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Harmonic coordinates for Kerr metric and its application to astrophysics

We solve the harmonic equations in Schwarzschild spacetime and get a harmonic coordinate system which can cover the event horizon. Also, we present it in one kind choice of $(T; R; \Theta^R; \Phi)$ and describe it in a Newman-Penrose formalism. Additionally, we find that the geometry of the slice in our choice is similar to that of the popular “1+log”-slice and it is not maximal. Noting the similarities between Kerr and Schwarzschild metrics in Kerr-Schild coordinate system, we get a harmonic coordinate system which can cover the outer event horizon in Kerr spacetime. For general axially-symmetric stationary spacetime, we firstly show that the existence and uniqueness of harmonic coordinates under the assumption of boundary conditions. Based on the harmonic metrics, we also firstly derive Post-Newtonian(PN) expansions, respectively, corresponding to spherically symmetric system and rotating axially symmetric system in the far-field limit and read off the multipole moments, which can be used in calculating PN dynamics and gravitational waves.