Resolving the mystery of transport within internal transport barriers

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Abstract. The Trapped Gyro-Landau Fluid (TGLF) quasi-linear model [G.M. Staebler, *et al.*, Phys. Plasmas **12**, 102508 (2005)], which is calibrated to nonlinear gyrokinetic turbulence simulations, is now able to predict the electron density, electron and ion temperatures and ion toroidal rotation simultaneously for internal transport barrier (ITB) discharges. This is a strong validation of gyrokinetic theory of ITBs, requiring multiple instabilities responsible for transport in different channels at different scales. The mystery of transport inside the ITB is that momentum and particle transport is far above the predicted neoclassical levels in apparent contradiction with the expectation from the theory of suppression of turbulence by $E \times B$ velocity shear. The success of TGLF in predicting ITB transport is due to the inclusion of ion gyro-radius scale modes that become dominant at high $E \times B$ velocity shear and to improvements to TGLF that allow momentum transport from gyrokinetic turbulence to be faithfully modeled.

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