Nonlinear MHD simulations of QH-mode plasmas in DIII-D

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The quiescent H-mode (QH-mode) regime originally developed at the DIII-D tokamak [1] provides high confinement without transient energy fluxes to plasma facing components associated with edge localized modes (ELMs). This operational regime has been extended to conditions suitable for ITER operation such as low torque input [2] and high normalized density operation [3]. In the QH-mode, the edge harmonic oscillation (EHO) is found to provide a continuous edge particle transport which replaces the periodic expulsion of particles and energy by ELMs. The EHO is thought to be a saturated kink-peeling mode driven unstable by current and rotation, which maintains the edge pressure gradient near but below the ELM instability boundary [4]. Understanding the nonlinear MHD physics mechanisms that lead to the growth of the kink-peeling mode and its saturation including the role of plasma rotation in these processes is essential to project QH-mode as an alternative ELM-free regime for ITER high Q operation.

With this objective, a quantitative comparison of the results by nonlinear MHD modelling of QH-mode plasmas with experimental measurements in DIII-D has been carried out and the first results will be presented in this paper. These simulations of QH-mode plasmas have been carried out with the JOREK code [5] both for ideal wall and resistive wall boundary conditions for low to medium n (up to n=10) modes. In these simulations it is found that low n kink-peeling modes are unstable and grow to a saturated level consistent with the physics picture put forward in [4] (see Figure 1). In the paper the role of plasma toroidal and poloidal rotation as well as the effect of the vacuum vessel wall on the destabilization and saturation of edge modes will be evaluated for experimental QH-mode conditions in DIII-D. The results obtained with JOREK will be compared to expectations from linear ideal MHD analysis of the pedestal plasma in these DIII-D QH-mode discharges with the MISHKA code.

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