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Current Profile Modification with Electron Cyclotron Current Drive[1]

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Generation of localized current by electron cyclotron (EC) waves offers the possibility of steady-state current sustainment, active current profile control, and instability suppression. This work represents the first proof-of-principle determination of both on-axis and off-axis current drive derived from local measurements of the internal magnetic fields. The EC waves are generated by two 110 GHz gyrotrons (0.9 MW and 0.8 MW for 1 s pulses) and are transmitted to the plasma by overmoded evacuated transmission line. The deposition can be varied by changing the poloidal angle of the final launching mirror or by changing the toroidal magnetic field. For central aiming with oblique launch, electron cyclotron current drive (ECCD) up to 100 kA has been driven with 1.2 MW of EC power. The current drive figure of merit has the expected linear dependence on electron temperature and is comparable to that in previous experiments on DIII–D for ECCD and for fast wave current drive. During the central ECCD, the loop voltage on axis becomes negative, indicating that the driven current density exceeds the Ohmic current density before the ECCD is applied. The internal inductance rises and the central safety factor $q(0)$ falls compared to the case without current drive, as expected. When the EC deposition is moved off-axis to $\rho = 0.4$, the total noninductive current rises by up to 100 kA compared to a discharge without ECCD, and the current profile broadens. The increase in noninductive current is both EC current drive and neutral beam current drive (NBCD) enhanced by the elevated temperature, but the broadening of the current profile indicates the bulk of the current is EC-driven current. The off-axis EC-driven current exceeds the current predicted by theoretical modeling, which is small due to the Ohkawa effect. The difference from linear theory is qualitatively consistent with previous calculations of electric field enhancement of ECCD. A scan of the major radius of the deposition at fixed minor radius ($\rho = 0.4$) indicates substantially more current is driven with the resonance on the high field side of the axis, as expected from consideration of the local fraction of trapped particles. The magnitude of the effects is being compared with Fokker-Planck code calculations.

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