§2. Spectral Asymmetry in Motional Stark Effect of a Neutral Beam Emission in a Toroidal Plasma and its Application to in Situ Measurement of the Beam Angular Divergence

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Beam divergence angle $\Delta\theta$ is an important parameter for calculation of the beam energy deposition profile in a plasma. It is measured in conventional using a calorimeter or spectroscopy method in advance of the plasma discharge.[1)]

Recently, the beam emission in the plasma with the motional Stark effect (MSE) has been studied by our simulation. The results show that the fine components on both wavelength sides of the central σ_0 component are spectrally asymmetric. The reason is finite beam angular divergence of the beam. In an ideal case that the plasma is so dilute that the beam attenuation in the plasma can be negligible and the magnetic field in the observed region of the beam emission is uniform, the relation between the difference of the wavelength width of the i-th components at the both sides of the central σ_0 component and the divergence angle of the beam can be obtained as

$$\delta(\Delta\lambda) \cong 4a(i)v_b B\lambda_0^2 \cos\zeta\Delta\theta. \qquad (1)$$

Here, the 'a(i)' is the i-th coefficient for the wavelength splitting of the i-th component with MSE, λ_0 is the wavelength of H_α(6562.8 Å), v_b is the beam velocity, B is the strength of the magnetic field and ζ is the intersection angle of the beam and the magnetic field. The $\delta(\Delta\lambda)$ may be enhanced when the variation of the magnetic field in the region of the beam emission is taken into the account.

As an application of this effect, the divergence angle of a heating beam on JFT-2M was determined by comparison of a simulation and a measurement of the beam emission.

The experiment was carried out on the JFT-2M tokamak with a neutral beam, energy of 32 keV, intersecting toroidal magnetic field of 1.3T at angle of 40.2° at the plasma center. The π component of the MSE spectra was measured with a spectrometer and a polarizer by viewing the beam at the angle of 29.9° at the plasma center. Fig. 1 shows the measured spectrum of the full energy beam emission.

The MSE spectra of the beam emission is simulated with a Lorentz instrumental function with full width at half maximum (FWHM) of 0.76 Å. The divergence angle of the injected beam is taken as a free parameter in the simulation. The best fit of the simulated MSE spectrum to the measured data gives the beam divergence angle of 1.35° ± 0.05° for the full energy beam component and of 1.55° ± 0.08° for the one-third energy beam. Here, the error bar were obtained from the uncertainty of the FWHM which is expected to be less than 5%.

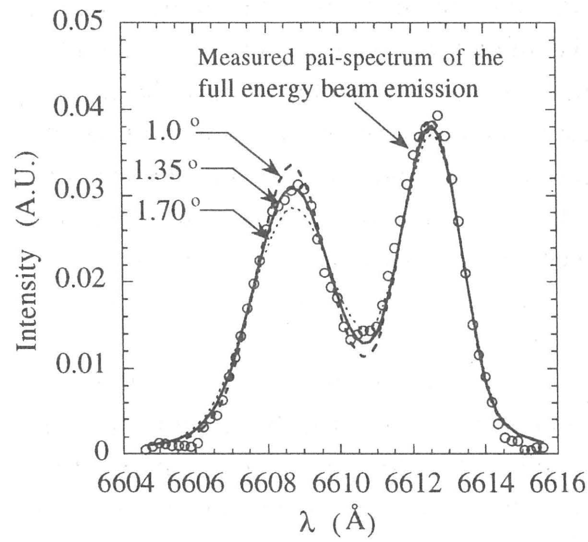

Fig.1 The π components of the motional Stark spectrum in JFT-2M measured using a polarizer 90° tilted with respect to horizontal direction. The solid line is a simulated result with the divergence angle of 1.35°.

1) H.Euringer et al, Rev. Sci. Instrum. **65**(1994), 2996.