§ 61. Estimation of Beam Divergence from Measurement of Motional Stark Effect

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Measurement of Motional Stark Effect (MSE) has been used to measure the pitch angle of magnetic field line in Tokamaks. The MSE system using imaging spectrometer was installed in LHD. The change of pitch angles are observed by using the MSE system. Furthermore, the divergence of the neutral beam injected by neutral beam injector was estimated from the width of the sigma spectrum which is measured by the MSE system.

Figure 1 shows the sigma spectrum emitted from the beam injected by NBI #2 with single ion source B and measured by MSE system. According to theoretical calculations, the profile contains tree components (0σ, 1σ+, 1σ-) of sigma spectrum with small width of splitting under the experimental configuration. The width of the spectrum is dominated by beam divergence of neutral beam injector which is larger than steering angle or of the beam temperature and instrumental width of the spectrometer. Therefore, the beam divergence of the neutral beam can be estimated from the width of the spectrum measured by MSE system. Because it is difficult to fit as overlapping of three Gaussian profiles with the full parameters, the calculated values of the width of splitting and ratio of intensity I_1/I_0 are used and it is assumed that the widths of the three spectra are same for the fitting. The beam energies which are used for calculation of width of splitting are directory measured by difference between the wavelength of the spectra and that of Hα (λ=656.28nm). The curves of the fitting are shown in Fig.1 as solid lines and the formula is follows.

$$I = I_0 \exp\left(-\left(\frac{\lambda-\lambda_0}{\sigma}\right)^2\right) + I_1 \exp\left(-\left(\frac{\lambda-\lambda_0-d\lambda}{\sigma}\right)^2\right) + I_1 \exp\left(-\left(\frac{\lambda-\lambda_0+d\lambda}{\sigma}\right)^2\right)$$

The spectra overlapping of three spectra agree with the measurement.

Figure 2 shows the profiles of width of the sigma spectrum obtained by the method which is above-mentioned. The profiles of width of the sigma spectra obtained by the calculations with given beam divergence are also plotted in the Fig.2. The width of the spectrum slightly depends on the position R because of the integration effect on the line of sight, which is observed in the measurement profile also. The width measured is in between the width calculated with 10 mrad and 15 mrad of beam divergence. The best estimate of beam divergence measured with MSE is 13 mrad, which is consistent with the design value of NBI.

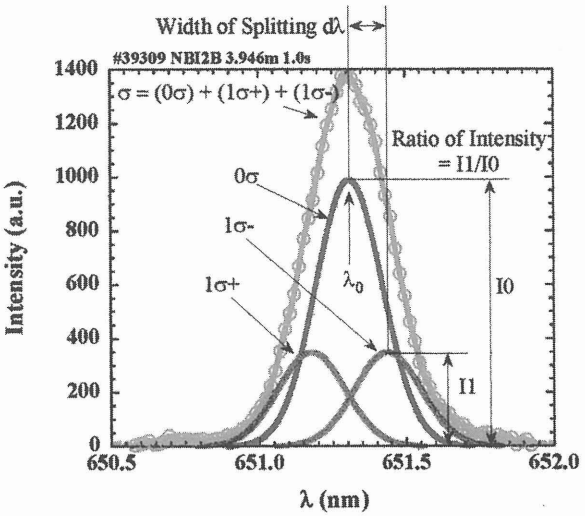

Fig.1. Sigma spectrum of MSE measurement (circle) fitted as overlapping of three Gaussian spectra (solid lines). $I_1/I_0 = 0.353$, $d\lambda$=0.13nm.

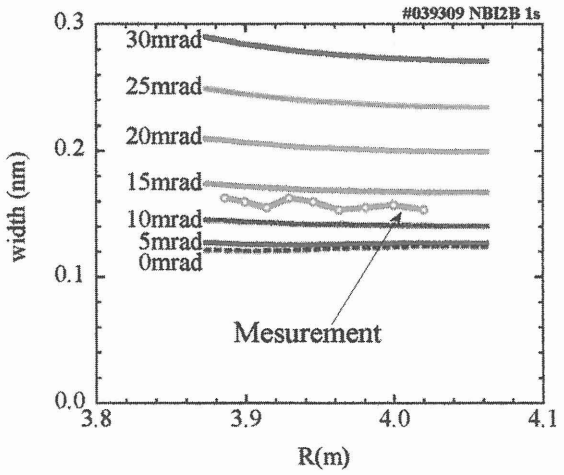

Fig.2. Profile of width of the sigma spectrum measured by the MSE system (circle) and estimated by calculation (line). The parameter of calculations is a beam divergence.