Electron Heat Confinement in Reversed Field Pinches [*]

J. W. James, E. D. Held
Physics Department, Utah State University
Logan, UT 84321-4415

Abstract

In this work, electron heat confinement times in reversed field pinches are predicted by calculating effective radial electron thermal diffusivities χ_{er} using various methods and compared to confinement times measured in experiments.

The first method derives the effective radial electron thermal diffusivity from the tangled nature of the magnetic field itself[†]. The relation of these stochastic diffusivities to the Lyapunov spectrum of the magnetic field is explored. Stochastic diffusivities are compared to those calculated directly from the component of the electron heat flow parallel to the magnetic field ($\vec{q}_{e_\parallel}$) throughout the magnetized plasma volume, but especially in regions outside the reversal surface where good flux surfaces still exist.

The second method determines χ_{er} directly from the radial component of $\vec{q}_{e_\parallel}$ in the plasma fluid energy equation. In these calculations, two different models are employed for the $\vec{q}_{e_\parallel}$ closure and the resulting diffusivities are compared in various magnetic field configurations. One model addresses the anisotropy in $\vec{q}_{e_\parallel}$ verses $\vec{q}_{e_\perp}$ by writing $\vec{q}_{e_\parallel}$ as an enhanced diffusion process which depends on local gradients in the temperature, while the other model includes effects from non-local variations in the temperature by integrating along the magnetic fieldline[‡].

The high-order finite element version of the plasma fluid code NIMROD[§] was used in a simulation that results in a magnetic field characterized by large amounts of field line chaos and a reversal surface near the plasma edge. Subsequently, the energy equation only was evolved in this frozen magnetic field to make the diffusivity calculations.

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