Normal Zeeman Effect

- Historically first to be derived (neglect of electron spin)
- Matched with experiment only for singlet series
  all others termed "anomalous."

Hamiltonian (for one valence electron)

$$\hat{H} = \frac{p^2}{2m} - \frac{Z_{eff}(r)\,\hbar c\alpha}{r} \underbrace{- \frac{e}{2m}\vec{L}\cdot\vec{B}}_{\hat{H}_{ext}}$$

align $\vec{B}$ along z-axis.

$$= \frac{\vec{p}^2}{2m} - \frac{Z_{eff}(r)\,\hbar c\alpha}{r} + \underbrace{\frac{|e||B|}{2m}}_{\text{Larmor frequency} = \omega_L} L_z .$$

Easy to model multi-valence e^-:

$$\hat{H} = \underbrace{\sum_i \frac{\vec{p}_i^2}{2m} - \frac{Z_{eff}(r_i)\,\hbar c\alpha}{r_i} + \sum_{i<j} \frac{\hbar c\alpha}{|\vec{r}_i - \vec{r}_j|}}_{H_{atom}} + \omega_L \underbrace{\sum_i L_{z_i}}_{\substack{\text{Total } z\text{-component of orb. ang. mom} \\ \Rightarrow \text{ or of the whole atom}}}$$

Work in basis where $\hat{H}_{atom}$ is diagonalized:

$$\hat{H}_{atom} |n, L, m_L\rangle = E_n |n, L, m_L\rangle$$

states of good total orb. angular momentum, quantized along z-axis.

But in this basis, $\hat{H} = \hat{H}_{atom} + \hat{H}_{ext}$ is also diagonal!

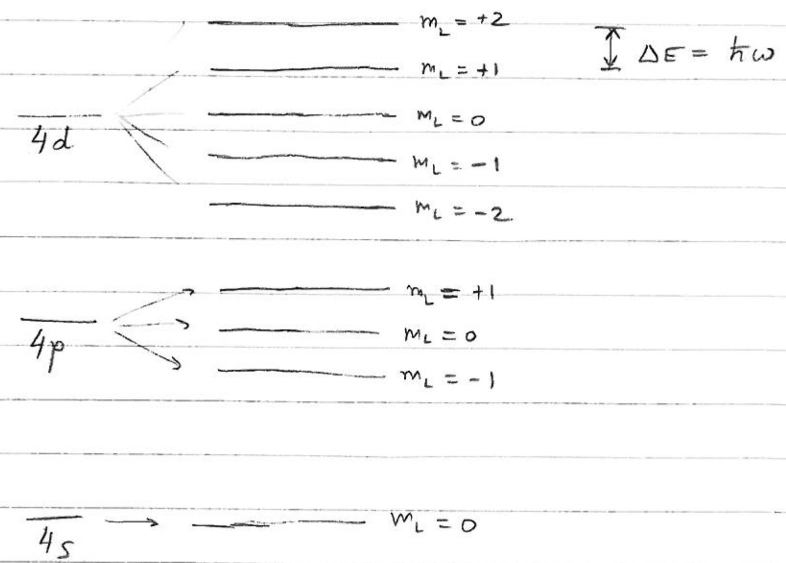
$$\hat{H} |n, L, m_L\rangle = \hat{H}_{atom} |n, L, m_L\rangle + \omega_L (L_{atom})_z |n, L, m_L\rangle$$

$$= (E_n + \omega_L \hbar m_L) |n, L, m_L\rangle$$

Normal Zeeman effect spectrum

$$E = E_n + \hbar\omega \, m_L$$

Each substate of a given L state is split - evenly



Radiation lines: Recall $\Delta L = \pm 1$ (not 0)

$$\Delta m_L = \{-1, 0, +1\}$$

photograph: