Quantifying electron cyclotron power deposition broadening in DIII-D

J.H. Slief [1,2], R.J.R. van Kampen[1,2], M.W. Brookman[3], M. van Berkel[1]

[1] *DIFFER, Eindhoven, the Netherlands*

[2] *Eindhoven University of Technology, Eindhoven, the Netherlands*

[3] *General Atomics, San Diego, USA*

Electron cyclotron (EC) radiation is a powerful tool in fusion devices. Compared to other heating and current drive methods, millimeter EC waves exhibit a particularly localized resonance and a radially narrow power deposition region. Localized deposition allows EC radiation to be used for a wide variety of applications, including (but not limited to) perturbative transport studies, profile control, and MHD control.

The exact width and shape of the power deposition profile must be well known for the above applications and is typically estimated using forward methods (i.e. beam/ray tracing). However, both experimental and numerical studies have indicated that power deposition profiles may be broader than traditional forward methods indicate and have linked this effect to plasma edge turbulence [1]. This has significant implications for EC applications in future large fusion devices [1]. To help quantify this effect ahead of ITER operation, we aim to measure the ECH power deposition profile in a set of DIII-D discharge and compare that to forward estimations.

We use four inverse methods to compute the deposition profile from ECE and Thomson scattering measurements: break-in-slope (BIS) [2], maximum likelihood estimation (MLE) [3], frequency domain least squares (FDLS) [4] and flux fit [5]. We apply these methods to a set of 6 discharges from DIII-D spanning a range of confinement modes (limited and diverted L-mode, H- and QH-mode and negative triangularity) and compare against the established ray-tracing code TORAY [6].

We measure significant broadening across all six discharges: between 1.6 and 6.2 times over the TORAY estimates depending on the discharge and method. Most of the broadening (i.e. in five out of six discharges) observed is between 1.6 and 3.6 times. We show that this level of broadening in ITER will have serious consequences for the NTM control system.

References

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