Characterization of Edge Stability and Ohmic H-mode in the PEGASUS Toroidal Experiment

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The PEGASUS Toroidal Experiment is an ultra-low aspect ratio ($A < 1.2$) spherical tokamak, enabling exploration of the unique plasma characteristics of the tokamak-spheromak overlap regime at near-unity A. Operation at near-unity A and high I_p/I_{TF} provides J_{edge}/B instability drive for peeling modes in PEGASUS. The modest temperatures and pulse length of PEGASUS permit detailed study of their properties [1], including unique time-resolved local measurements of the edge current density critical to stability predictions [2]. Peeling modes generate edge-localized, low-n (≤ 3) electromagnetic activity with amplitudes that scale strongly with measured J_{edge}/B instability drive, consistent with theory. Nonlinearly, peeling modes produce ELM-like, field-aligned, current-carrying filaments from an initial current-hole J_{edge} perturbation that detach from the edge and propagate outward. Their constant-velocity radial motions are in qualitative agreement with rates given by electromagnetic blob transport theory.

Ohmic H-mode has recently been achieved in a limited magnetic topology following installation of a new central column fueling system, consistent with reduced L-H power thresholds when using high-field-side fueling. Initial H-mode plasmas in PEGASUS exhibit: reduced D_α emission; a sharp, quiescent edge on visible imaging; improved energy confinement; and improved V-s consumption. An increased T_i heating rate is observed in H-mode. A reversal in intrinsic toroidal rotation occurs at the L-H transition, from counter-I_p in L-mode to co-I_p in H-mode. A clear pedestal in J_{edge} is formed in H-mode.

Routine H-mode PEGASUS operations enable unique measurements of ELM phenomena and support experimental tests of peeling-ballooning stability theory. In particular, the compatibility of the Hall probe J_{edge} diagnostic with the H-mode edge to date affords the opportunity to study current profile dynamics throughout the ELM cycle. Presently, Type I and III ELMs have been observed. A prominent current-hole perturbation is evident during Type III ELM crash events, similar to that seen in peeling mode studies [1]. A steepening of the J_{edge} gradient scale length as well as a slight hump in J_{edge} is observed prior to a Type I ELM, suggestive of the presence of bootstrap current. Particle trapping and associated neoclassical effects are expected to be very large in PEGASUS plasmas at $A \sim 1$. New divertor coils have been installed, providing access to conventional diverted magnetic topologies in the device. A multipoint Thomson scattering system is being commissioned [3] to measure core electron pressure profiles and aid the quantification of confinement enhancement in H-mode and the plasma resistivity at ultralow A.

Work supported by US DOE grant DE-FG02-96ER54375.

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[3] D.J. Schlossberg *et al.*, Rev. Sci. Instrum. **83**, 10E335 (2012)