ABSTRACT OF THE THESIS

This thesis describes an experimental study of some nonlinear phenomena in plasmas, like the formation and properties of a double layer, and evolution of a rarefaction waves, in the process of its propagation in plasmas. The experiments on double layers, were performed in a double plasma machine, and the rarefaction wave propagation studies were conducted in a similar device, but modified suitably.

A detailed study of the pseudo-double layers revealed, that it was due to a plasma blob, formed as a result of ionisation of additional neutral gas that leaked into the system, during the probe movement. These effects were observed only when the system was operated at a critical pressure. This led to the formation of potential and density discontinuities. Velocity measurements showed an ion front, moving at a velocity much greater than ion acoustic velocity. Further probing, revealed that it was due to the expansion of a plasma blob, in which was imbedded a double layer, moving almost at the
velocity of the front. From an adiabatic thermodynamic model and a model based on self similar expansion of plasma, we verified that it is possible to accelerate ions to large velocities in an expanding plasma in the direction of electron drift.

Operating the system, below the critical pressures as noted above, we succeeded in generating weak double layers with \( \frac{e \Delta \phi}{T_e} \approx 4 \) to 5. We observed criticality in the relative bias conditions too. Beyond a critical bias voltage especially around ionisation potential of the neutral gas, the entire plasma potential in the target region was rendered uniform, by disrupting a double layer.

In the course of our further investigations, we found that on modifying the bias configurations, we could successfully obtain strong double layers. A detailed investigation was carried out, and detected no restraints on the maximum amplitude to the ionisation potential, or electron temperatures. We were able to obtain double layers with \( \frac{e \Delta \phi}{T_e} \approx 50 \). A circuit model was carried out, which exhibited an increase in current in the modified configuration. This was verified, by experimentally, monitoring the electron currents in the two configurations. It was found, that the strength of the double
layers mainly depended on the currents involved in the system.

We next carried out a time evolution study of the rarefaction waves in a homogeneous and a current carrying plasmas. In the former case, we observed a phenomena, quite contrary to the fluid theories. The rarefaction wave was found to broaden at the minimum, and developed a shock wave at the trailing edge. The minimum, split into two troughs, one of which propagated at a supersonic speed and the other travelled at a subsonic speed. The KdV equation was numerically solved, with a rarefaction wave, as an initial condition. We did not observe, any result, similar to the experiments. Since the fissioning of the wave, could be due to trapping of charged particles, we have resorted to carry out some computer experiments by solving the ion Vlasov-Poisson equation.

In the presence of a small steady circuit, we pulsed the source plasma of the double plasma machine, and observed a rarefactive wave, to amplify, and also give rise to an ion acoustic type of turbulence. The compressive modes, that formed on the downstream sector damped out, while the dominant rarefactive mode evolved into an ion hole like double layer. Thus we were able to exhibit in the laboratory, for the first time, that
Double layers do originate from a rarefactive wave.