STUDY OF SELF-EXCITED ION ACOUSTIC WAVES IN A PLASMA

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This paper describes the observation of ion Plasma oscillation in spherical discharge system of different sizes. Spherical chambers of three different sizes viz 10cm,20cm, and 40cm diameter, with multiple ports were used for producing a discharge Plasma. The chamber was first evacuated to 10^{-6} torr , operating gas pressure in the range 10^{-4} to 10^{-2} torr. Externally no magnetic field was applied to the system. The Plasma system is set up as shown in figure 1. Multiple guns are employed as a Plasma source and two disc type probes are mounted in the horizontal plane , these probes are negatively biased and are connected to the CRO. All probes are movable under Vacuum.

As the potential on the gun electrodes is gradually increased a stable, quiescent homogenious Plasma is formed in the spherical chamber. If the potential is further increased then, at some stage it is found that the probe out put on the CRO suddenly shows the presence of a low frequency sinusoidal oscillation. The low frequency oscillation in the electron beam is equivalent to the bunching of electrons in the beam. It is possible that when the electron bunches pass any fixed point in a Plasma at a frequency they generate an electric field at that frequency and excite Plasma oscillations by a positive feedback mechanism. Anegatively biased disc type probe, immersed in the Plasma acts as a receiver probe and picks up these oscillations. The observed oscillation can be explained as a standing wave pattern in the spherical chamber. There is no change in the Phase of the signal from one point to another but the amplitude of the signal changes for a typical case showing the first harmonic of the fundamental frequency of oscillation.

The purpose in using three systems of different sizes, viz 10cm, 20cm , and 40cm diameter, was to study of the proximity of Plasma boundary on the oscillations.

<u>Oscillations in 20cm diameter spherical chamber.</u>

The Plasma oscillations got easily generated in the 20cm chamber. The waveform of the oscillations is sinu-

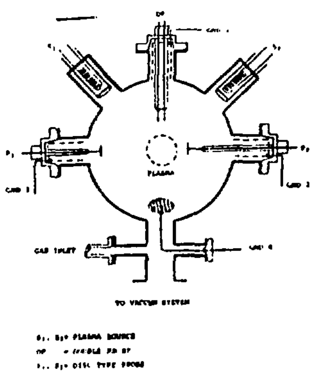

Fig:1 Experimental set up

soidal (figure 2) . Two types of measurements were carried out regarding the observed oscillations the oscillations frequency was measured and the oscillations amplitude was measured as a function of the distance of the probe from the centre of the sphere. It was also found that the oscillation would abruptly change in frequency if the parameters of the discharge were varied, several sets of measurements were made by changing the discharge controlling parameters like HT voltage on gun electrodes, background gas pressure, different guns and so on.

<u>Oscillations in 10cm diameter spherical chamber.</u>

The proximity of Plasma boundary seems to have a controlling influence in the Plasma processes occuring in 10cm diameter and discharge is less smooth compared to that in 20cm diameter spherical system. The waveform of the oscillations is sinusoidal as shown in figure. 3, the waveform is the same in all the three system,

<u>oscillations in 40cm diameter spherical system.</u>

it is much easier to produce and maintain stable and uniform plasma in the bigger system in which Plasma boundary is will away. The gas discharge can be operated with lower voltage between the cathode and the anode giving fairly low electric field in the plasma , in the 40cm plasma system, oscillations when excited appeared more like ion- bursts which quickly disappear afterwards . These bursts appeared to have frequencies above 100 KHZ. Efforts to excite stable low frequency oscillations by increasing

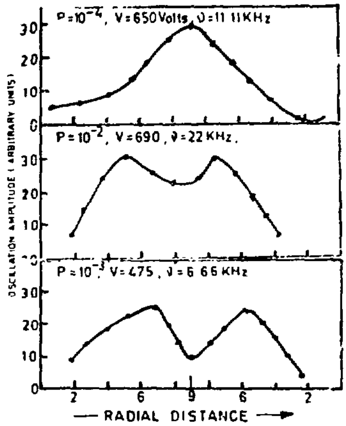

FIG-2: Position of Probe.

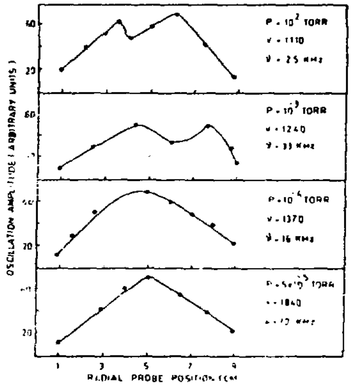

Fig: 3 Spatial variation of amplitude of low frequency oscillation in 10 cms sphere, Argon Plasma

the electron beam energy and density by applying higher HT voltage to the cathode and the anode were not successful . At first it was thought that in view of the large experimental volume avaibable in 40 cm spherical chamber multiple plasma sources would be required to produce sufficient plasma density . Therefore, experiment were carried out employing varying number of plasma sources. It was found that the crucial parameter was not the number of guns employed to produce plasma but was rather the operating gas pressure in the chamber. As long as the gas pressure was below

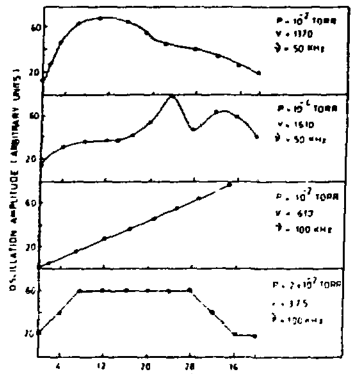

Fig 4 Spatial variation of amplitude of high frequency oscillation in 40 cms sphere

10^{-4} torr low frequency oscillations could be observed even with one gun only. Apparently at gas pressures above 10^{-4} torr, the low frequency oscillations in the 40 cm diameter system and damped out the waveform of the oscillations in this case also is sinusoidal as shown in figure 4.

Results.

The calculation shows that there is a good match between the observed and the calculated frequency the observed oscillations are sensitive to the parameters of the plasma in which they occur. If the discharge conditions were varied, it was found that the oscillation frequency varied discontinuously from mode to mode in a most striking manner. For example in a single run with 10^{-2} torr pressure, if an oscillation at frequency 6 KHZ is found to occur at the gun potential of 475 volts, then without altering the plasma condition when the potential was changed to 690 volts the frequency changed discretely to 25 KHZ whereas at the gun potential of 2130 volts the frequency changed to 47 KHZ. A small change in the pressure of the background gas will produce a completely new set of values for the gun potentials and the observed frequencies.

The rebialilty of the Plasma parameters determined from the probe measurements can be checked by comparing these with the low frequency ion sound wave oscillation measurements. The results of electron temperature determination by two methods are given in table 1. Summarizing we may sta'le that probes plasma waves and oscillations from very reliable diagnostic tools fcr the investigation of stationary d.c. low pressure plasma in the absence of magnetic fields. By their very nature the above two methods are mutually in dependent and non- perturbing type and therefore are the best condidates for selection as multiple diagnostic tools fcr simultaneous applications.

TABLE 1 : Measurement of low frequency oscillations in spherical systems.

Dia cm	P torr	H.T. voltage volts	ν obs. KHZ	T_e from waves 10^{-4} °K	T_e DP 10^{-4} °K
10		1370	16	2.2	1.8
20	10^{-4}	830	11.11	2.7	2.5
40		790	0.50	3.0	3.2

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