Neoclassical Transport Theory in DRAKON Plasma Confinement Systems

by

Yun-tung Lau

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Abstract

A DRAKON (a Russian acronym for long equilibrium configuration) is a closed-end plasma confinement systems consisting of two straight sections of low magnetic field, joined at the ends by two special connectors of high magnetic field, called CRELs (Connectors of Rectilinear ELements). These CRELs has the property that, as a result of their three-dimensional curvilinear configurations, no parallel plasma currents flow out of their ends, thereby keeping the equilibrium in the straight sections autonomous.

Before the transport studies, the equilibrium and stability properties of DRAKONs are analyzed. The equilibrium beta limits are typically 1–2% in the CRELs, resulting in the requirement of CRELs with ultrahigh magnetic fields in DRAKON reactors. The bad curvature drives for interchange instability from the straight sections and CRELs are found to be comparable. It is also demonstrated that the flute-like $m = 1$ interchange instability can be stabilized by a magnetic divertor. A conceptual design of a small triangular-CREL DRAKON, which utilizes such a magnetic divertor for stabilization, is presented.

The neoclassical transport properties of DRAKONs are investigated along with the development of neoclassical transport theory for arbitrary closed-end plasmas. General expressions for the Pfirsch–Schlüter and banana-plateau fluxes are obtained. When applied to DRAKONs with triangular CRELs, they yield Pfirsch–Schlüter fluxes comparable to classical fluxes. The banana-plateau fluxes are negligible. The nonsymmetric fluxes due to trapped particles are the dominating neoclassical fluxes in the small DRAKON, for which the energy confinement time is estimated to be about 4 msec.

As for the DRAKON reactors (a test reactor and a power plant), the confinement times are roughly estimated from a model for convective losses. The test reactor lies in the breakeven regime of the Lawson diagram, while the power plant in the ignition regime.

Thesis Supervisor: Ronald C. Davidson
Title: Professor of Physics; Director, Plasma Fusion Center