Local Helicity Injection Startup and H-mode Studies at Ultralow-*A* on Pegasus

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Operation at ultralow-*A* (~ 1) yields ready access to advanced tokamak physics at relatively small scale. The Pegasus spherical tokamak research program has two major thrusts: developing Local Helicity Injection (LHI) for non-solenoidal startup, and H-mode characterization with unique edge diagnostic access.

In LHI, edge injected current streams reconnect and relax to a tokamak-like plasma. A 0-D power balance model predicts $I_p(t)$ in LHI plasmas by balancing helicity input against resistive dissipation and inductive geometric effects. It predicts MA-class startup on larger devices, but accurate projections require further confinement studies. Initial Thomson scattering data show peaked, Ohmic-like pressure profiles in LHI and T_{e0} ~150 eV, in contrast with flat profiles associated with highly stochastic confinement. NIMROD simulations of divertor injectors elucidate the physics of LHI current drive[1], and are consistent with magnetic and optical measurements of outboard injection. A new divertor injector set is being installed to examine the relative influence of helicity versus inductive current drive, and for direct comparison to simulation.

H-mode plasmas are routinely attained on Pegasus and show typical characteristics including ELM excitation. Type I ELM dynamics are uniquely measurable at A~1 due to the low B_T and modest edge T_e. $J_{edge}(R, t)$ measured through a Type I ELM shows a complex pedestal collapse and filament ejection. In contrast, some low-*A* features are emerging. The L-H power-threshold (P_{LH}) on Pegasus exceeds the ITER scaling by 10-20x, with P_{LH}/P_{ITPA08} increasing sharply as $A \rightarrow 1$. P_{LH} is also insensitive to limited versus diverted topologies. Furthermore, Type III ELM toroidal mode numbers are low ($n \leq 1$-4) compared to high-*A* tokamaks ($n > 8$). Near-term facility and diagnostic upgrades will extend these studies and allow investigation of 3-D field effects on ELMs.

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[1] J. B. O'Bryan and C. R. Sovinec, *Plasma Phys. Control. Fusion* **56** (2014) 064005