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EX/P3-14: Inter-Machine Validation Study of Neoclassical Transport Modelling in Medium- to High-Density Stellarator-Heliotron Plasmas

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Stellarator-Heliotrons (S-H) offer an alternative route to steady-state fusion reactors and one mission of the largest S-H devices is to provide a physics basis for burning S-H plasmas. The S-H devices closest to reactor conditions play key-roles: the Large Helical Device and Wendelstein 7-X (under construction). In contrast to tokamaks, 3D magnetic fields in S-H lead even in the plasma core to localized, trapped particles significantly enhancing the radial neoclassical (NC) transport for reactor-relevant conditions (long-mean-free-path (lmfp), Te˜Ti, high nT\tau). In order to test a recently concluded benchmarking of calculations of NC transport coefficients, this study compares experimental findings with NC predictions for medium- to high-density S-H plasmas.

The focus of this study is put on recent experiments conducted in LHD and TJ-II also involving findings from Wendelstein 7-AS. This experimental inter-machine study was to test NC transport models in the transition from medium- to high-density, lmfp S-H (3D) plasmas at high heating power. In 3D magnetic configurations, radial electric fields (E_r) must arise to satisfy the ambipolarity condition which is not intrinsically satisfied as in axisymmetric tokamaks. In the plasma core, E_r complies with predictions for LHD and W7-AS, differences are found for TJ-II operating at lower densities. Steady-state energy balance analyses were performed using the integrated transport code, TASK3D for LHD discharges, and by ASTRA in TJ-II. For W7-AS, the experimentally determined particle and energy fluxes were compared to NC fluxes with transport coefficients from DKES and found to be consistent with NC theory up to 2/3 of the minor radius under lmfp, high nT\tau conditions. Cases with similar findings can be reported from LHD, but depend sensitively on the shift of the major plasma axis.

The inter-machine dataset obtained a variety of magnetic configurations will be comprehensively analyzed to assess the ranges of validity of NC transport predictions. This study is providing quantitative tests of the NC theory employed in the optimization of W7-X and to allow assessment of NC transport in the reactor-relevant regime of S-H devices. Moreover, the coupling of NC energy and particle transport is highly relevant for the discharge scenario development for large S-H devices in view of reactor operation scenarios.

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Collaboration (if applicable, e.g., International Tokamak Physics Activities)

International Stellarator-Heliotron Profile Database (Coordinated Working Group)

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