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On Fitting Rotating Bodies to Exterior Gravitational Fields

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Abstract. Some inequalities have to be satisfied if there is to exist a fluid source for a given exterior gravitational field. In the case of the Kerr solution one of the inequalities presented here is much more restrictive than those obtained by Boyer [1]. However, our conditions do not exclude the possibility of a fluid source for the Kerr spacetimes.

1. Introduction

Hernandez [2] has shown that for the Kerr metric a relationship is fulfilled between the total mass, M, the total angular momentum, J, and the quadrupole moment, Q:

$$Q = J^2/M\,. \tag{1.1}$$

Because of this very special relationship it is believed that the Kerr metric cannot represent correctly the external field of any realistic body [3]. However, the question of the existence of a rigidly rotating, perfect fluid source of the Kerr metric has not yet been answered[1]. This question can arise also in the cases of other exact vacuum solutions representing "rotation of something" such as the Tomimatsu-Sato [5] solution.

In this paper we shall extend a method which has first been used by Boyer [1] to exclude some configurations as sources of the Kerr metric. Boyer has proved that all possible boundaries of rigidly rotating, perfect fluid sources of a Kerr metric, for a given M and $a = J/M$, form at most a two-parameter family of surfaces. The first parameter, Ω, is the angular velocity of the rotating body. The second parameter, K, is connected with the polar radius of the body, r_p, measured in the Boyer-Lindquist coordinates:

$$r_p = M/K + \sqrt{(M/K)^2 - a^2}\,. \tag{1.2}$$

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1 According to a recent argument by Roos [12] the method used by Herlt in [4] is incorrect.