Experimental Study on **Ion Acoustic Wave Characteristics** in Multi-dipole Plasmas Chamber

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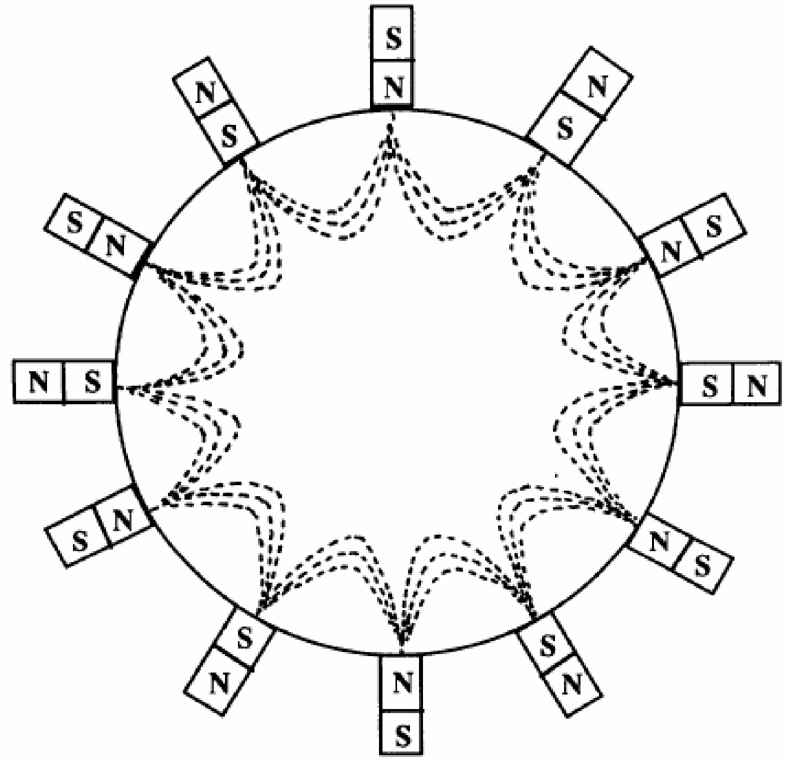
Abstract

Ion Acoustic Waves (IAW) are derived from the similarity to sound wave in collisionless plasmas. The longitudinal electric field in the ion acoustic wave arises from the space charge displacements developed by plasma density perturbation. Ion acoustic wave is experimentally excited in the plasma and its phase velocity is measured using the time of flight method. Since the phase velocity of IAW has the relation with the electron temperature, the measurement of the phase velocity gives the electron temperature indirectly. In this poster, the experimental technique how to generate the IAW and to discriminate the IAW is presented. This paper also describes the experimental observations of the linear dispersion relation and the saturation to the ion plasma frequency of IAW.

* Work partially supported by KSTAR project.

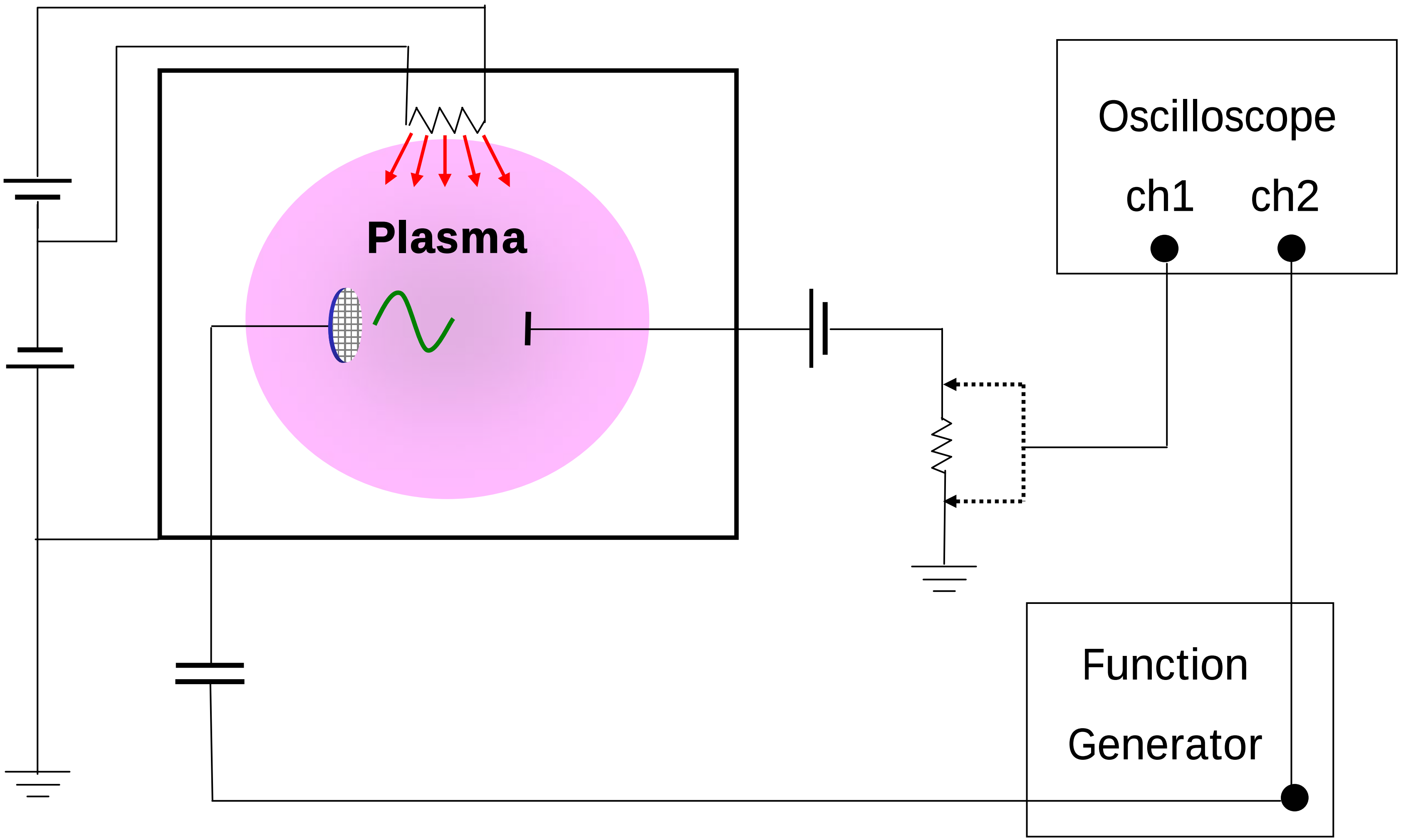
Multi-dipole Plasma System

Multi-dipole Chamber System



Magnetic Cups Field Lines

Schematic of Plasma Wave Experiment



Plasma Parameter Measurement

Gas : Ar

Base Pressure : $0.7 \times 10^{-5}\, Torr$

Gas Pressure : $2 \times 10^{-4}\, Torr$

$$V_f = -12.1V,\ V_p = 0.58V$$

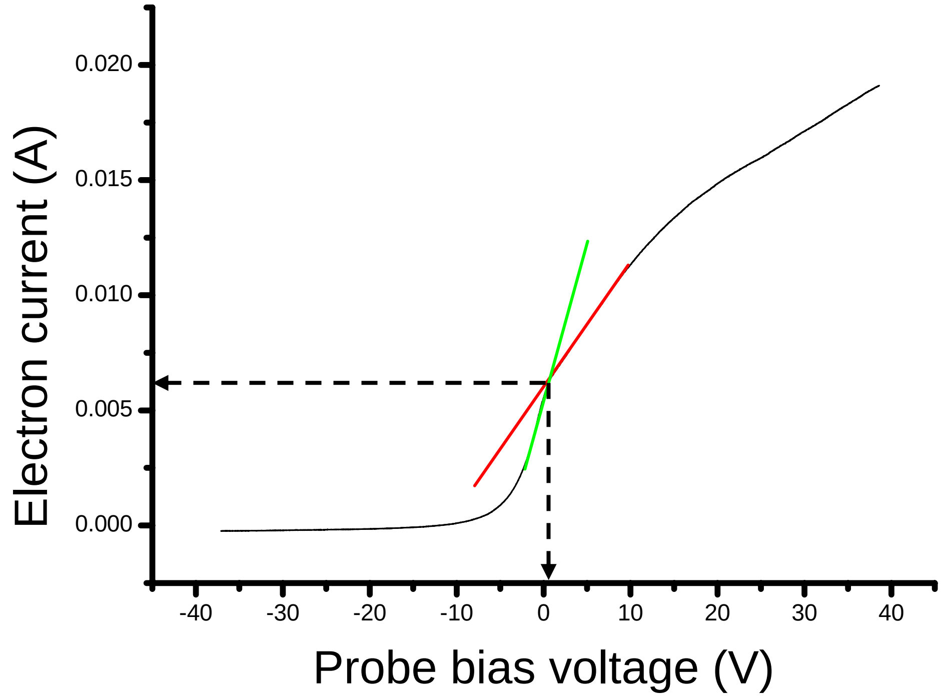
$$I_e^* = 0.00575A$$

$$I_e(V_B) = I_e^* \exp\left[\frac{-e(V_p - V_B)}{T_e}\right] \qquad ,V_B \le V_p$$

$$I_e = I_e^* \qquad ,V_B \ge V_p$$

$$T_e = \frac{e(V_p - V_B)}{\ln I_e^* - \ln I_e(V_B)} \cong 2.63eV$$

$$n_e = \frac{I_e^*}{Se\overline{\upsilon}_e} = \frac{I_e^*}{Se}\frac{1}{\sqrt{T_e / 2\pi m_e}} = 8.37 \times 10^9 [\# / cm^3]$$



Disk Type Langmuir Probe V-I Curve

Ion Acoustic Wave Experiment Condition

$$f_e(Hz) \approx 9000\sqrt{n_e(cm^3)} \cong 0.8GHz$$

$$f_i(Hz) \approx \frac{f_e}{\sqrt{40 \times 2000}} \cong 2.9MHz$$

$$f_{external} < f_{ion} < f_{electron} : \text{Ion Acoustic Waves Condition}$$

$$f_{ion} < f_{electron} < f_{external} : \text{cf.) Electron Plasma Waves Condition}$$

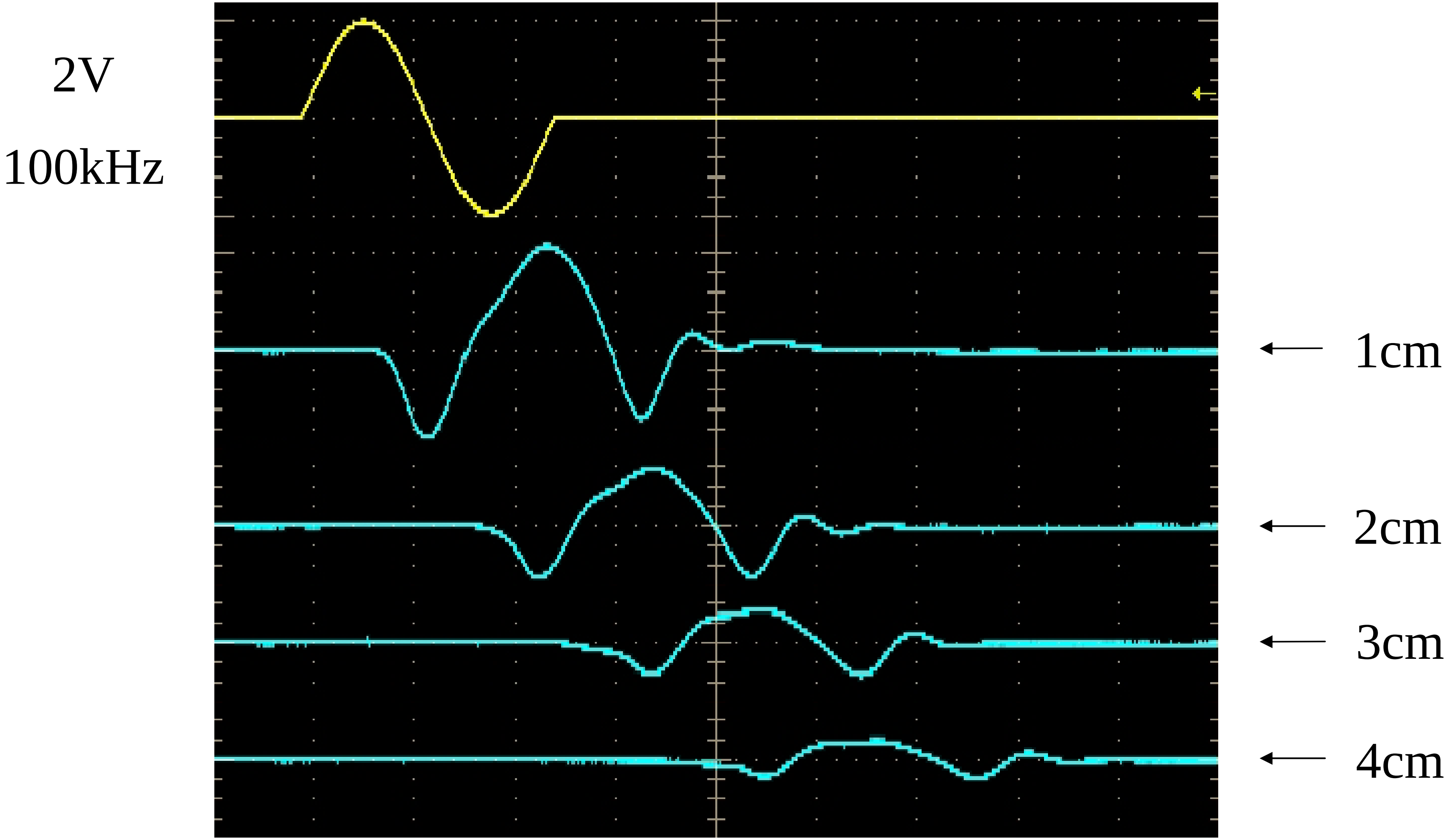
$$\text{Launching Wave Condition} : 20kHz \le f_{external} \le 2.8MHz$$

$$V_{applied} \cong \frac{T_e}{e} \text{ or } \frac{1}{2}\frac{T_e}{e} \approx 2V$$

$$\text{Measurement by The Time of Flight Method} \Rightarrow C_s = \frac{\Delta x}{\Delta t}$$

$$\frac{w}{k} \cong \left(\frac{kT_e}{M_i}\right)^{1/2} = C_s : \text{The dispersion relation for ion acoustic waves}$$

Time of Flight Method



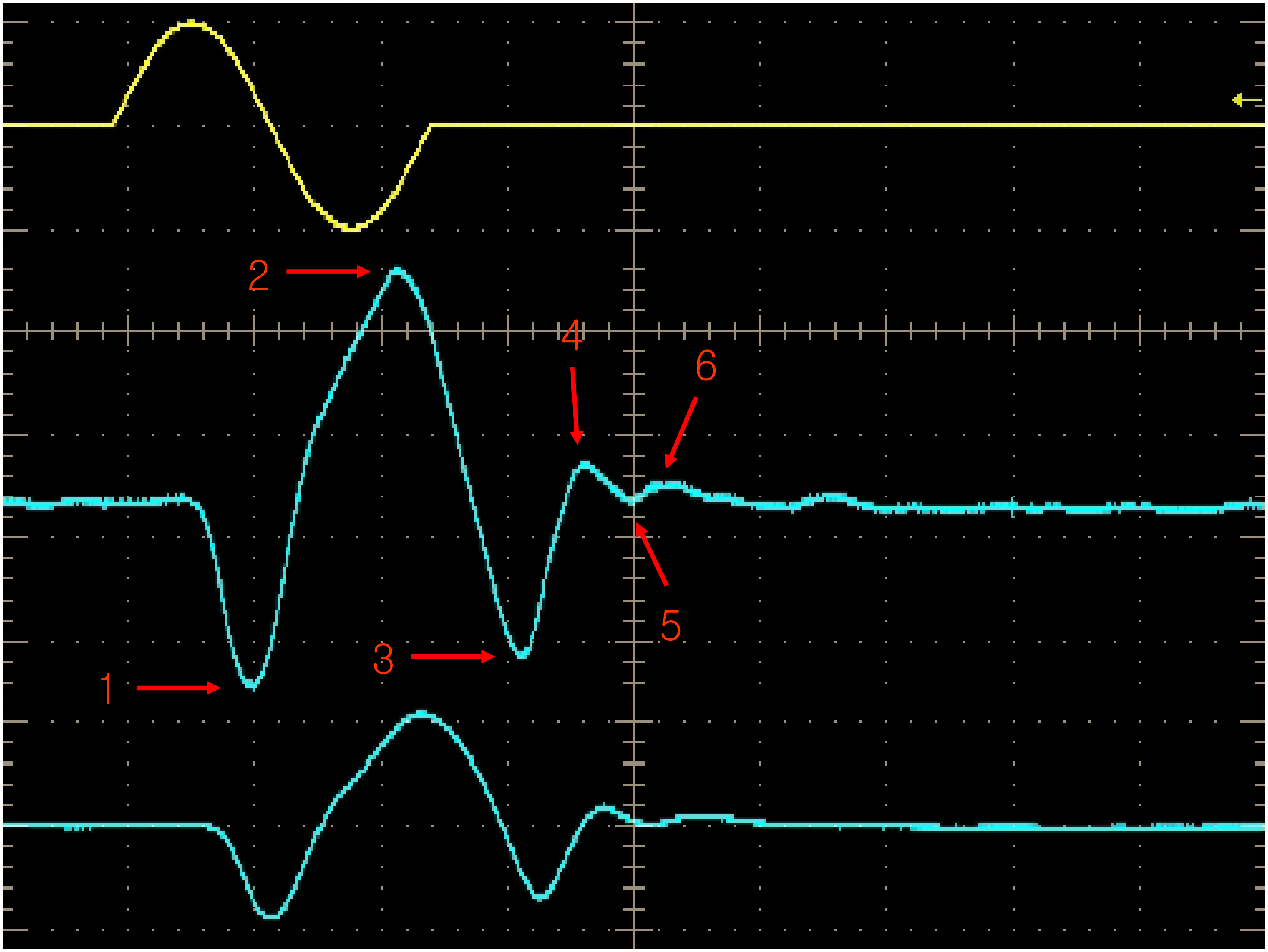
Ion Acoustic Wave Measurement

5V & 2V

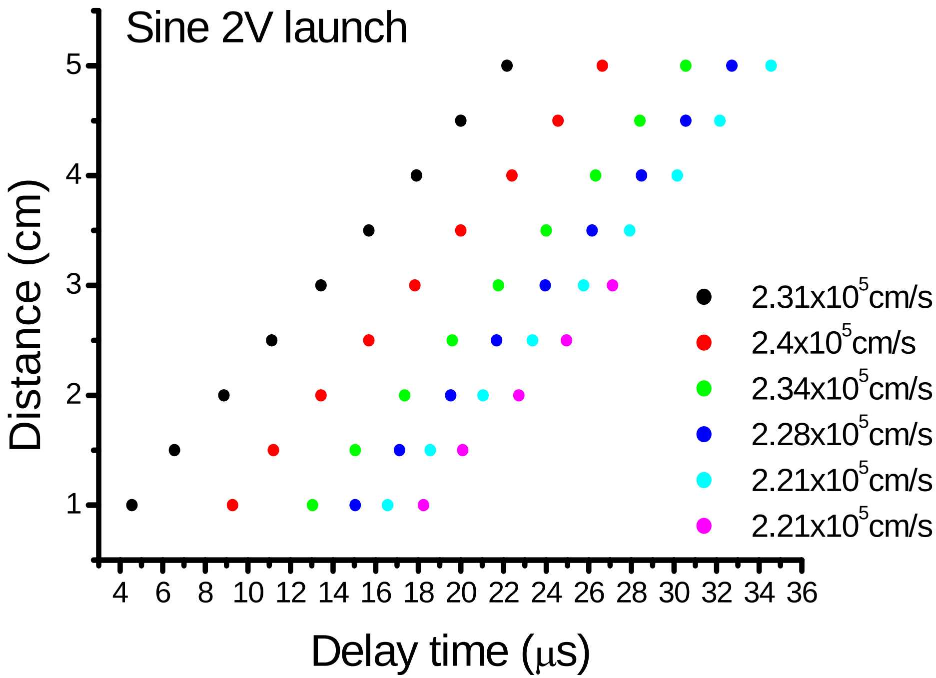
100kHz

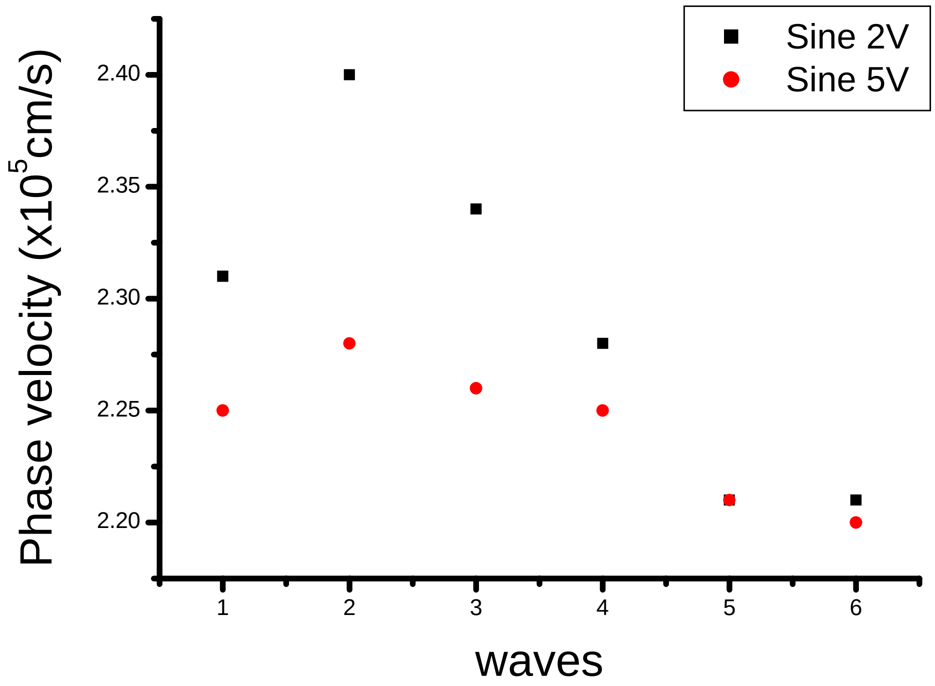
IAW Signal(5V)

IAW Signal(2V)



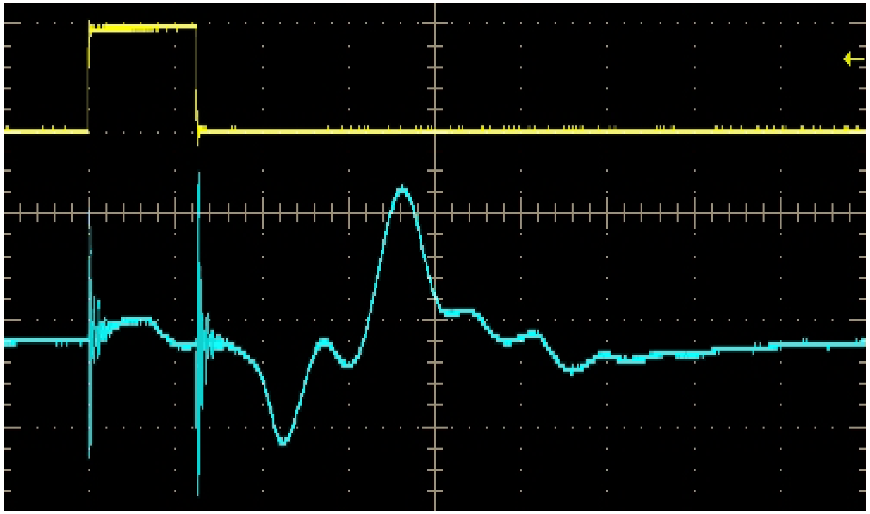
Comparison of Fast & Slow Wave





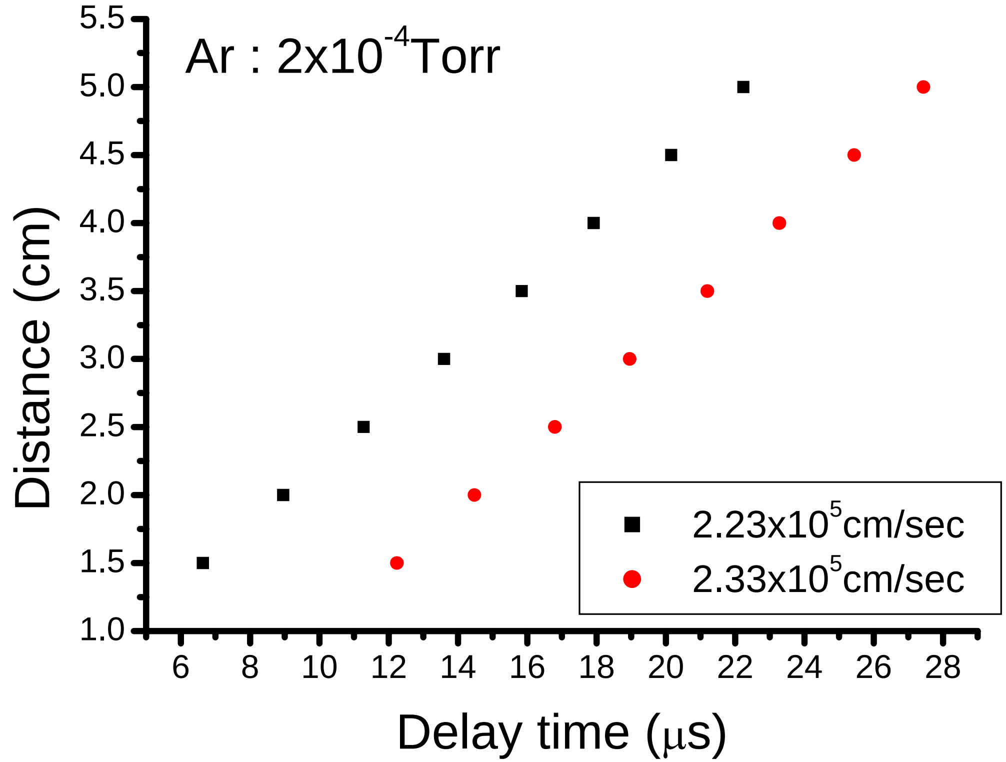
Which wave is the ion acoustic wave? Slow wave(5th wave) is the ion acoustic wave!

Square Wave Launch



Input Signal = Square Wave

(100kHz, Vpp=2V)



It's similar to ion acoustic wave velocity measured by launching sine wave of mesh grid.

The Dispersion Relation

Launching square wave

(20kHz ~ 2.8MHz)

FFT of Ion Acoustic Wave

⇩

Frequency Measurement

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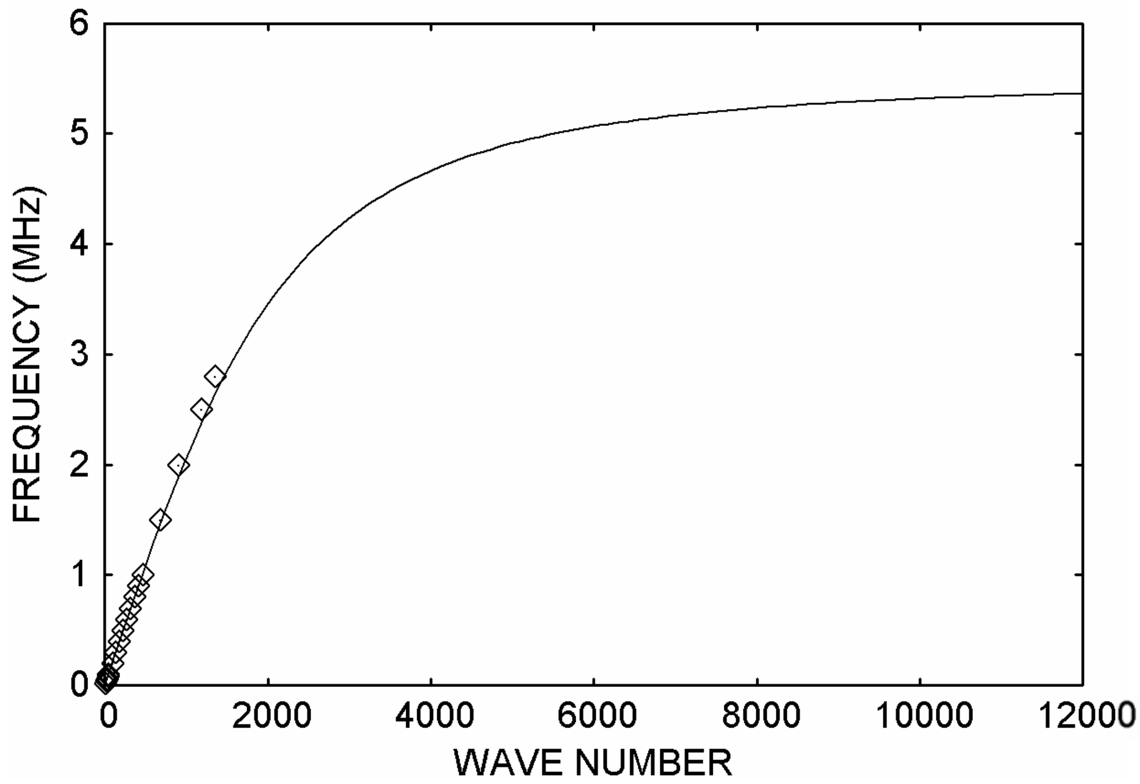
Wave Number Calculation

$$\frac{\omega}{k} = C_s$$

We know IAW velocity by time of flight method



Summary

In plasma, electrostatic wave phenomena can be observed just like sound wave.

- Experiment was carried in Multidipole plasma chamber.
- Ion acoustic wave velocity by T-O-F : 2.2×10^5 ~2.4×10^5 cm/sec in Argon plasma with 2×10^{-4} Torr gas pressure.
- Slow wave presents the ion acoustic wave.

The dispersion relation for the ion acoustic waves

- Wave frequency is measured by FFT of ion acoustic wave. And Wave number is calculated by dispersion relation equation