$$a = \frac{V}{b\,\omega_s} \quad , \qquad \theta(x) = \begin{cases} 1, & x > 0 \\ 0, & x < 0 \end{cases} \quad . \qquad\qquad (4) \text{ (Cont'd.)}$$

Here γ and β are the parameters of magnetoelasticity and anisotropy, $\Omega = gM_0$, and $\omega_S = \Omega[\beta + (H_0/M_0)]$. When $\vec{q} \parallel \vec{n}$ the edge dislocation does not experience deceleration. In the case when $\vec{q} \perp \vec{n}$ the values of the force differ little from (4) for either a screw or an edge dislocation. Formula (4) was derived for $V \ll s$, where s is the speed of sound; in this case the dispersion of the elastic moduli can be disregarded.

For typical values of the parameters, $b \sim 10^{-7}$ cm, $M_0 \sim 10^3$ G, $\Omega \sim 10^{10}$ sec^{-1}, $\gamma \sim 1$, and $\beta \sim 1$, the threshold velocity is $V_S = b\omega_s \sim [1 + (H_0/M_0) \times 10^3$ cm/sec; at the threshold we have $F \sim -[1 + (H_0/M_0)](10^{-1} - 10^{-2})$ dyne/cm. We note that the force of the electronic deceleration of dislocation has a similar value at $V \sim 10^3$ cm/sec [4]. It is observed experimentally in transitions to the superconducting state, when this force vanishes. We can therefore expect the here-considered observation of the mechanism of loss to spin waves to be experimentally feasible.

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EXPERIMENTAL VERIFICATION OF SIMILARITY THEORY AT THE CRITICAL POINT OF Ar

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Attempts to compare experimental results on critical phenomena with similarity theory [4] have been made in [1 - 3]. Most authors conclude that the agreement is satisfactory.

We think, however, that a comparison of the theory with experiments in which different exponents are determined by different investigators (and all the more in different laboratories) is incorrect. Indeed, all the relations in similarity theory are determined by degrees of the relative temperature $t = |(T - T_{cr})/T_{cr}|$, and are highly sensitive to the absolute values of T_{cr}. The "scaling" equations include both large exponents (on the order of unity, for example γ), and small ones (on the order of 0.1, for example α). As a result of the accumulation of the errors of each author and the addition of errors due to the different choices of T_{cr} (which can differ by several hundredths of a degree in different laboratories, since the matching of the different scales is of this order), the total error may turn out to be larger than the smaller exponent. Then the verification becomes completely meaningless, as indeed it was in most cases. To determine the small indices it is necessary to perform different experiments pertaining to one value of T_{cr} and characterized by identical systematic errors. To this end we investigated the coexistence curve of
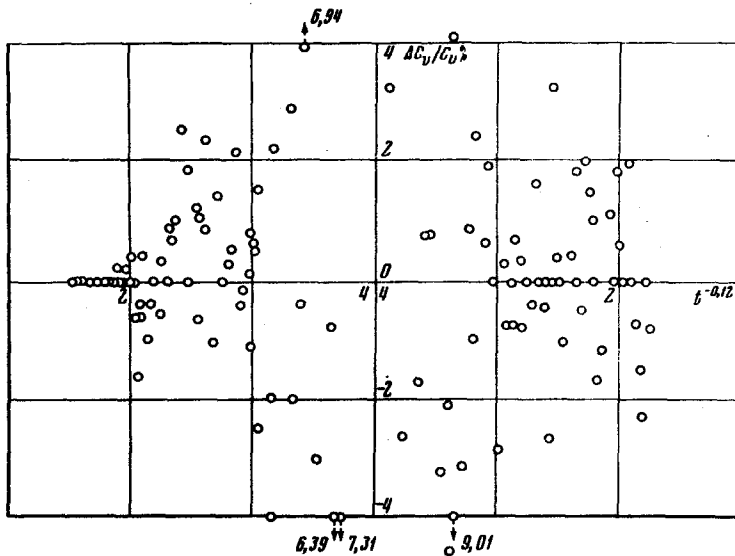
Fig. 1. Dependence of the error in the measured specific heat C_v relative to the approximating curve $C_v^{\pm} = A_{\pm}t^{-\alpha} + \beta_{\pm}$ for $\alpha = 0.12$, in per cent: the left side of the diagram is for $t < 0$, and the right side for $t > 0$.

spectrally pure argon ($\sim$99.99%) near the liquid-vapor critical point and measured its specific heat C_v as a function of the temperature and of the density.

We had to improve somewhat our specific-heat-measurement procedure [5, 6] and raise its accuracy to the level required for a comparison with our procedure for measuring the coexistence curve [7].

The calorimeter was surrounded by a thick-wall (0.5 mm) copper jacket to decrease the gradients on the surface. A decrease of the gradients by one order of magntiude leads to a corresponding improvement of the automatic regulation of the adiabatic regime. The stirring was automatized and its efficiency was raised to make the inhomogeneity parameter $\sim$0.005 [8]. These measures led to an appreciable increase of the accuracy (compared with [9]). Thus, the error of our specific-heat measurements did not exceed 2 – 4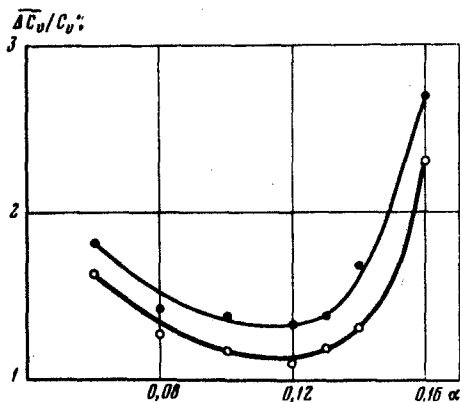% at a point width up to 0.006°. The scatter relative to the approximating curves $C_v^{\pm} = A_{\pm}t^{-\alpha} + B_{\pm}$ does not exceed this value (see Fig. 1) in the interval $2 \times 10^{-5} < t < 2 \times 10^{-2}$. In the past [6, 9] we insisted on a logarithmic character of the singularity of C_v at the critical point, since our accuracy did not allow us to distinguish between the values of the exponent in the range 0 – 0.2 in the earlier investigations [6] and 0 – 0.1 in [9]. The presently attained accuracy suffices to distinguish a critical exponent 0.02 – 0.04 from 0.

As a result we see clearly that an exponent α smaller than 0.06 and larger than 0.16 is excluded for both branches of the $C_v(t)$ curve (corresponding to $t < 0$ and $t > 0$). At the chosen values of ρ_{cr} and T_{cr} we can even increase the accuracy of the exponent by choosing the coordinates of the centers of the points not arithmetically

Fig. 2. Relative mean error of the specific heat $\overline{\Delta C}_v/C_v$ in per cent using an approximating curve $C_v^{\pm} = A_{\pm}t^{-\alpha} + B_{\pm}$ as a function of α: o – t <0, o – t > 0.

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$(T = T_1 + \Delta T/2)$, but by averaging the total heat consumed in heating at each point in the corresponding functional scale $t = \left(t_2^{-\alpha} - t_1^{-\alpha}\right)/2$.

Such a data reduction leads to exponent values $\alpha = \alpha' = 0.12 \pm 0.02$, where α is the exponent for $t > 0$ and α' for $t < 0$. Figure 2 gives an idea of the accuracy of the choice of α. It is difficult to determine the value of the exponent ε in the relation $C_v = D(\rho*)^{-\varepsilon} + C$, in view of the limited number of points corresponding to the small number of calorimeter batches. In [6] we expected a logarithmic $C_v(\rho*)$

Fig. 3. Logarithm of the specific heat C_v at $T = T_{cr} + 0$ vs. the logarithm of the dimensionless density $\rho*$: o – data from [6]; o – present data.

dependence, and therefore narrowed down sharply the region of possible comparison of this dependence with $C_v(t)$ with respect to the dimensionless parameter $\rho*$ ($\rho*$ is the density $|(\rho - \rho_{cr})/\rho_{cr}|$. However, if we consider the $C(\rho*)$ dependence in the entire measurement range of [6], then we obtain an exponent $\varepsilon = 0.34 \pm 0.15$. The low accuracy with which the exponent is determined is due to the same factors that accounted above for the poor agreement between the results of different authors. Different densities were measured with gases of different purity and with different thermometers, and were referred to different values of T_{cr} (cf. [6]).

In the present case several batches were studied with the same calorimeter and referred to the same value of T_{cr}, namely 150 665 $\pm$ 0.00005°K. (The difference between this value and that of [7] reduces to 10^{-5} dimensionless units and can correspond to a difference of 0.01% in the purity of the gases.) At such an accuracy, the $C_v(\rho*)$ dependence is determined with sufficient reliability, in spite of the small number of points.

The exponent ε, as seen from Fig. 3, equals 0.35 ± 0.04. Using the same sample, including the batches used to measure the specific heat, we measured the coexistence curve $\rho* = kt^\beta$, with $\beta = 0.33 \pm 0.02$. Similarity theory, as can be easily shown, yields the relation $\varepsilon = \alpha/\beta$. Thus, taking the values of α and β obtained by us, we obtain $(0.12 \pm 0.02)/(0.33 \pm 0.02) = 0.36 \pm 0.07$, which can be deemed to agree with the experimentally obtained value. As a result of our experiment we must admit agreement with similarity theory within the range about one-half of the small exponent α. We indicate that the exponent $\alpha = 0.12 \pm 0.02$ obtained by us practically coincides with the exponent 1/8 obtained in a computer experiment for the three-dimensional Ising model [10].
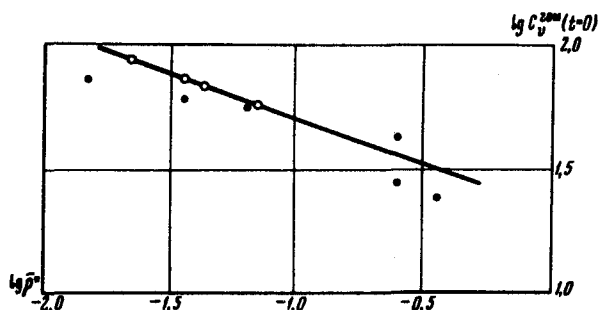
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MEASUREMENT OF THE LIFETIME AND OF THE SPIN-RELAXATION TIME OF ELECTRONS IN
SEMICONDUCTORS BY THE OPTICAL-ORIENTATION METHOD

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It was shown recently [1, 2] that in semiconducting crystals it is possible to attain an appreciable orientation of the spins of the non-equilibrium carriers as a result of interband transitions caused by absorption of polarized light. Observation of optical orientation makes it possible to extend to semiconductors the research methods widely used in atomic spectroscopy [3], and particularly to investigate relaxation processes in a crystal under stationary conditions.

In the present investigation we used the method of optical orientation to measure the temperature dependence of the lifetime and the spin-relaxation time of the non-equilibrium electrons in the interval 77 - 300°K using mixed p-type $Ga_xAl_{1-x}As$ crystals, for which a strong electron orientation was obtained earlier [2] at 77°K.

The orientation of the non-equilibrium electrons was produced by predominant population of one of the conductivity subbands with m = 1/2 or m = -1/2, with the electrons excited by circularly polarized light (σ^+ or σ^-, respectively) from the valence band to the conduction band. The degree of stationary orientation of the electron spins (P) in the presence of relaxation is determined by the relation [1 - 3]

$$P = \frac{P_0}{1 + \tau/T_1},$$

(1)

where T_1 is the spin-relaxation time and τ is the lifetime of the non-equilibrium electron in the conduction band, P_0 is the orientation in the absence of relaxation, determined by the probabilities of the transitions to the state with m = 1/2 or m = -1/2 upon absorption of circularly polarized light. In our case $P_0 = 0.5$ for the interband transitions $\Gamma_{15.val}^{3/2} - \Gamma_{1.con}^{1/2}$ [1, 2].

The times τ and T_1 determine also the total lifetime of the oriented spin T_{1M}:

$$\frac{1}{T_{1M}} = \frac{1}{\tau} + \frac{1}{T_1},$$

(2)

which can be measured from the decrease of the degree of orientation of the electrons in a transverse magnetic field (a phenomenon analogous to the Hanle effect in atomic spectroscopy [3]). The dependence of the degree of orientation on the magnetic field intensity (H) has in this case a Lorentz form:

$$P \sim \frac{1}{1 + (\omega_L g T_{1M})^2}.$$

(3)