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Numerical Relativity's Contribution to Theoretical Astrophysics, and Its Path Forward

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In the extreme violence of merger and mass accretion, compact objects like black holes, neutron stars, and white dwarfs launch the most luminous outbursts of electromagnetic, neutrino, and gravitational wave energy in the Universe. Modeling these systems realistically is extremely challenging, for two key reasons. First, the emission mechanisms often stem from magnetized flows and dynamical gravitational fields spanning many orders of magnitude in lengthscale and timescale, from the strong-field region near compact objects, to the often magnetically-dominated, weak-field regions far away. Second, the equations governing the dynamics are highly complex and nonlinear, including the full general relativistic (GR) field equations as coupled to the equations of GR radiation magnetohydrodynamics (RGRMHD).
I will review some of the current progress in using numerical relativity to advance theoretical astrophysics. In short, although numerical relativity simulations have begun to address key astrophysical questions, large gaps in our understanding remain. Bridging these gaps will require a continued focus on adding more physics to our simulations, as well as developing more computationally-efficient formulations of the equations and the algorithms for solving them.

[1]This is for an invited talk.