Linear absorption has been used to measure the optical density for the hyperfine structure (hfs) of the 4046.56 and 4358.35 A lines of mercury.

The optical density $p$ is readily measured with the apparatus described in [1]; the quantity actually determined is $R = I' / I''$, the ratio of the intensities $I'$ and $I''$ (corrected and uncorrected for reflection respectively). $R(p)$ can be calculated from theory [2], and for the part of the curve suitable for deducing $p$ we have

$$ R(p) = 1 + g \left( \frac{2M_1(2p)}{M_1(p)} - 1 \right), $$

in which $M_1(p) = e^{-p} \left[ J_0(ip) - iJ_1(ip) \right]$, $J_0$ and $J_1$ being Bessel functions and $g$ the loss of light by reflection.

The line has a dispersion form:

$$ P(u) = \frac{\delta}{\pi(u^2 + \delta^2)}, \quad u = \nu - \nu_0. $$

Let the line consist of $n$ overlapping hfs components; then $R(p)$ is

$$ R^n = 1 + g \left( \frac{2[A M_1(2A p_n) - B M_1(2B p_n)]}{A M_1(A p_n) - B M_1(B p_n)} \right), $$

$$ A = \sum_{i=1}^{n} \frac{\beta_n}{\beta_i} + \sum_{\kappa=1+1}^{n} \alpha_{\kappa i} \frac{\beta_n}{\beta_k}, \quad B = \sum_{\kappa=1+1}^{n} \alpha_{\kappa i} \frac{\beta_n}{\beta_k}. $$

We assume that the components have the same half-width, the optical densities being proportional:

$$ \delta_1 = \delta_2 = \ldots = \delta_n = \delta, \quad p_1 = \beta_2 p_2 = \ldots = \beta_n p_n, \quad \alpha_{ik} = \frac{2}{\pi} \arccotg \gamma_{ik}, $$

in which $\gamma_{ik} = \frac{\nu_i - \nu_k}{\delta}$, $\nu_i$ and $\nu_k$ being the centers of components $i$ and $k$.

There is [3] a direct relation between $p$ and the concentration of unexcited Na atoms:

$$ p = \frac{\pi e^2}{2mc} P(0) l f Na, $$

in which $e$ and $m$ are the charge and mass of an electron, $l$ is the source diameter, and $f$ is the oscillator strength.

Several measurements [4-6] have been made of this concentration in terms of $p$; measurement of the line width can give $f$ in addition, as in [7, 8].

A graphical method [9] may be used to find the optical densities for overlapping components. We have applied this to the hfs components of the 4046.56 and 4358.35 A lines of mercury with an apparatus as mentioned above. The light source was an NVO-500 mercury lamp, to which Bartel's model applies [10]. The hfs of these lines has been examined in detail [11-14]; the complex structure arises from the combination of hfs with isotopic shift. The line shape is highly characteristic: at the center there is an obviously broadened line (the unresolved lines for the even isotopes), with weaker satellites at the sides (hfs for the odd isotopes). Figures 1 and 2 show the level diagrams and observed distributions for the two lines as recorded with an ISP-67 spectograph having an autocollimation system of focal length 3000 mm.

The absorption curves were computed from Schüller's data for the relative intensities and separations of the components; the half-widths were corrected for the apparatus function. The $R(p)$ for 4046.56 A included five components; that for 4358.35 A, 10 components.

The absorption may be calculated by reference to the $p$ of any component; the method is applicable to any line whose components do not differ too greatly in intensity. Large differences cause the strongest component to restrict the
limits for the \( p \) of the weaker components. Figure 2 shows \( R(6) \) for \( p_1, p_3, \) and \( p_4 \) of the 4046.56 A line, with \( R(1) \) for a single line with \( p_3: p_1 = 5.48 : 15.52. \) \( R(6) \) has the same slope as \( R(1) \), so it gives \( p \) to about 15-20\%, as does

\[ R(2) \]

\[ R(3) \]

\[ R(4) \]

\[ R(5) \]

\[ R(6) \]

Fig. 1. Hyperfine structures of the 4046.56 and 4358.35 A lines of mercury.

\[ R(1) \]

\[ R(2) \]

\[ R(3) \]

\[ R(4) \]

\[ R(5) \]

\[ R(6) \]

Fig. 2. Absorption curves

\[ 1 \rightarrow R(5)(p_3), 2 \rightarrow R(5)(p_4), 3 \rightarrow R(5)(p_1), 4 \rightarrow R(1)(p) \]

\[ \text{Fig. 3. Linear absorption apparatus.} \]

1) ISP-22 (ISP-67) spectrograph; 2) objective, \( f = 200 \) mm; 3) diaphragm; 4) light source, NVO-500 Hg lamp; 5) achromatic lens, \( f = 100 \) mm; 6) wire; 7) concave mirror, \( r = 200 \) mm.

Fig. 4 shows the 4046.66 A line at high magnification. The \( R(6) \) curve gives the optical density for each component, though with a certain amount of error due to overlap. The results are

\[ p_1 = 0.7, p_2 = 0.7, p_3 = 10, p_4 = 1.5, p_5 = 0.37. \]

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