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Event Horizons in Static Electrovac Space-Times

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Abstract. The following theorem is established. Among all static, asymptotically flat electrovac fields with closed, simply-connected equipotential surfaces $g_{00} = \text{const.}$, the only ones which have regular event horizons $g_{00} = 0$ are the Reissner-Nordström family of spherisymmetric solutions with $m \geqq G^{1/2}|e|/c$. In the special case where the gravitational coupling of the electromagnetic energy density is neglected ($G = 0$) all solutions are computed explicitly, thus extending an earlier result of Ginzburg for a magnetic dipole in Schwarzschild's space-time. Possible implications for gravitational collapse are briefly discussed.

1. Introduction

Of central importance to the theory of gravitational collapse is the question whether event horizons are a fairly normal characteristic of very intense gravitational fields, or whether they are merely quirks of the special highly symmetric solutions which have so far been studied.

If we restrict ourselves to the class of asymptotically flat, static vacuum fields, it is already known [1] that the only regular event horizons are spherical. More precisely: among all fields in this class with closed, simply-connected equipotential surfaces $g_{00} = \text{const.}$, Schwarzschild's solution is the only one with a regular event horizon $g_{00} = 0$. This means that no static asymmetric perturbation of the Schwarzschild field which originates from sources *within* the critical surface $g_{00} = 0$ ($r = 2m$) can preserve a regular event horizon. (On the other hand, perturbations due to exterior sources, such as distant masses, leave the qualitative character of the event horizon unaffected [2].)

Quite generally, in the case of an arbitrary asymptotically flat field, it therefore seems natural to ask whether the regularity of an event horizon is destroyed by any asymmetric perturbation due to interior sources (e.g. mass quadrupole [3], magnetic dipole field [4], outgoing gravitational waves; an exception has to be made here for rotation — the Kerr manifold has a regular event horizon [5]).[1] If this were true, it would force a drastic reappraisal of our current ideas on the nature of gravitational collapse [6].

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[1] For instance, it might be conjectured that every vacuum field which has a regular event horizon and which is asymptotically flat (with an outgoing radiation condition) is algebraically special.