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Recent progress in integrated ICRF-edge plasma modeling

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Radio-frequency (RF) heating with waves in the Ion Cyclotron Range of Frequencies (ICRF) is one of the most promising heating methods in fusion plasmas. Understanding the plasma-wave interaction is crucial for the success of this auxiliary heating system. However, the physics involved is usually quite complex, with interconnections between the various mechanisms in place. Thus, integrated modeling by coupling multiple RF and plasma codes is necessary. This contribution summarizes the recent progress of the integrated ICRF-edge plasma modeling, mainly from the following aspects:

1. ICRF power coupling. The amount of power coupled from the antenna to the plasma critically depends on the width of the evanescent layer in front of the antenna, which is ultimately defined mainly by the plasma density profile in the scrape-off layer (SOL). The use of the local gas injection to influence the density profiles in the SOL in order to reduce the evanescence layer and, thus, to maximize the ICRF power coupling further motivates a quantitative characterization of the 3D SOL density profiles and antenna loading resistances. Integrated modeling by coupling the 3D edge plasma code EMC3-EIRENE (3D) [1] with the antenna codes FELICE [2], ANTITER [3] and RAPLICASOL [4] is performed for ASDEX Upgrade [5, 6]. Similar calculations are also done for JET [7], ITER [8] and DEMO [9].
2. ICRF enhanced sheath and convection. The parallel electric field of the wave, the RF sheath potential and the edge plasma density can influence each other. Two integrated modeling methods, one by coupling the EMC3-EIRENE code with the measured RF potential [10], the other by self-consistently running the EMC3-EIREN, RAPLICASOL and SSWICH [11] codes [12], are developed to calculate the RF rectified sheath potential and RF induced edge plasma convection.
3. ICRF-edge turbulence interaction. The edge plasma turbulence can scatter the RF waves and influence the heating efficiency, while the RF generated shear flow in the SOL can in turn influence turbulence, especially the filaments. These physics are studied with the integrated JOREK [13] and RAPLICASOL modeling [14].

It is worth mentioning that most of our integrated modeling results have been compared with the experimental data. Good qualitative/quantitative agreements have been obtained. In addition, light has been shed on many physical mechanisms by this integrated modeling. The final aim of this multidisciplinary effort is to build validate tools to optimize the antenna designs and RF heating scenarios for current and future fusion machines.

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