SYNOPSIS

The thesis has been divided into eight chapters.

Chapter I is of introductory nature. In this chapter we have critically reviewed the relevant work of some of the authors bringing forth the motivation of the researches carried out and the results achieved by us. The topics surveyed here by its very nature is centered round the problems we have tackled.

In Chapter II, we have discussed the interacting gravitational and massive (non-zero-rest-mass) scalar meson fields for the time-dependent axially symmetric Einstein-Rosen metric. It has been observed that the stress-energy tensor for the massive scalar meson field cannot be the source term for generating a gravitational field characterised by the metric considered. Later, the study has been extended to the case when a sourcefree electromagnetic field is coupled with the above interacting field and in this case also we have arrived at the same conclusion, viz., the mass of the scalar meson field turns out to be zero in both the cases. These results have been shown to be true even when the fields are assumed to be static.

In view of the results obtained in Chapter II as mentioned above, the only possibility of existence of the coupled fields in the axially symmetric case is that corresponding to zero-rest-mass scalar fields. As such in Chapter III we have taken up the problem of coupled fields (sourcefree electromagnetic and zero-rest-mass scalar meson fields) and obtained a class of exact solutions in the case of nonstatic axially symmetric Einstein-Rosen metric. The field equations for such coupled fields being highly non-linear, various mathematical restrictions have been imposed both on the electromagnetic four potential components as well as on the scalar potential to obtain the solutions. The solutions are obtained in three different cases each having some subcases of its own. It has been observed that in the absence of the scalar meson field some of our solutions reduce to the solutions obtained by Misra and Radhakrishna (1962) who have considered only the electromagnetic field.

Chapter IV is a continuation of the work of Chapter III. The exact solutions obtained there are restricted in the sense that the solution considered for the scalar wave equation is of a very particular type. In fact, it has always been assumed to be static which may not be the case in general. In the present work this restriction has been removed and we have got a class of exact solutions which is more general than those presented in Chapter III.

In Chapter V, we have investigated the physical implications of some of the solutions obtained in the IIIrd Chapter. Applying the wellknown duality theorem of Bonnor (1954) it has been observed that the solutions obtained above are not all independent. In fact knowing a solution of one case we can derive the other. However, these dual solutions do not represent different physical distributions and as such need not be treated separately. A comparative study of the solutions in the presence of the electromagnetic field when the scalar meson field is present and when it is absent has been carried out and it has been seen that the presence of the scalar meson field does not affect the behaviour of the solutions. Following Bonnor's (1957) definition of non-singular fields, it has been found that the fields represented by the solutions are not everywhere regular and also that the solutions do not represent a field of line mass. The intrinsic singular behaviour of the solutions as seen from the study of the Kretschmann curvature invariant has also been discussed.

In Chapter VI we have dealt with the problem of non-existence of massive scalar meson fields for a special 'class one' metric. This metric has been obtained by introducing a gravitational disturbance function in the flat metric of cylindrical polar coordinates. The metrics of class one are physically important from the point of view of the theories of fundamental particles as evident from the work of Fronsdal (1959), Joseph (1962), Rosen et al. (1964), who have shown that the extra dimensions obtained by embedding a Riemannian space may allow the interpretation of elementary particle symmetries. It has been shown that the stress-energy tensor for a massive scalar meson field cannot be the source term to generate the gravitational field characterised by the class one metric considered by us.

Buchdahl (1959) has obtained a theorem by which one can generate solutions corresponding to zero-rest-mass static scalar meson fields from those of empty spacetime solutions.

We have in Chapter VII extended his results to the case when the scalar meson field is having a non-zero-rest-mass.

In the concluding chapter we have investigated the existence of static spherically symmetric perfect fluid distributions of matter with superposed zero-rest-mass scalar meson fields. We have first considered the interior solutions developed by Tolman (1939) and constructed the 'reciprocal solutions' for the same using the investigations of Buchdahl (1959) to avail of a wider class of interior solutions. Various physical situations corresponding to these wider class of solutions with or without the superposed scalar meson fields have also been discussed.