August 2017

Microwave Power Scattering by Plasma Fluctuations

Experiments at the DIII-D National Fusion Facility measure the interaction between RF power and millimeter-scale turbulence

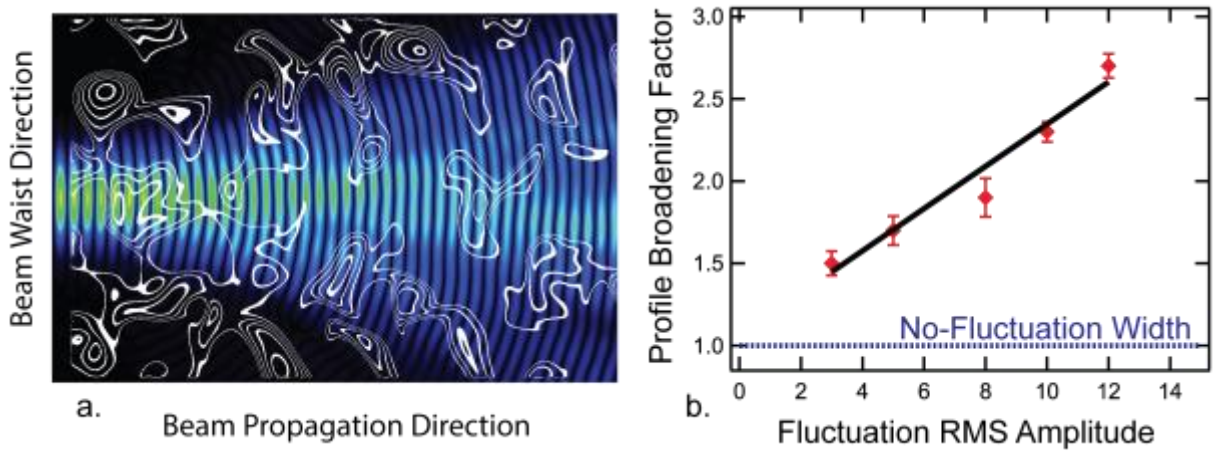

Fig: a.) Simulations find microwave beam propagation through turbulent structures of a similar scale (shown in white) leads to broadening of the RF beam. b.) A collection of different regimes on the DIII-D tokamak finds a linear relation between the edge fluctuation level and the degree of beam broadening as compared with fluctuation-free ray tracing.

Images by A. Koln, M. Brookman (Fig. a courtesy of EPJ Web of Conferences)

The Science

Megawatts of microwave power are precisely targeted to ensure high performance in fusion plasmas. An investigation on the DIII-D tokamak has looked for evidence of the scattering of RF power by density fluctuations through perturbative heating experiments, identifying the first correlation of deposition broadening with edge fluctuation level.

The Impact

Localized RF current drive can be used to sustain high-gain magnetic fusion reactors by controlling the plasma current profile and suppressing the formation of magnetic islands. ITER, the magnetic fusion reactor currently being built by an international collaboration including the United States, will use 20 MW of targeted microwave power to prevent disruptions caused by

magnetic islands and improve plasma confinement. Broadening of the RF deposition, evidenced for the first time in this work from the response of the electron temperature to RF heating modulations, could increase the power or modulation requirements of this technique.

Summary

In a set of DIII-D experiments, a variation of edge conditions over different plasma regimes produce an order of magnitude variation in edge RMS density turbulence measured by Doppler Backscattering. Analysis of microwave power modulation in these discharges has found an x1.4-2.7 broadening of the radial deposition of electron cyclotron waves as compared with TORAY-GA, the ray tracing code which has been used to compute power requirements for the ITER fusion reactor [1]. Density fluctuations present in the tokamak edge have been predicted to forward scatter RF waves with comparable wavelength [2]. This work supports a strong linear correlation between RMS fluctuation amplitude and the degree of broadening which has only previously been simulated [3]. These experiments provide a dataset against which of fluctuation-sensitive RF propagation simulations are being compared.

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Funding

This material is based upon work supported by the Department of Energy, Office of Fusion Energy Sciences, using the DIII-D National Fusion Facility, a DOE Office of Science user facility, under Award DE-FC02-04ER54698 and DE-FG03-97ER54415. DIII-D data shown in this paper can be obtained in digital format by following the links at https://fusion.gat.com/global/D3D_DMP

Publications

“Experimental Measurement of ECH Deposition Broadening: Beyond Anomalous Transport” M.W. Brookman *et al, EPJ. Web,.* Accepted for Publication (2016)

“Experimental Evidence of Edge Fluctuation Broadening of ECH Deposition at DIII-D” M.W. Brookman et al, *Bull. Amer. Phys. Soc* T04.00014 (2016)

Related Links

[1] La Haye, R.J., et al., Nucl. Fusion 46, 451 (2006)

[2] A Köhn et al., Plasma Phys. Control. Fusion 58, 105008 (2016)

[3] Y. Peysson et al., Plasma Phys. Control. Fusion 58, 124028 (2016)