Impurity Turbulent Transport Studies using Gyro-Fluid Models

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Impurity transport is modeled with gyrofluid simulations and theory for C-Mod discharges with internal transport barriers (ITBs) with peaked main-ion profiles that would lead to higher core reactivity in ITER. We collected a small database of relevant C-Mod discharges and calculate and estimate the large number of dimensionless parameters required to obtain the eigenvalues and eigenvectors for each discharge. From the eigenvectors, which give the polarization of the multi-component fluctuations, we construct the main ion and impurity particle fluxes to within a component fluctuation spectrum $I(k)$ function. We use simulations and nonlinear theory to derive formulas for the spectrum. The result is a fast code that gives the particle fluxes as a function of the state of the plasma that could run in realtime on the transport time scale. To determine the separate diffusivities and pinch velocities we plot the particle flux versus the density gradient for each species and extract the slope and the intercept of the resulting function using a straight line fit as shown in Fig.1. Both peaked and hollow impurity profiles are observed in C-Mod and analyzed with theory and simulations. The I-mode with peaked density and temperature profiles is analyzed. We extrapolate the C-Mod parameters for boron to the ITER parameters for beryllium to search for trends of interest for the large tokamak. The results for quasilinear fluxes for a specified plasma discharge with measured boron profile in C-Mod are as shown in Fig. 1 for a typical hollow impurity profile. The four component eigenvector $X(k_y) = [\delta n_e, \delta n_i, \delta n_z, e\phi_k]$ is computed. The transport fluxes are used in the UT-radial transport code called TBD developed in 2000 to deal with the fast time and small space scales of ITBs and was used to produce transport barriers[2]. In C-Mod ITB plasmas, a deep "well" in the radial electric field profile is inferred from the spectral shifts of line emissions.

References

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