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Improved microphysics in neutron star merger simulations[1]

FRANCOIS FOUCART, Lawrence Berkeley National Laboratory

Neutron star mergers are expected to be among the main sources of gravitational waves detectable by the Advance LIGO/VIRGO/KAGRA detector network. In many cases, these mergers are also likely to power bright electromagnetic transients, including short gamma-ray bursts and "kilonovae," the optical/infrared emission due to the radioactive decay of neutron rich elements in material unbound by the merger. These EM counterparts can provide important information on the environment in which the merger takes place and the nature of the binary, and their detection could shed a light on the origin of short gamma-ray bursts and of r-process elements. Numerical simulations of neutron star mergers using general relativistic codes are required to understand the merger dynamics, the impact of the equation of state of the neutron star on the gravitational wave signal, and the potential of a given binary to power electromagnetic counterparts to that signal. Until recently, however, general relativistic codes used very simple models for the neutron star - often a simple gamma-law equation of state without any additional microphysics. Although sufficient to model the gravitational wave signal before merger, this cannot be used to follow the post-merger evolution of the system, or even some aspects of the disruption of the neutron star. To do so, nuclear-theory based equations of state with temperature and composition dependence have to be used, and the effects of neutrinos and magnetic fields should be taken into account. In this talk, I will discuss current efforts to include more advanced microphysics in general relativistic simulations, what we can do so far, and what the remaining computational challenges are. I will also show how existing numerical simulations have helped us constrain the outcome of neutron star mergers, and what remains to be done in order to extract as much information as possible from upcoming gravitational wave and electromagnetic observations.

[1]Einstein Fellow