Emission Spectra of KI:Tl at 12°K*

R. EDGERTON† AND K. TEEGARDEN‡
Institute of Optics, University of Rochester, Rochester, New York
(Received 27 August 1963; revised manuscript received 29 June 1964)

Emission spectra were measured for separate excitation by light absorbed in the *A*, *B*, *C*, and *D* impurity absorption bands of single crystals of KI:Tl at 12°K. Five emission bands are reported. Three emission bands are identified as direct transitions from the energy levels related to the *A*, *B*, and *C* absorption bands. Excitation in the *D* absorption band is found to excite an additional low-energy emission band which corresponds to a forbidden transition in absorption.

INTRODUCTION

WE have recently reported the emission spectrum of KI:Tl at 12°K for excitation in all the impurity absorption bands simultaneously.[1] Below 35°K several emission bands are present that are quenched at higher temperatures. Emission spectra for excitations by absorption of light in each of the impurity absorption bands separately at 12°K are reported in this article.

The experimental techniques are similar to those reported previously[1] except that the sample was irradiated with monochromatic light using a hydrogen arc (Nester lamp) and a monochromator (Bausch and Lomb, plane grating, blazed for around 2200 Å, dispersion 33 Å/mm). Using a band pass of 17 Å it was possible to excite the sample with light absorbed in each of the absorption bands separately.

EXPERIMENTAL RESULTS AND DISCUSSION

Absorption of light in the A absorption band produces an emission spectrum as shown in Fig. 1. In addition to the single, intense emission band peaking at 3356 Å (3.69 eV), there is a very weak amount of emission in the region of 4300 Å. Note the scale change by a factor of 30.

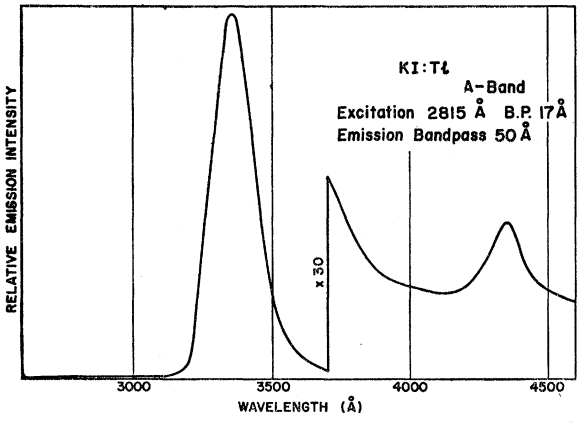

FIG. 1. Emission spectrum of KI:Tl at 12°K excited by light absorbed in the A band at 2811 Å with band pass of 17 Å.

The emission spectrum for absorption of light in the B band is shown in Fig. 2. An emission band peaking at approximately 2870 Å (4.32 eV) is observed in addition to the emission band referred to above at 3356 Å. The 2870-Å emission band shows some reabsorption in the region of the A absorption band. This reabsorption would account for some or all of the emission in the 3356-Å band. It is also possible that some of the 3356-Å emission is due to a thermal transition to the level responsible for the A absorption band.

The emission spectrum for absorption of light in the C band is shown in Fig. 3. An emission band peaking at some value under the A absorption band is observed. An estimate of the approximate peak value of this emission band is 2783 Å (4.45 eV). The reabsorption of this emission will lead to the emission at 3356 Å. In addition to these two emission bands, weak emission bands at 3078 Å (4.06 eV) and 4300 Å (2.88 eV) are observed. Thermal transitions may play a role in the appearance of these emission bands.

The emission spectrum for absorption of light in the D band is shown in Fig. 4. For this excitation energy the 4300-Å (2.88 eV) emission band is very intense. The presence of the 4300-Å (2.88 eV) emission band in Fig. 3 is primarily due to the overlap of the D absorption band with the C absorption band. The 3356-Å emission band

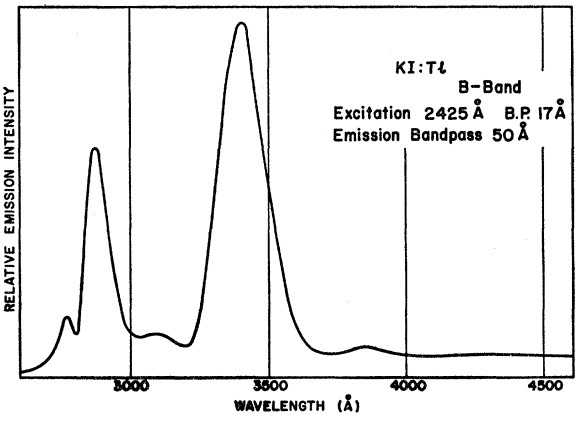

FIG. 2. Emission spectrum of KI:Tl at 12°K excited by light absorbed in the B band at 2430 Å with band pass of 17 Å.

* Supported in part by the U. S. Army Research Office, Durham, North Carolina.
† Present address: Physics Department, Carleton College, Northfield, Minnesota.
‡ Alfred P. Sloan Foundation Fellow.
[1] R. Edgerton and K. Teegarden, Phys. Rev. **129**, 169 (1963).

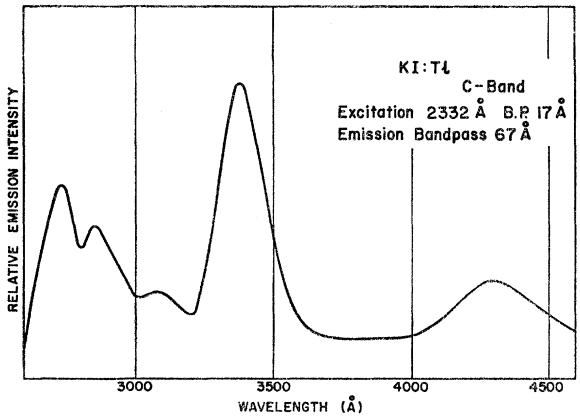

FIG. 3. Emission spectrum of KI:Tl at 12°K excited by light absorbed in the C band at 2325 Å with band pass of 17 Å.

shown in Fig. 4 is excited directly by absorption of light in the D band. This was observed by noting that the excitation spectrum of the 3356-Å emission band showed peaks at the positions of both the C and D absorption bands. The presence of the weak amount of emission in the region of the A absorption band could be due either to the small overlap with the C absorption band or to weak direct excitation of the 2870-Å emission band by light absorbed in the D band.

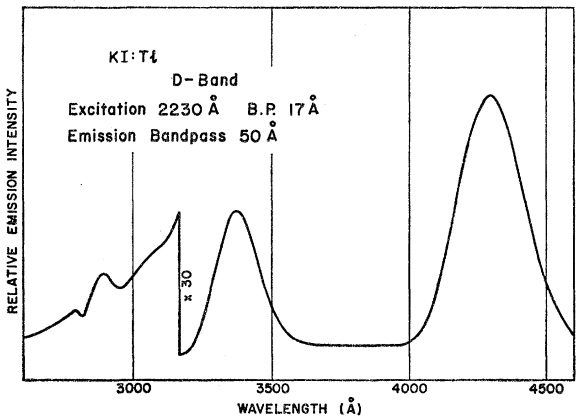

FIG. 4. Emission spectrum of KI:Tl at 12°K excited by light absorbed in the D band at 2238 Å with band pass of 17 Å.

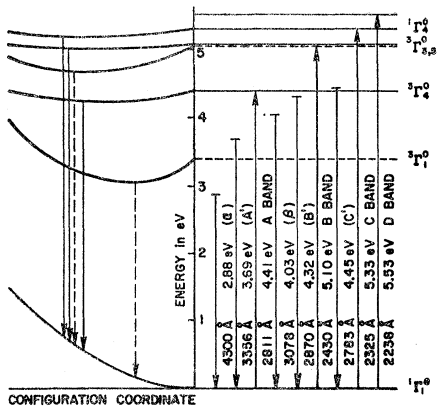

FIG. 5. Suggested configuration coordinate diagram using absorption and emission energy values of KI:Tl at 12°K. Values of the absorption bands (A, B, C, and D) and emission bands (A′, B′, C′, α, and β) are indicated on the right.

The five emission bands observed can be described by the model proposed in our previous paper.[1] Each of the five excited states of the thallous ion in a cubic field. Figure 5 is a configuration coordinate sketch which illustrates that model. The positions of the absorption and emission bands which are indicated on the right-hand side of the figure are the only data that is used to construct the diagram.

Excitation in the D absorption band does not result in the center being in an additional higher energy excited state. Instead, the center makes some sort of internal transition and the result is the population of the two lowest excited states of the center. It is a curious fact that at temperatures below 30°K the only excitation energy that results in the population of the lowest energy level, the $^3\Gamma_1^\circ$ level, is the highest energy impurity absorption band, the D band.

Experiments on the polarization properties of the emission when excited with polarized light have corroborated the identification of the 3356-, 2870-, and 2783-Å emission bands as direct radiative decays from the levels associated with the A, B, and C absorption bands.