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

Practicum Pre-Proposal Information

Fellow Information

Fellow
Gabriel Casabona

Department
Physics

University
Northwestern University

Work Phone
9739310297

Email
gcasabona1@gmail.com

Current Mailing Address
4700 North Racine Avenue
Apt 301
Chicago, IL 60640

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

Division
Center for Theoretical Astrophysics

Address
Los Alamos National Laboratory P.O. Box 1663
Los Alamos, NM 87545

E-mail
korobkin@lanl.gov

Phone
(505) 667-5061

Fax

Practicum Proposal

Provide a brief 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 billions 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 AdLIGO and Virgo. Now, more accurate gravitational-wave templates are needed to decypher these and future detections.

Neutron stars bear a solid crust, which is anticipated to have exceptional strength. Studies show that the crust can leave observable imprint on the gravitational wave signal. In this practicum project, it is proposed to numerically examine how crust affects tidal deformability of an equilibrium neutron star. Specifically, a neutron star with a crust will be prepared in equilibrium state, and then subjected to a periodic quadrupolar perturbation, mimicking 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 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.

Submitted by **Gabriel Casabona**

Send completed form to the following address:

DOE Computational Science Graduate Fellowship Program
Krell Institute
Attn: DOE CSGF Coordinator
1609 Golden Aspen Drive, Suite 101
Ames, IA 50010
Phone: 515-956-3696
Fax: 515-956-3699
csgf@krellinst.org