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

[2] W. F. Giauque and H. L. Johnston J. Am. Chem. Soc. 5 1, 2300 (1929).

[3] R. Clusius and F. Konnertz, Naturforsch. **4a**, 117 (1949)

[4] H. Alt, Ann. d. Physik 1 9, 739 (1906)

[5] Mathius et al., Leiden Comm. No. 162a (1922)

Translated by D. C. West
307

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

Z. L. MORGENSHTERN

*P. N. Lebedev Physical Institute,*
*Academy of Sciences, USSR*
(Submitted to JETP editor July 19, 1955)
J. Exper. Theoret. Phys. USSR **29**, 903-904
(December, 1955)

I N 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[1] and the wavelengths of the exciting light[2] 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 lumines-cent 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[3], and also of some finely-crystalline organic phosphors[4].

Our measurements were carried out in a photo-metric 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$4cm), which had a slot (4 × 10 mm) for the entrance of the exciting light, and an aperture ($\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 crys-tal (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 photo-multiplier.

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

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

excitation in the shortwave region of absorption
the Tl yield no longer depended on its concentra-
tion[1]. In KCl-Tl, according to our measurements,
the concentration of Tl was $1.5 \times 10^{-4}$ gm Tl/gmKCl;
the data for KCl-Tl correspond well with those
available in the literature[5]. It should be noted
that in KI-Tl the variations in the value of the
yield for various crystals (with high content of Tl)
is found to be greater during excitation with
$\lambda = 245$ m$\mu$ than with $\lambda = 285$ m$\mu$ . This is easily
explained by the different degree of overlapping
of the short wave region of Tl absorption with the
boundary of absorption of the lattice itself, which,
as has been shown[2], is inactive.

The above method was also used to measure the
quantum yield of several organic monocrystals.
The coefficient of reflection in this case was
measured directly. With excitation of $\lambda = 250$ m$\mu$
the yield amounts to: for tolane 0.57; for dibenzyl
0.44; for stilbene 0.43; for naphthalene 0.18.
These values correspond satisfactorily with the
data of other authors.

I thank M. N. Alentsev and M. D. Galanin for
their valuable advice and help during the comple-
tion of this work.

* The cap was constructed by E. E. Bukke.

[1] L. M. Beliaev, M. D. Galanin, Z. L. Morgenshtern
and Z. A. Chizhikova, Dokl. Akad. Nauk SSSR **99**,
691 (1954); Dokl. Akad. Nauk SSSR **105**, 57 (1955).

[2] Z. L. Morgenshtern, Dokl. Akad. Nauk SSSR **105**,
250 (1955).

[3] M. N. Alentsev and L. A. Vinokurov, Izv. Akad.
Nauk SSSR, Ser. Fiz. **15**, 725 (1951).

[4] M. D. Galanin and Z. A. Chizhikova, J. Exper.
Theoret. Phys. USSR **26**, 624 (1954).

[5] W. Bünger, Z. Physik **66**, 311 (1930).

Translated by L. A. D'Asaro
308

# The Surface Tension of Liquid He³ in the Region of Very Low Temperatures (1.0-0.35°K)

K. N. ZINOV'EVA
*Institute of Physical Problems,*
*Academy of Sciences, USSR*
(Submitted to JETP editor September 15, 1955)

EARLIER[1] we discussed our measurements of
the surface tension of liquid He³ from the criti-

cal temperature to 0.93°K by the method of capil-
lary rise[4]. In the present work we have continued
the measurements to lower temperatures using our
earlier capillaries with diameters of 0.360, 0.224,
and 0.188 mm. By pumping on He³ vapor, we were
able to carry the measurements to 0.35°K.

The temperature of liquid He³ was determined by
the vapor pressure of He³, measured with a Mcleod
gauge. In the temperature interval 0.5-1.0°K we
used the temperature scale of Sydoriak and Roberts
(see reference 2). Below 0.5°K, the temperature
was calculated from the vapor pressure, using an
empirical formula given in reference 2. The pres-
sure of the saturated vapor of He³ at a temperature
of 0.35°K was 0.008 mm Hg. To measure the posi-
tion of the level in the capillary we used a cathe-
tometer, KM-5, which enabled us to read the height
with an accuracy of 0.001 mm. However, as in the
previous work, the actual accuracy of the reading
was no better than several hundredths of a milli-
meter, since the observation of the meniscus was
made through eight dewar vessel walls. The shape
of the meniscus did not vary, and the guide line
was adjusted for some average position of the di-
vision line. The error, introduced by the deforma-
tions of the heterogeneous glass, and noted by us
earlier[1], was no greater than $\pm 2\%$.

The measurement proceeded in the following way.
After the temperature had reached the lowest point,
around 0.3°K, the pumping was stopped and the
liquid slowly warmed up. In the warming process,
regular measurements were taken of the vapor pres-
sure of He³ and the height of rise of the liquid in
the capillary. The warm-up time from 0.3° to 1.0°K
took approximately 2.5 hours.

The calculation of the coefficient of surface ten-
sion was made according to the equation $\alpha = \rho g r h /2$,
where the value of $\rho$, the density of liquid He³, was
taken from the paper of E. C. Kerr[3]. The results
obtained in the temperature interval 0.35-1.0°K, aver-
aged for the three capillaries, are shown in Fig. 1
together with earlier data[1]. Also shown are the re-
sults obtained by others[4,5]. As we can see from
the figure, the results from all three papers are in
satisfactory agreement. (The old data have been
recalculated using the new densities[3].)

The error in determining the value of the surface
tension in the region of very low temperature is ap-
proximately 5%. The maximum scatter of the indi-
vidual points is shown by the arrows on the figure.

As we can see from the graph, the surface ten-
sion of He³ below 0.6°K approaches its limiting
value equal to 0.152 dyne/cm. This value is 2.3
times smaller than the limiting value $\alpha_0$ for He⁴,
which is assumed to be equal to 0.35 dyne/cm on