Isotope effect on pedestal formation in flux driven nonlinear fluid simulations

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The L- to H-mode transition occurs at a critical power which increases with magnetic field, density and plasma surface [1]. The impact of the ion mass (D vs H, T or He) also modifies the power threshold which is found to be higher in H than in D [2]. Although this isotope effect has been observed in many tokamaks worldwide, it still remains poorly understood.

In order to understand the physics mechanisms behind the pedestal formation and the isotope impact, we are using a 3D flux driven non-linear fluid code, EMEDGE3D, to model the plasma turbulence at the edge of the confined region.

Our study brings new understanding regarding this issue by means of EMEDGE3D simulations. This code already captured the self-generated pedestal formation above a given power source [3]. Since then, diamagnetic effects and magnetic fluctuations are now accounted for. We show that at realistic edge resistivity, the diamagnetic coupling is a key ingredient for stabilizing turbulence [4], while magnetic fluctuations are destabilizing. This is important since the empirical scaling predicts the power threshold to strongly increase with β.

Using the improved electromagnetic model of EMEDGE3D, a pedestal formation is recovered when the heating power exceeds a threshold. The key ingredient for the pedestal formation still appears to rely on the coupling between the radial electric field, the equilibrium pressure gradient and the poloidal velocity. Similarly to [3], the neoclassical friction is artificially increased. Further work is required to understand such a need.

The power threshold for the pedestal formation is shown to increase by a factor slightly smaller than $\sqrt{A}$ when changing the ion mass from D to H. Indeed, the linear growth rate increases with ion mass. Nonlinearly, coherently, the confinement time is higher in D than H. Consequently, a pedestal formation is obtained at a larger heating source, needed to enforce a larger ExB shear when reducing the ion mass.

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