Numerical Relativity: Modeling and Simulation of Astrophysical Sources of Gravitational Waves. The goal of our Numerical Relativity (NR) program is to study strong-field gravitational dynamics and radiation phenomena of closely interacting compact objects in astrophysics, such as black holes and neutron stars, or other phenomena, such as gravitational core collapse and supernovae explosions. These phenomena are also believed to be the source of powerful gravitational waves (GWs) and energetic gamma-ray bursts (GRBs). To understand these phenomena, we need to solve the Einstein’s General Relativity (GR) field equations numerically, with/without matter and electromagnetic (EM) fields, with the aid of powerful supercomputers. Learn More ...

Computational Relativistic Astrophysics: Magnetohydrodynamical Simulation of Supermassive Black Holes in their Astrophysical Environments. The goal of this program is to study the dynamics and radiation of the accretion disks and other astrophysical environments around supermassive black-holes that we know exist at the core of galaxies. These phenomena are expected to be the source of powerful EM signals and relativistic jets which can be detected by the NSF Large Synoptic Survey Telescope (LSST) and other astronomical observatories. Combined general relativistic magneto-hydrodynamics (GR-MHD) simulations are used to model these phenomena. Learn More ...

Gravitational Wave Astrophysics and Observations: Data Analysis. We are part of the LIGO Scientific Collaboration (LSC) with the goal to analyze the data taken by the NSF experiment, the Laser Interferometer Gravitational-Wave Observatory (LIGO), and other detectors, searching for GW signatures of astrophysical systems such as binary black holes and/or neutron stars in close binary orbits, supernova explosions, rapidly spinning deformed neutron stars, and the extreme conditions in the early universe shortly after the Big Bang. GWs are distortions in the fabric of the spacetime, predicted by Einstein's GR theory, which travel at the speed of light. The LIGO experiment, which uses an L-shaped interferometer to measure changes in the fabric of the spacetime smaller than a proton in the difference between the 2.5-mile lengths of its "arms". Learn More ...

Galactic and Stellar Dynamics. Galactic Dynamics use N-body simulation to study the complexity of the gravitational dynamics of galaxies and star clusters, such as our own Milky Way. Learn More ...

Advanced Computation and Visualization. We develop open source codes, such as the Einstein Toolkit, and other visualization software for astrophysics and gravitational wave simulations on petascale/exascale supercomputers. Learn More ...