Substance	Concentration, at%	ΔN exper.	ΔNtheor.	$\Sigma N m$	$n(l)$	R
Bi	0	$6{,}75 \cdot 10$	0	$2{,}1 \cdot 10^{-11}$	2,3	0,024
Bi – Te	0.0006	$5{,}3.\ 10^{16}$	$1 \cdot 10^{17}$	$2{,}25 \cdot 10^{-11}$	5.1	0,013
Bi – Te	0.0012	$1{,}05 \cdot 10^{17}$	$2 \cdot 10^{17}$	$2{,}9 \cdot 10^{-11}$	4.8	0,027
Bi – Sb	0.5	$1{,}38 \cdot 10^{16}$	0	$1{,}7 \cdot 10^{-11}$	2.5	0,055

A comparison of the microwave power passing through the samples of pure and alloyed Bi shows that the attenuation increases with increasing alloy content. The same is evidenced also by the fact that with increasing alloying the distinctly resolved interference pattern shifts into the region of stronger fields (see the figure). At the same time, the depth of modulation on the Shubnikov - de Haas (SH) effect curves plotted by us is practically independent of the degree of alloying. Thus, the alloying exerts an influence on the damping of the microwave oscillations, without causing a decrease in the amplitude of the SH effect. This contradiction can be resolved by assuming that alloying gives rise in Bi to a new type of carriers, and the mobility of these carriers is small. The presence of such carriers requires that an additional conduction band be present somewhat above the Fermi level (higher by several millielectron volts), or else a valley of the band L, or else an impurity level [3]. Although the presence of such band-structure elements does not agree with the usually accepted scheme [4], their presence is also favored by a certain increase of the quantity $\Sigma N m$ with increasing alloying, and also the fact that the microwaves have a small degree of damping in the alloy Bi - Sb 0.5 at.%, in which the Fermi level is lower than in pure Bi.

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DIRECT PROOF OF THE EXISTENCE OF AN EXCITED NEGATIVE C^- ION AND THE DETERMINATION OF THE BINDING ENERGY OF THE ELECTRON IN IT

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The question of the possible existence of excited negative ions is of considerable interest both from the point of view of the theory (verification of approximate method of calculating the binding energy) and from the practical point of view (physics of gas discharge and of low-temperature plasma, astrophysics).

For a number of negative ions (mainly elements of groups III and IV of the periodic system), the theory admits of the possible existence of metastable excited states with the same electron configuration as the ground state of the ion [1]. However, indirect experimental confirmation of the existence of an excited state, presumably $1s^2 2s^2 2p^3\ ^2D$, was obtained only for the ion C^- [2 - 4]. Theoretical investigations reported in [5 - 7] likewise do not offer reliable proof of the existence of a bound excited state ^2D of this ion. If the excited state ^2D of the C^- ion exists, then it should have a very low binding energy and can be readily destroyed by an electric field. In this connection, we have undertaken to observe by means of a direct experiment the excited C^- ion, using a procedure developed by us earlier for the investigation of the He^- ion [8].

The measurements were made with a setup described in our papers [9, 10]. A beam of C^- ions was obtained by charge exchange of C^+ ions of 100-keV energy in a chamber filled with air; the beam was then passed through a region with a constant electric field $E \leq 400$ kV/cm. We measured the ratio of the current I of the beam of C^- ions passing through the field E, to the current I_0 at $E = 0$.

The experimentally measured plot of $I/I_0 = f(E)$ for the C^- ions is shown in Fig. 1. The same figure shows the analogous plot for a beam of O^- ions, obtained under the same conditions. The constancy of the ratio $I/I_0 = 1$ (accurate to 1%) for the O^- ions in the entire interval of fields E from zero to 380 kV/cm demonstrates both that they are not destroyed by the electric field and that the beam is not attenuated by defocusing by the field. For C^- ions in the region $E = 60 - 200$ kV/cm, a decrease of the ratio I/I_0 from 1 to 0.32 is observed. We attribute this decrease of I/I_0 to destruction of the weakly-bound excited state ^2D by the field, since the ground state ^4S of the C^- ion has a binding energy 1.27 eV [2, 11] and should be destroyed at fields much larger than those considered here [12]. The excited state of the ion C^- has a multiplicity differing from that of the ground state, and is therefore metastable with a lifetime exceeding 10^{-5} sec [3]; this is much larger than the time of flight of the ions from the place of their production to the place of registration ($\sim$2 μsec). It can therefore be assumed that the constant value $I/I_0 = 0.32$ at $E > 200$ kV/cm is the fraction of the ions C^- in the ground state, which are produced in the charge exchange. Therefore the fraction of the ions in the excited state is unexpectedly large and equal to 0.68. It is interesting that the indicated fractions are close to the statistical population of the states ^4S and ^2D, 0.285 and 0.715, respectively.

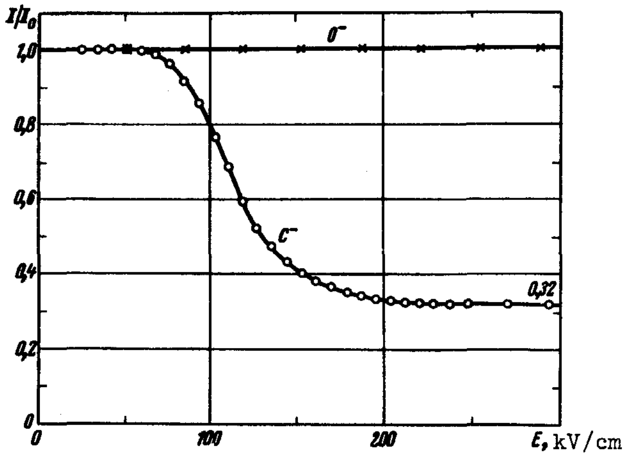

Fig. 1. Decay of negative C^- ion in the excited state ^2D in an electric field. The charge-exchange target thickness is $p\ell = 5 \times 10^{-3}$ Torr-cm.

Measurements were made of the dependence of the fraction of the excited ions F on the target thickness $p\ell$ (where p is the pressure in the charge-exchange chamber, ℓ is the length of the chamber) and the energy of the C^+ ions. These measurements gave a monotonic decrease of F from 0.72 at $p\ell = 2 \times 10^{-4}$ Torr-cm to 0.36 at $p\ell = 5 \times 10^{-2}$ Torr-cm; this decrease can be attributed to the influence of multiple collisions that lead to destruction of the excited ions.

The experimentally measured $I(E)/I_0$ dependence can be expressed in the following form:

$$\frac{i(E)}{i_0} = \frac{1}{F}\left\{\frac{I(E)}{I_0} + F - 1\right\}. \qquad (1)$$

Relation (1) characterizes the relative destruction of only the excited ions by the field. It makes it possible to find the average decay probability W_{av} of the C^- ion in the field E:

$$\frac{i(E)}{i_0} = \exp[-W_{av}(E)t], \tag{2}$$

where $t = 3 \times 10^{-10}$ sec is the time of flight of the ion through the field region.

It follows from [13] that the probability of the decay of the orbital ion in the field is determined by the expression

$$W = \frac{\alpha}{\epsilon} E \exp\left(-6.83 \cdot 10^7 \frac{\epsilon^{3/2}}{E}\right), \tag{3}$$

where ε is the binding energy of the electron in eV, E is in V/cm, W is in $\sec^{-1}$, and α is a constant that depends on the state of the ion.

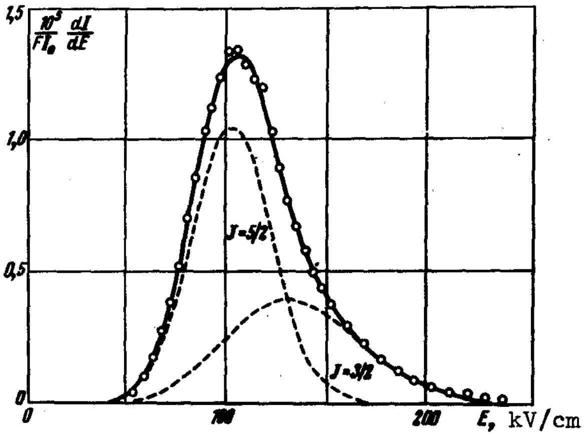

Fig. 2. Electric spectrum of negative ion C^- in the excited state ^2D. Circles - experiment. Dashed - calculated line contours for the state $^2D_{5/2}$ and $^2D_{3/2}$; solid curve - their sum. The thickness of the charge-exchange target is $p\ell = 5 \times 10^{-3}$ Torr/cm.

Formulas (2) and (3) make it possible, on the basis of the experimentally obtained relation (1), to calculate the binding energy ε of the electron in the excited C^- ion. However, the accuracy with which the binding energy is determined by such a method depends on the composition of the beam of the excited ions, namely, on whether it contains ions of one state or ions of several substates (fine-structure or Stark components), which have different probabilities of decay in the field.

More detailed information on the composition of the beam and its destruction in the field can be obtained by plotting the "electric spectrum" of the ions (Fig. 2), which constitutes the differential relation [10]:

$$\frac{1}{FI_0}\frac{dI}{dE} = f(E). \tag{4}$$

A relation similar to (4) can be obtained also by calculation, namely by differentiating (2) with respect to E. Thus, evidence of a correct description of the composition of the negative-ion beam and of the correct determination of the binding energy ε is agreement between the forms of the experimental ion spectrum and the calculated one. Using the expression for the average probability (2), we were unable to obtain this agreement. Nor could the results be reconciled with the interpretation wherein the ^2D level of the C^- ion is split in the field in accordance with m (the projection of the orbital angular momentum of the weakly-bound electron on the field direction), an interpretation advanced by us for the He^- ion [8].

We then assumed that the excited state of the C^- ion in the electric field splits into two components, $^2D_{5/2}$ and $^2D_{3/2}$, with different values of the total angular momentum J. In the absence of a field, these components can be regarded as degenerate, since the constant of the fine splitting for the level $2p^3\ ^2D$ is negligibly small [14]. Under such an assumption, expression (2) should be written in the following manner

$$\frac{i(E)}{i_0} = g \exp[-W_1(E)t] + (1 - g) \exp[-W_2(E)t], \qquad (5)$$

where g is the fraction of the ions in the state with J = 5/2 relative to the total number of excited ions; W_1 is the probability of their decay; (1 - g) and W_2 are respectively the fraction and probability of decay of the ions in the state with J = 3/2. The electric spectrum should consist in this case of two lines corresponding to the states $^2D_{5/2}$ and $^2D_{3/2}$, which may also not be resolved. Assuming splitting in accordance with J, we processed separately the measured relations (1) and (4). For the probability of decay in the field, we used for both states expressions (3) with different α and ε. The reduction yielded the same value of the binding energy (accurate to 2%) for the states $^2D_{5/2}$ and $^2D_{3/2}$, namely ε = 0.035 eV, and yielded values 1.12×10^5 and 2.8×10^4 for the coefficient α in formula (3) in the case of $^2D_{5/2}$ and $^2D_{3/2}$, respectively. We also determined the fractions of the states g = 0.6 and (1 - g) = 0.4, which agree exactly with their statistical weights.

Figure 2 shows the line contours of the individual states $^2D_{5/2}$ and $^2D_{3/2}$, calculated from formulas (5) and (3), as well as their summary curve, which describes well the experimental spectrum.

Thus, according to our data, the binding energy of the excited C^- ion in the state ^2D is (0.035 ± 0.0002) eV.

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MEASUREMENT OF THE ANGULAR CORRELATION BETWEEN THE NEUTRON SPIN AND THE ELECTRON MOMENTUM IN THE DECAY OF POLARIZED NEUTRONS

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Precision measurement of the coefficient of angular correlations in β decay of the neutron is of great importance for the explanation of the form of weak interactions.