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OV/5-2Ra: Overview of Results from the MST Reversed Field Pinch Experiment

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This overview of results from the MST program summarizes physics important for the advancement of the RFP as well as for improved understanding of toroidal magnetic confinement in general. Evidence for the classical confinement of ions in the RFP is provided by analysis of impurity ion transport. With inductive current profile control, the test-particle diffusivity for ions in a stochastic magnetic field is reduced below the classical transport level. (The neoclassical enhancement of radial transport is negligible in the RFP.) Carbon impurity measured by CHERS reveals a hollow profile and outward particle convection. Modeling of classical transport agrees with the profile evolution, and temperature screening explains the hollow profile. Classical confinement is also observed for energetic ions created by 1 MW NBI. The energetic ion confinement is consistent with classical slowing-down and ion loss by charge-exchange. The first appearance of Alfven eigenmodes and energetic particle modes by NBI in a RFP plasma are obtained. MST plasmas robustly access the quasi-single-helicity state that has commonalities to the stellarator and "snake"formation in tokamaks. The dominant mode grows to 8% of the axisymmetric field strength, while the remaining modes are reduced. Energy confinement is improved as a result. Predictive capability for tearing mode behavior has been improved through nonlinear, 3D, resistive MHD computation using the measured resistivity profile and Lundquist number, which reproduces the sawtooth cycle dynamics. New two-fluid analysis that includes Hall physics and gyro-viscosity has established a new basis for understanding physics beyond a single-fluid model. Nonlinear two-fluid (NIMROD) computation reveals coupling of parallel momentum transport and current profile relaxation. Large Reynolds and Maxwell stresses, plus separately measured kinetic stress, indicate an intricate momentum balance and possible origin for MST's intrinsic plasma rotation. Microturbulence from drift-wave-like instabilities might be important in the RFP when magnetic fluctuations are reduced. New gyrokinetic analysis indicates that micro-tearing modes can be unstable at high beta, with a critical gradient for the electron temperature that is larger than for tokamak plasmas by roughly the aspect ratio. Supported by US DoE and NSF.

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