NEW STRENGTH TO PLANCK'S LENGTH CHOICE

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Abstract

The calculation of the total mass of a spacetime in which an observer-independent scale of length exist is possible through the use of Heisenberg Uncertainity Principle. In the following paragraphs we show that such a spacetime has a total mass equal to the mass of our Universe observed by the WMAP Nasa spacecraft if the cited observer-independent scale of length is determined by the Planck's length lp.

This result gives new strength to fundamental theories that make use of lp as a length with a "special role", like the various string theories.

1. Introduction

The theoretical description of a general class of spacetimes in which observer-independent scales of both velocity and length exist can be found in recent-years published papers (Amelino-Camelia 2001). Besides, from another point of view, it is possible to affirm that a "stringy nature" (i.e. a Universe in which a string theory can be successfully applied) needs only two constants: a maximum velocity for satisfying the relativistic invariance principle and a minimum length for quantization (Veneziano 1986). For these reasons the two cited values are of great importance in the search for a theory that binds together the small and the large scales of the Universe, i.e. a theory that could lead to sinergies between General Relativity and Quantum Mechanics.

The debate related to the value of the maximum velocity needed for the relativistic invariance was solved long time ago with the selection of *c*, i.e. the speed of light in vacuum. This value is universally accepted because of its role in General Relativity.

Regarding the minimum length the debate is still open, but the most "appreciated" candidate is Planck's length lp, the only length that can be obtained combining General Relativity constants (c and G) together with the Quantum Mechanics constant ħ:

$$lp = \sqrt{(\hbar G/c^3)} \sim 10^{-35}\ \mathrm{m} \qquad (1)$$

The aim of the present work is giving an evidence based on real experimental data to support the choice of Planck's length as the correct minimum length in our Universe. We give a simple way for calculating the mass of the Universe through the use of Planck's length and then we compare the obtained result with the data provided by the Nasa WMAP spacecraft. The selection of this process was obvious, for us, because we believe that the properties of such a "unifying" constant like the Planck's length can emerge only applying the rules and laws of Quantum Mechanics to large systems mainly ruled by General Relativity (like our Universe at large scale is).

2. Universe Mass' calculation through Heisenberg Uncertainity Principle

The calculation of the Universe mass is possible using the Heisenberg Uncertainity Principle (HUP). It is sufficient obtaining an expression for the mass from the best-case HUP for the lenght-momentum couple (i.e. selecting the = operator instead of the ≥) and then maximizing the obtained expression:

$$\Delta x \Delta p = \hbar/2 \qquad (2)$$

$$m \Delta x \Delta v = \hbar/2 \qquad (3)$$

$$m = (\hbar/2)/\Delta x \Delta v \qquad (4)$$

The maximization of this expression requires the selection of minimum values for Δx and Δv. According to (Amelino-Camelia 2001) it is possible to select the Planck's length for the minimum value of Δx, and then proceed from there for the selection of the minimum value of Δv. Using the simplest definition for velocity, i.e. v = s/t, we can minimizing it through the selection of the biggest amount of time and the smallest length. For this last one our selection is coherent with the above considerations, so we choose lp. For the biggest amount of time we can use the age of the

Universe, or its good approximation given by the 1/H value, where H is the Hubble constant. In this way we obtain the smallest observable velocity at any given time in our spacetime, because calculated through the ratio between the smallest selected length (lp) and the largest possible observation period (the age of the Universe). Our research group is at work for finding deeper implications on the existence of the cited “minimum value of velocity”, however, such as possible impacts on the quantization of fundamental quantities.
With the chosen values the mass obtained is:

$$m = (\hbar/2)/(lp*(lp*H)) \qquad (5)$$

$$m = (c^3)/(2GH) \sim 10^{52} \text{ Kg} \qquad (6)$$

This is the largest calculable mass in a spacetime in which HUP is valid and the Planck's length is the minimum length.

3. Universe Mass' calculation through 2008 WMAP Nasa Spacecraft Data

2008 WMAP NASA spacecraft data (NASA/WMAP Team 2008) confirmed that the the density of the Universe (ρ) is equal to its critical density calculated by the Friedmann equations (Friedmann 1922), i.e. $3(H^2)/8\pi G$. This fact confirmed also the Euclidean geometrical structure for our Universe, leading to an estimation of Universe mass based on the assumption that its volume could be calculated as the volume of a sphere, i.e. $V=(4/3)\pi(r^3)$. In other words:

$$m = \rho V \qquad (7)$$

$$m =((H^2)(r^3))/(2G) \qquad (8)$$

The selection of the value for the radius r can be done considering the space travelled by a ray of light for the entire duration of the Universe (Ua), i.e. r = c*Ua. Using the above mentioned approximation for which Ua = 1/H we obtain the following value for the mass of the Universe:

$$m = (c^3)/(2GH) \sim 10^{52} \text{ Kg} \qquad (9)$$

Please note that this value, and the expressions used for its calculation, are widely accepted by the scientific community, and are also used by Nasa itself in their official publications (NASA Glenn Research Centre).

4. Conclusions

A spacetime in which Relativity applies, in which observer-independent scales of both velocity and length exist and are respectively determined by *c* and lp, and in which HUP is valid has a a total mass equal to:

$$m = (c^3)/(2GH) \sim 10^{52} \text{ Kg} \qquad (10)$$

In our Universe Relativity applies, an observer-independent scale of velocity exist and is determined by *c*, HUP is valid and the total mass is equal to:

$$m = (c^3)/(2GH) \sim 10^{52} \text{ Kg} \qquad (11)$$

For these reasons it is very probable that in our Universe an observer-independent scale of length exists and it is determined by Planck's length lp.

References

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