" SPECIAL GEOMETRICAL SYMMETRIES OF THE KERR-NEWMAN BLACK HOLE "

PREFACE

The dissertation consists of three chapters. Chapter I is titled BLACK HOLES AND NEWMAN-PENROSE FORMALISM. It is an exposition of the historical aspects of Black Holes and the mathematical technique adopted to analyse them in the later chapters. In Section I, we give a popular version of Black Hole. Types of Black Holes are described in Section-2. The main mathematical tool for the dissertation is the Newman-Penrose (NP) formalism. An exposition of this null tetrad approach is presented in the Section 3. The primary attention in this dissertation is on the "Kerr-Newman Black Hole" (KNBH) which is the most general Black Hole known so far. The dynamical features and geometrical features of KNBH are delineated, exploiting the null formalism in Section 4. The next section contains the physical Components of Weyl tensor, Maxwell Scalars for KNBH. The chapter begins with the Newman's Flow diagram on the central role of Black Hole in theoretical physics.

No originality is claimed for the contents of this chapter. The following two chapters are believed to have some new results.

SPECIAL GEOMETRICAL SYMMETRIES OF KERR-NEWMAN BLACK HOLE are explored in Chapter II. At the outset the importance of the operator called the Lie derivative is presented. Section 2 deals with the concept of geometrical symmetry. Under the caption of motions and collineations sixteen geometrical symmetries of a gravitational field have been identified by Davis (1974). These are enumerated in Section 3. In the next section the importance of symmetries is described. The procedure for transcribing the tensor equations into conditions on NP scalars is explained in Section 5. The two trivial geometrical symmetries of KNBH in terms of Killing vectors are enumerated in Section 6. Section 7 deals with stationary observer and Killing vector field. The static observer, Killing horizon and ergosurface are dealt in the next section. As a pilot study of non-trivial symmetries we have considered the strongest symmetry viz., $\pounds_{\underline{V}^k} g_{ij} = 0$, when g_{ij} correspond to the gravitational potentials of Kerr-Newman Black Hole and $\underline{V}^k$ corresponds to a real null vector of the Newman-Penrose tetrad. The necessary and sufficient conditions for the existence of $\pounds_{\underline{l}} g_{ab} = 0$, $\pounds_n g_{ab} = 0$ are expressed in terms of the conditions on the NP spin coefficients and it is followed by an explicit evaluation of these conditions for the KNBH. The hyper-surfaces on which the symmetry called isometry (generated by a real null congruence) holds good in KNBH are determined in Section 9. Another symmetry called SELF SIMILAR DISTRIBUTION characterized by $\pounds_{\underline{l}} g_{ab} = A g_{ab}$ is found to be incompatible with KNBH (vide section 10). In Section 11, our attention is on DYNAMICAL SYMMETRIES. The necessary and sufficient conditions for the existence of dynamical symmetries : $\pounds_{\underline{l}} F_{ab} = 0$ and $\pounds_{\underline{l}} T_{ab} = 0$ are obtained, when dynamical tensors T_{ab}, F_{ab} are the stress tensor field and the electromagnetic tensor field of KNBH respectively. The hyper-surface on which the functional form invariance (with respect to $\underline{l}^a$) of the field tensor F_{ab} for the KNBH exists is determined. The symmetry $\pounds_{\underline{l}} T_{ab} = 0$ is shown to be untenable.

Chapter III is titled SPECIAL FEATURES OF KERR-NEWMAN BLACK HOLE. In Section 1, we investigate the complexion vector field of the Black hole. The non-singular electromagnetic field of KNBH will be an essentially electric field if and only if the null tetrad is expansion-free and twist-free.

The Nijenhuis tensor field of the KNBH is the second special feature investigated in the next section. The necessary and sufficient conditions for the vanishing of Nijenhuis tensor are :

(i) the optical parameters of $\underline{l}^a$ and N^a vanish,

(ii) either of the null congruences is parallelly propagated along the other.

In Section 3, the existence of Zilch tensor field for the KNBH is shown.

Special transports in KNBH are explored in Section 4.

(i) <u>Jaumann Transport</u> : The loss of angular momentum of the KNBH is established when the stress energy momentum tensor of Black Hole is (stationary) Jaumann propagated with respect to the congruence $\underline{l}^a$ or m^a.

(ii) <u>Fermi-Walker Transport</u> : We investigate the effects on the optical kinematical parameters due to the Fermi-Walker transportation of the four null congruences $Z^a=(\underline{l}^a, n^a, m^a, \bar{m}^a)$ in the NP-formalism.

We cite the necessary and sufficient conditions for $F_u Z^a_{(\alpha)} = 0$ for the specification $u^a = 2^{-1/2}(\underline{l}^a+n^a)$. In this case $\underline{l}^a$ represents a rigid null congruence, while only shear tensor of n^a is affected by the angular momentum of Black hole under Fermi-Walker transportation of tetrad $Z^a_{(\alpha)}$ with respect to n^a .