

Physics 102 - February 28, 2011

- Recitations - NOT this week
Sorry for confusion
- EXAM GRADING

Bohr model of the atom (1912)

- Positive Nucleus
- electrons orbit in circles
- only particular "discrete" orbits

1913

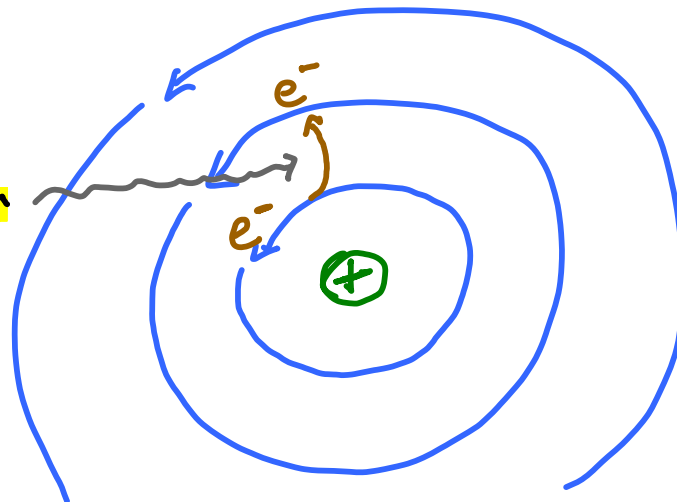


known as quantization

- electric (Coulomb) force holds electron on circle as it orbits ... attracts electron toward nucleus

- Nuclear ATOM
- Discrete STABLE circular orbits

Absorb (photon)
 e^- makes transition from low Energy orbit to high energy orbit



Possible orbits for electron

Transition from high energy orbit to low energy orbit
→ emission of photon

Werner Karl Heisenberg
(1901 - 1976)

Nobel Prize in physics - 1932
for "the creation of quantum
Mechanics"

(Max Born, Pascual Jordan - co-workers)



Erwin Rudolf Josef Alexander Schrödinger
(1887 - 1961) Austria

1933 Nobel Prize in physics

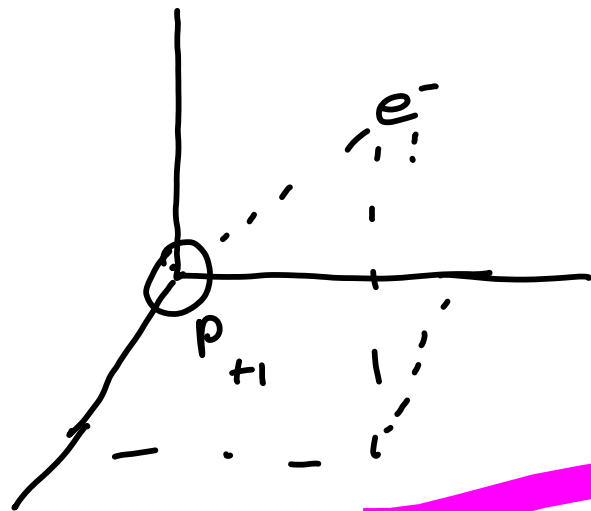
1926 - Paper on wave Mechanics of Matter
Annalen der Physik

"for discovery of new and productive forms of
atomic theory"

general

$$-\frac{\hbar^2}{2m} \frac{d^2 \psi(x)}{dx^2} + V \psi(x) = E \psi(x) \quad \text{Schrödinger's Equation}$$

Just so
you've seen
it



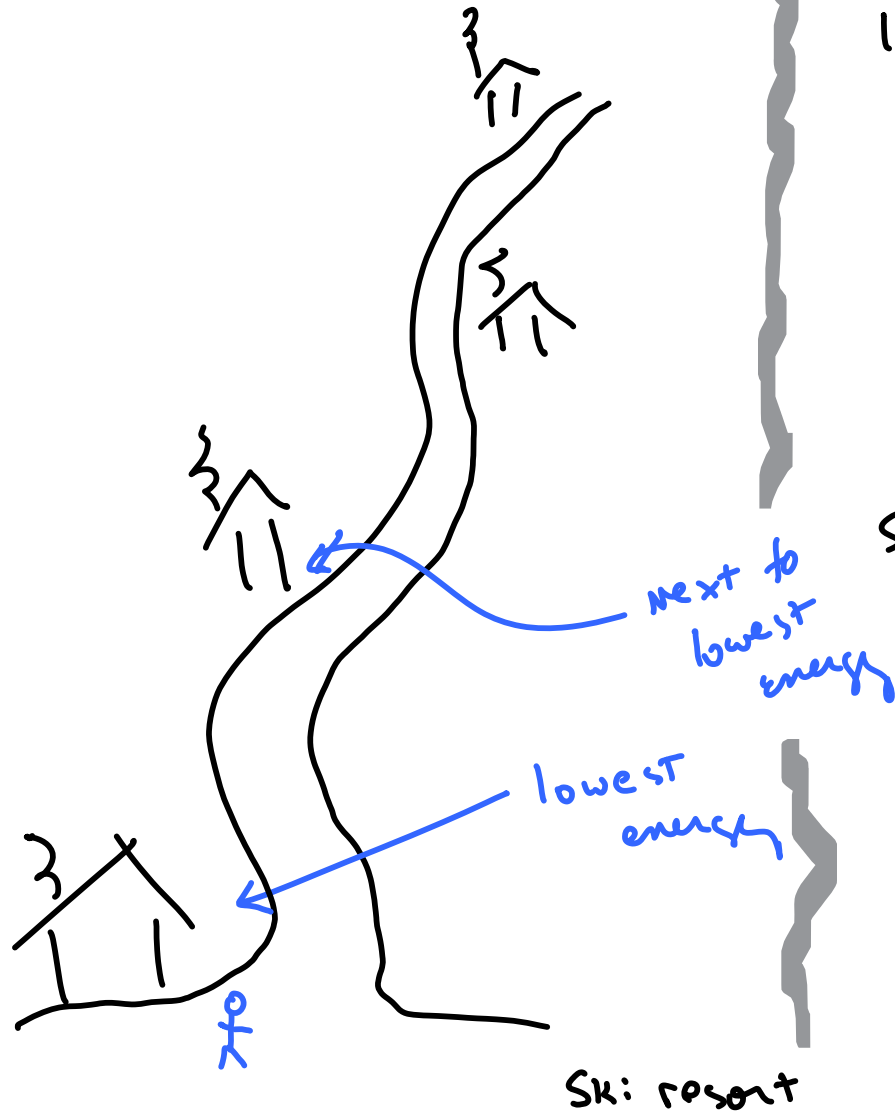
e^-
in spherically symmetric
potential
(force)

Plus into
Schrödinger's eqn

what comes out of this

→ particular spatial and energy
are allowed

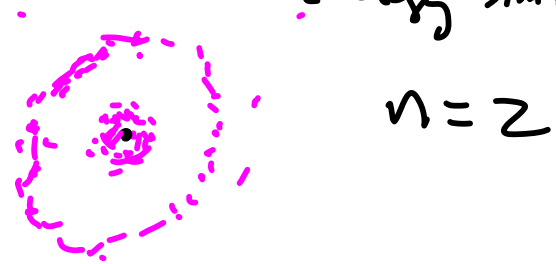
→ quantum states



Sketch of probability of where you might find e^- if it were in the H atom
lowest energy state



Same for second lowest energy state



Only discrete energies and spatial states allowed for the electron to occupy → orbital

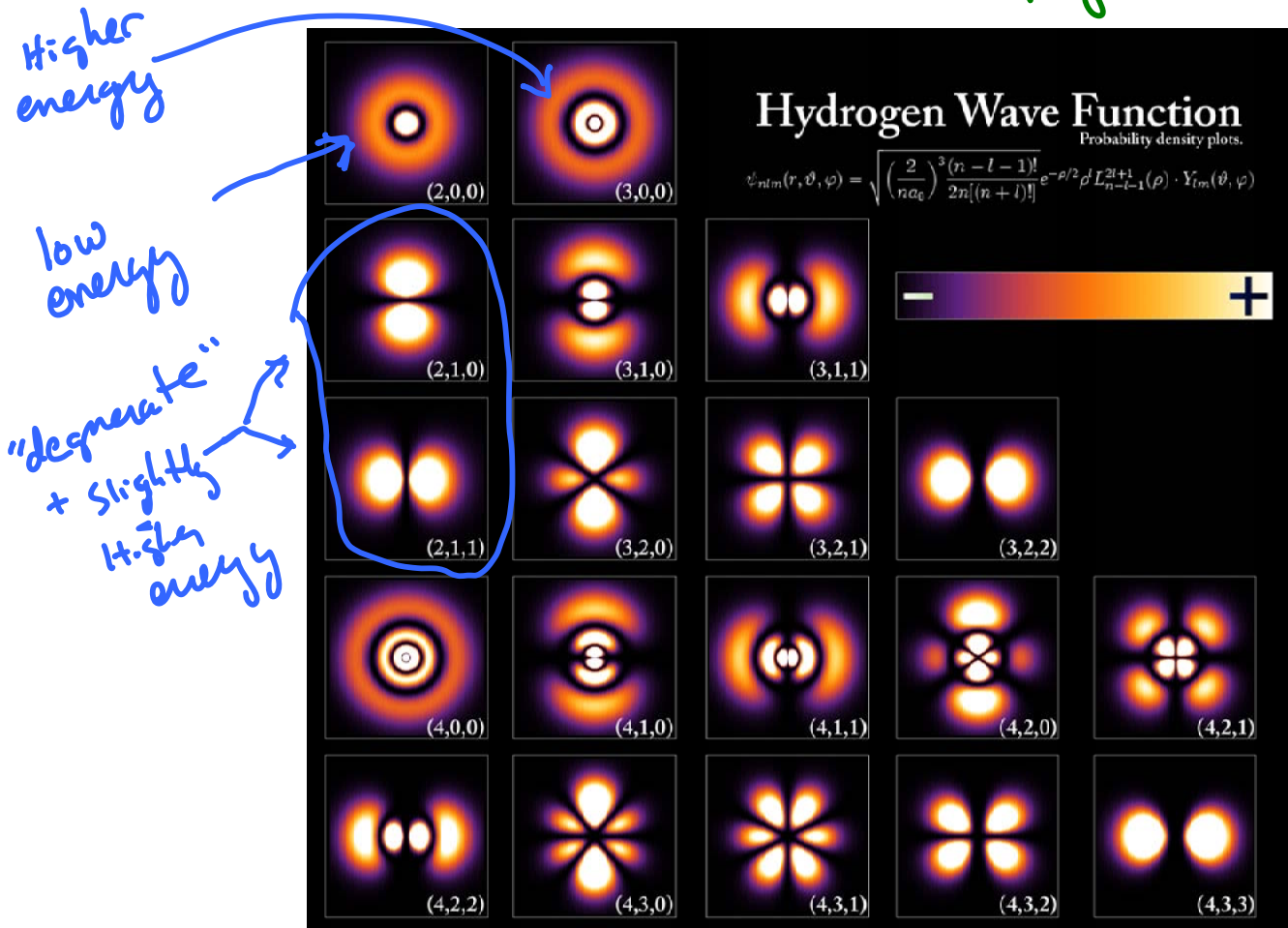
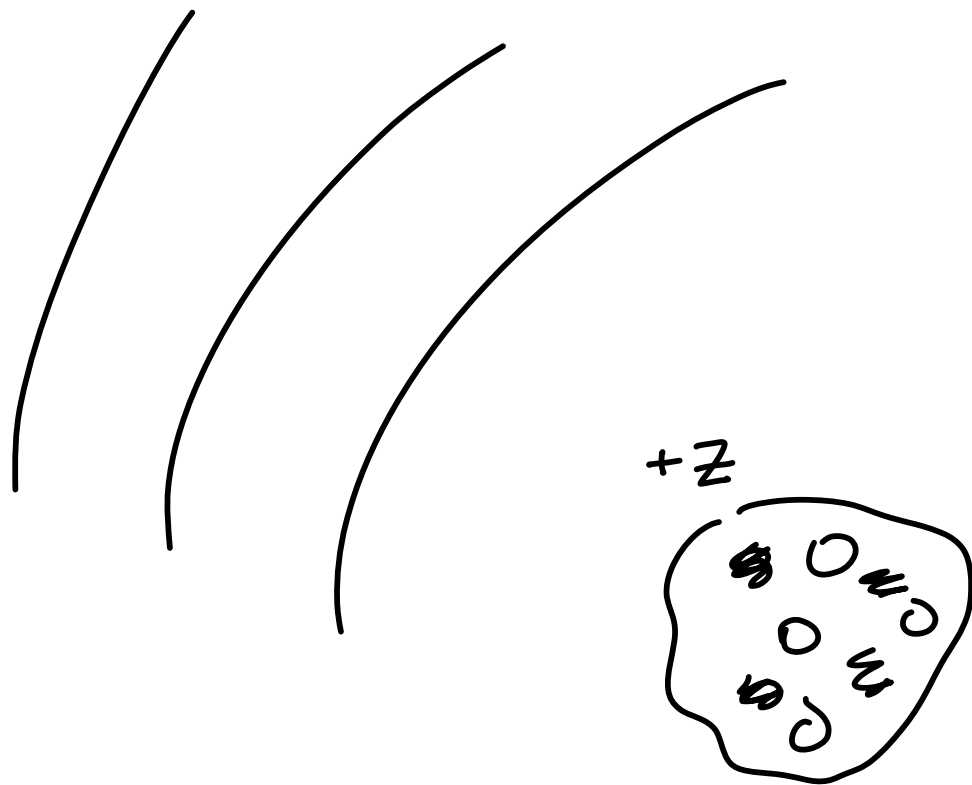


figure from http://en.wikipedia.org/wiki/File:Hydrogen_Density_Plots.png

Hydrogen $Z = 1$
 Helium $Z = 2$
 Lithium $Z = 3$
 \vdots
 $Z = 120$



Z protons \oplus
 $(A - Z)$ neutrons \ominus

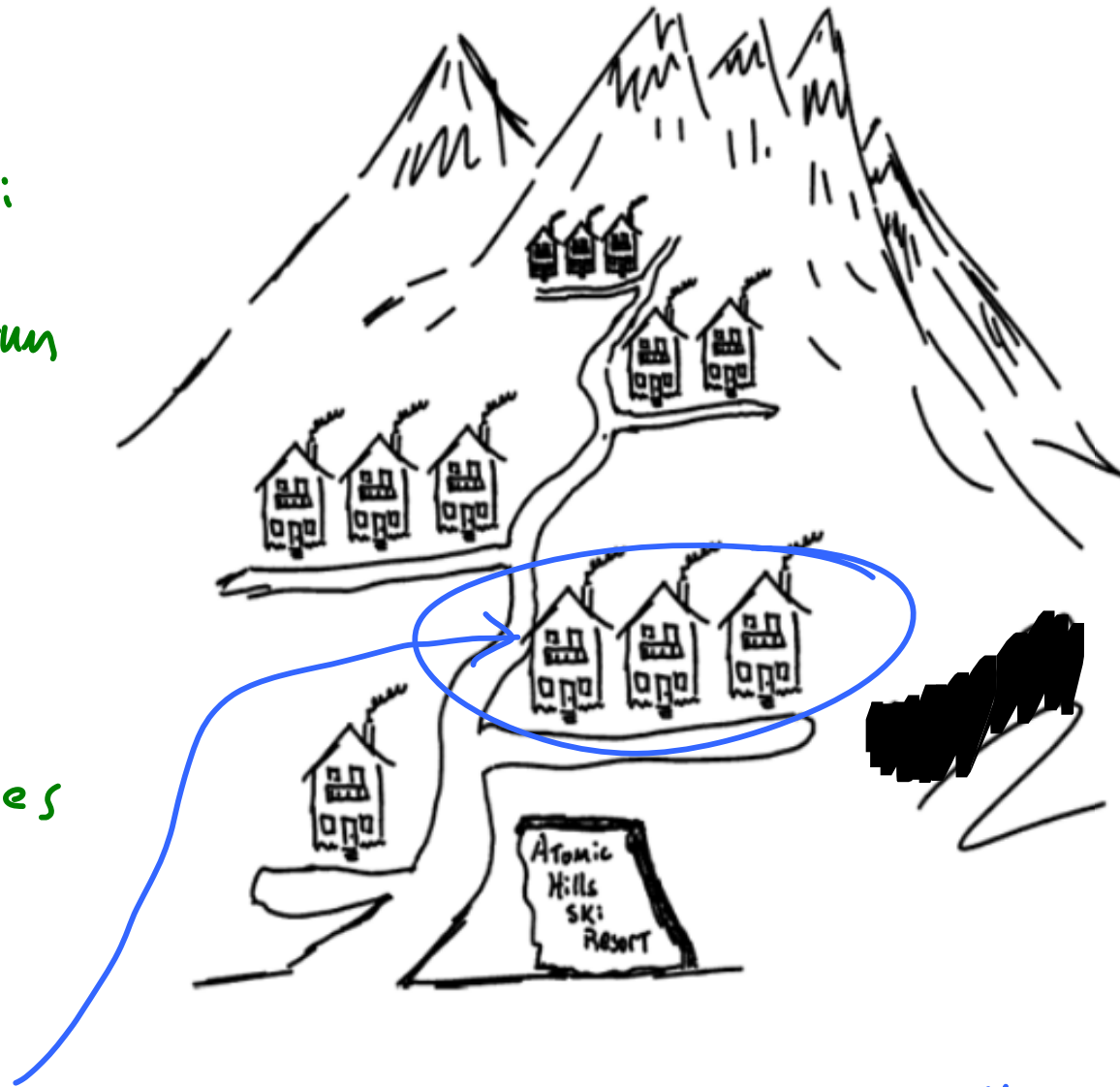


Basic Structure of atom

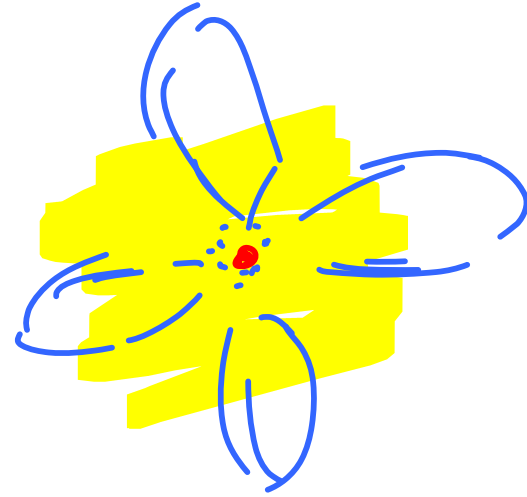
Analogy of
condos in a ski
village to
allowed quantum
STATES in an
atom.

discrete places
to reside.

different energies
to reach those
places.



Some states with different spatial configurations have the same energy — Said to be "degenerate" ... no judgement on morals of electrons.



as Z increases \rightarrow # electrons increase
 \uparrow
protons in nucleus

How do these electrons populate the available orbitals?

To answer this we need to investigate

Particle Promiscuity

Stern-Gerlach experiment - 1922

→ Discovery that electrons have Spin

Spin

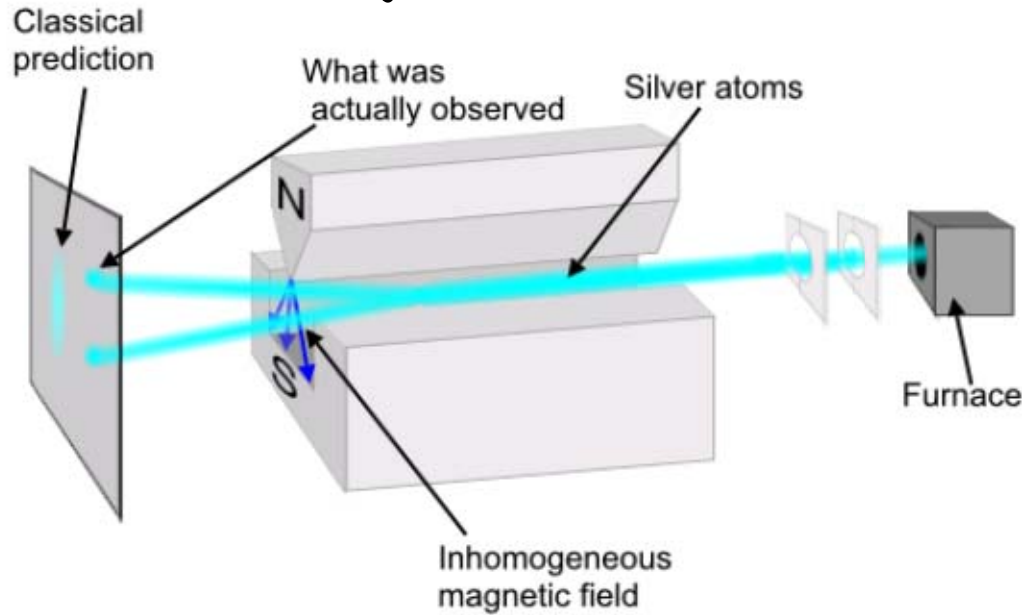


Diagram from
Wikipedia

Otto Stern



-wikipedia

"If this nonsense from Bohr will
prove to be right we will quit physics."
(Stern vowed in 1913)

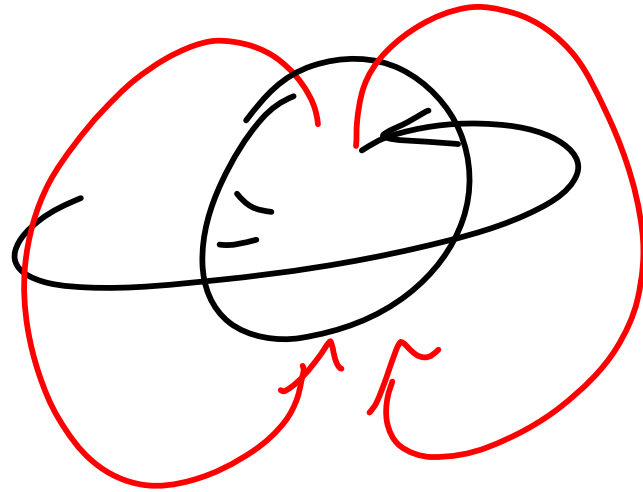
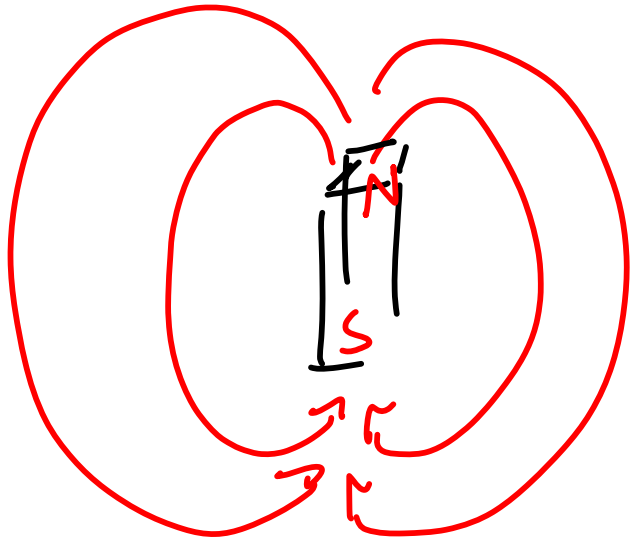
as quoted in Phys. Today Dec 03

Walther Gerlach



from phys Today article
(Dec. 03)

Particles have intrinsic Spin



Spin is quantized

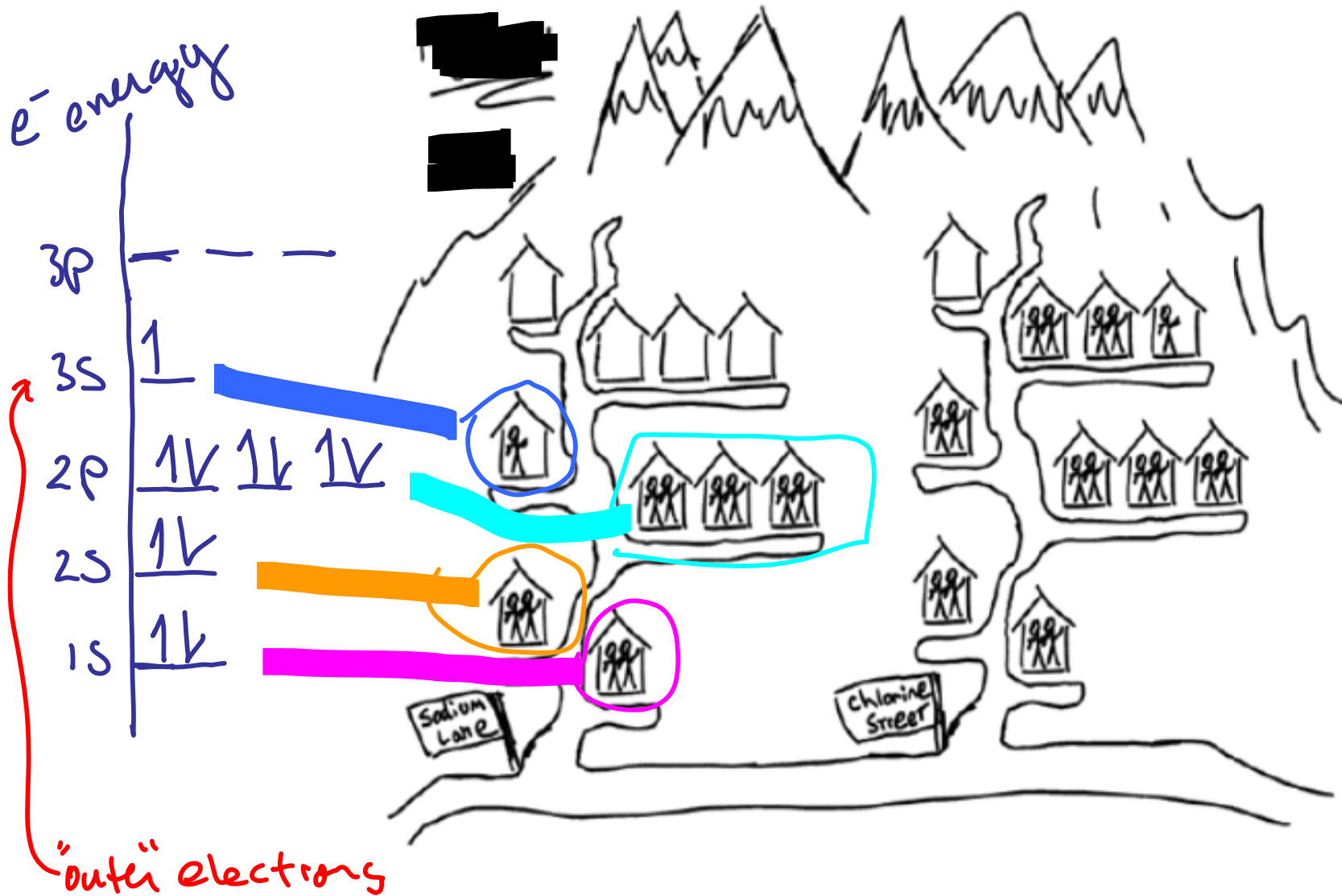
$0, \frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}$

Integer spin $0, 1, 2 \dots$ Bosons
half integer spin $\frac{1}{2}, \frac{3}{2}, \frac{5}{2} \dots$ Fermions

→ only 1 particle per quantum state

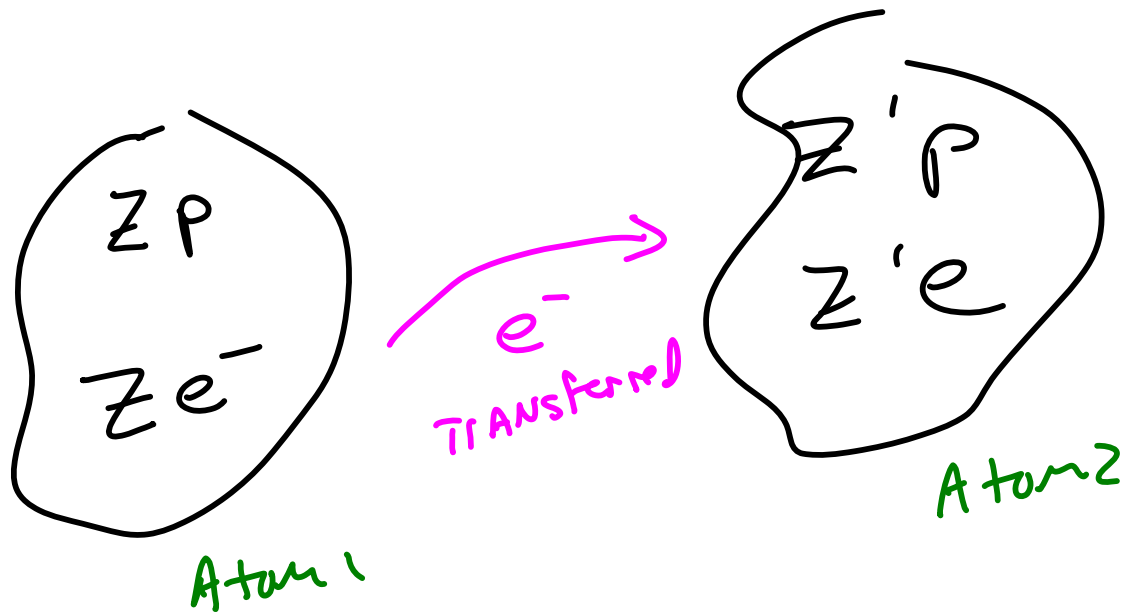
↘ Promiscuous
happily share quantum state,

electrons have spin $\frac{1}{2}$ - fermions



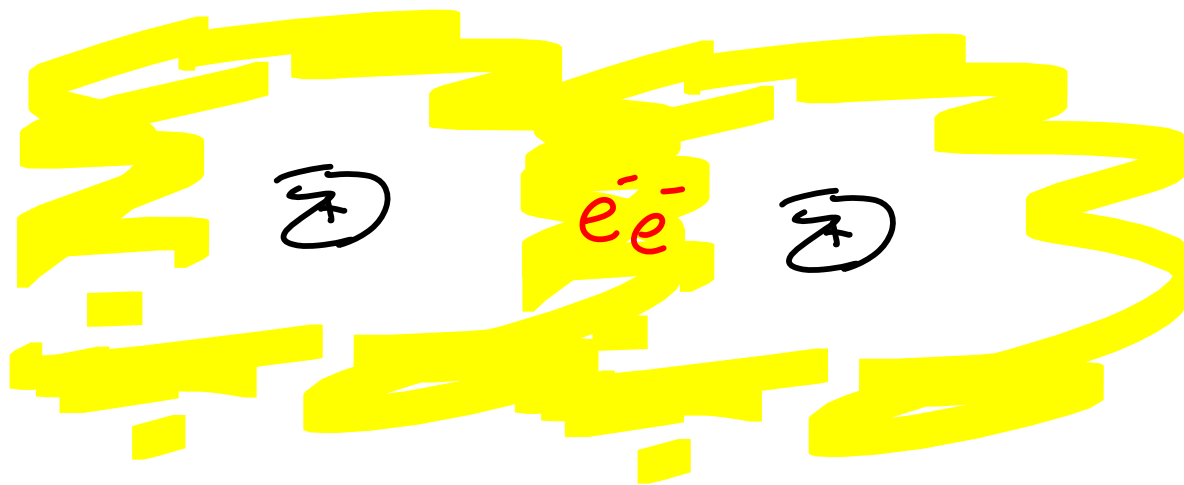
most important

in determining size + chemical characteristics
of atom



ionic bond





Covalent
bond

Very reactive in this column

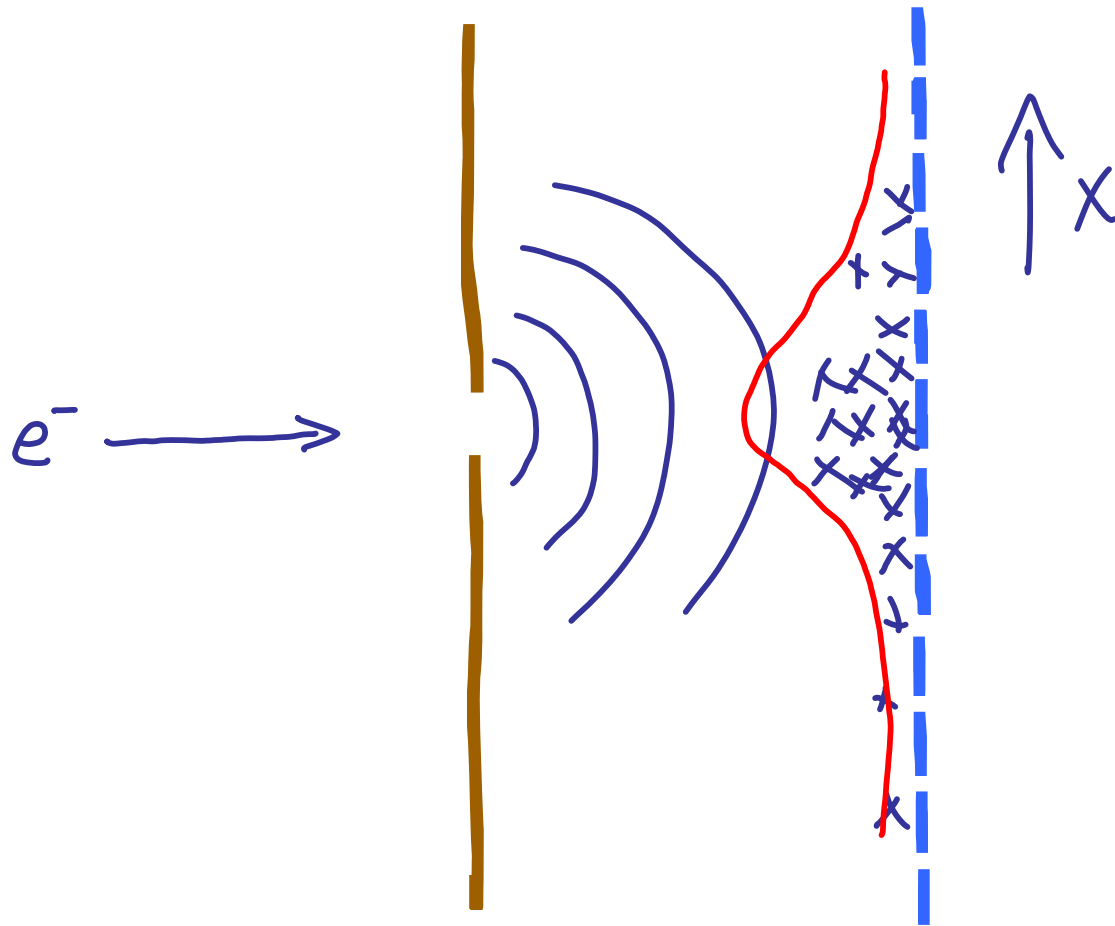
Very inert in this column

Los Alamos National Laboratory Chemistry Division

Periodic Table of the Elements

1A 1 H Hydrogen 1.008	2A 4 Be Beryllium 9.012											3A 5 B Boron 10.81	4A 6 C Carbon 12.01	5A 7 N Nitrogen 14.01	6A 8 O Oxygen 16.00	7A 9 F Fluorine 19.00	8A 2 He Helium 4.003	
3 Li Lithium 6.941	11 Na Sodium 22.99	12 Mg Magnesium 24.31	3B	4B 21 Ti Titanium 47.88	5B 23 V Vanadium 50.94	6B 24 Cr Chromium 52.00	7B 25 Mn Manganese 54.94	8B 26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	11B 29 Cu Copper 63.55	12B 30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
19 K Potassium 39.10	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Cesium 132.9	56 Ba Barium 137.3	57 La* Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.9	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 208.9	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)	
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac~ Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (264)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Ds Darmstadtium (271)	111 Uuu Ununundium (272)	112 Uub Ununbium (277)	114 Uuq Ununquadium (296)	116 Uuh Ununhexium (298)	118 Uuo Ununoctium (?)				
Lanthanide Series*			58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (147)	62 Sm Samarium (150.4)	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0		
Actinide Series~			90 Th Thorium 232.0	91 Pa Protactinium (231)	92 U Uranium (238)	93 Np Neptunium (237)	94 Pu Plutonium (242)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (249)	99 Es Einsteinium (254)	100 Fm Fermium (253)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (260)		

Very reactive in this column



$\psi(x)$ NOT well defined

Probability

$\psi^2(x)$ is well defined \rightarrow probability

Max Born German (1882-1970)



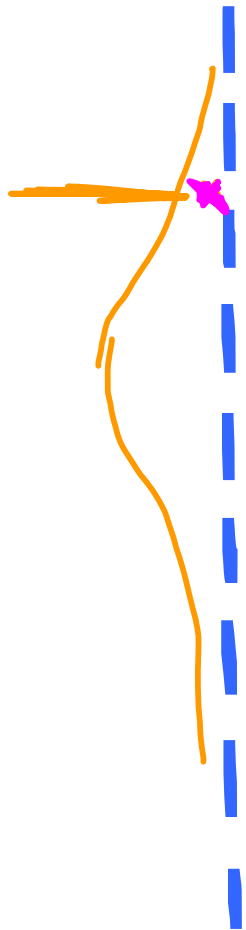
1954 Nobel Prize in physics

"For his fundamental research
in quantum mechanics,
especially for his statistical
interpretation of the
wavefunction"

$\psi(x)$ wave function

$\psi^2(x) \sim$ probability of finding particle
in region of space

e^- →



wave
function
collapse

←
probability