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

Practicum Evaluation Information

Site Information

Practicum Dates: 07/1/2022 - 10/21/2022

Practicum Location: Los Alamos National Laboratory

Practicum Supervisor: Oleg Korobkin

Fellow's Practicum Evaluation

Project title

Neutron Star Crust Tracking in Dynamical Spacetime

1. Please provide a brief summary of the project. This information may be used in publicizing future practicums.

Neutron stars (NS) are the densest objects in the known universe. Their basic structure consists of neutron-degenerate fluid encapsulated by a relatively thin crust. Recent astronomical observations of gamma-ray and x-ray bursts have led some astronomers to theorize that these may be caused by the cracking of the crust of a NS in a binary system. Since NS are both highly massive and dense, they experience relatively high gravitational perturbations from their companions. The goal of this project is to model and simulate the role that these perturbations have on the NS crust, specifically looking at what happens when the gravitational perturbations matches the resonance frequency of the crust.

2. Describe your specific contribution to the project.

My goal for the project was to model and develop a script that solves the relativistic Tolman-Oppenheimer-Volkov (TOV) equation of state in dynamical spacetime. This code will then be incorporated into the larger code base SPaRTA, which has been in development with the purpose of modeling various physics of neutron stars.

3. Was your involvement in this project appropriate to your research interests, skills and knowledge? Please give specific examples.

Although my thesis research is related to neutron stars, the scope of the practicum focused on physics that is not related but tangential to what I do focus on. My research is primarily focused on general relativistic fluid dynamics, whereas the practicum research was focused on solving the equation of state of the NS crust in dynamical spacetime. Therefore, it was a combination of general relativity, thermodynamics, and solid mechanics, the latter two being relatively new to me.

4. Would you have been able to participate in this type of work had you not received the fellowship?

I do not believe I would have been able to participate in this type of work without the fellowship. It's most likely that I would not have known this work was even happening and that I would have had the opportunity to visit and work at any national lab.

5. List any contributions to publications or reports you made during the practicum.

At the moment, my work is not part of any publication. However, it is planned to be part of future research publications as it relates to the overall code base SPaRTA.

6. List and describe any presentations which resulted from your practicum work.

At the time of writing this evaluation, I have not presented this work in a formal setting. I am planning on giving a presentation on this work at the beginning of next year.

7. In retrospect, what value did the experiences of your practicum have for you?

There are a handful of ways that I found this practicum to be valuable. The first is that I was able to learn new physics, numerical techniques, and coding. The latter two are skills I know will be useful as a computational scientist moving forward, regardless of the field I end up working in. The physics I learned in this research expanded upon certain topics I have covered in previous coursework. This allowed me to think about physics differently, primarily on how to do theoretical research that can be addressed using computational methods. I also learned a lot from various conversations I had with people at the lab and talks that I attended. I also made connections with people that I am extremely grateful for.

8. In what ways has the practicum influenced your career planning?

The lab gave me an inside look at what life is like working at a lab. LANL is considered to be a prestigious place to have a career in, especially in astrophysics. Now that I have experienced it first-hand, I believe I have a more balanced view on having a career at a national lab. In the previous section, I mentioned the positive experiences I had. The main reservation I now have is that I am not sure if working on science that I cannot publish is meant for me, especially considering that I do not know the details about it since I do not have clearance. Being around scientists, from graduate students to staff members, that are as passionate about their research as the people I met was a great experience and motivated me to continue working on becoming the best scientist I can possibly be. However, there was a level of stress I saw amongst them, primarily with graduate students and post-docs, that I have not seen in the academic setting. The lab pays graduate students very well compared to academia, and research is conducted at a higher pace with more available computational resources that are far more sophisticated compared to most academic institutions, but conversations I had with graduate students showed me that advising and mentoring is not taken as seriously as in the academic environment. Specifically with LANL, the area has beautiful scenery and cost of living is superior to most places I've resided in within the country, but one thing I noticed in my experience there and was brought up by almost every graduate student and post-doc, was that the overall social life is not conducive for people in our age group who don't have families nearby. A friend of mine who is an alumna of my program and is now a post-doc there shared with me that she does not enjoy living there and is patiently waiting for her contract to end so that she can move on to something else. I also noticed that she did not look happy the way she was during her PhD, and showed signs of being depressed. She also shared with me that most post-docs she knows of feel the same way. Given my culture and interests, and possibly the fact that I have only ever lived in major cities, I felt the same way. Although I plan on continuing my work with the lab, I do not plan on coming back long-term for the rest of my time as a graduate student.

While I was there, I was also privy to information regarding proposals. I noticed from being in meetings, and also conversations with my adviser, that the lab's research focus seems to be moving in a direction outside of my research interests. Although I shared the information above, I still am considering it a place for doing a post-doc.

9. Will your practicum be a basis for your thesis? Please note the specific area(s).

Although it was not the initial intention, it is possible that I might combine this with my current research or maybe make it an additional project. Since it all relates to neutron stars, I think that it's possible that I might do so. Aside from it being related, I also really enjoyed the work, so much so that I will be continuing the collaboration regardless of whether it becomes part of my thesis. I'll make my final decision when I approach my candidacy exam at the end of this academic year.

10. How can the practicum be improved? Please comment on your overall impression of this experience.

I'd like to preface my following statements by clarifying that I know most, if not all, of these issues are out of the control of Krell, but feels necessary to share nonetheless.

One improvement that could have been made was being assigned a desk with other graduate students. I was assigned a desk in the same office as my practicum adviser. It was a positive experience in the sense that we were able to address issues regarding research immediately, however not being able to socialize with the graduate students who were there for the summer or long-term was not ideal. By the time I was put in a vicinity with other students, the majority of them had already left after completing their respective internships.

Another major issue I faced was that my computational skills were not at the level that was expected from me. When I first reached out to my practicum adviser, I asked him if there was anything I could begin learning so that I would be ready by the time I arrived. I was told that it would not be necessary, as I would be able to learn in the beginning as I got started. I believe this was stated with the assumption that my computational and numerical skills were much higher than they were. Although I did eventually learn what I needed to know to make progress, I certainly did not accomplish what was expected of me. I believe that having an understanding on what prior knowledge one should have before beginning the practicum to have the opportunity to learn them would be beneficial.

The last issue I will mention, which I know is definitely outside of what the fellowship can do but may be worth mentioning to future fellows when considering practicums, is that I was not able to receive my ongoing medical attention and treatment that I have been working on for the past two years. As some of the administrative staff knows, I had major setbacks throughout the pandemic related to ongoing health concerns that caused me to delay my practicum and my overall progress in graduate school and fellowship requirements, such as the POS, thesis related research, and courses. I've made a lot of progress since then, and just days before leaving for the practicum, my doctor informed me in an appointment that according to Illinois state law, she is not allowed to meet with me while I am out of state, and that she cannot send me prescriptions out of state. This was a serious problem for me, which resulted in a lengthy and costly process to receive my medication. I had strong withdrawal symptoms for a couple of weeks because of this that took a considerable amount of time to recover from, which negatively affected my work. I didn't feel comfortable sharing this with my practicum adviser, especially considering some conversations we had in the beginning, so I know I made a bad impression that I am actively trying to recover. My doctor knew about this trip well beforehand, so if I were to have been informed by her in advance, then I could have made the proper