Provide a brief description of your proposed practicum project: (3000 character max)

Neutron star mergers are catastrophic cosmic events that are exciting for multiple reasons: they generate gamma-ray bursts – brilliant flashes of high-energy electromagnetic radiation; they produce powerful gravitational waves, detectable from billions of light-years away; and they are most likely the primary source of heavy r-process nucleosynthesis in nature. Recently, a few of them were discovered by gravitational wave detectors, LIGO and VIRGO, along with electromagnetic counterparts and high-energy neutrinos. Now, more accurate gravitational-wave templates are needed to decipher these and future detections.

Neutron stars bear a solid crust, which is anticipated to have exceptional strength. Studies show that the crust can leave an observable imprint on the gravitational wave signal. In this practicum project, it is proposed to numerically examine how the crust affects tidal deformability of a neutron star in equilibrium. Specifically, a neutron star with a crust will be prepared in an equilibrium state, and then subjected to a periodic quadrupolar perturbation, mimicking the gravitational field imposed from a companion in a binary system. The effect of the perturbation will be measured and employed for calculating corrected tidal deformability. The latter can then be plugged into post-Newtonian expressions for gravitational waves of a neutron star binary inspiral.

The proposed study will be conducted using SPaRTA, a novel hybrid OpenMP/MPI, fully general-relativistic framework. This code is currently being developed at Los Alamos National Laboratory, and will be used for simulating neutron star mergers. The latter includes an adaptive curvilinear multi-block grid that can be fine-tuned to resolve the crust with very high accuracy.

As a first step, we will work on the design of a crust-conforming curvilinear multi-block grid. We envision that the so-called "cubed sphere" configuration is best suited for this problem. We will then work on load-balancing this configuration and optimizing the grid resolution for best performance. Finally, we will perform several fully general-relativistic medium- and high-resolution runs of realistic configurations of neutron stars subjected to periodic quadrupolar perturbations. Our findings will be summarized in a publication.

Describe the relationship, if any, of proposed practicum work with your thesis work: (2400 character max)

The main similarity between this project and my thesis work is that they both explore areas of general relativity. My thesis work is based on numerical relativity modeling, purely focusing on gravitational waves, whereas this practicum project will focus on the multi-physics problem of resolving the crust of the neutron-star, electromagnetic radiation of the breaking of the crust, and the exotic fluid-matter that is theorized to exist in the interior of the neutron star.

List computational resources required for practicum project, if any: (2400 character max)

$\langle todo \rangle$

Are you planning on utilizing any of the HPC resources at the lab? (2400 character max)

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