

The proton (or deuteron) velocity distribution function (PVDF) in a magnetically confined fusion plasma can be anisotropic in the velocity space on a certain condition. The PVDF in low density plasma heated with neutral beam injection (NBI) is expected to be anisotropic. The magnetic dipole (M1) transitions between the levels of ground state configuration of multiply ionized ions are observed in a visible spectral region and the population of the upper level of M1 transitions are created due to the collisional excitation by protons[1]. Anisotropic collisional excitation produces population imbalance or alignment on the upper level. The emission form the aligned level is polarized.

Argon gas was puffed into the LHD vacuum vessel then the NBI started plasmas. The emission from the plasmas was resolved into orthogonally polarized components with the polarization separation optics (PSO). Two types of the PSO were used. One consisted of a polarization separation Glan-Thompson prism and a pair of lens couplers. The other consisted of two Glan-Taylor prisms and a pair of lens couplers. The each image of the optical fiber cores of 400 μm diameter for the orthogonal polarization components was coaxially overlapped. The image was 50 mm-diameter circle at $R=3.75 \text{ m}$. Ten lines of sight were equipped to cover the poloidal cross section at #1-O port for the poloidal observation as shown in Fig. 1.

![Fig. 1. Ten lines of sight cover the poloidal cross section at #1-O port.](image)

The relative intensities for 14° and 104° polarized components are calibrated with a standard spectral irradiance lamp and a white diffuse reflectance target. The polarization degree $P=(I_{14°}-I_{104°})/(I_{14°}+I_{104°})$ of the M1 transitions varies -0.026, 0.034 and -0.016 on three sequential exposures started at $t=0.500$, 0.750, 1.000 s shown in Fig. 2. The negative polarization degree represents qualitatively that the intensity of the $\sigma$ components is higher than the $\pi$ components. The longitudinal alignment $A_l$ of the M1 transition between $^1P_{1/2}$ and $^3P_{3/2}$ terms is expressed as

$$A_l = \frac{I_\sigma - I_\pi}{I_\sigma + 2I_\pi} = \frac{\sigma(p)}{\pi(p)}$$

where $I_\sigma$ and $I_\pi$ are the intensity of $\sigma$ and $\pi$ polarized components. The alignment $\sigma(p)$ and the population $\pi(p)$ are expressed as

$$\sigma(p) = \frac{1}{2} \left( \rho_{3/2} - \rho_{5/2} - \rho_{1/2} - \rho_{3/2} \right)$$

and

$$\pi(p) = \rho_{3/2} + \rho_{1/2} + \rho_{1/2} + \rho_{3/2}$$

where $\rho_{M_l}$ is the population of the magnetic sublevel $M_l$. The negative polarization degree is explained by the negative alignment, or positive $A_l$, created via the collisional excitation by directional protons. When the PVDF is prolate spheroid or axially dominant in velocity space, the negative alignment is excited by the proton collision. The qualitative analysis is underway with population-alignment collisional-radiative (PACR) model.