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Ion Cyclotron Range of Frequency Power: Progress in Operation and Understanding for Experiments with Metallic Walls

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Significant progress in applying ICRF power to ASDEX Upgrade (AUG) has been achieved in the last years; this progress has been associated with a similar progress in our understanding and capability to model the relevant processes. The two main challenges of the ICRF system (power coupling and impurity production) have been tackled successfully.

First, the outer mid-plane gas injection techniques that improve the coupling of the fast wave to the confined plasma by increasing the density in front of ICRF antenna have been well established experimentally and consistently modelled numerically. With midplane gas puffing, the local edge density increase in front of the antenna leads to a shift of the fast wave cut-off position closer to the antenna by 2cm. The results were confirmed with the new density measurements in front of the antenna. The ICRF coupling increases by 120 pct (25 pct for top gas puffing).

Second, with the installation of the 3-strap antennas in AUG, it was clearly demonstrated that the ICRF-specific tungsten (W) sputtering can be successfully mitigated with a proper antenna design. The reduction of the W sputtering with the 3-strap antennas has been achieved by minimising the RF currents on the antenna surfaces that are exposed to the scrape-off-layer (SOL) plasma. The strap power balance measurements confirm that the local RF currents, rectified DC currents and the W sputtering yield at the antenna side limiters experience a clear minimum close to a phasing between the central and the outer straps of 180 deg and a power balance ratio Pcen/Pout of 2. For this optimal choice, the local source of sputtered W at the limiters is reduced by a factor between 1.5 and 6, depending on the location. This is understood, modelled and confirms the hypothesis of sheath rectification as the source of the sputtered W.

Furthermore, the new 3-ion ICRF heating scenario, which can produce very energetic particles, has been successfully reproduced in AUG.

The progress in operation, as well as in understanding and modelling capability is strongly supported by improved ICRF diagnostic coverage including density measurements directly in front of the antenna by reflectometry, advanced RF coupling characterisation, measurements of antenna limiter currents, B-dot probes, Ion Cyclotron Emission (ICE) measurements as well as by the dedicated test arrangement IShTAR.

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