

Interrelationships of  $e$ ,  $h/e$  and  $e/m$ 

In a report<sup>1</sup> presented some twenty months ago on the values of  $e$ ,  $h$  and  $e/m$ , attention was directed to the numerous inconsistencies shown by the experimental data. More recent developments have resolved a number of these inconsistencies, and it now seems possible to reduce all the really precise experimental data in such a way that only one fundamental discrepancy remains. Because of the great amount of experimental material here involved, it is necessary to omit all details in the present brief letter. I wish merely to remark that I am now using for  $e$  the value<sup>2</sup>  $2.99776 \times 10^{19}$  cm./sec., in place of the former 2.99796.

As a result of several recent investigations, it seems practically certain that the wave-lengths of X-rays derived from ruled gratings ( $\lambda_g$ ) are correct. The summary of this work given by Bearden<sup>3</sup> leads to the result that such wave-lengths are 0.2034 per cent larger than wave-lengths on the conventional Siegbahn scale ( $\lambda_s$ ). As is well known, one can calculate the wave-lengths of X-rays, if one knows the value of  $e$ , and if, in addition, one assumes that calcite is a geometrically perfect crystal of known density, molecular weight, etc. In my previous work<sup>4</sup>, I made this assumption, and X-ray wave-lengths then appeared in all theoretical expressions merely as a certain known function of  $e$ , which in turn was one of the quantities to be evaluated.

With the new assumption that such wave-lengths are known and are equal to  $\lambda_g$ , several of the theoretical relations are much simplified. If we discard the evaluation of certain constants such as the Bohr magneton and the fine structure constant, which are not yet sufficiently precise for our purpose, there remain experiments that lead respectively to an evaluation of (1)  $e$ , (2)  $e/m$ , (3)  $h/e$ , (4)  $(h/e)(e/m)$ , (5)  $(e/h)(e/m)$ . The last two experiments are respectively the measurement of the Compton shift and the measurement of the energy of photoelectrically ejected electrons by means of their deflection in a magnetic field<sup>5</sup>.

The direct determinations of  $e/m$  are now very consistent, and the weighted average of the five latest results, based on four distinctly different methods, is  $(1.75762 \pm 0.00026) \times 10^7$  E.M.U. Because of the apparent correctness of this result, I have inserted it in functions (4) and (5), to get thus two additional determinations of  $h/e$ . The latest results for methods (4) and (5), when treated in this way, give almost identical values of  $h/e$ , and this agreement is significant, since there would be a disagreement of 1.5 per cent in the two values if one should adopt Bond's suggestion<sup>6</sup> that the 'true' value of  $e/m$  is 137/136 of the observed value.

With the addition of the two indirect methods for obtaining  $h/e$  just mentioned, there are six distinctly different methods for evaluating this important ratio, of which by far the most precise is the determination of the Duane-Hunt limit of the continuous X-ray spectrum<sup>7</sup>, and it is gratifying to find that the present best results for each of the six methods are mutually consistent. For the final weighted average, I obtain  $h/e = (1.37588 \pm 0.00027) \times 10^{-17}$  E.S.U. If now one assumes the truth of the Bohr formula for the Rydberg constant, and substitutes in this formula the values of  $e/m$  and  $h/e$  just given, one

obtains  $e = (4.7824 \pm 0.0015) \times 10^{-10}$  E.S.U. It is this value that cannot now be reconciled with the direct measurement of  $e$ , and this constitutes the outstanding discrepancy mentioned earlier.

If one assumes that  $\lambda_g/\lambda_s = 1.002034 \pm 0.000016$  (the probable error is due to Bearden<sup>3</sup>) and if one assumes also that calcite is a geometrically perfect crystal, then, using the best constants for calcite, one obtains  $e = (4.8029 \pm 0.0005) \times 10^{-10}$  E.S.U., which may be called the grating value of  $e$ . Until recently this result was supposed to be in serious disagreement with the oil-drop value, but Kellström's recent work on the viscosity of air<sup>7</sup> indicates otherwise. Since the resulting oil-drop value,  $4.816 \pm 0.013$ , is far less accurate than the grating value, one may adopt  $4.8029 \pm 0.0005$  as the best direct determination of  $e$ , and the discrepancy with the indirect value  $4.7824 \pm 0.0015$  is then seen to be more than ten times the sum of the stated probable errors.

Because of the variety of methods now available for the measurement of  $e/m$  and of  $h/e$ , and the consistency of all results, it seems reasonable to assume that the adopted average values of these two quantities are essentially correct. With this assumption there remains, so far as I can now see, only two possible explanations of the major discrepancy in  $e$ : (1) the Bohr formula for the Rydberg constant is not correct, (2) the method of calculating  $e$  on the assumption of a geometrically perfect calcite crystal is not correct.

There still remains the third possibility that all measured values of  $h/e$  are too low due to systematic errors of one sort or another (including possible errors of theory), but since almost any such error that can be imagined would affect a portion of the experimental results in one sense, and another portion in the opposite sense, and since all of the present results are in fact quite consistent, this last possibility seems to be ruled out.

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<sup>1</sup> R. T. Birge, *Science*, **79**, 438 (1934).

<sup>2</sup> R. T. Birge, *NATURE*, **134**, 771 (1934).

<sup>3</sup> J. A. Bearden, *Phys. Rev.*, **48**, 385 (1935).

<sup>4</sup> R. T. Birge, *Phys. Rev.*, **40**, 228 (1932) and reference 1.

<sup>5</sup> H. R. Robinson, *Phil. Mag.*, **18**, 1086 (1934).

<sup>6</sup> W. N. Bond, *NATURE*, **133**, 327 (1934).

<sup>7</sup> G. Kellström, *NATURE*, **136**, 682 (1935). See also R. T. Birge, *Phys. Rev.*, Dec. 15, 1935.

## Pressure Effect on Predissociation

THE absorption spectrum of S<sub>2</sub> vapour shows two regions of predissociation (marked by the diffuseness of the bands) which are known to extend over a considerable spectral range, including several bands belonging to different vibrational states. Using, however, an extremely low vapour pressure of sulphur—this may be obtained experimentally by heating carbon disulphide vapour in the absorbing cell up to about 500° C.—the previously diffuse bands appear sharp, with the exception of one band ( $v'' = 0$ ,  $v' = 16$ ) which is situated nearest to the predissociation limit and remains quite diffuse. (The spectrum extends only over a limited range; for this reason the first predissociation limit could not be observed.) The next following band ( $v'' = 0$ ,  $v' = 17$ ) shows a broad but well developed rotational fine structure.

A similar observation has been made previously<sup>1</sup> in the absorption spectrum of SO<sub>2</sub>. This spectrum contains diffuse bands situated between 2764 Å. and

\* In fact, if one uses only this result and the best determinations of  $e/m$ , the final conclusions of this letter are unchanged.