General Relativity and Quantum Cosmology

Self force via m-mode regularization and 2+1D evolution: II. Scalar-field implementation on Kerr spacetime

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This is the second in a series of papers aimed at developing a practical time-domain method for self-force calculations in Kerr spacetime. The key elements of the method are (i) removal of a singular part of the perturbation field with a suitable analytic "puncture" based on the Detweiler--Whiting decomposition, (ii) decomposition of the perturbation equations in azimuthal (m-)modes, taking advantage of the axial symmetry of the Kerr background, (iii) numerical evolution of the individual m-modes in 2+1-dimensions with a finite difference scheme, and (iv) reconstruction of the physical self-force from the mode sum. Here we report an implementation of the method to compute the scalar-field self-force along circular equatorial geodesic orbits around a Kerr black hole. This constitutes a first time-domain computation of the self force in Kerr geometry. Our time-domain code reproduces the results of a recent frequency-domain calculation by Warburton and Barack, but has the added advantage of being readily adaptable to include the back-reaction from the self force in a self-consistent manner. In a forthcoming paper---the third in the series---we apply our method to the gravitational self-force (in the Lorenz gauge).

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