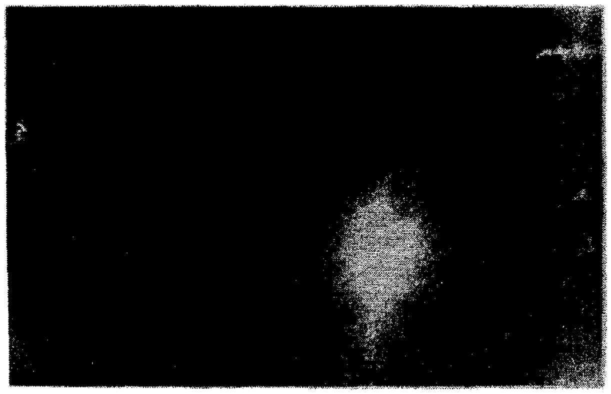

Fig. 2. Picture observed when the vector-synchronism conditions are satisfied.

incidence of the laser radiation on the metanitroaniline crystal is probably due to the presence of scattering in the crystal. No vector synchronism is observed when a plate cut perpendicular to the cleavage plane (parallel to the (001) plane of the crystal) is irradiated. When the laser radiation is focused on the crystal with a short-focus lens, the intensity of of the second-harmonic cone increases sharply, as does also its width. In this case, obviously, the number of combinations of wave vectors satisfying the vector-sychronism condition increases. The cone connected with the vector synchronism remains practically unchanged following small (up to 30°) rotations of the crystal about the x or z axis, and this is probably connected with the relatively small change of the birefringence following such rotations. The vector-synchronism angle changes very little also when the temperature of the crystal is varied from 77 to 350°K. We did not attempt to observe collinear synchronism, since the metanitroaniline crystals are easily split when the plates are cut in directions not coinciding with the cleavage plane.

Obvervations of vector synchronism were quite recently made in [7] with uniaxial ADP crystal. The experiments described by us indicate that metanitroaniline crystals are a much more convenient object for the investigation of vector synchronism.

[1] B.L. Davydov, L.D. Derkacheva, V.V. Dunina, M.E. Zhabotinskii, V.F. Zolin, L.G. Kreneva, and M.A. Samokhina, ZhETF Pis. Red. 12, 24 (1970) [JETP Lett. 12, 16 (1970)].

[2] B.L. Davydov, L.D. Derkacheva, V.V. Dunina, M.E. Zhabotinskii, V.F. Zolin, L.G. Loreneva, and M.A. Samokhina, Opt. Spektr. 30, 503 (1971).

[3] K. Hermann, Burak. Z.f. Kristallograph. A67, 189 (1928).

[4] A.N. Winchell, The Optical Properties of Organic Compounds, New York, 1954, p. 147.

[5] M.V. Hobden, J. Appl. Phys. 38, 4365 (1967).

[6] J. Warner, Opt. Electronics 1, 25 (1969).

[7] G.V. Krivoshchekov, V.I. Stroganov, V.M. Tarasov, V.I. Samarin, and V.A. Ryabinets, Izv. Vuzov Fizika, No. 12, 120 (1970).

PENNING IONIZATION IN COLLISION OF FAST UNEXCITED Rb ATOMS WITH Ar ATOMS

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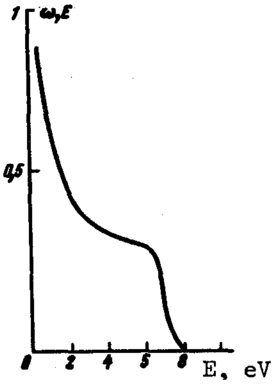
In a study of the energy spectrum of electrons emitted following single collisions of Rb atoms with Ar atoms, performed by a previously described procedure [1, 2], we observed that at an energy $T = 200$ eV in the laboratory system (relative approach velocity $v \sim 2 \times 10^6$ cm/sec) the spectrum contains, besides the group of slow electrons, also a clearly pronounced group with energy of approximately 7 eV. As seen from the figure, which shows the integral spectrum of the electrons

$$\omega = \int_E^\infty \rho(\epsilon)\, d\epsilon$$

the contribution of the indicated group to the total number of electrons is approximately 30% at this energy T.



Integral spectrum of electrons emitted in collisions of fast Rb atoms with Ar atoms, T = 200 eV.

The appearance of the indicated group cannot be attributed to excitation of the lowest-order states of the Rb atoms ($(4p)^5 5s\,^2P_{3/2}$, energy of emitted electrons E = 11.1 eV) and Ar ($3s3p^6 4s$, E = 9.4 eV).

One can attempt to explain the appearance of this group of electrons by assuming that as the Rb and Ar come close together a certain "effective level" is excited in the quasimolecule made up of these particles, at the expense of the kinetic energy of their relative motion; this level corresponds to the configuration $3p^5 4s$ of the isolated Ar atom, with an excitation energy on the order of $U_{exc} \simeq 11.5 - 11.7$ eV. Its excitation energy can be transferred in the same collision act to the Rb atom, and this causes the latter to become ionized and to emit a free electron with energy $E = U_{exc} - U_I \cong 7.3 - 7.5$ eV, which agrees with the energy of the electrons in the discrete group observed by us (U_I is the ionization potential of the Rb atom).

Favoring the "effective-level" hypothesis are the following: It is known that the excitation energy of the lowest lying levels of the isolated Ar atom, corresponding to the electron configuration $3s^2 3p^5 4s$, are close to one another and amount to 11.49, 11.57, 11.66, and 11.77 eV for ${}^3P_2^0$, ${}^3P_1^0$, ${}^3P_0^0$, and ${}^1P_1^0$, respectively [3, 4]. When the colliding particles come very close together the energy levels are perturbed. In addition, the "collision time" τ of the Rb and Ar atoms at $v \sim 2 \times 10^6$ cm/sec is $\lesssim 10^{-14} - 10^{-15}$ sec, which is much less than the time of relaxation of the metastable states ${}^3P_2^0$ and ${}^3P_0^0$ and de-excitation of the ${}^3P_1^0$ and ${}^1P_1^0$ states.

The process explained by the indicated hypothesis, while a unique analog of the Penning-ionization process in collisions of the second kind with participation of metastable atoms, differs from the latter in that it occurs in a single collision act, and that its short duration makes it possible for quasimolecule terms corresponding not only to metastable but also to ordinary excited states of the inert-gas atoms to take part in it.

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[1] V.I. Ogurtsov and Yu.F. Bydin, ZhETF Pis. Red. 10, 134 (1969) [JETP Lett. 10, 85 (1969)].

[2] V.I. Ogurtsov and Yu.F. Bydin, Zh. Eksp. Teor. Fiz. 57, 1908 (1969) [Sov. Phys.-JETP 30, 1032 (1970)].

[3] S.E. Frish, Opticheskie spektry atomov (Optical Spectra of Atoms), M., 1963, p. 262.

[4] Ch. Moore, Atomic Energy Levels, Circular of National Bureau of Standards, USA, 1949.

DETERMINATION OF THE RADIUS OF STRONG INTERACTION OF Pb AND THE MEAN FREE PATH OF THE π^0 MESON IN NUCLEAR MATTER

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It was shown in [1 - 3] that the main contributions to the photoproduction of π^0 mesons on nuclei at high energies and small meson-emission angles are made by Coulomb production and coherent production. The absence of interference between these processes makes it possible to separate the coherent production from the Coulomb production and to write down the cross section for coherent production of π^0 mesons in the form

$$d\sigma/d\Omega = CA^2|F(q)|^2\sin^2\theta\,, \tag{1}$$

where A is the mass number of the target nucleus, $F(\vec{q})$ is the form factor of the nucleus, θ is the angle of emission of the π^0 meson, and $C\sin^2\theta$ is the square of the amplitude of production of the π^0 meson on the nucleon and is independent of the spin and isospin.

We analyze in this paper the results of our investigations of the photoproduction of π^0 meson on the lead nucleus at a primary-photon energy 1.1 GeV [4], in order to obtain the parameters of the nucleon distribution in the nucleus and to determine the mean free path of the π^0 meson in nuclear matter.

We have compared the experimentally measured cross sections with the results of calculations by formula (1). The form factor $F(\vec{q})$ was calculated by the method developed in [1], with allowance for the interaction of the π^0 mesons in the final state with the nucleus. The density distribution functions of the nucleons in the nucleus were chosen in accord with the uniform model and the Woods-Saxon model. The uniform model is characterized by a radius R and the Woods-Saxon model is described by a radius R and a parameter a = 0.545 F. The free path λ of the π^0 meson in the nucleus and the value of R were determined by minimizing the sum

$$\sum_{i=1}^{13} \frac{d\sigma_i/d\Omega - d\sigma_i^T/d\Omega}{\sigma_i^2}\,, \tag{2}$$

where $d\sigma_i/d\Omega$ is the experimentally obtained differential cross section, $d\sigma_i^T/d\Omega$ is the theoretical cross section, and σ_i is the measurement error.

Table 1

Nucleon distribution model	R, F	λ, F	χ^2	Degrees of freedom	$P(\chi^2)$
Uniform	$7.10^{+0{,}10}_{-0{,}08}$	$3.10^{+0{,}11}_{-0{,}13}$	1,11	11	~1
Woods-Saxon	$7.45^{+0{,}12}_{-0{,}10}$	$4.92^{+0{,}12}_{-0{,}14}$	0,99	11	~1