Development of hybrid (high β) plasmas for D-T operation in JET

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A key aim of the 2021 JET deuterium-tritium (D-T) experiments was to demonstrate steady high fusion power (10-15MW) with the ITER-like Be/W first wall. Plasmas were developed using D, repeated with T to investigate and mitigate isotope effects, and run with D-T to maximise fusion power. Compared with high current (q_{95}~3) 'baseline' plasmas, the JET 'hybrid' scenario has reduced current (2.3MA at q_{95}~4.5-5) and increased q_0 (≥1) to avoid deleterious MHD modes and access favourable confinement properties at high poloidal β (>1). This candidate approach for ITER had never previously been tested using T or D-T fuel.

In this presentation the process of 'hybrid' D-T scenario development will be explained for key phases from current ramp-up to termination, all of which are sensitive to isotope effects and impurities from the wall. For example, in the ohmic current ramp, used to pre-form the q-profile, an increase in central impurity radiation with main ion isotope mass was anticipated from previous mixed H-D experiments[a] and predictive modelling, allowing mitigation actions to be rapidly implemented for T and D-T. During the early H-mode phase, prevention of impurity influxes at the edge pedestal was the primary method for core radiation control using a combination of screening and ELM flushing. This was more challenging for T & D-T plasmas compared with D, and fine adjustment of heating and gas fuelling was needed to avoid excessive edge radiation and to establish regular ELMs with H_{98}≥1. After careful adaptation for D-T, high fusion power was achieved, broadly consistent with previous modelling predictions[b] given the available heating power. This led to a record fusion energy for a plasma with $n_D \approx n_T$ of ~46 MJ.

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