The EPED Pedestal Model: Gyrokinetic Extensions, Experimental Tests, and Application to ELM-suppressed Regimes

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Accurate prediction of the pressure at the top of the edge transport barrier (or "pedestal height") is a key element of the assessment and optimization of fusion performance in tokamaks. We develop and test a model, EPED, for the H-mode pedestal height and width based upon two fundamental and calculable constraints: 1) onset of non-local peeling-ballooning modes at low to intermediate mode number, 2) onset of nearly local kinetic ballooning modes (KBM) at high mode number. Gyrokinetic and MHD calculations in realistic edge geometry are used to accurately assess both constraints and employ them in a predictive pedestal model with no adjustable parameters. Detailed studies of the KBM and related instabilities with GYRO and TGLF are described. Extensive tests of the EPED model on several tokamaks have been completed and additional tests are planned. On Alcator C-Mod, a series of experiments testing the model over a wide range of magnetic field (3.5, 5.4 and 8 T) have recently been completed, finding good agreement with EPED predictions of pedestal height and width. On DIII-D, experiments have been conducted to further test the EPED model and KBM physics with a new higher resolution edge Thomson system and turbulence diagnostics. On JET, the model has been compared to a large dataset of 137 discharges, allowing detailed statistical comparisons and finding good (~20% or better) agreement with the model. Studies of ELM suppression with 3D magnetic fields suggest that a combination of the EPED model and realistic plasma response calculations may yield a plausible model for ELM suppression, including prediction of the required range of q_{95}. Pedestal prediction and optimization for ITER and reactor scale devices are also discussed.

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