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Mean Lives of Mercury Lines λ2537 and λ1849

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The mean life of the mercury line λ2537 was measured by the alternating voltage method previously described by Webb. The radiation was excited in a quartz tube by impact with electrons from a hot cathode. The photoelectric system was contained in a separate tube also of quartz. The photoelectric surface was zinc evaporated on a nickel plate. Measurements of the apparent life were made with diminishing mercury vapor pressures until further reduction of pressure produced no change in the measured rate of decay of the radiation. At these low pressures (below 3×10^{-4} mm, for the geometry used) the absorption and reemission of the radiation was negligible and the true life of a single excitation process was measured. This was found to be 1.08×10^{-7} sec. with an estimated precision of one percent.

Absorption coefficient of λ1849. An absorption cell with a one mm thick absorbing layer of mercury vapor was mounted so as to move in and out between the excitation and photoelectric tubes used in the above measurements. The absorption of λ1849 was measured at pressures such that the absorption of λ2537 was negligible. From this the atomic absorption coefficient for the main component of the line was found to be 6.2×10^{-11} from which the mean life of the 2^1P_1 state was calculated to be 2.9×10^{-10} sec. with an estimated precision of 25 percent.

SEVERAL determinations have been made of the mean life τ of the 2^3P_1 state in mercury, which results in the radiation of λ2537. Eldridge,[1] v. Keussler,[2] Olson[3] and Hanle[4] measured the depolarizing effect of a steady magnetic field on the light from a mercury resonance lamp illuminated with polarized light and from the rate of the Lamor precession and its effect on the polarization of the radiation calculated τ. They give the values 0.88×10^{-7} sec., 1.13×10^{-7} sec., 0.98×10^{-7} sec., and approximately 10^{-7} sec. respectively. Fermi and Rasetti[5] and Breit and Ellett[6] determined τ to be of the order of 10^{-7} sec. by finding the period of the alternating magnetic field at which the depolarizing effect disappeared. Tolman[7] derived a formula relating τ to the absorption of the line and from the absorption measurements of Fuchtbauer, Joos and Dinkelacker[8] calculated τ to be 1.03×10^{-7} sec. Kopferman and Tietze[9] and Zemansky[10] used Tolman's formula but assumed the shape and breadth of both the emission and absorption lines in calculating

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[1] J. A. Eldridge, Phys. Rev. **24**, 234 (1924).
[2] V. v. Keussler, Ann. d. Physik **82**, 793 (1927).
[3] H. F. Olson, Phys. Rev. **32**, 443 (1928).
[4] W. Hanle, Zeits. f. Physik **30**, 93 (1924).
[5] E. Fermi and F. Rasetti, Zeits. f. Physik **33**, 246 (1925).
[6] G. Breit and A. Ellett, Phys. Rev. **25**, 888 (1925).
[7] R. C. Tolman, Phys. Rev. **23**, 693 (1924).
[8] Chr. Füchtbauer, G. Joos and O. Dinkelacker, Ann. d. Physik **71**, 204 (1923).
[9] H. Kopferman and W. Tietze, Zeits. f. Physik **56**, 604 (1929).
[10] M. W. Zemansky, Phys. Rev. **36**, 219 (1930).

τ and found it to be 1.04×10^{-7} sec., and of the order of 10^{-7} sec., respectively. Ladenburg and Wolfsohn[11] measured the index of refraction of mercury vapor for wave-lengths very close to 2537A and calculated τ from a dispersion formula to be 1.14×10^{-7} sec. These methods are somewhat indirect. The first direct observation of the decay of the radiation was made by Wien.[12] The intensity of the radiation from the ions in a canal ray tube was found to fall off exponentially and from this rate of decay the mean life was calculated as 0.98×10^{-7} sec. Interpretation of his results is somewhat difficult since, due to the method of excitation, it is impossible to determine when and how the atom is excited to the state in question.

Webb and Messenger[13] investigated the persistence of $\lambda2537$ excited in mercury vapor by electron impact using the method described below. Due to absorption and reemission of the radiation the persistence changed with the concentration of mercury atoms through which the radiation passed. As the concentration was reduced the persistence approached a limiting value which is the mean life of the excited 2^3P_1 state. However the construction and sensitivity of their experimental tube did not permit a precise determination of τ. The present investigation was undertaken to make a more precise determination of τ using more sensitive and more advantageously designed apparatus.

METHOD

The method used was one previously developed in this laboratory[14] in which the excitation was produced by electron impact excited by alternating voltages in such a way that excitation occurred only during the positive half cycles. The radiation was detected by a photoelectric system to which were applied alternating voltages of the same frequency and phase as those applied to the excitation system so that there was practically no current to or from the photoelectric surface during the negative half cycles. For very low frequencies ("zero frequency") practically all the energy is radiated during the positive half cycle and there is a maximum photoelectric current; while as the frequency is increased, due to persistence of the radiation, an increasing fraction of the energy arrives at the photoelectric system during the negative half cycles, so that the resulting electrometer current is decreased. For the photoelectric system used, at infinite frequency the current dropped to approximately 50 percent of its value at "zero frequency." The relation of the electrometer current to the frequency is usually expressed as the variation with the frequency of the ratio, R, of the electrometer current at any given frequency to that at "zero frequency," and will be referred to below as the "R-frequency" curve. To calculate τ from this relation it is necessary to assume the law governing the falling off of the radiation after the instant of excitation. It is assumed throughout that this law follows an exponential rela-

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[11] R. Ladenburg and G. Wolfsohn, Zeits. f. Physik **65,** 207 (1930).

[12] W. Wien, Ann. d. Physik **73,** 483 (1924).

[13] H. W. Webb and H. A. Messenger, Phys. Rev. **33,** 319 (1929).

[14] H. W. Webb, Phys. Rev. **24,** 113 (1924); F. G. Slack, Phys. Rev. **28,** 1 (1926); reference 13; R. H. Randall, Phys. Rev. **35,** 1161 (1930).

tion and from the form of the excitation-time curve of the excitation system and the characteristics of the photoelectric system the value of τ may be determined by suitable integrations from the R-frequency curves. In the simple case where the excited radiation varies with the time according to a sine law during the positive half cycle and the photoelectric current falls from saturation value to zero immediately after the reversal of the voltage, these integrations can be made analytically and we find that:[15]

$$1/\tau = 2\pi f_{1/2} \tag{1}$$

where $f_{1/2}$ is the frequency at which the R-frequency curve has dropped halfway to its final value at infinite frequency. If the above conditions do not obtain then the integrations involved in calculating τ must be done either partially or completely by graphical methods. However in most cases τ is given by Eq. (1) to within 10 percent.

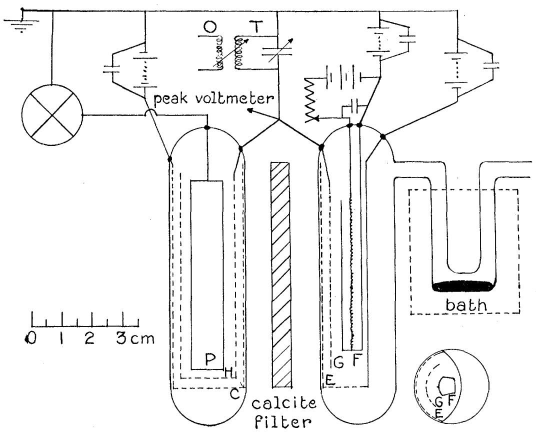

Fig. 1. Schematic diagram of apparatus and electrical circuits.

APPARATUS

The excitation and photoelectric systems were put in separate experimental tubes. This had the advantage that no metastable atoms excited by electron impacts could reach the photoelectric surface and there set electrons free, and the further great advantage that the path through mercury vapor traversed by the radiation was shortened and hence the chance of absorption and reemission was greatly reduced. Fig. 1 is a schematic diagram of the apparatus showing the essential parts drawn to scale.

The excitation system was in a tube of fused quartz containing three electrodes, F, G and E. F was a hollow, unipotential, hot cathode made of platinum sheet with a tungsten heater down the center. The surface facing G was coated with oxide. G was an accelerating grid made of 0.17 cm mesh nickel gauze. E was a shielding grid made of 0.34 cm mesh nickel gauze with a nickel sheet portion back of F. This experimental tube was connected to a

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[15] Reference 13, pp. 321–322.

mercury diffusion pump which was operating whenever observations were being taken. Between this tube and the pump, surrounded by a bath in a Dewar flask, was a mercury well which controlled the vapor pressure in the excitation system. The temperature of the bath was thermostatically controlled so that it could be held constant to within 0.3°C at any given temperature from 0°C to −40°C. When the bath was used at temperatures below environment the necessary cooling was obtained by a copper rod which made thermal connection between the bath and a hopper filled with carbon dioxide snow. The size of the rod was so chosen that it carried off heat a little more rapidly than the bath gained heat from the surroundings which difference was supplied by a small electric heater controlled by the thermostat. A mechanical stirrer was used.

The photoelectric system was in a tube of fused quartz and contained three electrodes *P*, *H* and *C*. *P* was the light sensitive surface and was a nickel cylinder onto which a film of zinc had been evaporated. *H* was a collecting grid of 0.17 cm mesh, and *C* a shielding grid of 0.34 cm mesh nickel gauze. In preparing this tube it was baked at 450°C and pumped for several hours before the zinc was deposited. While depositing the zinc the cylinder *P* was cooled by passing water through a reentrant tube (not shown on the diagram) while the rest of the system was kept hot. A freeze-out trap between the tube and the pump was immersed in liquid air which prevented any mercury from going into the photoelectric system. This tube was sealed off with residual gas at a pressure of less than 10^{-5} mm of mercury.

Zinc was chosen for the surface *P* since radiations of wave-length longer than about 3000A do not effect it appreciably. Between the excitation and photoelectric tubes was placed a filter 10.5 cm long 2.0 cm wide and 0.7 cm thick made of calcite split from a large block so that the surfaces were unscratched. Calcite absorbs radiations shorter than about 2100A. Hence only radiations from the excitation tube lying between 2100A and 3000A produced any appreciable photoelectric current.

The cathode was heated by a 12 volt storage battery and all other d.c. voltages were supplied by small dry cells. The alternating voltages were supplied by two vacuum tube oscillators, 0, using the Hartley circuit. One had a fixed frequency of 40,000 cycles (equivalent to "zero frequency" for the mean life of $\lambda 2537$) and the other one was variable from 10^5 to 10^7 cycles. Care was taken to keep the wave form of these voltages simple sinusoidal. The voltage applied to the experimental tubes was the drop across the condenser in a tuned circuit, *T*. This circuit was tuned sharply and was coupled inductively to the oscillators with the coupling very loose. In order that the a.c. component of the emission current which passed through this circuit should not effect the wave form of the voltage applied to *G* and *H*, the coil was made with very few turns and the condenser was correspondingly large. The tests for wave form described in earlier papers[16] were made for each frequency. These tests are very necessary when high frequencies are used. They indicated that at no time was error introduced due to faulty wave form.

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[16] H. W. Webb, reference 14, pp. 119–120.

G and H were connected directly and given the same a.c. voltage since with any other circuit indeterminable phase shifts between them were difficult to avoid when using high frequencies. A peak voltmeter with a microammeter in the grid circuit was used to measure the amplitudes of these voltages. With this circuit the peak voltage could be measured to one percent and when determining the ratio of the electrometer current at high to that at the reference low frequency the peak voltages at the two frequencies could be made the same to within one tenth of one percent. The frequency was measured to within one half of one percent with a wavemeter which was calibrated against the harmonics of a known oscillator.

The photoelectric currents were measured with a Compton quadrant electrometer of about 8000 mm per volt sensitivity.

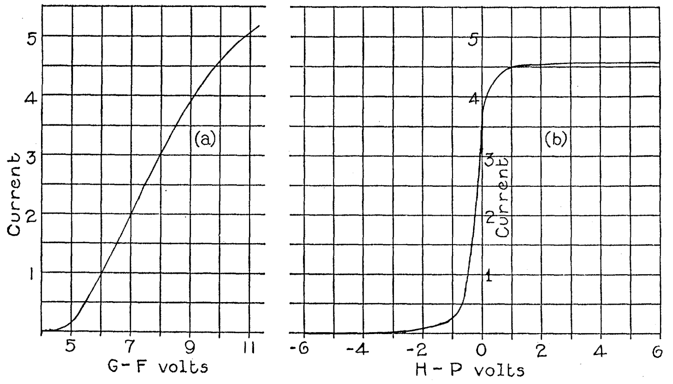

Fig. 2. Curve (a), typical excitation curve. Curve (b) photoelectric characteristic.

Experimental and Results

In determining the R-frequency curves the procedure was as follows. With liquid air around the mercury well the excitation tube was baked at 400°C for several hours to make sure that no drops or films of mercury remained in the tube. The mercury well was then immersed in the bath which had previously been set at the desired working temperature which was held constant throughout a series of observations. To ensure equilibrium no observations were taken until at least twleve hours after immersion in the bath. The steady current characteristics of the excitation and photoelectric tubes were then found. Typical curves showing these characteristics are reproduced in **Fig. 2.** In determining the characteristic excitation curve, (a) Fig. 2, which gives the relation of the accelerating voltage of the electrons in the excitation system to the excitation of radiation as measured by the photoelectric effect, E and F were always at the same voltage which voltage was negative and variable. The other voltage conditions were: $G=0$, $C=7.5$, $H=9.0$, and $P=0$ volts. For the photoelectric characteristic curve, (b) Fig. 2, which shows the variation of the photoelectric current with the voltage $H-P$ for constant radiation falling on the surface, the conditions were: $E=F=-10.0$, $G=0$, $C=7.5$, $P=0$, and H variable from -6.0 to $+6.0$ volts. After making the tests for wave form and proper functioning of the apparatus, the electrodes, F and E were set at -5.1 volts, G, H and P at zero volts and an alternating voltage, usually 6.0 volts peak value, was impressed on G and H. The ratio R of the electrometer current at high frequency to that at the reference low frequency was then determined as a function of the frequency. An example of the resulting R-frequency curve is shown in (a) Fig. 3 where the ordinates are the current ratios and the abscissas are the frequencies. From this curve τ was calculated by the use of Eq. (1).

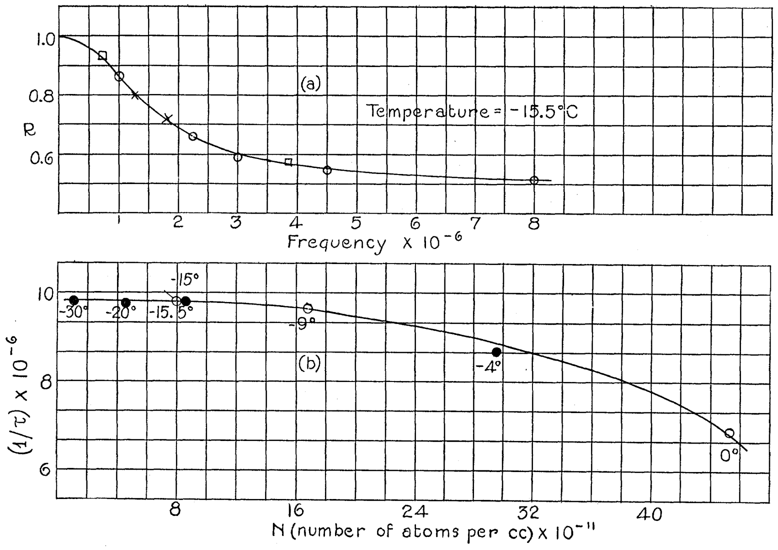

Fig. 3. Curve (a), typical R-frequency curve. Curve (b) persistence of λ2537 vs. concentration.

Following the same procedure as above τ was determined for different mercury vapor pressures in the excitation tube. Its variation with the concentration of mercury atoms is shown in curve (b) Fig. 3 where the values of the reciprocal of τ are the ordinates and the mercury vapor concentrations are the abscissas. The temperatures marked on the curve are those of the mercury well while N is the concentration after correcting for the temperature of the excitation tube. It will be noted from the curve that for values of N greater than 8×10^{11} τ begins to increase being about 40 percent larger at 0°C than at -15°C. The rate of increase of τ with vapor pressure (due to absorption and reemission which lengthens the apparent life) is determined by the depth and shape of the layer of mercury vapor passed through by the radiation and is therefore dependent on the geometry of the excitation tube. The particular curve shown includes data from excitation tubes in which the emergent radiation had traversed layers of vapor of approximately the same thickness. This curve shows that at well temperatures less than about -15°C a further decrease in pressure produces no measureable change in τ so that the persistence measured at these pressures is the mean life associated with the initial excitation and radiation process. It should be noted that the values of τ

shown on this curve are uncorrected for the departure from a simple sinusoidal form of the excitation-time curve (i.e., the relation of the excitation to the time during the positive half cycle) and for the difference of the actual photoelectric current characteristic from the ideal one assumed in deriving Eq. (1). (Actually this current dropped from maximum to zero in about one sixth of a period instead of immediately after the reversal of the voltage.)

A precise determination of the mean life was then made. With a well temperature of $-20°C$ the steady current characteristics of the experimental tubes were carefully determined. It was found that the excitation-time curve could be expressed with necessary precision by the first three terms of a sine series extending through the positive half cycle. Assuming that radiation excited at time $t=0$ decreased according to the exponential $e^{-t/\tau}$, and integrating over the excitation-time curve the emission of the radiation as a function of the time was found for a given frequency. This integration was done analytically. By multiplying the radiation arriving at the photoelectric surface at successive times by the corresponding ordinates of the experimentally determined photoelectric characteristic, the relation of the photoelectric current to the time was then found. The integration of this curve gave the electrometer current. This latter integration was necessarily done graphically. This calculation was carried out for the reference low frequency and for several frequencies near the half value ($f_{1/2}$) so that the form of the R-frequency curve as a function of the product of this frequency and the unknown τ, was accurately known in this region. The ratio R was then determined experimentally for several frequencies near the half value. Thirty observations of R were taken for each frequency which determined the values of this ratio with a precision of one percent. From these values and the calculated curve the value of τ, the mean life of the 2^3P_1 state, was found to be 1.08×10^{-7} sec. with an estimated precision of one percent.

These measurements of τ might be in error if transitions other than $1^1S_0-2^3P_1$ were present in sufficient amounts. If the radiation associated therewith produced appreciable photoelectric action and the mean life were different from that being measured, or if the transitions were to the 2^3P_1 state whether the corresponding radiation effected the photoelectric surface or not, the persistent radiation would vary with the time in a more complex way (due to the several lives involved) and the R-frequency curves would not have the form calculated above. The lines λ2655, $2^3P_1-4^1D_2$ and λ4358, $2^3P_1-2^3S_1$, are two possible cases of transitions followed by $1^1S_0-2^3P_1$. We know that the mean life of $2^3P_1-2^3S_1$ is approximately one half of that of the 2^3P_1 state[17] and would expect a measureable delay in the emission of λ2537 if the 2^3S_1 state were excited to a marked degree. Experimentally however these curves were always found to have the calculated form. A further test was made by determining the ratio R at a given frequency with the peak value of the alternating voltage at 6.0; 5.0, 4.0, and 2.5 volts in turn. If transitions other than $1^1S_0-2^3P_1$ were effecting τ appreciably R would change with the above changes in voltage. No such change was observed. These tests indi-

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[17] R. H. Randall, reference 14, p. 1167.

cate then that the persistence measured is the true mean life of a single atomic process in question.

ABSORPTION COEFFICIENT OF λ1849

The apparatus used in the measurement of the life time of λ2537 was, with minor changes, found to be adaptable for the measurement of the absorption coefficient of mercury vapor for λ1849, and so a determination of this quantity was made in order to form an estimate of the mean life of the 2^1P_1 state. The calcite filter used cut out 30 to 60 percent (depending on the excitation voltage) of the total radiation excited in the excitation tube. This radiation was of wave-length shorter than about 2100A, for the most part λ1849. As found above the absorption of λ2537 is negligible by layers of mercury vapor not thicker than 3 or 4 mm and concentrations not greater than 8×10^{11} atoms per cc, while the absorption of λ1849 is of a convenient magnitude for measurement.

A screen with a 1.3 cm aperture was put immediately in front of the photoelectric tube which was placed 7.5 cm from the excitation tube. Midway between the photoelectric and excitation tubes was placed the absorption cell which was made by cementing into a metal frame two circular plates of crystal quartz 3 mm thick and 50 mm in diameter. The inner surfaces were one mm apart so that this was the thickness of the absorbing layer of mercury vapor. The absorption cell was connected to a mercury well, similar to that described above, which was connected to a mercury diffusion pump. The absorption cell, the well and the pump were mounted together on a slide so that the absorption cell could be readily moved in and out from between the excitation and photoelectric tubes. To compensate for the absorption of the quartz walls, when the cell was out two plates of quartz identical with the walls of the absorption cell were substituted.

Before the absorption cell was sealed into the system the well was cooled to a temperature below the environment and kept thereafter at a low temperature in order to prevent the formation of films or drops of mercury in the cell. In order to insure equilibrium, whenever the pressure in the absorption cell was changed the bath was held at the desired temperature for at least 24 hours before observations were taken.

The voltages used on the excitation and photoelectric tubes were: $P=E=F=0$, $G=85.0$, $C=9.0$ and $H=6.0$.

With a calcite filter, the absorption-wave-length characteristics of which were known, it was found that about 45 percent of the radiation was greater than λ2100, that is λ2537 and possibly some λ2200, the balance being λ1849 and other radiation of wave-length less than λ2100, probably the spark line λ1942. Of these only λ1849 suffered appreciably absorption in the cell. The amount of λ1849 was approximately 35 percent but as it was not possible to determine this value with sufficient precision the measurements were so made that this was unnecessary.

Let E_0 be the amount of λ1849 which falls on the photoelectric surface when the absorption cell is not in and let C be the amount of unabsorbable radiation which falls on the photoelectric surface (which amount is constant), E_0 and C being measured in terms of photoelectric response. The total radiation falling on the photoelectric surface when the cell is out (i.e., when there is no absorption) is then E_0+C. Let E be the total amount of λ1849 falling on the absorption cell (also measured by photoelectric response) and let A be the fraction of it which is absorbed. Then the radiation falling on the photoelectric surface when the cell is in, is composed of three parts: (1) the unabsorbed portion of E_0 (2) the unabsorbable radiation C and (3) the part of AE which when reradiated reaches the photoelectric surface. If it is assumed that half the absorbed radiation goes forward and the other half goes back upon reradiation then this third part would be given by βAE where β is a fraction depending on the geometry of the apparatus. Let f be a function of the concentration in the cell which gives the ratio of the reradiated light which goes forward to that which would go forward if the above assumption were true. Then the radiation falling on the photoelectric surface when the absorption cell is in is: $E_0(1-A)+C+f\beta AE$ and the ratio r of the photoelectric response with the absorption cell in to that with the absorption cell out is:

$$r = \frac{E_0(1-A)+C+f\beta AE}{E_0+C} \tag{2}$$

from which:

$$A = \frac{(1-r)(1+C/E_0)}{(1-f\beta E/E_0)}\,. \tag{3}$$

Since the line has hyperfine structure A does not depend in a simple manner upon the absorption coefficients. If the components of the line do not overlap appreciably:

$$A = \frac{I_1A_1+I_2A_2+I_3A_3+\cdots}{I_1+I_2+I_3+\cdots} \tag{4}$$

where I_1, I_2, $\cdots$ are the intensities of the components and A_1, A_2, $\cdots$ are the absorptions experienced by each. Now if $(k_0l)_n$ is the product of the absorption coefficient for the center of the line and the thickness of the absorbing layer for the nth component it has been shown that:[18]

$$A_n = 1 - \frac{\displaystyle\int_{-\infty}^{\infty}\exp\left\{-\left[\omega^2(k_0l)_n e^{-(\Delta\nu_E/\Delta\nu\ \cdot\,\omega)^2}\right]\right\}d\omega}{\displaystyle\int_{-\infty}^{+\infty}\exp\left(-\omega^2\right)d\omega} \tag{5}$$

where l is the thickness of the absorbing layer and $\Delta\nu_E/\Delta\nu_A$ is the ratio of the breadths of the emission and absorption lines. Zemansky has evaluated the expression (5) for different values of $\Delta\nu_E/\Delta\nu_A$.[19] In the present experiments the breadth of both emission and absorption lines were due to Doppler

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[18] M. W. Zemansky, reference 10.

[19] Reference 10, pp. 222–224.

effect (since the natural breadth may be neglected within the precision of the experiment) and $\Delta\nu_E/\Delta\nu_A$ was calculated to be 1.2. In curve (a) of Fig. 4 A_n is plotted against $(k_0l)_n$ for this value of $\Delta\nu_E/\Delta\nu_A$.

From the work of Schuler and Keyston[20] we find for λ1849 a hyperfine structure of six resolved lines of relative intensities: 5.5:6.8:69.9:4.5:11.0:2.3 The first and fifth are due to isotope 199, the second, fourth and sixth to isotope 201 and the third is due to the five even isotopes unresolved. The fourth and fifth lie close together and may be taken as a single line in calculating absorption, but the others are sufficiently separated that with the Doppler breadths met with in this experiment their overlapping may be neglected.

If the absorptions of the different isotopes be assumed proportional to their concentrations and if the relative absorptions of the components from one isotope be assumed proportional to the statistical weights of the end states involved, we find, after combining the values for the fourth and fifth lines, the relative values of (k_0l) for the components to be: 0.079:0.098:1.00 :0.22:0.033. Using Eq. (4) and curve (a) Fig. 4 we can now compute A as a function of $(k_0l)_3$, the absorption coefficient of the strongest component. The result is shown in curve (b) of Fig. 4, the total absorption A being plotted as ordinates and $(k_0l)_3$ as abscissas.

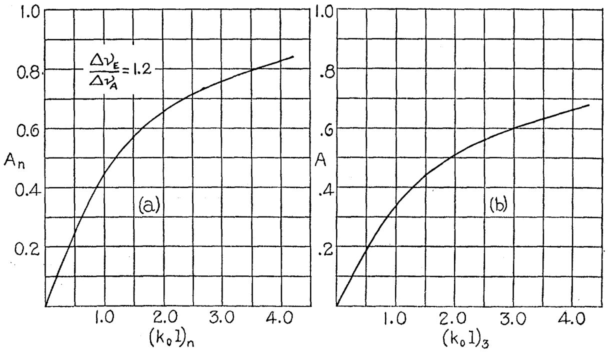

Fig. 4. Curve (a), absorption of single line vs. absorption coefficient. Curve (b), total absorption of λ1849 vs. absorption coefficient of strongest component.

To find the value of $(k_0l)_3$ as a function of Nl, the product of the total concentration of mercury atoms and the thickness of the absorbing layer, the procedure was as follows. The ratio r was measured for several concentrations in the absorption cell. The results are shown in curve (a) of Fig. 5 where the ordinates are the values of r and the abscissas are the products of the number of atoms per cc times the thickness of the absorbing layer. The three points indicated by circles were taken with a pressure in the excitation tube corresponding to a well temperature of −30°C. The points shown by the square and the triangle were taken with the pressure in the excitation tube decreased by 60 percent and increased by 60 percent respectively. That these points

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[20] H. Schüler and J. E. Keyston, Zeits. f. Physik **72**, 423 (1931).

fall on the same curve as the others shows that pressure effects such as broadening and reversal of the line in the excitation tube were negligible. The value of $\beta E/E_0$ was calculated from the geometry of the apparatus with a precision of about 15 percent. The function f was found by graphical integrations. With concentrations such that the absorption was very small f was unity and decreased slowly with increasing concentration, approaching zero as the concentration approached infinity. The value of C/E_0 could not, however, be obtained by measurements at very large values of N (for which A would be unity and f zero) since the absorption of λ2537 became appreciable and therefore C was no longer constant. Measurements of C/E_0 by means of filters was also subject to too large errors. Consequently C/E_0 was found by trial and was taken as the value which substituted in Eq. (3) and combined with the data of curve (a) Fig. 5 and curve (b) Fig. 4 gave most nearly a linear relation between $(k_0l)_3$ and Nl. The result is shown in curve (b) Fig. 5 which gives a value of $(k_0l)_3/Nl$ of 6.2×10^{-11}, or $(k_0)_3=6.2\times10^{-11}N$. From the steps taken in obtaining this value the precision is estimated as 25 percent.

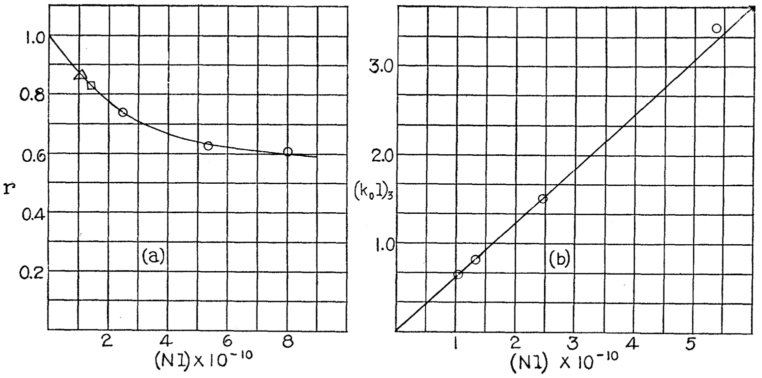

Fig. 5. Curve (a), ratio of photoelectric response with absorption cell in to that with it out vs. concentration times thickness of absorbing layer. Curve (b), absorption coefficient of strongest component vs. concentration times thickness of absorbing layer.

It has been shown that[21]

$$\sum (k_0l)_n = \frac{2}{\Delta\nu_A}\left(\frac{\ln 2}{\pi}\right)^{1/2} \frac{\lambda_0^2}{8\pi\tau}\cdot\frac{g_2}{g_1}\cdot Nl$$

where $\Delta\nu_A$ is the Doppler breadth of the absorption line, λ_0 is the wavelength of the center of the line g_2 and g_1 are the apriori probabilities of the states which give rise to radiation λ_0, and τ is the mean life of the excited state. Now $\Delta\nu_A=1.5\times10^9$ sec.$^{-1}$, $\lambda_0=1.85\times10^{-5}$ cm, and $g_2/g_1=3/1$.

Since the even isotopes have only one unresolved component we may obtain the value of τ for them (we have already assumed τ to be the same for all the isotopes) by putting on the left-hand side of the above equation the value of $(k_0l)_3$ found above and for N the concentration of the even isotopes, which is 0.699 times the total concentration of mercury atoms. We get then:

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[21] W. Zehden and M. W. Zemansky, Zeits. f. Physik **72**, 442 (1931).

$$\tau = 2.9 \times 10^{-10} \text{ sec.}$$

As estimated above the precision is about 25 percent. Ladenburg and Wolfsohn[22] by fitting constants into a three term dispersion formula found an f-value which led to a life for the 2^1P_1 state of 1.6×10^{-9} sec. The reason for the large disagreement between these two values is not evident.

The author wishes to express his thanks to Professor Harold W. Webb for suggesting this investigation and for his many suggestions and continued help throughout the experiment.

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[22] Reference 11.