Modelling of ICRF heating in ASDEX Upgrade discharges with pure wave heating relevant to the ITER baseline scenario

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The baseline or reference scenario is one of the basic operational scenarios foreseen for ITER. It is envisaged to deliver fusion power of 500 MW and fusion gain Q~10 using ELMy H-mode discharges at I_p =15 MA, B_T = 5.3 T, normalized plasma pressure β_N = 1.8 and normalized confinement H_{98y2} = 1 with a safety factor q_{95} = 3. Experiments on present-day devices provide important insights in preparing ITER operation. This paper focuses on modelling of ICRF heating in ASDEX Upgrade (AUG) plasmas with pure wave heating, i.e. ICRF and ECRF heating. These discharges are of interest because they approach the conditions of burning ITER baseline plasmas with predominant electron heating by fusion-born alpha particles and small externally applied torque. The discharges were carried out at I_p = 0.9-1.15 MA, B_T = 1.8-1.85 T with q_{95} = 3 and 3.6. Up to 3.9 MW of ICRF power was applied with a frequency of 30 MHz tuned to a H minority ion resonance at r/a ≈ 0.2-0.3 on the high-field side. Up to 3.4 MW of ECRF power was applied using 140 GHz in X3 mode. Stable discharges with β_N = 1.2-1.7 and H_{98y2} = 0.75-1.1 were obtained. We have modelled the discharges using the ICRF modelling code PION. Considering $n_H/(n_H+n_D)$ = 5% which is typical in AUG plasmas and the full ICRF toroidal mode number spectrum, we find that H minority heating dominates, absorbing 55-70 % of P_{ICRF}, while direct electron damping and 2nd harmonic D damping are about 25-40 % and 5-10 %, respectively. Due to the off-axis ICRF resonance, the average energy of ICRF-accelerated ions is relatively low, and they heat prominently bulk ions in collisions. The total ICRF electron heating is limited to about 40% of P_{ICRF}. We find that the electron heating fraction by ICRF could be improved (1) by operating at 1.95T which moves the ICRF resonance to the plasma center or (2) using 55 MHz which places the 2nd harmonic H resonance in the plasma center. The latter provides an energetic H minority tail that favours strong electron heating (up ~70% of of P_{ICRF}) with a central power deposition and a similar single-pass damping as H minority heating.