§20. Confinement Study of High Energy Ions with Neutron Measurements

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Neutron measurement in a nuclear fusion experiment provides not only the plasma ion temperature but also information on behavior of energetic ions in a plasma. In CHS, an efficient neutron diagnostic system has been established[1] and applied to deuterium plasmas[2]. In the present experiment, the decay rate of neutron emission strength was measured after termination of a short pulse injection of a hydrogen beam doped with 1% deuterium. By comparing the experimental decay rate with the calculated decay assuming the classical slowing down without loss, the fast ion confinement time τ_c can be deduced.

Fig.1 shows a typical time evolution of the neutron emission strength S_n resulting from the tangential co-beam injection into a deuterium plasma with the central electron temperature $T_e(0)$=1.2 keV and the line-averaged electron density $n_e=0.6\times10^{19}$ m^{-3}. The beam injection energy E_B was 38 keV and the pulse duration 6 ms. It is seen that S_n, which originates in beam-plasma reactions, rises until the end of the beam pulse, then, begins to decay approximately exponentially.

By assuming that the d-d reactivity decreases exponentially as injected ions slow down classically and the background deuteron density is constant after the beam termination and by taking account of ion loss during slowing down, the neutron decay time is expressed as follows[2,3],

$$1/\tau_{n\text{-}exp} \approx 1/\tau_c + 1/\tau_{n\text{-}classical}, \qquad (1)$$

$\tau_{n\text{-}classical}$ is estimated from the Sivukhin's theory[4].

Fig. 2 shows the measured neutron decay time $\tau_{n\text{-}exp}$ against the predicted neutron decay time $\tau_{n\text{-}classical}$ in B_T of 0.88 T and 1.7 T. The solid line represents the condition of $\tau_{n\text{-}exp}$ $\tau_{n\text{-}classical}$. It is seen that $\tau_{n\text{-}exp}$(dot circles) does not agree with $\tau_{n\text{-}classical}$. By strengthening B_T, the fast ion confinement was clearly improved. From eq. (1), the confinement time τ_c of fast ions was deduced to be about 3 ms. For the plasma with B_T of 1.7 T, the longer τ_c of about 8 ms was obtained.

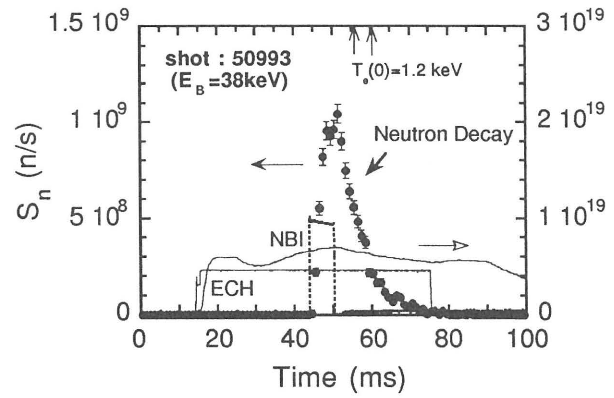

Fig. 1 Typical diacharge of short pulse neutral beam injection experiment. B_T and R_p was 1.7 T and 92.1 cm, respectively.

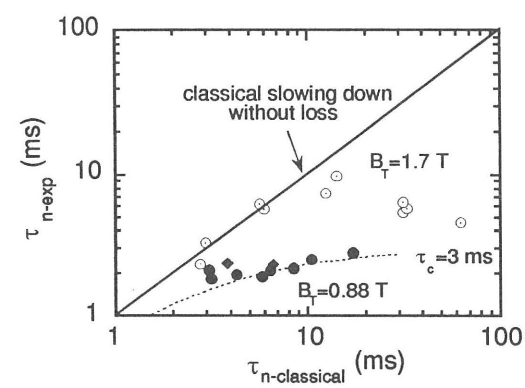

Fig. 2 Measured neutron decay $\tau_{n\text{-}exp}$ time against the predicted neutron decay time $\tau_{n\text{-}classical}$ assuming classical slowing down of neutral beam-injected fast ions in B_T of 0.88 T and 1.7 T.

Reference

1) Isobe, M. et al. : Rev. Sci. Instrum. **66**(1995) 923.
2) Isobe, M. et al. : to be appeared in Rev. Sci. Instrum..
3) Tobita, K. et al. : Nucl. Fusion **34**(1994)1097.
4) Sivukhin, D.V. : Rev. of Plasma Physics, Vol. **4**, Consultants Bureau, New York(1966).