

<sup>3</sup> J. A. Harvey, *Canad. J. Phys.* **31**, 278 (1953).

<sup>4</sup> L. K. Peker and L. A. Sliv, *Izv. Akad SSSR, Ser. Fiz.* **17**, 411 (1953).

<sup>5</sup> E. D. Courant, *Phys. Rev.* **82**, 703 (1951).

<sup>6</sup> C. G. Shull and E. O. Wollan, *Phys. Rev.* **81**, 527 (1951).

<sup>7</sup> H. Pomerance, *Phys. Rev.* **88**, 412 (1952).

Translated by B. G. Saunders  
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the penetration depth found by Pippard<sup>1</sup>.

We express our thanks to A. I. Sha'nikov for his interest in this work.

<sup>1</sup> A. B. Pippard, *Proc. Roy. Soc. (London)* **203**, 195 (1950).

Translated by R. T. Beyer  
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## Crystalline Anisotropy of the Intermediate State

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(Submitted to JETP editor July 18, 1955)

*J. Exper. Theoret. Phys. USSR* **29**, 897 (December, 1955)

## Heat of Vaporization of Oxygen in the Temperature Range 80-106°K

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(Submitted to JETP editor July 21, 1955)

*J. Exper. Theoret. Phys. USSR* **29**, 902-903 (December, 1955)

WE have undertaken experiments on the investigation of the moments of forces which act through the agency of a magnetic field on a monocrystalline sphere of lead of high purity (99.998%), placed in the intermediate state. The specimen was mounted on a torsion suspension so that the [010] axis could be vertical and was placed (at a temperature of 3.65 °K) in a magnetic field whose direction could be changed in the horizontal plane. In addition, we superimposed a small (1-2 oersteds) magnetic field, which changed its sign with a period of 30 sec. Under these conditions we could observe the moments, which evidently have a reversible equilibrium character, and which arise as a consequence of the dependence of the surface tension at the boundary of the superconducting and normal phases on the orientation of this boundary with respect to the lattice. The great scatter of the results of various experiments, which is connected with the imperfections of the lattice of the specimens, does not permit a completely reliable quantitative check. However, qualitatively speaking, the two samples that we investigated gave results in agreement, namely, that the free energy of the specimen, as a function of the angle between the field and the tetragonal axis has maxima in the [100] and [001] directions. The intermediate minimum is located approximately at an angle of 25-35° with respect to the tetragonal axis. The height of the maxima for our samples (diameter 12.6 mm, 50% superconducting phase) was of the order of  $10^{-3}$  erg. These results are evidently in qualitative agreement with the anisotropies of

UP to the present time the heats of vaporization of condensable gases as a function of temperature have been little studied, although they are of both practical and theoretical interest. The basic theoretical methods of calculating heats of vaporization require the knowledge of a great number of other quantities. Experimental determinations have been few and insufficiently reliable.

We have undertaken to investigate the heat of vaporization of oxygen from 80° to 106°K by a precision method which we have developed, carried out as follows. A calorimeter contains an evaporator filled with the liquid, and a measured amount of power is applied. The vapor which forms is collected by condensation in a light tank and weighed at room temperature on an analytical balance. During the weighing period the evaporation process goes on in another similar flask.

The apparatus which has been constructed for this purpose includes:

(1) a vacuum adiabatic calorimeter, similar to the one described previously<sup>1</sup>, with a number of changes and improvements;

(2) a system of two capillaries leading out of the calorimeter; one is used during filling and evaporation, and the other is connected to a mercury manometer;

(3) a gas system consisting of two thin-walled stainless steel tanks, closed by vents of original construction, a Bourdon manometer, and operating valves used during the period of evaporation.

Thirty-five measurements were made of the heat of evaporation at seven different temperatures. The

value of the heat of vaporization at the normal boiling point served as a check on the method. The following table compares the heats of vaporization

at the normal boiling point as measured by various workers in recent years:

	L (cal/mole)	T(°K)
Giauque and Johnston <sup>2</sup>	1628.8 ± 1.6	90.13
Clusius and Konnertz <sup>3</sup>	1630.0 ± 1.5	90.19
Present measurement	1628.7 ± 1.3	90.19

Our measurement agrees satisfactorily with the previous results.

The heats of vaporization at different temperatures are presented below, and are shown in the

figure compared to the experimental data of Alt<sup>4</sup> and to values calculated from the empirical formula of Mathias<sup>5</sup>.

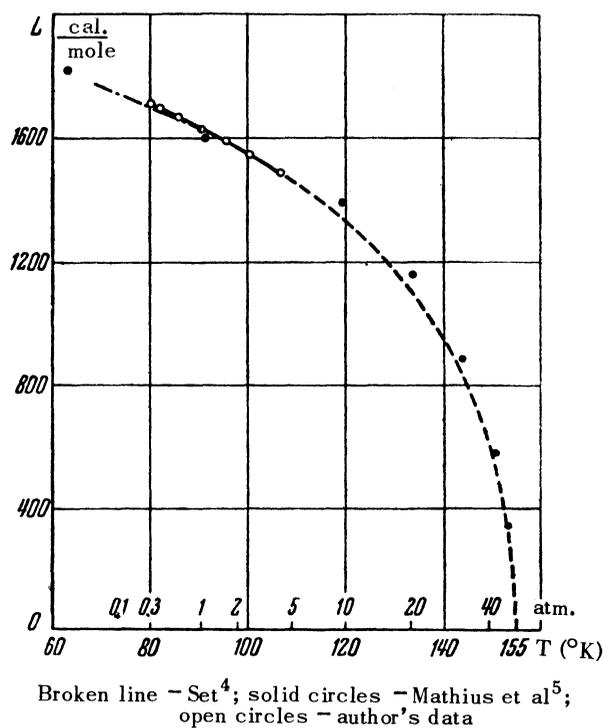
T° K	80.0	81.5	85.4	90.2	95.1	100.0	106.0
L (cal /mole)	1706	1696	1665	1628	1587	1544	1490

The dashed line on the graph represents the curve calculated from our choice of empirical expression:

I should like to express my deep gratitude to P.

G. Strelkov for his constant attention and interest in this work.

$$L^2 = 67208,68 (T_{cr} - T) - 555,221 (T_{cr} - T)^2 + 2,32505 (T_{cr} - T)^3.$$



<sup>1</sup> V. N. Kostriukov, R. A. Alikhanov, B. N. Samoilov and P. G. Strelkov, *Zh. Fiz. Khim.* **28**, 650 (1954)

<sup>2</sup> W. F. Giaque and H. L. Johnston *J. Am. Chem. Soc.* **51**, 2300 (1929).

<sup>3</sup> R. Clusius and F. Konnertz, *Naturforsch.* **4a**, 117 (1949)

<sup>4</sup> H. Alt, *Ann. d. Physik* **19**, 739 (1906)

<sup>5</sup> Mathius et al., *Leiden Comm. No. 162a* (1922)

Translated by D. C. West

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## Measurement of the Absolute Quantum Yield of Photoluminescence of Alkali-Halide Crystals

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(Submitted to JETP editor July 19, 1955)

*J. Exper. Theoret. Phys. USSR* **29**, 903-904

(December, 1955)

In earlier works the dependence of the relative quantum yield of photoluminescence of crystals of KI-Tl and NaI-Tl on the concentration of the activator<sup>1</sup> and the wavelengths of the exciting light<sup>2</sup> was investigated. In the present work the absolute quantum yield of luminescence of these crystals during excitation in the absorption region of the activator was investigated.

For determining the absolute quantum yield a method was used in which the number of luminescent quanta and the number of absorbed quanta of exciting light was measured with the aid of a substance which is luminescent under the action of the one as well as the other radiation, and which has a constant quantum yield in the entire measurable region. This method has been applied earlier to the measurement of the absolute luminescence yield of powdered phosphors which radiate in the ultra-violet<sup>3</sup>, and also of some finely-crystalline organic phosphors<sup>4</sup>.

Our measurements were carried out in a photometric sphere, which made it possible to take into account the entire flux of luminescence. As a measurable luminescent substance a powdered, light yellow phosphor was taken. The preliminary tests showed that the quantum luminescence yield of this phosphor does not depend on the wavelength in the region 240-500  $m\mu$ , and the absorption coefficient of the surface of the

powdered layer of phosphor is constant (about 0.95) in this region. The excitation and radiation spectrum of the crystals KCl-Tl, KI-Tl, and NaI-Tl is in this region.

The measurements were carried out with light excitation from a hydrogen lamp through a spectrometer SF-4, with a cap enclosing an FEY-19 photomultiplier and an amplifier\*. The crystal was placed in an aluminum sphere ( $\phi 4$ cm), which had a slot ( $4 \times 10$ mm) for the entrance of the exciting light, and an aperture ( $\phi 10$ mm) for the exit of the luminescent light. The sphere was lined in the interior with a thick layer of phosphor. The exciting light fell on the crystal and part of it was reflected while the remainder was absorbed, producing luminescence of the crystal (special attention was given so that the absorption of exciting light in the crystal was complete). The reflected light as well as the luminescent light of the crystal caused a glow of the phosphor, which was registered by the photomultiplier.

The reflected (Fresnel) exciting light was measured with the help of another nonabsorbing crystal, the back face of which was blackened. A crystal of NaCl was used for this purpose. The small difference in the index of refraction is unimportant, in view of the small size of the correction. The incident exciting light (in order to preserve the geometry) was similarly measured with the aid of a nonabsorbing crystal, the back face of which in this case was covered with magnesium oxide. It is obvious that if in the first measurement we obtain the reading  $a$ , in the second  $b$ , and in the third  $c$ , then the quantum yield will equal  $\eta = (a - b) / (c - d)$ . The results of the measurements of yield are presented in the following Table.

Crystal	$\lambda_{\text{excit.}}$ ( $m\mu$ )	$\eta$	Note
KCl-Tl	246	0.80	Different crystals
KJ-Tl	245	0.80	
		0.70	
KJ-Tl	285	0.93	One and the same crystal, different method of calculation of the reflected light
		0.77	
		0.74	
NaJ-Tl	260	0.76	
NaJ-Tl	293	0.40	
		0.61	

The concentration of Tl in the crystals KI-Tl and NaI-Tl was sufficient so that during the

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(both of our own and of JETP)

Vol.	Page	Column	Line	Reads	Should read
2	434	2	22	27.3 $\mu$	23.7 $\mu$
2	557	Fig. 10			On the right hand side, abscissa values should read 0, 200, 400, 600, 800, 1000.
2	591	2	7	$A = \frac{e^2 H_{00}^2 \delta_{00}^2}{mc^2}$	$A = \frac{e^2 H_{00}^2 \delta_{00}^2}{mc^2}$
2	754	1	3 ff.	_____	<sup>14</sup> B. B. Kinsey and G. A. Bartholomew, Phys. Rev. <b>82</b> , 380 (1951). <sup>15</sup> B. B. Kinsey and G. A. Bartholomew, Phys. Rev. <b>83</b> , 234 (1951).
2	771	1	10	Intermediate State	Intermediate State of Tin
	771	1	19	sphere of lead	sphere of tin
3	145	1	1	$R = 10 ec$	$R = 1/ec$