Experimental Edge Fluctuation Broadening of ECRF on the DIII-D Tokamak

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Millimeter-scale turbulence is associated with a broadening of the deposition of gyrotron power used for heating and current drive in the DIII-D tokamak. Over a set of edge conditions produced in DIII-D experiments, Doppler backscattering measures an order of magnitude variation in density fluctuation level which scales linearly with a x1.4-2.7 broadening of ECH deposition as compared with TORAY-GA, the ray tracing code which has been used to compute gyrotron power requirements for ITER [1]. Density fluctuations present in the tokamak edge have been predicted to forward scatter RF waves with comparable wavelength [2]. This interaction can broaden the power deposition profile, impacting the utility of ECRF for local heating and current drive [3]. These predictions are verified through thermal transport analysis of experimental data, which is used to resolve the 1D radial ECH power deposition profile [4]. The T_e perturbation produced by modulation of gyrotron power is used to calculate an electron heat flux. Fitting this flux to diffusive, convective, and coupled transport terms based on the measured perturbation can resolve ECH deposition width to within ~20%. A clear discrepancy exists between experimental profile width and that derived from ray tracing using measured 1D profiles on DIII-D. Quantifying the effect of fluctuations on ECCD prior to ITER first plasma will require predictive codes, validated on the current generation of machines, but sensitive to scattering effects. Experimental parameters from DIII-D discharges have been used in a set of RF propagation codes effects – both full wave (EMIT-3D*, IPF-FDMC [1]) and kinetic ray & beam tracing codes (LUKE/C3PO [2], WKBEAM [5]) all of which reproduce a degree of broadening. The magnitude of edge fluctuation broadening observed in DIII-D could increase power requirements for NTM suppression on ITER.

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