Master Thesis Project (30 hp):

Solar wind interaction with lunar crustal fields

Department of Physics at Umeå University
Contact: Shahab Fatemi (shahab.fatemi@umu.se)

Are you fascinated by space, computational modeling, and plasma physics? Join our exciting research project and explore the complex interaction between the solar wind and the Moon's unique crustal magnetic fields!

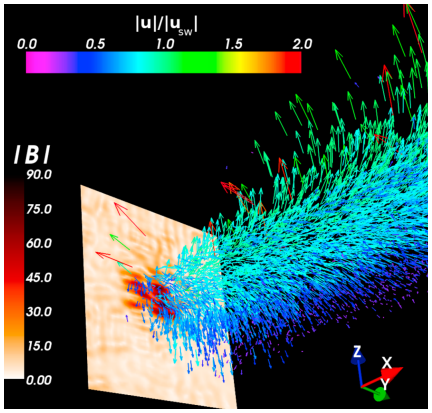

Fig. 1. Solar wind interaction with a localized crustal field [Fatemi et al., 2015]

Project Title:

Solar wind interaction with lunar crustal fields.

Introduction:

Lunar exploration is rapidly gaining momentum, with more than ***50 missions*** planned over the next 8 years to land on the Moon's surface. The Moon's proximity, potential resources like water ice, and its role as a stepping stone for future Mars missions make it a prime target for scientific research. However, many aspects of the Moon remain poorly understood, particularly its magnetic environment. While the Moon lacks a global magnetic field, certain regions, known as lunar crustal fields, retain ancient magnetic signatures. These localized fields are thought to shape the Moon's plasma environment and contribute to the formation of mysterious surface features called "lunar swirls". These bright and dark patterns, visible from Earth with good binoculars, are believed to result from the deflection of solar wind plasma by the crustal fields, altering surface weathering processes. In November 2025, NASA's Lunar Vertex mission will investigate these swirls and the Moon's magnetization for the first time, marking a significant step forward in lunar science, and Umeå University is involved in this fascinating exploration through Dr. Fatemi.

Project Overview:

In this project, you will use the Amitis code (www.amitiscode.com), a cutting-edge, high-performance GPU-based simulation tool, to model how the solar wind interacts with the Moon's crustal magnetic fields on a global scale. Your main objective will be to analyze the simulation results and explore how the interaction between the solar wind and lunar crustal fields impacts the Moon's plasma and electromagnetic environment. You will compare these simulations with spacecraft observations to gain deeper insights. Additionally, you will work with three different spherical harmonic models to represent the lunar crustal fields. By running simulations, you will determine which spherical harmonic model and set of parameters best represent the lunar magnetic environment.

Expected knowledge and skills:

- Basic understanding of 3D geometries,
- Space physics and/or plasma physics,
- Experience with Python for data analysis,
- Enthusiasm for space plasma physics and computer simulations.

No model development is required, making this project ideal for students interested in data-driven simulation and analysis. Do not miss the chance to contribute to lunar exploration!

For more details or to apply, please contact Dr. Shahab Fatemi at the Department of Physics at Umeå University (e-mail: shahab.fatemi@umu.se).