05aE12P

高ダイナミックレンジBalmer-α線分光法による LHDコアプラズマ中水素原子密度のポロイダル分布の評価

Evaluation of the poloidal density distribution of neutral hydrogen atoms in LHD core plasmas by high dynamic-range Balmer-α spectroscopy

藤井恵介[1]，後藤基志[2]，森田繁[2]，蓮尾昌裕1
FUJII Keisuke[1], GOTO Motoshi[2], MORITA Shigeru[2], HASUO Masahiro[1]

[1]京大工，　[2]核融合研
[1]Kyoto Univ, [2]NIFS

For a magnetically confined fusion plasma, study of neutral hydrogen transport in the core region is important to understand the source distribution of electrons and protons. Since hydrogen atoms are free from magnetic field, their density distribution may depend not only on the normalized radius, ρ, but also on the poloidal angle, θ.

Recently, we found that Doppler shifted Balmer-α emission of hydrogen atoms in the core region can be detected in far wings of the line profile [1]. In this work, we evaluated $n_H(\rho, \theta)$ from the Balmer-α line profiles observed for an LHD plasma by multiple lines of sight and a Monte-Carlo simulation for hydrogen transport.

In the simulation, we assume that the poloidal distribution of atom flux flowing into the core region from the outmost surface of the plasma, $\Phi(\theta)$ [m^{-2}/s], has asymmetricity caused by large atom flux from the helical divertor; its θ dependence is given as

$$\Phi(\theta) = \Phi_0 + \Phi_1\cos(\theta) + \Phi_2\cos(2\theta) \qquad (1)$$

where Φ_0 is the average atom flux. Φ_1 and Φ_2 represent the asymmetricity. We trace trajectories of hydrogen atoms from the outmost surface with taking the electron impact ionization and proton impact velocity change into account. Here, we use spatial distributions of n_e and T_e measured by the Thomson scattering method and assume $n_e = n_p$ and $T_e = T_p$, where n_e and T_e are the density and temperature of electrons, respectively, and n_p and T_p are those of protons. After 10^7 traces, $n_H(\rho, \theta)$ and atomic velocity distribution are statistically simulated.

From $n_H(\rho, \theta)$ and the velocity distribution, we reconstruct the Balmer-α line profiles considering the emission rate of atoms, Doppler shift of the emission, and the emission integration along the line of sight. And then, we determine Φ_0, Φ_1 and Φ_2 by fitting the reconstructed spectra to the observed ones. The result of the fit is shown by the gray solid curves in figure 1. The result shows a good agreement. It is noted that the result without the asymmetricity of the flux, i.e. $\Phi_1 = \Phi_2 = 0$, does not fully represent the observed spectra as shown by the dashed curves in figure 1.

The evaluated $n_H(\rho, 0)$ and $n_H(\rho, \pi/2)$ are shown in figure 2. Poloidal asymmetricity is clearly seen. In the outside region ($\rho > 1.1$), $n_H(\rho, 0)$ is evaluated to be larger than $n_H(\rho, \pi/2)$ reflecting the higher atom flux from the helical divertor. On the other hand, in the core region, the tendency reverses reflecting the horizontally elongated shape of the LHD plasma.

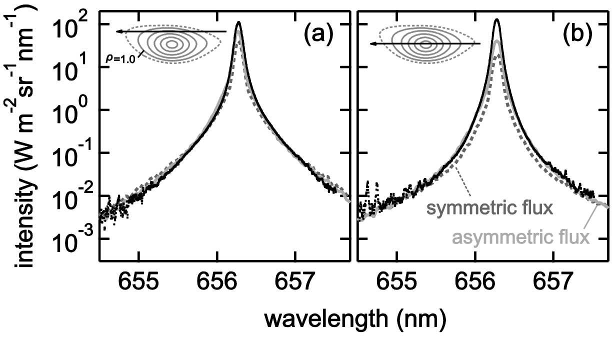

Fig.1 Dots: The Balmer-α spectra observed with (a) edge and (b) central view ports of the LHD. Insets show the poloidal cross section and the lines of sight. The gray solid curves show the reconstructed result with asymmetric atom flux. The gray dashed curves show the result with symmetric atom flux.

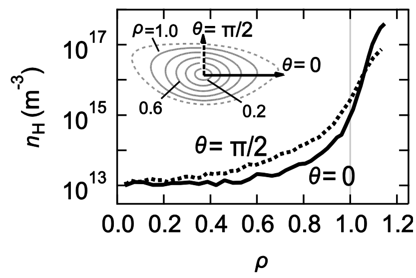

Fig.2 Evaluated atom density distribution at $\theta = 0$ and $\pi/2$. The inset shows the poloidal cross section of LHD.

[1] K. Fujii et al, *Phys. Plasmas* **20**, 012514 (2013).