Confinement and Transport in the National Spherical Torus Experiment (NSTX)

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Studies have been conducted in order to characterize both the global and thermal energy confinement as well as the local transport at low aspect ratio in high power L- and H-mode NSTX discharges. The global and thermal confinement times are found to be enhanced relative to scalings developed from higher aspect ratio devices for both L- and H-modes. While systematic scans indicate dependences on plasma current and heating power that are similar to those at higher aspect ratio, statistical analyses indicate a weaker current dependence and a significant dependence on B_T. These parametric dependences translate into favorable dependences with decreasing normalized gyroradius ρ_* and collisionality ν_* ($B\tau\sim\nu_*^{-0.4}$), and a β_T dependence that varies from unfavorable ($B\tau\sim\beta^{-0.65}$) to null ($\sim\beta^0$), depending on the specific statistical analysis used. The electron channel usually dominates the loss of energy of NSTX plasmas, with $\chi_e>\chi_i$ in the core of the plasma. The ion thermal diffusivity in the core (r/a<0.5) are typically 2 to 10 times greater than the NCLASS neoclassical value, but can drop to near neoclassical values farther out in the plasma. Non-local effects can modify the neoclassical transport and thus the value of the neoclassical thermal diffusivity. Improved electron confinement has been observed in plasmas with a fast initial current ramp which develop a region of reversed magnetic shear in the core, as confirmed with MSE measurements. "Enhanced pedestal H-modes", with energy confinement time enhancements of ≥2.7 over L-mode scaling values and significant plasma pedestal values, with $T_i\sim T_e\sim600$ eV at the top of the pedestal have been observed. Nonlinear electrostatic GYRO simulations of ITG/TEM microturbulence in L-mode NSTX plasmas have been carried out and show that the simulations with adiabatic electrons produces much weaker transport than those with a fully kinetic treatment. ExB shear greatly reduces the transport. Transport is also strongly reduced in simulations with radial domains that include a linearly stable region in the deep core (r/a~0.3-0.4), a finite ρ_* effect known as 'turbulence draining'.

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