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JET isotope experiments and scenario development: towards the DT phase

E. Joffrin[1] and JET contributors

EUROfusion Consortium, JET, Culham Science Centre, Abingdon, OX14 3DB, UK

[1] IRFM, Centre de Cadarache, Saint-Paul-lez-Durance, 13108 Cedex, France

In 2015-16, JET has started a multi-campaign effort including experiments in D, H and T, leading up in 2019 to the first experiments in D-T mixtures since 1997 and the first ever with the ITER mix of plasma-facing component materials [1].

The dependences of plasma properties on the main ion isotope mass, as well as on isotope composition have been explored in detail in the recent hydrogen campaign [2] and compared with reference D pulses. A striking feature of ELMy H-mode operation in Hydrogen, as compared to Deuterium, is a significantly lower energy confinement time, consistent with previous observation in JT-60U with a carbon wall. The results also suggest that the isotope dependence of the confinement in H-mode is higher than in the standard IPB98y2 ITER scaling ($M^{0.19}$).

It is found that the L-H power threshold in H is about twice that of reference plasmas in deuterium, showing a 1/M scaling for the L-H transition consistently with results from JET with a carbon wall and in other devices. The establishment of H-D mixtures with controlled isotope ratios has allowed the coverage of the full range between 1% and 99% in H/(H+D). When the isotope ratio H/(H+D) is changed, interestingly, strong variations of the L-H threshold were observed for H/(H+D)<20% and >80%. However, in between this range, the power threshold is essentially constant at a value roughly equal to the average of the thresholds in H and D.

Experiments with shallow D pellet injection into H plasmas successfully established core H/(H+D) ratios near 50%, which is encouraging in view of ITER fueling by pellets. Moreover, several ICRH scenarios were tested in majority H plasmas, with applications to JET D-T experiments and the ITER non-active phase. These included successful demonstrations of the efficacy of several schemes proposed for JET D-T and ITER, such as, for example, the three-ion H-(3He)-D.

In addition to the isotope results, significant progress on scenario compatibility with the ITER-like wall has been achieved using 27 to 33 MW NBI+ICRF of combined input power. The maximum DD fusion yields have been extended to 2.3×10^{16} neutrons/s to 2.9×10^{16} neutrons/s for duration approaching 5s. This level of DD neutrons is equivalent to 7.5 to 8.5 MW of fusion power in DT and is projected to reach 12 to 13 MW of fusion power with the 40 MW of input power that will be available in JET in 2018.

The campaigns in 2018 will continue the scenario optimization and address the isotope physics in the full tritium phase. This will then lead to a DT campaign in 2019, aiming at providing key answers on alpha and fast particle physics in support of ITER.

Reference

[1]: X. Litaudon et al., “Overview of the JET results in support to ITER”, 26th IAEA Fusion Energy Conference, Kyoto 2016, Japan, OV-1

[2] : I. Nunes et al., “First results from recent JET experiments in Hydrogen and Hydrogen - Deuterium plasmas“, 26th IAEA Fusion Energy Conference, Kyoto 2016, Japan, PDP-2