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Magnetic Topology Evolution and Thermal Energy Transport in Coaxial Plasma Gun Spheromak Simulations*

G. A. Cone and C. R. Sovinec

Department of Engineering Physics, University of Wisconsin-Madison
1500 Engineering Drive, Madison WI 53706

Abstract

Earlier nonlinear resistive MHD simulations of spheromak decay from a sustained state with open magnetic field and electrostatic helicity injection have shown the transient formation of closed magnetic flux surfaces.[1] The computations were performed in the limit of zero plasma-β and do not provide direct information on energy transport; however, the magnetic topology change suggests that the decay phase has relatively good confinement properties, consistent with the temperature profile peaking observed in many spheromak experiments.[2] To provide a more definitive assessment of the MHD evolution, subsequent simulation efforts[3,4] include finite plasma-β, Ohmic heating, and internal energy transport—modeled using an anisotropic thermal conductivity tensor. Here, we have found direct evidence of temperature profile peaking during spheromak decay that is sensitive to the specified $\chi_{\|}/\chi_{\perp}$ ratio, though the results obtained with a simplified coaxial gun geometry[3] lack sufficient numerical refinement.

Recent updates to the preprocessor for the NIMROD code[5] improve the realism and accuracy of finite plasma-β simulations in the coaxial gun configuration. The new finite element mesh avoids sudden changes in element dimensions across the mesh and conforms closely to the curved cross sections of the flux conserver and the central electrode in the SSPX experiment.[6] In addition, time-dependent boundary conditions at the entrance of the plasma gun region model the circuit current waveform of the SSPX power supply. A comparison is made between simulations using an applied tangential electric field and simulations where the total current across the electrodes is specified through the toroidal magnetic field at the surface that represents the insulating gap. The purpose of this comparison is to investigate how any differences in the current drive may affect the evolution of closed magnetic flux tubes and energy confinement.

[1]C. R. Sovinec, J. M. Finn, and D. del-Castillo-Negrete, Phys. Plasmas **8**, 475 (2001).
[2]T. R. Jarboe, Plasma Phys. Controlled Fusion **36**, 945 (1994).
[3]G. A. Cone, C. R. Sovinec, H. Tian, and B. I. Cohen, Bull. Am. Phys. Soc. **47**, No. 9, p. 43, presentation BP1 70 (2002).
[4]R. H. Cohen, B. I. Cohen, C. R. Sovinec, and G. A. Cone, “Searching for a Better Spheromak with NIMROD,” 2003 Intl. Sherwood Fusion Theory Conf.
[5]A. H. Glasser, C. R. Sovinec, R. A. Nebel, et al., Plasma Phys. Control. Fusion **41**, A747 (1999).
[6]E. B. Hooper, L. D. Pearlstein, R. H. Bulmer, Nucl. Fusion **39**, 863 (1999).

*This work is supported by the U.S. Dept. of Energy.