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OV/5-2Ra & OV/5-2Rb: Overview of Results from the MST Reversed Field Pinch Experiment; Overview of the RFX Fusion Science Program

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

OV/5-2Rb: Overview of the RFX Fusion Science Program
With a program well-balanced among the goal of exploring the fusion potential of the reversed field pinch (RFP) and that of contributing to the solution of key science and technology problems in the roadmap to ITER, the European RFX-mod device has produced a set of high-quality results since the last 2010 Fusion Energy Conference. RFX-mod is a 2 MA RFP, which can also be operated as a tokamak and where advanced confinement states have 3D features studied with stellarator tools. Self-organized equilibria with a single helical axis and improved confinement (SHAx) have been deeply investigated and a more profound understanding of their physics has been achieved. First wall conditioning with Lithium provides a tool to operate RFX at higher density than before, and application of helical magnetic boundary conditions favour stationary SHAx states. The correlation between the quality of helical states and the reduction of magnetic field errors acting as seed of magnetic chaos has been robustly proven. Helical states provide a unique test-bed for numerical codes conceived to deal with 3D effects in all magnetic configurations. In particular the stellarator equilibrium codes VMEC and V3FIT have been successfully adapted to reconstruct RFX-mod equilibria with diagnostic input. The border of knowledge has been significantly expanded also in the area of feedback control of MHD stability. Non-linear dynamics of tearing modes and their control has been modelled, allowing for optimization of feedback models. An integrated dynamic model of the RWM control system has been developed integrating

the plasma response to multiple RWMs with active and passive conducting structures (CarMa model) and with a complete representation of the control system. RFX has been operated as a tokamak with safety factor kept below 2, with complete active stabilization of the (2,1) Resistive Wall Mode (RWM). This opens the exploration of a broad and interesting operational range otherwise excluded to standard tokamaks. Control experiments and modelling led to the design of a significant upgrade of the RFX-mod feedback control system to dramatically enhance computing power and reduce system latency. The possibility of producing D-shaped plasmas is being explored.

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