§12. Depolarization Effects to Ignition Condition of Spin-Polarized D-^{3}He Fueled Fusion

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By use of spin-polarized fuels in a D-^{3}He fusion reactor the enhancement of reactivity brought a moderation of required plasma and engineering parameters 1). In order to see the depolarization effects a parametric study of polarized D-^{3}He fueled fusion reactor in an FRC is carried out for the purpose of comparing the results with "ARTEMIS" 2). In this study positively polarized deuteron and helium-3 are injected as fuels of D-^{3}He fusion reactions. The cross-section with the angular momentum J =1/2 is neglected. The particle balance equations for plasma ions with polarized components as well as the power balance equation give the self-ignition condition for the case of the same plasma temperature of 83.5 keV and the same neutron power fraction to net electric power of $P_n / P_{net} = 0.06$ of "ARTEMIS" design. In this study energy confinement time is assumed to be half of particle confinement time and depolarization time of deuteron and helium-3 are also assumed to be equal. From the self-ignition condition, the D-^{3}He cross-section enhancement factor is obtained as a function of the depolarization time $\tau_{depol.}$ normalized by the particle confinement time τ_N in Fig.1. This figure shows if the the depolarization time is twenty times longer than the particle confinement time, the enhancement factor keeps its value larger than 1.4. The real plasma and device parameters are determined under the condition of heat wall loading by neutrons and radiation of 2.0 MW/m^2, which is acceptable to the today's technology. The cross-section enhancement factor and the ion density ratio are obtained as a function of the depolarization time in Fig.2 (a). Figure 2 (b) shows the plasma radius r_s, plasma length l_s, and plasma volume V_p as a function of the depolarization time. The depolarization time of 20 sec. reduces the plasma volume to 50 m^3, which should be compared to "ARTEMIS" design (with unpolarized D-^{3}He fuels) of 190 m^3. The requirement to the plasma parameters are relaxed by the introduction of spin-polarized fuels. The required plasma density and energy confinement time are shown in Fig.2 (c). The depolarization time of 20 sec. decreases the required energy confinement time up to 2 sec. from 7 sec. of unpolarized fuels. On the other hand, the increment of the required plasma density from 5×10^{20} m^{-3} to 7×10^{20} m^{-3} is not a limiting factor because the higher density plasmas have been already achieved in the FRC experiments.

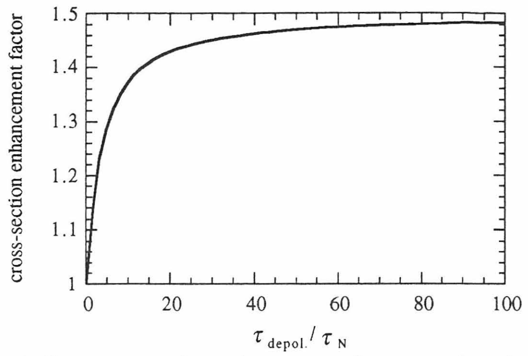

Fig. 1. The cross-section enhancement factor as a function of $\tau_{depol.} / \tau_N$.

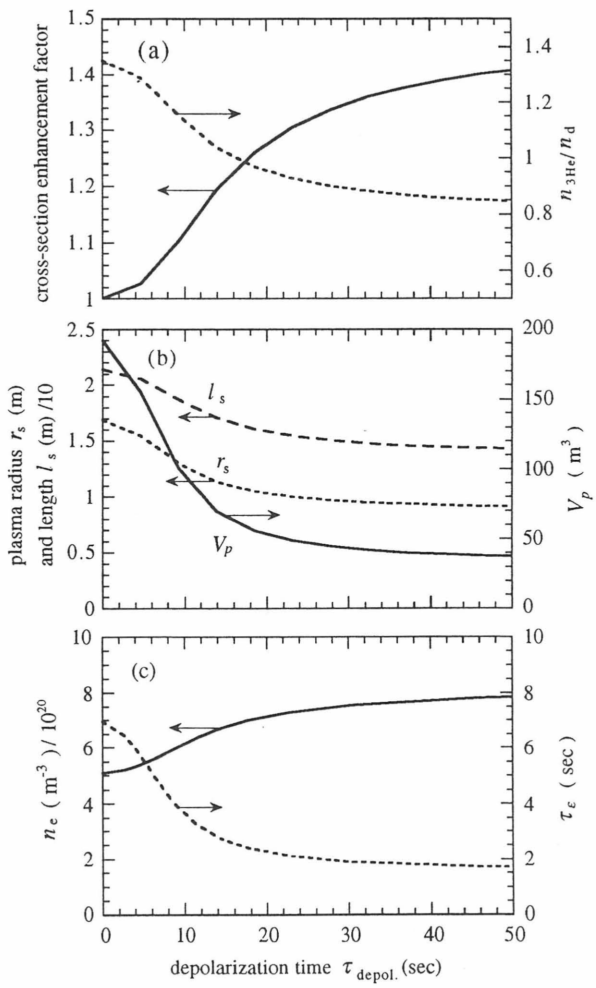

Fig. 2. The cross-section enhancement factor and the ion density ratio (a), dimensions of plasma r_s, l_s, and V_p (b), and plasma density n_e and energy confinement time τ_ε (c) as a function of depolarization time $\tau_{depol.}$.

References

1)Tomita, Y., Takahashi, T., and Momota, H. : Nucl. Instrm. Methods A **402** (1998) 421.

2)Momota, H. *et al.*, *Proc. 7th Int. Conf. on Emerging Nuclear Energy Systems*, Chiba, Japan 20 - 24 September 1993 (1993) p.16.