NEW METHOD OF REGISTRATION OF IONIZING-PARTICLE TRACKS IN CONDENSED MATTER[1)]

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For a fast and controlled registration of charged-particle tracks in condensed media, it is possible to use the electrons produced by the particle on its path in the medium (so-called "electronic method" of track registration). It is obvious that the working medium of an electronic track detector must be a dielectric, in which free electrons can exist. It is known that in liquefied (and solid) noble gases, free electrons[2)] are produced on the track of ionizing particles. In an external electric field, these electrons move from the region of the track, and consequently can be prevented from recombining with the ions on the track. We have shown in an earlier paper [4] that the free electrons produced on α-particle tracks in liquid xenon can be accelerated in either a constant or a pulsed electric field to energies ∿10 eV, i.e., we have demonstrated the possibility of controlling the particle tracks in liquefied noble gases by the electronic method (see also [3]). However, the detection of tracks of ionizing particles with the aid of an electric discharge localized on the track (in a manner similar to that used in spark and streamer chambers) is difficult in liquefied gases, since the electric fields required to produce the discharge are of higher intensity (about 10^6 V/cm, [3]).

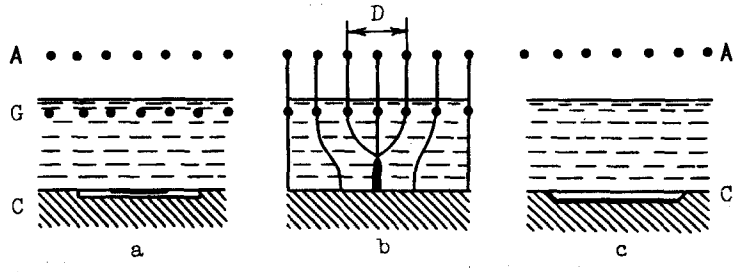

Fig. 1. Experimental setups: a) Three-electrode chamber with α source: A - anode, G - grid, C - cathode. Distance AG - 1 cm, GC - 2 cm, liquid layer over the grid about 0.1 cm. b) The same, but an injector is mounted on the cathode. The force lines of the electric fields, which determine the diameter of the electron emission region from the surface of the liquid, are shown. c) Two-electrode system with α source on the cathode. AC - 1 cm, liquid layer 0.4 cm.

We investigated a principally new method of detecting tracks of ionizing particles in condensed matter (liquid argon), consisting in the following: 1) Owing to the drift of the electrons in the electric field, the "electron image" of the track (i.e., the aggregate of free electrons located in the space along the track of the ionizing particle) is transferred to the liquid-gas interface. 2) In an electric field, the electrons go from the liquid into the gas as a result of electrostatic emission. 3) The electron image of the track is registered in the gas by any known method (for example, we have registered emission electrons with the aid of a spark discharge in the gas).

[1)]Reported at the Conference of Filmless, Spark, and Streamer Chambers, Dubna, April 1969.

[2)]See, e.g., [1]. A review of work on electron conductivity of ionized liquefied noble gases can be found in [2] and [3].

Figure 1 shows the arrangement of chambers with two or three flat electrodes. The anode and the grid are made in the form of a flat system of parallel wires of 0.05 mm diameter, the distance between wires being 0.6 mm. In the three-electrode chamber it was possible to vary independently the electric field intensities in the liquid and in the gas. In experiments performed by schemes a and b in Fig. 1, a photoelectronic multiplier located over the anode registered first the scintillation flash due to the α particle in the liquid argon, and then, after the electrons left the track of the α particle and entered the gas, it registered the gas glow produced when the electrons drifted through the gas in the electric field [5]. The time between the appearance of the scintillation flash in the liquid and the occurrence of the electroluminescence of the gas is determined by the electron drift velocity in the liquid.

The "depth" coordinate of the electron cloud emerging from the liquid (scheme a of Fig. 1) was determined from the drift time with accuracy not worse than 10^{-2} cm (the electrons traversed a path of 2 cm in an electric field of ∿10 kV/cm within a time ∿10 μsec). It follows therefore that the electron diffusion coefficient in liquid argon in fields ≤ 10 kV/cm is of the order of 1 cm^2/sec, i.e., at a liquid-layer depth of approximately 1 m the accuracy with which the coordinates of the track in the liquid is determined from the location and time of appearance of the emission electrons in the gas should be not lower than the accuracy attained in bubble chambers.

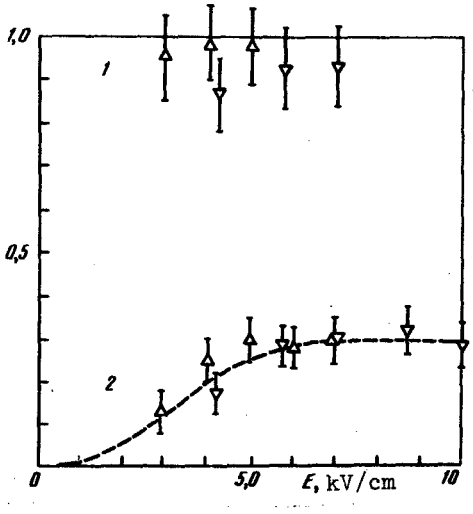

Fig. 2. Probabilities of emission of electrons from liquid argon (curve 1) and of the passage of electrons through a grid in a liquid (curve 2). Δ - field in GC gap 9 kV/cm, V - 11 kV/cm.

For an exact determination of two important parameters, namely the probability of emission of the electron from the liquid into the gas and the probability of the passage through a grid electrode immersed in the liquid, a large number of electrons was injected into the liquid from sharp and thin (diameter 0.1 mm) tungsten needles (scheme b of Fig. 1). The ratio of the injection currents in the grid-anode and the grid-cathode gaps, with the gaps completely filled with liquid, yields the transparency of the grid to the electrons, and the ratio of the same currents when the grid-anode gap is partly filled makes it possible to find the probability of emission of the electron from the liquid into the gas. From the measurement results, which are shown in Fig. 2, we see that the electron emission probability can be close to unity, and the grid transparency coefficient can be close to 30% (in a gas the transparency of the grid to electrons reaches 80% at a pressure of 10 atm.

Figure 3 shows the image of the active region of an source immersed in liquid argon. The emission of electrons from the liquid was effected in a constant electric field of approximately 3 kV/cm, and the discharges in the gas (50% argon, 50% neon) was initiated by a high-voltage pulse generator (pulse duration approximately 100 nsec, amplitude approximately 40 kV).

We have thus shown that the registration method investigated by us, which is based on the emission of electrons from a liquid into a gas, can be used to produce a controlled fast liquid track detector for ionizing particles - a large-volume emission chamber. The most promising method of registering emission electrons in a gas, in our opinion, is to use a multifilament proportional chamber [6], which ensures rapid, automatic and filmless acquisition of information concerning the track.

It is obvious that an analogous method can be used to register, in condensed media, the electron image of any type of ionizing radiation (e.g., x rays) and to convert the electron image into an optical one (see Fig. 3).

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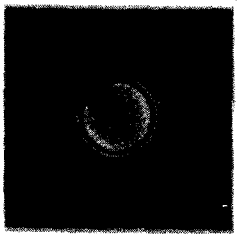

Fig. 3. Image of active surface of α source immersed in liquid argon. Active-region diameter 35 mm, liquid layer 0.4 cm. The bright ring around the active region is due to the reflection of the light of the sparks from the rounded part of the polished electrode (Fig. 1c).

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GASDYNAMIC CO_2 LASER WITH ESCAPE OF THE SHOCK-TUBE HEATED WORKING MIXTURE THROUGH A SLIT

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We measured and observed generation in the 10 μ region on the vibrational transitions of CO_2, during the course of escape of a heated gas mixture through a slit into vacuum (the escape was accompanied by rapid cooling).

The suggestion that gnneration can be attained by adiabatic expansion of a mixture of CO_2 and N_2 gases was formulated in the invention disclosure [1] and in [2]. The general idea of the possibility of obtaining inverted population between energy levels with different relaxation times following an abrupt change of the system temperature was advanced in [3]. Calculation of the inversion produced when nitrogen with carbon dioxide is cooled were made for the general case and for the case of a Laval nozzle in [2, 4, 5], and for the case of escape through a slit in vacuum in [6]. Experimental investigations of the problem were initiated in [7], where escape through a slit was used. Cooling of CO_2 and mixtures based on it by the substance in which inversion is obtained was investigated by the rarefaction-wave method in [8, 9] and by the method of expansion through a slit in [10], where promising results were obtained. Lasing on CO_2 molecules was recently obtained [11] with the aid of a nozzle, using a ternary mixture (He, N_2, CO_2).

In the present investigation, amplification and generation of laser radiation by CO_2 molecules were observed with the gas expanded through a slit. In this case [6], the rates of cooling are larger than those obtained with a nozzle. Just as in [11], we used a ternary mixture (73% He, 18% CO_2, 9% N_2). The mixture was heated to 1800 ± 200°K (and a pressure of 25 atm) in a shock tube behind a reflected shock wave (SW). The shock tube (see Fig. 1), with