## SPECIAL ARTICLES

### PHOTOIONIZATION OF CAESIUM VAPOR[1]

SERIOUS discrepancies between the results of different observers on the continuous absorption and photoionization of alkali vapors have indicated the desirability of repeating the photoionization experiments. Mohler, Foote and Chenault[2] have published measurements of the relative photoelectric sensitivity of caesium vapor using the effect of positive ions on a negative space to detect ionization. Later, Little[3] made direct measurements of the photoionization. There is fair agreement as to the form of the sensitivity curve but Little's absolute value of the atomic absorption coefficient, $2.2 \times 10^{-21}$, is surprisingly low.

The atomic absorption coefficient $k(\nu)$ at a frequency $\nu$, derived by equating the number of quanta absorbed to the number of ions produced, is:

$$k(\nu) = Ih\nu/eNpl\, J(\nu)$$

where $I/e$ is the number of ions, $J(\nu)/h\nu$ the number of quanta incident, $Np$ the number of atoms per cc and $l$ the length of the ionization chamber.

The ionization chamber was designed to reduce to a minimum the surface photoelectric effect of the radiation. The anode was a cylinder 8 cm long and 3 cm in diameter with holes 1 cm in diameter in each end. The cathode was a strip 1 cm wide, and nearly as long as the cylinder, placed a few millimeters from the side of the cylinder. This served as the receiving plate and was protected by guard rings from surface leakage. The containing tube was quartz with a flat window at one end and a horn-shaped light trap at the other end. The body of the tube was held at about 220° C. while an appendix containing the caesium was kept at some lower temperature by a separate electric heater.

The beam of light from a circular diaphragm in front of a mercury arc (110 volt uviarc) focused by a quartz fluorite achromat was small enough to pass through the holes in the anode cylinder without striking them. The image just filled the receiving surface of a disk thermopile which could be placed at the position of the ionization chamber. The thermopile calibration was determined under operating conditions by means of a radiation standard.[4]

Since the sensitivity curve of caesium is known it was not essential to use monochromatic radiation provided the spectral energy distribution was known. This was measured with a Bausch and Lomb monochromator and a linear thermopile. Comparison of the photoionization and the radiation flux was based on the effect of radiation from the mercury arc passed through a water cell and Corning purple glass G986 A. The caesium sensitivity has a maximum at the limit 3184 A and drops rapidly to about 15 per cent. of this value at 2700 A. Mercury lines on the red side of 3130 A give no ionization while 3130 has by far the greatest effect of all the lines. The purple glass transmits mercury lines from 4047 to 2967 A, while a filter of the purple glass and ordinary window glass cuts out 3130 and all lines of shorter wavelength. The addition of window glass to the filter reduces the photoionization to zero and the thermopile readings to about 50 per cent. of the effect with purple glass alone. It was found that about 31 per cent. of the arc radiation transmitted by the purple glass was 3130 while 78 per cent. of the photoionization came from 3130. On the basis of these data and corrections for absorption in quartz windows, k for 3130 has been computed from measurements of the ion current at caesium pressures ranging from .005 to .06 mm (146 to 201° C.). Pressures were computed from an equation based on data by Kroner:[5]

$$\log\ p = -3966/T + 7.165$$

The currents were proportional to the pressure within experimental error and gave a mean value of $k\ (3130) = 1.85 \times 10^{-19}$. This proportionality and the absence of any effect with lines on the red side of 3130 confirm the absence of any surface effect. Measurements with radiation resolved by a monochromator check this value with somewhat lower precision. On the basis of the spectral sensitivity curve we derive the value $k\ (3184) = 2.3 \pm .2 \times 10^{-19}$. The error comes largely from uncertainty in measuring the temperature of the caesium while uncertainties in the vapor tension data introduce a considerably larger error not included in the estimated error.

The discrepancy between our result and Little's value ($k(3130) = 2.2 \times 10^{-21}$) is not understood. Experimental magnitudes were about the same in his work as in ours except as concerns the observed ion current, which was about fifty times as large in our experiment. Little's methods were in many respects more accurate than ours but various check experiments seem to rule out the possibility of any serious error in magnitude in our result. An insufficient amount of caesium or a trace of oxidation from a slight air leak can give rise to abnormally low values of vapor density and of k.

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[1] Publication approved by the director of the Bureau of Standards of the U. S. Department of Commerce.

[2] *Phys. Rev.*, 27: 37, 1926.

[3] *Phys. Rev.*, 30: 109, 1927, and correction note, p. 963.

[4] Coblentz, *Bull. Bureau Standards*, 11: 87, 1914.

[5] Rowe, *Phil. Mag.*, 3: 354, 1927.