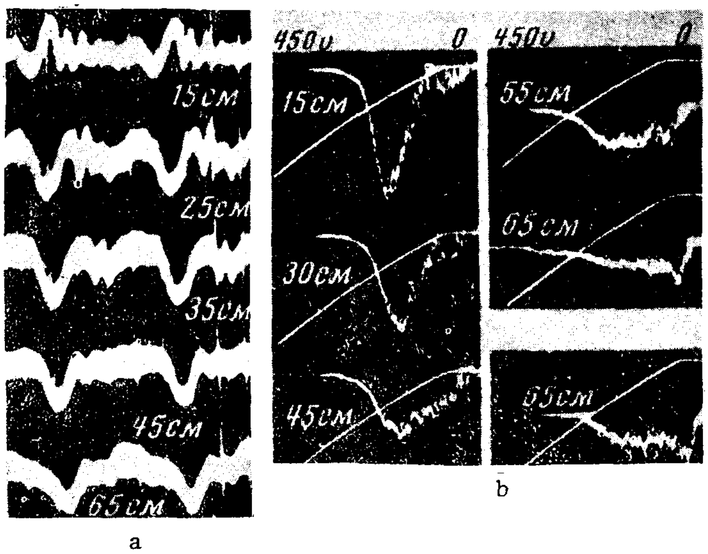


Fig. 2. Evolution of the wave profile (a) and of the energy distribution of electrons (b).

maximum near 120 MHz. The profile of these oscillations is shown in the upper oscillogram (Fig. 2a). During each modulation period (10^{-7} sec), a negative pulse is clearly seen against the background of the oscillations. The oscillations vanish in the course of propagation, and the narrow packet takes the form of a soliton wave. The vanishing of the oscillations is due to the interaction between the harmonics and to a redistribution of the energy over the spectrum, processes that lead to soliton formation. As to the evolution of the energy distribution function f(E), which is shown in Fig. 2, we see that the beam smears out rapidly in the low-energy direction, and a tail of accelerated particles appears in the distribution at the end of the system. For comparison, the last figure shows f(E) obtained when usual two-stream instability develops without beam modulation; in this case there is no high-energy tail.

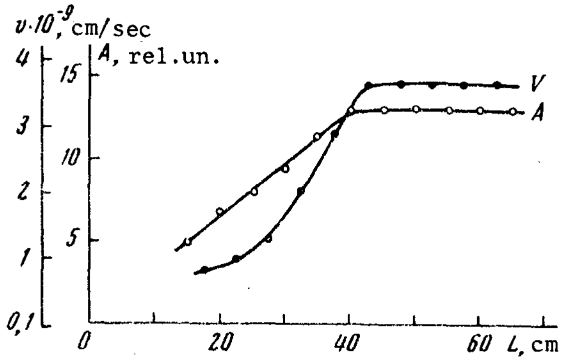


Fig. 3. Amplitude and velocity of solitary wave vs. distance.

As the soliton develops, its amplitude and velocity change (Fig. 3). We see that the velocity increases with increasing amplitude, in agreement with the known solution of the KdV equation. Over a certain length (40 cm) the amplitude and velocity increase, and then remain constant. The maximum velocity of the solitary wave is 4 – 5 times larger than the initial wave velocity.

The results show that a mechanism for the excitation of solitary Langmuir wave exists in a beam-plasma beam. The principal role in this mechanism is played by the beam-plasma instability.

[1] B. N. Rutkevich, A. V. Pashchenko, V. D. Fedorchenko, and V. I. Muratov, Zh. Tekh. Fiz. 42, 493 (1972) [Sov. Phys.-Tech. Phys. 17, 391 (1972)].
[2] H. Ikezi, P. J. Barrett, R. W. White, and A. I. Wong, Phys. Fluids 14, 1997 (1971).
[3] S. M. Krivoruchko, Ya. B. Fainberg, V. D. Shapiro, and V. I. Shevchenko, ZhETF Pis. Red. 17, 344 (1973) [JETP Lett. 17, 244 (1973)].
[4] G. S. Gardner, J. M. Green, M. D. Kruskal, and R. M. Miura, Phys. Rev. Lett. 19, 1095 (1967).

ELECTRON-ION RECOMBINATION IN AN ELECTRIC FIELD

V. S. Shepel'

Submitted 30 July 1973
ZhETF Pis. Red. 18, No. 8, 480 – 483 (20 October 1973)

The influence of an external electric field on the electron-ion recombination in gases was investigated experimentally. It was observed that the recombination coefficient of electropositive gases (He, N_2) depends on the field intensity.

In the study of phenomena connected with electron-ion recombination in gases it is usually assumed that at fixed values of the temperature and gas pressure the recombination coefficient is constant and does not depend on the external electric field.

The direct experimental study of this question is made difficult by the fact that the known methods of investigating recombination in gases reduce in essence to measurement of the rate at which the charged-particle density decreases in a decaying plasma of a weakly-ionized gas under the condition that the charged-particle density is governed entirely be recombination processes [1, 2]. Since application of an external electric field causes currents to flow in the plasma, these methods are not suitable for the study of the dependence of the recombination coefficient on the field intensity.

We have used a method by which the possible influence of the electric field on the electron-recombination coefficient in gases can be observed. It is known that the current in an ionization chamber operating close to saturation can be represented as a certain function of the dimensionless parameter $\alpha Q d^2/K_1 K_2 E^2$ [3 - 5]. Here α is the recombination coefficient, Q is the ionization density and is proportional to the intensity of the external radiation, K_1 and K_2 are the mobilities of the positive and negative carriers, d is the "effective" value of the inter-electrode gap and is determined by the geometry of the chamber electrodes, and E is the electric field intensity in the working volume of the chamber. The influence of diffusion and of the space charge near saturation can be neglected [6]. At a fixed chamber geometry, all the states characterized by different values of Q and E but corresponding to the same degree of saturation are similar to each other and are connected by the relation

$$\frac{\alpha Q d^2}{K_1 K_2 E^2} = \text{const} , \qquad (1)$$

which is equivalent to the relation $Q \sim E^2$ if α, K_1, and K_2 are constant. The assumption that the electron mobility is constant is valid only in sufficiently weak fields, when the electron drift velocity is much smaller than their thermal velocity. In this case any deviation from the $Q \sim E^2$ relation is evidence of the dependence of the coefficient of electron-ion recombination on the field intensity.

The experiment was performed with an ionization chamber having plane-parallel electrodes (d = 2.6 mm) and placed in a homogeneous beam of Co^{60} γ radiation. We compared the values of Q and E for states characterized by a degree of saturation ε = 90%. The value of Q can be identified, apart from a constant factor, with the chamber saturation current. The figure shows the experimental A = f(E) curves obtained for He at a pressure P = 13 atm (curve 1) and for N_2 at P = 4 atm (curve 2).

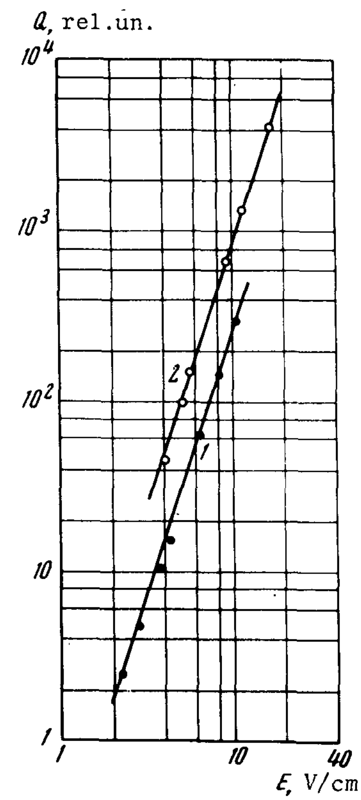
As seen from the figure, the experimental data can be described by a relation of the type

$$Q \sim E^n , \qquad (2)$$

where n = 3.2 ± 0.3 for He and n = 3.1 ± 0.3 for N_2. During the course of the experiments, the ratio E/p did not exceed 6×10^{-3} V/cm - mm Hg, and the current density did not exceed 5×10^{-11} A/cm^2. The data of [2, 7] show that the electron drift velocity in the investigated gases and in the investigated range of variation E/p is directly proportional to the field intensity, and the electron temperature differs little from the neutral-gas temperature. Consequently, the assumption that the temperature and electron mobility of the electrons are constant is valid.

A comparison of formulas (1) and (2) for the dependence of the recombination coefficient on the field intensity yields the expression $\alpha \sim 1/E\gamma$, where $\gamma \simeq 1$ for He and N_2.

The observed phenomenon can be explained theoretically by starting from the theory of dissociative recombination [8], since at pressures above several dozen mm Hg the predominent type of electron-ion recombination is dissociative recombination [2, 9].



Plot of Q = f(E) at ε = 90%.

Collision of an electron with a positive molecular ion produces a neutral molecule in a highly-excited Rydberg state; this molecule decays either by auto-ionization or by dissociation into neutral atoms. In an electric field, the rate of decay with formation of a free electron increases, and the rate of the competing dissociative-decay process decreases correspondingly. This picture agrees qualitatively with the arguments advanced in [10] in a description of predissociation in an electric field.

The author thanks A. B. Dmitriev for a useful discussion of the work.

[1] L. B. Loeb, Basic Processes of Gaseous Electronics, Univ. of California, 1955, Chap. IV.
[2] E. W. McDaniel, Collision Phenomena in Ionized Gases, Wiley, 1964.
[3] I. W. Boag and T. Wilson, Brit. J. Appl. Phys. 3, 222 (1952).
[4] N. I. Shteinbock, Zh. Eksp. Teor. Fiz. 27, 615 (1954).
[5] V. S. Polikanov, Zh. Tekh. Fiz. 38, No. 12 (1968) [Sov. Phys.-Tech. Phys. 13, No. 12 (1969)].
[6] E. M. Vol'f and V. S. Polikanov, ibid. 39, 143 (1969) [14, 99 (1969)].
[7] R. W. Warren and J. H. Parker, Phys. Rev. 128, 2661 (1962).
[8] J. N. Bardsley, J. Phys. (Proc. Phys. Soc.) B1, 365 (1968).
[9] J. A. Wayne and J. B. Gerardo, Phys. Rev. Lett. 28, 1096 (1972).
[10] F. J. Cames and U. Wenning, Chem. Phys. Lett. 5, 195 (1970).

ASYMMETRY OF THE CROSS SECTION OF THE REACTION $\gamma d \to \pi^0 d$ AT A PHOTON ENERGY 350 MeV

V. B. Ganenko, V. B. Gorbenko, Yu. V. Zhebrovskii, L. Ya. Kolesnikov, I. I. Miroshnichenko, S. I. Naisteter, A. L. Rubashkin, V. M. Sanin, and P. V. Sorokin
Physico-technical Institute, Ukrainian Academy of Sciences
Submitted 20 August 1973
ZhETF Pis. Red. 18, No. 8, 483 — 486 (20 October 1973)

Investigation of the coherent photoproduction of π^0 mesons on deuterium yields valuable information both on the deuteron structure and on the isotropic structure of the pion photoproduction amplitudes on nucleons.

Only a limited number of studies have been made of the differential cross sections of the reaction $\gamma d \to \pi^0 d$ in the region of the first πN resonance [1 - 3]. Data on the cross-section asymmetry due to polarized photons in this reaction are practically nonexistent [4, 5].

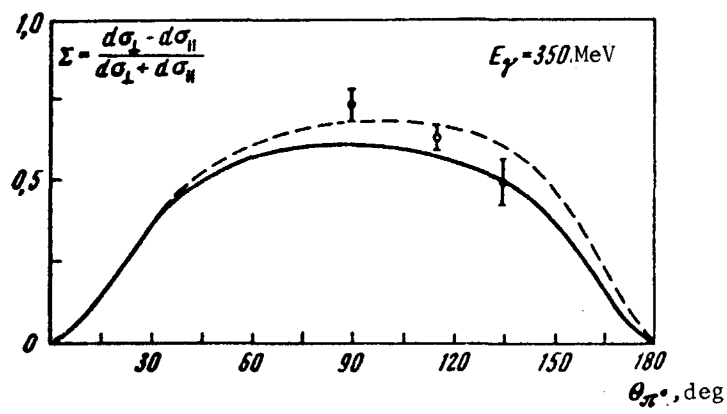


Fig. 1. Angular distribution of the asymmetry of the cross section of the reaction $\gamma d \to \pi^0 d$ at photon energy 350 MeV: • — our data, o — data of [4]. Dashed line — calculation on the basis of the BDW analysis [12] with allowance for the S wave; solid — with allowance for S + D waves.

The study of the asymmetry of the cross section of the reaction $\gamma d \to \pi^0 d$ reaction with polarized photons is of particular interest, since it does not depend on the form factor of the deuteron and on the interaction in the final state, and can yield additional information for a multipole analysis of pion photoproduction on individual nucleons.

We report here, for the first time, results of the measurement of the asymmetry of the cross section of the reaction $\gamma d \to \pi^0 d$ by polarized photons of energy 350 MeV, in which the pion is emitted in c.m.s. angles 90 and 135°, and results of a calculation of the angular distributions of the cross-section asymmetry in the photon energy range 180 — 800 MeV, in the S and S + D wave approximation.

The experiment was performed with a beam of linearly-polarized photons [6] obtained from coherent bremsstrahlung of electrons in a diamond single crystal.