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TH/P3-08: Coupling of Current and Flow Relaxation in Reversed-Field Pinches due to Two-Fluid Effects

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We present a computational study of the coupling between dynamo and momentum transport, motivated by findings of two-fluid effects in the Madison Symmetric Torus (MST). Laser polarimetry and magnetic probes measure correlated current-density and magnetic-field fluctuations during sawtooth events [1,2]. With ion skin depths being 0.1-0.2 a, the correlation implies significant Hall dynamo effect. It also implies net Lorentz force from the fluctuations, which can act to redistribute parallel flow. Linear computations elucidate the underlying magnetic tearing and show electron-ion decoupling from kinetic-Alfven-wave (KAW) physics when the sound gyroradius exceeds the resistive tearing width. With warm ions, results also produce a drift regime, where growth rates are smaller than in the resistive-MHD limit [3]. Analysis shows that the ion drift results from poloidal curvature and the radial variation of B, both of which are significant in pinch profiles. Nonlinear multi-helicity simulations qualitatively and semi-quantitatively reproduce the Hall dynamo and the flow profile relaxation that are observed in the laboratory [4]. The scaled magnitude of the computed Hall dynamo is comparable to the 40 V/m inferred from core-mode correlations in 400 kA MST discharges. Relaxation in our two-fluid modeling affects flows parallel to the large-scale B-field, inducing a net increase in the core and a net decrease in the edge. The orientation of this change is consistent with observations, and the magnitude is comparable to the 10 km/s in MST. Computations also reproduce competing Reynolds stress from flow fluctuations, which has been measured through Mach probes in the edge of MST [2]. The helicity of the large-scale B-field can affect the relative orientation of current-profile and flow-profile relaxation, and computational results on its influence are presented. Also, relaxation in MST starts with a net flow profile, and numerical results with and without initial flow are compared. *Supported by US DOE DE-FG02-06ER5480, DE-FG02-85ER53212, and NSF PHY-0821899. [1] W. X. Ding, D. L. Brower, et al., Phys. Plasmas 13, 112306 (2006). [2] A. Kuritsyn, G. Fiksel, et al., Phys. Plasmas 16, 55903 (2009). [3] J. R. King, C. R. Sovinec, and V. V. Mirnov, Phys. Plasmas 18, 42303 (2011). [4] J. R. King, C. R. Sovinec, and V. V. Mirnov, accepted for publication in Phys. Plasmas.

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