Observation of knock-on tail formation in deuteron velocity distribution function by ICRF-heated energetic protons in the large helical device

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As a large-angle scattering process of energetic ions, Nuclear Elastic Scattering (NES) is known [1]. A large fraction of ion energy can be transferred during single NES event in contrast with Coulomb scattering. After the hydrogen beam injection, an increment of over one order of magnitude of the neutron generation rate by D(d,n)^{3}He reaction was observed under the condition of high electron temperature ($T_e(0) \approx 10$ keV) in the LHD [2]. The reason of the increment was the formation of knock-on tail in deuteron distribution function through NES with energetic NBI protons. In this research, the increment of DD neutron generation rate after the ICRF heating was observed in the LHD. The increment cannot be explained by the change of ion temperature and plasma density. The possibility of the knock-on tail formation in deuteron distribution function is discussed.

The number of ICRF-heated energetic protons was estimated from the counts of Diamond Neutral Particle Analyzer (DNPA) [3]. The number of pure ICRF-heated energetic protons was estimated by subtracting the DNPA counts of the shot with NBI#1 (180 keV, hydrogen) from the DNPA counts of the shot with the NBI#1 and ICRF.

The ICRF-heated proton velocity distribution function is assumed to be a high temperature Maxwellian with reference to the above DNPA counts data, and using the assumed proton distribution function, the knock-on tail in deuteron distribution function via NES is estimated by Boltzmann collision integral calculation [4].The formation of knock-on tail in deuteron velocity distribution function requires 1) the presence of energetic protons and 2) the high electron temperature ($T_e(0) \approx 10$ keV) that were met in several experiments. The increment of the neutron generation rate may be due to the formation of the knock-on tail in deuteron velocity distribution function via the NES with the ICRF-heated energetic protons.

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