# EXPERIMENTAL INVESTIGATION OF DOUBLE-LAYERS FORMED BY ION-ACOUSTIC TURBULENCE

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Numerical simulations carried out by Sato and Okuda[1] have shown that double-layers can be formed by ion-acoustic turbulence excited by a drifting population of cold electrons in a background plasma. The corresponding anomalous resistivity gives rise to a localized potential step that further accelerates the cold electrons and maintains the ion-acoustic double-layer. This bootstrap mechanism has been investigated in a double-plasma device at INPE. The usual grid separating the source and target plasmas has been replaced by a magnetic picket fence made of permanent magnets with a 0.15T magnetic flux density at the surface. The working pressure is $4.2 \times 10^{-4}$mbar (Argon) and typical plasma parameters are: electron density $n_e = 1.2 \times 10^{15} m^{-3}$, electron temperature $T_e = 2.2$eV, and ion temperature $T_i \lesssim 0.2$eV. The plasma potential is measured by an emissive probe and the electron drift velocity by double faced Langmuir probes.

When only the source plasma is turned on, a stream of cold electrons ($T_e \cong 0.3$eV) diffuses through the magnetic fence and is detected in the target chamber. When the target plasma is also turned on, a density unbalance can be setup between the two plasmas with the relative density of the cold beam streaming into the target plasma $n_b/n_e \cong 0.13$. The drift velocity $v_d$ of the beam is much larger than the ion-acoustic velocity $C_s$ ($v_d/C_s \cong 20$ in a pure Argon plasma). Under these conditions, strong ion-acoustic turbulence is generated in the target plasma. The corresponding spectrum has been measured and agrees reasonable well with the prediction of the modified Kadomtsev spectrum from renormalized theory[2]. The turbulent anomalous resistivity is estimated to be $\eta^* \cong 7.0 \Omega$m, at the position of maximum density fluctuations, corresponding to an effective collision frequency $\nu^* \cong 3.1 \times 10^7 s^{-1}$, much larger than the electron-neutral collision frequency. From the measured temperature profile it can be verified that the diffusing cold electrons are heated by the turbulent fields up to the temperature of the plasma electrons, on a scale length corresponding to the extent of the double-layer ($\sim 200\lambda_e$). The measured potential step is of the order of 0.4V.

In order to check the role of the ion-acoustic turbulence on the formation of the double-layer, a gradual quenching of the turbulence is effected by the introduction of small quantities of Helium in the discharge to enhance Landau damping. The spectrum of the ion-acoustic turbulence is measured for relative concentrations of Helium ions, r, equal to 0, 0.03, 0.07 and 0.23. For increasing concentrations of the light ion the level of fluctuations decreases and is almost nonexistent for r = 0.23. There is also a corresponding decrease in the value of $v_d/C_s$ and in the potential step of the double layer, which does not form at the highest value of r. In this case (r = 0.23) two electron temperatures are observed in the target plasma. The value of the drift

velocity, measured in the presence of the double-layer in the case of a pure Argon plasma, is consistently above the threshold value for the excitation of ion-acoustic turbulence predicted by linear theory. However, in the Argon-Helium mixture the double-layer persists for drift velocities much smaller than the values computed from linear theory, suggesting that the threshold values are lowered in the presence of strong turbulence.

1. J. Sato and H. Okuda, Phys. Rev. Lett. 44, 770 (1980).
2. D.I. Choi and W. Horton Jr., Phys. Fluids 17, 2048 (1974).