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High Frequency Gravitational Radiation in Kerr-Schild Space-Times*

A. H. Taub

Mathematics Department, University of California, Berkeley, California, USA

Abstract. Vaidya has obtained general solutions of the Einstein equations $R_{ab}=\sigma\xi_a\xi_b$ by means of the Kerr-Schild metrics $g_{ab}=\eta_{ab}+H\xi_a\xi_b$. The vector field ξ_a generates a shear free null geodetic congruence both in Minkowski space and in the Kerr-Schild space-time. If in addition it is hypersurface orthogonal, the Kerr-Schild metric may be interpreted as the "background metric" in a space-time perturbed by a high frequency gravitational wave. It is shown that Vaidya's solutions satisfying this additional condition are of only two types: (1) Kinnersley's accelerating point mass solution and (2) a similar solution where a space-like curve plays the role of the time-like curve describing the world line of the accelerating mass. The solution named by Vaidya as the radiating Kerr metric does not satisfy the hypersurface orthogonal condition.

1. Introduction

It is the purpose of this paper to apply the methods and results of Vaidya [1] and of MacCallum and Taub [2] to the discussion of high-frequency gravitational waves in Kerr-Schild space-times. The latter authors have described such waves and their gravitational effects by assuming that they produce a space-time whose metric tensor is given by

$$g_{\mu\nu}(\varepsilon^{-1}X)=\mathring{g}_{\mu\nu}(X)+\varepsilon(\alpha_{\mu\nu}(X)e^{i\Psi(X)\varepsilon^{-1}}+\bar{\alpha}_{\mu\nu}(X)e^{-i\Psi(X)\varepsilon^{-1}}), \tag{1.1}$$

where the bar over a quantity denotes the complex conjugate operation.

Thus they assume that the "background" metric, $\mathring{g}_{\mu\nu}(X)$, is a slowly varying function of coordinates and that the perturbation due to the gravitational wave, given by the coefficient of ε in Eq. (1.1) is described by a slowly varying complex

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