Massachusetts Institute of Technology, for the absorption measurements in the 0.8μ to 7μ region.

* Sponsored by the ONR, the Army Signal Corps, and the Air Force under ONR contract.

[1] Courtesy of the National Lead Company, Titanium Division, Research Laboratory, South Amboy, New Jersey.

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Absorption Spectrum of Thallium-Activated Potassium Chloride Phosphor at Low Temperatures

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AN important feature of recent quantitative theoretical work on solid-state luminescence is the effect of zero-point energy in maintaining broad absorption and emission spectra at low temperatures.[1] A comparison of experimental optical absorption of KCl:Tl in the band near 5 ev due to Tl^+, reported here, with calculated absorption indicates the existence of zero-point energy[2] of the calculated order of magnitude.

A clear crystal of KCl:0.00021 Tl grown from the melt in a furnace of the type described by Strong[3] is clamped in the copper sample holder of the cooling apparatus shown in cross section in Fig. 1. The only openings in the holder are two 3×5-mm rectangles

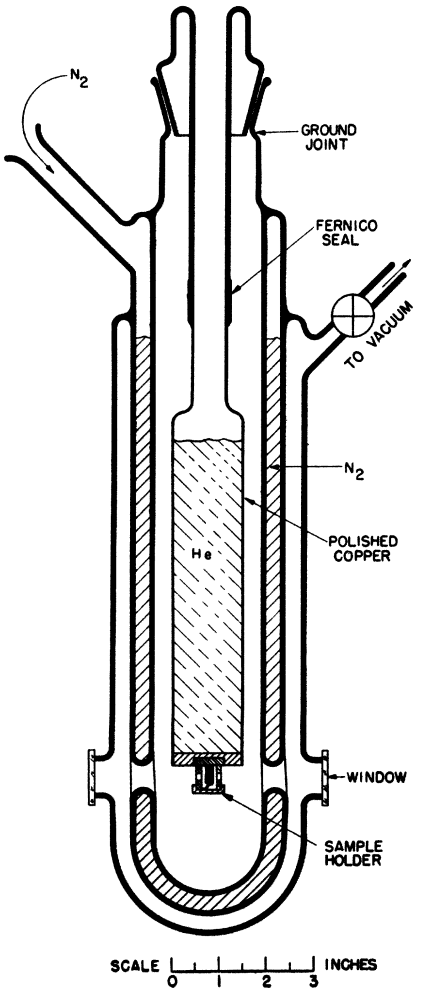

FIG. 1. Apparatus for optical absorption of crystals at liquid helium temperature.

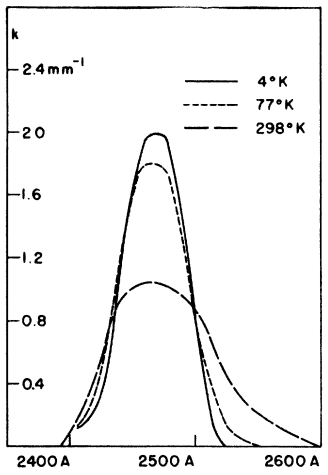

FIG. 2. Absorption spectrum of KCl:Tl as a function of temperature.

to allow passage of transmitted light. An advantage in the construction of this apparatus is that there are only two quartz windows in the optical path. These, being at room temperature, can be attached with vacuum sealing wax. Except for the inner container, the apparatus is of Pyrex, silvered on all surfaces exposed to the vacuum. The apparatus with crystal in position is placed between a low voltage hydrogen discharge lamp and the entrance slit of a recording grating spectroradiometer. Heating of the crystal by the hydrogen lamp is found to be negligible. Recordings of the light from the source transmitted by the crystal at room temperature, then with liquid N_2 in both coolant containers, and finally with liquid helium in the inner container are obtained. From these and a recording of the unattenuated output of the hydrogen lamp, the absorption as a function of wavelength at the various temperatures as given in Fig. 2 is determined. The error in estimation of half-widths of the absorption band is less than 10 percent. On continued irradiation by the hydrogen lamp at 77°K or 4°K a weak absorption band not shown in Fig. 2, possibly due to V-centers,[4] developed in the crystal with peak at 2340A. The thallous ion absorption reported here has been obtained taking care to minimize development of V-centers, since the two absorption bands overlap to some extent.

Table I compares the experimental half-widths in electron volts with the calculated values. If zero-point energy is neglected, only the 4°K half-width is affected appreciably, being reduced to 0.031 ev. There is no doubt that the experimental values can be reconciled only with the values calculated using zero-point energy; and the zero-point energy used in the calculations must be of the correct order of magnitude. It should be pointed out also that the experimental variation with temperature in peak height of absorption shown in Fig. 2 agrees well with the calculated absorption.[1] The area under the absorption curve is substantially independent of temperature, the oscillator strength being 0.06 in all cases.

TABLE I. Absorption half-width.

Temp.	Experimental	Calculated
4°K	0.108 ev	0.122
77°K	0.127	0.132
298°K	0.204	0.193

We are indebted to Dr. M. D. Fiske of the cryogenic laboratory for assistance and advice in designing the double vacuum flask and in the use of liquid helium.

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