Real-time multichannel tokamak plasma profile simulations using the RAPTOR code and the QLK-NN first-principle transport model

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Real-time capable yet accurate simulations of the plasma profile evolution have important applications in discharge preparation and optimization, real-time profile reconstruction and control.For the first time, real-time-capable coupled simulations of the kinetic profiles T_e, T_i and n_e and q profile have been obtained that agree well with experimental data. The RAPTOR rapid profile evolution code was used for this purpose, coupled to a first-principle based model to predict the transport coefficients for the kinetic profiles. This transport model, named QLK-NN, is a neural network emulation of results from the QuaLiKiz quasilinear gyrokinetic code [1]. This allows the fluxes to be evaluated in less than a millisecond per radial point per time step. An initial version of QLK-NN, named QLK-NN4Dkin, extending the original proof of principle in [2] to include kinetic electrons, takes as inputs the normalised logarithmic ion temperature gradient R/L_{T_i}, the ion to electron temperature ratio T_i/T_e, the safety factor q, and magnetic shear s and returns the electron and ion heat flux, and electron diffusion and pinch coefficients. This model was trained in the regime where turbulence drive is dominated by ITG modes and has proven successful in reproducing kinetic profiles from a well-diagnosed JET discharge by setting only the kinetic profile boundary conditions at the top of the pedestal [3]. First results using RAPTOR with a more advanced version of the neural network transport model, QLK-NN10D [4], are also presented. This model is trained on an extended parameter space including further dependence on the electron temperature gradient, the density gradient, local aspect ratio, collisionality, impurity content, and perpendicular flow shear, and covers ITG/TEM/ETG turbulence regimes. First experimental tests are foreseen on JET and MST1 devices in 2018.

References

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