

§4. Observation of Vortex Pair in the HYPER-I Device

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A pair of vortices has been observed in the High Density Plasma Experiment Device (HYPER-I).

When the plasma is produced at a pressure 3×10^{-2} Torr (Argon), a pair of bright oval structures is spontaneously formed. A typical structure taken by a CCD camera is shown in Fig. 1. The structure has been stationary for the whole period of the microwave discharge. The size of each bright oval region is about $10\text{cm} \times 5\text{cm}$. Figure 2 shows the density contour measured by a Langmuir probe. The density contour coincides with the CCD image, showing the bright oval regions are localized plasma columns. The peak density is $6 \times 10^{12}\text{cm}^{-3}$ and is 4-5 times higher than the background density, which exhibits a flat profile over the whole plasma cross section.

The flow structure has been measured with a directional Langmuir probe. The axial and azimuthal ion velocities are measured along the horizontal line indicated by A'-A in Fig. 1. The velocity normalized by the ion sound velocity C_s is shown in Figs. 3 and 4. The hatched regions in Figs. 3 and 4 correspond to the full half-widths of the high density regions, and the dashed lines indicate the positions of density peaks. As shown in Fig. 3, the azimuthal velocity is proportional to the distance from each density-peak. Therefore, the two plasma columns are a vortex pair rotating rigidly in the same directions, which is opposite to the direction of $E \times B$ rotation (the direction of electron diamagnetic drift).

As shown in Fig. 4, the axial velocity has positive value of 0.2 at the peak. On the other hand the velocities at the steep density-gradient regions, i.e. at the boundary of hatched regions in Fig.4, are negative, showing that there exist axial velocity shear layers at the edge of vortices. These vortices are thus considered to be confined within the axial shear layer.

Identification of the mechanism of rotation and interaction of the vortices are now in progress.

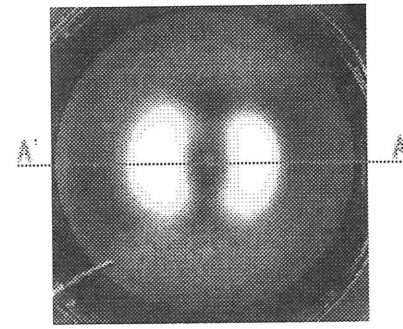


Fig. 1. CCD image of vortex pair

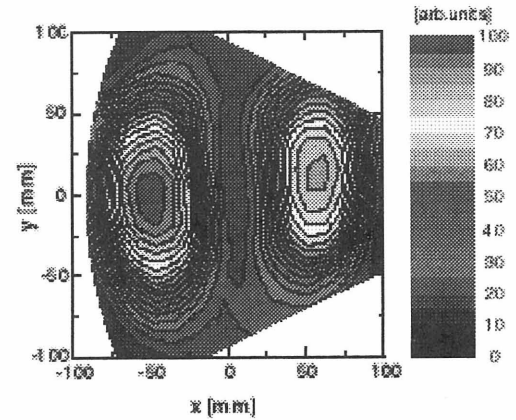


Fig. 2. Density contour normalized by the peak density

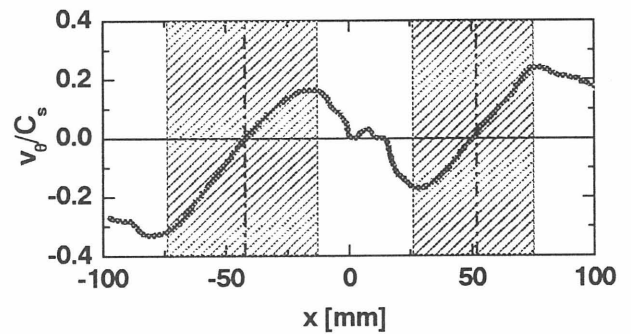


Fig. 3. Azimuthal velocity profile

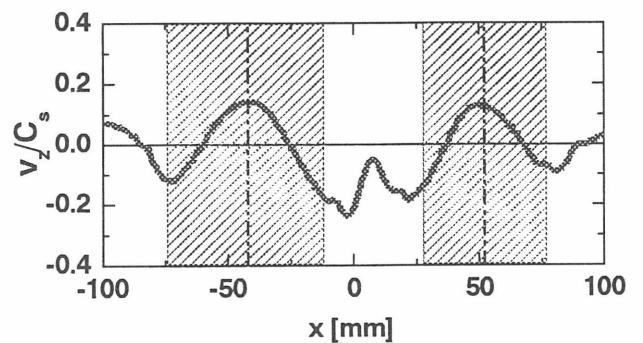


Fig. 4. Axial velocity profile