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Nonlinear MHD simulations of Quiescent H-mode in ASDEX-Upgrade and ITER

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Both nonlinear simulations and experiments of DIII-D QH-mode plasmas show that E×B rotation plays an essential role for obtaining the QH-mode. However, the mechanism for the QH-mode onset and its saturation, the influence of other rotation flows such as neoclassical flow, diamagnetic flow as well as the influence of resistive wall still remains unclear due to the complexity of the physics of edge plasma non-linear MHD stability. Hence, understanding the physics mechanisms leading to the saturation of the EHO in QH-mode plasmas and the role of plasma rotation in EHO behaviour is an important issue to support experiments in ASDEX-Upgrade to access the QH-mode regime and to assess whether the QH-mode could be a viable alternative regime for an ITER high Q scenario.

In this work nonlinear MHD simulations of ASDEX-Upgrade QH-mode plasma #17686 have been performed with the non-linear MHD code JOREK for the first time. The low-n kink-peeling modes (KPMs) have been found unstable and grow to a saturated level in the edge of the ASDEX-Upgrade QH-mode plasma. This leads to a helical structure on the plasma density, which is associated with the 3-D localisation of the KPM at the separatrix in the toroidal and poloidal direction. The influence of neoclassic rotation, E×B rotation and diamagnetic rotation on QH-modes have been investigated to understand the physics mechanisms leading to the QH-mode behaviour and to support the achievement of QH-mode plasmas in the ASDEX-Upgrade device.

The simulations for ITER Q=10 scenario have been extended to include n=0-5 modes and n=0-10 modes and including a resistive wall. The results show that the inclusion of a resistive wall has a significant influence on the non-linear evolution of KPMs in ITER plasma while this effect is found to be small in QH-mode simulations of DIII-D plasmas. The simulations show E×B rotation/shear plays an important role for ITER high Q plasmas to enter and remain in the QH-mode regime. The results of these simulations will be evaluated in the paper to determine whether this regime is an option for high fusion performance operation at the specific characteristics of ITER plasmas.

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