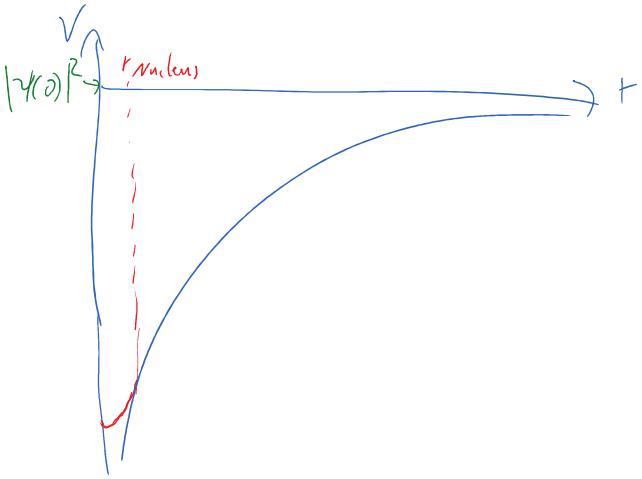
Specific mass shift : the other electrons' mass shift

Volume shift: finite nucleus size

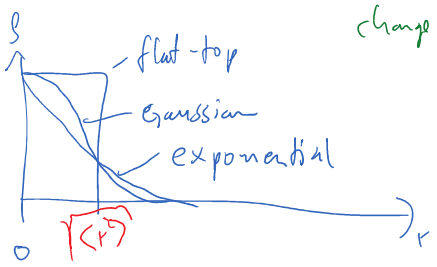
$\rightarrow V_{coul} \neq \frac{1}{r}$ at $r < r_{nucleus}$




$\langle r_N^2 \rangle$ = mean square charge radius

$$\langle r_N^{(2)} \rangle = \iiint r^2 \rho(r)\, d^3r$$

$\rho$ ↑ charge density

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## Quantum numbers

n : principal quantum number

$V_{coul} \propto \frac{1}{r}$

$E(n) = -R_\infty \cdot \frac{m_{red}}{m_e} \frac{1}{n^2}$


radial part of S.E.

l : orbital angular momentum quantum number

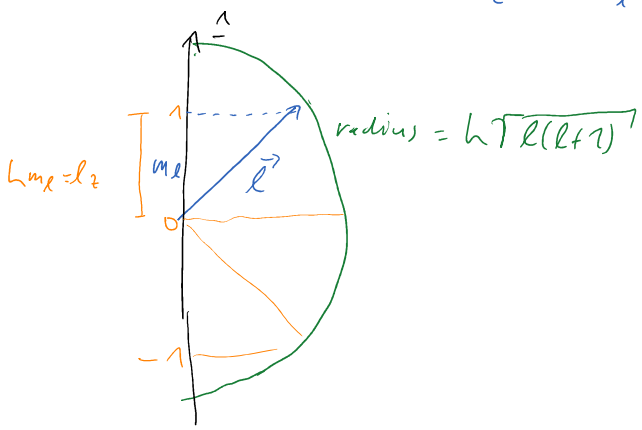
angular part

$l = 0 \ldots n-1$

$m_l$ : projection onto "an axis" = $\hat{z}$

$m_\ell = -\ell, \dots \ell$

$|\vec{\ell}| = \hbar\sqrt{\ell(\ell+1)}$ $\quad \ell_z = \hbar m_\ell$




- Spin

$\pi^-$ : $s = 0$

$e^-$ : $s = \frac{1}{2}$

$s = \frac{1}{2}$ $\quad |\vec{s}| = \hbar\sqrt{\frac{1}{2}\left(1+\frac{1}{2}\right)}$

$= \hbar\sqrt{\frac{3}{4}}$

$s_z = \hbar m_s$

$m_s = -\frac{1}{2}, +\frac{1}{2}$

$\downarrow \quad \uparrow$

all these (spins + orbital angular momenta) couple

H atom: $\vec{j} = \vec{\ell} + \vec{s}$

j: total angular momentum

$m_j = -j \dots j$

LS coupling

$\vec{L} = \sum_i \vec{\ell_i}$

$\vec{S} = \sum_i \vec{s_i}$

$\vec{J} = \vec{L} + \vec{S}$

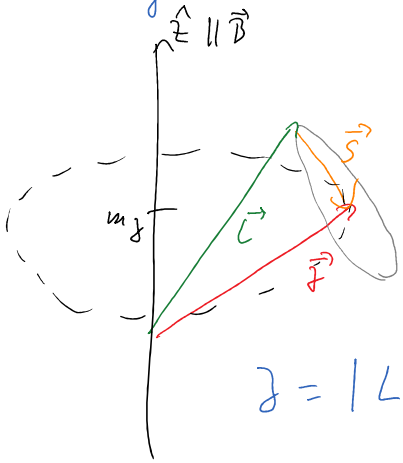
jj coupling

$\vec{j_i} = \vec{\ell_i} + \vec{s_i}$

$\vec{J} = \sum \vec{j_i}$

$S' = \sum_i$

$\vec{J} = \vec{L} + \vec{S}$ $\qquad \vec{J} = \sum_i \vec{j}_i$




$J = |L-S| \dots L+S$

$m_J = -J \dots J$

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nuclear spin $I$ ← nucleons $s = \frac{1}{2}$ n, p

nuclear angular momentum

total spin of (atom + nucleus)

$\vec{F} = \vec{J} + \vec{I}$

$m_F = -F \dots F$

---

$n$ principal $1 \dots \infty$

$l$ / $L$ orbital angular momentum $l = 0 \dots n-1$ for $1e^-$

$m_l$, $m_L$ projections $-L \dots L$

$s$ / $S$ spin $\frac{1}{2}$ or Hund

$m_s = -S \dots S$ $\qquad S_z = \hbar \cdot m_s$ z component

total angular momentum

$j$ / $J$ $\vec{J} = \vec{L} + \vec{S}$ $\qquad |l-s| \leq j \leq l+s$

$$m_j = -j \dots j$$

$I$ nuclear Spin

$$m_I = -I \dots I$$

magn. moment $\mu_I = g_I \mu_N I$

$I = \frac{1}{2}$ for proton

1 deuteron

$\frac{1}{2}$ triton

0 helium

similar for electrons

$$\vec{\mu}_s = -g \mu_B \cdot \vec{S}$$

$$\boxed{\vec{F} = \vec{j} + \vec{I}}$$

$$F = |I - j| \dots I + j$$

$$m_F = -F \dots F$$