Validation of local and non-local neoclassical predictions for the radial transport of plasmas of low ion collisionality

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Neoclassical (NC) transport is a fundamental aspect of stellarator plasma scenario development: predictive 1D transport simulations (see for example [1]) with NC transport at the core, complemented with simple models for anomalous transport at the edge, allow for estimates of confinement time, power load to the walls, fuelling and heating requirements... This way to proceed has been supported by a step-by-step systematic validation of the predictions of NC theory with experimental results in a number of medium-sized stellarators (LHD, W7AS, TJ-II...) in regimes as reactor-relevant as possible (see [2] and refs. therein). Generally speaking, these simulations tend to show, with some exceptions, reasonable agreement between the experimental and the NC particle and heat fluxes within the core region. A relevant feature of these studies is that all of their NC simulations rely on the local ansatz of NC transport and make use of the monoenergetic approach. A recent contribution (see [3] and refs. therein) has extended them by investigating, for several discharges, differences between the results of local and monoenergetic NC codes (e.g. DKES) and non-local, non-monoenergetic NC codes (FORTEC-3D). These differences could explain some of the discrepancies between NC simulations and the experimental results, or improve the results in those situations where the agreement is at best rough.

In this work we expand the range of these studies. The CXRS system permits us to measure the full ion temperature radial profile and identify TJ-II discharges [4] in which ion collisionality is relatively low (up to one fifth of that studied in previous cases) and the electron collisionality is low, but not too much (so that the radial electric field is in the ion root). This situation is closer to reactor relevant conditions than in previous NC studies in TJ-II. Thus in this work we enlarge our experimental database of discharges and, for some of them, we calculate local NC fluxes with DKES, non-local NC fluxes with FORTEC-3D and experimental fluxes with the transport suite ASTRA. Comparison between them shows that non-local NC effects are not important in the core, neither for the particle nor for the ion heat flux, while they bring the predicted heat flux closer to the experimental one at outer positions.