Multi-channel flux-driven quasilinear turbulent transport prediction over many confinement times

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Quasilinear turbulent transport models have emerged as a successful tool for prediction of the tokamak plasma state. They are valid in the tokamak core, where $\delta n/n < 10\%$. Their success hinges on the reproduction of local nonlinear gyrokinetic fluxes, with a computational cost reduced by a factor $\sim \times 10^6$. This opens up the study of nonlinear interplay between transport channels over many confinement times, uncovering new physics vital for interpretation of experiments, validation of theory, and discharge design and optimization. We review the main results reached over the past 10 years, with emphasis on the range of validity of the quasilinear approximations, and verification against nonlinear simulations. We focus on significant progress recently achieved in the linear gyrokinetic transport model QuaLiKiz (Bourdelle *et al.* Plasma Phys. Control. Fusion 58 (2016) 014036), now capable of tractable simulation of flux-driven dynamic profile evolution including all transport channels: ion and electron heat, main particles, impurities, and momentum. Validation of the model in integrated modelling simulations of JET hybrid and baseline plasmas is presented. We also include the impact of rotation and temperature anistropy induced poloidal asymmetry on heavy impurity transport, important for W-transport applications. Finally, we present a proof-of-principle of a realtime capable emulation of quasilinear transport models by nonlinear regression using neural networks. This opens up the enticing possibility of bringing first-principle-based transport models into the control room for fast discharge preparation, realtime supervision, and model-based predictive control.