Quantum and relativistic viewpoints on the origin of the universe and consequence.

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Abstract

We examine a quantum point of view about the origin of the universe. We try to provide a simple relativistic perspective on the origin of the universe at Planck time without changing the Big Bang theory. We suggest a beginning of a toy cosmology model that is in agreement with the ΛCDM model with respect to the mass of the universe.

Introduction

The theory of quantum mechanics and the theory of general relativity always discuss the initial conditions of the universe. We will try to give a simple answer to this question concerning its mass. This answer is developed and proposes a simple approach to cosmology based on the Planck mass flow rate.

1) Quantum point of view on the origin of the universe.

It is remarkable that the energy density of the quantum matter resulting from $m_P$, $m_Pc^2/l_P^3 = 4.63 \times 10^{113} \text{ J/m}^3$ be extremely close to the energy of the quantum vacuum of the quantum field theory: $l_P^{-2} \approx 3.83 \times 10^{69} \text{ m}^2$.

Indeed, with the Planck force, $F_P = c^4/G$, and the quantum vacuum energy of the quantum field theory, we obtain this quantum vacuum energy density: $F_P l_P^{-2} \approx 4.63 \times 10^{113} \text{ J/m}^3$.

It would thus seem that the matter of the universe seen by the observer, would emerge naturally at its instant $t_P$, from a fluctuation of the energy of the quantum vacuum and reciprocally. This could be a quantum solution to the origin of the universe. We would have, in the literal and mathematical sense, a division between the "mass" of the universe and its volume, i.e. the vacuum of the universe, from the Planck time of the observer.

2) Determination of the mass of the universe at Planck time in the ΛCDM model.

We assume a flat universe, i.e. with zero curvature. For an observer, whose universe origin is at time $t_P$, the radius of its observable universe in the ΛCDM model is $r_P = 2c t_P$, hence its volume $V_P$:

$$V_P = \frac{4\pi}{3}(2l_P)^3 = 4.415 \times 10^{-130} \text{ m}^3$$

Its critical density $\rho_c$ expressed in kg/m$^3$ is at time $t_P$:

$$\rho_c = \frac{3(Ht_P)^2}{8\pi G} = \frac{3}{8\pi G t_P^2} = 6.153 \times 10^{55} \text{ kg/m}^3$$

(note: expressed in J/m$^3$, we have $\frac{8\pi c^2}{3} = 4.63 \times 10^{113} \text{ J/m}^3$)
where $H(t_P)$ is the Hubble constant at Planck time $t_P = 1 / H(t_P)$ and $G$ the gravitational constant.

Under these conditions, the mass of the observable universe, at Planck time $t_P$, is exactly 4 Planck mass.

3) **Beginning of a toy cosmological model under $\Lambda$CDM model conditions**

For verification purposes, it seems possible to obtain the mass of the universe from the $\Lambda$CDM model otherwise. This could eventually lead to the development of a simple toy cosmological model unknown to the author, built around the Hubble constant, the Hubble time, $t_H = 1 / H$, the Planck mass flow rate and a variable coefficient $\alpha_H$

$$\alpha_H = \text{radius of the observable universe} \quad \text{(from calculation of the $\Lambda$CDM model)} \quad \text{divided by the Hubble radius at time} \ t_H :$$

$$\alpha_H \approx 46.12 \text{ billion light years} / 14.45 \text{ billion light years} \approx 3.19 \text{ today if } H_0 = 67.66 \text{ km/s/Mpc, } \Omega_\Lambda = 0.6889.$$  

or $\alpha_H \approx 2$ at Planck time and $\Omega_\Lambda \approx 0$

$c^3/G$ is the Planck mass flow rate,

t$_H = 1/H$ is the Hubble time ($\approx 4.56 \times 10^{17} \text{ s} = 14.45 \text{ billion light years today}$)

The total "mass" of the universe in the sense of the $\Lambda$CDM model is determined by the relation:

$$M_H = \rho_c V_H$$

$$M_H = \frac{3}{8\pi G} \frac{4\pi}{3} (c t_H \alpha_H)^3$$

$$M_H = \frac{1}{2} \frac{c^3}{G} t_H \alpha^3_H$$

i.e. for $H = 67.66 \text{ km/s/Mpc}$ and $\Omega_\Lambda = 0.6889$:

$$M_H \approx 2.99 \times 10^{54} \text{ kg}$$

in other words, the total "mass" of the universe $\Lambda$CDM today.

**Conclusion**

We have highlighted a succinct quantum approach to the origin of the universe.

We have proposed a determination of the mass of the universe at Planck time in the framework of general relativity in agreement with the quantum energy density.

On this basis, we have tried to lay the foundations of a simple toy cosmology model allowing the calculation of a total "mass" of the universe that exactly matches that of the $\Lambda$CDM model at the same time $t_H = 1 / H$. The variable coefficient $\alpha_H$ could, eventually, be used to put limits on the cosmic inflation scenario.

**References:**
