$|\psi\rangle$

$\parallel$

$|n, l, m_l, m_s\rangle$ — $m_l \hbar$; $m_s \to \pm\frac{1}{2}$

Principal Q. # (n); $\hookrightarrow l(l+1)\hbar^2$

Ground State $n=1$: $E_n = -13.6\ eV \cdot \frac{Z^2}{n^2}$

$l=0, m=0, m_s = \pm\frac{1}{2}$

1st excited State $n=2$: $E_2 = \frac{1}{2^2} \cdot E_1 = -3.4\,eV$

$l=0, m=0$

$l=1, m=-1$

$m=0$

$m=1$

# of states $= n^2 \cdot 2$

$\mathrm{Prob}(r, \Delta\tau) \sim |\psi|^2 \cdot \Delta\tau$

$\frac{1}{\pi a_0^3} e^{-2r/a_0}$

$\Delta\tau = r^2 dr \sin\theta\, d\theta\, d\varphi$

$$\mathrm{Prob}(r \ldots r+\Delta r) = |\psi|^2 r^2 \Delta r \underbrace{\int_{\varphi=0}^{2\pi}\int_{\theta=0}^{\pi} \sin\theta\, d\theta\, d\varphi}_{4\pi}$$

$$= \frac{4r^2}{a_0^3} e^{-2r/a_0} \Delta r$$

XC HW #1: Prove that $\int_0^\infty \frac{4r^2}{a_0^3} e^{-2r/a_0} dr = 1$

XC HW #2: Web page #4

$\vec{L} = m\, \vec{r} \times \vec{v}$ Orbital Angular Momentum

$\vec{S}$ $[I\vec{\omega}]$

Spin

$\hookrightarrow$ all particles

$l = 0, 1, 2 \ldots$

$m_l = 0, \pm 1, \ldots \pm l$

$s = 0, \frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}$

$m_s =$ steps of 1 $\to \pm s$

$s=0$ $m_s = 0$

$\frac{1}{2}$ $m_s = \pm\frac{1}{2}$

1 $m_s = -1, 0, +1$

$\frac{3}{2}$ $m_s = -\frac{3}{2}, -\frac{1}{2}, +\frac{1}{2}, +\frac{3}{2}$

$\vec{S}^2$: eigenvalue is $s(s+1)\hbar^2$

S_z: eigenvalues are $m_s\hbar$

E_n

Relativity
+ Spin
Fine structure

Hyper
fine
Structure

$n=3$

$n=2$ — $\ell=1$, $\ell=0$

$n=1$

$S_p = \frac{1}{2}$

Bigger atoms?

$Z > 1$

neutral atom $\rightarrow n_{elec} = Z$

Pauli Principle!

$\underbrace{\text{Spin-}\tfrac{1}{2}\text{ particles}}_{=\text{Fermions}}$ are anti social

H	$Z=1$
He	2
Li	3
Be	4
B	5
C	6
N	7
O	8