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Cosmological Parameters and Expansion History of our Universe

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Abstract: The publication of the theory of relativity has since provided us with the knowledge to determine certain cosmological parameters of our Universe. Revealing the instability of a static, homogenous, isotropic Universe that is finite in size has led to the introduction of the Cosmological Constant into the Cosmological equations. Derivations of different cosmological parameters are exhibited in this paper, and evaluated to theoretically model the evolution of the Universe under different circumstances. Such circumstances include the curvature of space, and the domination of different densities, corresponding to matter, radiation, and the Cosmological Constant. Modelling the expansion history requires distance parameters, Hubble parameters, and scale factors to be derived. In an experimental study, these models were used to predict different properties as well as the overall nature of the Universe. Data obtained from multiple studies of 255 Supernovae revealed the Hubble parameter at current time to be 45.95 +/- 2.3 kilometres per second per mega parsec. Analysis of redshift velocities and luminosity distances determined a matter density of the Universe at current time to be 46 +/- 0.5 % of the critical density, with the Cosmological Constant density remaining ambiguous given an unknown curvature of the Universe. Possible ranges for the density parameter of the CC were determined and concluded along with the current matter density, current age, and current Hubble Parameter of the Universe, as well as a discussion of different scenarios regarding curvature of space and the fate of the Universe.

1. Introduction

The nature of the Universe has played a fundamental role in our understanding of cosmology, and has always presented an element of surprise through the observations of different physical phenomena. What is perhaps the most significant aspect about the nature of the Universe is its evolution through time, requiring the famous theory of relativity to derive cosmological parameters to explain how it changes with time. In the case of a spatially finite homogenous isotropic Universe, expansion or contraction becomes a viable solution when considering the attractive forces of gravity due to matter, however, instability of such a Universe that remains static becomes the only option in the absence of a force required to counteract the attractive forces of gravity (i.e. a repulsive force). The introduction of the Cosmological Constant can represent this repulsive force in Cosmological equations in order to provide the viability of a static finite Universe as described. Theoretically, this constant should make feasible a stable finite homogenous isotropic Universe that is either static, expanding or contracting.

The subject of this paper is to discuss the expansion history of a spatially finite Universe under the consideration of the Cosmological Constant acting as an extra density parameter. With the addition of the Cosmological Constant, deriving Cosmological parameters such as Scale Factor and Hubble Constant from the famous Friedmann equation will provide information on the properties of the Universe under different circumstances. The redshift of light also plays an important role in understanding the expansion history of such a Universe since it is required to analyse distances to objects. The fact that the expansion of a finite Universe causes the "spreading out" of matter across all of space means analysing the redshift of luminous objects provides details on the rate of expansion. The study of Type 1a Supernovae, the Cosmic Microwave Background Radiation, and Baryonic Acoustic Oscillations require theoretical distance models such as proper distances and luminosity distances as functions of redshift, before analysis and comparisons are made with retrieved data. The analysis and evaluation of this data is followed by the discussion of the meaning of the apparent findings, ending with a conclusive statement regarding the overall expansion history of the Universe.