

Please note: For summer 2021, GRAP is offered as a **remote** opportunity. If conditions change (Tufts allows international travel, and the country where the research takes place allows incoming student researchers), we will consider allowing students to travel internationally.

Faculty: Mark Hertzberg, Assistant Professor, Physics and Astronomy, Arts & Sciences

Project Locations: Remote work from home or at Tufts University/Tokyo, Japan (with the possibility of visiting other cities in Japan as needed)

Dates: June/July, with flexibility

Project Title: Exploring the dark universe

Project Details: The project is at the interface of cosmology, particle physics, and astrophysics. The specific project will involve the investigation of aspects of the dark universe, which can include dark matter, dark energy, and other dark sectors. One focus can be on so-called axions, which are the current most favored particles beyond the Standard Model. These lead to interesting forms of dark matter. The project will involve developing new techniques to probe the axion. Other work can include probes of dark sectors, including new particles that may have weak Interactions with the Standard Model. Furthermore, new models of dark energy that involve new predictions for observation can be pursued. Comparison to observational data will be made in all the above topics. The international impact is very significant, as the nature and behavior of the dark universe is a pressing problem at the core of fundamental physics and astronomy, and is a major research subject around the world. In particular, this is one of the primary interests at several institutions in Japan, including some of the faculty's colleagues, which is a country that would be ideal to host the student. Several pieces of progress have already been made on this subject. The faculty member has already written several papers laying the ground work for this project. Furthermore, the faculty member has already began collaboration with colleagues in Japan, and it would be the ideal place to continue this important work.

Tasks and Responsibilities of Research Assistant:

1. Learn background material on dark matter and dark energy
2. Become familiar with appropriate Lagrangians that govern their dynamics
3. Become familiar with numerical code to solve the appropriate differential equations
4. Set up code that can solve for axion evolution, dark sector interactions, or dark energy evolution
5. Read the literature on current experimental limits on beyond the Standard Model probes
6. Compute the new signatures of axion and other models
7. Compare the predictions to existing data; make predictions for future experiments
8. Summarize all results into a research paper, in collaboration with Japanese colleagues and faculty member

Since the work is in theoretical physics, we use computers and mathematics and data; much can be done virtually. In summer 2020, Professor Hertzberg offered a similar opportunity that was completed via regular Zoom meetings. If international travel is allowed, the student would travel to Japan to collaborate with international colleagues in person.

Qualifications:

1. Strong interest in research, especially cosmology, particle physics, astrophysics
2. Some background in computational work, or willingness to learn

3. Some background in calculus and differential equations is desirable, or willingness to learn

Housing in Japan: The International House of Tokyo Tech provides accommodation to international researchers to promote international exchange in education and research. The International House is a non-smoking residence for researchers from abroad. The IH office staff, who speak Japanese and English, are able to help with information, procedures, and life at the IH. Similar accommodations will be arranged in other cities if needed.