§3. Wave Excitation by Amplitude Modulation of Microwave

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In the HYPER-I device, a microwave of 2.45 GHz from a klystron amplifier (CW) was introduced into a vacuum chamber with an inner diameter of 300 mm and a length of about 2000 mm along an axial magnetic field through a quartz window at an end. Since the axial magnetic field was divergent and its intensity slightly decreased with a distance z from the window, a plasma was produced and sustained at an electron cyclotron resonance layer at $z \simeq 1065$ mm (875 G). In the previous experiment of the amplitude modulation of the microwave, we observed that plasma densities (Ar^+) varied with the frequency of the amplitude modulation of the microwave and its 2nd and 3rd harmonics and propagated with a speed of $\sim 3 \times 10^4$ m/s.

In this experiment of the amplitude modulation of the microwave, to observe a pressure variation of ambient argon gas, we set two microphones at $z = 1175$ mm and $z = 1555$ mm, the heads of which were about 10 mm outward from the inner surface of the vacuum vessel to keep away from the plasma. The frequency range of each the microphone (AMD-708-RC) was from 50 Hz to 16 kHz and its circuit used is shown in Fig. 1. When the frequency of the amplitude modulation of the microwave was swept from 0.2 kHz to 16 kHz with a duration of 8 s between microwave power of 3 kW and 7 kW under argon gas with a pressure of $\sim 1 \times 10^{-3}$ Torr, the output signal of the microphone at $z = 1175$ mm was measured for 0.1 s and its power spectrum is represented as shown in Fig. 2. This figure shows two peaks: one of the two peaks indicates a frequency of about 4.5 kHz, which corresponds to the frequency of the amplitude modulation of the microwave at the time measured; and the other peak indicates a frequency of about 2 kHz ($= \omega/2\pi$). Since the peak of about 2 kHz was observed for any frequency of the amplitude modulation of the microwave, about 2 kHz seems to be an eigenfrequency of a sound wave excited in a cylindrical vessel with a diameter of 300 mm ($= 2a$) and a length of 2000 mm ($= 2\pi/k_z$). With the use of the relation,

$$\frac{\omega^2}{{c_0}^2} = {k_z}^2 + \left(\frac{2.4}{a}\right)^2 ,$$

the sound speed of argon gas is estimated as $c_0 \simeq 7.8 \times 10^2$ m/s, which indicates that the temperature of argon gas is about 1700° K.

A phase difference between the output signals of the two microphones was not obtained because the coherence between the two signals was not high enough. However, the relation between the variations of the gas pressure and the plasma density will be investigated.

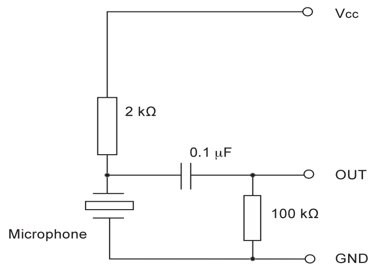

Fig. 1: Circuit of microphone.

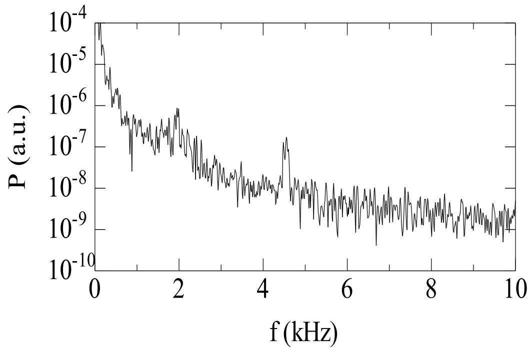

Fig. 2: Power spectrum of output signal of microphone at $z = 1175$ mm.