ABSTRACT

- Effects of nuclear elastic scattering (NES) [1] on fast-deuterium slowing-down properties (fusion reaction rate coefficient, energy transfer) were observed in the LHD deuterium plasma.
- Numerical simulations (on the basis of the Boltzmann-Fokker-Planck (BFP) model[2]) could explain the observed results.
- The NES effect would be appreciable in the future reactor-grade plasma.


BACKGROUND

- A large fraction of the energetic-ion energy is transferred to bulk ions in a single NES event, and the energetic-ion slowing-down properties are influenced by NES (as well as the Coulomb collision)[3].
  (i) Fractional energy deposition from energetic to bulk ions tends to increase due to NES compared with when we only consider Coulomb collision.
  (ii) NES causes distortion in both energetic and bulk distribution functions, and sometimes fusion reaction rate coefficients are changed compared with the values for the Maxwellian plasma.
- We have developed the BFP model to understand the NES effect[2]. These phenomena could be appreciable in a thermonuclear plasma and the understanding with experimental validation would be important.


CHALLENGES / METHODS / IMPLEMENTATION

EXPERIMENT

On the large helical device (LHD), we attempted to observe the NES effects by looking at the DD neutron. We devoted our attention to measure the increment in the DD neutron generation rate ((a) fusion reaction rate coefficient) and increment in the DD neutron decay time ((b) energy transfer process from protons to energetic deuterons).

NUMERICAL SIMULATION

We tried to understand the experimentally observed phenomena by using the Boltzmann-Fokker-Planck model[2].

LHD equipment and D(d,n)3He, 6Li(d,p)7Li cross sections

Nuclear elastic scattering [1]

\[
\frac{d\sigma}{d\Omega}_{\text{NES}} = \frac{d\sigma}{d\Omega}_{\text{Total measured}} - \frac{d\sigma}{d\Omega}_{\text{Coulomb}}
\]

Large-angle scattering process

Boltzmann-Fokker-Planck Model [2]

\[
\left( \frac{\partial f}{\partial t} \right)_\text{FP} + \sum_{i} \left( \frac{\partial f_i}{\partial t} \right)_\text{NES} + \frac{1}{v^2} \frac{\partial}{\partial v} \left( v^2 f_i - \tau_{i\gamma} f_i \right) + S_i(v) - L_i(v) = 0
\]

CONCLUSION

- More than one order of the DD reaction rate coefficient enhancement due to high-purity H beam injection was observed.
- Delay in the DD neutron decay time due to high-purity H beam injection was observed.
- The above results were analyzed by using the BFP model.
- The observed results can be explained quantitatively by considering the NES effect in addition to the Coulombic collisional interaction between energetic ions.

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