a pulsed generator with high degree of collimation and monochromaticity of the beam.

In conclusion we note that the operating position of the prism in the cavity depends to some degree on its temperature conditions. However, at a constant pulse repetition frequency this circumstance introduces practically no complication in the laser operation. To be sure, at the prism position corresponding to mode selection one observes an appreciable rise in threshold pump (by a factor 3 - 4) for the first lasing pulse, but after the next two or three pulses the threshold pumping drops to the statinary level.

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[1] A. G. Fox and T. Li, Bell System Tech. J. 40, 453 (1961).
[2] S. A. Collins and G. R. White, Appl. Optics 35, 3446 (1964).
[3] J. A. Giordmaine and W. Kaiser, J. Appl. Phys. 2, 448 (1963).
[4] V. I. Talanov, Izv. Vuzov, Radiofizika 10, No. 2, 1967 (in press).

* The possibility of combined mode selection using simultaneous spatial and angular limitation is considered in [4].

## CORRELATION OF FINAL CHARGE STATES OF PARTICLES IN DISCRETE ENERGY LOSSES IN ATOMIC COLLISIONS

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To explain the discrete energy losses in atomic collisions [1,2], models based on the concepts of single-electron [3] and collective [4,5] excitation have been proposed. Since none of these interpretations can as yet be regarded as unique, it is necessary to obtain additional experimental data on the singularites of inelastic atomic collisions.

Fano and Lichten [3] propose that for $Ar^+ + Ar$ collisions the excess-inelastic-loss line $R_I^*$ (53 eV) corresponds to removal of M-electrons, while the lines $R_{II}^*$ (263 eV) and $R_{III}^*$ (475 eV) are connected with formation of L-vacancies in one or both colliding particles, respectively, accompanied by Auger transitions after the scattering. If this is the scheme of the process, then an identical correlation should appear for the final charge states of the particles upon excitation of the lines $R_I^*$ and $R_{III}^*$, whereas excitation of the $R_{II}^*$ line is connected with introduction of additional inverse correlation. Of considerable interest to the interpretation of the discrete-loss mechanism is therefore an analysis of the correlation of the final charge states upon excitation of each of the discrete-loss lines.

The correlation of the final charge states was investigated for the processes $Ar^+ + Ar \to Ar^{m+} + Ar^{n+} + (m + n - 1)e$ (denoted 1,0,m,n for short) under condition when all three lines are simultaneously excited (energy of incoming particles $T_0$ = 50 keV, their laboratory scattering angle $\nu = 7°30'$). A coincidence method was used to determine the relative probabilities of the elementary processes 1,0,m,n upon excitation of each of the lines. Inasmuch as the approach distance was fixed, all collisions corresponded to one and the same pattern of electron term crossing.

In the analysis of the experimental data, we used the standard methods of correlation theory. In particular, we considered the lines of regression of n with respect to m and of m with respect to n (see the figure), i.e., the dependence of the conditional mathematical expectation value of the charge of one of the particle on the charge of the other particle, for example

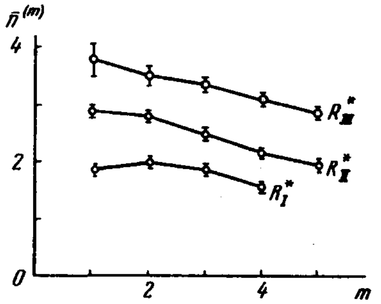
$$\bar{n}^{(m)} = \sum_n n N_{m/n} / \sum_n N_{m/n} = f(m) ,$$

where $N_{m/n}$ is the number of coincidences corresponding to the process 1,0,m,n. We have also determined the correlation ratios $\eta_{m/n}$ and $\eta_{n/m}$, which characterize the decrease in the width of the charge distribution of one of the particles when a specified value is assigned to the charge of the other. The correlation ratios were determined from the formula

$$\eta^2_{n/m} = \sum_m (\sum_n N_{m/n})(\bar{n}^{(m)} - \bar{n})^2 / \sum_m \sum_n N_{m/n}(n - \bar{n})^2 .$$

It has turned out that when each line is excited $\eta_{m/n} = \eta_{n/m}$, and that the corresponding values of $\eta$ for the three lines are $\eta_I = 0.06 \pm 0.02$, $\eta_{II} = 0.28 \pm 0.04$, and $\eta_{III} = 0.22 \pm 0.07$.

The errors quoted correspond to a fiducial probability 0.68 and are connected principally with the statistical errors arising in the coincidence registration and the errors arising in the separation of the R* lines. The total number of coincidences registered in the study of the different processes is about $10^5$.




Conditional mathematical expectation of the charge $\bar{n}^{(m)}$ of the recoil particle vs.the charge of the incoming particle upon excitation of various energy-loss lines R*. $Ar^+$ + Ar collisions; $T_0$ = 50 keV; $\nu = 7°30'$.

The attained accuracy permits certain definite conclusions to be drawn with respect to the correlation of the final charge states m and n. An examination of the correlation ratios and of the regression lines shows that when the $R^*_I$ line is excited the correlation is very insignificant, but for the lines $R^*_{II}$ and $R^*_{III}$ the correlation is quite large and is the same within the limits of experimental accuracy. This result does not agree with the conclusions expected on the basis of the Fano and Lichten model. Furthermore, it shows that the discrete energy losses are difficult to explain if one considers the excitation of levels of arbitrary nature, belonging to isolated atomic particles. The correlation data confirm the conclusion of our earlier paper [6] that the discrete energy losses are connected with processes that occur not in isolated particles but in the system produced during the collision time.

The question of the correlation of the final charge states is considered also in papers by Everhart et al. [7,8]. Their conclusions do not agree with ours and, in their opinion, confirm the Fano-Lichten model. The cause of this discrepancy, in our opinion, is that the authors of [7,8] did not carry out the required mathematical analysis of the results, and their conclusion concerning the correlation is based on an analysis of only the conditional charge distributions, which are very sensitive to random errors. On the other hand, the random errors in [8] could not be small, since the data cited show that the total number of registered coincidences in the correlation investigation did not exceed $10^3$.


[1] V. V. Avrosimov, Yu. S. Gordeev, M. N. Panov, and N. V. Fedorenko, ZhTF 34, 1624 (1964), Soviet Phys. Tech. Phys. 9, 1256 (1965).
[2] E. Everhart and Q. C. Kessel, Phys. Rev. Lett. 14, 247 (1965).
[3] U. Fano and W. Lichten, Phys. Rev. Lett. 14, 627 (1965).
[4] M. Ya. Amusia, Phys. Lett. 14, 36 (1965).
[5] M. Ya. Amus'ya, ZhTF 36, 1409 (1966), Soviet Phys. Tech. Phys. 11, 1053 (1967).
[6] V. V. Afrosimov, Yu. S. Gordeev, M. N. Panov, and N. V. Fedorenko, ZhTF 36, 123 (1966), Soviet Phys. Tech. Phys. 11, 89 (1966).
[7] Q. C. Kessel, A. Russek, and E. Everhart, Phys. Rev. Lett. 14, 484 (1965).
[8] Q. C. Kessel and E. Everhart, Phys.Rev. 146, 16 (1966).


## OBSERVATION OF ELECTRIC "DOMAINS" IN HIGH-RESISTANCE GaAs WITH THE AID OF THE ELECTROOPTIC EFFECT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We investigated the inhomogeneities of the distribution and the oscillations of the electric field in an n-type GaAs crystal at T = 80°K. As is well known, electric instability was observed experimentally in Ge [1,2], in CdS [3], and in the semiconducting GaAs [4-6].

In this investigation we measured the local electric field intensity with an optical probe, using the Pockels electrooptic effect [7].

The measurements were made on single-crystal semple of semiconducting GaAs doped with iron. Their resistivity at 80°K was of the order of $10^{10}$ ohm-cm. The samples were parallelepipeds measuring 6 x 3 x 3 mm. The electrodes were of indium and deposited on the [111] plane. The distance between the electrodes was 3 mm. The remaining four sides, on which there were no electrodes, were subjected to thorough optical polishing.

The sample was placed between two crossed polaroids and illuminated with plane-polarized monochromatic light of quantum energy smaller than the forbidden-band width and with the $\vec{e}$ vector at an angle of 45° to the direction of the electrostatic field.

The anisotropy introduced by the electric field gives rise to birefringence in the crystal. For the GaAs crystal, whose symmetry class is $\bar{4}3m$, the phase difference between the two rays depends on the electric field intensity (the Pockels effect) and its value in degrees is in our case

$$\delta^\circ = \frac{\sqrt{3}\,\pi}{\lambda}\, n_0^3 r_{41} EL\,, \tag{1}$$

where $\lambda$ is the wavelength of the light, $n_0$ the refractive index of the crystal in the absence of an electric field, E the electric field intensity, L the length of the crystal in the light propagation direction, and $r_{41}$ the electrooptic coefficient, which is equal to $\sim 3 \times 10^{-10}$ cm/V for $\lambda = 0.9\ \mu$.

The intensity I of the light passing through the sample and the two crossed polaroids is

$$I \sim \sin^2 \frac{\delta^\circ}{2}\,. \tag{2}$$