ADVANCES IN NOVEL FRC PLASMAS*

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The recent prediction[1] of the stabilization of a Field Reversed Configuration (FRC) tilt instability by weak, spontaneously generated + and – toroidal magnetic fluxes leads us to investigate this and other novel FRC plasmas. The Swarthmore Spheromak Experiment (SSX)[2] is being modified to produce FRCs within a copper cylindrical flux conserver by merging two gun-generated, counter-helicity spheromaks. Frozen flux from external reconnection control coils (RCCs) will control the extent of spheromak reconnection and thus the residual + and – B_T surrounding the two magnetic axes in a CT doublet equilibrium, thereby enabling a test of the Ref. 1 prediction. Single-axis FRCs will also be made and studied.

A new finite-element, Grad-Shafranov, free-plasma-boundary equilibrium solver with doublet CT capability was written and used to design the SSX RCCs, whose frozen flux controls the final plasma shape. The code was validated against analytic equilibria, including a new analytic FRC solution having a pressure *vs*. flux profile of $p(\psi) \sim \psi^2$.

Two-fluid (electron and single ion species) calculations show that rotating FRCs self generate + and – B_T. Centrifugal density stratification makes ∇p non-perpendicular to magnetic surfaces, especially near their axial extremes, and results in a non-zero $\nabla \times E$. The total generated toroidal flux is zero, but calculated local dB_T/dt are sizeable at Mach ~ 0.1. Therefore, it might not be necessary to externally drive B_T if it is needed for stability.

The doublet CT is a new configuration and has not been previously studied. A doublet FRC ($B_T = 0$) can be interchange-stable inside and outside its figure-eight separatrix, by compressibility and average good curvature, respectively. The usual strong compressibility stabilization just inside the bounding separatrix is also present.

If radial transport is diffusive, near-spherical geometry yields the lowest power steady-state FRC fusion reactors. Oblate FRCs can be tilt stabilized by an external wall or active feedback coils. We outline a D-^{3}He reactor based on a steady-state oblate FRC.

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[1] Yu.A. Omelchenko, Phys. Plasmas **7**, 1443 (2000).
[2] C.G.R. Geddes, T.W. Kornack, M.R. Brown, Phys. Plasmas **5**, 1027 (1998).