Contribution ID: **494** Type: **Poster**

Scattering of EC waves by Edge Turbulence: Measurements and modelling in TCV and TORPEX

Friday, 21 October 2016 14:00 (4h 45m)

High power electron cyclotron (EC) waves are used worldwide to drive current locally in the magnetically confined plasmas in toroidal devices. Narrow beams are launched obliquely from antennas well outside the plasma, entering it through the scrape-off layer (SOL) and plasma edge to stabilize neoclassical tearing modes (NTMs).
In nearly all tokamaks, stellarators and reversed-field pinches, the SOL is an extremely turbulent region with frequent, large-density, poloidally-localized, field-aligned blobs propagating rapidly towards the walls of the device. In tokamaks, blobs are observed in L-mode discharges and between Edge Localized Modes (ELMs) in H-mode plasmas. ELMs themselves cause rapid periodic changes in density and temperature in the edge pedestal region of the plasma.
In contrast to present day devices, the path length from edge-to-resonance in future devices, such as ITER, will be long enough that even small perturbations (scattering) of the beam near the edge may lead to significant beam spreading, resulting in a reduction of the peak EC driven current and thus an increase in the power required to stabilize NTMs.
This paper describes measurements made on two machines at SPC to quantify EC wave scattering by blobs; the small low-temperature, low-field, toroidally-magnetised device TORPEX and the medium sized tokamak TCV. In both, scattering of a transmitted radio-frequency (RF) beam is measured as opposed to localized plasma absorption, current drive, or associated plasma quantities. The transmission path length in TCV is similar to the edge-to-resonance length in ITER. Low power, low frequency waves are launched in TORPEX and high-power, high frequency waves in TCV. The received mm-wave signal is correlated with measurements of the blobs using conditional averaged sampling (CAS) of an extensive array of in-situ Langmuir probes in TORPEX and 2D modelling of the effect of blobs on the RF signal using the RF module of COMSOL shows good agreement with measurements. On TCV ex-plasma diagnostics - in particular a fast framing camera and an array of wall-mounted Langmuir probes - are used instead for CAS.

This work was partly supported by the Fonds National Suisse pour la Recherche Scientifique

Paper Number

EX/P8-28

Country or International Organization

Switzerland

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Session Classification: Poster 8

Track Classification: EXC - Magnetic Confinement Experiments: Confinement