§13. ICRF Wave Excitation and Propagation in the GAMMA 10 Tandem Mirror

Fukuyama, A. (Kyoto Univ.),
Yamaguchi, Y., Ichimura, M. (Univ. of Tsukuba)

The waves in the ion-cyclotron range of frequency (ICRF) are widely used for the plasma production, heating, and stabilization of the magneto-hydrodynamic (MHD) instabilities. The plasma production depends strongly on the wave excitation in the plasma. The wave excitation is affected by the boundary conditions and the eigenmodes are formed in both radial and axial directions because the inhomogeneous scale length of the plasma and the magnetic field configuration is in the same order of the wavelength in the present experimental conditions[1, 2].

A wide-band RF probe system has been developed in GAMMA 10 for studying the eigenmode formation of excited waves experimentally [3]. Figure 1 shows a schematic diagram of the RF probe system used in the anchor cell. A bar-type antenna is installed in the peripheral region in the anchor cell. The low power RF pulse is applied to the antenna via a wide-band impedance matching circuit. The current driven in the antenna is detected by a small pickup coil. The applied frequency is swept between 8 and 20 MHz. The excited waves in the plasma are measured by a magnetic probe located in the opposite side of the anchor mid-plane. The formation of eigenmodes is described by using the antenna-plasma and plasma-probe complex transfer function. The transfer function can be directly obtained from the complex amplitude of the excited wave by dividing that of the current on the antenna.

$$G(j\omega) = \frac{Y(j\omega)}{U(j\omega)} \tag{1}$$

Here, ω is the angular frequency of RF pulse. $Y(j\omega)$ and $U(j\omega)$ are the Laplace transform of the input and the out signals for the system, respectively. The coupling between the antenna and the plasma can be described by an electric circuit model with *RLC* resonance as followings,

$$G(j\omega) = \sum \frac{-j\omega M\left(1-\omega^2 L_a C_a + j\omega C_a R_a\right)^{-1}}{R_p + j\left(\omega L_p - \dfrac{1}{\omega C_p}\right)} \tag{2}$$

where M is the mutual inductance between the antenna and eigenmode, and $R_{a,p}$, $L_{a,p}$ and $C_{a,p}$ are the resistance, inductance, and capacitance of antenna (a), and plasma (p), respectively. If the real and imaginary parts of the transfer function are plotted in the complex-plane, the resultant curve with the resonance becomes a circle. There are several frequency peaks on the real and imaginary parts of the transfer function. Figure 2 shows an example of the eigenmode formation observed in the GAMMA 10 anchor cell. Such a resonant behavior in the complex-plane is observed in the frequency above the cyclotron frequency at the antenna location. The eigenmodes in the fast wave region are clearly excited in the anchor cell of the GAMMA 10.

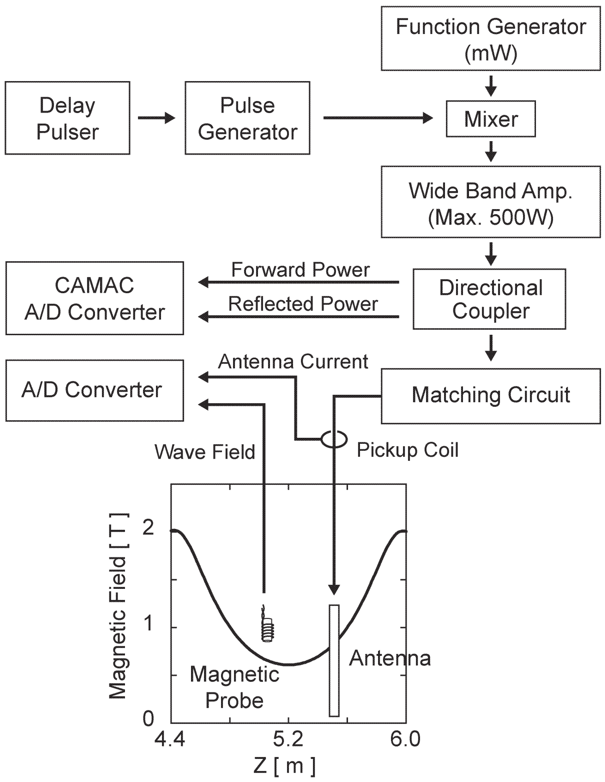

Fig.1. Schematic diagram of the RF probe system

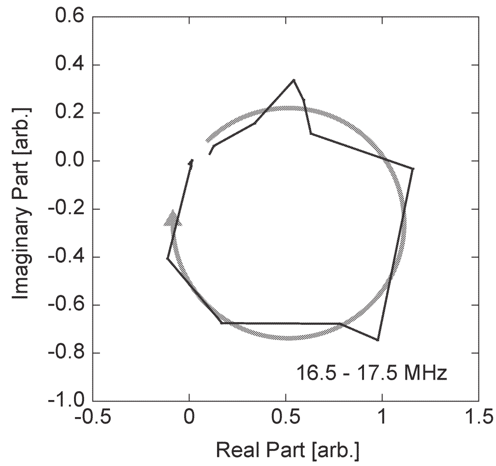

Fig.2. An example of trajectory in the complex-plane for the peak near 17 MHz. The trajectory is approximately circle, which indicates the resonant excitation of the eigenmode.

[1] Fukuyama, A. and Ichida, A., Proc. of 1996 Int. Conf. on Plasma Phys., Vol.2, p.1342 (1997).

[2] Yamaguchi, Y., et al., Plasma Phys. Control. Fusion, **48** (2006) 1155-1163.

[3] Y. Yamaguchi, et al., Rev. Sci. Instrum., **77** (2006) 10E904-1 - 10E904-3