COMputational Astrophysics and Cosmology Workshop (COMAC2018) MHD Simulations in Astrophysics and Space Plasma

Monday 02 July 2018 - Friday 06 July 2018

Lotus Pang Suan Kaew Hotel

Scientific Programme

The workshop consists of lectures and hands-on practical sessions cover topics in astrophysical MHD simulations and space plasma.

Topics

1. Kinetic Theory of Collisionless Plasma (Dr. Jonathan Nichols)

The motion of particles in E-M fields, pitch angle evolution and an intro to the fluid description of a plasma

Topics of particle motion in steady electromagnetic fields include:
Motion in uniform and non-uniform steady B fields - gyration, mirror motion, first adiabatic invariant.
E_|| is usually zero
ExB drift
Frozen in flow
Gradient and curvature drifts
Briefly, effect of collisions - Pedersen and Hall currents, loss cone

Practical Session:
In the practical session, the students will be led through coding up a simple solver for uniform B (zero E) using first an Euler stepper, then RK4. They will then be given a more complex version with particle populations, various E and B configurations (uniform, irrotational grad B, mirror), along with options such as collisions, wave-particle interactions, absorption etc. for the students to explore the concepts discussed above. Student will be guided with a few set tasks/preset configurations etc.

2. Magnetic field and plasma models for giant planets (Prof. Nick Archilleos)

Basic introduction to magnetospheres and MHD

Practical Session: magnetodisc model, which is force balance and magnetic field structure

3. particle-in-cell (PIC) models (Dr. Patrick Guio)

4. Magnetosphere-Ionosphere Coupling (Dr. Licia Ray)
MHD codes are excellent at describing large scale system dynamics, but what happens when small scale or non-ideal physics get in the way? In astrophysical regions with small plasma densities and large magnetic field strengths, MHD becomes too computationally intense to describe the global system. Additionally, MHD cannot describe the magnetic field-aligned electric fields that often develop in the high latitudes of planetary systems. To circumvent this problem, magnetosphere-ionosphere (MI) coupling models are often used. We will cover the ins and outs of MI coupling models: underlying assumptions, applications, and their place in the broader context of Astrophysical Modelling.

5. Lectures and tutorial on MPI and CUDA (Dr. Jongsoo Kim)
In order to do competitive high-resolution simulations, one has to use a numerical code designed for using hundreds or thousands of computing cores. In fact, most of MHD codes available today are written based on the MPI library, which enables us to use many cores in a distributed computing cluster. Students, who are going to use those codes, should be familiar with the library. Scientific computation with GPUs are now getting popular in almost every discipline of science. This trend is due to the fact that GPUs have many more computing cores and much faster memory than CPUs (Computing Processing Units) do. With the invent of the CUDA, GPU programming for scientific

calculations becomes possible for scientists and engineers without in-depth knowledge of computer programming. Lectures and Tutorials on MPI and CUDA are prepared for students who are not familiar with MPI and CUDA. Brief introduction of the MPI and CUDA will be given. Then there will be tutorials on several problems, addition of two vectors, multiplication of two matrices, calculation of the pi value, and solution of Poisson equation, etc.