Developing the Quasi-Continuous Exhaust regime on ASDEX Upgrade and JET in preparation for ITER and DEMO

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*** *See the author list of "Progress on an exhaust solution for a reactor using EUROfusion multi-machines capabilities" by E. Joffrin et al. to be published in Nuclear Fusion Special Issue: Overview and Summary Papers from the 29th Fusion Energy Conference (London, UK, 16-21 October 2023).*

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Developing regimes devoid of large ELMs which are compatible with metal walled operation is of paramount importance for the reliable operation of future fusion devices. The quasi-continuous exhaust regime (QCE), well established at AUG[1] and TCV[2], is emerging as a promising H-mode operational regime which combines high pedestal top pressure with exhaust-relevant high separatrix density.

This work presents IPED scans of plasma shaping (principally elongation and triangularity) demonstrating that the critical gradients for the global peeling-ballooning and separatrix ballooning modes grow apart as shaping increases. This allows operational space for the separatrix mode, hypothesised to dominate the transport during the QCE, at high plasma shaping, as observed in experiments. The critical pressure gradient at the separatrix can then be translated into a critical separatrix density by applying a scaling using a collisional broadening ansatz; the combination of critical shaping and density for QCE access is well known from experiments and is reproduced by this model.

With the emerging understanding of the QCE and its potential reactor relevance, significant experimental time was devoted during the 2023 JET D and DT campaigns to developing the QCE scenario there. The regime has now been demonstrated at high power and low collisionality, making use of the size and full shaping capabilities of JET. The QCE was obtained at plasma currents up to 2.25 MA, at a q_{95} as low as 3.3, and, in a separate scenario, at pedestal top collisionalities as low as 0.3, demonstrating the compatibility of the regime with low nu^* operation and a wide range of operational conditions, including neon seeding.

The combination of MHD and parameterised separatrix gradients allows the QCE operational space to be investigated for any device. Using a step-ladder approach of learning from experiments on AUG and TCV, along with the model described here, allowed us to demonstrate the regime on JET. The successful extrapolation of the QCE to a large device and the predictive capability of the model encourages greater confidence not only in the existence of the QCE at ITER, but in our pedestal predictions for future devices in general.

[1] M. Faitsch, et al. *Nuclear Fusion*, 63(7), 2023.

[2] B Labit, et al. *Nuclear Fusion*, 59(8), 2019.