Plasma edge modelling with ICRF coupling

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This contribution mainly addresses two important issues of plasma heating with waves in the Ion Cyclotron Range of Frequencies (ICRF): i) improving the ICRF power coupling; ii) understanding the ICRF – edge plasma interactions.

The coupling of ICRF power to the plasmas depends sensitively on the scrape-off layer (SOL) density in front of the antennas because the fast wave is evanescent below the cut-off density. Previous experiments on ASDEX Upgrade and JET indicate that by shifting the fuelling gas source from the divertor to the main chamber, the density in front of the antennas and thus the ICRF coupling can be greatly increased. To understand this, the 3D edge plasma fluid and neutral particle transport code EMC3-EIRENE was used to calculate 3D SOL density, and the FELICE and RAPLICASOL codes were used to calculate the antenna coupling resistances. Good qualitative agreements are found between simulations and experiments. They indicate that midplane gas puffing close to the antennas increases the ICRF coupling most significantly (by ~120%) and top gas puffing increases the coupling only to a moderate level (by 20%-40%). Calculations for ITER also show that midplane gas valves close to the antennas are most effective in increasing ICRF coupling in ITER.

There is a mutual influence between ICRF waves and plasma density at the edge, and in particular the measured density convection at the plasma edge is likely influenced by ICRF waves. This density convection is simulated with EMC3-EIRENE code by supplying the sheath potential as input in two different modalities: i) measured (forced problem); ii) calculated by running in an iterative loop - RAPLICASOL code for $E_{\|}$, SSWICH code for the sheath potential, and EMC3-EIRENE itself for the plasma density (consistency loop). The calculated density convection is in qualitative agreement with the measurements from reflectometers embedded in the antenna or reciprocating probe. The results indicate that large convective cells develop in the top and bottom of the antennas when operated with unfavorable phasing and power ratio between the straps. In comparison to the conventional 2-strap antenna, the novel 3-strap antennas installed in ASDEX Upgrade decrease the sheath potential and the associated $E\times B$ convection when operated with the proper phasing and power ratio.