Project Title:
Particle acceleration by a cosmic ray mediated shock wave

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 most important mystery in space physics is how energetic particles, so-called cosmic rays, are produced. One plausible mechanism is the acceleration of charged particles by a shock wave. Since the flow speed of plasma in space easily becomes supersonic making the presence of a shock wave ubiquitous. The acceleration mechanism of cosmic rays by a shock wave that has been developed is known as diffusive shock acceleration (DSA). In DSA, particles are scattered by MHD waves back and forth across the shock wave and gain energy because of the difference of the flow speeds of the upstream and the downstream. The energy spectrum predicted from the theory well explains the observed spectrum of cosmic rays. However, the standard theory does not include any feedback from cosmic rays, treating cosmic rays as test particles. It has been verified that when the cosmic ray pressure is comparable to the pressure of the thermal plasma, the shock structure is mediated by cosmic rays – a so-called cosmic ray mediated shock wave. This effect may change the efficiency of particle acceleration at the mediated shock wave. It is believed that the acceleration likely becomes more efficient than at a non-mediated shock wave.

The purpose of this project is for the student to investigate how a CR-mediated shock wave accelerates particles by combining a MHD model for the background plasma and the Parker transport equation for cosmic rays. S/he will assemble a list of the very strong and possibly mediated shocks that have been observed in the solar wind, do a comprehensive analysis of the plasma and magnetic properties for these shocks, and then compare the mediated shocks to more typically observed shocks observed regularly in the solar wind, i.e., not very strong and not apparently mediated by energetic particles. The database will be used to test and validate the developed self-consistent MHD and Parker transport model. If time permits, s/he will compare the modeling results with observations of an extreme shock wave in the heliosphere.

Disciplines:
Physics, Math, Computer Science, Space Science

Is U.S. citizenship required to participate in this project?
No

Internship Location and COVID-19 related Backup Plan
The internship location is the University of Alabama in Huntsville. Due to the COVID-19 pandemic, we are preparing multiple options to ensure that the internship will take place. We are looking at least at an in-person, hybrid, and fully virtual option. For any in-person component we will ensure that there is adequate physical spacing between workspaces, following all university cleaning protocols.

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