Numerical Relativity (NR) uses advanced numerical techniques in supercomputers to simulate the relativistic, strong-field dynamics and radiation of merging compact binaries, such as black holes and neutron stars, and other similar phenomena that are governed by Einstein’s theory of General Relativity (GR). Analytical relativity (AR) methods, based on Post-Newtonian expansions of the GR equations and black-hole perturbation theory, are also used to study respectively the early phases of the inspiral of compact object binaries and the resulting black-hole remnant.

The RIT’s Numerical Relativity group is one of the largest and internationally renowned group in the modeling and simulation of compact binaries in extreme astrophysical environments. The group contributed to the 2005’s breakthrough in this field (e.g. see for example the moving puncture approach), which have opened new frontiers in gravitational wave astrophysics.

The moving puncture approach has permitted the first calculations gravitational radiation from merging black holes with arbitrary masses and spins, the discovery of large gravitational-radiation recoils (up to 4000 km/s) from merging spinning supermassive black-holes, the study of spin dynamics effects, such as spin-flips, precession and hang-up orbits and extreme mass-ratio binaries. The original moving puncture papers was recently highlighted by the APS as one of the landmark papers of the century on the subject of general relativity, starting with a contribution from Einstein himself.

You can download some of the associated movies and waveforms data here.

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Projects and Collaborations:

- The NR has lead the field of NR through a number of projects funded by the NASA ATPF 07-ATFP07-0158 [7], and NSF PHY-0722315 [8], PHY-0653303 [9], PHY-0714388 [10], PHY-0722703 [11], OCI-0832606 [12], PHY-0903782 [13], PHY-0969855 [14], PHY-1305730 [15].

- The group participates in the Numerical Injection Analysis NINJA Project [16] is to bring the numerical relativity and data analysis communities together to pursue projects of common interest in the areas of gravitational wave detection, astrophysics and astronomy.

- The group is part of the Einstein Toolkit Consortium [17] which actively develop and support open software for relativistic astrophysics to take advantage of emerging petascale computers and advanced cyber infrastructure. This consortium is funded by NSF PHY 0903973/0903782 [13]/0904015 (CIGR [13]), NSF PHY 0653303 (XiRel [18]).

- The CCRG numerical relativity group is collaborating with the Blue Waters Team [19] at the National Center for Supercomputing Applications (NCSA) through a series of NSF Petascale Resource Allocation (PRAC [12]) awards OCI-0832606 [12] and OCI-1516125 [20]. Blue Waters is one of the most powerful supercomputers in the world with a peak performance of 10 petaflops (10 quadrillion calculations every second). It can achieve a sustained performance of 1 petaflop running a range of science and engineering codes.