The Zeeman effect

weak field: $B$ is less than internal magnetic field.

$$\Delta E = -\mu_B B = \frac{e}{2m} (L + 2S) \cdot B$$

'process about \( \vec{J} \)

$$\mu_{\text{total}} = \mu_{\text{orb}} + \mu_{\text{spin}} = -\frac{e}{2me} (L + 2S)$$

$$\Delta E = g_L m_J \mu_B B$$

$$g_L = \frac{3J^2 - L^2 + S^2}{2J^2} \quad \text{('Landé factor') }$$

\[ \begin{array}{c}
\text{E} \\
\text{no field} \\
1S_{1/2} \\
2p_x \\
2p_y \\
2p_z \\
\text{field} \\
2p_{1/2} \\
2p_{3/2} \\
1S_{1/2} \\
\text{L-S coupling} \\
\end{array} \]

\[ \begin{array}{c}
\text{m}_{j} = \frac{1}{2} \\
m_{j} = \pm \frac{1}{2} \\
m_{j} = \pm \frac{3}{2} \\
\end{array} \]
Strong Field - The Paschen-Back effect

$B$ is much larger than internal fields

$\Delta E = \vec{m} \cdot \vec{B}$

$\Delta E = -m_2 \cdot B_z = \frac{e}{2m} (L_z + 2S_z) B_z$

$\Delta E = \frac{e \hbar}{2m} (m_z + 2m_z) B_z$

Spin orbit coupling becomes unimportant

Selection rules become

$\Delta m_S = 0$

$\Delta M_L = 0, \pm 1$

$\Delta L = \pm 1$
In class problem: for a hydrogen atom in a strong magnetic field, $\vec{B}$.

A. Draw the splitting of the $1s$ and $2p$ states.

B. Using the selection rules, draw the observed lines on the $2p \rightarrow 1s$ transition.

C. Is there a $2s \rightarrow 1s$ transition?