angular momentum:

$$\underline{L} = m\,\underline{r} \times \underline{v}. \quad -(19)$$

Here $\underline{v}$ is observed experimentally to be constant, so $\underline{L}$ increases linearly with $\underline{r}$. From Eq. (18) it is seen that:

$$\boxed{R^a{}_b \sim T^b} \quad -(20)$$

in order of magnitude if

$$q^b \sim \omega^a{}_b \quad -(21)$$

in order of magnitude. It is seen from Fig (1) that in the inner region of the galaxy, the velocity $v$ is much smaller than in the spiral arm region, where it is constant experimentally. This is the reason for Eq. (17).

In the spiral arm region the EH theory does not hold because of eq. (18).

A solution of eq. (18) is:

$$R^a{}_b = -\frac{1}{2}\kappa\,\epsilon^a{}_{bc}\,T^c \quad -(22)$$

and

$$\omega^a{}_b = -\frac{1}{2}\kappa\,\epsilon^a{}_{bc}\,q^b \quad -(23)$$

(see previous work). Here $\kappa$ is a wave number:

$$\kappa = \frac{\omega}{v} \quad -(24)$$

where $\omega$ is an angular velocity and $v$ is a linear velocity. Therefore $\omega$ is ~~the~~ angular velocity corresponds to the angular momentum (19) and $v$ is the velocity in eq. (19) or eq. (1). It is seen that $R^a{}_b$ has become dual to $T^c$ and therefore is another way of representing $T^c$, and so the motion is dominated by torsion, can be represented by eqs. (7) and (8). This is not Newtonian motion at all, it is the constant spinning of spacetime. It manifests itself in the clearly observable spirals of galaxies and galaxy clusters.