

13th International Stellarator Workshop

Initial Results From an International Collaboration on Neoclassical Transport in Stellarators

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A first status report is presented, summarizing the results obtained to date through an international collaboration on the topic of neoclassical transport in a number of devices belonging to the stellarator family. The principal goals of this collaboration are:

- (1) A thorough benchmarking of the various methods used to calculate neoclassical transport coefficients. These include (where appropriate): analytic theory, field-line integration techniques, Monte Carlo simulations, and numerical solutions of the ripple-averaged and drift kinetic equations.
- (2) An improved physical understanding of stellarator-specific transport processes.
- (3) On the basis of the first two points, the creation of an efficient “neoclassical data base” to facilitate the analysis of experimental results and to provide an interface for predictive transport codes.

The devices currently under investigation are representative of the extensive configuration space available to stellarators: the classical heliotron/torsatron Large Helical Device (LHD), in operation at Toki, Japan; the heliac TJ-II, in operation at Madrid, Spain; the quasi-axisymmetric National Compact Stellarator Experiment (NCSX), in the planning stage at Princeton, USA; and two advanced stellarators of the Wendelstein line, W7-AS in operation at Garching, Germany, and the helias W7-X which is under construction at Greifswald, Germany.

Although the magnetic-field spectra of these devices differ considerably, all results exhibit some common qualitative features. In particular, regimes in which the radial transport coefficients scale as ν^0 , ν^{-1} and $\nu^{1/2}$ (where ν is the perpendicular collision frequency) can be identified successively in collision frequency scans from high to low values of ν . This is possible in spite of the fact that the transport level in these configurations varies greatly. The presence of a radial electric field is responsible for the transition from the ν^{-1} to the $\nu^{1/2}$ regime, marking a local maximum in the radial transport coefficients. At this transition, the transport coefficient which characterizes the bootstrap current also reaches its maximum value and then decreases with decreasing collision frequency. The only exception is provided by W7-X, which has a magnetic-field spectrum optimized for small bootstrap current; this optimization suffers a modest degradation if a radial electric field is present.

Conference Topic: 4

Poster is preferred: no

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