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GR simulations of binary black hole-neutron stars: Precursor electromagnetic signals

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— We present a new computational method for smoothly matching general relativistic ideal magnetohydrodynamics (MHD) to its force-free limit. The method is based on a flux-conservative formalism for MHD and its force-free limit, and a vector potential formulation for the induction equation to maintain the zero divergence constraint for the magnetic field. The force-free formulation evolves the magnetic field and the Poynting vector. Our force-free code passes a robust suite of tests, performed both in 1D flat spacetime and in 3D curved (black hole) spacetimes. Our matching technique successfully reproduces the aligned rotator force-free solution. As an application, we performed the first general relativistic, force-free simulations of neutron star (NS) magnetospheres in orbit about spinning and non-spinning black holes with BH:NS mass ratio 3:1. We find promising precursor EM emission: typical Poynting luminosities at, e.g., an orbital separation of 6.6 times the NS radius, are $L \sim 6 \times 10^{42}$erg/s for a $1.4M_{\odot}$ NS endowed with a dipolar magnetic field with polar strength 10^{13}G. The Poynting flux peaks within a broad beam of 40 degrees in the azimuthal direction, establishing a possible lighthouse effect.

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