Equilibrium theory of the pressure pedestal in High (H) mode tokamak plasmas*

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Recently, using two-fluid Hall-MHD equations, Mahajan and Yoshida [1,2] have developed a theory of plasma relaxed states with flow. The theory gave rise to the so-called double-Beltrami states (DB) obtained by the interaction of the magnetic and velocity fields. The present work extends the earlier theory [2] by allowing for non-constant density, which is determined self-consistently by an equation of state, and limits the maximum pressure gradient by the ideal ballooning stability criterion. It is shown that the detailed solution of the DB system with physically meaningful boundary conditions, augmented by the ballooning mode stability condition, determines uniquely the pedestal width and the pedestal height. The theoretically derived expressions for the height and width can be readily cast into forms that are equivalent to the empirical scaling laws currently in vogue. The intrinsic dependence of the pressure pedestal width and height is the ion skin-depth. By using the stability criterion for ideal ballooning modes, it can be expressed in the form involving the poloidal ion-gyroradius. This is therefore very different from the orbit loss theories for which the poloidal larmor radius is the instrinsic scale-length. Furthermore in magnitude the scalesize is found to be larger than the poloidal larmor radius, which is also consistent with observations. The numerical solutions for the non-constant density, indicate that the computed equilibria have both toroidal as well as poloidal flows. Furthermore the edge density and temperature profiles for different "equations of state" have been computed, and those for the adiabatic constant γ=3, valid for a strongly magnetized plasma, are found to be consistent with observations. The direction of the radial electric field is also inward. The comparison of the theory predictions with data on some of the large machines is very promising.

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2. S. M. Mahajan and Z. Yoshida, Phys. Plasmas **7**, 635 (2000)

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