Fusion research in stellarators and tokamaks in Europe

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JET is presently preparing for a set of experimental campaigns using tritium and deuterium-tritium mixtures as the plasma fuel, aiming at obtaining the maximum possible operational experience of a nuclear tokamak as well as a fusion science knowledge base in preparation for ITER. The current planning includes operations with DD, H, HT and HD plasmas, before the final high performance D-T experiments in the DTE2 campaign, foreseen for 2020. The planned DTE2 campaign will not set records *per se* but rather demonstrate integrated performance in conditions as close as is presently possible to ITER. The scope of DTE2 for physics and technology studies is much greater than for previous tritium experiments at JET. The 14 MeV neutron budget for DTE2 is 1.7x1021, which is seven times the budget for all previous tritium campaigns in the past. The on-site tritium inventory will be increased to 60g, three times the amount available for the first large D-T experiments (DTE1) in 1997.

No other fusion device has the capability to operate with tritium. The results will thus be the only experience of tokamak operation in a nuclear environment prior to the active phase of ITER operation. The planned DT experiment in JET will be the culmination of this effort to provide experiments in conditions as close as possible to those foreseen for ITER and thus the best possible preparation and training for ITER.

The recently discovered 3-ion ICRH scenario has been successfully tested on JET and the American tokamak Alcator C-Mod (MIT, Boston). The principle of this scenario is to arrange the plasma conditions such that the 3rd resonant ions are located very close to the mode conversion layer determined by the other two plasma constituting ions. The experiments in C-Mod and JET confirm the very efficient heating obtained using this scenario, and the results have been published very recently in Nature Physics. A further application is the use of fast accelerated beam ions as the resonating species. This was demonstrated in JET last summer (2016). This scenario has important applications in D-T plasmas, using accelerated D or T beam ions, and could this contribute to increase strongly the fusion output and Q value. Preparatory experiments are included in the JET plan for the coming 2 years, in view of the DTE2 phase.

W7-X had first successful plasmas in He in December 2015, heated with ECRH. In February 2016 the working gas was switched to hydrogen. The first operation phase (OP 1.1) in H was successfully finished in March 2016. At the end of this very successful campaign the discharge duration was close to 6 seconds, the heating energy was increased to 4 MJ and electron temperatures of ~10 keV were achieved. Due to the low densities (~ 1019 cm-3) and the pure electron heating by ECRH, the ion temperatures reached only 2 keV. Since then, W7-X underwent a next upgrade, including the installation of the test divertor unit, the installation of the carbon tiles on the inner plasma vessel wall, an upgrade of existing diagnostics and the installation of new diagnostics.

Currently a first experimental campaign (OP1.2a) with this new test divertor is taking place up to December 2017. First results of OP1.2a will be shown in the presentation. A second campaign (OP1.2b) will start in June 2018.

References

1. Ye.O. Kazakov, J. Ongena, J.C. Wright et al., *Nature Physics* **13**, 973-978 (2017) <http://dx.doi.org/10.1038/nphys4167>
2. J. Ongena et al., *EPJ Web of Conferences* **157**, 02006 (2017) <https://doi.org/10.1051/epjconf/201715702006>