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C. Charbonnel, F. Combes and R. Samadi (eds)

A SYMMETRIC MILNE UNIVERSE : A SECOND CONCORDANT UNIVERSE?

Benoit-Lévy, A.[1] and Chardin, G.[2]

Abstract. The Standard Model of Cosmology predicts a rather strange composition for the energy content of our Universe: ≈70% of unknown Dark Energy and ≈25% of undetected Dark Matter, whereas ordinary matter accounts for just ≈5%. Although this representation fits rather well cosmological observations, it lacks physical meaning and is therefore unsatisfactory. We study here an alternative universe with equal quantities of matter and antimatter, in which antimatter is supposed to present a negative active gravitational mass, resulting in a coasting Milne cosmology. We present here some characteristics of this symmetric Milne universe and show that it is very surprisingly consistent with Big-Bang Nucleosynthesis, Cosmic Microwave Background and Type Ia Supernovae.

1 Introduction

In this contribution, we present the unconventionnal cosmology of a universe containing equal quantities of matter and antimatter which is supposed to present a negative gravitationnal mass. The principal motivation for this comes from General Relativity through the work of B. Carter (Carter 1968) on Kerr-Newmann metric. A Kerr-Newmann geometry with the charge, mass and spin of the electron will connect two spaces; if in the first one the ring is seen as an electron, in the second one, symmetries in the metric reverse the sign of the charge and the mass. This symmetry strongly evokes antimatter and the Kerr-Newmann solution appears as a positron in this second space.

The main consequence of this assumption is that on scales larger than the typical separation between matter and antimatter the Universe appears as gravitationally empty and is therefore characterized by a linear scale factor $a(t) \propto t$.

This symmetric Milne universe, due to the time dependence of the scale factor, does not have an horizon and therefore no inflation scenario is required. The age of the Universe is simply given by $t_H = H_0^{-1} \approx 14 \times 10^9$ years, which solves the age problem for the Universe just as ΛCDM does, but without Dark Energy. Requiring neither Dark Energy, nor Dark Matter or inflation, the symmetric Milne Universe is devoid of any free parameters.

2 Time-temperature relation and Big-Bang Nucleosynthesis (BBN)

General considerations about linearly evolving universe has been developped in (Gehlaut et al. 2003; Kaplinghat et al. 2000). As the temperature evolves as $T \propto t^{-1}$ (instead of $T \propto t^{-1/2}$ in standard cosmology), timescale is drasticaly modified during BBN. As an example, the age of the Universe at a temperature of 1 MeV is three years instead of the standard 1 s. Despite this tremendous quantity of time, a thermal nucleosynthesis of helium-4 and lithium-7 is possible as weak interactions decouple at a temperature around $T \approx 80$ keV. In order to obtain the observed abundance of helium-4, a very high baryonic density, characterized by the baryon to photon ratio η is required: $\eta = 8 \times 10^{-9}$, more that ten times the standard value. It should be noted that this high baryonic density, predicted by BBN removes the need for non-baryonic Dark Matter. Deuterium and helium-3 are strongly depleted and need to be somehow produced shortly after BBN. Presence of separated domains of matter and antimatter naturally provides a means to produce deuterium and helium-3 in adequate quantities.

[1] CEA/IRFU & IN2P3/CSNSM
[2] Université Paris Sud 11 & IN2P3/CSNSM

3 Type Ia Supernovae

Distance measurements of SNIa since 1998 are usually interpreted as demonstrating an accelerated expansion and that our Universe is composed of ≈70% of an unknown Dark Energy component. Fig 1(left) shows the Hubble Diagram for the Type Ia SNe of the first year of the SNLS (Astier et al. 2006). Whereas, the Einstein-de Sitter model seems rather clearly excluded, the difference between Milne and ΛCDM is much subtler. We fitted the data against the symmetric Milne Universe and obtained a value for the absolute magnitude which differs from that of ΛCDM by ≈0.1 magnitude. On fig. 1(right), we present the residuals for these two models which turn to be very similar and hard to distinguish.

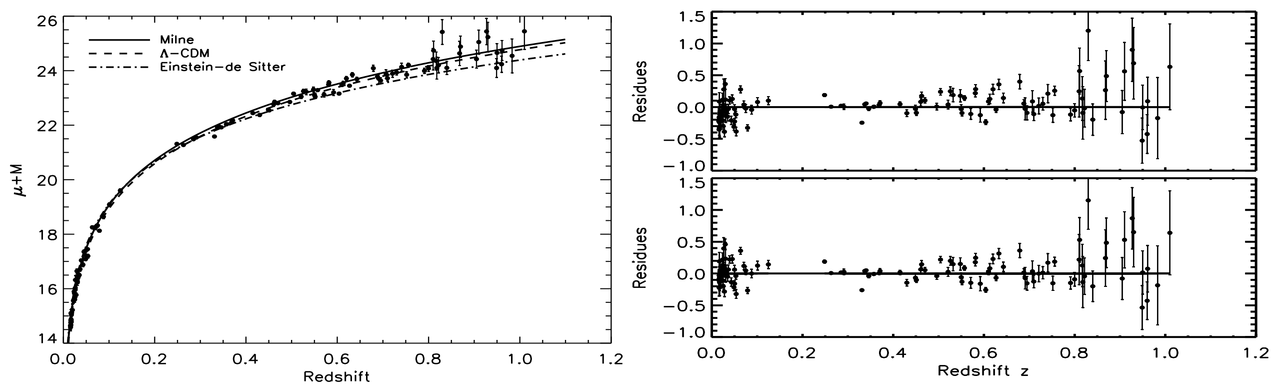

Fig. 1. *Left.* Hubble diagram for Milne, Λ-CDM and Einstein-de Sitter models. *Right.* Residuals of the Milne (top) and the Λ-CDM (bottom) adjustment for the first year SNLS data. It is clear from this figure that the difference between the two models is marginal within the present systematic errors.

4 Cosmic Microwave Background

Precise measurements of the first acoustic CMB peak usually lead to the conclusion that our Universe has a nearly zero spatial curvature. A priori, an open space such as the Milne universe is expected to give a very small value for the angular scale of first acoutic peak. Formally, this scale corresponds to the angle under which is seen the sound horizon at decoupling. For the symmetric Milne universe, this angle reads $\theta = \left(\int c_s d\eta\right)\left(\frac{\sinh(\ln(1+z_{dec}))}{1+z_{dec}}\right)^{-1}$, where c_s is the speed of sound in the baryon-photon fluid (grossly equal to $c/\sqrt{3}$) and z_{dec} is the redshift of decoupling. The integration should be made between the epoch of generation of sound waves around the QGP transition and decoupling.

Very surprisingly, the integration yields $\theta \approx 1^\circ$, which is the observed scale.

5 Conclusion

The symmetric Milne universe, containing equal quantities of matter and antimatter with negative mass reveals itself to be surprisingly in good agreement with main cosmological tests. Despite unresolved questions, it should be seen as a serious and much simpler alternative to standard ΛCDM cosmology, without unobserved Dark Energy and Dark Matter components.

References

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