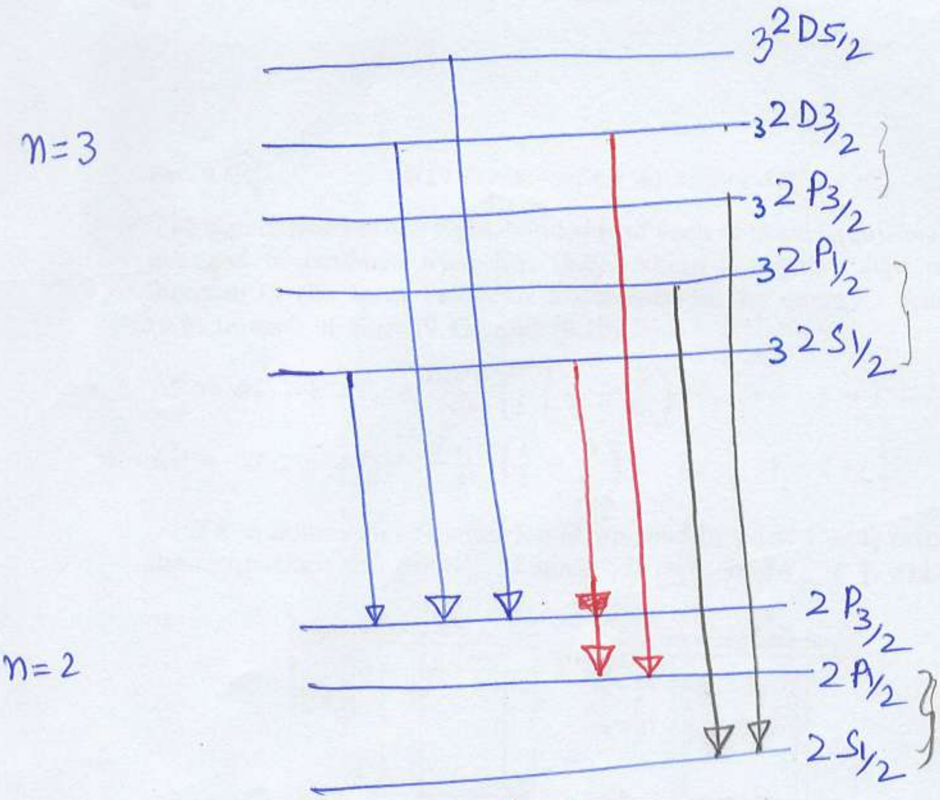
H_α Fine structure :-

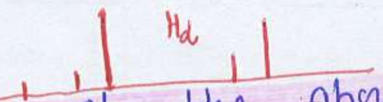
(Fine structure of H_α line)

($\alpha \rightarrow$ n diff is 1
$\beta \rightarrow$ ... 2
$\gamma \rightarrow$ ... 3
$\delta \rightarrow$ ... 4
$\epsilon \rightarrow$ ... 5

Dirac + Fine str. + lamb-shift

$\left\{ \Delta J = 0, \pm 1 \quad \Delta L = \pm 1 \right.$





The two pairs of the above transition which are given below have identical transitions

$2D_{3/2} \longrightarrow 2P_{1/2}$, $2P_{3/2} \longrightarrow 2S_{1/2}$ $\Big]$ $\Delta L = +1$, $\Delta J = +1$

$2P_{1/2} \rightarrow 2S_{1/2}$, $2S_{1/2} \rightarrow 2P_{1/2}$ $\Big\}$ $\Delta L = +1$, $\Delta J = 0$

The fine structure of H_α line should have five components. Applying the intensity rules.

$\Delta L = -1$	$\Delta J = -1$	Most intense line
$\Delta L = -1$	$\Delta J = 0$	Less intense line
$\Delta L = +1$	$\Delta J = +1$	weaker line
$\Delta L = +1$	$\Delta J = 0$	weakest line

i.e. $\boxed{\Delta L = \pm 1 \; ; \; \Delta J = 0, \pm 1}$

$\Delta L = -1 \quad \Delta J = -1$
$= +1 \quad \Delta J = +1$
Most Intense line

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The sign in front of the right-hand side of each of these equations has been changed to conform with Eq. (9.9), where a positive sign means an increase in the term value, or a decrease in the energy. Adding Eq. (9.9) to each of Eqs. (9.11) and (9.12),

$$\Delta T = \Delta T_{l,s} + \Delta T_r = \frac{R\alpha^2 Z^4}{n^3}\left(\frac{1}{l+1} - \frac{3}{4n}\right) \quad \text{for} \quad j = l + \frac{1}{2},$$
$$\Delta T = \Delta T_{l,s} + \Delta T_r = \frac{R\alpha^2 Z^4}{n^3}\left(\frac{1}{l} - \frac{3}{4n}\right) \quad \text{for} \quad j = l - \frac{1}{2}. \tag{9.13}$$

If k in Sommerfeld's equation is replaced by l and $l + 1$, respectively, these equations will result. If again k is replaced by $j + \frac{1}{2}$, which is just

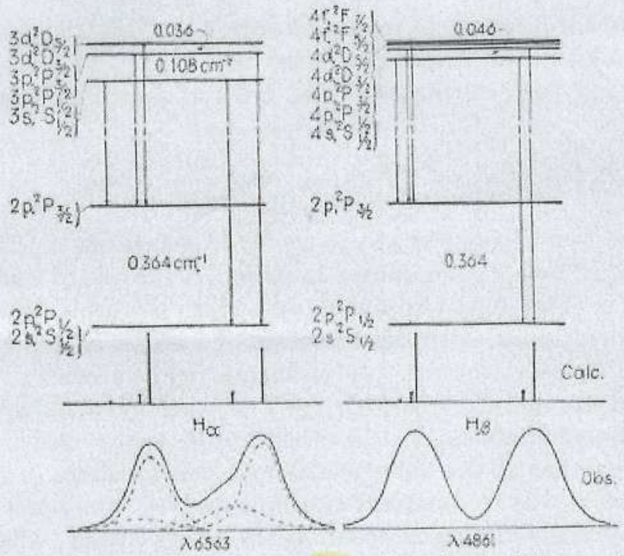

FIG. 9.4.—Schematic diagrams of the lines H_α and H_β, in the Balmer series of hydrogen.

the same as replacing $l + 1$ and l of Eq. (9.13) by $j + \frac{1}{2}$, we obtain the single equation

$$\Delta T = \frac{R\alpha^2 Z^4}{n^3}\left(\frac{1}{j + \frac{1}{2}} - \frac{3}{4n}\right). \tag{9.14}$$

9.3. Observed Hydrogen Fine Structure.—Schematic diagrams of the theoretical fine structure of the first two lines of the Balmer series of hydrogen are shown in Fig. 9.4. Applying selection and intensity rules, both H_α and H_β should be composed of two strong components and three weaker ones. Neither one of these patterns has ever been resolved into more than two components. The best results to date are those of Lewis, Spedding, Shane, and Grace,[1] obtained from H^2, the behavior of

[1] LEWIS, G. N., and F. H. SPEDDING, *Phys. Rev.*, **43**, 964, 1933; also SPEDDING, F. H., C. D. SHANE, and N. S. GRACE, *Phys. Rev.*, **44**, 58, 1933.