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Searching for a better spheromak with NIMROD*

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Abstract

Resistive MHD simulations of steady driven spheromaks in simple cylindrical and gun-driven geometries consistently exhibit only chaotic field lines with relatively short connection length to a wall. We describe here a series of NIMROD simulations aimed at finding a more attractive spheromak. Specifically we follow two approaches: (1) pulsed operation, and (2) steady drive but with suppression of low-toroidal-mode-number global modes.

For approach (1), we simulate spheromak formation and decay with finite pressure and temperature evolution. With the driving electric field on, helicity is driven in from the edge of the plasma; and magnetic energy increases (for times less than the L/R time). A spheromak forms due to the action of the n=1 instability, and closed flux surfaces can appear transiently. Pulsing the driving electric field off allows the n=1 mode and its harmonics to decay in time faster than does the n=0 spheromak structure, and with enough poloidal field built up, closed flux surfaces emerge over significant volumes and then decay away. Repeated pulsing of the drive field on and off can increase the magnetic energy and the volume of closed flux surfaces during decay. The simulations address the influence of plasma flows in the temperature evolution equation.

For approach (2), we explore the possible conseequences through a driven simulation which suppress all odd toroidal harmonics, and hence in particular the global $n = 1$ mode. We find a configuration with an appreciable volume of closed flux surfaces which lives for a time long compared to the resistive decay time (but ultimately collapses.) The configuration is characterized by spontaneous oscillations in the poloidal flux, in the extent of the closed-flux-surface region, and in the parallel current.

We also explore a possible route to achieving a configuration with reduced $n = 1$ activity, via introduction of a rigid passive conducting structure which fills part of the central column. This work complements a parallel effort analyzing central-column stability via a variational principle.[3]

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[3]D.D. Ryutov, R.H. Cohen and L.D. Pearlstein, paper at this meeting.