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# Enhanced measurements for MHD validation using integrated data analysis on the MST fusion research experiment

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Over the past several decades, numerical simulation has successfully described various dynamical phenomena in fusion research plasmas. Substantial effort is now being applied to enhance the quantitative predictive capability of numerical simulation. Two key tools for this effort are quantitative validation and integrated data analysis (IDA). To perform validation, results of a numerical simulation are globally tested against experimental measurements to identify areas of quantitative agreement and disagreement. As a platform for validation activities, MST is usually operated as a reversed-field pinch (RFP), which produces a complementary parameter space to tokamaks and stellarators. Validation efforts on MST are concentrated on simulation of processes within the scope of MHD, using the codes DEBS (nonlinear, single-fluid, visco-resistive MHD) and NIMROD (nonlinear, two-fluid, extended MHD). Specific effort is being applied to characterize how magnetic turbulence within the plasma scales with Lundquist number. Another validation effort underway is investigation of the spatial distribution and influence of fluctuation-induced Hall effect and Maxwell stress as represented by two-fluid models. The measurement needs for validation often cannot be met by single-instrument diagnostics considered in isolation. IDA provides a method to address this challenge by maximizing the usefulness of the information recorded by a set of diagnostics. The goal of IDA is to combine data from heterogeneous and complementary diagnostics, considering all dependencies within and between diagnostics, in order to obtain the most reliable measurements in a transparent and standardized way. IDA has been used on MST to combine information from two diagnostics (charge-exchange recombination spectroscopy and soft x-ray tomography) to produce a robust measurement of effective charge (Zeff) with quantified uncertainty.

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