Monte Carlo Neutrino Transport in Supernovae and GRBs

Neutrino interactions dominate the energetics of core-collapse supernovae (CCSNe) and determine the composition of the matter ejected from CCSNe and gamma-ray bursts (GRBs). Three dimensional (3D) CCSN and neutron star merger simulations are rapidly improving, but still suffer from approximate treatments of neutrino transport that cripple their reliability and realism. I use my relativistic time-independent Monte Carlo neutrino transport code SEDONU to evaluate the effectiveness of leakage, moment, and discrete ordinate schemes in both of these scenarios, and calculate neutrino pair annihilation rates to try to explain the jet launching mechanism of GRBs. I also developed a relativistic extension to the Random Walk approximation that greatly accelerates convergence in diffusive regimes, making full-domain simulations possible. All of these improvements will culminate in a coupled Monte Carlo - two moment transport scheme efficient enough to incorporate into the to-date most accurate global three-dimensional GRMHD simulations.