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# The quasi-continuous exhaust regime in ASDEX Upgrade and JET: An ELM-free integrated reactor scenario

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An integrated reactor scenario combines good core conditions to achieve high fusion gain together with a plasma edge that guarantees a safe power exhaust solution. For decades, the type-I ELMy H-mode was the preferred operational regime offering high density and energy confinement time. However, it became clear in recent years that large edge localised modes (ELMs) are not acceptable for the integrity of the first wall of a reactor. With this, regimes with active ELM suppression, like applying external magnetic perturbations, or naturally type-I ELM free regimes have become the focus of extensive research. The quasi-continuous exhaust (QCE) regime is one candidate for an integrated reactor scenario without large transients.

This presentation will introduce the characteristics and physics basis of the QCE regime. Significant improvements in the understanding of the QCE regime have been achieved in recent years. The existence of QCE and the absence of type-I ELMs is explained by two main aspects. First, strong shaping - large elongation and triangularity and the highly correlated closeness to double null is needed. Second, sufficient fuelling to achieve high enough density at the pedestal foot, close to the separatrix, is required. This aspect is attributed to localised ballooning modes being responsible for the enhanced transport, either ideal or resistive in nature. The high density at the separatrix will also be needed for a power exhaust solution in future reactors. The QCE fits well within the drift-Alfven turbulence picture of the SepOS framework. It combines the operational limits of ideal ballooning modes and the back-transition to L-mode. Further, it presents a qualifier for the turbulence level. Indeed, in QCE a broadening of the scrape-off layer power fall-off length is observed in ASDEX Upgrade and TCV and also reported in similar regimes in DIII-D and EAST.

The QCE regime was recently successfully achieved in JET using the experience from ASDEX Upgrade and TCV. Similar to ASDEX Upgrade, it shows low core radiation levels without impurity accumulation despite the absence of large ELMs. In addition, adding small amounts of neon as radiating species proved beneficial in avoiding the occurrence of large ELMs while reaching power detachment. The QCE regime was part of the third D-T campaign and successfully demonstrated in plasmas with an even mixture of deuterium and tritium. These plasmas showed an increase in stored energy typical for D-T operation in JET.

From these experimental findings and the derived models, a first extrapolation to ITER and EU-DEMO parameters can be done. These machines are foreseen to operate with strong shaping, above what is needed in ASDEX Upgrade and JET to realise the QCE regime. It is speculated that due to the similarity of the separatrix values between existing tokamaks and the future large-scale devices the second access criterion for QCE is also met.