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Bondi H, van der Burg M G J & Metzner A W K. Gravitational waves in general relativity. VII. Waves from axi-symmetric isolated systems. *Proc. Roy. Soc. London Ser. A* 269:21-52, 1962.
[King's College, University of London, England and Cornell University, Ithaca, NY]

An asymptotic expansion along outgoing light cones in terms of the reciprocal radius is used. The isolated source can change its quadrupole and higher moments in an autonomous manner. The variations in the gravitational field propagate with the speed of light, reducing the mass of the source (its monopole moment) as the essential second order effect. [The *SCI*® indicates that this paper has been cited in over 340 publications.]

Gravitational Waves in General Relativity

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In summer 1955 there was a conference in Bern to commemorate that it was 50 years since Einstein had launched relativity on the world while working in the patent office in that city. It was a particularly good meeting, modest in size, well organized, and chaired by Wolfgang Pauli. During it, the divergence of views became apparent on how "real" the gravitational waves were that arose in the new mathematical apparatus of general relativity. A few months earlier, I had arrived at King's College, London, as the new professor of mathematics and had felt that general relativity would be a good focus of interest for the applied side of our department. After Bern and the encouragement received there, I was determined that gravitational waves should become the very centre of our interest, especially after F.A.E. Pirani joined me as a colleague. With excellent students and postdocs (L. Marder, M.G.J. van der Burg, Ray Sachs, and A. Trautman), the place just hummed.

It was clear that a major continued effort would be needed, and so we launched the series on "Gravitational waves in general relativity."[1-12] From the beginning I was very suspicious of the value of linearized treatments of the topic. Not only is general relativity by its nature a nonlinear theory, but the question of the "reality" of the waves essentially concerned whether they transported energy. Such transport is a fundamentally nonlinear phenomenon.

Once we had begun to understand the simple cases of plane and of cylindrical waves, I was determined that we should look at the emission of waves by an isolated body. Since there can be no spherically symmetric waves, the only simplification we could permit ourselves was axial symmetry. Van der Burg and I tackled this problem, introducing a suitable coordinate system for treating it. This system made it relatively easy to incorporate asymptotic flatness at infinity and the outgoing wave condition. We fought our way through the heavy manipulative mathematics and then tackled the problems of the physical interpretation of our equations, which inevitably gave a more sophisticated picture than we had expected.

By the time I left in March 1960 for a sabbatical term at Cornell University, I felt the problem was essentially solved. However, the transformation properties of our metric remained unclear. While at Cornell, I asked A.W.K. Metzner to investigate these, and thus his contribution is to the study of this group. I gave talks at Cornell and at King's (after my return in summer 1960) on the topic but was rather slow about the writing up, so this paper (VII in the series) only appeared in 1962. While I did not expect the general case (i.e., without the assumption of axial symmetry) to show any new phenomenon, I was delighted when Sachs, who had spent some time at King's, solved it rapidly. His paper is the subsequent one in the series.[7]

My interest in gravitational waves in particular and in energy transfer in general continues, as my recent paper shows.[12] I am delighted that the kernel of it all, paper VII, is still widely cited. In my judgement, it is my most important paper in a long career.

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