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Reduction of Particle and Heat Transport in HSX with Quasisymmetry[1]

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The Helically Symmetric Experiment (HSX) has a helical direction of symmetry in the magnetic field strength. As a result of this symmetry, the theoretical neoclassical transport is reduced to the level of an axisymmetric device. This neoclassical transport is in addition to the anomalous contribution to the total transport. Experimentally, the electron collisionality is in the long mean free path regime so that neoclassical electron transport can be studied as a function of the magnetic field spectrum. Here we report experimental measurements of differences in electron temperature and density profiles between the quasihelically symmetric configuration (QHS) and configurations with the symmetry broken. The central electron temperature in QHS is significantly higher than that in the configuration without symmetry (~450 vs. ~250 eV) under the same conditions. Ray tracing calculations show that the absorbed power is localized to within r/a~0.2 for both configurations, and the total absorbed power is scaled to match diamagnetic measurements. The resulting electron thermal conductivity in the core increases from ~3 m^2/s for QHS up to ~8 m^2/s as the symmetry is broken. With central heating and peaked temperature profiles, the density profile is centrally peaked in QHS, while for nonsymmetric plasmas the profile is flat or hollow as has been typically observed in conventional stellarators with ECH. Decreasing the temperature gradient in nonsymmetric plasmas results in a peaking of the density profile. The experimental particle flux has been inferred using a set of absolutely calibrated H_α detectors coupled with 3D neutral gas modeling. In the core of the plasma the neoclassical particle flux in the nonsymmetric configuration is comparable to the experimental flux. This neoclassical flux is dominated by particle flux driven by the temperature gradient, verifying that the flattening of the density profile in the nonsymmetric configuration is caused by neoclassical thermodiffusion. In QHS, the neoclassical particle flux (including thermodiffusion) is reduced, leading to a peaked density profile in the presence of a peaked temperature profile.

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