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Critical Gravitational Collapse with a Charged Scalar Field

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In recent groundbreaking work, it was shown that there is a regime of critical collapse where the critical solution is an extremal Reissner-Nordström black hole. It was also conjectured that such critical phenomena would occur for the spherically symmetric Einstein-Maxwell-charged scalar field system. In this work, we report on early developments to test this conjecture. We perform the 3+1 decomposition for the Maxwell equations as well as the massless Klein-Gordon equation. We implement the evolution of the vector potential $^{(3)}A_i$ in the existing numerical relativity code BAMPS, which introduces the curl constraint $\mathcal{G}_A^i = (D \times A)^i - B^i$. To check for the correctness of the code, we simulate an electromagnetic dipole in flat background and Reissner-Nordström black hole in fixed background. The first simulation was successful, showing exponential convergence. However, the latter one showed exponential growth of $\mathcal{G}_A^i$ with resolution and in time. This suggests that constraint damping for $\mathcal{G}_A^i$ needs to be implemented in the future.

Field of Research/Work

Cosmology, Astrophysics, and Gravitation

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