Thursday, April 11, 2024

Selection Rules for E1 transitions

($\vec{B}_{DC} = B_{DC}\hat{z}$ is still present)

$$\Omega = \frac{-e}{\hbar} \underbrace{\langle n', L', J', F', m_F' |}_{\langle e|} \vec{E}_{AC} \cdot \vec{R} \underbrace{| n, L, J, F, m_F \rangle}_{|g\rangle}$$

For π-polarization

(replace $\vec{B}_{AC}$ with $\vec{E}_{AC}$)

└ $\vec{E}_{AC} \parallel \vec{B}_{DC} \parallel \hat{z}$

$\Omega \neq 0$ for $\begin{cases} \Delta F = 0, \pm 1, \Delta m_F = 0 \\ \Delta L = \pm 1 \end{cases}$

Exception: $\Omega = 0$ for $\begin{cases} \Delta F = 0, m_F = 0 \\ \Delta L = \pm 1 \end{cases}$

For σ-polarization

$\Omega \neq 0$ for $\begin{cases} \Delta F = 0, \pm 1, \Delta m_F = \pm 1 \\ \Delta L = \pm 1 \end{cases}$

note: $\sigma_+ : \Delta m_F = +1$

$\sigma_- : \Delta m_F = -1$

Cycling transition (D_2 line): see overhead slides

Optical pumping

$F=2 \rightarrow F'=3$ with $\sigma^\pm$ light $\Rightarrow$ all population goes to $m_F = +F$ or $m_F = -F$

$F=2 \rightarrow F'=2$ with $\sigma^\pm$ light $\Rightarrow$ perfect alignment

↳ all population goes to $m_F = +F$ or $m_F = -F$ ↳ transition goes dark.

$F=2 \rightarrow F'=2$ with π light $\Rightarrow$ perfect alignment

↳ all population goes to $m_F = 0$ ↳ transition goes dark.