QUASINEUTRAL PARTICLE SIMULATION APPROACH FOR WHISTLERS

Lampe, Martin [1], Joyce, Glenn [2], Manheimer, Wallace [3]

[1]Naval Research Laboratory - Code 6709, Washington, DC 20375-5346
[2]School of Computational Sciences, George Mason University, Fairfax, VA 22030
[3]Icarus Corp., Bethesda, MD

We have developed a new simulation scheme for whistlers which is fully kinetic and fully nonlinear, works in homogeneous or inhomogeneous situations, is not restricted to a single coherent mode, eliminates the speed-of-light time scale and the electron plasma oscillation time scale, and concentrates simulation resources on the parts of the electron distribution that make kinetic contributions to wave growth. The elements of the scheme are as follows. (1) The plasma is represented as a cold fluid component plus a set of simulation particles. At our option, the simulation particles can be chosen to represent any part of the electron velocity distribution that is of kinetic interest, e.g. the complete ensemble of energetic electrons, or only a set of resonant electrons. (2) Quasineutrality (QN) is assumed, i.e. div J=0. We emphasize that this does not mean that there are no electrostatic fields, only that $|n_i - n_e| << n_e$ and that the electric field E is determined by QN, rather than by solving Poissons equation. This assumption is appropriate when the frequencies of interest are slow compared to the plasma frequency, and it eliminates plasma oscillations from the system. In our case, an elliptic equation for E is derived that combines Faradays and Amperes laws, the cold fluid momentum equation, and a stress tensor constructed from the particle velocities. (3) The displacement current is neglected, since the waves of interest are slow compared to c. This is similar to the Darwin model. However, (1) and (2) allow us to neglect the *full* displacement current, not just the solenoidal part, and thereby avoid all of the complications of the Darwin model. (4) Faradays and Amperes laws, rather than a momentum conservation equation, are used to push the cold fluid velocity. This guarantees QN. (5) The simulation particles are pushed in standard PIC fashion. (6) The magnetic field is determined by Amperes law. In the linear regime, the scheme reproduces the quasi-longitudinal dispersion relation for whistlers, and is accurate for propagation angles up to the resonance cone. A stable and accurate predictor-corrector scheme is used to solve the equations. The code need not resolve spatial scales smaller than the wavelengths of interest, nor time scales shorter than the gyrofrequency. We have used the code to study long-time nonlinear evolution of whistler instabilities; results will be shown for a variety of situations.

Abstract Submission Form

2004 National Radio Science Meeting

Abstract: lampe22522

Date Received: September 24, 2004

1. (a) Martin Lampe
4216 Van Buren Street
University Park, MD
20782-1187 USA
`lampe@nrl.navy.mil`
(b) 202-767-4041
(c) 202-767-1607

2. H - Waves in Plasma
3. (a) Radiation belt physics
4. I - Invited Paper, Program chair: Ganguli/Ginet
5. No special instructions