306(3): Fuller Analysis of the Balmer Series of H

In general the H spectrum is given by:

$$\frac{1}{\lambda} = R\left(\frac{1}{n'^2} - \frac{1}{n^2}\right) \quad -(1)$$

where

$$R = 1.097373 \times 10^{7} \ m^{-1} \quad -(2)$$
$$= 1.097373 \times 10^{5} \ cm^{-1}$$

The visible part of the spectrum is given by the Balmer series, defined by:

$n' = 2$, $n = 3$	$H\alpha$	red
$n = 4$	$H\beta$	blue
$n = 5$	$H\gamma$	violet
$n = 6$	$H\delta$	violet
$n = 7$	$H\epsilon$	ultra violet
$n = \infty$	$H\infty$	ultra violet

For $n' = 2$

$2s$, $n' = 2$, $l = 0$, $m = 0$
$2p$, $n' = 2$, $l = 1$, $m = -1, 0, 1$

For $n = 3$

$3s$, $n = 3$, $l = 0$, $m = 0$
$3p$, $n = 3$, $l = 1$, $m = -1, 0, 1$
$3d$, $n = 3$, $l = 2$, $m = -2, -1, 0, 1, 2$

For $n = 4$

$4s$ $n = 4$, $l = 0$, $m = 0$
$4p$, $n = 4$, $l = 1$, $m = -1, 0, 1$
$4d$, $n = 4$, $l = 2$ $m = -2, -1, 0, 1, 2$
$4f$, $n = 4$, $l = 3$, $m = -3, -2, -1, 0, 1, 2, 3$

2) The selection rules are:

any Δn, $\Delta l = \pm 1$, $\Delta m = 0, \pm 1$ — (3)

For linear polarization:

$$\Delta m = 0 \quad \text{— (4)}$$

The $H\alpha$ Line ($n' = 2$ to $n = 3$)

This occurs at 15,241.4 cm^{-1} in the red part of the visible. For linear polarization there are three transitions:

a) $2s \rightarrow 3p$ ($\Delta l = 1$)
b) $2p \rightarrow 3s$ ($\Delta l = -1$)
c) $2p \rightarrow 3d$ ($\Delta l = 1$)

which in the absence of any other influence all occur at 15,241.4 cm^{-1}. However, the Evans Morris shifts split these into three lines.

The $H\beta$ Line ($n' = 2$ to $n = 4$)

This occurs at 20,576 cm^{-1} in the blue, and for linear polarization there are three transitions:

a) $2s \rightarrow 4p$ ($\Delta l = 1$)
b) $2p \rightarrow 4s$ ($\Delta l = -1$)
c) $2p \rightarrow 4d$ ($\Delta l = 1$)

These are again split into three lines

The Infra-red line ($n' = 3$ to $n = 4$)

This occurs at 5,334.4 cm^{-1} in the infra-red, and for linear polarization there are

3) five transitions:

a) $3s \rightarrow 4p$ $(\Delta l = 1)$
b) $3p \rightarrow 4s$ $(\Delta l = -1)$
c) $3p \rightarrow 4d$ $(\Delta l = 1)$
d) $3d \rightarrow 4p$ $(\Delta l = -1)$
e) $3d \rightarrow 4f$ $(\Delta l = 1)$

So the Evans Morris shifts will split this infra-red line into five lines.

For left circularly polarized probe radiation:

$$\Delta m = 1 \quad -(5)$$

and for right circularly polarized probe radiation:

$$\Delta m = -1 \quad -(6)$$

so more splittings will appear.

These splittings are all due to fundamental quantum theory. The longer the path length the greater the separation between the splittings. This will be investigated systematically in the next note