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

K.H. Burrell[1], A.M. Garofalo[1], W.M. Solomon[2], M.E. Fenstermacher[3], D.M. Orlov[4], T.H. Osborne[1], J.-K. Park[2] and P.B. Snyder[1]

[1]*General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA*
[2]*Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543-0451, USA*
[3]*Lawrence Livermore National Laboratory, Livermore, California 94550-0808, USA*
[4]*University of California-San Diego, La Jolla, California 92093, USA*

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 $\nu^*{}_{ped} \sim 0.05$, $\beta^{ped}{}_T \sim 1\%$ and $\beta_N = 2$. Discharges have confinement quality $\mathrm{H}_{98y2} = 1.3$, in the range required for ITER. Preliminary low $q_{95} = 3.4$ QH-mode plasmas reached fusion gain values of $\mathrm{G} = \beta_\mathrm{N}\ \mathrm{H}_{89} / q_{95}{}^2 = 0.4$, 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 ≥ 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.