講演番号をこちらに

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Validation of a Fokker-Planck code for current drive analysis in fusion plasmas

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Current drive (CD) in fusion plasmas is essential for maintaining a steady state, improving transport, and controlling instabilities. The CD using electron cyclotron (EC) waves is called ECCD, and is used for rotational transform control, transport barrier formation, neoclassical tearing mode (NTM) control, and Alfvén mode control. The validation of an ECCD model is desired to estimate the experimental efficiency of ECCD and to predict the efficiency with high prediction accuracy extrapolated to fusion reactors. In tokamaks, although measurements can give ohmic and bootstrap currents, measurements cannot simply provide the current distribution of ECCD from experiments. Therefore, developing a theoretical approach is valid. As a practical matter, the kinetic code TRAVIS is used to evaluate the power absorption and current driven by ECCD in LHD plasmas. In some cases, however, it cannot explain the driven current for experiments. The discrepancy may be due to problems of an electron diffusion model in the velocity and real space involved in the ECCD code.

In this study, the quasilinear code TASK/FP, which calculates the Fokker-Planck equation (FPE), is used to evaluate the efficiency of ECCD. The DC electric field term, the Coulomb collision term, and the Quasilinear diffusion term of the FPE are compared with the theoretical equations and calculated values in the reference paper to validate the models. As a result of the validation, the electrical conductivity obtained from the FP calculations is in good agreement with the analytical solution of the Spitzer conductivity as shown in Figure 1.1 and 1.2, which means we can verify the operation of the DC electric field term and the Coulomb collision term is correct. The time evolution of the ECCD efficiency as shown in Figure 2, is in good agreement with the values in the reference [1] in calculations with a simplified model simulating a lower hybrid current drive (LHCD) by giving the constant diffusion coefficient. The velocity distribution function, in this case, is also in good agreement with the calculations of the previous study [1]. This allowed us to verify the operation of the Quasilinear diffusion term. Further validation will be carried out by the influence of trapped particles due to non-uniform magnetic field.

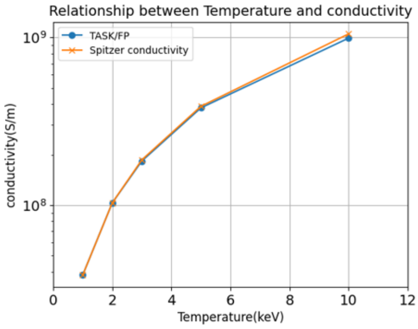

Figure.1.1 Relationship between Temperature and conductivity

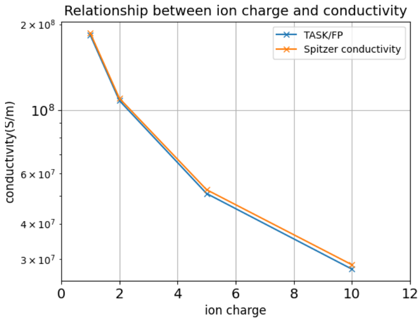

Figure.1.2 Relationship between Ion charge and conductivity

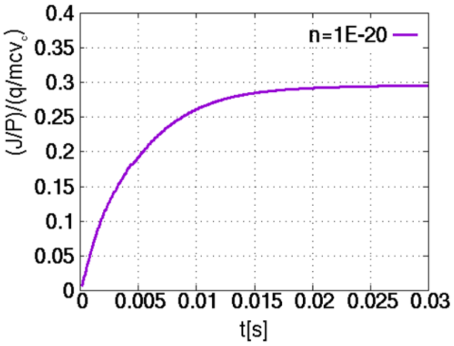

Figure.2. Time evolution of the normalized current drive efficiency, $J/P = 0.295q/mcv_c$ in steady state, in good agreement with the literature value $0.296q/mcv_c$

[1] Karney, C. F., Fisch, N. J. (1985). Efficiency of current drive by fast waves. The Physics of fluids, 28(1), 116-126.