Physics 102 - October 12, 2009

- Exam 1 Wednesday Hoyt
- Bring Calculator
- 3x5 index card w7 formulas, etc. allowed
- Q+A Sessions
  - Today 6-7 pm Goergen 109
  - Tomorrow 4-5:30 pm B+L 208
Last Time

Electrons are Waves

Quantum Mechanics

\[-\frac{\hbar^2}{2m} \frac{d^2 \psi(r)}{dx^2} + V \psi(r) = E \psi(r)\]

Spherical geometry

\[F = \frac{k \cdot q_1 \cdot q_2}{r^2}\]

"Coulomb's law"

I hope this looks familiar!

Quantized Spatial locations

Quantized Atomic "states" or "orbitals"
Explains single $e^{-}$ atom spectra

What about atoms with more than 1 $e^{-}$?

Also called the Atomic Number

$Z$ protons

$(A-Z)$ neutrons

$nuclear$

$10^{-15} m \sim size\ of\ nucleus$

$A \approx Atomic\ Mass$

$\sim size\ of\ Atom$

$\sim \#protons + \#neutrons$
Different $Z \rightarrow$ Different $\# C^-$

in neutral Atom

$\rightarrow$ Different chemical characteristics

$\rightarrow$ Nearly 100 elements in nature

"Elements"

How do electrons fill the orbitals?

(or populate the condos?)
In 1922, particles discovered to have intrinsic Spin

intrinsic "magnetic moments"

Think of as small bar magnets

Particle spin is quantized

0, \( \frac{1}{2} \), 1, \( \frac{3}{2} \), 2, \( \frac{5}{2} \), ...
Bosons - can share the same condensate or quantum state

Fermions - only 1 to a state

In each orbital or condensate, can have 2 e- - one spin "up" and one spin "down"
Chemical Bonds

Ions = Atom ± e⁻ added or removed (NOT neutral)

Ionic Bond

Atom 1: \( zP \)
\( zP (z-1)e^- \)

Atom 2: \( z'P \)
\( z'P (z'+1)e^- \)

Transferred electron: \( e^- \)
Covalent Bond

+ nucleus

- nucleus
Periodic Table of the Elements

John Newlands - English analytical chemist (1837-1898) ... arranged table of elements by atomic masses

Antoine Lavoisier
France (1743-1794)
"Father of Modern Chemistry" quantitative analysis
guillotined during French Revolution

Alexandre-Émile Béguyer de Chancourtois
France (1820-1886)
Dmitri Mendeleev
Russian (1834 - 1907)

When elements arranged by mass - see a certain periodicity in their chemical properties.
### Periodic Table of the Elements

- **Los Alamos National Laboratory Chemistry Division**

#### Elements in Black
- **Solid at Room Temperature**

#### Elements in Red
- **Gas at Room Temperature**

#### Elements in Blue
- **Liquid at Room Temperature**

#### Lanthanide Series
- Symbols: Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu

#### Actinide Series
- Symbols: Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

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*Element names in blue are liquids at room temperature. Element names in red are gases at room temperature. Element names in black are solids at room temperature.*
Imagine e\(^{-}\) passing thru thin slit. The electron wave is diffracted (spreads out). Where does the electron hit the film/detector? Quantum mechanics only provides us with a Probability Distribution of where the electron might hit.

\[ \psi(x) \text{ not well defined} \]

\[ \psi^2(x) \rightarrow \text{probability distribution} \]
Max Born  German  (1882 - 1970)

1954 Nobel Prize in physics
"For his fundamental research in quantum mechanics, especially for his statistical interpretation of the wave function"

\[ \psi(x) \text{ wave function} \]

\[ \psi^2(x) \sim \text{probability of finding particle in region of space} \]
Once electron hits the film/detector we know with 100% certainty where the electron hits
- so wavefunction has to "collapse"
Just determining the slit that the e\(^{-}\) passes thru (even with non-destructive detector) is sufficient to collapse the wave function.
Schrödinger's Cat

Thought experiment: nucleus has 50:50 chance of decaying and killing the cat. What is the "state" of the cat before box opened?

Copenhagen Interpretation

nucleus quantum state = \( \frac{1}{2} \) (decayed) + \( \frac{1}{2} \) (not decayed)

cat state = \( \frac{1}{2} \) (dead) + \( \frac{1}{2} \) (alive)
Overall wavefunction does not collapse. It evolves in time. "Decoherence" forces wavefunction to evolve into different streams that do not interact.