Abstract

As a sequel to (Berman, 2008a), we show that the rotation of the Universe can be dealt by generalised Gaussian metrics, defined in this paper. Robertson-Walker’s metric has been employed with proper-time, in its standard applications; the generalised Gaussian metric imply in the use of a non-constant temporal metric coefficient modifying Robertson-Walker’s standard form. Experimental predictions are made.
1. Introduction

Standard aspects concerning the treatment of rotation in General Relativity (GRT), were outlined by Islam (1985). Rotation of the Universe was dealt by Berman from several angles, like the Machian (Berman, 2007; 2007a; 2007b; 2007c) and under the Robertson-Walker’s metric (Berman, 2008; 2008a). We now shall be dealing with the cosmological metric that would be fitted for the study of a rotating and expanding Universe, in a parallel approach with new kinds of arguments.

It is usual and practical, to employ metrics ”adapted” to solve a given physical problem. Any metric induces a topology. The same topology, nevertheless, can be met by other less adapted metrics. The whole set of metrics, can be used to solve any particular problem. According to Synge (1960), what matters is only curvature in each given point, and not, for instance, a typical observer’s proper quadri-acceleration along his world-line, for some metric. Joshi (1993) comments that GRT restricts spacetime, according to the principle of local flatness and its Special Relativistic framework. However, local restrictive physics, do not affect global topology of the spacetime manifold. Boundary conditions, to the contrary, limit the possible topologies. One such condition is revealed by Mach’s Principle, and may satisfy macroscopical approaches, but for microphysics, a more elaborated topology must be found. In a private communication, A. Sant’Anna, has pointed out that micro-topologies are now under research, in order to produce viable scenarios in Quantum computer theory.

Without delving in the above related details, I showed elsewhere, that for a GRT rotating model, Robertson-Walker’s metric could be generalised in order to fit the problem of rotation plus expansion. This will be the subject of our present paper.

2. Rotating Evolutionary Metrics

When we are not working with proper time $\tau$, but make a transformation to any other time-coordinate $t$. Generally, instead, we write:
\[ d\tau^2 \equiv g_{00}(r, \theta, \phi, t) \, dt^2 \quad . \quad (1) \]

The Robertson-Walker's metric is written usually in terms of proper time, namely,

\[ ds^2 = d\tau^2 - \frac{R^2}{(1+k \frac{r^2}{4})} \, d\sigma^2 \quad . \quad (2) \]

If we change from the angular coordinate \( \phi \) towards \( \tilde{\phi} \), such that:

\[ \tilde{\phi} = \phi - \omega \, t \quad , \quad (3) \]

or,

\[ d\tilde{\phi} = d\phi - \omega \, dt \quad , \quad (3a) \]

we shall find that tri-dimensional metric element becomes,

\[ d\tilde{\sigma}^2 = dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta \, (d\phi - \omega dt)^2 = \]

\[ = d\sigma^2 + r^2 \sin^2 \theta \, \omega^2 dt^2 - 2\omega \, r^2 \sin^2 \theta \, d\phi \, dt \quad . \quad (4) \]

The new metric is of the following form:

\[ ds^2 = g_{00}dt^2 - \frac{R^2}{(1+k \frac{r^2}{4})^2} \, [d\sigma^2 - 2\omega r^2 \sin^2 \theta \, d\phi \, dt] \quad , \quad (5) \]

with,

\[ g_{00} = 1 - \frac{\omega^2 R^2 r^2 \sin^2 \theta}{(1+k \frac{r^2}{4})^2} \quad . \quad (5a) \]

Consider now a totally comoving observer: his proper time is given by,

\[ d\tau^2 = g_{00}dt^2 = [1 - \omega^2 R^2] \, dt^2 \quad , \quad (6) \]

where

\[ \omega = \frac{\omega^2 \sin \theta}{(1+k \frac{r^2}{4})} \quad . \quad (7) \]
If we want to preserve $g_{00} > 0$, so that equation (6) represents real proper time, we may solve the problem with,

$$\omega = \frac{\alpha}{R},$$

(8)

with $\alpha^2 < 1$.

For instance, we could fix $\dot{\alpha} = 0$ so that, $\alpha = \alpha(r)$ then we would also find,

$$\omega = \frac{\beta}{R},$$

with a similar condition, $\dot{\beta} = 0$, and $\beta = \beta(r)$.

We call $\omega$ as the effective angular speed of the Universe; it has a striking similarity with Berman’s solution for a Machian rotating Universe (Berman, 2007b). We notice that such angular speed causes a kind of centripetal ubiquitous acceleration having a universal character and which caused the so-called Pioneer anomaly, in two space probes, launched by NASA more than thirty years ago. By the same token, we define a tangential speed,

$$V = \omega R < 1.$$  

In order to make contact with usual cosmological theory, we consider now that, the non-diagonal metric term which points towards a Universal precession of gyroscopes, is in the same token, as in the Lense-Thirring metric. Consider now a semi-comoving observer, defined by the condition $d \tilde{\phi} = 0$. If we write,

$$\omega = \frac{d\tilde{\phi}}{dt},$$

the non-diagonal term becomes diagonalized, like,

$$2\omega^2 R^2 d\phi \, dt = 2\omega^2 R^2 dt^2.$$  

(9)

In this case, the apparent temporal metric coefficient becomes,

$$(g_{00})_{ap} = 1 - \omega^2 R^2 + 2\omega^2 R^2 = 1 + \omega^2 R^2.$$  

(10)

With the value of $\omega$ given by relation (8) the apparent temporal metric coefficient becomes time-independent. Of course, the real temporal coefficient is then also so.
3. Generalised Gaussian Metrics

We refer to Berman (2007; 2007a), for a presentation of the Gaussian metrics which does not suffer from the "trap" of considering \( g_{00} = \text{constant} \) for their definition. What really matters in a Gaussian metric, is that the time axis is orthogonal to the tri-space. When such metric represents a tri-space which is not into rotation around the time axis, coordinate time means proper time \( \tau \). Now relax the restriction, and consider that the orthogonal tri-space is rotating around the time axis: the time coordinate that we must use is \( t \), defined by (1). This was indeed shown in the previous section, and points to what we shall call Generalised Gaussian metrics.

Berman’s definition of Gaussian metrics (Berman 2007; 2007a), constrains only the metric by the condition,

\[
g^{ij} \frac{\partial g_{00}}{\partial t} = 0 \quad (i, j = 1, 2, 3) \quad (11)
\]

On the other hand, Gaussian normal coordinates, are defined by the condition,

\[
g_{00}(t) = 0 \quad . \quad (12)
\]

Then, the following condition applies for a comoving observer:

\[
g_{00} u^0 = 1 \quad , \quad (13)
\]

where, \( u^0 \) is the temporal component of the quadri-velocity.

From the cosmological point of view, it has been suggested that rotation of the Universe is associated with cosmic microwave background radiation’s quadrupole anisotropies. These have not been significant: this may be attributed to low angular speeds, less than what is possibly measured by present technology. We must remember that the cosmic no-hair conjecture is really established by means of an inflationary phase erasing the angular speed (remember equation (8), with \( R \) exponentially increasing).

Another point is that CMBR analyses, only apply to the equation of null geodesics, \( ds = 0 \). To the contrary, the Pioneer anomaly deals with \( ds \neq 0 \). It must be stressed that a variable temporal metric coefficient has been studied long ago by Gomide and Uehara (1981).
4. Final Comments

The rotation of the Universe, not only explains the Pioneers’ anomaly, but would be in
the right direction, in order to explain the left handed preference of neutrinos’ spins, parity
violations and the related matter-antimatter asymmetry (Feynman et al., 1965). It has
been found that the DNA helix is left handed. Our bodies are not symmetric; molluscs have
likewise shells; aminoacids in living bodies, too (Barrow and Silk, 1983).

We predict that chaotic phenomena, and fractals, in the Universe, as well as rotations of
Galaxies and their clusters, must have a predilection towards the left hand. We predict that
the directions of the magnetic field of the Universe, and rotation, are related with the laws
of electrodynamics and the left-hand.

It is important to note the preliminary results on the Universe rotation, by Birch (1982;
1983) and Gomide, Berman and Garcia (1986). Sciama’s inertial theory (Sciama, 1953), also
contemplated a rotation speed of the type given by us (see (8)). The spin of the Universe is a
subject of two recent, and a forthcoming, papers by Berman (2007b; 2007c; 2008). Machian
rotations are dealt by Berman (2007; 2007a).

I predict that with improving technological tools, the rotation of the Universe will be
experimentally measured in the future.

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