Transport and bootstrap current in a small aspect ratio torus

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Synopsis

Transport theory at high aspect ratio is based on the "small gyro-radius expansion", which assumes that $\rho_i/a \equiv \rho* << 1$. In addition, it is generally assumed that $|B_\theta/B_\phi| << 1$. In low aspect ratio tokamaks [1], often referred to as spherical torii, these assumptions are invalid. They are also fundamental to the derivation of the drift kinetic equation.

In order to determine the magnitude of the correction to collisional transport and bootstrap current due to finite gyro-radius, we compare the result of the gyro-average orbit code ORBIT [2, 3] with those from the full orbit code GYROXY[4]. We coin the word omniclassical to refer to transport calculations based on full particle orbits in general toroidal geometry with arbitrary aspect ratio.

Two equilibria from the National Spherical Torus Experiment (NSTX)[5], were chosen as representative low aspect ratio equilibria. In NSTX for most particle orbits the displacement of the particle from its nominal flux surface is much larger than the neoclassical banana width. To carry out the numerical simulations, monoenergetic distributions of particles are allowed to evolve under the influence of pitch angle scattering.

The resultant omni- to neoclassical bootstrap and diffusivity ratios are determined versus outboard radius for a large beta equilibrium. Both bootstrap current and diffusion are significantly larger than neoclassical, also in a low beta discharge.

*This work was supported by the U.S. Department of Energy Grant under contract number DE-AC02-76CH03073.

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