STUDY OF A DUST TRAP BY OBSERVATION THE DISCHARGE GLOW IN A MAGNETIC FIELD

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INTRODUCTION

In the study of dust plasma [1-3] for engineering and technological applications, it is of particular interest to study volumetric plasma-dust formations localized near the walls of plasma installation in the presence of a strong magnetic field. Among experimental studies of dusty plasma in the strong magnetic field, for example, [4-6], only two works were carried out with volumetric dust structures [7-8]. But all studies were performed in the uniform magnetic field. This paper first studies dusty plasma in the form of the volume dust structure created in the highly non-uniform strong magnetic field.

The dust trap characteristics used are currently taken from the description of the running strata [10-12]. Studies of standing strata in magnetic field, excepting the [13], do not exist [14,15]. The study of the formation of the running strata in the magnetic field [16] shows that newly occurring strata in the magnetic field cannot be the dust traps preserving the dust component throughout the change in the magnetic field. Due to the almost complete uncertainty of this issue, for the initial model estimates of the characteristics of the strata in the magnetic field (length, field intensity, electronic temperature), it was decided to measure the glow picture of the standing strata in the magnetic field. Possible transverse compression and longitudinal elongation (relatively to magnetic field) of the glow picture will make it possible to make assumptions about the change of parameters and their connection with the dynamics of rotation of the dust structure in the area of magnetic induction of 1000 G - 2000 G.

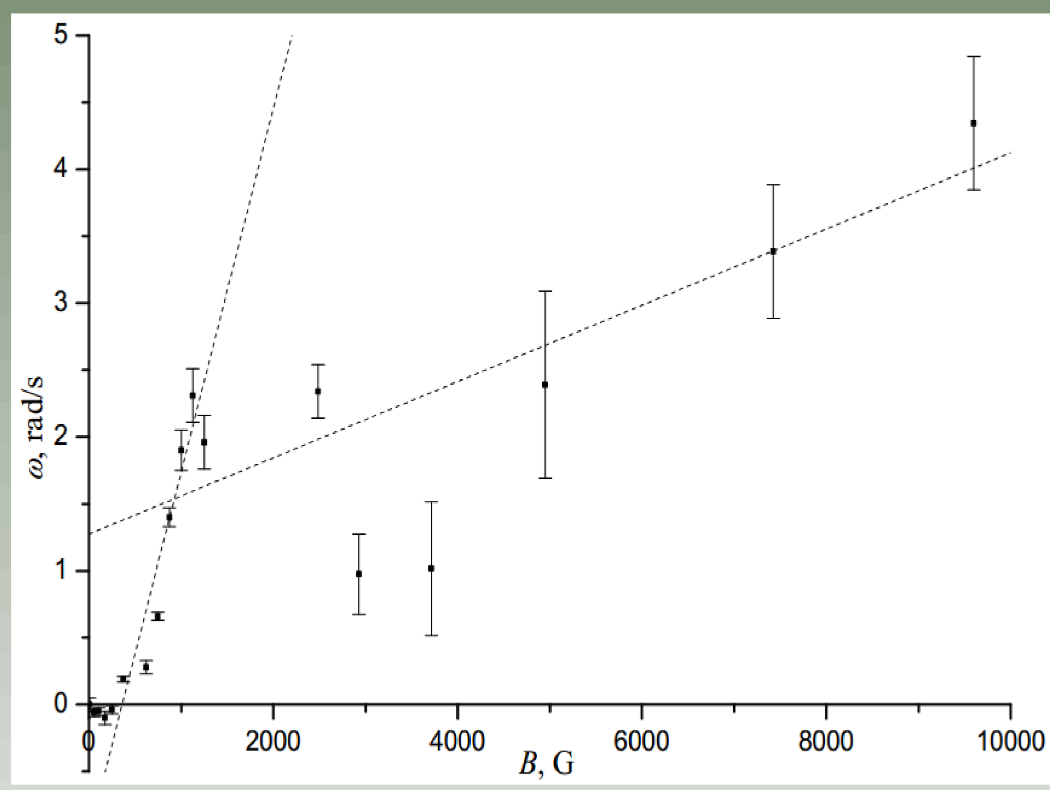

Fig. 1. The dependence of angular velocity of horizontal cross section of dusty plasma structure formed in a striation trap of glow discharge on the induction of magnetic field. Conditions: plasmaforming gas is neon, discharge current is 1.4 mA, gas pressure is 0.6 Torr, polydisperse quartz particles with main size 5-6 mkm.

EXPERIMENT

The experiment used a 120 cm high glass discharge tube with inner diameter of 20 ± 1 mm, in which the stratified DC discharge was ignited. The tube itself was placed in a longitudinal (relative to gravity) magnetic field with magnetic induction values in the range of 0 – 2700 G. The magnetic coil that created the field had the following geometric parameters: the height is of 10 cm, the diameter of the inner hole is of 10 cm, the outer diameter is of 26 cm. To output the image of the light of the discharge to the computer screen, a periscope video camera with a shooting frequency of 25 f/s and a resolution of 640 by 480 was used. The experiment was carried out under the following conditions: helium at pressures 0.1 Torr and lower, neon at pressures from 0.5 to 0.8 Torr and discharge current in both gases 1.5 mA. Fig.2 shows the sketch of experimental setup.

RESULTS AND DISCUSSION

Initially, there were the direct observations of the longitudinal dimension of the first standing strata in helium at relatively low pressures of 0.1 Torr and less. When the magnetic field was imposed, already in 400 G the striation was elongated by an amount comparable to the length of the magnetic coil; so that it was partially in the non-uniform magnetic field. It can be said that in small magnetic fields the striation had the elongation, qualitatively described in the available literature [13,14]. Strata in helium and hydrogen in the magnetic field are significantly elongated. In our experiments in helium, the magnetization $\omega_i\tau_i = 1$.

In the observations in neon we had the opportunity to achieve the magnetization of ions $\omega_i\tau_i = 0.25$. First, when the magnetic field was turned on, the standing strata system shifted towards the anode as a whole. Second, there was a narrowing of the glow part of the striation, the more, the closer to the head of the striation (closer to the strata-forming insert). The diameter of the glow differs from the diameter of the current channel in the insert; it can be seen in Figure 3 how the glow becomes conical. Under the conditions used, we found no explicit extension of the striation, as in helium. With the overall picture of strata displacement as a whole, it is likely that the length of the first studied striation varied little, at least by the characteristic picture of longitudinal glow. In Fig. 3 it is possible to compare the glow picture of the first strata in magnetic fields corresponding to different tangents of inclination angle in dependence of angular velocity on magnetic induction, Fig. 1. Fig.4 shows the integral glow of first striation in the fields of 1000 G and 2700 G.

Using Fig.4, it is possible to estimate the longitudinal gradient of the integral glow. Further, the glow can be matched to the excitation function in the striation, similar to the work of [10]. From direct measurements, we can only qualitatively conclude that with the growth of the magnetic field, the longitudinal gradient of the electron temperature ∇T_e decreases in the striation. According to rotation mechanism model for eddy current (1) it is possible to expect that under condition of the magnetization $\omega_e\tau_e\ \omega_i\tau_i \geq 1$, the value of eddy electronic current decreases, reducing the angular velocity of rotation of dust structure.

$$curl\ \vec{j} = -b_e[\nabla n_e \times \nabla T_e], \quad (1)$$

Where ∇n_e is electron concentration gradient; b_e is the electron mobility.

Note that the change in the longitudinal gradient T_e is greater than the change in the radial concentration gradient and will dominate in (1).

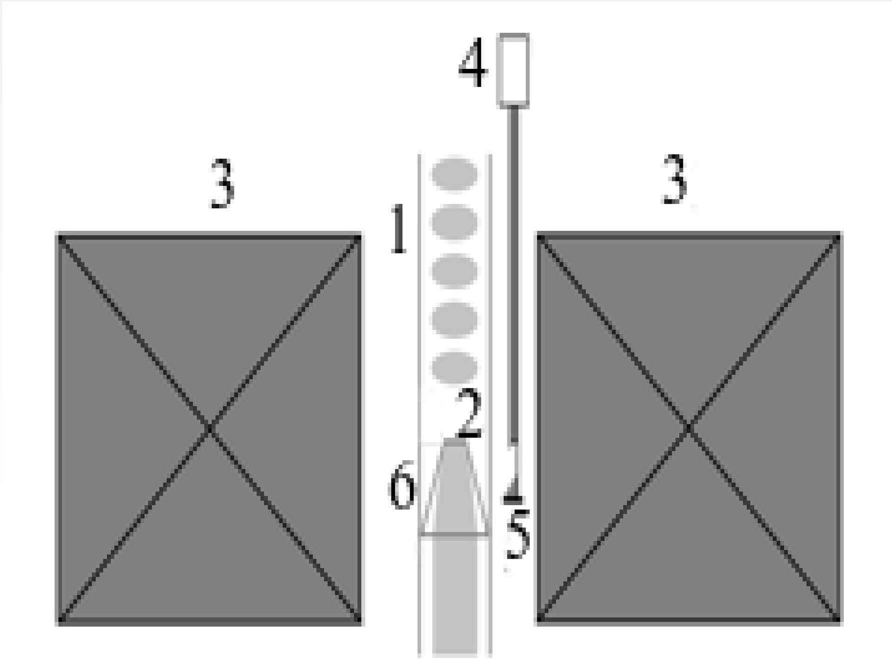

Fig.2. The sketch of the experimental setup. 1is the discharge tube; 2 is the stratified discharge; 3 is the magnetic coil; 4 is the videocamera; 5 is the periscope system for observation the discharge light; 6 is the dielectric insert.

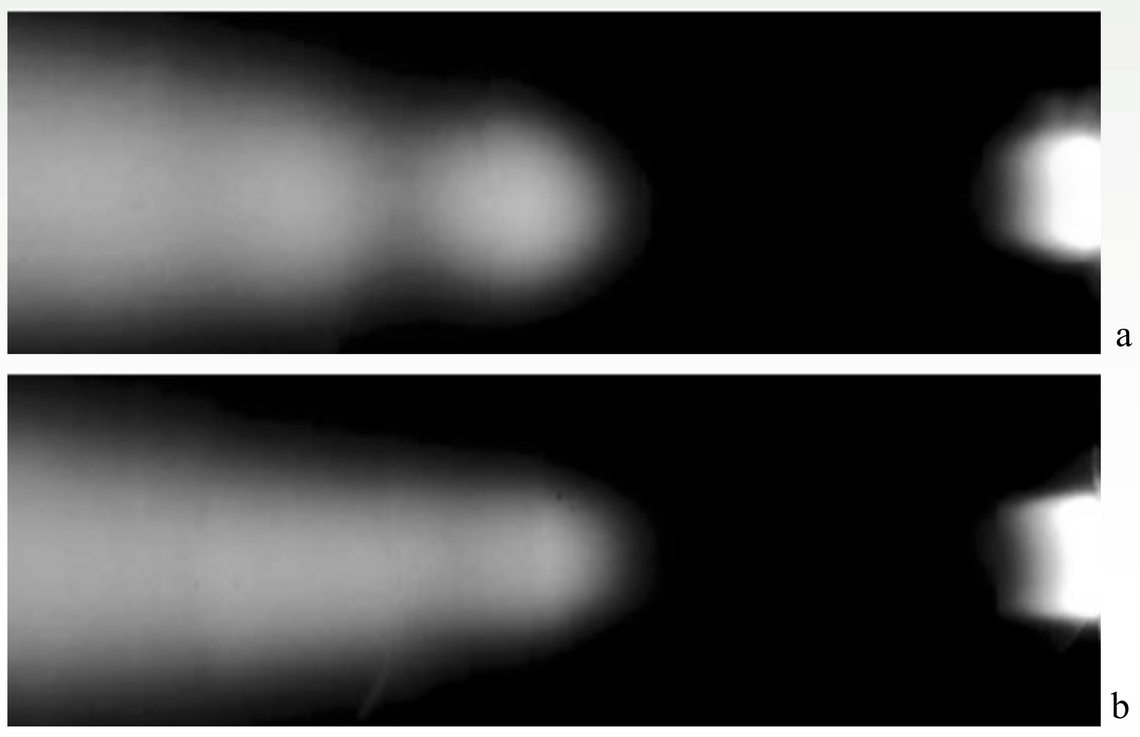

Fig.3. The images of the discharge at 1000 G (a) and 2700 G (b). At the right is the dielectric insert. Conditions: plasmaforming gas is neon, discharge current is 1.5 mA, gas pressure is 0.55 Torr, polydisperse quartz particles with main size 5-6mkm.

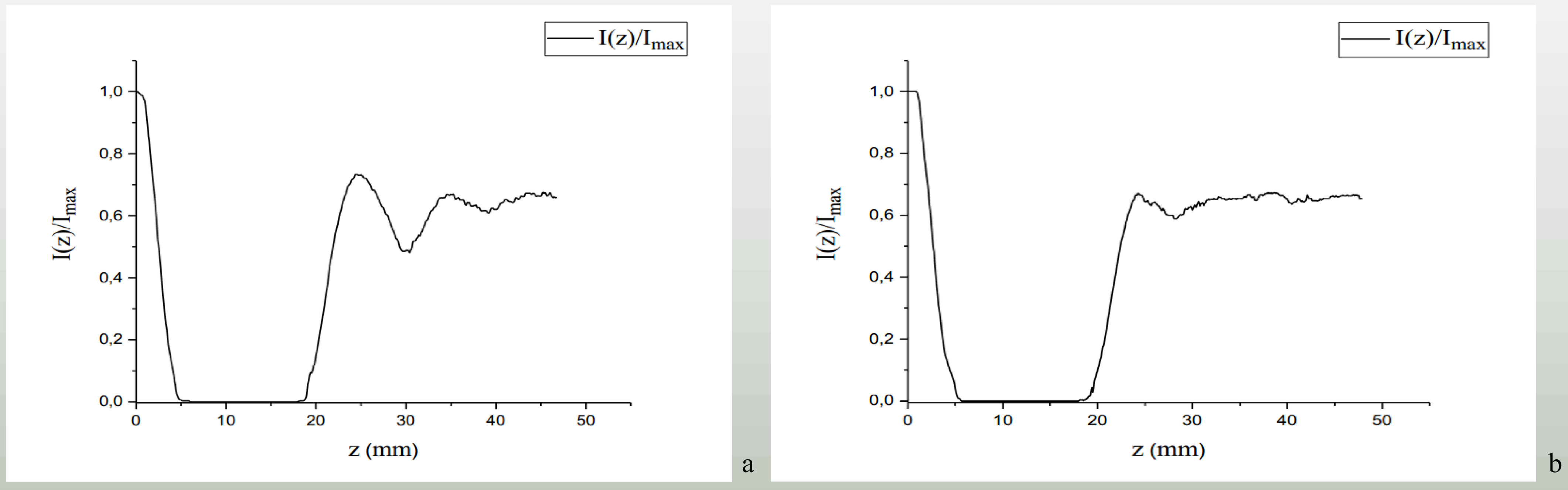

Fig.4. The dependence of the intensity of the glow on the vertical coordinate. The plots correspond to Fig. 3a and b. (a) – 1000 G; (b) – 2700 G.

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CONCLUSIONS

For the first time, the picture of the glow of the standing striation in the discharge of neon in a strong magnetic field of up to 2700 G was observed. Significant alignment of the integral light of the striation along the discharge axis was detected. It has been made the assumption about the reducing the longitudinal gradient of the electron temperature, which is the reason for the decrease in the angular rotation velocity of the dust structure in the striation in the magnetic field of about 1000 G due to the decrease in eddy electron current.

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