

Physics 102 — March 3, 2014

Ranking

BB issues w/ writing assignment 5 \rightarrow multiple columns



Schrödinger

$$-\frac{\hbar^2}{2m} \frac{d^2 \psi(x)}{dx^2} + V\psi(x) = E\psi(x)$$

$\hbar \equiv h/2\pi$
 input force here
 energy
 mass
 spatial dependence



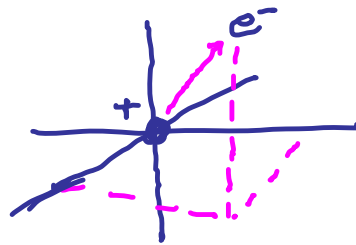
Heisenberg

Time independent
Schrödinger equation

wave equation for
waves/particles [can have mass]

$\psi(x) \equiv$ Wave function

$$-\frac{\hbar^2}{2m} \frac{d^2 \psi(x)}{dx^2} + V \psi(x) = E \psi(x)$$



For H atom input spherically symmetric Coulomb force here
Then solve

⋮

get discrete/quantized STATES
of energy and spatial position

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

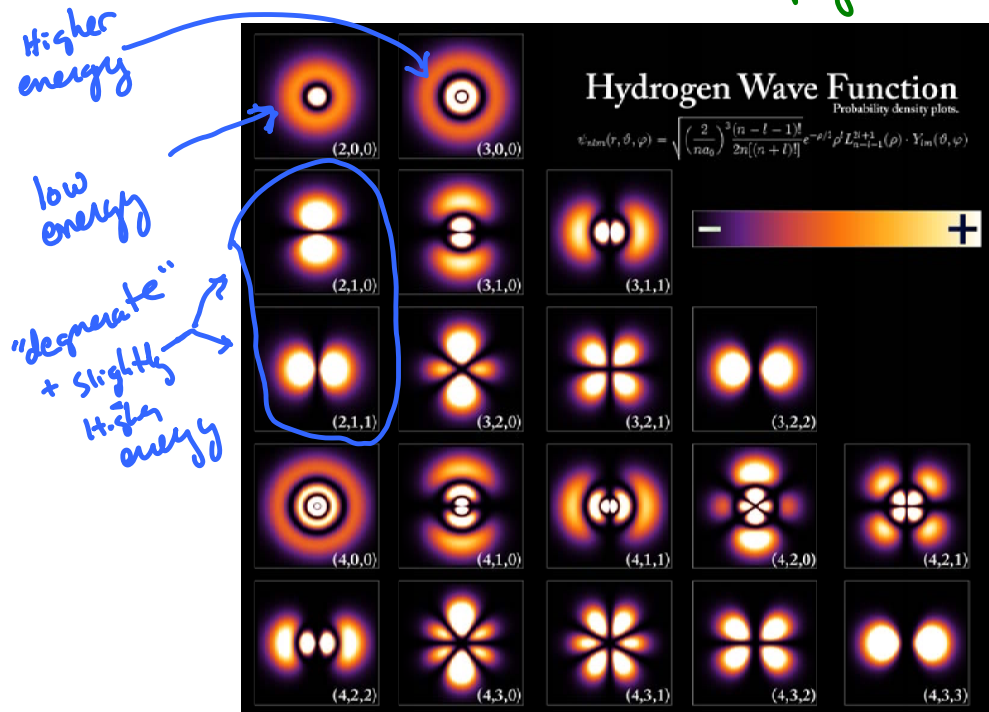
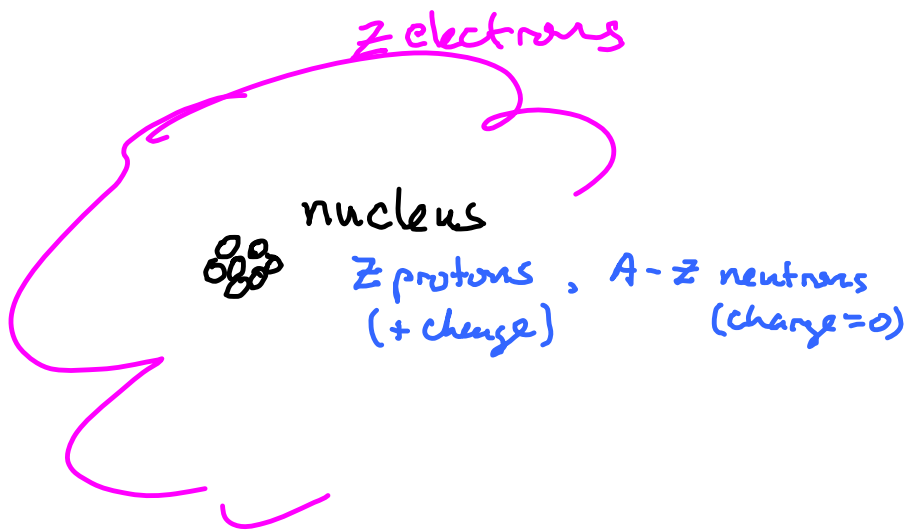


figure from http://en.wikipedia.org/wiki/File:Hydrogen_Density_Plots.png



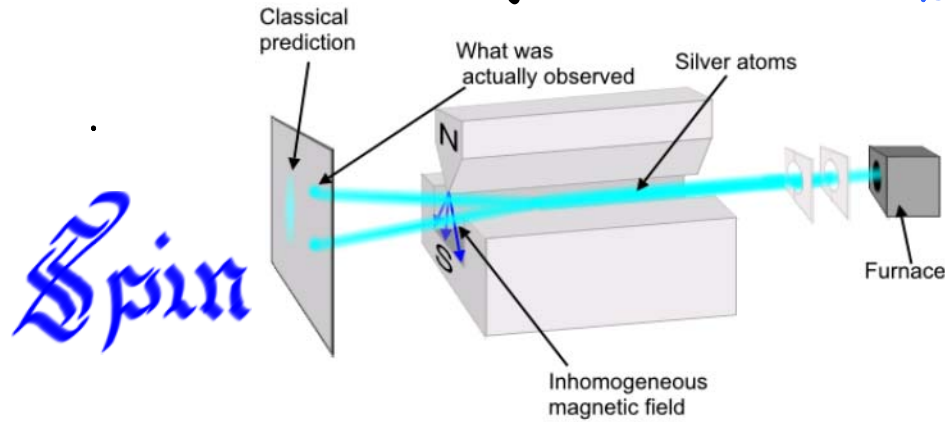
as Z increases
electrons increase

How do they populate
Available STATES/orbitals ?

→ particle promiscuity
is important

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)

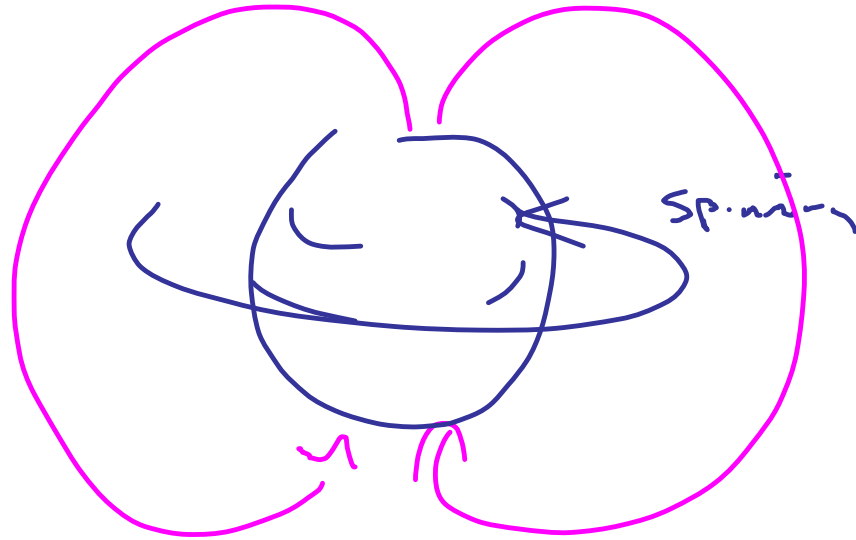
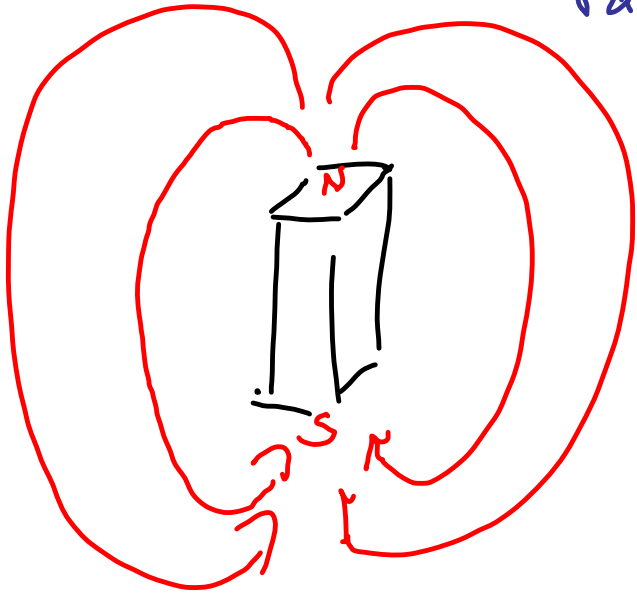
as quoted in Phys. Today Dec 03

Walther Gerlach



from phys Today article
(Dec. 03)

Particles have spin

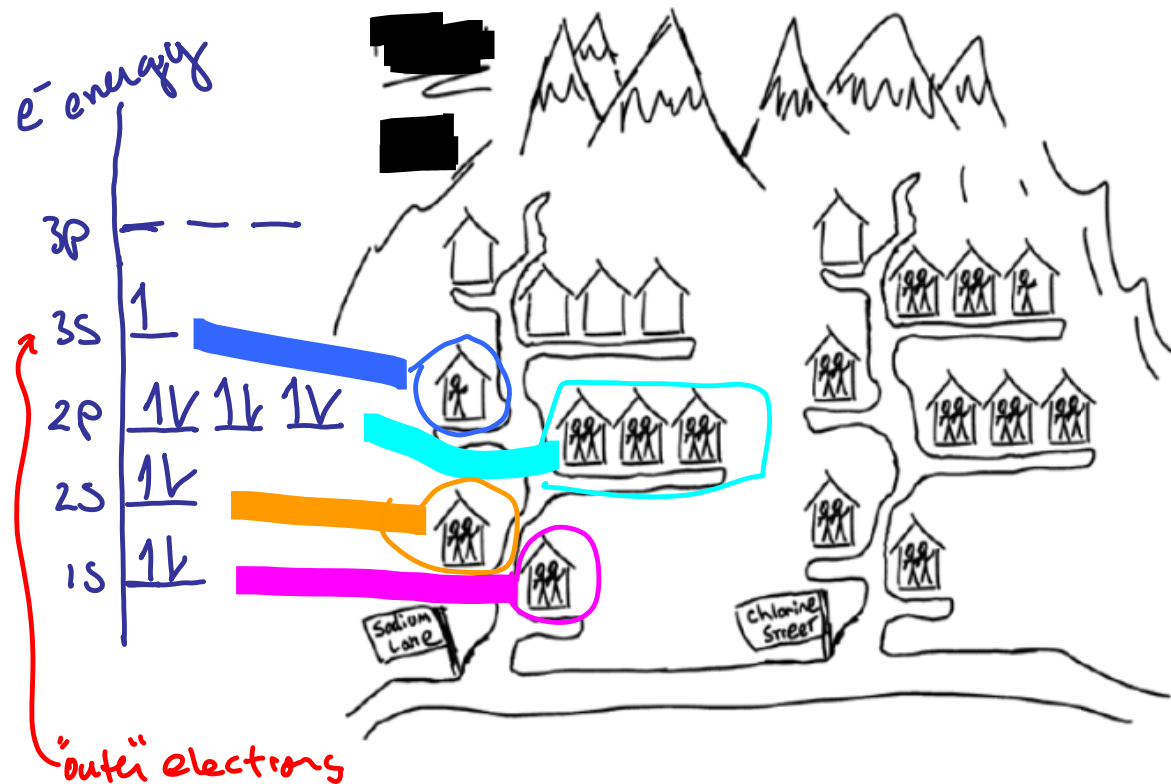


Spin is quantized

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

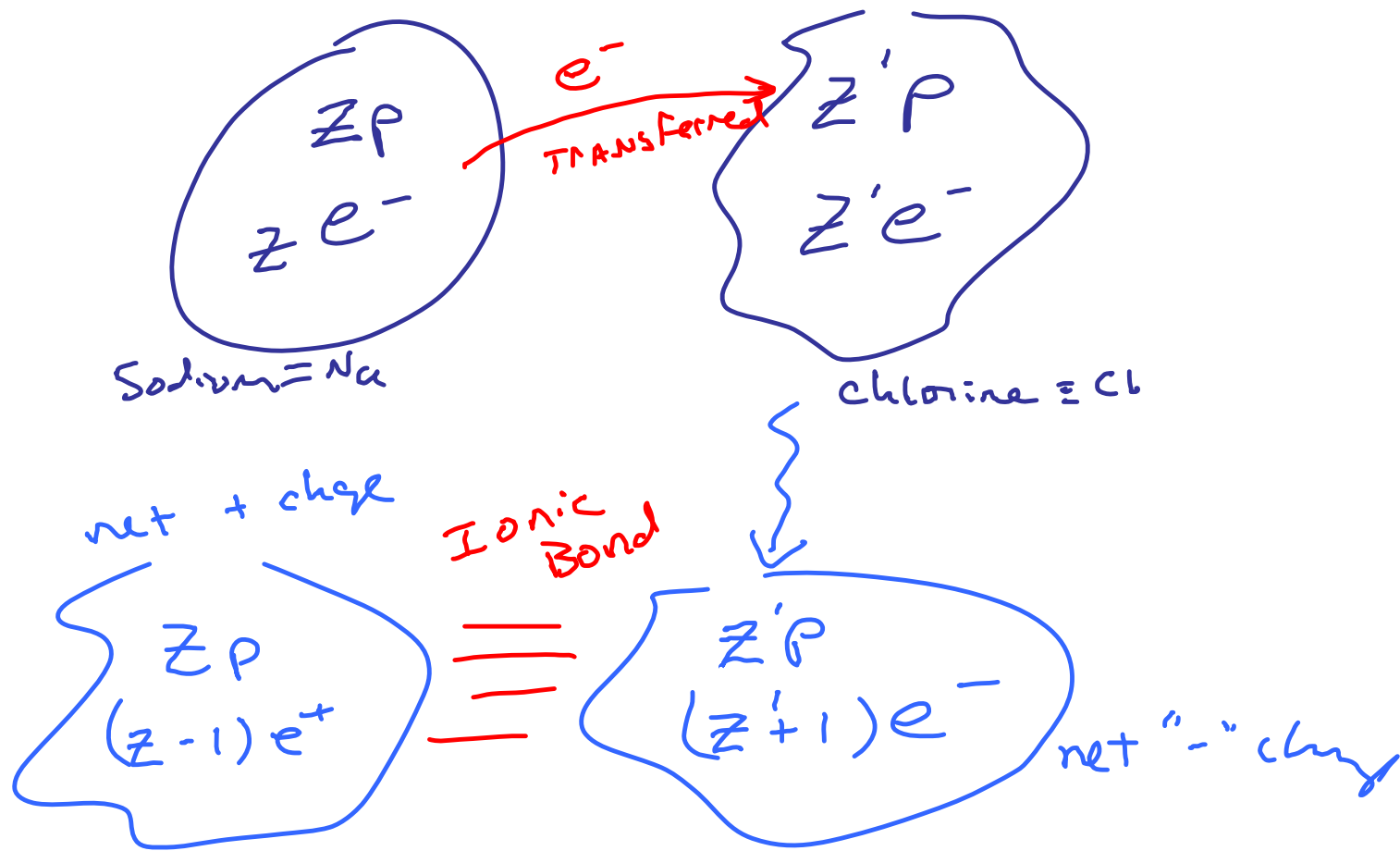
Integer spin \rightarrow Bosons
Bose-Einstein
STATISTICS

half-integer spin \rightarrow Fermions
 $e, \text{proton}, \text{neutron}$

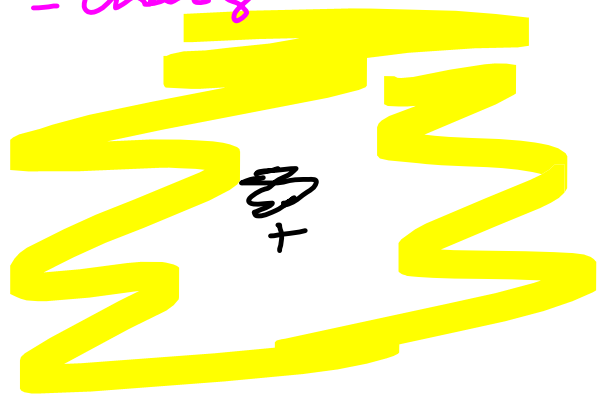


most important

in determining size + chemical characteristics
of atom



- charge

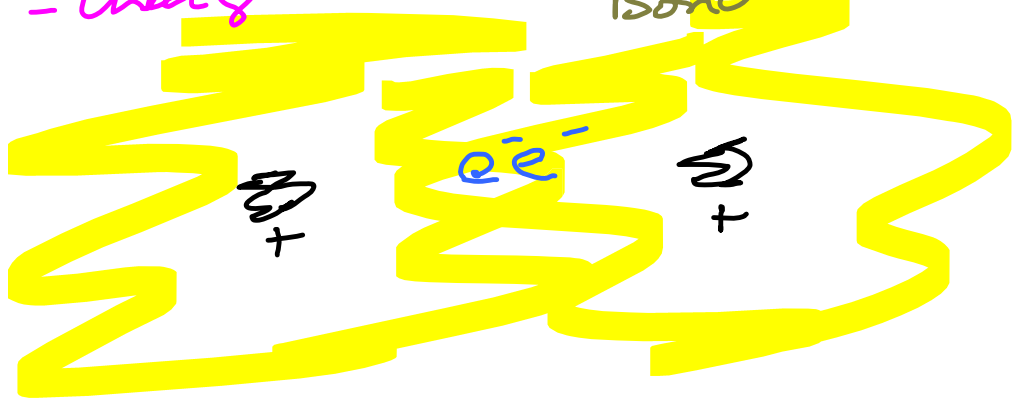


- charge



- charge

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	2 He Helium 4.003		3A	4A	5A	6A	7A	8A								
	3 Li Lithium 6.941	4 Be Beryllium 9.012			5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 18.99	10 Ne Neon 20.18								
	11 Na Sodium 22.99	12 Mg Magnesium 24.31			13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95								
	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
	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 183.8	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 Uu Ununium (272)	112 Uub Unbibium (277)	114 Uuq Ununquadium (289)	116 Uuh Ununhexium (289)	118 Uuo Ununoctium (?)			

Very reactive in this column

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 151.9	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 174.9
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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 (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (260)
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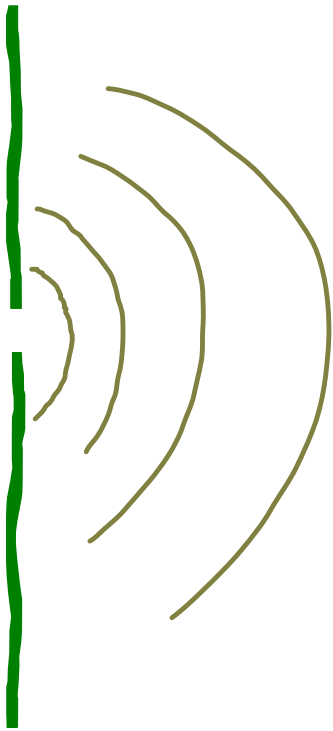
element names in blue are liquids at room temperature
 element names in red are gases at room temperature
 element names in black are solids at room temperature

Max Born German (1882-1970)

$\psi(x)$ wave function

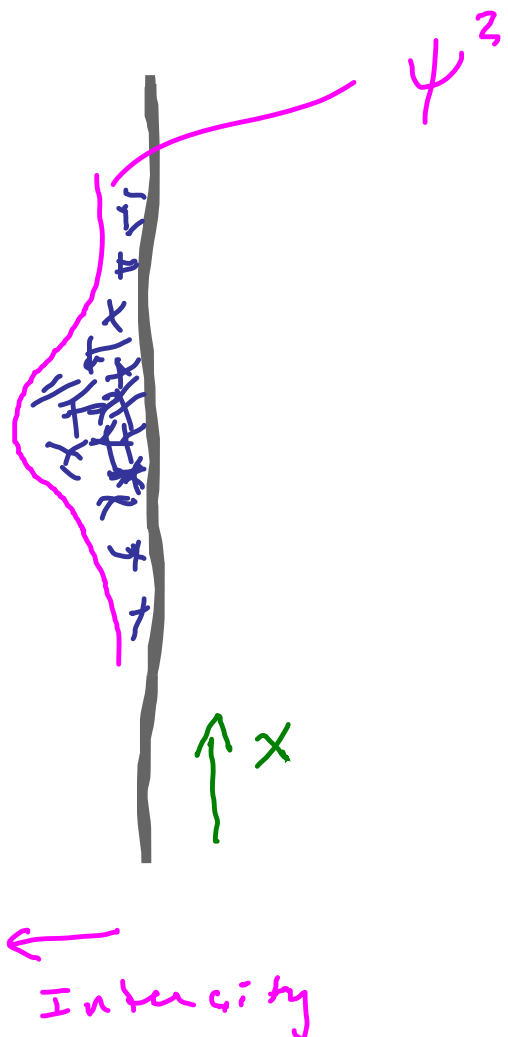
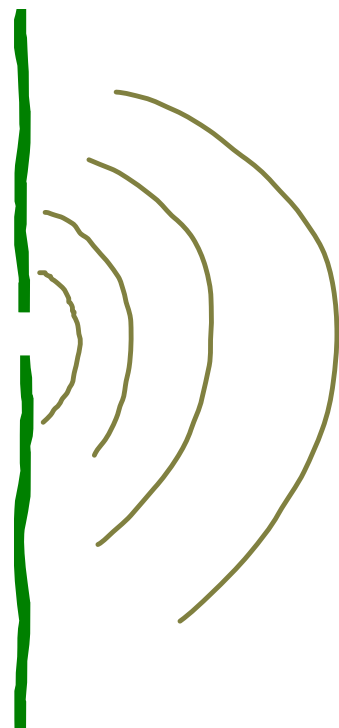
$\psi^2(x) \sim$ probability of finding the particle in that state

λ

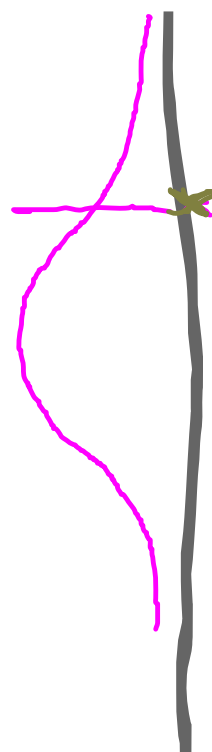


Intensity

$\square \rightarrow \lambda \rightarrow \lambda \rightarrow \lambda$



$\square \rightarrow \gamma \rightarrow \gamma \rightarrow \gamma$



ψ^2
Wave function
collapses
"instantly"

x

← probability

