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The Symmetries of Kerr Black Holes*

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Abstract. The Kerr solution describes, in Einstein's theory, the gravitational field of a rotating black hole. The axial symmetry and stationarity of the solution are shown here to arise in a simple way from properties of the curvature tensor.

I. Introduction

In the course of analyzing gravitational fields, special attention is often conferred upon the symmetries of the spacetime and upon the algebraic characterization of the curvature tensor. For example, the Kerr solution is axially symmetric and stationary, with an algebraically special vacuum curvature tensor of type {22}. On the former property, in part, is based the physical interpretation of the Kerr field; the exploitation of the latter property was tantamount to the discovery of the field [1].

In the case of the Kerr solution the symmetries can be inferred by an argument centering around properties of the curvature tensor. A more general inference of this sort holds, in fact, for the entire class of type {22} vacuum gravitational fields, as well as for those Einstein-Maxwell fields for which the electromagnetic field is of type {11} with its principal null rays aligned with those of the gravitational field[1]. It is in this more general context that the argument for the Kerr field will be delineated.

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[1] Kinnersley [2], in his careful exhaustive examination of these type {22} spacetimes, observed that all the solutions admit at least two Killing vectors.