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 achieved with the highest probabilities 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. 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. In FTU plasmas with multiple pellet injection the linear trend of the neo-Alcator scaling is extended and τ_E reaches values in excess of 100 ms [1], about 30% 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. A zero-dimensional analysis based on the global plasma power balance equation shows that, for moderately peaked plasma pressure profiles, operation at Q=10 is possible at densities about half the reference value. By increasing the density, operation at higher values of Q is also possible.

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