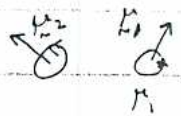


Spin-orbit coupling:

1) Physics fact: Interaction Energy between two dipole moments $E_{int} = \Gamma \mu_1 \cdot \mu_2$

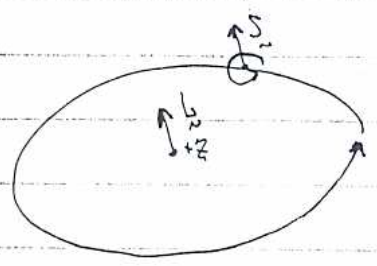
Γ
↑
small
constant

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But, for spinning/orbiting charged particles $\mu \propto L \Rightarrow E_{int} = \Gamma' L_1 \cdot L_2$

Now, consider a spinning + orbiting electron

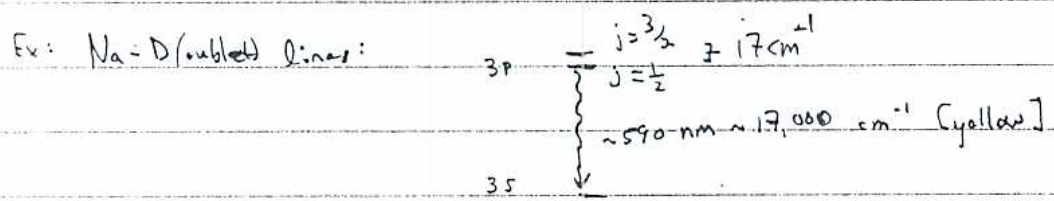


Interaction between electron's S, L
modifies $\hat{H} \Rightarrow$ Energy levels split
[depending on S, L]

Some details of S.O. coupling $E_{S.O.} = \lambda \hat{S} \cdot \hat{L}$; $\lambda \propto Z^4$ [S.O. coupling stronger in heavier atoms]

Energy level perturbations given by $E_{S.O.} = \tilde{\lambda} [j(j+1) - l(l+1) - s(s+1)]$ [Again, $\tilde{\lambda} \propto Z^4$]

where l = orbital + momentum, $s = \frac{1}{2}$, $j = l + s, \dots, |l - s|$

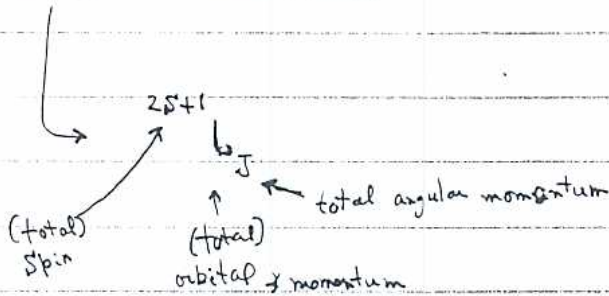


Calculate $\tilde{\lambda}$: $17 \text{ cm}^{-1} = \tilde{\lambda} \left\{ \left[\frac{3}{2} \left(\frac{3}{2} + 1 \right) - 1(1+1) - \frac{1}{2} \left(\frac{1}{2} + 1 \right) \right] - \left[\frac{1}{2} \left(\frac{1}{2} + 1 \right) - 1(1+1) - \frac{1}{2} \left(\frac{1}{2} + 1 \right) \right] \right\} = 3\tilde{\lambda}$

So, $\tilde{\lambda} = 5.67 \text{ cm}^{-1}$

Easily specified in terms of Term Symbols

Term Symbols + Selection Rules: (electron) term = Angular momentum characteristics of the quantum state of an atom



i.e. for $l=0$, $J=\frac{1}{2}$ only

For 1 (open shell) electron, rules are simple: $l=L$, $s=\frac{1}{2}$, $J=l+\frac{1}{2}, |l-\frac{1}{2}|$

E.g.: Na $1s^2 2s^2 2p^6 3s$

$\rightarrow l=0$; only term is $^2S_{\frac{1}{2}}$

Na $1s^2 2s^2 2p^6 3p$; $^2P_{\frac{3}{2}, \frac{1}{2}}$ } sodium D lines
 \downarrow
 $l=1$

For $>1 e^-$, life is complicated!; For low $Z \Rightarrow$ small U_{so} , use Russell-Saunders scheme

Add l_i 's to obtain L using Clebsch-Gordan series [see below]; add s_i 's to obtain S using C-G series

Then, add $L+S \Rightarrow J$ using C-G series

Closter-Gordan series for 2 \neq moments l_1, l_2 : $l_1+l_2, l_1+l_2-1, \dots, |l_1-l_2|$

Illustrate RS coupling scheme for ^{highly excited} Mg RL $3p^1 4p^1$
 $l_1=1, s_1=\frac{1}{2}$ $l_2=1, s_2=\frac{1}{2}$

Determine possible L's: $L = \overset{DPS}{2, 1, 0}$; Possible S's: $1, 0 \Rightarrow$ ${}^3D_{3,2,1}, {}^1D_2, {}^3P_{2,1,0}, {}^1P_1, {}^3S_1, {}^1S_0$

Selection Rules for Optical Transitions in Atoms = easily stated thru term symbols

For an allowed transition, must have:

[\leftrightarrow Ang. momentum conservation]

$$\Delta S = 0$$

$$\Delta L = 0, \pm 1 \text{ w/ } \Delta l = \pm 1 \text{ for at least 1 electron}$$

$$\Delta J = 0, \pm 1, \text{ except } J=0 \not\rightarrow J=0 \text{ forbidden}$$

For large coupling, RS scheme breaks down ["jj coupling" scheme becomes appropriate];

S, L become progressively worse q.n.'s; above selection rules break down.