Prediction of kinetic profiles using a new transport solver based on global optimization techniques

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To validate transport models driven by turbulence, which generally predominates transport in tokamaks, and/or predict kinetic profiles using them, coupling of a transport solver and transport models is indispensable. Many turbulent transport models show strongly nonlinear dependence on the gradient of kinetic profiles and such stiff behavior makes it difficult to robustly obtain smooth kinetic profiles without wiggles in less computation time.

In [1], we have proposed the basic concept of an intrinsically oscillation-free transport solver based on global optimization techniques, even though stiff transport models are employed. The code, dubbed GOTRESS, benefiting from both a genetic algorithm [2] and Nelder-Mead method [3], solves the steady-state transport equations. GOTRESS does not require any derivatives in the course of calculation because the governing equations are not spatially discretized. Instead, the integral equations are successively solved at each grid to fit the conducted heat fluxes to the target fluxes that are obtained by integrating heat source and sink over the volume. Multi-species, collisional equipartition, actual shaped equilibria are all taken into account. GOTRESS is parallelized by MPI to reduce computation time. Even in a strong reversed shear plasma such as a current hole plasma, it just takes tens of seconds until GOTRESS satisfies a convergence criterion with CDBM or IFS/PPPL model, the latter of which is a very stiff model. Owing to MPMD, GOTRESS can be executed in a straightforward manner together with a parallelized transport model like TGLF and/or a neural-network-based transport model even if it is written in Python.

GOTRESS can be exploited as a kernel of an integrated transport modeling, which makes it possible to robustly predict steady state profiles in future devices such as JT-60SA and also to check the validity of prescribed profiles that have been used.

References

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