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Subdivertor fuel isotopic content detection limit for JET and impact on the control of ICRH for JET-ILW and JET-DT operation

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In preparation for JET Deuterium-Tritium Experiments 2 (DTE-2) and to assure readiness to provide fuel cycle-relevant measurements, the subdivertor fuel isotopic ratio detection limit, as determined by Penning optical gas analysis (OGA) [1, 2], was recently researched. Reevaluation of OGA data from DTE-1 [1] revealed a 1% uncertainty (error bar) at the 1% T/(H+D+T) concentration level. A similar detectability limit (at ˜1% concentration) was found for H/(H+D) when evaluating a more recent JET ICRH-specific dataset. This analysis also shows a persistent ˜ 1% systematic offset of the OGA with respect to divertor spectroscopy values. These studies are in support of substantial diagnostic upgrade for DTE-2 aiming to assure this isotopic detectability, as well mitigate gradual deterioration partly caused by coating of viewport windows by the OGA's own Penning discharge.
The importance of resolving isotopic concentrations at the ˜1% level during ICRH plasmas was also explored. When (H/(H+D)) is reduced from 2% to <1%, an increase of core plasma Ti and a decrease of Te are measured [3, 4]. This is consistent with full wave ICRH modelling indicating that when the concentration of the minority species is low enough, 2nd harmonic D absorption becomes dominant over the fundamental H minority absorption; if the plasma density is large enough, it provides collisional bulk ion heating rather than the typical electron heating observed with H minority absorption. The higher background Ti in conjunction with the RF acceleration of the D NBI ions to supra-source energies leads to an increase of the neutron yield by 30% in the case explored. For the same case, the increase of the energy of the fast H tail at small minority concentrations also contributes to sawtooth stabilization. This would imply that the ability to measure, and ultimately control, the fuel isotopic content down <˜ 1% concentration level is important for optimizing the performance of a given ICRH scheme in fusion devices. The ability of the OGA technique to act as a global diagnostic of the isotopic mix is of great consequence for ITER, where divertor spectroscopy is unlikely to work, at least for such low concentrations [2].– [1] D.L. Hillis et al., RSI 70 (1999) 359; [2] C.C. Klepper et al., 2017 JINST 12 C10012; [3] E. Lerche et al., 2016 NF 56 036022; [4] M Goniche et al., 2017 PPCF 59 055001

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