spectrum of the induced luminescence practically coincide.

The features of the aforesaid effect of transformation of the average infrared radiation into visible light can be attributed to the following electronic transition mechanism. As is well known, the main mechanism of carrier recombination in gallium phosphide with impurity density $N \geq 10^{16}$ cm^{-3} is the interimpurity recombination of the carriers captured by donor-acceptor pairs. The first to recombine are close pairs with small distances between the donor and acceptor centers. The pairs with sufficiently large interimpurity distances can be in a charge-exchange state for a sufficiently long time. Infrared irradiation of a sample containing such nonrecombining remote pairs ionizes the impurity centers making up these remote pairs. The generated photocarriers can be captured by already-recombined close pairs and take part in the new process of recombination by the close pairs. The spectral composition and the kinetics of the photoluminescence and reradiation should be the same in this case. The excitation, recombination, and impurity photoconductivity spectra should also be the same. The relaxation of the remote charge-exchange pairs at low temperatures should be determined essentially by the intensity of the infrared radiation ionizing them. As already emphasized above, all these features were observed in the experiment.

In conclusion, the authors thank T. M. Lifshitz and D. S. Nedzvedskii for interest in the work and a discussion of the results.

[1] E. F. Gross and D. S. Nedzvedskii, Dokl. Akad. Nauk SSSR 152, 989 (1963) [Sov. Phys.-Dokl. 8, 1335 (1964)].

[2] D. F. Nelson and K. F. Rodgers, Phys. Rev. 140, No. 5A (1965).

[3] D. G. Tomas, J. J. Hopfield, and W. W. Augustyniak, ibid. 140, No. 1A (1965).

OBTAINING HOLOGRAMS WITH AN INCOHERENT LIGHT SOURCE

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In [1] are presented theoretical considerations and a description of an experimental procedure for obtaining holograms using an incoherent radiation source with $\Delta\Lambda/\Lambda \leq 0.1$. The experimental results of [1] were obtained with a source (superhigh-pressure mercury lamp) in which, as a result of filtering, $\Delta\Lambda \sim 100$ Å.

We obtained on the basis of the procedure of [1], holograms with unfiltered radiation from a superhigh-pressure mercury lamp and an incandescent lamp.

The experimental setup is shown in Fig. 1. Figure 2 shows holograms obtained with unfiltered radiation of a mercury lamp (a) and an incandescent lamp (c) and the images (b, d) reconstructed from these holograms with the aid of a laser.

In holography by the scheme of Fig. 1, the "carrying three-dimensional grating" in the holography plane is the image of the diffraction grating. This image can be regarded as a result of interference between zero- and first-order rays diffracted by the grating. The achromatism of such a holography system (independence of the period d of the interference pattern of the wavelength Λ) is due to the fact that the convergence angle of the interfering rays (θ) is proportional to the wavelength, $d = \Lambda/\sin\theta(\lambda) = \text{const}$. The dimensions of the

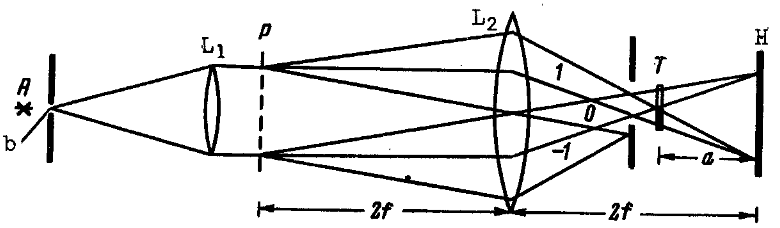

Fig. 1. Achromatic system for holography. Light source A - DRSh-250 mercury lamp or 300 W incandescent lamp, $b = 0.4 - 0.8$ mm, $f_{L_1} = 60$ cm, $f_{L_2} = 40$ cm. Lattice period $d = 1.5 \times 10^{-3}$ cm. The diffraction grating was an interference pattern recorded on a "Mikrat-VR" photographic plate and obtained in a converging laser beam. The distance from the hologram H to the transparency T is $a = 18 - 25$ cm. A glass of the same thickness as the transparency was installed to compensate for the path difference in first order.

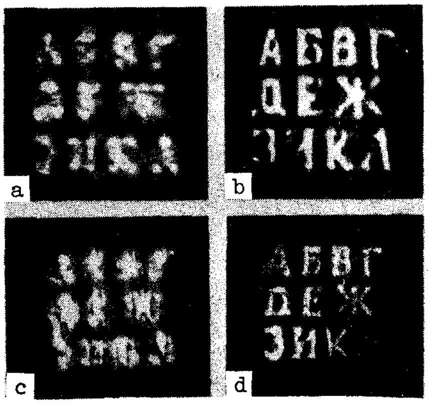

Fig. 2. Holograms obtained with a mercury lamp (a) and an incandescent lamp (c) without filtering, and the reconstructed images. The line thickness on the transparency is 0.1 mm. The exposure time is 5 sec for holograms obtained on on "Mikrat-300" films and 2 min for "Mikrat-VR" films (at $b = 0.4$ mm). The images were restored in light of an LG-35 He-Ne laser.

coherence region in the plane of the diffraction grating $\Delta L \sim f_{L_1}\lambda/b \approx 5 \times 10^{-2}$ cm, whereas the dimensions of the diffraction gratings are $\simeq 2$ cm.

The less stringent requirements of the considered holography scheme with respect to the degree of spatial coherence of the source (A in Fig. 1) can apparently be explained in the following manner. If we consider an illuminated diffraction grating as the light source, then we can obtain in the focal point of the lens a coherence spectrum [2] whose lines coincide with the spectral lines of light dispersed by the grating for each wavelength Λ.

Experience has shown that it is necessary to take into account in practice the influence of the aberrations of the lens, thus complicating this simple reasoning scheme.

The fringes of the reconstructed image of Fig. 2b are the result of sinusoidal modulation of the contrast in the image of the lattice, due to the shift of its frequency for the two mercury spectral lines in which the main intensity of the radiation is concentrated.

An estimate of the period of the modulation with allowance for chromatic aberration only gives good agreement with experiment. However, the dimension of the region of visibility of the interference pattern cannot be attributed to chromatic aberrations only.

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[1] E. N. Leith and J. Upatnieks, J. Opt. Soc. Amer. 57, 975 (1967).
[2] M. Franson and S. Slansky, Coherence in Optics (Russ. Transl.), Nauka, 1967.

INVESTIGATION OF THE SPECTRUM OF ELECTRONS RELEASED UPON COLLISION OF Ar^+ IONS WITH Ar ATOMS

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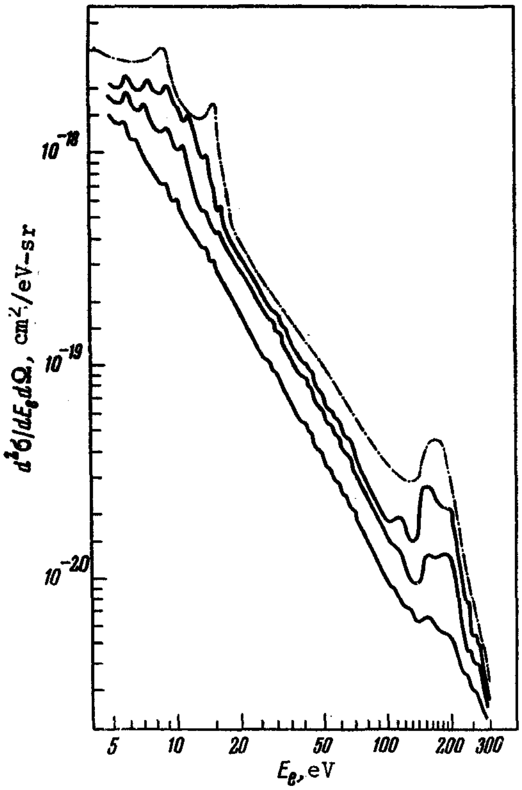
In order to clarify the character of the mechanism of inelastic atomic collisions, particularly the question of the nature of characteristic inelastic energy losses [1,2], great importance attaches to the study of the energy spectrum of the electrons released in ionization processes in which heavy atomic particles take part.

We present in this paper preliminary results of such an investigation for the Ar^+-Ar pair at three values of the collision energy (5, 15, and 25 keV) in the electron energy range 5 - 300 eV. The experimental procedure will be described in detail later. The electrons were analyzed by energy in a cylindrical electrostatic analyzer of the Blauth type [3]. The electron emission angle, determined by the first-order focusing condition, was 54.5° to the beam axis. The high resolving power of the instrument ($\leq 1\%$) in conjunction with high sensitivity and a low relative error of the measurements ($\leq \pm 6\%$) has made it possible to observe a whole series of structural singularities in the energy distribution of the electrons.

The figure shows the obtained electron energy spectrum. The ordinates show the absolute magnitudes of the differential electron-production cross sections per unit solid angle and per unit energy interval, and the abscissas show the electron energies E_e. The dashed curve represents, for comparison, the data of [4]. As seen from the figure, it is possible to separate in the electron energy spectrum a continuous part that decreases smoothly with increasing electron energy in accordance with a power law (approximately like $E_e^{-5/3}$), and a



Energy distributions of the electrons released in collisions between Ar^+ ions and Ar atoms. The solid lines show the data of the present paper. The upper curve corresponds to a colliding-ion energy 25 keV, the middle curve to 15 keV, and the lower one to 5 keV. The electron emission angle is 54.5°. The dashed curve shows the data of [4] for the same pair of particles at a colliding-ion energy 100 keV and at an electron emission angle 160°.