QUIESCENT H-MODE OPERATION USING TORQUE FROM NON-AXISYMMETRIC, NON-RESONANT MAGNETIC FIELDS

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Abstract. Quiescent H-mode (QH-mode) sustained by magnetic torque from non-axisymmetric magnetic fields is a promising operating mode for future burning plasmas including ITER. Using magnetic torque from \( n = 3 \) fields to replace counter-\( I_p \) torque from neutral beam injection, we have achieved long duration, counter-rotating QH-mode operation with NBI torque ranging continuously from counter-\( I_p \) up to co-\( I_p \) values of about 1 Nm. This co-\( I_p \) torque is about 3 times the scaled torque that ITER will have. This range also includes operation at zero net NBI torque, applicable to RF wave heated plasmas. These \( n = 3 \) fields have been created using coils either inside or, most recently, outside the toroidal coils. Experiments utilized an ITER-relevant lower single-null plasma shape and were done with ITER-relevant values \( \nu_p \sim 0.05, \beta_p T \sim 1\% \) and \( \beta_N = 2 \). Discharges have confinement quality \( H_{98 y^2} = 1.3 \), in the range required for ITER. Preliminary low \( q_{95} = 3.4 \) QH-mode plasmas reached fusion gain values of \( G = \frac{\beta_N}{H_{89}} \frac{q_{95}^2}{q_{95}^2} = 0.4 \), which is the desired value for ITER; the limits on G have not yet been established. This paper also includes the most recent results on QH-mode plasmas run without \( n = 3 \) fields and with co-\( I_p \) NBI; these shots exhibit co-\( I_p \) plasma rotation and require NBI torque \( \geq 2 \) Nm. The QH-mode work to date has made significant contact with theory. The importance of edge rotational shear is consistent with peeling-ballooning mode theory. We have seen qualitative and quantitative agreement with the predicted NTV torque.