Commun. math. Phys. 27, 87—102 (1972)

The Time Symmetric Initial Value Problem for Black Holes

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Received March 14, 1972

Abstract. The time symmetric initial value problem for black holes is discussed. It is shown that if a solution contains marginally trapped surfaces these correspond to minimal surfaces lying inside the black holes. Such minimal surfaces must have spherical topology. These minimal surfaces are used to obtain lower bounds for the areas of event horizons and upper bounds for the efficiency for radiating gravitational radiation. It is shown that moving black holes closer together reduces the energy available and that a single initially distorted black hole (perhaps formed just after a very assymetric collapse) cannot radiate more than 65% of its rest mass away. "Wormholes" are also briefly discussed.

Introduction

Recently important advances have been made in the theory of black holes in General Relativity. Hawking [1] has provided a precise definition of a black hole in a weakly asymptotically simple space-time as a connected component of that part of a partial cauchy surface S which is inside the future (past) event horizon, $\dot{J}^-(\mathscr{I}^+), (\dot{J}^+(\mathscr{I}^-))$. He has used this definition to show that in a strongly asymptotically predictable spacetime which contains no "naked singularities" then the area of the boundary of a black hole $\partial B(t)$ must increase (decrease) with time. The reader is referred to Hawking's paper for the definitions of $\dot{J}^-(\mathscr{I}^+)$ etc. He has applied these results to obtaining upper bounds on the amount of gravitational radiation emitted when charged, rotating black holes initially very far apart fall into one another. To do this he has invoked another crucial assumption – the Carter-Israel conjecture which claims that in any asymptotically flat system containing one or more black holes, the exterior solution will eventually settle down to that of Kerr-Newman.

The two principal reasons for this belief are:

1. Solutions representing a stationary exterior with no singularities on or outside the event horizon seem to be restricted to the Kerr-Newman family [1].