Fokker-Planck modelling of Electron Cyclotron Current Drive including magnetic diffusion self-consistently

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The bounce averaged Fokker - Planck model is a widely accepted method for the calculation of the noninductive current drive generated by Electron Cyclotron (EC) waves. However, the common realization of the model does not include inductive effects of the current density evolution [1]. Any changes in the current density induced by EC waves are followed up by changes in the electric field profile which tend to counteract the EC-driven current. This synergism between EC-driven current and the ohmic current could be particulary important for the on-axis deposition where the current densities of both of them are comparable. Under these circumstances, the use of neoclassical resistivity in the diffusive evolution of the current density is not correct. In the first place when we try to describe the switch on of the EC field the relevant timescales are shorter than the collisional timescales. On these timescales the concept of resistivity is ill defined. In the second place the evolution of the velocity distribution is subject to the combined action of the locally induced electric field and the EC-wave field. The synergy between EC-wave absorption and the electric field will result in a decrease of the resistivity.

In this report the problems of treating these equations fully self consistently will be addressed. The use of the induction equation for the electric field evolution invariably leads to numerical instability. An approximate solution for the electric field evolution is proposed by introducing an artificial resistivity at every time step which is based on the solution of the Fokker - Planck model at that time step. This method is acceptable for cases where the non inductively driven current density is not too large compared to the inductively driven one. Using the approximate method, several typical situations are modelled which can occur in a tokamak, such as on- and off- axis depositions of the EC waves. The results with an electric field evolving in time and radius are compared to the outcome with a constant electric field.

References

[1] E. Westerhof, Open Questions In Electron Cyclotron Wave Theory, EC13 Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating, Nizhny Novgorod, Russia, 17-20 May 2004.