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High pressure streamer chamber with holographic detection and small admixtures stabilizing discharge process *

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Electron tracks are detected in helium and hydrogen streamer chambers at pressure of 5 atm. Track images were obtained by the holographic detection method using a pulse dye laser. In the helium streamer chamber the tracks were detected when small regulating admixtures of methane (0.01%–0.09%) were given.

1. Introduction

It is shown in papers [1], [2] that a helium streamer chamber (HSC) may be successfully employed as a detector and a "thin target" simultaneously. The chamber efficiency increases with the increasing gas pressure due to a higher probability of interaction of particles from the accelerator and nuclei of the filling gas. Lasers used for the detection of charged particle tracks in HSC allow a better localization of particle trajectories and higher accuracy in determining the interaction peak [3–8].

As it is shown in paper [8], the use of lasers for detection of charged particle tracks in HSC became possible by adding to helium 0.1–0.9% of methane and up to 1% of water vapour; the pressure of the filling gas varied between 2 and 5 atm.

The purpose of this paper is to find out the optimum conditions for HSC operation at 5 atm pressure with laser detection. The admixtures of methane and

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water vapour varied within 0.01–0.09% and 0.3–0.9‰ respectively. Lower admixtures of methane (down to hundredths of a per cent) improve the purity of the helium chamber-target. The results of these investigations are compared with those obtained in a hydrogen chamber at 5 atm pressure under the same experimental conditions.

2. Equipment

Figure 1 shows a schematic drawing of the experimental set-up. A 90 Sr β-source was used as the electron source. Electrons passed through the streamer chamber and entered the scintillation counter which produced a starting signal. This signal

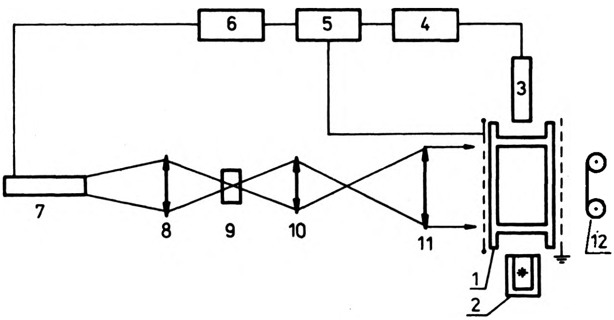

Fig. 1. Block-diagram of the experimental set-up: 1 — streamer chamber, 2 — source of electrons, 3 — scintillation counter, 4 — electron trigger system, 5 — PVG, 6 — delay line, 7 — nitrogen pulse laser, 8 — quartz lens, 9 — bulb with rhodamine 6G, 10, 11 — optical lenses, 12 — film

was applied via the electron triggering system to the input of the pulse voltage generator (PVG). The signal, taken from the PVG second cascade electrode, passed through the delay cable to trigger the nitrogen laser discharge gap. A positive high-voltage pulse from the PVG output was delivered to one electrode of the streamer chamber, the other electrode being earthed. A bulb with rhodamine 6G, used to illuminate the chamber with visible light, received a light pulse ($\lambda = 337.1$ nm) through a quartz lens. The light pulse from rhodamine ($\lambda = 570$ nm), being formed by a parallel telescope, illuminated the fiducial volume of the chamber. Unlike the authors of paper [8] we have used a cylindrical plexiglass streamer chamber of diameter of 70 mm and 10 mm high (inner dimensions). The ends of the cylinder had windows of 10 mm thick plexiglass. The chamber electrodes were made of 100 μm parallel wires spaced by 3 mm from one another.

The shock capacity of the PVG of the standard Arkadyev–Marx type (the PVG consists of seven sections) was 3000 pF. The high-voltage pulse amplitude was about 140 kV. The voltage stability of the PVG's power supply had a 4% dispersion. The delay of the PVG output signal with respect to the starting signal from a photomultiplier was 400 ns.

The laser was triggered by a signal from the PVG second cascade electrode;

the delay time of the signal with respect to the PVG pulse was changed within 125 ns–3.2 μs by means of a cable delay line.

To fill the streamer chamber with helium and admixtures of methane and water vapour we have employed a vacuum system which ensured initial vacuum of about 10^{-2} Torr. To clean the chamber properly, it was evacuated for a long period of time and washed with helium. In the well-cleaned streamer chamber electron tracks could be observed visually and their diffractional images (pictures) detected by means of laser instruments.

3. Experimental results

Shadowgrams of electron tracks were in our experiments obtained in the HSC at helium pressure of 5 atm with methane admixtures within 0.01–0.09%. Shadowgrams of streamers were recorded on a micrat-300 film which was placed on the side opposite to the illumination source at 10 cm distance from the chamber. During the experiment the electric field intensity in the chamber was not less than 40 kV/cm, being thus more than twice higher than in the experiments described in papers [6], [8].

Shadowgrams were made for various methane admixtures and various delay periods of the laser trigger with respect to the PVG break-down (the helium pressure was 5 atm). Figures 2a, b show, as an example, two shadowgrams for 0.02% and 0.05% methane admixtures, respectively.

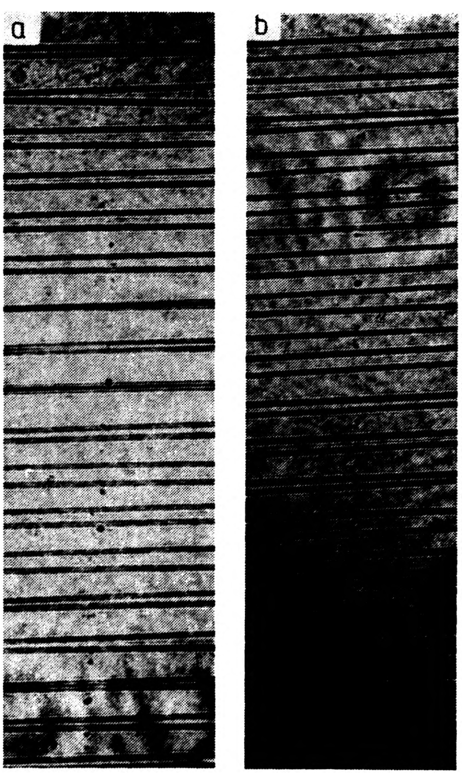

Fig. 2. Shadowgrams of tracks, obtained in the helium streamer chamber at 5 atm pressure, laser pulse delay time being 2.2 μs. **a** – 0.02% methane admixture, **b** – 0.05% methane admixture

We were interested in the dimensions of images of streamers recorded on the film as diffraction pictures. The number of streamers as a function of the diameter of the streamer's image was measured. These distributions for 0.02%, 0.05% and 0.09% methane admixtures are shown in Figs. 3a–c. For all the admixtures, the

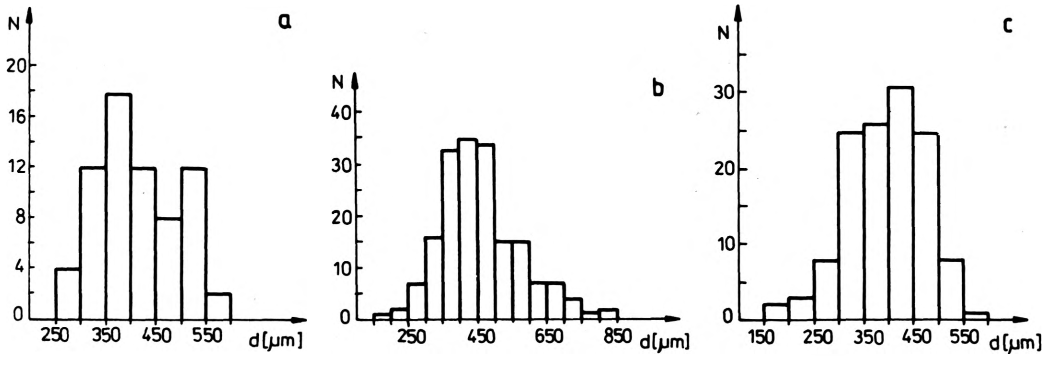

Fig. 3. Distribution of the number of streamers on electron tracks in the helium streamer chamber according to their diameters: **a** – 0.02% methane admixture, **b** – 0.05% methane admixture, **c** – 0.09% methane admixture

average diameter of the central spot of a streamer diffraction image was 400 μm. This value together with the length of illuminating lightwaves and the distance from the film to the centre of the chamber helped us to estimate the real diameter of the streamer.

4. Density of the number of streamers

The results of previous investigations [8], [9] have shown that the density of the number of streamers grows with the increasing laser delay time with respect to the triggering of the PVG. Since the delays ranged within 1–2 μs, we have chosen the laser delay time not less than 2 μs. In this case, in the streamer chamber filled with helium and various methane admixtures and at the pressure of 5 atm, there were 5 streamers per 1 cm of track length. This value, being larger than those obtained in paper [8], can be explained by the higher intensity of the electric field in our streamer chamber.

5. Hydrogen streamer chamber of 5 atm's gas pressure

The experimental set-up described above and the hydrogen-filled chamber were used to obtain electron tracks in hydrogen. The aim of this stage of our experiment was to find out how to observe electron tracks in a helium-chamber and a hydrogen chamber under the same experimental conditions (electric field intensity, laser delay range, gas pressure in the chamber). A high voltage pulse of a

140 kV amplitude was applied to the electrodes of the chamber. Electron tracks were recorded at gas pressures up to 5 atm. Diffraction images of streamers were recorded on the micrat–300 film, the laser delay time with respect to the moment of the PVG being triggered ranged from 0.5 to 3 μs. The images were used to measure central spots. The measurements have shown that the diameters of central spots ranged within a 150–750 μm (full-size scale). Figure 4 shows, as an example, an electron track in the hydrogen streamer chamber at 5 atm pressure.

Fig. 4. Shadowgrams of the track detected in the hydrogen streamer chamber at 5 atm pressure

The observed density of streamers in the hydrogen chamber was 4.5 cm^{-1}. This value is considerably lower than in the primary ionization under the given conditions. It means that the streamer development efficiency of an electron is markedly lower than 100%.

6. Conclusion

It is shown that tracks of charged particles can be successfully detected with lasers in a helium or a hydrogen chamber at 5 atm pressure. The helium chamber requires the admixtures of methane (hundredths of a per cent) and water vapour (tenths of a per cent).

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Стримерные камеры высокого давления с голографической регистрацией и малыми добавками примесей, стабилизирующих разряд

В работе приведены результаты регистрации следов электронов в гелевой и водородной стримерных камерах при давлении рабочего газа 5 атм. Изображения следов получены методом голографической регистрации при использовании импульсного лазера на красителе. В гелевой стримерной камере следы зарегистрованы с использованием малых регулирующих добавок метана в пределах от 0.01 до 0,09%.