REALIZATION OF EINSTEIN´S MACHIAN PROGRAM

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Abstract

The realization of Einstein´s Machian Program, is here accomplished.
1. Introduction

The purpose of the present Section is to give a viewpoint of the Einstein’s Machian Program, hinting that, under these optics, it may have been already attained through the possible rotation of the Universe. The Godlowski method of introducing rotation in Cosmology will be presented, then we solved the three NASA anomalies, which are the linear deceleration of the Pioneers in outer space, the spin-down of the same space-craft, and the fly-by anomaly that accompanies gravity assists, with a surplus of kinetic energy in the end. In the previous book (Berman, 2011d), neither fly-by anomaly, nor the Einstein’s program, nor the different kinds of relativistic rotations had been considered. According to Ni (2011), the ultra-precise Gravity Probe B experiment analysis leaves open the cosmic polarization rotation (which may be due to a Universal rotational state), and the limit of angular speeds attained by this experiment can be checked from the abstract of his paper to be around $10^{-17} \text{s}^{-1}$.

Though Einstein originally recognized Machian ideas as important, Barbour (1990) describes that Einstein concentrated first on the construction of a local gravitational theory, delaying consideration on the relativity of motion to a future global approach. According to Einstein, one should not speak in a gravitational theory, on absolute accelerations of a coordinate system, as much as, in the Special Relativity Theory; one could not work with absolute speeds of an observer. This apparent betrayal of Machian ideas was necessary in order to create the field equations of General Relativity. Mach, on the other side, placed the distinguished accelerated reference frame, within the distant stars; i.e., the local distinguished reference frames could be identified by looking at the Cosmos as a whole.

Godlowski (2011) has reviewed the universal rotational evidence. Fine-tuning arguments can also be invoked in favor of such rotation. Gamow (1946) considered that a rotation and expansion of the Universe could have the same physical origin, and we equated the angular speed with the Hubble’s parameter. Ni (2008; 2009) shows that a rotation of 0.1 radians exists in the polarization of CMBR. If we divide this angle by the age of the Universe, we find
about $10^{-19}\text{rad/s}$. Chechin (2010) finds the same result, by other token. The present author, thinks that it is the ripe time now to reconsider the role of the distant stars reference frame as a paradigm of accelerations, and introduce the Universal rotation as proposed by Berman (2007). The angular speed $\omega \simeq \frac{c}{R}$ was adopted, because it carries a peculiar rotational state of the Universe, with deceleration $a_{cp} = -\omega^2 R$ which coincides with the Pioneers anomalous deceleration described in next Section. In 2010, Berman and Gomide (2010) succeeded in making a full General Relativistic model of the rotating and expanding Machian Universe that was further generalized by Berman and Gomide (2011a) into a full class of models, thus explaining the three NASA anomalies.

The proof that Gamow (1946) is correct, lies on the following calculation: consider a Machian Universe (a “spherical” ball) and let us calculate the Newtonian gravitational acceleration on the surface, $a_g = -\frac{GM}{R^2}$. If the zero-energy Universe is considered, so that the sum of the inertial energy $Mc^2$ with the negative self-energy $\frac{GM^2}{R}$, and is equated to zero, we find $\frac{GM}{c^2 R} \simeq 1$. With this approximation, we obtain $a_g \simeq -\frac{c^2}{R} = -9 \cdot 10^{-8} \text{cm/s}^2$ = first Pioneer anomaly.

On the other hand, when Godlovski’s et al. (2004) idea is taken into account for a rotating Universe (see Section 3), we will find, neglecting the cosmological constant, $\kappa \rho = 6H^2$, and with $\rho = \frac{M}{\frac{3}{4}\pi R}$, and $H \simeq \omega$, we recover the result $\omega \simeq \frac{c}{R}$, thus winding up with Berman’s angular speed of the Universe. So Einstein’s Machian program now has the prototype of a distant stars acceleration – it is the Pioneers first anomaly in action, as we shall see next.

2. THE THREE NASA ANOMALIES

I.

Several authors have alerted the scientific community about the fly-by anomaly: during Earth gravity assists, spacecraft has suffered from an extra-energization, characterized by a positive extra speed, such that, measured “at infinity” the hyperbolic orbiting object presented an empirically calculated $\Delta V/V$ around $10^{-6}$. A formula was supplied, (Anderson et al., 2008),

$$\frac{\Delta V}{V} = \frac{2\omega R}{c},$$
where $\omega$, $R$ and $c$ stand for the angular speed and radius of the central mass, and the speed of light in vacuo. Wilson and Blome (2008) delivered a lecture in Montreal, and called the attention to the fact that the most trusted cause for both this anomaly, and the Pioneers, would be “rotational dynamics.” I had, by that time, published my results on the Pioneers Anomaly, through the rotation of the Universe (Berman, 2007). Now, I shall address the three anomalies.

The first Pioneers Anomaly is the deceleration of about $-9.10^{-8}\text{cm.s}^{-2}$ suffered by NASA space-probes traveling towards outer space (Anderson et al., 2002). It has no acceptable explanation within local Physics, that might also solve the other two anomalies. But, if we resort to Cosmology, it could be explained by the rotation of the Universe. Be cautious, because there is no center or axis of rotation. We are speaking either of a Machian or a General Relativistic cosmological vorticity. It could apply to each observed point in the Universe, observed by any observer. Another explanation, would be that our Universe obeys a variable speed of light Relativistic Cosmology, without vorticities. However, we have shown elsewhere, that both models are equivalent.

Ni (2008; 2009), has reported observations on a possible rotation of the polarization of the cosmic background radiation, around 0.1 radians. As such radiation was originated at the inception of the Universe, we tried to estimate a possible angular speed or vorticity, by dividing 0.1 radians by the age of the Universe, obtaining about $10^{-19}\text{rad.s}^{-1}$. Chechin (2010), and Su and Chu (2009) results are in concordance.

The numerical result is very close to the theoretical estimate, by Berman (2007),

$$\omega = \pm c/R = 3.10^{-18}\text{rad.s}^{-1}, \quad (8.2.1)$$

where $c$, $R$ represent the speed of light in vacuum, and the radius of the causally related Universe.

If we calculate the centripetal acceleration corresponding to the above angular speed (8.2.1), we find, for the present Universe, with $R \approx 10^{28}\text{cm}$ and $c \simeq 3.10^{10}\text{cm/s}$,

$$a_{cp} = -\omega^2 R \approx -9.10^{-8}\text{cm/s}^2. \quad (8.2.2)$$

Our model has been given a General Relativistic cosmological equivalent treatment (Berman and Gomide, 2010, 2011), with the same results (8.2.1) and (8.2.2). This value matches the observed experimentally deceleration of the NASA Pioneers’ space-probes. Now,
Hubble’s constant, in the authoritative Weinberg’s book (Weinberg, 2008), is quoted as 
\[ H_0 = 3.10^{-18} \text{s}^{-1}. \] We are, thus, tempted to write,

\[ \omega \simeq \pm H. \]  (8.2.3)

The key result for all these subjects, is that hyperbolic motion, extends towards infinity, and, thus, qualify for cosmological alternatives, and boundary conditions. The fly-bys and the Pioneers are in hyperbolic trajectories, when the anomalies appear, so that Cosmology needs to be invoked.

If we take an imperfect fluid, the Raychaudhuri’s equation yields a vorticity term. But may also, with a non-diagonal metric like Kerr’s, introduce rotations. The most general kind of rotating Universe, that resembles the Robertson–Walker’s one, with perfect fluids, would be a generalized Robertson–Walker’s metric containing a metric temporal coefficient that could vary with time. In terms of the existing theory of Gaussian metrics (Berman, 2008), we may say that such rotating solution implies that the whole tri-space, rotates relative to the temporal axis, which is orthogonal to the tri-space.

We, now, shall follow an idea by Godlowski et al. (2004), and supply another General Relativistic model of an expanding and rotating Universe. Their idea, is that the homogeneous and isotropic models, may still rotate relative to the local gyroscope, by means of a simple replacement, in the Friedman–Robertson–Walker’s equations, of the kinetic term, by the addition of a rotational kinetic one (Berman, 2011).

II.

3. THE GODLOWSKI EQUATIONS

Consider the flat Robertson–Walker’s metric,

\[ ds^2 = dt^2 - R^2(t) d\sigma^2 \]

Einstein’s field equations for a perfect fluid with perfect gas equation of state, and Robertson–Walker’s metric has two. The first, is an energy-density equation; the second is a definition of cosmic pressure, which can be substituted by energy momentum conservation. But, upon writing the \( \dot{R}^2 \) term, we shall add an extra rotational term, namely
$(\omega R)^2$, in order to account for rotation. If we keep (8.2.3), the effective Hubble’s parameter, becomes,

$$H^2 = \frac{\dot{R}^2}{R^2} \approx \frac{\dot{R}^2}{R^2} + \frac{(\omega R)^2}{R^2} \approx H^2 + H^2 \approx 2H^2$$

and, the field equations become, for a flat Universe,

$$6H^2 = \kappa \rho + \Lambda \quad (8.3.1)$$

with,

$$p = \beta \rho \quad (8.3.2)$$

and,

$$\dot{\rho} = -3\sqrt{2}H \rho (1 + \beta). \quad (8.3.3)$$

The ten field equations reduce to (8.3.1) and (8.3.3), through the standard Robertson–Walker’s metric. As Berman(2011) has pointed out, the Solar system localized Physics would not be altered by such rotation. First of all, our rotation is not Godel’s. Second, we have argued that hyperbolic motions, which extend to infinity, and, thus, transcend the local Physical picture, ARE INDEED, affected, but closed localized orbits, are NOT. Schwarzschild’s metric, does the job without any Hubble’s parameter being introduced in the Solar system. Cosmology has its own rules, and its own observers—co-movers. Local gravitation, even a General Relativistic one, has other rules and other observers. The reader should remember that at most, this is an unresolved issue, for the time being, and one should not adopt radical views.

The usual solution, with Berman’s deceleration parameter models, render (Berman, 1983; Berman and Gomide, 1986),

$$R = (mDt)^{1/m}, \quad (8.3.4)$$
$$H = (mt)^{-1}, \quad (8.3.5)$$
$$\ddot{R} = -qH^2 R = -(m - 1)H^2 R. \quad (8.3.6)$$

Notice that we may have a negative deceleration parameter, implying that the Universe accelerates, probably due to a positive cosmological “constant.” But, nevertheless, it is subjected to a negative rotational deceleration, a kind of centripetal one, that acts on each observed point of the Universe, relative to each observer, given by relation (8.2.2), so that,

$$\ddot{R} = -qH^2 R = qa_{cp}. \quad (8.3.7)$$
We now supply the necessary relations among the constants, so that these equations be observed, namely,
\[ m = \frac{3}{2} \sqrt{2} (1 + \beta) = \pm \frac{\sqrt{6}}{\sqrt{\kappa \rho_0 + \Lambda_0}}, \]  
\[ \rho = \rho_0 t^{-2}, \]  
\[ \Lambda = \Lambda_0 t^{-2}. \]  
(8.3.3)  
(8.3.9)  
(8.3.10)

III. THE SECOND PIONEERS ANOMALY

The angular acceleration of the Universe, taking a positive angular speed, is given by,
\[ \alpha_u = \dot{\omega} = -\frac{cH}{R} = -\frac{c^2}{R^2}. \]  
(8.4.1)

The spins of the Pioneers were telemetered. And, as a surprise, show that the on-board measurements yield a decreasing angular speed when the space-probes were not disturbed. Turyshev and Toth (2010) published graphs (Figures 2.16 and 2.17 in their paper) from which it is clear that there is an angular deceleration of about 0.1 RPM per three years, or,
\[ \alpha \approx -1.2 \times 10^{-10} \text{rad/s}^2. \]  
(8.4.2)

As the diameter of the space-probes is about 10 meters, the linear acceleration is practically the Pioneers anomalous deceleration value, in this case, \(-6.10^{-8} \text{cm.s}^{-2}\). The present solution of the second anomaly, confirms our first anomaly explanation.

I have elsewhere pointed out that we are in face of an angular acceleration frame-dragging field, for it is our result (8.4.1). For the Universe, that causes the result (8.4.2), through the general formula,
\[ \alpha = -\frac{cH}{l}, \]  
where \(l\) is the linear magnitude of the localized body suffering the angular acceleration frame-dragging.

IV. THE SOLUTION OF THE FLY-BY ANOMALY

Consider a two-body problem relative to an inertial system. The same argument by Godlowski et al. (2004), makes us consider that the additional speed, measured at infinity,
relative to the total speed, measured at infinity, is proportional to twice the tangential speed of the earth, $w_e R_e$, divided by the total speed $V + w R \approx c$ taken care of the Universe angular speed.

This is because we may write,

$$\frac{\Delta V}{V} = \frac{V + \omega_e R_e - (V - \omega_e R_e)}{c} = \frac{2\omega_e R_e}{c} \approx 3 \times 10^{-6}.$$  

The trick, is that infinity in a rotating Universe, like ours, has a more precise meaning, when Rotational Cosmology plays the game, because of the hyperbolic trajectory.

Now, returning to the Machian discussion. To Mach, the definition of distinguished reference systems was directly related to the dynamical status of the whole Cosmos. Einstein, on the other hand, was led to define the inertial systems as those where the laws of nature could be expressed in the simplest form. But Einstein, after deriving his field equations, as a local gravitational theory, searched for boundary conditions that could fulfill Machian theory. If the Universe rotates, as we have hinted, we can explain the NASA anomalies, we see that General Relativity field equations are correct, and the Machian dream has come true. We conclude that a rotating and expanding Universe makes both Einstein and Mach theories correct. I dare to say that this is probably the unique solution for the Einstein–Machian Program.

V.

4. THERE ARE NO EXTERNAL AGENTS FOR THE UNIVERSE

The Universe Can Have no External Agents: Improving Einstein’s Program

If the Universe has no external “cause” and if it rotates, it would be interesting to calculate that its spin is constant in time. In a prior paper (Berman 2011a), it demonstrated the possibility that the so-called Einstein’s Machian Program could have been finally completed, through the possible rotation of the Universe; and, after reviewing an earlier paper (Berman, 2011) published by Astrophysics and Space Science, whereby the Godlowski method of introducing rotation in Cosmology was presented, then we solved the three NASA anomalies: the linear deceleration of the Pioneers in outer space, the spin-down of the same space-craft,
and the fly-by anomaly that accompanies gravity assists, with a surplus of kinetic energy in the end. According to Ni (2011), the ultra-precise Gravity Probe B experiment analysis, leaves open the cosmic polarization rotation (which may be due to a Universal rotational state), and the limit of angular speeds attained by this experiment can be checked from the abstract of his paper to be around $10^{-17}\,s^{-1}$. Earlier, Ni (2008; 2009) had estimated the rotation in 0.1 radians, and we had divided by the age of the Universe, finding a possible angular speed around $10^{-19}\,s^{-1}$. A recent paper by Sidharth (2010), placed the angular speed around my (Berman, 2007) own prediction, $3.10^{-18}\,\text{rad.s}^{-1}$.

Though Einstein originally recognized Machian ideas as important, Barbour (1990) describes that Einstein concentrated first, into the construction of a local gravitational theory, delaying consideration on the relativity of motion, to a future global approach. According to Einstein one should not speak, in a gravitational theory, on absolute accelerations of a coordinate system, as much as, in the Special Relativity Theory; one could not work with absolute speeds of an observer. This apparent betrayal of Machian ideas, was necessary in order to create the field equations of General Relativity. Mach, on the other hand, placed the distinguished accelerated reference frame, within the distant stars, i.e., the local distinguished reference frames, could be identified by looking at the Cosmos as a whole.

Godlowski (2011) has reviewed the universal rotational evidence. Fine-tuning arguments can also be invoked in favor of such rotation. Gamow (1946) considered that a rotation and expansion of the Universe could have the same physical origin, and we equated the angular speed with the Hubble’s parameter. Chechin (2010) finds the same result, by other token. The present author, thinks the time is ripe now to reconsider the role of the distant stars reference frame as a paradigm of accelerations, and introducing the Universal rotation as proposed by Berman (2007). The angular speed $\omega \equiv \frac{c}{R}$ was adopted, because it carries a peculiar rotational state of the Universe, with deceleration $a_{cp} = -\omega^2 R$ which coincides with the Pioneers anomalous deceleration already described. In 2010, Berman and Gomide (2010) succeeded in making a full General Relativistic model of the rotating and expanding Machian Universe that was further generalized by Berman and Gomide (2011a) into a full class of models, thus explaining the three NASA anomalies.

So Einstein’s Machian program now has the prototype of a distant stars absolute centripetal de-acceleration – it is the Pioneers first anomaly in action, as we shall see. For the sake of completeness, we mention the three NASA anomalies, solved by the rotation of the
Universe, in the next Section. Then, we review the theoretical framework, and show that in this model, we may have a constant Universal spin, the sort of thing that is expected for a physical system without external causes.

VI.

Upon considering that Planck’s constant renders the spin of Planck’s Universe, Berman (2007; 2010) expected that the Universal Spin could be calculated by,

\[ L = MRc = \frac{4}{3} \pi R^4 \rho c. \]  

(8.7.1)

When we plug (8.3.9), we are left with, imposing constant \( L \),

\[ R \propto t^{1/2}, \]  

(8.7.2)

\[ m = 2. \]

Thus, from (8.3.8), we find the equation of state with a negative cosmic pressure, as expected from the recent Supernovae observations interpretations,

\[ p = -0.07 \rho. \]  

(8.7.3)

VII. 5. CONCLUDING REMARKS

We have seen that General Relativity accounts for a possible rotating Universe, and the amount of the deceleration coincides with the P.A. We have shown that even variable speed of light theory or Machian semi-relativistic theories also led to the P.A. There is a point that needs clarification. According to Raychaudhuri’s equation, if we consider a non-shearing case, a non-accelerated system would be described by the equation, adapted to Robertson–Walker’s original metric,

\[ 6 \ddot{R} = -\kappa \left( \rho + 3p - 2 \frac{\Lambda}{\kappa} \right) R + 4 \omega^2 \dot{R}, \]  

(8.8.1)

while, in the Generalized Robertson–Walker’s metric,

\[ 6 \ddot{R} = -g_{00} \kappa \left( \rho + 3p - 2 \frac{\Lambda}{\kappa} \right) R - 3g_{00} \dot{R} \dot{g}^{00} \]
or,

\[ 6\dot{R} = -g_{00}\kappa \left( \rho + 3p - \frac{2\Lambda}{\kappa} \right) R + 6\dot{R}\omega, \]  
(8.8.2)

but for the Generalized Robertson–Walker’s metric, there are two different solutions, and we would take the negative angular speed solution, in order to account for a left-handed Universe. In our semi-relativistic treatment of Chapter 3, what really was needed was a solution for \( L^2 \), so that one could choose, if necessary in order to coincide with Chapter 4, a negative angular speed. In Chapter 4, angular speed can also be chosen with a negative sign; this can be done, for all that matters is the centripetal acceleration, which depends on the square of \( \omega \). However, we must remember that a positive \( \omega = c/R \) also rotates the Universe with the Pioneers deceleration.

We conclude that the Raychaudhuri’s vorticity is NOT what we call here the angular speed of the rotation of the Universe. What we have shown is the rotation of the entire spatial Universe around the orthogonal time-axis.

By increasing sophistication, we may develop scientific theories which could \emph{a priori} cover almost any possible characteristic of the Universe that could actually be observed. By the same token, the reader should remember that current theoretical cosmological models may easily be turned down by future astronomical observations. However, at the same time, scientists would come with “many” others, that could be adapted to “new” astronomical data, which on its own, could afterwards go also to the \emph{oblivium}. The Pioneers Anomaly seems to obey the known laws of Physics, if the Universe rotates, or the speed of light is variable according to our model. The secondary anomaly, the spinning down of the spacecraft, received an explanation as due to the rotation of the Universe. The left-hand of creation is also accounted by equation (8.8.2) with a negative angular speed. This introduces a partial decelerating contribution, but if lambda is large enough; and positive, in order to produce a larger acceleration, \( \ddot{R} \geq 0 \), and the Pioneers anomalies will still be there.

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