LOCAL MEASUREMENTS OF CURRENT DRIVE BY ELECTRON CYCLOTRON WAVES

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The phenomenon of current drive is a sensitive measure of the interaction in velocity space between electrons and electron cyclotron waves. By changing the parallel wavenumber and damping strength, the peak location of the resonant interaction can be varied in velocity space with measurable consequences for the electron cyclotron current drive (ECCD). Distortions in the electron distribution function caused by quasi-linear effects, or the effects of a parallel electric field and the trapped-passing boundary, can also alter the current drive. Fokker-Planck codes contain a complete model of this wave-particle interaction, but experimental validation of the physics is needed. This is best accomplished by comparing a local measurement of the current density driven by electron cyclotron waves to the theoretical computations.

Several methods are available for measuring the ECCD. The majority of studies on tokamaks and stellarators have determined the magnitude of the current drive using the zero-dimensional circuit equation [1]. This is a particularly accurate method when complete non-inductive current drive is achieved [2]. If internal magnetic measurements are available, *e.g.*, from motional Stark effect (MSE) spectroscopy, then the location and width of the ECCD profile, in addition to the magnitude, can be measured even for small driven currents. Quantitative determination of the ECCD profile falls into three categories: deduction, induction, and modulation. In the deductive approach, the non-inductive current drive is found from the evolution of the poloidal magnetic flux obtained from a time series of magnetic equilibrium reconstructions constrained by MSE data [3]. In the inductive approach, the measured MSE signals are compared to realistic simulations using a coupled transport-equilibrium code that contains an ECCD model [4]. The parameters of the ECCD model — location, width, and magnitude — are adjusted until a best fit is obtained. In the modulation approach, the ECCD profile is found directly from the periodic response of the MSE signals to a slow modulation of the gyrotron power using the poloidal flux diffusion equation [5].

Using these analysis methods, detailed measurements of the ECCD have tested the velocity space wave-particle interaction in several machines, the goal being to validate a predictive model of ECCD. In particular, the effects of electron trapping have been studied using scans of the poloidal and radial location of deposition as well as varying the electron pressure. Scans of the parallel wavenumber allowed both co and counter ECCD to be checked. The quasi-linear effects from high power density and the parallel electric field were also examined. Overall, the measured ECCD was found to be in better agreement with quasi-linear Fokker-Planck codes than calculations using only linear theory.

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