OFF-AXIS ELECTRON CYCLOTRON CURRENT DRIVE MEASUREMENTS ON THE DIII–D TOKAMAK*

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Local measurements of the current density profile driven by electron cyclotron waves have been made on the DIII–D tokamak. Since electron cyclotron current drive (ECCD) experiments for advanced tokamak scenarios need narrow beams in nearly pure X–mode to satisfy the requirement of highly localized deposition and current drive, the deposition profile and polarization of the absorbed electron cyclotron waves were measured by modulating the injected power while the fraction of launched X–mode power was scanned from nearly 0 to nearly 100%. For central ECCD, the current drive efficiency was measured to be in excess of $0.4\times10^{19}\,\mathrm{Am^2W}$. The deposition location of the electron cyclotron waves was varied in both the radial and poloidal directions using a steerable antenna to test the effect of trapped electrons on the current drive. A poloidal angle scan of the deposition location from the high field side to the low field side of the torus at nearly fixed radius showed a decrease in the measured ECCD, indicating that the current drive efficiency was degraded by the effects of electron trapping. However, the experimental decrease in ECCD was not nearly as strong as the theoretical prediction from bounce-averaged Fokker-Planck calculations, which predicted that the current drive should go to zero (or even negative) when the resonance was on the low field side. In addition, a radial scan of the deposition location at fixed poloidal angle showed no degradation in the measured ECCD efficiency beyond that associated with the decrease in the local electron temperature, whereas bounce-averaged Fokker-Planck calculations again predicted a large decrease due to trapped electron effects. Theoretical investigations indicate that finite collisionality, neglected in bounce-averaged calculations, may be responsible for the higher than expected ECCD efficiencies for off-axis deposition. Additional experiments in ELMing H–mode plasmas will study the potential problems with electron cyclotron wave propogation through the steep density gradient region near the plasma edge, where the WKB approximation may be no longer valid and unwanted mode coupling may take place between the X–mode and O–mode branches, and where ELMs may refract the beam and spread out the deposition region.

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