CHAPTER I

INTRODUCTION

All relativistic cosmological models possess an initial singularity as is evident from the existing singularity theorems (Hawking and Ellis,1974). These singularity theorems are proved by assuming special properties of the energy-momentum tensors. Since not all kinds of matter fulfill these energy conditions, one may naturally look forward in search of cosmological models without initial singularity. However, with perfect fluid only as material source one cannot avoid the Big-Bang singularity. The inclusion of other fields viz., mesonic fields in the cosmic matter may lead to the possibility of examining such a situation. The investigations reported in the thesis may be looked upon as a tentative and partial attempt in this direction. We have taken the view that in the highly condensed state of matter near the epoch ($t = 0$) the matter must have microscopic interactions such as the presence of quantised scalar and vector fields. However, as t becomes large (say the present epoch) the effect of the presence of these fields might be small and the matter may be approximated by the perfect fluid hypothesis.

In the process, we have developed physically viable solutions of Einstein's equations describing Robertson-Walker homogeneous cosmological models with the quantized fields, mentioned above, as material sources. We have taken the energy-momentum tensor into the general theory of relativity as a consequence of the principle of equivalance. Once we couple the meson fields with the metric tensor via the field equations we have to look upon the field potential as a macroscopic entity.

The investigations carried out in the thesis may be broadly classified into two types of work, viz, (i) mathematical (ii) phenomenological. We would like to stress at the outset that the physics behind the phenomena involved is our main interest and the mathematical investigations have been ancillary and play the supporting role.

The thesis comprises of six chapters of which the present one is introductory in nature. This chapter deals with a survey of the basic facts of cosmology and presents a critical review of the relevent work of some of the authors bringing forth the motivation and the results achieved by us. The topics surveyed here, by their nature, are centered round the problems we have tackled.

1.1 BASIC FACTS OF COSMOLOGY :

Cosmology, as a common man understands, is that branch of astronomy which deals with the large scale structure of the universe as a whole. Prior to the inception of general relativity physicits tried to understand the structure of the universe via the Newtonian theory of gravitation. The initial concept that gravitation will play a vital role in knowing the structure of the universe was well founded because of the involvement of the huge masses in the picture. Apart from gravitation other common interactions of physics are either of short range or do not seem to be important in the universal scale. Electromagnetic theory, the only other long -range theory of basic physics, is unlikely to be important because the galaxies which are major constituent of the universe as well as the intergalactic medium, are known to be electrically neutral.

As is well-known Newtonian Cosmology did not make progress mainly because of the difficulties in arriving at a static model of the universe. Einstein had the same difficulty in trying to develope a static model within the relativistic framework. To overcome this difficulty, he considered a modified set of equations.

$$R_{ij} - \frac{1}{2} R g_{ij} + \Lambda g_{ij} = -8\pi T_{ij} , \qquad (1.1)$$

where Λ is a constant with dimensions $(\text{length})^{-2}$. Here it may be mentioned that, in obtaining the Schwarzschild solution we were assuming $\Lambda = 0$ and obtained the correct value for perihelion precession. If the Λ -term is present it is at least small enough not to affect the result namely, the fundamental length $\Lambda^{1/2}$ must be very large compared with characteristic dimensions of the solar system. Λ is therefore called the cosmological constant. We now, in the following, discuss some of the basic facts of relativistic cosmology.

1.1(a) THE OBSERVATIONAL BACKGROUND :

The analysis of the observational data may lead one to understand the cosmological picture in its true perspective. A cosmologist, as a first approximation, treats the galaxy as a point. A galaxy, like our own has a bun like shape, with the longest diameter 10^{23} cm. The mass of our galaxy is 10^{11} $M_\odot$. Treating the galaxies as a point may be somewhat justified if we take note of the fact that the characteristic distance scale of the observable universe is $\sim 10^{28}$ cm. In this range there lie $\sim 10^{10}$ galaxies which indicates that the average separation between two galaxies is nearly 10^{25} cm, which is 100 times the galactic diameter. The size and separation ratio is small enough to justify the point-like assumption. By observable universe we mean that portion of the universe which is 'seen' by best telescopes. Also, since the mass of a galaxy is small compared to the mass of the observable universe, a typical galaxy does not influence the cosmological picture significantly. The number of galaxies (viz., 10^{10}) is large enough to justify a smooth fluid approximation for galaxies in the universe.