ICRF heating scenarios in the ITER non-active phase operations

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Access to H-mode conditions is one important operation milestone in the ITER non-active phase of operations allowing the characterization of plasma behaviour in H-mode at the ITER scale, the commissioning of edge localized mode (ELM) control schemes, and preparation for H-mode scenarios in the active phase with DD or DT plasmas. On the basis of present understanding, access and sustainment of H-mode plasmas in the ITER non-active operational phase will require high levels of auxiliary power even for half-current/half-field (7.5MA and 2.65T) plasmas. This requires the use of all available auxiliary heating power including ion cyclotron resonance frequency (ICRF) heating in addition to hydrogen neutral beam injection (H-NBI) and electron cyclotron (EC) wave heating. For half-current/half-field plasmas in the non-active phase operations, the potential ICRF heating schemes are second harmonic He\textsuperscript{3} minority heating in H plasmas and fundamental frequency H minority heating in He plasmas [1]. In this work, these two main ICRF heating schemes are investigated in depth using a full wave ICRF code, TORIC [2]. Multiple ion species heated by ICRF heating and H-NBI are included and a range of background plasma conditions (L-mode/H-mode profiles with varying minority ion concentration) are considered, in order to address the feasibility of the ICRF heating schemes in the ITER non-active phase operations. As expected from theory and in agreement with previous results, second harmonic He\textsuperscript{3} minority in H plasmas is found to be very ineffective with low single pass absorption while the fundamental frequency H minority heating in He plasmas is very effective with good single-pass absorption near the plasma centre. In addition, coupling of ICRF power in half-current/half-field He H-modes has been evaluated with the ANTITER II code [3] to be as effective as for 15 MA/5.3T DT H-mode plasmas with Q = 10, which is the design point of the ITER ICRF antenna. In this paper, sensitivity of single-pass absorption and ICRF power coupling to the plasmas in the foreseen ITER non-active scenarios will be documented in detail.

[1] R.V. Budny et al., 2012 Nucl. Fusion 52 023023
[3] A. Messiaen et al., 2010 Nucl. Fusion 50 025026