Newly Observed Structure in He II λ 4686

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IN the λ 4686 (3 *s*, *p*, *d*, −4 *s*, *p*, *d*, *f*) line complex of ionized helium the fourth strongest component ($3_{\frac{1}{2}}-4_{\frac{1}{2}}$, in the notation n_j) has been observed to consist of two lines with a separation tentatively evaluated at 0.16±about 0.02 cm^{-1}. The red member appears the stronger, in a ratio of at least 2 to 1 and possibly as great as 5 to 1.

Upon the Dirac theory for one-electron spectra, the ($3_{\frac{1}{2}}-4_{\frac{1}{2}}$) component would be single, since the energy would depend only on n and j. However, the hydrogen alpha-anomaly, long emphasized by Houston[1] and confirmed by the microwave study of Lamb and Retherford,[2] has led to recent conjectures that the $ns_{\frac{1}{2}}$ level lies above the value predicted by the Dirac theory by the amount $r_n(Z^4)$, or r_n, where the dependence on n is approximately $r_n \doteq r_1 n^{-3}$. Thus in the line studied the third ($3_{\frac{1}{2}}-4_{\frac{3}{2}}$), fourth ($3_{\frac{3}{2}}-4_{\frac{1}{2}}$), and seventh ($3_{\frac{3}{2}}-4_{\frac{3}{2}}$) components are split, each into two members, making the line system 11-fold instead of eightfold.

Bethe's[3] approximate calculation of the interaction of the atom with the radiation field leads to a value of about 0.13 cm^{-1} for $r_3(\mathrm{He}^4)$; here we are assuming that the average excitation potential is so nearly independent of the principal quantum number that, for a two-digit approximate calculation, we may neglect its variation. If the level shift is treated as varying exactly as n^{-3}, our observation of the splitting yields a tentative value of 0.113±about 0.014 cm^{-1} for $r_3(\mathrm{He}^4)$. These two values appear to be in satisfactory agreement. Details are given in Fig. 1.

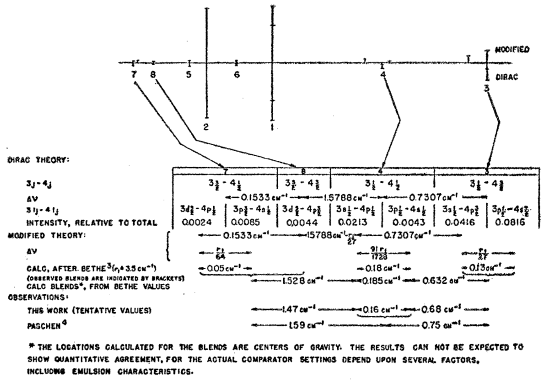

FIG. 1. Certain separations in the He II line complex λ 4686.

All the plates used up to the present were made in the second order of a grating with a nominal second-order resolution of 0.130 cm^{-1} for lines of equal intensity. Thus it could resolve the 0.16 cm^{-1} separation of the component described, but not the expected somewhat smaller separation of an adjacent component of this line complex with a calculated intensity ratio of almost 2:1.

Work is in progress upon this line complex and upon the lines 3–5 and 4–5 of the He II spectrum, and a more detailed account will be submitted. The project is being supported by the Office of Naval Research.

We are grateful to F. E. Geiger, Jr. for his collaboration in the early stages of this research.

[1] W. V. Houston and Y. M. Hsieh, Phys. Rev. **45**, 263 (1934).
[2] W. E. Lamb, Jr. and R. C. Retherford, Phys. Rev. **72**, 241 (1947).
[3] H. A. Bethe, Phys. Rev. **72**, 239 (1947).
[4] F. Paschen, Ann. d. Physik **82**, 689 (1927).

Half-Life of Tritium*

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BY collecting and measuring the He^3 produced by the beta-decay of tritium, a value of 12.1±0.5 years has been obtained for the half-life of tritium. This value is based on results on two samples and is markedly different from the accepted value of 31±8 years obtained by counting "radioscale" quantities.[1]

Each sample of tritium was first analyzed for its tritium and protium content. Each sample's volume was measured and each was allowed to stand to permit the He^3 to accumulate. At the end of a given period of time the He^3 was separated from the gas by removing all the hydrogen (tritium and protium) through a palladium valve. The helium was further purified by passing it over copper oxide at 450°C (to burn any hydrogen to water) and then through an activated charcoal trap at liquid nitrogen temperature. The volume of He^3 collected was observed. This helium showed no trace of He^4 in an emission spectrum obtained by electrodeless discharge, and the He^3 lines exhibited the expected shift.

The isotopic analysis of the original hydrogen was accomplished in two ways. First, a sample of hydrogen of measured volume was quantitatively burned to water, and the water was weighed. Assuming atomic weights of 1 and 3, calculation was made of the tritium to protium ratio. The second method of analysis involved comparison of the intensities of the T_α and H_α lines from emission spectra obtained on calibrated plates. These spectroscopic observations and those on the He^3 plates were made by Dr. J. K. Brody and Dr. Frank Tomkins of this Laboratory.

These analyses agreed with each other to within 5 percent and were found to be consistent with readings obtained on the beta-activity of each sample by means of an ion chamber.

The $T_2/(H_2+T_2)$ ratio for the first sample was 0.71 and for the second 0.74. After an elapsed time of 51 days, the conversion of T to He^3 was 0.00815 in the first sample; after 197 days, the conversion was 0.03025 in the second sample. The tritium half-life was 11.85 years in the first case and 12.35 years in the second.

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[1] R. D. O'Neal and M. Goldhaber, Phys. Rev. **58**, 574 (1940).