Name: Gabriel Casabona **Year 2 of 4**

Practicum Proposal Information

Fellow Information

Fellow
Gabriel Casabona

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Site Information

Participating center for practicum **Los Alamos National Laboratory**

Proposed dates at center (minimum 12 weeks) **06/14/2021 - 09/17/2021**

Practicum coordinator **Kary Myers**

Has the center coordinator given tentative approval for the proposed dates and area of research? **No**

Practicum Supervisor for Project (the person to whom you will be reporting).

Name
Oleg Korobkin

Title
R&D SCIENTIST

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Practicum Proposal

Provide a description of your proposed practicum project:

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 millions of light years away; and they are most likely the primary source or 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 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 have shown that the crust can leave 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 of a companion in a binary. The effect of the perturbation will be measured and employed for calculating corrected tidal deformability. The latter can then be plugged in the 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 multiblock grid that can be fine-tuned to resolve crust with very high accuracy.

As a first step, we will work on the design of such crust-conforming curvilinear multiblock 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 perturbation. Our findings will be summarized in a publication.

How will your practicum research broaden your perspective beyond your thesis research?

Neutron stars are some of the most exotic objects in the universe. They are at the cusp of extreme environments with regard to solid state and nuclear physics, along with general relativity. This will be a unique experience for me because it will challenge my knowledge in physics overall. The computational aspect is also completely different from my research, since there will be a heavy focus on improving different aspects of code development, such as parralelization and mesh configuration.

List computational resources required for practicum project, if any:

HPC systems at LANL accessed via the Turquoise and/or Yellow networks will be used for this project, namely Grizzly and Badger MPI clusters. While a desktop computer will not be absolutely necessary, access to a desktop and/or additional displays will facilitate code development.

Are you planning on utilizing any of the HPC resources at the lab?

The main LANL HPC resource for this practicum project will use existing allocation on the Grizzly and Badger clusters.

Signature of Fellow DocuSigned by: Gabriel Casabona 7B1D107FD5CF428... Date 1/12/2021

Fellow's University Advisor: Shane Larson

I have read and approved the above request.

Advisor's Signature _____ Date _____

Send completed form to the following address:

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