Transport in High Density Igniting Plasmas*

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On the basis of presently known stability and transport properties of magnetically confined plasmas, ignition can be more readily achieved in compact, high field, high density devices. Ignitor is characterized by a toroidal field $B_T \leq 13$ T, compact dimensions ($R_0 \cong 1.32$ m), a relatively low aspect ratio ($R_0/a \cong 2.8$), and a considerable plasma elongation and triangularity ($\kappa \cong 1.83$, $\delta \cong 0.4$). The reference central density is about 10^{21} m^{-3}, and the plasma current $I_p \cong 11$ MA. Confinement and transport issues for Ignitor can be investigated in existing high field, high density experiments such as FTU (Frascati Tokamak Upgrade), which can operate in a region of parameters complementary to that of most other existing devices. In particular, the scaling of confinement with density at high fields has been addressed in recent FTU experiments for $B_T = 7.2$ T, $I_p = 0.8$ MA. As was already observed in other high field machines, the energy confinement time τ_E increases with density up to a saturation value corresponding to those of the so-called L-mode regime when the density profiles are relatively flat. This saturation occurs at a level roughly equal to half the "density limit". The injection of pellets to prevent the confinement saturation was suggested for the Alcator C experiment to stabilize the Ion Temperature Gradient (ITG) driven modes by means of an adequate density gradient. The role of density profile peaking and multiple pellet injection in sustaining enhanced confinement regimes in FTU plasmas are presented together with expectations for Ignitor taking into account that the plasma current is higher and the plasma temperature is also 10 times higher than in FTU. In these FTU plasmas the linear trend of the neo-Alcator scaling is extended and τ_E transiently reaches values in excess of 100 ms [1], with a significant overall improvement above the ITER-97L scaling, for n_{e0} as high as 8×10^{20} m^{-3}, close to the Ignitor reference central density. The corresponding effective thermal diffusivity $\chi^E \cong a^2/4\tau_E \cong 0.2$ m^2/s is within the range of the values estimated for Ignitor in order to reach ignition, on the basis of current thermal transport models. The possibility of achieving H-mode confinement in Ignitor has been also investigated for a double null configuration with the X-points laying on the first wall and with $I_p \cong 9$ MA, and $a \cong 0.44$ m.

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