Self-reversal in hydrogen Lyman-α line profile

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Detailed line profile of the Lyman-α is measured with a VUV spectrometer for high density discharges in the Large Helical Device (LHD). The spectrometer has a focal length of 3 m and is equipped with a 1200 grooves/mm grating. The observation is carried out for discharges with the internal diffusion barrier (IDB). The radiation is accumulated for 1 s after termination of pellet injections during which the line-averaged electron density is decreased from $2.5 \times 10^{20}\,\mathrm{m}^{-3}$ to $1.1 \times 10^{20}\,\mathrm{m}^{-3}$. Figure 1 shows an example of the measured line profiles which shows self-reversal at the profile center.

The line profile is analyzed with the equation of one-dimensional radiation transport which is expressed as [1]

$$I(\lambda) = \int_{-L/2}^{L/2} \eta(\lambda) \exp\left[-\kappa(\lambda)\left(\frac{L}{2} - x\right)\right] \mathrm{d}x, \quad (1)$$

where $I(\lambda)$ is the line profile to be measured, $\eta(\lambda)$ and $\kappa(\lambda)$ are the emission and absorption coefficients, respectively, and L is the thickness of the radiation and absorption medium.

The coefficients $\eta(\lambda)$ and $\kappa(\lambda)$ depend on the ground state density $n(1)$ and the $n = 2$ level density $n(2)$, respectively, and the both on the line profile $P(\lambda)$. The electron temperature, electron density, and $n(1)$ are assumed to be constant in the medium, and the spatial distribution of $n(2)$ is evaluated with a formula by Molisch which is a numerical solution of Holstein equation [2].

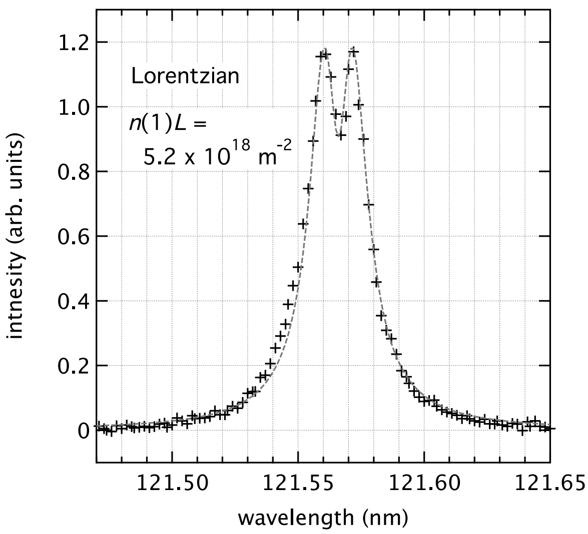

Figure 1: Example of the observed Lyman-α line profile which shows self-reversal (crosses). The dashed-line is the fitting result.

The observed line profile in Fig. 1 is found well fitted with $n(1)L = 5.2 \times 10^{18}\,\mathrm{m}^{-3}$ when a Lorentzian profile is employed for $P(\lambda)$. The result indicates, for example, $n(1) = 5.2 \times 10^{19}\,\mathrm{m}^{-3}$ when the medium has 10 cm thickness. The fitting result is shown with the dashed line in Fig. 1.

[1] T. Fujimoto, Plasma Spectroscopy, Oxford Press, Oxford (2004)
[2] A. F. Molisch et al., Radiation Trapping in Atomic Vapours, Oxford Press, Oxford (1998)