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

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Abstract Text:
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, 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 ? 1. P_LH is also insensitive to limited versus diverted topologies. Furthermore, Type III ELM toroidal mode numbers are low (n?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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