Integrated Modeling of Spheromak MHD and Energy Transport*

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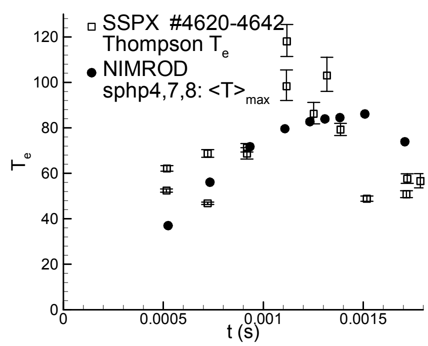
Abstract

Through numerical simulation, we have previously shown that the zero-beta MHD model reproduces the most important magnetic characteristics of electrostatically driven spheromaks, including poloidal flux amplification, n=1 activity during formation, periodic relaxation events in some conditions, and closed flux-surface formation during decay [1]. While these numerical results are at least qualitatively consistent with many spheromak experiments, the energy confinement properties [2] of the predicted magnetic topology in sustained conditions [3] cannot account for peak observed temperatures [4]. Recent computations include temperature evolution that is consistent with the simulated evolving magnetic topology, using thermal transport coefficients, electrical resistivity, and Ohmic heating appropriate for collisional plasmas. The temperature dependencies of the coefficients produce striking effects in the simulated spheromak evolution. The cold edge plasma tends to impede parallel thermal conduction to the wall in the driven conditions with chaotic magnetic topology, allowing the plasma core temperature to reach tens of eVs, as expected [2]. However, when the drive is temporarily removed, the cold edge plasma assists magnetic reconnection, so that large closed flux surfaces form rapidly, and core temperatures increase to approximately 100 eV. Applying a second current pulse, as in some SSPX discharges [4], is shown to improve performance by delaying the onset of MHD modes that are resonant in the closed-flux region. A detailed comparison of results from nonlinear simulations with laboratory measurements from SSPX confirms the effectiveness of the integrated MHD/energy transport modeling for this application.



Comparison of integrated MHD/energy transport simulation results with measured temperatures in the SSPX spheromak. [SSPX data courtesy of H. S. McLean.]

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