L to H mode transition: Parametric dependencies of the temperature threshold

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On a global scale, the L to H mode transition happens above a critical power threshold. On a local scale, a critical temperature threshold (T_{th}) is often reported to characterize the transition [1]. The parametric dependencies of this local criterion are easier to compare to theoretical approaches based on local mechanisms. Such a comparison is presented here.

The L to H mode transition is modelled by a ratio of two time scale: one characterizing the turbulence and the other the mean radial electric field shear (ExB shear). The assumption made is that the transition in H mode occurs when the ExB shear time scale exceeds the turbulence one [2]. The ExB shear is constrained by a value at the last closed flux surface depending on the temperature gradient [3] and a more inner value where the poloidal velocity is given by the neoclassical theory accounting for the transition from the banana, plateau and Pfirsch-Schlütter regimes. The background turbulence results from a competition between Ion Temperature Gradient and Trapped Electron Modes (ITG-TEM) at low collisionality and Resistive Ballooning Modes (RBM) at higher collisionality [4] modelled analytically using the fluid limit formulations [5,6]. The ratio of the analytically derived γ_{turb} by γ_{ExB} is function of the temperature. By changing one parameter (B, density, etc.) a critical value of $\gamma_{turb}/\gamma_{ExB}$ can be reached at different temperatures. For an arbitrary value of $\gamma_{turb}/\gamma_{ExB}$, the parametric behaviour of this temperature threshold (T_{th}) can be studied. The impact of B on T_{th} is such that the most robust parametric dependences of the power threshold, namely $P_{th} \propto n\,B\,S$, are recovered. The existence of a minimum in density is found to result from the change of the nature of the underlying turbulence, ITG-TEM at low density and RBM at higher densities. The minimum in density is shifted towards larger value in case of lower Z_{eff} as observed recently in JET-ILW (ITER Like Wall) [7]. An isotopic effect is reported leading to higher threshold for lower ion mass as found experimentally [8].

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