Alabama Plasma Internship Program

Project Title:
Space Plasma Physics: Solar wind, pickup ions, turbulence, and particle acceleration

Subproject 5:
The Generation and Propagation of Interstellar Pickup Ions

Project Reference Code:
UAH-Zhao

Host Facility:
The University of Alabama in Huntsville

Host Facility Location:
301 Sparkman Dr.
Huntsville, AL 35899
https://www.uah.edu/

Project Description:
The Sun plays an important role in space plasma physics. The surface of the Sun expands outward at a certain speed (called the solar wind), until the ram pressure of the solar wind is balanced by the interstellar medium pressure. The expansion of the solar wind stops, forming a bubble-like space area in the interstellar medium, called the heliosphere. Due to the rotation of the Sun, the solar wind forms a Parker spiral in the expansion process. Note that the magnetic field freezes in the solar wind plasma and convects with it. Solar wind provides a unique opportunity to study various processes in plasma. In the solar wind, waves and turbulence are everywhere. The dissipation of turbulence is thought to be responsible for the heating of coronal plasma to millions of degrees Kelvin, the acceleration of the solar wind, and the heating of the solar wind. Similarly, several theoretical (Zank et al. 2014, 2015; le Roux et al. 2015, 2016, 2018) and observational (Khabarova et al. 2015, 2016, 2017, 2018; Zhao et al. 2018, 2019; Adhikari et al. 2019) studies have found that when solar energetic particles (SEPs) propagate through the “sea” of magnetic islands, they accelerate in situ. In addition, some studies have also shown the presence of pickup ions (PUIs) in the solar wind (Zhao et al. 2019). PUIs are produced due to the charge exchange between solar wind protons and interstellar neutrals. Waves, turbulence, and PUIs have their own characteristics, and they can change the shape of the heliosphere, and the termination shock (TS).

We divide the project into six sub-projects. Our research project involves i) a parametric study of cowling resistivity, ii) mapping of the solar wind’s magnetic field, iii) evolution of turbulence in the inner heliosphere, iv) magnetic reconnection and plasma acceleration, v) the generation and propagation of interstellar pickup ions, and vi) hybrid simulation including neutrals. The student are feel free to choose any one of our project. Students will be involved with state-of-the-art research under the direction of Dr. Zank (and his research scientists Dr’s Lingling Zhao and Mehmet Yalim (Sarp) and postdocs, Dr’s Samira Tasnim, Masaru Nakanotani, Haoming Liang, and Laxman Adhikari).

Alabama Plasma Internship Program

Description of Subproject:
As interstellar neutral particles stream into the heliosphere, they are ionized and picked up by the solar wind. These particles are called interstellar pickup ions (PUIs), which are typically singly charged. It is generally assumed in theories that the newly born PUIs rapidly form a nearly isotropic distribution and undergo advection and adiabatic cooling. The result of these processes is a "filled-shell" distribution. Although the existence of PUIs was proposed for decades, direct measurements of PUIs were only available within 5 astronomical units from the Sun until recently. The NASA New Horizon (NH) mission travels towards the interstellar medium and is currently located about 40 astronomical units from the Sun. NH is the first mission that has the capability of measuring PUIs at such a distance and such measurements have raised new questions regarding of the PUI distribution. For example, PUI distribution may deviate from the classical model prediction, especially near the interplanetary shocks. It is therefore necessary to consider more sophisticated models which include effects of spatial and momentum diffusion, pitch-angle scattering, stochastic acceleration, etc. The goal of this project is to compare PUI distributions under different mechanisms to NH observations. The student will learn basic data analysis techniques and apply them to help understand the physical processes that govern the generation and propagation of PUIs.

Disciplines:
Physics, Math, Computer Science, Space Science

Is U.S. citizenship required to participate in this project?
Yes

Name(s) of Mentor(s) and contact information:
Lingling Zhao (lz0009@uah.edu)
Gary Zank (gpz0001@uah.edu)

Internship Coordinator/ HR manager:
Dana Waller (dsw0012@uah.edu)

The name and contact information of personnel at the host facility is provided for further assistance with questions regarding the host facility or the project.

Interns will not enter into an employee/employer relationship with the host facility. No commitment with regard to later employment is implied or should be inferred.