Fine Structure of $D\alpha$ with Increased Resolution

The fine-structure analysis of the first member of the Balmer series of deuterium, commonly called $D\alpha$, has been reported within the past two years by three sets of investigators in five published papers.[1–5] The general "doublet" structure of the line is readily observable under high dispersion, but the chief minor component resulting from the coincident transitions $2p\,^2P_{1/2}-3s\,^2S_{1/2}$ and $2s\,^2S_{1/2}-3p\,^2P_{1/2}$ has never been resolved from the closely adjacent high frequency main component. The theoretical interval between these components is 0.108 cm^{-1}, and consequently a half-intensity breadth of less than 0.108 cm^{-1} would theoretically be needed to effect a resolution of the components. This would require that the discharge be maintained at about 100°K, and since this is so close to the temperature of liquid-air, it has generally been considered unlikely that the components would ever be resolved with liquid-air cooling.

Recently the fine-structure of $D\alpha$ has been reinvestigated by the authors, using approximately 100 percent deuterium gas kindly given to them by Professor H. C. Urey of Columbia University. The optical equipment was a Zeiss triple-prism spectrograph and a pair of heavily silvered Hilger 7-cm quartz etalon plates, used with a constant 5-mm invar spacer. On several of the plates taken of a low pressure, low current-density discharge the chief minor component was resolved, as is clearly shown in the reproduction of an original microphotometer tracing, Fig. 1.

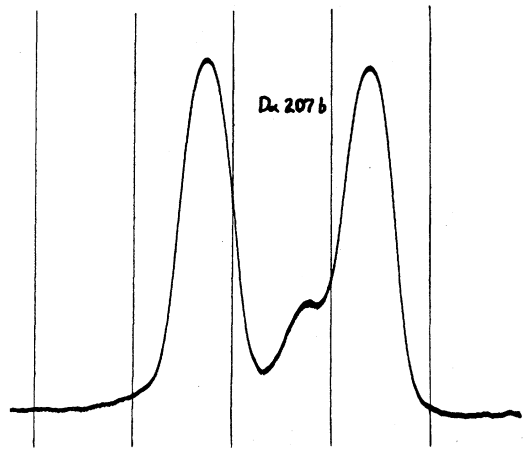

FIG. 1.

The measured half-intensity breadth of the high frequency main component is 0.120 cm^{-1}, which indicates clearly that in order to be resolved the minor component must be considerably more than 0.108 cm^{-1} from the main component. Measurements of analyzed curves taken from several plates result in an average interval of 0.134 cm^{-1} between the centers of the components, thus indicating a wide deviation from theory. A possible cause of this deviation is the Stark effect resulting from ionic electric fields in the discharge.

Plates have also been taken by using a 3-mm etalon spacing of the light from a discharge containing equal amounts of hydrogen and deuterium. From the measured interval between the components $2p\,^2P_{3/2}-3d\,^2D_{5/2}$ of the two isotopes a value for e/m has been computed. The new value of the Faraday based on the physical scale of atomic weights,[6] and the atomic weights of hydrogen and deuterium as determined by Bethe[7] from atomic disintegration data have been used in the calculations. The newly obtained value for e/m is $1.7577\pm0.0004\times10^7$ e.m.u./gram.

The value of this constant recently reported by Shane and Spedding[8] using the new value of the Faraday and the old atomic weight values is $1.7579\pm0.0003\times10^7$ e.m.u./gram. However, these authors failed to correct the measured interval between corresponding components of the two isotopes to the interval in vacuum, although they used in their calculations the Rydberg constant for hydrogen reduced to vacuum. The result of this oversight is to make their value 0.0005×10^7 e.m.u./gram too small. However, their e/m value is increased by just 0.0005×10^7 e.m.u./gram when the new atomic weight values determined by Bethe are used. Hence their result with these corrections remains at $1.7579\pm0.0003\times10^7$ e.m.u./gram.

The investigations briefly reported in this letter will be published later in greater detail.

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[1] Spedding, Shane and Grace, Phys. Rev. **44**, 58 (1933).
[2] Gibbs and Williams, Phys. Rev. **45**, 221 (1934).
[3] Williams and Gibbs, Phys. Rev. **45**, 475 (1934).
[4] Kopferman, Naturwiss. **22**, 218 (1934).
[5] Spedding, Shane and Grace, Phys. Rev. **47**, 38 (1935).
[6] See Shane and Spedding, Phys. Rev. **47**, 36 (1935), for a report of the new Faraday value.
[7] Bethe, Phys. Rev. **47**, 633 (1935).
[8] Shane and Spedding, Phys. Rev. **47**, 33 (1935).