§29. Polarization Effect on Electron Cyclotron Absorption in LHD

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In general, there are no othogonal eigenpolarizations when the absorption or the dichroism is taken into account. In the cases of the circular and linear dichroism, there are two othogonal eigenpolarizations. In these cases, the Jones matrix for the transverse electric field of the propagating wave is expressed with the eigenpolarization, and then the Jones matrix can be transferred to the Mueller matrix to describe the evolution of the Stokes parameters for a homogeneous slab plasma. To study polarized radiative transfer of electron cyclotron wave, the Mueller matrix that includes the effects of both birefringence and dichroism is dealt with here. Full Stokes parameters are used to describe the polarization state. Each component of the full Stokes parameters is expressed as S_i $(i = 0, 1, 2, 3)$, and a three-dimensional vector $\mathrm{s} = (S_1, S_2, S_3)$ is defined here. The reduced Stokes parameters of the fast characteristic eigenmode s_f can be written, in terms of the azimuth angle and the ellipticity, θ and ϵ, as $\mathrm{s_f} = (\cos 2\theta \cos 2\epsilon, \sin 2\theta \cos 2\epsilon, \sin 2\epsilon)$. The evolution equations of polarization states for full Stokes parameters obtained from the Mueller matrix are as follows:

$$\frac{dS_0}{dz} = -2\frac{\omega}{c}k_\mathrm{s}\frac{S_0 + \mathrm{s_s}\cdot\mathrm{s}}{2} - 2\frac{\omega}{c}k_\mathrm{f}\frac{S_0 + \mathrm{s_f}\cdot\mathrm{s}}{2}, \text{ and}$$

$$\frac{d\mathrm{s}}{dz} = -\frac{\omega}{c}k_\mathrm{s}(S_0 + \mathrm{s}\cdot\mathrm{s_s})\mathrm{s_s} - \frac{\omega}{c}k_\mathrm{f}(S_0 + \mathrm{s}\cdot\mathrm{s_f})\mathrm{s_f} + \frac{\omega}{c}(k_\mathrm{s} + k_\mathrm{f})\mathrm{s_f}\times(\mathrm{s_f}\times\mathrm{s}) - \frac{\omega}{c}(n_\mathrm{s} - n_\mathrm{f})\mathrm{s_f}\times\mathrm{s},$$

where the scalar and vector products are taken for the components of $i = 1$, 2 and 3. Here, the complex refractive indexes are defined as $(n_{\mathrm{f,s}} - ik_{\mathrm{f,s}})$ for the fast and slow modes.

For the perpendicular injection, eigenvalues under the uniform shear should be defined, including the shear term in an order of $[(c/\omega)\alpha]^2$, where α is a shear of the magnetic field. For the polarization, the effect of the shear is in an order of $[(c/\omega)\alpha]$. This effect is neglected here as a first step. In our case, a pure perpendicular injection is not available, and the effect of the magnetic field component along the wave vector was discussed. In use of the obtained equations, the case of the pure perpendicular injection is described here. In the perpendicular injection, the complex refractive indexes in the frequency range of the second harmonic for the X-mode can be written by the function F_q introduced by Dnestrovskii in the lowest order of thermal corrections. For the O-mode, the refractive index is approximated as the cold one in this lowest order. Real and imaginary parts of these equations are used here. Figure 1 shows the electron temperature profile for the ECH target plasma to investigate the dependency of the single path absorption on the polarization state. The target plasma is produced with the 82.6GHz gyrotrons. The electron density is about $1.0 \times 10^{19}\mathrm{m}^{-3}$, and the magnetic field is 1.5T. This target plasma is additionally heated with the 84GHz gyrotron at the 2nd harmonic on-axis heating. The change of the diamagnetic signal when the 84GHz gyrotron is turned on is used to evaluate the absorption power. Figure 2 shows the absorption power deduced from the diamagnetic signal and the single path absorption rate calculated, when the $\lambda/4$ polarizer is rotated. The single path absorption rate is evaluated as the term of $[1 - S_0]$ after the single path. When the $\lambda/4$ polarizer is rotated, not only the azimuth angle of the polarization ellipse θ but also the ellipticity ϵ is changed in our case. This effect on the ellipticity ϵ is included in the calculation. The absorption power deduced from the diamagnetic signal is not a direct measure of the single path absorption rate, because the wave may be absorbed after multiple reflections at the wall. Nevertheless, the dependence of the power is qualitatively consistent with the single path absorption rate calculated using the obtained equations.

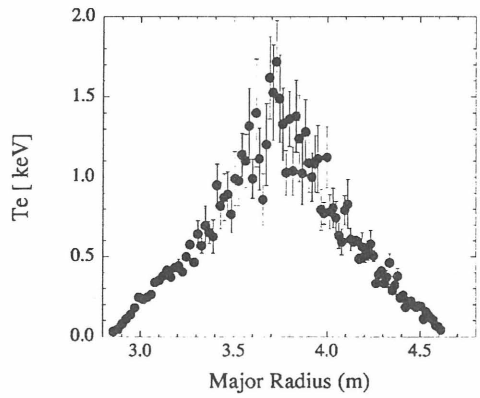

Fig.1:The electron temperature profile of the target plasma.

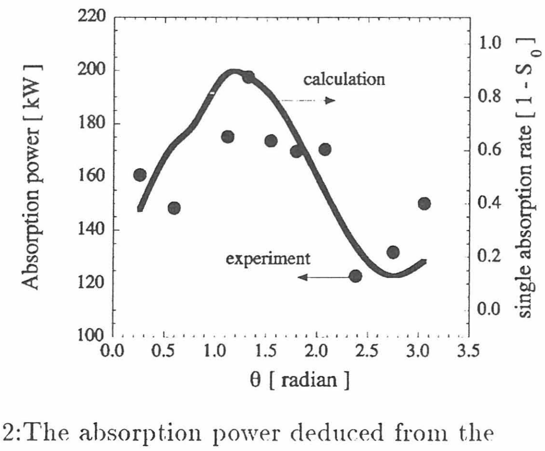

Fig.2:The absorption power deduced from the diamagnetic signal and the calculated single path absorption rate.