PLASMA PHYSICS VIA COMPUTER SIMULATION

USING PARTICLES

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This course starts with one-dimensional electrostatic models and progresses to two and three dimensions, and then to fully electromagnetic models; applications are given with all models.

The tentative schedule is as follows:

Part I, November 18, 19, 20, 1981. 12 hours of lecture

The validity of particle simulations.

Overview of and methods used in a 1d electrostatic code, ES1.

Projects for ES1: cold plasma oscillations, hybrid oscillations, two-stream instability, beam-plasma instability, Dory-Guest-Harris (ring) instability; initial parameters, selected results.

Particle-fluid combination (hybrid); application to weak beam-plasma instability, ring-plasma instability.

Effects of the spatial gridding on the physics: dispersion, stability.

Algorithms for 2d codes: inversion symmetry, collisions, self-heating.

Stretching 1d codes to 2d: lower-hybrid drift instability using linearized electron susceptibility and check with 2d results.

Stretching 1d codes to 3d: drift-cyclotron modes in a mirror machine.

Spatial smoothing, using Fourier or digital filtering, in 1, 2, 3d.

Caution on the use of ik for ∇ and $-k^2$ for ∇^2; distributed vs local.

Adding collisions, creation-annihilation (ionization-recombination), radiation.

Treatment of fields and particles at boundaries (emitting, absorbing, reflecting).

Part II, December 9, 10, 11, 1981. 12 hours of lecture

Methods used in a 1d electromagnetic code, EM1: applications.

Methods used in a 2d electromagnetic code, ZOHAR: applications.

Darwin and magnetostatic versions of electromagnetic codes; extension to quasineutral coding: applications.

Energy conserving algorithm.

Multipole expansion algorithms; comparison with weighted particles.

Effects of the time stepping on the physics: explicit methods.

Use of implicit time stepping to filter out high frequencies: limitations to implicit methods: orbit averaging: applications.

Initial values for nonuniform velocity and spatial distributions: quiet start versus use of random (or other) numbers: application to Landau damping.

Non-neutral plasmas: plasma diodes, sheaths, double layers, expanding plasmas.

Transport, long time scales.

Comments on use of several ion species

Course notes, in outline form, will be available. Main text is Birdsall and Langdon, PLASMA PHYSICS via COMPUTER SIMULATION, McGraw-Hill, 1982.