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Plasma Formation Studies and Plans for the Pegasus Toroidal Experiment

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The PEGASUS Toroidal Experiment is designed to explore techniques to minimize the center column of a spherical torus while maintaining good stability and confinement at very high beta. Initial studies are focused on stability boundaries as $A \rightarrow 1$ at both high and low toroidal beta, with an emphasis on edge-q and kink stability limits as functions of plasma geometry. Achievement of high I_N and high TF utilization as $A \rightarrow 1$ will be the focus of these efforts followed by the exploration of high β_t stability limits. Studies at relatively high TF and modest I_p/I_{tf} should allow access to ballooning limits in the range of $\beta_N \geq 6$, while operation at lower field may access near-unity β_t and regions of high I_N where wall stabilization is not required for external stability. The PEGASUS Toroidal Experiment is uniquely poised to explore the tokamak/spheromak transition regime in the near future. To this end, a new low-inductance toroidal field coil set will allow transient exploration of the $I_p/I_{tf} > 3$ regime and associated plasma relaxation phenomena. Initial operations are focused on startup plasmas and discharge evolution control, where $I_p \sim 0.1$ MA has been achieved with $I_p/I_{tf} \sim 1$, $A = 1.15 - 1.4$, $R = 0.25 - 0.35$ m, and at $B_t = 0.07$ T. High current ramp rates are observed (30 - 200 MA/s) with correspondingly highly elongated plasmas (> 3) both at high (0.07 T) and low (0.04 T) toroidal field. At ramp rates ≥ 30 MA/sec, a large-scale MHD instability, identified as a double tearing mode on the predecessor MEDUSA experiment, occurs during the formation stage and limits the ultimate current achieved. Many plasmas terminate with a series of Internal Reconnection Events (IRE's). Magnetic reconstruction is accomplished using TokaMac, a plasma equilibrium reconstruction code, which incorporates measurements from a Rogowski loop, magnetic pickup coils, and flux loops. Time-evolving currents in the vacuum vessel wall are modeled as a set of mutually coupled axisymmetric current filaments. Initial magnetic reconstructions indicate β_t on the order of 15% have been achieved. Completion of the power systems is in progress to allow operation at full pulse length (0.04 s) and plasma current (0.3 MA), to provide a target plasma for the Higher Harmonic Fast Wave (HHFW) heating system, and to provide access to high β regimes. Non-inductive startup and sustainment techinques are also being developed, including current injection via plasma guns and radio frequency heating and current drive using either Electron Bernstein Waves or HHFW.

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