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Simulated and Measured Electron Thermal Transport with Varying Magnetic Stochasticity in the MST RFP

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New high spectral resolution simulations with the 3D, nonlinear, resistive MHD code DEBS have been made at a Lundquist number of $S \approx 4 \times 10^6$, matching that of 400 kA standard discharges in the MST. At this Lundquist number: (1) DEBS reproduces many features of the MST plasma including a well defined sawtooth cycle during which the spectrum of tearing modes dynamically evolves, (2) simulations were run for many sawtooth cycles so that synthetic diagnostic data could be sawtooth-ensembled and compared directly to experimental data, (3) the experimentally measured electron thermal diffusion profile agrees reasonably well with Rechester-Rosenbluth thermal diffusion when the degree of magnetic stochasticity is high, and (4) when the stochasticity is relatively low, magnetic structures are seen in the DEBS data that correlate to electron temperature structures observed in the core region of MST with the recently upgraded Thomson scattering system. The TS system on MST is now capable of measuring the temporal evolution of the Te profile at up to 25 kHz, representing an important advance in the diagnosis of high-β plasmas that are inaccessible to ECE. In addition to resolving the Te dynamics of the sawtooth cycle, this enhanced diagnostic capability has enabled confinement measurements for plasmas that spontaneously exhibit extended sawtooth-free periods with reduced stochasticity. During these periods, the energy confinement time triples, reaching 3 ms, while the central Te increases to over 1 keV, and runaway electrons, generally absent from standard discharges, are observed. These reduced stochasticity periods can last for many energy confinement times with an approximately constant magnetic equilibrium, and thus may be a useful future development path for the RFP.
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