APR09-2009-020105

Abstract for an Invited Paper
for the APR09 Meeting of
the American Physical Society

Relativistic Compact Objects and their Environs

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The violent birth of black holes and neutron stars during core- collapse supernovae and merging events probes the fundamental nature of gravity, neutrinos, high-density equations of state, and beyond-QED-strength magnetic fields. Post-birth these compact objects continue to be of significant interest by powering pulsar wind nebulae, active galactic nuclei, x- ray binaries, and giant flares from magnetars. Recent time-dependent numerical general relativistic magnetohydrodynamic (GRMHD) simulations have broken new ground in explaining these systems' birth and evolution, including how magnetized accretion flows around rotating black holes launch ultrarelativistic jets and how pulsars power their surroundings. I discuss some of these recent successes, outstanding questions such as how core-collapse supernovae occur, and how future time-dependent simulations will play a vital role in progressing our understanding of compact objects and their environments.