International Recognized Double-Blind Peer Reviewed Multidisciplinary Research Journal
Review Of Research
ISSN 2249-894X **Impact Factor : 3.1402 (UIF)**
Volume - 4 | Issue -9 | June - 2015 **Available online at www.lbp.world**

COSMOLOGY, COSMOLOGICAL AND BIANCHI MODELS

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Short profile

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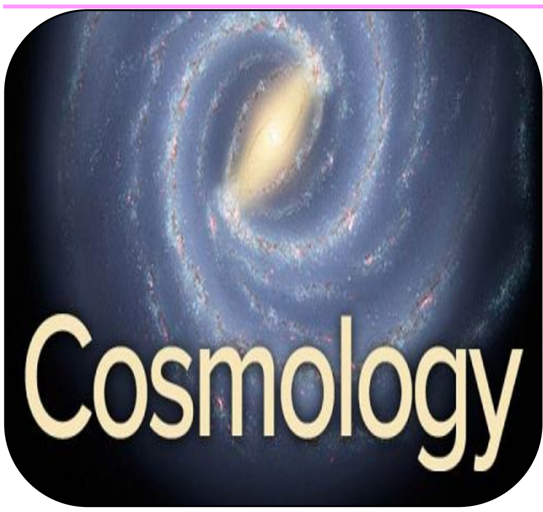

ABSTRACT

Cosmology is a branch of science that deals with the study of large scale structure of the universe. The Universe consists of stars, star clusters and galaxies or the nebulae, pulsars, quasars as well as cosmic rays and background radiation. The basic problem in cosmology is the dynamics of the system. The fundamental force keeping solar systems, stars and galaxies together is the force of gravity. The other long range interactions such as electromagnetic forces may be disregarded because the galaxies, which are major constituents of the universe as well as the intergalactic medium, are known to be electrically neutral.

Bianchi type cosmological models are important in the sense that these are homogeneous and anisotropic in which a process of isotropization of universe is studied through the passage of time. Moreover, from the theoretical point of view anisotropic universes have a greater generality than isotropic models. Here, we present a brief description of Bianchi space-times.

Key Words: *cosmological models, intergalactic medium.*

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INTRODUCTION

Cosmology and Cosmological Models

It is well known that Einstein's general theory of relativity is a satisfactory theory of gravitation, correctly predicting the motion of test particles and photons in curved space-time; but in order to apply to the universe one has to introduce simplifying assumptions and approximations. The first approximation that is usually made is that of continuous matter distribution. The study of cosmology is based on the cosmological principle, which states that on a sufficiently large scale the universe is homogeneous and isotropic. Physically, this implies that there is no preferred position, preferred direction or preferred epoch in the universe. Thus, by using the cosmological principle we assume that the universe is filled with a simple macroscopic perfect fluid (devoid of shear-viscous, bulk-viscous and heat conductive properties). Its energy-momentum tensor T_{ij} is, then given by

$$T_{ij} = (\rho + p)u_i u_j - p g_{ij} \qquad \text{..........(1)}$$

where ρ is its proper energy density p is the isotropic pressure and u_i is four-velocity of the fluid particles (stars etc.)

The study of the large scale structure of the physical universe is the main aim of cosmology. Cosmologists construct mathematical models of the universe and they compare these models with the present day universe as observed by astronomers. The theory of cosmological models began with Einstein's development of the static universe in 1917. In 1922, Hubble published his famous law relating to apparent luminosities of distant galaxies to their red shifts.

That is

$$V = HD \qquad \text{..........(2)}$$

where V is the speed of recession of galaxy at a distance D from us and H is Hubble's constant. Because of this observed red shift of spectral lines from distant galaxies and static models of the universe were ruled out and non-static models gained importance.

Friedmann (1922) was the first to investigate the most general non-static, homogeneous and isotropic space-time described by the Robertson-Walker metric

$$ds^2 = dt^2 - R^2(t)\left\{\frac{dr^2}{1-kr^2} + r^2 d\theta^2 + r^2 \sin^2\theta d\phi^2\right\} \qquad \text{..........(3)}$$

where R (t) is the scale factor, k is a constant which is by a suitable choice of r can be chosen to have values +1, 0 or -1 according as the universe is closed, flat or open respectively. He has also discussed the evolution of the function R (t) using Einstein field equations for all three curvatures.

It has been both experimentally and theoretically established that the present day universe is both spatially homogeneous and isotropic and therefore can be well described by a Friedmann-Robertson-Walker (FRW) model (Patridge and Wilkinson 1967, Ehlers et al. 1968). However, there is evidence for a small amount of anisotropy (Boughn et al. 1981) and a small magnetic field over

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cosmic distant scales (Sofue et al. 1979). This suggests a very large departure from FRW models at early stages of evolution of the universe. Thus, it is useful to study cosmological models which may be highly anisotropic. For the sake of simplicity it is usual to restrict oneself to models that are spatially homogeneous. The spatially homogeneous and anisotropic models which are known as Bianchi models present a medium way between FRW models and completely inhomogeneous and anisotropic universes and thus play an important role in current modern cosmology. Hence, in the following section, a brief discussion of Bianchi space-times is presented.

BIANCHI MODELS

Space-times admitting a three-parameter group of automorphisms are important in the discussion of cosmological models. The case where the group is simply transitive over the three-dimensional, constant-time subspace is particularly useful. Bianchi (1898) has shown that there are only nine distinct sets of structure constants for groups of this type so that the algebra may be easily used to classify homogeneous space-times. Thus, Bianchi type space-times admit a three parameter group of motions and hence have only a manageable number of degrees of freedom.

CONCLUSION

Bianchi type cosmological models are important in the sense that these are homogeneous and anisotropic in which a process of isotropization of universe is studied through the passage of time.The study of cosmology is based on the cosmological principle, which states that on a sufficiently large scale the universe is homogeneous and isotropic.

Cosmologists construct mathematical models of the universe and they compare these models with the present day universe as observed by astronomers.Because of this observed red shift of spectral lines from distant galaxies and static models of the universe were ruled out and non-static models gained importance.

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