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Competition between parallel viscosity and ion-neutral friction in damping the parallel flow in a quasisymmetric stellarator[1]

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Experimentally measured parallel ion flows and radial electric fields in the quasisymmetric configuration of the HSX stellarator have been shown previously to be inconsistent with standard neoclassical calculations. To examine this inconsistency, improvements have been made in both experimental technique and theoretical modeling. A charge exchange spectroscopy system has been upgraded to measure the counter-streaming Pfirsch-Schlüter parallel ion flows from which flux surface averaged parallel ion flows and the radial electric field can be obtained without using the radial force balance equation. This method provides an improved measurement of the parallel ion flows and radial electric fields in the core of the plasma where the poloidal flow measurements have large uncertainties. Along with the improvements in diagnostics, the neoclassical transport code PENTA has been modified to include collisions with background neutrals. Toroidal and poloidal arrays of H-alpha detectors in conjunction with the neutral transport code DEGAS provided radial and temporal profiles of neutral density in the plasma. Including neutral friction in the neoclassical calculation significantly damps the parallel ion flow and resolves the inconsistency of the parallel flow and radial electric field for the quasisymmetric magnetic geometry. The calculated radial electric field values are relatively unchanged with the inclusion of neutral friction. As the decrease in ion parallel flow is matched by an increase in the electron flow, the bootstrap current is also found to be insensitive to the neutral friction. In a configuration of HSX in which the quasisymmetry is intentionally degraded, the effect of neutral friction is found to be less important due to the increase in the neoclassical parallel viscosity.

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