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EX/P4-36: Local Helicity Injection Startup and Edge Stability Studies in the Pegasus Toroidal Experiment

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Studies on the Pegasus ultralow aspect ratio tokamak are exploring: nonsolenoidal startup using localized helicity injection via edge current injection; and edge peeling mode stability and dynamics. The helicity injection operating space is constrained by helicity injection and dissipation rates and a geometric limit on plasma current. Extrapolation of this technique to other devices requires understanding of the dissipation mechanisms and development of appropriate operating scenarios. To address these issues, the Pegasus program is focused on extending helicity injection startup and growth to ~0.3 MA plasma currents and relatively long pulse lengths. In addition to using plasma arc current sources, recent experiments demonstrate the feasibility of using passive electrodes to grow discharges for relatively long pulse lengths. Shaped electrodes serving as current and helicity sources can be optimized with respect to both helicity and relaxation constraints. Bursts of MHD activity are observed during helicity injection, and correlate with rapid equilibrium changes, including inward motion of the magnetic axis and redistribution of the toroidal current. Internal magnetic measurements show the creation of a poloidal null prior to the formation of a tokamak-like equilibrium, and the redistribution of current into the core region as the plasma evolves. The MHD activity results in strong ion heating, with ion temperatures ~ 1 keV observed. The plasma arc injector impedance is consistent with a double-layer sheath at the extraction aperture. The increasing understanding developed in these studies support scalability of the helicity injection technique to large devices. Operation at near-unity aspect ratio with high plasma current relative to the toroidal field allows study of peeling modes, a cause of Edge Localized Modes (ELMs) in larger devices. Peeling modes in Pegasus appear as coherent edge-localized electromagnetic activity with low toroidal mode numbers and high poloidal mode numbers. Internal magnetics and fast framing images show the formation of current-carrying field-following filamentary structures, which briefly accelerate radially, detach from the plasma, and propagate radially at a constant velocity. The filaments'acceleration and propagation velocity all correspond to the predictions of electromagnetic blob theory.

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