Mathematics > Differential Geometry

Null Asymptotics of Solutions of the Einstein-Maxwell Equations in General Relativity and Gravitational Radiation

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We prove that for spacetimes solving the Einstein-Maxwell (EM) equations, the electromagnetic field contributes at highest order to the nonlinear memory effect of gravitational waves. In [5] D. Christodoulou showed that gravitational waves have a nonlinear memory. He discussed how this effect can be measured as a permanent displacement of test masses in a laser interferometer gravitational wave detector. Christodoulou derived a precise formula for this permanent displacement in the Einstein vacuum (EV) case. We prove in Theorem 6 that for the EM equations this permanent displacement exhibits a term coming from the electromagnetic field. This term is at the same highest order as the purely gravitational term that governs the EV situation. On the other hand, in Chapter 3, we show that to leading order, the presence of the electromagnetic field does not change the instantaneous displacement of the test masses. Following the method introduced by D. Christodoulou in [5] and asymptotics derived by N. Zipser in [8] and [9], we investigate gravitational radiation at null infinity in spacetimes solving the EM equations. We study the Bondi mass loss formula at null infinity derived in [9]. We show that the mass loss formula from [9] is compatible with the one in Bondi coordinates obtained in [4]. And we observe that the presence of the electromagnetic field increases the total energy radiated to infinity up to leading order. Moreover, we compute the limit of the area radius at null infinity in Theorem 7.

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