Physics Understanding of the Pedestal Power Dependence: Implications for a First Principles Pedestal Model*

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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. One aspect of predicting the pedestal height that has a particularly strong impact on fusion reactor performance is the dependence of pedestal height on input power. A significant average positive correlation between input power and pedestal height has been observed in empirical database studies, though this dependence is absent in some regimes. Here we study pedestal power dependence via detailed studies of MHD constraints on the pedestal, and consider implications for pedestal transport and first principles models of the pedestal height.

It has been established that the edge pedestal height in standard ELMing H-mode is generally constrained by intermediate wavelength MHD instability, as posited by the peeling-ballooning model (e.g. 1-2). While the MHD constraint itself does not have an explicit power dependence, it can in fact correlate to power, via at least three mechanisms: 1) <u>Pedestal width</u>: the MHD constraint on the pedestal height is dependent (though not linearly dependent because the stability constraint is non-local [2]) on the pedestal width, and this width may have a power dependence. 2) <u>Shafranov shift</u>: the MHD constraint, particularly for strongly shaped plasmas, depends strongly on the Shafranov shift, a non-local quantity which in turn depends on core profiles which have a power dependence. 3) <u>Kink/peeling constraint</u>: At low collisionality, the MHD constraint is due to current driven kink/peeling modes, and pedestal pressure gradients can increase with power in this regime without immediately exceeding the MHD constraint.

We find that the Shafranov shift physics, taking into account pedestal width variation with height, largely explains DIII-D observations in the studied cases. In particular, it explains both cases in which no significant pedestal power dependence is observed, and cases with large power dependence. We then use this result to account for all MHD-related dependencies, infer the underlying physics of the pedestal width, and construct initial versions of a first principles pedestal model.

[1] P.B. Snyder, *et al.*, Phys. Plasmas **9** (2002) 2037.
[2] P.B. Snyder, *et al.*, Plasma Phys. Control. Fusion **46** (2004) A131.

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