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Electron Bernstein Wave Heating in the Toroidally Magnetized System

Authors : Johan Buermans, Kristel Crombé, Niek Desmet, Laura Dittrich, Andrei Goriaev, Yurii Kovtun, Daniel López-Rodriguez, Sören Möller, Per Petersson, Maja Verstraeten

Abstract : The International Thermonuclear Experimental Reactor (ITER) will rely on three sources of external heating to produce and sustain a plasma; Neutral Beam Injection (NBI), Ion Cyclotron Resonance Heating (ICRH), and Electron Cyclotron Resonance Heating (ECRH). ECRH is a way to heat the electrons in a plasma by resonant absorption of electromagnetic waves. The energy of the electrons is transferred indirectly to the ions by collisions. The electron cyclotron heating system can be directed to deposit heat in particular regions in the plasma (https://www.iter.org/mach/Heating). Electron Cyclotron Resonance Heating (ECRH) at the fundamental resonance in X-mode is limited by a low cut-off density. Electromagnetic waves cannot propagate in the region between this cut-off and the Upper Hybrid Resonance (UHR) and cannot reach the Electron Cyclotron Resonance (ECR) position. Higher harmonic heating is hence preferred in heating scenarios nowadays to overcome this problem. Additional power deposition mechanisms can occur above this threshold to increase the plasma density. This includes collisional losses in the evanescent region, resonant power coupling at the UHR, tunneling of the X-wave with resonant coupling at the ECR, and conversion to the Electron Bernstein Wave (EBW) with resonant coupling at the ECR. A more profound knowledge of these deposition mechanisms can help determine the optimal plasma production scenarios. Several ECRH experiments are performed on the TOroidally MAgnetized System (TOMAS) to identify the conditions for Electron Bernstein Wave (EBW) heating. Density and temperature profiles are measured with movable Triple Langmuir Probes in the horizontal and vertical directions. Measurements of the forwarded and reflected power allow evaluation of the coupling efficiency. Optical emission spectroscopy and camera images also contribute to plasma characterization. The influence of the injected power, magnetic field, gas pressure, and wave polarization on the different deposition mechanisms is studied, and the contribution of the Electron Bernstein Wave is evaluated. The TOMATOR 1D hydrogen-helium plasma simulator numerically describes the evolution of current less magnetized Radio Frequency plasmas in a tokamak based on Braginskii’s legal continuity and heat balance equations. This code was initially benchmarked with experimental data from TCV to determine the transport coefficients. The code is used to model the plasma parameters and the power deposition profiles. The modeling is compared with the data from the experiments.

Keywords : electron Bernstein wave, Langmuir probe, plasma characterization, TOMAS
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