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PTRANSP Tests Of TGLF And Predictions For ITER

Robert V. Budny, Xingqiu Yuan, S. Jardin, G. Hammett, G. Staebler and
Members Of The ITPA Transport and Confinement Topical Group and
JET EFDA Contributors

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PTRANSP tests of TGLF and predictions for ITER

R.V. Budny[1], Xingqiu Yuan[1], S. Jardin[1], G. Hammett[1], G. Staebler[2], members of the ITPA Transport and Confinement Topical Group, and JET EFDA Contributors[3]

[1]PPPL, P.O. Box 451, Princeton, NJ 08543, USA, [2]GA, San Diego, CA, USA [3]See the Appendix of F. Romanelli *et al.,* Proceedings of the 23rd IAEA Fusion Energy Conference 2010, Daejeon, Korea
e-mail contact of main author: budny@princeton.edu

Introduction - One of the physics goals for ITER is to achieve high fusion power $P_{\rm DT}$ at a high gain $Q_{\rm DT}$. This goal is important for studying the physics of reactor-relevant burning plasmas. Simulations of plasma performance in ITER can help achieve this goal by aiding in the design of systems such as diagnostics and in planning ITER plasma regimes. Simulations can indicate areas where further research in theory and experiments is needed. To have credible simulations integrated modeling is necessary since plasma profiles and applied heating, torque, and current drive are strongly coupled.

The PTRANSP code [1–3] is being used to generate time-dependent integrated predictions. Time dependent predictions are necessary to include evolving processes such as plasma formation, termination, and transients such as magnetic field diffusion, sawtooth effects, and accumulation of ash from the DT reactions. The PTRANSP predictions are self-consistent in that the heating, current-drive, torques and equilibria are calculated using predicted plasma profiles, and vice versa. These are included in the local flux-averaged energy, momentum, and magnetic field evolutions. Many effects are included such as sawtooth mixing and accumulation of ash.

Predictions for ITER have been performed using physics-based models such as GLF23 [4]. This model achieve approximate agreement predicting measured temperatures and toroidal rotation v_ϕ. Examples of predictions are in Ref. [5]. An improved Trapped gyro-Landau Fluid model TGLF [6] contains physics not included in GLF23 such as realistic shaped finite aspect ratio (Miller) flux geometry, collisionality, and a larger set of basis functions for fitting the ITG, TEM, ETG, and electromagnetic kinetic ballooning mode turbulence simulated with a large database of non-linear runs using the GYRO code [7]. TGLF achieves more accurate predictions of temperatures measured in DIII-D and JET L-mode, H-mode and hybrid discharges than does GLF23.

This paper describes a major upgrade to PTRANSP which implements TGLF. The upgrade uses a new robust solver for stiff transport models. Both GLF23 and TGLF are incorporated. The implementation of TGLF is verified by comparing with results derived using the XPTOR code, and is tested using H-mode plasmas from JET. Predictions for ITER plasmas are given and compared with predictions using GLF23.

PT_SOLVER - The new solver is modular, parallel, and multi-regional. The solver does not depend on PTRANSP internals and is being made available through the NTCC website [8]. The solver is used to integrate the highly nonlinear time-dependent equations for ion, and electron temperatures and densities, and angular momentum with implicit Newton iteration methods. The user controls the choice of transport models attached to the solver, with a range of neoclassical and/or turbulent, or semi-empirical or data driven choices available. These include turbulent transport models such as GLF23 and TGLF. For the more CPU-intensive transport models such as TGLF, a multi-level, communicator splitting method is used to parallelize the computation of transport coefficients using MPI. This allows the code to run on a flexible number of CPUs. Two-level parallelization is implemented in PT_SOLVER: parallelization of flux-surfaces; and in the $\rm k_y$ spectrum domain.

The data are communicated between PTRANSP and PT_SOLVER via "Plasma State" files [9] containing axisymmetric MHD equilibrium, plasma and source profiles (1D and 2D), and associated scalar data. The interface provides easy data access (allowing, for instance, rezone, and an interpolation function). Data in the plasma state is component based fortran 90 type.

Tests - Predictions of temperature profiles from the standalone module are compared with those predicted by XPTOR (the standard tool for TGLF predictions) and from experiments. A crucial step in the verification that TGLF is implemented correctly is comparison of the heat flux profiles predicted

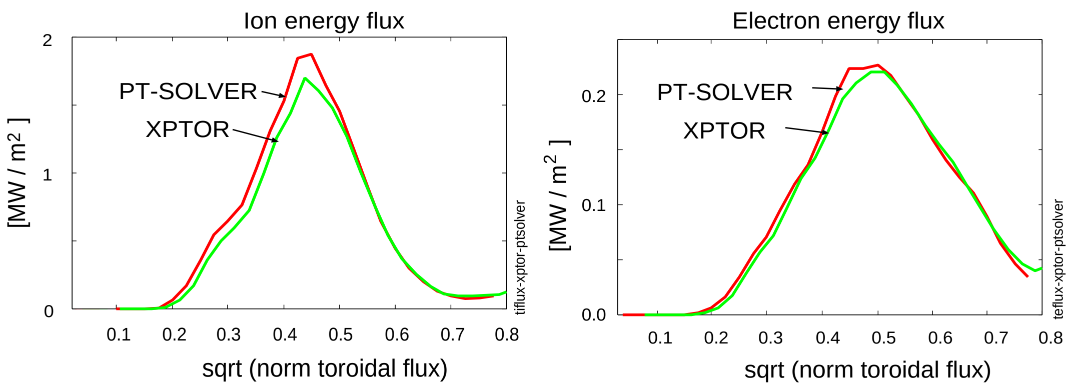

FIG. 1: Compare initial ion and electron heat fluxes computed by XPTOR and PT_SOLVER

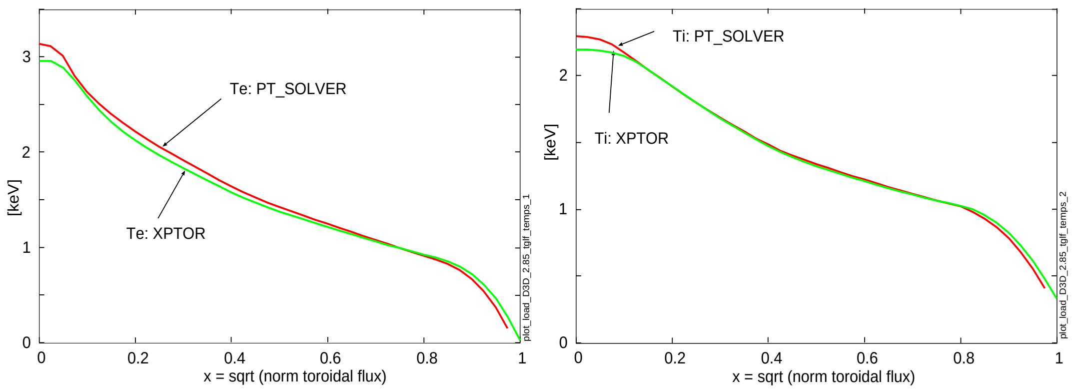

FIG. 2: Compare predicted ion and electron temperatures computed by XPTOR and PT_SOLVER

using input profiles. Comparisons for a discharge are shown in Figure 1. Comparisons of the predicted temperatures are shown in Figure 2. Different formulations for the differencing schemes (first order in XPTOR and second order in PT_SOLVER) lead to small differences in the predictions. Comparisons of results predicting T_e and T_i profiles measured in ITER baseline demonstration plasmas from the ITPA profile database [10] are given.

Predictions - ITER H-mode plasmas are predicted using the GLF23 and TGLF modules are compared.

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Information Services
Princeton Plasma Physics Laboratory
P.O. Box 451
Princeton, NJ 08543

Phone: 609-243-2245
Fax: 609-243-2751
e-mail: pppl_info@pppl.gov
Internet Address: http://www.pppl.gov