Article

Is the Universe Rotating?

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Abstract

Numerous observations and studies suggest that the universe has some sort of overall rotation. We consider this matter and provide a new angle.

Key Words: universe, rotation, gravity, spin

1. Introduction

Let us start by recapitulating some salient features of our solar system. By and large, the sun and other planets of the solar system are in the same plane. The planets revolve around the sun in the same direction, which happens to be also the direction of rotation of the sun. Moreover the plane of revolution of the planets is the equatorial plane of the sun. The orbits of the planets are nearly circular and are well spaced, that is with clear separation between the planets. The same features are also observed of the satellites of the planets. In the above we have not considered a few exceptional cases, as they will not affect the following considerations. Another interesting feature of the solar system is that the angular momentum of all the planets put together is some fifty times the angular momentum of the sun. This last observation is apparently contrary to expectation. That is because the sun is so much more massive than all the planets put together, and so, given even its slow rotation, the expectation would be that its angular momentum would be very high.

Based on these considerations, astronomers are broadly agreed on the following scenario for the origin of the solar system [1]. We start with a huge cloud, predominantly of Hydrogen which extends beyond the present dimensions of the solar system. Such a cloud would be spinning slowly and at the same time contracting under its own weight. This would cause it to spin with increasing speed, till eventually an equatorial disc of material is ejected. The same thing would happen again and again. The planets condense out of such discs. A mechanism that provides for the transfer of angular momentum from the sun to the planets is found in magneto hydrodynamic considerations. This model can also explain, broadly, the composition of the various planets, for example the denser and smaller planets which are closer, and the giant planets which are farther and are made up of predominantly Hydrogen and Hydrogen compounds. The details are omitted here as these are not relevant for the sequel.

2. "Spin"

If we now step out of the solar system and take a look at what is happening in the Milky Way galaxy, we find stars orbiting the central nucleus of the galaxy, much like the orbiting planets. This imparts an overall spin of the galaxy. It is also quite remarkable that galaxies like the

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Milky Way have satellite galaxies which too obey the broad types above like revolution in the same plane, like the planetary orbits revolution in the same direction and so on. All this undoubtedly points to a similar origin.

With this preface we consider the following. There appears to be a broad self similarity across different scales in the universe. For example the model of the atom, the solar system, the galaxy, as seen above and even the satellite galaxies of galaxies. We will now argue that it is as if there are different Planck constants at different scales given by

$$h_1 \sim 10^{93} \quad (1)$$

for super clusters;

$$h_2 \sim 10^{74} \quad (2)$$

for galaxies and

$$h_3 \sim 10^{54} \quad (3)$$

for stars. And

$$h_4 \sim 10^{34} \quad (4)$$

for Kuiper Belt objects.

In equations (1) - (4), the h_i play the role of the Planck constant, in a sense to be described below. The origin of these equations is related to the following empirical relations

$$R \approx l_1 \sqrt{N_1} \quad (5)$$

$$R \approx l_2 \sqrt{N_2} \quad (6)$$

$$l_2 \approx l_3 \sqrt{N_3} \quad (7)$$

$$R \sim l \sqrt{N} \quad (8)$$

and a similar relation for the KBO (Kuiper Belt objects)

$$L \sim l_4 \sqrt{N_4} \quad (9)$$

where $N_1 \sim 10^6$ is the number of superclusters in the Universe, $l_1 \sim 10^{25} cms$ is a typical supercluster size, $N_2 \sim 10^{11}$ is the number of galaxies in the Universe and $l_2 \sim 10^{23} cms$ is the typical size of a galaxy, $l_3 \sim 1$ light years is a typical distance between stars and $N_3 \sim 10^{11}$ is the number of stars in a galaxy, R being the radius of the Universe $: 10^{28} cms, N \sim 10^{80}$ is the number of elementary particles in the Universe and l is a typical elementary particle Compton wavelength and $N_4 \sim 10^{10}, l_4 \sim 10^5 cm$, is the dimension of a typical KBO (with mass $10^{19} gm$ and L the width of the Kuiper Belt $\sim 10^{10} cm$ cf.ref.[2]).

The size of the Universe, the size of a supercluster etc. from equations like (5)-(9), as described in the references turn up as the analogues of the Compton wavelength. For example we have

$$R = \frac{h_1}{Mc} \tag{10}$$

where M is the mass of the universe. One can see that equations (1) to (10) are a consequence of gravitational orbits (or the Virial Theorem) and the conservation of angular momentum viz.,

$$\frac{GM}{L} \sim v^2, MvL = H \tag{11}$$

(Cf.refs.[3, 4]), where L, M, v represent typical length (or dispersion in length), mass and velocities at that scale and H denotes the scaled Planck constant. As another example, if we use the figures for the mass $(\sim 10^{44} gm)$, velocity $v(\sim 300 km/sec)$ and radius L of a galaxy $(\sim 10^{24})$, we can recover (2).

We can indeed give a rationale for (1) from a slightly different point of view by considering in the equation for the spin in the linearized General Relativistic case, the universe itself with $N \sim 10^{80}$ particles.

In the case of the electron, it was shown [2] that the spin was given by,

$$S_K = \int \varepsilon_{klm} x^l T^{m0} d^3x = \frac{h}{2} \tag{12}$$

where the domain of integration was a sphere of radius given by the Compton wavelength. If this is carried over to the case of the universe, we get from (12)

$$S_U = N^{3/2} h \approx h_1 \tag{13}$$

where h_1 which is the same as in (10), and S_U denotes the counterpart of electron spin (Cf.ref.[2]). In deducing (13), use has been made of (8).

With $N \sim 10^{80}$, the number of elementary particles in the universe h_1 in (13) turns out to be the spin of the universe itself in broad agreement with Godel's spin value for Einstein's equations [5, 6]. Incidentally this is also in agreement with the Kerr limit of the spin of the rotating Black Hole. Further as pointed out by Kogut and others, the angular momentum of the universe given in (13) is compatible with a rotation from the cosmic background radiation anisotropy [6]. Finally it is also close to the observed rotation as deduced from anisotropy of cosmic electromagnetic radiation as reported by Nodland and Ralston and others [7, 8].

In the above $h_1 \sim 10^{93}$ and we immediately have

$$R = \frac{h_1}{Mc} \tag{14}$$

which is (10) and where R the radius of the universe is the analogue of the particle Compton wavelength in the macro context and M is the mass of the universe. This itself substantiates our claim that the entire universe with its constituents rotates in the above self similar sense.

There is another way of looking at this. Let us consider a Kerr Black Hole. As is known its horizon is given by [9]

$$r = \frac{GM}{c^2} + (\frac{G^2M^2}{c^4} - a^2)^{1/2} \tag{15}$$

where a is the angular momentum of the rotating Black Hole and is given by

$$a = MRc \tag{16}$$

where R is the radius of the Black Hole. We can see from (15) and (16) that the radius R is given by

$$R \sim \frac{GM}{c^2} \tag{17}$$

Indeed it is well known that (17) holds good for the universe as a whole [10, 11]. In other words we can indeed treat the universe as a Kerr Black Hole exactly as in the discussion leading to (14).

3. Remarks

1. We would expect that such a rotation of the universe would lead to a anisotropy in the cosmic microwave background, and as pointed out above, this indeed seems to be the case. Additionally Palle [13] too argues from WMAP data for such an anisotropy.

We could also expect some magnetic effects due to this rotation. This would follow from a relation first put forward by Blackett [14] viz.,

$$\mu \sim \left(G^{\frac{1}{2}}/c \right) L \tag{18}$$

In (18) μ is the magnetic movement while L is the angular momentum of a cosmic object. This has been discussed in detail by De Sabbata [15]. We note that (18) gives a huge contribution for the magnetism if we use the value h_1 from (14) for L. However as can be calculated it leads to an average magnetism density $\sim 10^{-5} gauss$. Feeding into (18) the values for a typical galaxy, we get instead a field density $\sim 10^{-12} gauss$. It may be mentioned that such cosmic (including galactic magnetism) has been detected [16, 17].

Finally it may be mentioned that many years ago in the context of Mach's Principle, Pietronero too investigated this problem [18].

2. The author's cosmological model (Cf.ref.[10]) leads to a uniform cosmic acceleration, c^2/R. Such an acceleration has been observed and in fact is also the otherwise inexplicable acceleration of the Pioneer spacecrafts. (Incidentally this uniform acceleration could also be shown to follow from the otherwise ad hoc MOND hypotheses). This is completely consistent with the above considerations. What is interesting is that this leads to an Unruh radiation temperature,

$$kT \sim \frac{\hbar}{c} \cdot \frac{c^2}{R} \sim 10^{-45} \tag{19}$$

What is very interesting is that the cosmic temperature (19) is identical to the cosmic temperature obtained from Black Hole Thermodynamic theory, as deduced by the author (Cf.ref.[10])).

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