Project Title: Investigation of Pickup Ion Velocity Distributions and Their Relationship with Magnetic Turbulence using IMAP Observations

Project Reference Code: Khanal-UAH

Name of Project Leader: Krishna Khanal

Host Facility: University of Alabama in Huntsville

Internship Location: Cramer Research Hall

Host Facility Location: 301 Sparkman Drive NW, Huntsville, AL 35805

Project Description (roughly 300 words):
Pickup ions (PUIs) are created when neutral atoms entering the heliosphere become ionized and are subsequently picked up by the solar wind magnetic field. Newly formed PUIs gyrate around the solar wind magnetic field and are initially expected to form highly anisotropic velocity distribution functions (VDFs), commonly referred to as ring-beam distributions. These distributions evolve through interactions with magnetic fluctuations and other transport processes. Magnetic turbulence can scatter PUIs in pitch angle, modifying their initial ring-beam distributions toward more isotropic distributions. The recently launched Interstellar Mapping and Acceleration Probe (IMAP) mission provides an opportunity to investigate this relationship using high-energy-resolution measurements from the Compact Dual Ion Composition Experiment (CoDICE), together with magnetic field and solar wind observations. This project will focus on examining the VDFs of H^+ and He^+ pickup ions under different magnetic turbulence conditions near 1 AU. The student will analyze in situ observations from IMAP and carry out the following main tasks: (1) identify suitable solar wind intervals characterized by different levels of magnetic turbulence; (2) examine the three-dimensional VDFs and pitch-angle anisotropies of H^+ and He^+ pickup ions; (3) characterize magnetic turbulence by measuring the strength of magnetic field fluctuations and their power spectra; (4) compare the observed pickup-ion distributions under different turbulence conditions to investigate their relationship with pitch-angle scattering and isotropization; and (5) explore possible differences in how H^+ and He^+ pickup ions respond to magnetic turbulence.

Disciplines: physics, math, computer science

Importance:
This project will provide the student with hands-on experience in analyzing spacecraft data. The student will develop skills in analyzing particle velocity distributions, magnetic turbulence, and applying statistical methods. Through this work, the student will gain a better understanding of pickup-ion dynamics and wave-particle interactions. The results will contribute to our understanding of how magnetic turbulence affects the evolution of pickup-ion distributions and particle transport in the heliosphere.

Requirements:

- Preferred Major
  - Physics, Math or Computer Science
- Class work
  - Physics, Math or Computer Science
- Programming knowledge
  - Basic knowledge of Python or similar
- Software knowledge
  - NA
- Other

Biography (roughly 100-150 words):

Krishna Khanal is a postdoctoral research scientist at the Center for Space Plasma and Aeronomic Research (CSPAR) at the University of Alabama in Huntsville (UAH). He earned his PhD from UAH in May 2025. His research focuses on space plasma physics, with particular interests in solar wind turbulence, coronal heating, magnetic reconnection, and particle transport and acceleration in the heliosphere. His work involves theoretical modeling and analysis of spacecraft observations to better understand the physical processes governing space plasmas, including turbulence and wave-particle interactions.

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

Contact information:

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Name(s) of Mentor(s) and contact information:

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Internship Coordinator/ HR manager:

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