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Stabilization of the FRC Tilt Mode by a Self-Generated Toroidal Field

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The Field-Reversed Configuration (FRC) is normally believed to be confined by purely poloidal fields. However, this assumption has never been put to a serious test in the FRC experiments because of the complexity of appropriate experimental techniques. The previous [D.W. Hewett, Nucl. Fusion **24**, 349 (1984); R.D. Milroy and J.U. Brackbill, Phys. Fluids, **29**, 1184 (1986)] and most recent [Yu.A. Omelchenko, to be published in Phys. Plasmas (2000)] results of the two-fluid and kinetic simulations of FRC formation indicate the spontaneous generation of an antisymmetric, large-scale toroidal magnetic field with the characteristic amplitude of order 20%–30% of the axial field strength. This effect is caused by the inherent axial shear in electron azimuthal velocity and underlines the importance of including the Hall term in the FRC equilibrium models. This work focuses on the effect of the self-generated toroidal field on the tilt stability of both fluid-like and kinetic FRCs. The required equilibria are obtained and tested for stability with a 3-D, hybrid, PIC code FLAME [Yu.A. Omelchenko and R.N. Sudan, J. Comp. Phys. **133**, 146 (1997)] by simulating the reversed theta-pinch formation of kinetic (low-s) and fluid-like (high-s) FRCs with and without toroidal field. In both cases this study has found the toroidal field effects to substantially reduce (by an order of magnitude) the tilt growth rate. The stable "doublet-like" FRCs (D-FRCs) are composed of two long-lived antisymmetric spheromaks with strong poloidal flows inside the separatrix. The toroidal magnetic field pressure and these flows are argued to explain the robust stability of the experimentally observed FRCs, which cannot be achieved by considering the kinetic (finite-orbit) and geometric effects alone.

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