Understanding the Physics of EHO Generation in DIII-D Including the Role of Rotational Shear

K.H. Burrell¹, X. Chen¹, A.M. Garofalo¹, G.R. McKee², C.M. Muscatello³, P.B. Snyder¹, W.M. Solomon⁴, and Z. Yan²

¹General Atomics, P.O. Box 85608, San Diego, California, USA
²University of Wisconsin, Madison, Madison, Wisconsin, USA
³University of California, Davis, Davis, California, USA
⁴Princeton Plasma Physics Laboratory, Princeton, New Jersey, USA

email: burrell@fusion.gat.com

This work summarizes the results of recent experiments that investigated the role of edge rotation and rotation shear on quiescent H-mode plasmas, demonstrating that the shear on the small radius side of the edge Er well is important in QH-mode physics. QH-mode is a robust, stationary operating mode without edge localized modes (ELM) which was first discovered in DIII-D and has subsequently been investigated on ASDEX-U, JET and JT-60U. The key to QH-mode operation is the presence of an edge electromagnetic mode, the edge harmonic oscillation (EHO), which provides the extra transport to allow the edge plasma to reach a transport equilibrium with edge pressure gradient and current density just below the ELM limit [1]. Experimental results are consistent with the theoretical prediction that the EHO is a kink-peeling mode that is destabilized by edge rotational shear at edge conditions near but below the ELM limit [1]. Theory suggests that the essential rotation speed is \(E_x/B_\theta\), the angular toroidal rotation speed driven by the E x B drift; initial analysis of experimental data is consistent with this expectation [2,3].

Experiments demonstrate that the coherent EHO goes away when rotation and rotation shear decrease too much. Recent results indicate that it is the shear in the inner side of the Er well that is the important shear for driving the coherent EHO. In strongly shaped plasmas with good error field correction, ELMs are mostly absent even at low shear since broadband MHD remains and apparently provides sufficient particle transport to maintain density control as shots go through zero rotation. Edge pressure pedestal width and height both increase as rotation drops. The rotation characteristics of the coherent EHO and broadband MHD suggest they are different modes. The broadband MHD rotates toroidally in co-Ip direction independent of plasma rotation while the coherent EHO rotates toroidally in the direction of the plasma rotation independent of plasma current direction. The poloidal phase velocity of the coherent EHO and broadband MHD have opposite signs when neutral beam injection is in the counter-Ip direction.

*This work supported in part by the U.S. Department of Energy under DE-FC02-04ER54698, DE-FG02-89ER53296, DE-FG02-99ER54531, and DE-AC02-09CH11466.