Development and Validation of a Predictive Model for the Pedestal Height*

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The pressure at the top of the edge transport barrier (or "pedestal height") strongly impacts fusion performance. Predicting the pedestal height in future devices such as ITER remains an important challenge for plasma theory. While uncertainties remain, MHD stability calculations, accounting for diamagnetic stabilization, have been largely successful in predicting the observed maximum pedestal height, when the barrier width is taken as an input. However, the strong correlation between the stability-constrained height and the width, along with measurement uncertainty in the width, have complicated prior efforts to discern the dependencies of the width. Here, we employ the peeling-ballooning stability calculations as a constraint, accounting for the strong correlation of the width and height, and allowing study of the dependencies of the width itself. A simple equation for the pedestal width is derived [~(beta_pol_ped)^1/2] and successfully compared to a large set of DIII-D data. Combining this simple model of the pedestal width with direct stability calculations using the ELITE code, we develop a new predictive pedestal model, EPED1, which allows quantitative prediction of the pedestal height and width in both past and future experiments. Pedestal height predictions with EPED1 were made before a dedicated set of pedestal height variation experiments on DIII-D. The predictions were found to be in very good agreement with the DIII-D observations, in which pedestal height varied more than an order of magnitude. EPED1 is found to quantitatively capture the observed complex dependencies of pedestal height on shape, q, collisionality and global beta in large statistical studies. We present comparisons to observations on multiple tokamaks, as well as predictions for ITER and other next step devices.

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