SYNOPSIS

The investigations presented in the thesis have been classified into two parts, A and B, dealing with some physical distributions in Einstein's and Sen-Dunn theories of gravitation.

The problems considered in Einstein theory, in part A, pertain to the interactions of gravitational and scalar meson fields (with or without mass) in the presence of either electromagnetic field or perfect fluid distribution. These may be looked upon as tentative and partial attempts towards the problem of combining the gravitational theory and the quantum theory into a unified structure. In fact, we are interested to find out physically significant models representing scalar meson fields in the framework of Einstein theory. The importance of the study of interacting fields (gravitational and zero-mass scalar fields) in presence of perfect fluid distribution with different equations of state is well-known. The relevance of the equation of state, viz., pressure = mass density, (which we have considered in some of the investigations) is consistent with the limiting velocity of sound wave equating the velocity of light. These studies might be helpful in knowing different situations involving 'white holes' lagging core of a big bang cosmology or rotating neutron-stars (pulsars). In the literature these fluids with $p = D$ are called 'Zel'dovich fluid' or 'stiff fluid'.

The studies carried out in part B deal with the finding out of physical viable models representing different distributions in the framework of Sen-Dunn theory of gravitation. This theory is one of the scalar-tensor theories which attempt to fully take into account the Machian effects. The studies would help in comparing the new theory with Einstein and Brans-Dicke theories of gravitation and decide among them which theory is in accordance with observational data.

The thesis containseight chapters of which the first chapter is introductory. Chapters II to V dealing with Einstein theory form the Part A and the remaining chapters forming part B concerns Sen-Dunn theory.

In chapter I, we have surveyed various topics centering round the problems we have tackled viz., the concept of symmetry, in particular, axial and plane symmetries, perfect fluids, scalar fields (complex and real) and the Sen-Dunn scalar tensor theory of gravitation. We have reviewed the relevant work of some of the authors bringing forth, in proper perspective, the motivation of the investigations carried out and the results obtained by us.

In chapter II, we have studied the problem of interacting complex scalar fields with gravitational field in the presence of perfect fluid distribution for cylindrically symmetric Einstein-Rosen metric. It has been observed that the mass-parameter associated with complex scalar field vanishes and perfect fluid distribution reduces to Zel'dovich fluids where the rest-mass density is equal to the proper pressure. This result, has also been found to be true when the Einstein field equations are considered in its more general form including the cosmological term Λ, for interacting gravitational and relativistic magnetofluids. Consequently, we have solved the relativistic field equations representing Zel'dovich fluid coupled with zero-mass scalar fields for the Einstein-Rosen metric.

Chapter III deals with the physical interpretation of the solutions obtained in the earlier chapter. The solutions obtained have been studied with the special reference to singular behaviour, the CPT (Charge Conjugation, Change in Parity and time reflection) transformation and the C-energy contribution. The nature of the complex field is also discussed.

Einstein field equations corresponding to plane-symmetric interacting zero-mass scalar fields and perfect fluid distributions have been solved in chapter IV, obtaining exact solutions for the following physically important cases:

a) Disordered distribution of radiation (D = 3p).

b) 'Zel'dovich fluid' distribution (D = p).

c) Perfect fluid distribution ($D > p$).

d) Matter distribution in internebular space ($D = 3p/2$).

It has been observed, for the case (a), that the only possible distribution that can exist is that asymptotically tending to plane-symmetric vacuum solution. Some general features of the solutions viz., the behaviour of a test particle, the distribution characteristics such as the stress, scalar of expansion and rotation, and the reality conditions have been discussed.

In chapter V, we have presented a class of exact solution to Einstein's field equations for interacting self-gravitating irrotational fluids and sourcefree electromagnetic fields considering a time-dependent plane symmetric metric. One of the solutions has been obtained by reducing the original metric with the help of 'Characteristic co-ordinates'. It has been observed that one of our solutions, in the absence of electromagnetic fields, is identical with the solutions obtained by Sistero (1976) for plane symmetric zero-rest mass scalar field distributions.

In chapter VI, a class of exact solutions has been obtained corresponding to vacuum field equations of the Sen-Dunn (1971) theory of gravitation, for the non-static cylindrically symmetric Marder's metric. It has been observed that, given any solution of the vacuum field equations of Einstein theory, it is possible to generate the solution of the corresponding field equations of Sen-Dunn theory. The solutions have been found to preserve the wave character as in Einstein theory. Continuing our search for exact solutions in the Sen-Dunn theory of gravitation, we have solved in chapter VII the corresponding non-vacuum ($T_{ij} \neq 0$) field equations representing charged perfect fluid distributions. When the scalar interaction function $x^o = 1$, one of our solutions is found to be identical with the corresponding solution of Einstein theory as obtained by Singh and Uppadhyay (1974).

In the concluding chapter, by assuming a relation between the g_{44}- Component of the metric tensor, the electromagnetic potential ψ and the scalar interaction function x^o, we have obtained an exact solution for plane-symmetric static charged dust distribution in the framework of Sen-Dunn theory of gravitation. It has been observed that, for the solution obtained, the ratio of charge density to mass density is related to the scalar interaction function x^o such that for small values of x^o the charge density far exceeds the mass-density.