Theoretical Considerations for the High Field Line of Experiments to Investigate Fusion Burning Plasmas*

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On the basis of the results obtained by advanced toroidal confinement experiments, high values of the confinement parameter $n\tau$ (n=particle density and τ=energy replacement time) can be expected to be reached considering that the maximum particle density is found to be related to the average current density $\bar{J}_{\parallel} \sim \bar{B}_p / \bar{a}$ ($\bar{a}$ being the mean plasma minor radius and $\bar{B}_p$ the mean poloidal field) and that the time τ has a favorable dependence on I_p. Then, if $\tau \propto I_p$, the maximum values of $n\tau_E$ should be related to $\bar{B}_p^2$ as $I_p \simeq 5\bar{a}\bar{B}_p$. Moreover, if we consider the mean plasma pressure to be limited by the magnetic pressure $\bar{B}_p^2/(2\mu_0)$, the mean plasma reactivity represented locally by $n^2\langle\sigma_F \mathrm{v}\rangle \propto n^2 T^2$, for D-T burning plasmas, can be expected to be related to $\bar{B}_p^4$. Thus the main guiding feature for the line of high field experiments conceived until now is that of attaining the highest possible values of $\bar{B}_p$. These considerations have in fact been supported by sophisticated numerical simulations that have been carried out by 1+1/2 D transport codes [1, 2, 3].

An important additional criterion that has driven the designs of this line of experiments is that of having a strong Ohmic heating rate minimizing the need for an auxiliary heating system. Assuming that the loop voltage is about constant, as has been observed experimentally when only Ohmic heating is present, the best option to pursue is to combine relatively high values of both $\bar{B}_p$ and $\bar{J}_{\parallel}$. *Sponsored in part by the U.S. DoE.

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