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TH/P6-08: Differences Between QL and Exact Ion Cyclotron Resonant Diffusion

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This work reports on some differences between ICRF quasi-linear (QL) diffusion theory and diffusion coefficients obtained with an exact orbit calculation using the DC (Diffusion Coefficient) code. The calculations model NPA experimental results for an Ion Cyclotron Resonant Heating (ICRH) C-Mod minority heating experiment. The DC results indicate a shorter rampup time for NPA fluxes than obtained using QL theory, in general agreement with the experiment.
Diffusion coefficients calculated with ICRF quasilinear(QL) theory are compared with results from exact Lorentz orbits in full-wave fields from the AORSA full-wave code. The orbit-calculations are carried out using the parallelized, DC code which calculates nonlinear RF diffusion by suitable average of RF induced changes in particle velocity by numerically integrating the ion Lorentz force equation in the combined equilibrium and RF EM fields. Inclusion of a full toroidal mode spectrum shows that most correlations cease to exist after one poloidal circuit, justifying modeling of the diffusion with the dominant n_phi=10 mode, neglecting correlations beyond the first turn. This enables faster time-dependent modeling of the minority hydrogen distribution function. The radial power absorption profiles are quite close, whether using QL theory or the full DC diffusion coefficients. However, a significant discrepancy does appear for pitch angle diffusion at near perpendicular angle in velocity space. Our working hypothesis is that this results from a finite gyro-orbit effect, which becomes important at higher energies.
The C-Mod, vertically viewing Neutral Particle Analyzer has, in separate studies by Dr. Aaron Bader, MIT, been shown to produce steady state spectra in reasonably good agreement with the coupled AORSA(QL)-CQL3D Fokker-Planck simulations. However, the NPA fluxes achieve steady state more rapidly than the QL simulations predict, and also decay significantly faster. On the other hand, the coupled, time-dependent AORSA-DC-CQL3D calculation shows that the additional pitch angle scattering, discovered with DC, provides an explanation of the more rapid NPA flux turn-on. The vertical NPA is particularly sensitive to the near perpendicular velocity fast ions populated by the additional pitch angle scattering. Simulation of the turn-off phase of the fast ion distribution is in progress.

Country or International Organization of Primary Author

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