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# Interaction between turbulence and ICRF

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Radio-frequency (RF) heating with waves in the Ion Cyclotron Range of Frequencies (ICRF) is one of the most widely used heating methods in nowadays magnetic confinement fusion devices. It can interact with turbulence, which is a natural phenomenon caused by small fluctuations in fusion plasmas. In this contribution, the interaction between turbulence and ICRF has been systematically studied. Both experimental and numerical results on the ASDEX Upgrade tokamak will be presented.

ICRF influences turbulence mainly by generating convective cells close to the antenna. The convective cells are generated by the inhomogenous enhanced sheath potential in the SOL, which is caused by sheath rectifications on the antenna and nearby wall due to the component of RF electric fields parallel to the magnetic field lines. The convective cells influence the turbulence transport in the SOL by the convective flows. To understand this, the Gas Puff Imaging (GPI) diagnostic is used to measure the dynamics of blobs, and the Langmiur probes in the midplane and divertor are used to measure the radial and parallel particle and energy fluxes. It is found that the ICRF convective cells generate shear E×B plasma flow (usually in the level of 1km/s) in the far SOL, which can stretch, distort and even break up the blobs poloidally [1]. Moreover, the generated shear plasma flow can lead to blob stopping, which is expected to facilitate divertor detachment. These results suggest that externally generating shear flow in the SOL can be considered as a method to modify blob transport and control the radial transport of heat fluxes.

Turbulence influences ICRF mainly by influencing the propagation of ICRF waves. In particular, the filaments and ELMs in the SOL can cause a strong scattering of the fast wave and a global perturbation of the wave fields. To understand this, experimentally, the B-dot probes near the ICRF antennas are used to measure the RF wave fields. The GPI and Langmiur probes are used to measure filaments. Numerically, the 3D edge turbulence code BOUT++ [2] with the six-field two-fluid model [3] is used to calculate the turbulence and ELMs in the SOL, and the 3D antenna code RAPLICASOL [4] is used to calculate the wave fields and the coupling resistance. Our results suggest that the larger size of the filament or the larger density perturbation inside the filament is, the larger wave scattering will be [5]. The wave scattering leads to a decrease of heating efficiency as less RF power reaches the resonance layer in the plasma core. In addition, the filaments redirect part of the RF power flow in the direction perpendicular to the magnetic field lines to the direction parallel to the magnetic field lines. [6]. The redirected power flow is largest within the filament. The redirection of RF power flow by filaments can be a new mechanism to explain the observed hot spots on the powered antennas.

Our studies greatly improve our understanding on the interaction between turbulence and ICRF, including the modification of the turbulence eddies by RF convective cells and the scattering of the RF waves by turbulence. The results are not only important for developing methods to better control turbulence transport in favorable ways, but also vital for improving RF heating efficiency and reducing undesired plasma-wall interactions in fusion devices. Further work with more quantitative comparisons between experiments and simulations will shed more light on these.

References

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