# Transport at high beta in spherical tokamaks

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A key priority for spherical tokamak (ST) transport research is to understand the mechanisms responsible for confinement scaling at high beta (~20%), especially as collisionality is reduced towards that envisioned for future ST-based fusion nuclear science facilities. Previous research in the National Spherical Torus Experiment (NSTX) has indicated that heat loss through the ions is often close to collisional (neoclassical) transport limits. This is a consequence of the equilibrium configuration at high beta and large rotation shear suppressing electrostatic, ion gyroradius scale, drift wave turbulence mechanisms. Recent analysis and theoretical predictions have shown that a zoology of theoretical drift wave turbulence mechanisms are predicted unstable that can contribute to anomalous electron energy losses. Depending on location in the plasma and operating regime, these drift waves can be electrostatic or electromagnetic in nature, exist at ion or electron larmor radius scales, and exhibit unique sensitivities to plasma gradients (density, temperature) and equilibrium properties. In addition to gradient-driven drift waves, measurements and simulations predict the onset of global and compressional Alfven eigenmodes driven by the presence of energetic ions from neutral beam heating in high power discharges. These modes are predicted to cause large energy loss via stochasticized electron orbits, as well as redistribution of energy via coupling to kinetic Alfven waves damped further out in the plasma. Experimental evidence suggests these additional mechanisms may limit peak electron temperatures in NSTX. The upgrade to NSTX (NSTX-U) was recently completed to double the toroidal field strength (0.5→1.0 T), plasma current (1→2 MA) and neutral beam heating power (6→12+ MW). This will allow access to new parameter regimes while also providing increased flexibility to modify equilibrium current and rotation profiles, in order to better clarify our understanding of underlying transport mechanisms and validate theoretical predictions. Interestingly, NSTX-U also fills a gap in parameter space ($\beta$~20%, A=R/a~1.7, $\rho_*=\rho/R$~1/100, $M=v_{Tor}/c_s$~0.5) between compact toroids and conventional aspect ratio tokamaks, providing an opportunity to unify understanding of various instability and transport mechanisms. This work is supported by US DOE contract DE-AC02-09CH11466.