current capability is $\sim 15\times 10^6$ amperes in 2.8 μsec with $dI/dt \sim 6\times 10^{12}$ amp/sec. With this apparatus, fields of 100 000–500 000 gauss have been generated with magnetic pressures up to $\sim$10 000 atmospheres in a single-turn coil with magnetic mirrors, producing high-energy radiation at the time of maximum current as observed through 2 cm Pb on a scintillation counter.[4,11]

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[11] *Note added in proof.*—A similar apparatus (Scylla) has been assembled at the Los Alamos Scientific Laboratory and measurements of neutron production have been reported by Boyer, Elmore, Little, and Quinn, Proceedings of the Geneva Conference on Peaceful Uses of Atomic Energy, Vol. 32, P/356 (1958); Elmore, Little, and Quinn, Phys. Rev. Letters **1**, 32 (1958).

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Absorption Spectrum of KCl:Tl at Low Temperatures

David A. Patterson
United States Naval Research Laboratory, Washington, D. C.

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The ultraviolet absorption spectrum of thallium in single-crystal potassium chloride has been accurately measured down to 187 mμ at 295°, 77°, and 4°K. The asymmetry apparent in both major bands at room temperature disappears at low temperature. The existence of two kinds of singlet thallium centers in slightly different crystalline environments is suggested as a possible explanation.

The general structure of the optical absorption spectra characteristic of thallium in alkali halide crystals has been known for some time. It consists of two principal bands called the *A* and *C* bands and a much weaker *B* band ($\lambda_A > \lambda_B > \lambda_C$). These absorptions and two emission bands associated with them have been ascribed to a center composed of a substitutional thallium ion and its chlorine nearest neighbors. A "configuration coordinate diagram," which gives the energy levels of the center as functions of a distance parameter, has been proposed by Seitz and developed quantitatively for KCl:Tl by Williams to explain the center's behavior. Inherent in the model is the assumption that the absorption and emission bands are simple and Gaussian in shape. Recent excitation data[1] have indicated that another more complex center is active in the *A*-band region and is responsible for the visible emission band. The present absorption data show further complexity in both *A* and *C* bands. The absorption measurements were made with a Cary model 14M recording spectrophotometer with which considerably greater accuracy and detail can be obtained than has been previously available, particularly in the short-wavelength *C* band. The data were taken at 295°, 77°, and 4°K using a Dewar described elsewhere.[2] The single crystal used was grown by the Kyropolous technique and had a Tl concentration in the crystal of about 19 ppm. Results of identical runs without samples were subtracted from the data before plotting.

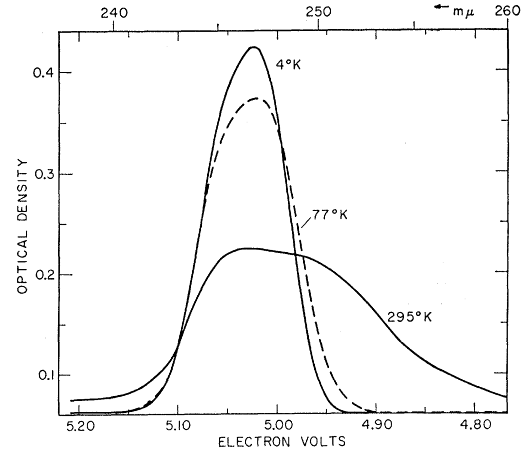

Fig. 1. The *A*-band absorption in KCl:Tl.

The *A* band is shown in Fig. 1. The general behavior with temperature is similar to that of the excitation spectrum for ultraviolet emission[1] and to previously published absorption data.[3] The absorption half-width at room temperature (0.202 ev) matches Johnson and Studers'[3] value very well. The low-temperature half-widths however are about 15% lower, with measured values of 0.107 ev at 77° and 0.094 ev at 4°K. In addition, the band at low temperatures is very nearly symmetric, in contrast to the obvious asymmetry found at room temperature. Thus it is apparent that the room-temperature absorption half-width must not be used to compute or check the simple configuration

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[1] D. A. Patterson and C. C. Klick, Phys. Rev. **105**, 401 (1957); K. H. Butler, J. Electrochem. Soc. **103**, 508 (1956).

[2] G. A. Russell and C. C. Klick, Phys. Rev. **101**, 1473 (1956).

[3] P. D. Johnson and F. J. Studer, Phys. Rev. **82**, 976 (1951).

coordinate curves for the center which assume a single symmetric band. Klick and Schulman[4] have shown that the configuration coordinate curves can be computed from the low-temperature peak positions and half-widths of the absorption and emission bands. The physical significance of the resulting curves can be evaluated by using them to compute the room-temperature *emission* half-width and comparing it with the experimental value. We shall use the notation U for peak position, H for half-width and the subscripts A and E for absorption and emission. When the 4°K experimental values ($U_A=5.024$ ev, $U_E=4.120$ ev $H_A=0.094$ ev and $H_E=0.32$ ev) are used to derive the ground ($^1S_0$) and first excited ($^3P_1$) states in the configuration coordinate diagram, the resulting computed H_E at 295°K is 0.71 ev. This is to be compared with the experimental value of 0.54 ev and represents somewhat closer agreement than a previously published value of 0.91 ev.[5]

Since the A-band absorption asymmetry disappears at low temperatures and the equations of the configuration coordinate curves are obtained using these low-temperature, single-band data, it should be interesting to use these equations to compute the (single band) absorption half-width to be expected at room temperature. The resulting calculated value of $H_A=0.163$ ev seems reasonable since it is less than the experimental (complex band) value of 0.202 ev. If a qualitative resolution of the complex, room-temperature A band is now carried out assuming a symmetric band peaked at 247 mμ with this calculated half-width, a second band with a maximum at about 253 mμ results.

The B and C bands lie in a spectral region which is inaccessible to most instruments with the result that good, detailed data on the bands have been lacking. The Cary spectrophotometer used in this work extends to 185 mμ and has made accurate study of the bands possible. The measurements have been extended to 4°K and are plotted in Fig. 2. The temperature-dependent behavior is quite similar to that of the A band in Fig. 1. At 295°K, both figures show a broad band with marked asymmetry on the low-energy side. At low temperature, both sharpen into nearly symmetric, apparently single bands. The experimental C-band half-widths are 0.38, 0.234, and 0.207 ev at 295°, 77° and 4°K, respectively. The values at 295° and 77° are 25–30% less than those previously published[6] and no 4°K values are available for comparison.

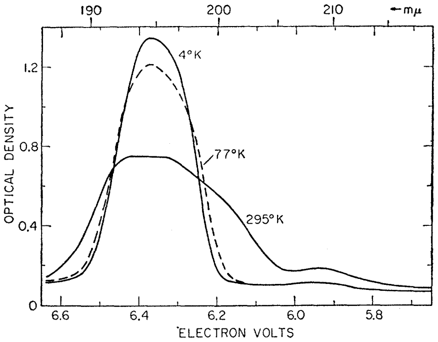

FIG. 2. The B- and C-band absorptions in KCl:Tl.

Recently Eppler and Drickamer[7] have found that, accompanying the phase change (NaCl-type to CsCl-type) induced by pressure in KCl:Tl, there is a discontinuous shift (by about 5 mμ) of the A band to higher energy. This structure dependence, plus the fact that TlCl has the CsCl-type structure, suggests that a partial explanation of the complex absorption bands might be the existence of two kinds of singlet thallium centers, one in NaCl-type surroundings and another in a local CsCl-type environment. Assuming this picture, the disappearance of the low-energy components at low temperatures in Figs. 1 and 2 might indicate that CsCl-type centers are preferred at low temperature. Similarly, the disappearance of the low-energy component in the excitation spectrum observed in crystals with very low (<1 ppm) Tl concentrations could be interpreted as meaning that the CsCl-type center is also preferred at low concentrations. Results of further studies of the effects of temperature and thallium concentration will be reported at a later date.

ACKNOWLEDGMENT

It is a pleasure to acknowledge the continued interest and assistance of Dr. C. C. Klick with whom the structure-sensitive, two-center idea originated.

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[4] C. C. Klick and J. H. Schulman, J. Opt. Soc. Am. **42**, 910 (1952).

[5] F. E. Williams, J. Chem. Phys. **19**, 457 (1951).

[6] P. D. Johnson, J. Chem. Phys. **22**, 1143 (1954).

[7] R. A. Eppler and H. G. Drickamer, J. Phys. Chem. Solids **6**, 180 (1958).