**Project Title**:
Simulation of dust particles in an ambient magnetic field

**Project Reference Code:**
UAH-Nakanotani

**Host Facility**:
The University of Alabama in Huntsville

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

**Project Description**:
Dust particles exist everywhere in interstellar and interplanetary space and can form interesting structures. For example, the dust tail of a comet appears due to an interaction between a comet and the solar wind, the well-known rings of Saturn are made of micron- to submicron-sized dust particles, and a nebula is a giant cloud of dust particles and plasma gas. Some nebulae are nurseries for the birth of stars. Since dust particles are charged, they can couple with ambient plasma, a gas of charged particles, in space (so-called dusty plasma). This coupling modifies the dispersion relation of linear waves and causes wave damping due to dust particles. Moreover, charged dust particles experience the Lorentz force from the magnetic field, which universally exists in space.

In this project, we focus on a self-gravitational instability due to dust particles, such as the Jeans instability. The instability occurs when the dust pressure cannot balance the gravitational force, so that dust particles begin to experience self-contraction. It is thought to be a fundamental process governing the collapse of astrophysical objects and the formation of stars. The main purpose of the project is for the student to derive the dispersion relation of the Jeans instability in an ambient magnetic field and develop and use a simulation code to study the nonlinear evolution of the instability. The simulation technique we will use is the so-called Particle-In-Cell (PIC) simulation method. In the simulation, dust particles are treated as a super-particles representing a certain number of dust particles, and the gravitational potential is defined on grids in the simulation domain. The super-particles are advanced by solving the equation of motion including the gravitational force and the Lorentz force of the ambient magnetic field, and the gravitational potential is solved using the Poisson equation. The student will achieve the understanding of the dynamics of dust particles in an ambient magnetic field through theory and simulation.

**Disciplines**:
Physics, Math, Computer Science, Space Science

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

**Internship Location and COVID-19 related Backup Plan**

The internship location at the University of Huntsville. We are planning for an in-person internship. However, due to the continuing COVID-19 pandemic, we are preparing additional options to ensure that the internship will take place, such as a hybrid or fully virtual option.

**Name(s) of Mentor(s) and contact information**:
Masaru Nakanotani (mn0052@uah.edu)
Gary P. 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.