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A Family of Jordan-Brans-Dicke Kerr Solutions

C. B. G. McIntosh

Mathematics Department, Monash University, Clayton, Victoria, Australia

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Abstract. A family of solutions of the vacuum Jordan-Brans-Dicke or scalar-tensor gravitational field equations is given. This family reduces to the Kerr rotating solution of the vacuum Einstein equations when the scalar field is constant. The family does not have spherical symmetry when the rotation is zero and the scalar field is not constant. The method used to generate the new solutions can also be used to obtain vacuum Jordan-Brans-Dicke solutions from any given vacuum stationary, axisymmetric solution.

1. Introduction

Heckmann, Jordan and Fricke [1] and Brans [2] have discussed static spherically symmetric solutions of the vacuum Jordan-Brans-Dicke [JBD] gravitational field equations. The first solution in the list of four families of solutions which Brans gives is a generalisation of the Schwarzschild solution of the vacuum Einstein field equations but has the property that the event horizon of the Schwarzschild solution becomes a singular surface and may not be termed a "black hole". The Brans solution I was later discussed in a different context and with different interpretation by Janis *et al.* [3] (see also [4–6]). Charged versions of Brans' solutions were recently given by Buchdahl [7] and Luke and Szamosi [8].

Hawking [9] and Johnson [10] (cf. Thorne and Dykla [11]) say that the only black holes in the JBD theory [12] are Einstein black holes. This means that the Kerr family of solutions with constant scalar field are the only stationary black hole solutions of the vacuum JBD equations provided that the Carter conjecture is true. Nariai [5] suggests that the lack of black holes solutions with non-constant scalar field means that the JBD theory gives quite different predictions for gravitational collapse to those in the Einstein theory.

So far there have been no exact rotating solutions of the vacuum JBD equations which reduce to the Kerr solution when the scalar field is zero. A family of such solutions is given in this paper. They are axisymmetric and stationary but do not reduce in the static case (when