energies of the corresponding impurities (the singlet ground state is indicated) [7 - 10]. ε_i of Si:B could not be measured directly, since the photoconductivity signal $\Delta\sigma$ just begins to grow at the short-wave boundary of the employed spectrometer (5 meV).

	Ge : Sb	Ge : P	Ge : As	Ge : Ga	Si : P	Si : B
$\varepsilon_{D^-(A^+)}$, meV	0.95	1.2	1.55	2.4	2.2	≥ 5
$\varepsilon_{D^0(A^0)}$, meV	10.2	12.8	14	11	45.3	46

Evidence indicating that the obtained values of the long-wave boundary of the photoconductivity correspond to the binding energies ε_i of the D^- (or A^+) centers is provided by the following experimental results:

1. In samples with low compensation of the main impurity (<5%), in the absence of interband illumination, the long-wave photoconductivity boundary is clearly observed, whereas in strongly compensated samples it appears only following additional illumination.

2. The obtained values of ε_i depend significantly on the type of impurity and correlate with the depth of the ground state of the corresponding impurity.

3. In samples with impurity density $\leq 10^{12}$ cm^{-3}, the long-wave photoconductivity boundary is not observed even at maximum additional illumination.

We note that the value of the photoconductivity at $\varepsilon > \varepsilon_i$ increases with decreasing temperature and with increasing impurity density and additional-illumination level.

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[1] E.A. Davis and W.D. Compton, Phys. Rev. 140, A2183 (1965).
[2] A.Honig, 13th Conf. Phys. Semicond. 1970, Boston, Extended Abstracts FAC-2.
[3] P.I. Dean, I.R. Haynes, and W.F. Flood, Phys. Rev. 161, 711 (1967).
[4] M.A. Lampert, Phys. Rev. Lett. 1, 450 (1958).
[5] M.B. Golant, R.L. Vilenskaya, E.A. Zyulina, Z.F. Kaplun, A.A. Negirev, V.A. Parilov, G.B. Rebrov, and V.S. Savel'ev, Prib. Tekh. Eksp. No. 4, 136 (1965).
[6] E.M. Gershenzon and G.N. Gol'tsman, ZhETF Pis. Red. 14, 98 (1971) [JETP Lett. 14, 63 (1971)].
[7] I.H. Reuzer and P. Fisher, Phys. Rev. 135, A1125 (1964).
[8] R.A. Jones and P. Fisher, J. Phys. Chem. Sol. 26, 1125 (1965).
[9] R.L. Aggarwal and A.K. Ramdas, Phys. Rev. 140, A1246 (1965).
[10] H.I. Hrostowski and R.H. Kaiser, J. Phys. Chem. Sol. 4, 148 (1958).

ESTIMATE OF CHARGE DENSITY ON DISLOCATIONS IN NaCl CRYSTALS

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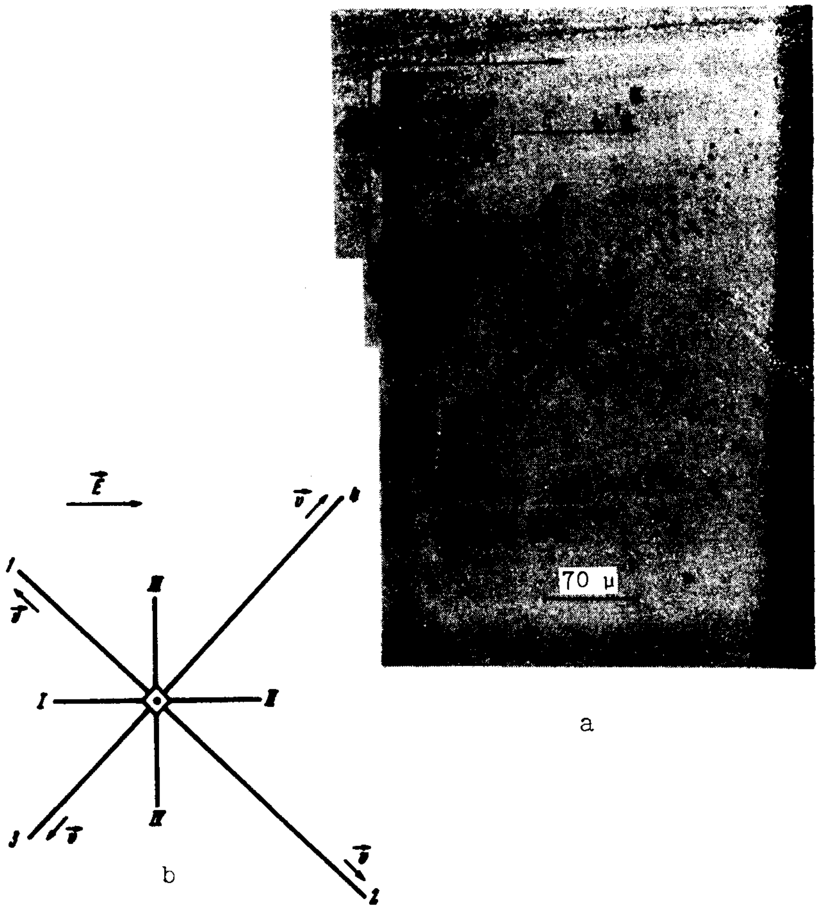
The most important characteristic of dislocations in ionic crystals is the linear density of the effective (uncompensated) charge distributed along the



a

b

Characteristic asymmetrical dislocation rosette produced following microindentation in an electric field E = 26 kV/cm. The arrows show the directions of dislocation motion.

dislocation line. Until recently, this density was estimated either by indirect methods [1 - 3] or by starting from model representations [4], and therefore such estimates are highly approximate. We describe here a new experimental method of determining the linear charge density on dislocations produced and moving in NaCl crystals following simultaneous action of a concentrated load and an external electric field.

1. We measured the lengths of the rays of the dislocation rosettes (i.e., the ranges of the leading or frontal dislocations), following microindentation of the (001) surface of NaCl single crystals with and without an external electric field. The samples were bars measuring 4 × 4 × 10 mm, cleaved along the cleavage plane (yield point σ_y = 250 g/mm^2; initial dislocation density N = 10^4 cm^{-2}, total concentration of divalent impurities 10^{-2} at.%). The microindentation was with the PMT-3 instrument with a diamond pyramid point, and the load on the indentor was 3 g. In the experiments with the electric field, the samples were placed between vertical capacitor plates; the vector of the external electric field $\vec{E}$, whose direction coincided with the [100] direction of the crystal lattice of the sample, was collinear with the diagonal of the imprint. After producing a number of imprints, the samples were etched in glacial acetic acid. This produced around each imprint an indentation dislocation rosette characteristic of the deformation under the action of a concentrated load.

2. When investigating the action of an external electric field along the rays of the dislocation rosette one should expect above all a change in the length of the so-called edge rays, i.e., the ranges of the leading dislocation of the edge type, since it is precisely the edge dislocations which conserve

the charge as they move. As to the screw dislocations, their lengths can also change, since the half-loops making up the screw rays of the rosette have edge components as a result of their curvature. The change of the lengths of the screw rays under the influence of the field should, however, be relatively small. The experimental data obtained by microindentation of NaCl crystals in an external electric field confirm these assumptions.

The table lists the distances, averaged over 300 rosettes, from the rosette center to the leading dislocations in the edge and screw rays, distributed relative to the external-field vector in the manner shown in Fig. a.

	Length of screw rays (μ)				Length of "edge" rays (μ)			
	ℓ_{oI}	ℓ_{oII}	ℓ_{oIII}	ℓ_{oIV}	ℓ_{o1}	ℓ_{o2}	ℓ_{o3}	ℓ_{o4}
$E = 0$	29	29	28,5	28.5	67	67	66	66
$E = 26$ kV/cm	30	29,5	29,5	30	68	81	67	79

Experiment shows that the mean lengths of the screw rays obtained with and without the field are practically the same. The lengths of the screw rays $\ell_{oII}(\ell_{oI})$ and $\ell_{oIII}(\ell_{oIV})$ that have different orientations relative to the vector $\vec{E}$ are likewise equal (Fig. b). This means that we can neglect the additional mechanical stresses in the crystal, which are connected with the electrostriction, the inverse piezoeffect that is possible in this case (in spite of the central symmetry of the NaCl crystals), and the ponderomotive forces between the elements of the instrument. Therefore the average 20% increase (with an rms error not larger than 2%) of the lengths ℓ_{o2} and ℓ_{o4} of the edge rays, in which the dislocations moved along the component of the vector $\vec{E}$, can be attributed directly to interaction of the positively-charged edge dislocations with the external electric field.

3. This circumstance has enabled us to find the average linear charge density on the edge dislocation. The parts of the samples were indented with the external electric field replaced by uniaxial compression of the sample. By varying the pressure on its ends in the corresponding slip planes, additional cleavage stresses τ_b were produced, causing the same increase in the ranges of the leading edge dislocations as under the influence of the electric field. Experiment yielded $\tau_b = 26$ g/mm². Equating the additional forces acting on a unit length of the leading dislocation in an external electric field and in a uniaxially stressed state, we obtain

$$\rho_+ = \frac{r_b^{(20\%)} b}{E \cos 45^\circ} = 8.4 \cdot 10^{-4} \text{ CGSE A/cm} \qquad (1)$$

($\vec{b}$ is the Burgers vector of the edge dislocation).

4. The lengths of the edge rays in which the dislocations moved in a direction opposite to the component of the vector $\vec{E}$ in the corresponding planes, turned out to be practically equal (within the limits of experimental error) with and without a field (see ℓ_{o1} and ℓ_{o3} in the table). With such motion relative to the vector $\vec{E}$, the ranges of the edge dislocations with negative uncompensated charge should increase, viz., a calculation analogous to that in Sec. 3 yields the upper limit of the average linear density of the possible negative charge on the dislocations:

$$\rho_- = \frac{r_b^{(2\%)} b}{E \cos 45^\circ} = - 8 \cdot 10^{-5} \text{ CGSE A/cm} \qquad (2)$$

where $\tau_b^{2\%}$ is the additional cleavage stress causing a 2% elongation of the edge rays. This quantity (in absolute magnitude) is at the same time a measure of the accuracy of the estimate of the linear charge density given by relation (1).

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[1] R.L. Sproull, Phil. Mag. 5, 56, 815 (1960).

[2] R. Strumane, R. de Batist, and S. Amelinckx, Phys. Stat. Solidi 3, 8, 1379 (1963).

[3] A.A. Urusovskaya, Review in: Dinamika dislokatsii (Dislocation Dynamics), Khar'kov, 1968, p. 611.

[4] I.V. Zagoruiko, Kristallografiya 10, 81 (1965) [Sov. Phys.-Crystallogr. 10, 63 (1965)].

SONOLUMINESCENCE FOLLOWING FOCUSING OF LASER RADIATION INTO A LIQUID

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We report here data on the sonoluminescence phenomenon [1], which is observed upon collapse of cavitation voids produced in a liquid by a laser beam.

We used in the experiments a ruby laser operating in the monopulse regime, with radiation energy 0.5 J and duration 30 - 50 nsec, and also in the free-running regime. The experimental setup is shown in Fig. 1. The laser beam after passing through a Ks-15 filter (1) was focused by a lens (F = 2 cm) into a liquid (water, carbon tetrachloride, acetone) filling a cell (2) with blackened interior surface. The cell had symmetrically placed windows of optical glass, through which the luminescence of the liquid was recorded with the aid of an FEU-18A or FEU-22 photomultiplier (3) on an OK-17 oscilloscope. The spectral regions were separated with interference filters and with standard filters of colored glass (4). The laser radiation was monitored by diverting part of the radiation to an FEU-22 photomultiplier (5) with the signals recorded with an S-1-11 and an OK-17 oscilloscope (to establish the time correlation).

A piezoelectric pickup (6) with resolution 0.25 μsec was placed in the cell. The pickup registered pressure pulses at distances from 5 to 10 mm from the focal region, and the signal was fed from the pickup through a cathode follower (7) to the second channel of the OK-17 oscilloscope.

It is known that when monopulse laser radiation acts on a liquid, breakdown occurs at the focus of the beam and a pulsating cavity is produced [2]. The maximum radius R of the cavity is determined mainly by the radiation energy.

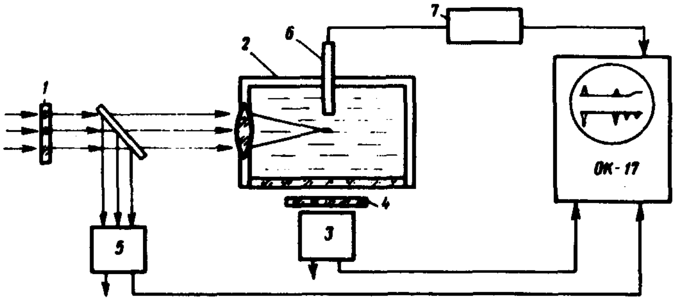

Fig. 1. Experimental setup: 1 - Ks-15 filter, 2 - cell with investigated liquid, 3 - FEU-18A or FEU-22 photomultiplier; 4 - filters, 5 - FEU-22 photomultiplier, 6 - piezoelectric pickup, 7 - cathode follower.