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Maximization of ICRF Power by SOL Density Tailoring with Local Gas Injection

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Experiments have been performed under the coordination of the ITPA on several tokamaks, including ASDEX Upgrade (AUG), JET & DIII-D, to characterise the increased ICRF antenna loading achieved by optimising the position of gas injection relative to the RF antennas. On DIII-D, AUG and JET (with the C-wall and recently the ITER-Like Wall) a 50% increase in the antenna loading was observed when injecting deuterium in ELMy H-mode plasmas using mid-plane inlets close to the powered antennas and, in the case of JET, with smaller improvement when using inlets located at the top of the machine. The gas injection rate required (˜0.7×1022el/s in AUG, ˜1.5×1022 el/s in JET) is compatible with good plasma energy confinement and no degradation of confinement was observed when using the mid-plane or top inlets instead of divertor valves. Optimized gas injection was also found to be beneficial for reducing tungsten (W) sputtering yield at the AUG antenna limiters. On JET, a reduction of the plasma W content is also observed when using mid-plane or top gas inlets during ICRF heating. Electron density measurements in the scrape-off layer (SOL) at the outer mid-plane were made on AUG, JET and DIII-D. On all machines an increase in the SOL density was measured when puffing gas from the mid-plane and from the top in the casae of JET. With nearby midplane inlets, the antenna loading increase is however higher than the predictions based on antenna coupling analysis using the SOL electron density measured at distant toroidal locations, pointing towards toroidal asymmetries in the SOL density. Modelling the specific effects of divertor/top/mid-plane injection on the outer mid-plane density is being carried out using EDGE2D for JET; preliminary simulations indeed indicate that outer mid-plane gas injection maximizes the density increase in front of the antennas. The extrapolation of these experimental results and modelling to ITER will be discussed and the requirements for further modelling highlighted.

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