Resolving broadening of ECRH deposition due to edge turbulence in DIII-D by heat deposition measurement

M W Brookman,[1,†] M B Thomas,[2] J Leddy,[2] C C Petty,[3] R J La Haye,[3] K Barada,[4] T L Rhodes,[4] Z Yan,[5] M E Austin,[1] K W Gentle,[1] and R G L Vann[2]

[1]Institute for Fusion Studies, Department of Physics,
University of Texas at Austin, Austin TX
[2]York Plasma Institute, Department of Physics,
University of York, York Y0105DD, UK
[3]General Atomics, San Diego, CA
[4]University of California, Los Angeles, CA
[5]University of Wisconsin – Madison, WI

(Dated: September 7, 2017)

Abstract

Interaction between microwave power, used for local heating and mode control, and density fluctuations can produce a broadening of the injected beam, as confirmed in experiment and simulation. Increased power deposition width could impact suppression of tearing mode structures on ITER[1]. This work discusses the experimental portion of an effort to understand scattering of injected microwaves by turbulence on the DIII-D tokamak. The corresponding theoretical modeling work can be found in M.B. Thomas et. al.: Submitted to Nuclear Fusion (2017) [Author Note - this paper to be published in same journal]. In a set of perturbative heat transport experiments, tokamak edge millimeter-scale fluctuation levels and microwave heat deposition are measured simultaneously. Beam broadening is separated from heat transport through fitting of modulated fluxes[2]. Electron temperature measurements from a 500 kHz, 48-channel ECE radiometer are Fourier analyzed and used to calculate a deposition-dependent flux[3]. Consistency of this flux with a transport model is evaluated. A diffusive(/ r˜ T_e) and convective(/ ˜ T_e) transport solution is linearized and compared with energy conservation-derived fluxes. Comparison between these two forms of heat flux is used to evaluate the quality of ECRF deposition profiles, and a 2 minimization finds a significant broadening of 1D equilibrium ray tracing calculations from the benchmarked TORAY-GA ray tracing code[4] is needed. The physical basis, cross-validation, and application of the heat flux method is presented. The method is applied to a range of DIII-D discharges and finds a broadening factor of the deposition profile width which scales linearly with edge density fluctuation level. These experimental results are found to be consistent with the full-wave beam broadening measured by the 3D full wave simulations in the same discharges[5].