RevMexAA (Serie de Conferencias), **40**, 5–8 (2011)

NONSINGULAR COSMOLOGICAL MODELS

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RESUMEN

En este artículo presento una breve introducción al estudio de modelos cosmológicos que pasan de una era de contracción acelerada a una fase de expansión, sin ser singulares.

ABSTRACT

A short introduction to the study of cosmological models that go from an era of accelerated collapse to an expanding era without displaying a singularity is presented.

Key Words: cosmology: theory

1. INTRODUCTION

The standard cosmological model (SCM) (see for instance Nakamura et al. 2010 for an updated review) furnishes an accurate and succesful description of the evolution of the universe, which spans approximately 14 billion years. The main hypothesis on which the model is based are the following:

- Gravity is described by General Relativity,
- The Cosmological Principle,
- Above a certain scale, the matter content of the model is described by a continuous distribution of matter/energy, which is described by a perfect fluid.

In spite of its success, the SCM suffers from a series of problems such as the initial singularity, the cosmological horizon, the flatness problem, the baryon asymmetry, and the nature of dark matter and dark energy[2]. Although inflation (which for many is currently a part of the SCM) partially or totally answers some of these, it does not solve the crucial problem of the initial singularity[3].

The existence of an initial singularity is disturbing: a singularity can be naturally considered as a source of lawlessness[4], because the spacetime description breaks down "there", and physical laws presuppose spacetime. Regardless of the fact that several scenarios have been developed to deal with the singularity issue, the breakdown of physical laws continues to be a conundrum after almost a hundred years of the discovery of the FLRW solution[5] (which inevitably displays a past singularity).

The existence of an initial singularity is disturbing for many other reasons[6]. To name just two, the Cauchy problem is not well-formulated in spacetimes with a singularity, and the initial singularity is inconsistent with the entropy bound. There are also hints that quantum gravitational effects may tame the singularity, as a consequence of the discreteness of the spectrum of some operators. As a consequence of all these arguments indicating that the initial singularity may be absent in realistic descriptions of the universe, many cosmological solutions displaying a bounce were examined in the last decades, starting from the first explicit solutions for a bouncing geometry obtained by Novello & Salim (1979) and Melnikov & Orlov (1979). In fact, there is a "window of opportunity" to avoid the initial singularity in FLRW models at a classical level by one or a combination of the following assumptions:

- Violating strong energy condition in the realm of GR;
- Working with a new gravitational theory, as for instance those that add scalar degrees of free-

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[2]Some "open questions" may be added to this list, such as why the Weyl tensor is null, and what the future evolution of the universe is.

[3]In fact, inflation presents some problems of its own, such as the identification of the inflaton with a definite field of some high-energy theory, the functional form of the potential V in terms of the inflaton, and the Transplanckian problem. See for instance Brandenberger (2009).

[4]For a discussion of the singularity theorems and of the concept of singularity see for instance Earman (1995).

[5]This acronym refers to the authors that presented for the first time the solution of EE that describes a universe with zero pressure (Friedmann) and nonzero pressure (Lemâitre), and to those who studied its general mathematical properties and took it to its current form (Robertson & Walker). For historical details, see Merleau-Ponty (1965).

[6]See Novello & Perez Bergliaffa (2008) for a complete list, as well as a detailed revision of nonsingular cosmological models.