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Experimental and numerical investigation of ICRF induced turbulence reduction across the scrape-off layer on the EAST tokamak

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In magnetic confinement fusion devices, the plasma particle and energy transport depend on the turbulence transport. Ion Cyclotron Range of Frequency (ICRF) wave heating can interact with the turbulence in the plasma edge and change the turbulence transport. To understand their interaction/correlation, the radial modification of turbulence by ICRF in the scrape-off layer (SOL) were investigated using midplane reciprocating Langmuir probe, reflectometry, Doppler reflectometry and Divertor probes on the EAST tokamak.

We showed a first demonstration that this interaction occurs at all radii and affects the turbulence across the whole SOL. It was observed that ICRF attenuates the large-scale turbulence structures (usually in the form of blobs) by breaking them into smaller ones, leading to a suppression of turbulence in the whole SOL. In addition, this turbulence reduction is accompanied by an increase in the high-frequency turbulence fluctuations and an increase in the poloidal velocity in the SOL. This poloidal velocity is generated by the radial electric field shear during ICRF.

Moreover, the poloidal velocity measured by the Doppler reflectometry is shown to be significantly increased when ICRF is switched on. It is generated by the ICRF induced radial electric field shear, and is in the same level as the one in the pedestal of a H-mode. This radial electric field shear is considered as one of the most probable reasons that causing turbulence reduction in the SOL.

Furthermore, BOUT++ simulations were carried out and the results are consistent with the experiments. They show that the large-scale turbulence structures are broken into small-scale ones by the radial electric field shear in the SOL, and this radial electric field shear is supposed to be generated by the RF-rectified sheath potential. The simulations also indicate that the radial electric field shear induced nonlinear coupling of high-n modes can further lead to the increase of high frequency fluctuations in the SOL.

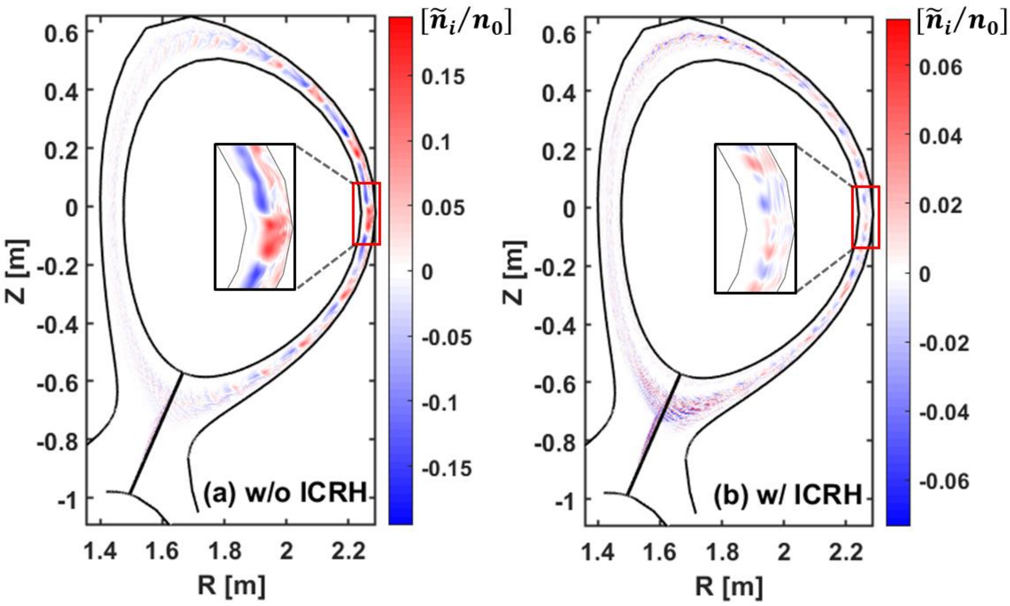

Figure 1. The BOUT++ simulated ion density fluctuations (a) without ICRH; (b) with ICRH.