Alabama Plasma Internship Program

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

Subproject 3:
Evolution of Turbulence in the Inner Heliosphere

Project Reference Code:
UAH-Adhikari

Host Facility:
The University of Alabama in Huntsville

Host Facility Location:
301 Sparkman Dr.
Huntsville, AL 35899
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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).

Description of Subproject:
Magnetized turbulence is commonly present throughout the solar wind, from the solar corona to the heliopause and possibly even in the interstellar medium. The solar wind has been used to study magnetohydrodynamic (MHD) turbulence from the beginning of the space age. Turbulence is thought to be responsible for several interesting phenomena in the solar wind, such as the solar wind heating, the coronal heating, acceleration of the solar wind, scattering of the solar energetic particles, etc. As the solar wind expands with distance, turbulence evolves with increasing heliocentric distance. The evolution of solar wind turbulence in the heliosphere can be described by turbulence transport model equations. Many turbulence transport model equations have been proposed to explain the evolution of turbulence in the solar wind. Zank et al. (1996) first proposed a theoretical model of turbulence to describe the evolution of fluctuating magnetic energy, and the correlation length of the magnetic field fluctuations. Zank et al. (1996) compared the theoretical results with the measurements of Voyager 1, 2 and Pioneer 11, and found that the theoretical results were in good agreement with observations.

The main purpose of this project is to understand how turbulence evolves with heliocentric distance between 0.3 and 1 astronomical unit (au) and its role in solar wind heating. In this project, the student will analyze the magnetometer and plasma data from Helios 2 spacecraft and solve simple forms of Zank et al. (2012) turbulence transport model equations. S/he will calculate the energy in forward/backward propagating modes, the residual energy, the fluctuating kinetic and magnetic energy, the correlation length, and the solar wind temperature from Helios 2 data set, and compare the observed results with the theoretical results. If time permits, s/he will compare the theoretical results with the measured results of the Parker Solar Probe. In this project, s/he will learn to solve turbulence transport model equations and data analysis technique.

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:
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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.