Title: Numerical studies of ionopsheric plasma phenomena.

Plasma is a partially or fully ionized gas, which contains electrons, ions and neutral particles. It is thus a fluid that is also subjected to electromagnetic forces. Plasma can be found both in nature and in man-made devices. Examples of naturally occurring plasmas are the Sun, interplanetary space, the Earth ionosphere, or atmospheric lightning, while man-made devices include tokamaks, or electric discharges such as light tubes or neon lights. Plasma is also characterized by collective phenomena and can support many types of waves and instabilities.

An instability that is of particular interest for the studies of the E-region ionosphere is the Farley-Buneman instability, which can be understood as a modified two-stream instability. Due to collisions with neutral particles, ions become unmagnetized while the electrons are subject to the ExB drift. Under certain conditions, when the difference in the flow velocity for the two species is large enough, the plasma instability occurs. This kinetic instability has been extensively studied theoretically, and is now being studied numerically, in particular with the particle –in-cell methods (PIC).

To simulate the Farley-Buneman instability, it is crucial to accommodate for long wavelength in the direction of the magnetic field. This makes the PIC simulations challenging: accommodating long wavelengths in the simulations and resolving the smallest spatial scales, i.e., the Debye length requires large computer memory for the grid, and distribution of the grid on several processors.

In the present project, we will focus on the development of the flexible Poisson solver for the PIC simulations that can be used on parallel computer systems and will be incorporated into the existing DiP3D PIC code at the plasma- and space physics group, UiO. The solver will be operating on a regular grid, and will open for possibility of using/implementing different boundary conditions.

With the new solver implemented, we will proceed to study the Farley-Buneman instability for the ionospheric conditions, and characterize the instability in terms of plasma parameters and flow speed. The results will be discussed in the context of recent literature on the topic.

Timeplan / Milestones:

September 2015:

Determining the framework of the parallel field solver. Learning the DiP3D code structure.
Literature review on the PIC codes and methods for solving the Poisson equation.

October-November 2015:

Development of the new parallel field solver. Testing in the parallel environment.

December 2015:

Finalizing the solver, creating documentation in terms of performance and utility.

January 2016:

Literature review on the Farley Buneman instability.
Running simulations on supercomputer with the DiP3D code.

February 2016:

Performing numerical simulations and data analysis.

March 2016:

Discussion of the results.

April 2016:

Thesis writing.

Assoc. Prof. Wojciech Jacek Miloch

Gullik Killie

Gullik V. Killie