§4. 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) is 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 is divergent and its intensity slightly decreases with a distance z from the window, a plasma is produced and sustained at an electron cyclotron resonance layer at $z \simeq 1065$ mm (875 G). Then, a density modulation at the electron cyclotron layer would be caused by an amplitude modulation of the microwave and might propagate as a wave. The purpose of this study is to observe such the wave if it exists.

Figure 1 shows how a frequency of ion saturation currents of a single probe placed at $z = 1175$ mm and $r = 0$ mm varied as a function of a time when the modulation frequency of the microwave power varied from 0.2 kHz to 2 kHz for a duration of 8 s. In this case, the average power of the microwave was about 4.5 kW and the magnitude of its modulation was about 1 kW; the ambient pressure of argon gas was about 0.8 mTorr. We find that the frequency of the dominant density modulation varied in accordance with that of the microwave modulation. In addition, we also find the frequency of the smaller density modulation varied with the frequency being twice that of the microwave modulation.

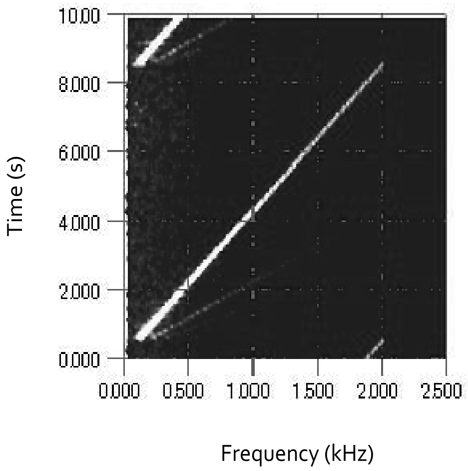

Fig. 1: Relationship between a frequency of ion saturation current of a single probe placed at $z = 1175$ mm, $r = 0$ mm and a time when modulation frequency of microwave varies from 0.2 kHz to 2 kHz.

Now, let us see the power spectrums of the ion saturation currents of single probes placed at $z = 1175$ mm ($r = 0$ mm) and at $z = 1555$ mm ($r = 0$ mm), which are shown in the top and middle traces of Fig. 2. Since they were measured at $t \simeq 1.1$ s, we find that the frequency of the dominant density modulation was about 0.36 kHz and that of the smaller density modulation was about 0.72 kHz. The coherency between the two signals are also shown in the bottom trace of Fig. 2 and indicates that the two signals were correlated. Thus, we evaluate their phase difference and find that there was no significant phase difference for the signals of the dominant modulation, but a distinct phase difference for the signals of the smaller modulation. In other words, it seems that the dominant density modulation took place in the entire space and didn't propagate but the smaller density modulation propagated with a speed of $\sim 3 \times 10^4$ m/s, which was about 10 times higher than an ion sound speed.

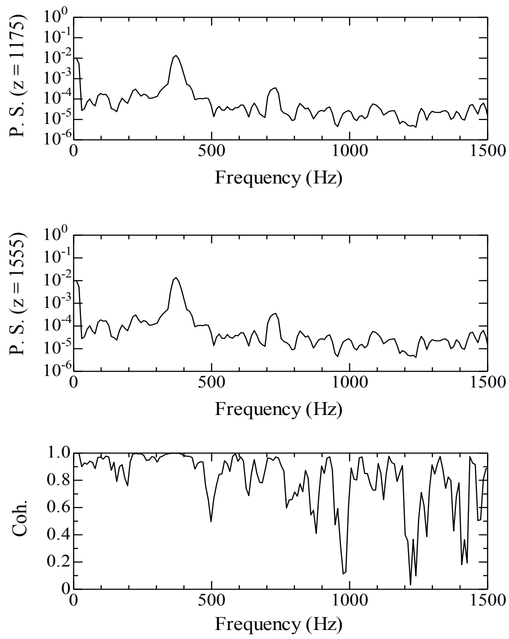

Fig. 2: Power spectrums of ion saturation currents of single probes placed at $z = 1175$ mm, $r = 0$ mm and at $z = 1555$ mm, $r = 0$ mm, which were measured at $t \simeq 1.1$ s, are shown by the top and middle traces; and their coherency is shown by the bottom trace.