§27. Optimum Polarization for Microwave Reflectometry in a Sheared Magnetic Field

Ejiri, A., Nagasaki, K. (PPL. Kyoto Univ.)

The microwave reflectometry has been developed and used to measure density profiles and fluctuations in many devices. In helical devices we must take into account the effect of the shear. For microwave reflectometry, usually launched wave vectors are perpendicular to the magnetic fields, and O-mode or X-mode are used. In a sheared plasma, however, both modes can couple through the sheared field. Generally, the reflected wave has both components, although pure O- or X-modes are injected. Since we want pure O-mode or X-mode reflection to simplify the measurements, the condition to launch pure modes must be found, otherwise we must deconvolute both modes from measured two components. Usually this is very difficult.

Here we calculate the effect of shear by solving one-dimensional second order equations. Let us take the axis z along the wave propagation direction, and $E_\parallel$, $E_\perp$ are O- and X- modes components of the electric field. Then the equations are given as[1]

$$\frac{d^2E_\parallel}{dz^2}+\left(\frac{\omega^2}{c^2}N_O{}^2-\phi^2\right)E_\parallel=2\phi\frac{dE_\perp}{dz}+\frac{d\phi}{dz}E_\perp$$

$$\frac{d^2E_\perp}{dz^2}+\left(\frac{\omega^2}{c^2}N_X{}^2-\phi^2\right)E_\perp=-2\phi\frac{dE_\parallel}{dz}-\frac{d\phi}{dz}E_\parallel \quad ,$$

where N_O, N_X are refractive indices of O- and X-modes, respectively. $\phi=d\theta/dz$ is the shear of the field. Now we solve these equations for the case of inside launching at the toroidal section of the horizontally elongated plasma in CHS. We use the following plasma parameters; B_0=0.6 [T], n_{e0}=0.3 x 10^{20} [m^{-3}], R_{ax}=0.92 [m], and we launch the wave with the frequency of 39 [GHz]. With these parameters, both O- and X-mode cutoff layers exist in the plasma. Thus, standing waves exist in the plasma, and the system has two independent solutions. In order to achieve standing waves the equations are solved backward from the evanescence region. Some solutions are obtained from random initial conditions. Appropriate linear-combination of the solutions can make pure O-mode, and pure X-mode waves, which are defined as the waves having only O- or X-mode reflection. For the conditions we calculated, both modes are linearly polarized throughout their path, although, in general, they could be elliptically polarized.

Figure 1 shows the rotaion angle (polarized direction) of these modes. The modes do not change their rotaion angle in the vacuum. Near the cutoff region, both modes rotate along the sheared field. However, there is a transient region at the boundary. This region is characterized by the condition[2],

$$|N_O-N_X|\approx\frac{2c}{\omega}\phi \quad .$$

When the left hand side is dominant, both O- and X-modes propagate independently, and their rotaion angles follow the field. When the right hand side is dominant, the waves have the inertia to preserve their polarization. In the case we studied, this transient region located just inside the boundary. Thus, for this condition the microwave should be launched with the rotaion angle parallel or perpendicular to the field slightly inside the plasma boundary to achieve pure O- or X-mode reflection.

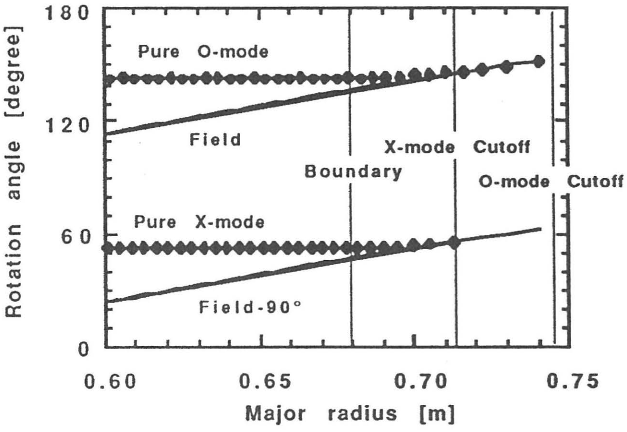

Fig.1 Rotaion angle and field line angle.

References

1)Fidone,I. and Granata,G., Nucl. Fusion 11 (1971), 875.

2)Bell G.L., et al., Nucl. Fusion 33 (1993) 875.