# Physics 102 - February 28, 2011

- Recitations — NOT this week
  sorry for confusion
- EXAM grading

# Bohr model of the atom (1912)

1913

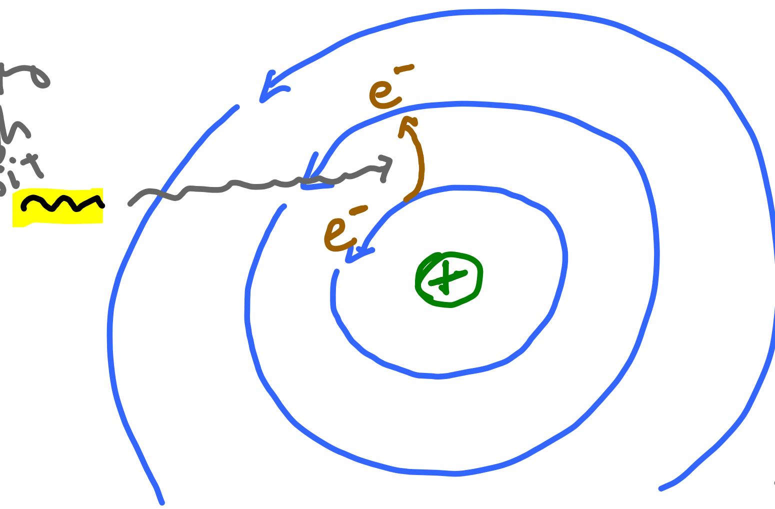
- Positive Nucleus
- electrons orbit in circles
- only particular "discrete" orbits

  ↑ known as quantization

- electric (coulomb) force holds electron on circle as it orbits ... attracts electron toward Nucleus

- Nuclear ATOM
- Discrete STABLE circular orbits

Absorb $\gamma$ (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

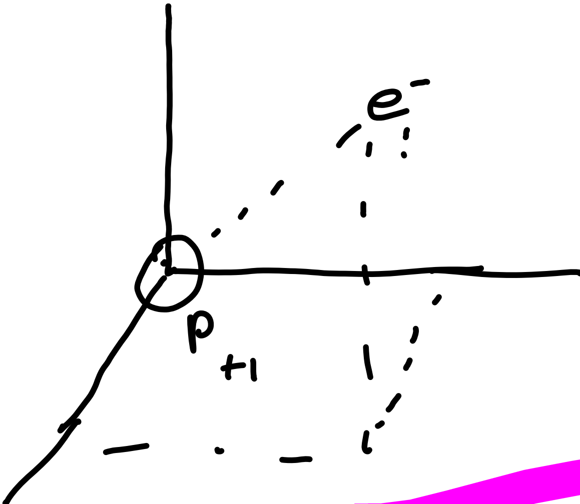
"for discovery of new and productive forms of atomic theory"

general

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

Schrödinger's EQUATION

Just so you've seen it




$e^-$

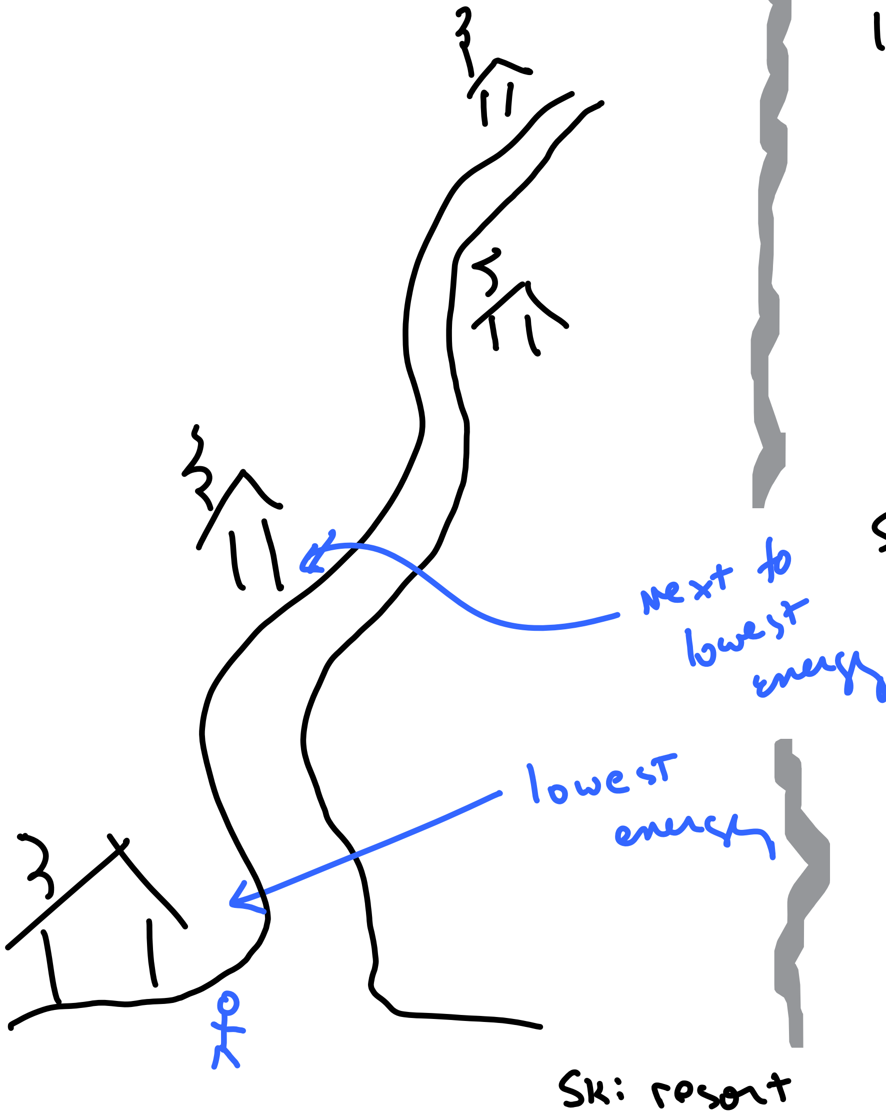
in spherically symmetric potential (force)

Plug 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

$n=1$

Same for Second lowest Energy State

$n=2$

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

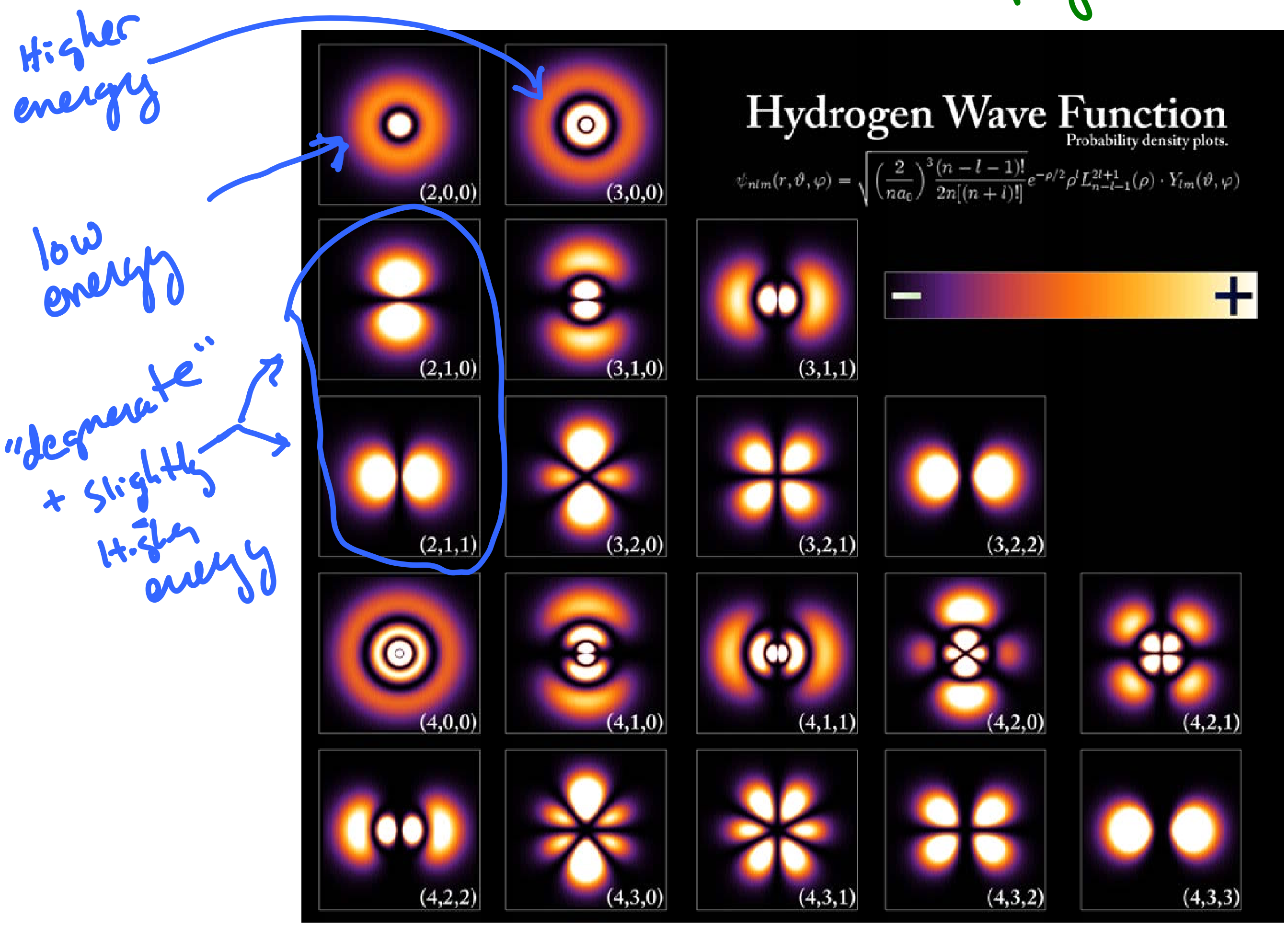
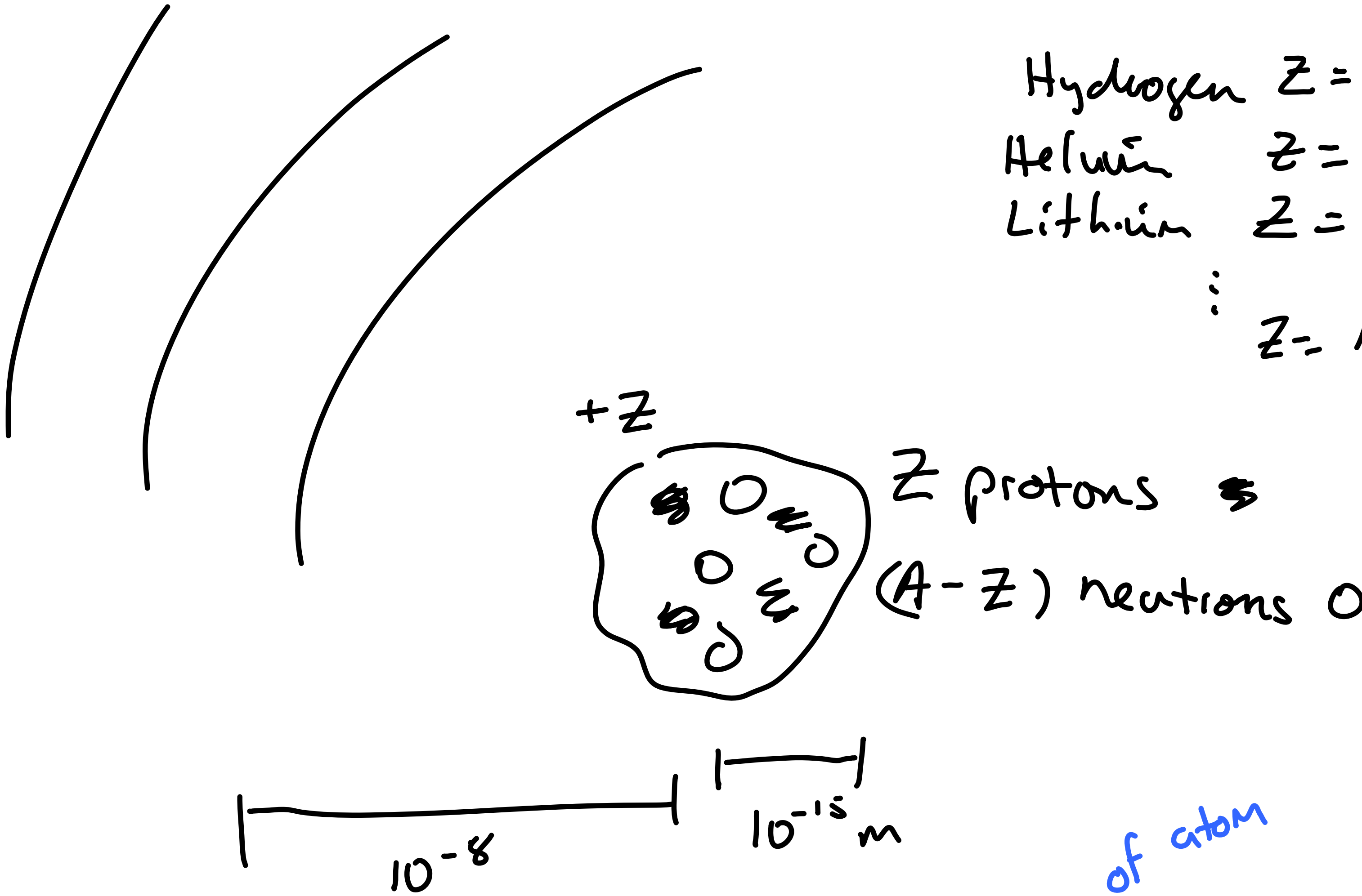



figure from http://en.wikipedia.org/wiki/File:Hydrogen_Density_Plots.png

Hydrogen $Z = 1$
Helium $Z = 2$
Lithium $Z = 3$
⋮
$Z = 120$



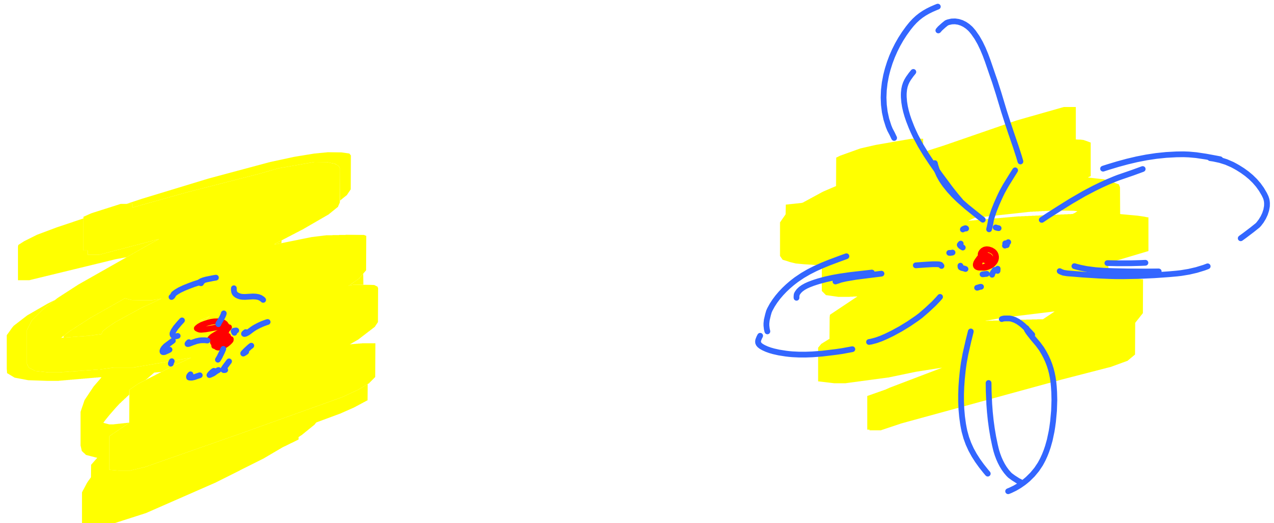

Basic Structure of atom

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 → # electrons increase

↑

# 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

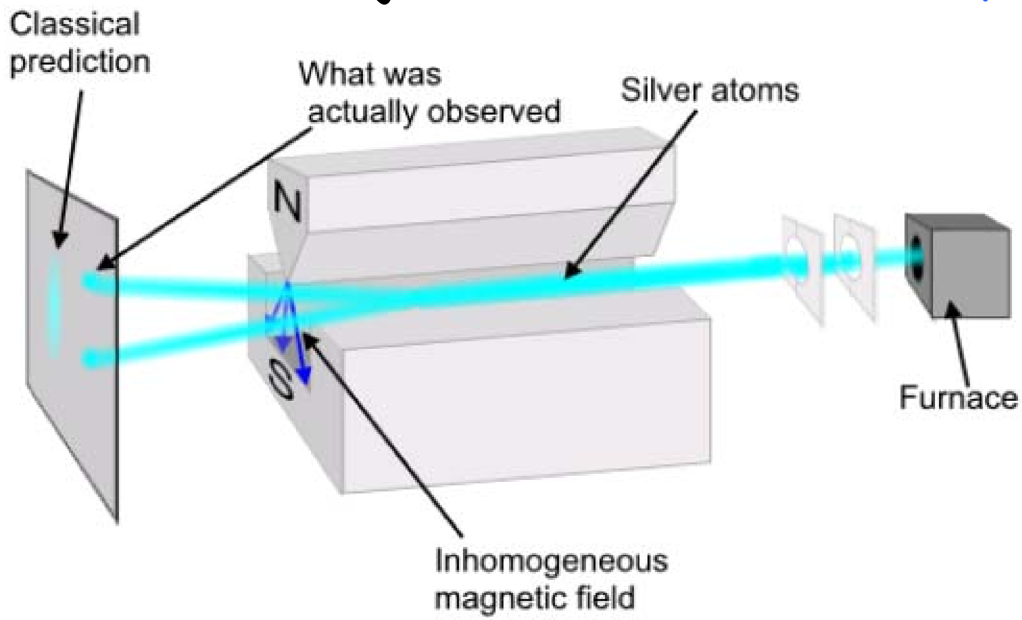
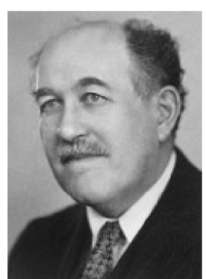



Diagram from Wikipedia

Otto Stern

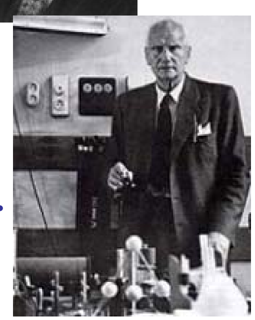


-wikipedia

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

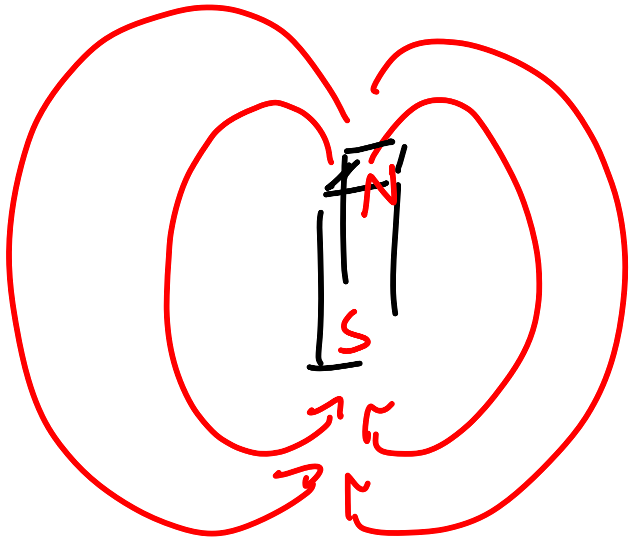
as quoted in Phys. Today Dec 03

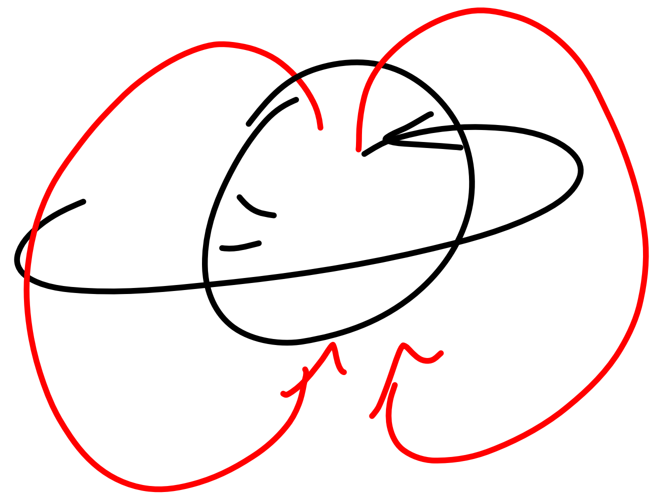
Walther Gerlach



from Phys Today article (Dec. 03)

Particles have intrinsic Spin



Spin is quantized

0, 1/2, 1, 3/2, 2, 5/2

Integer spin 0, 1, 2 . . . Bosons

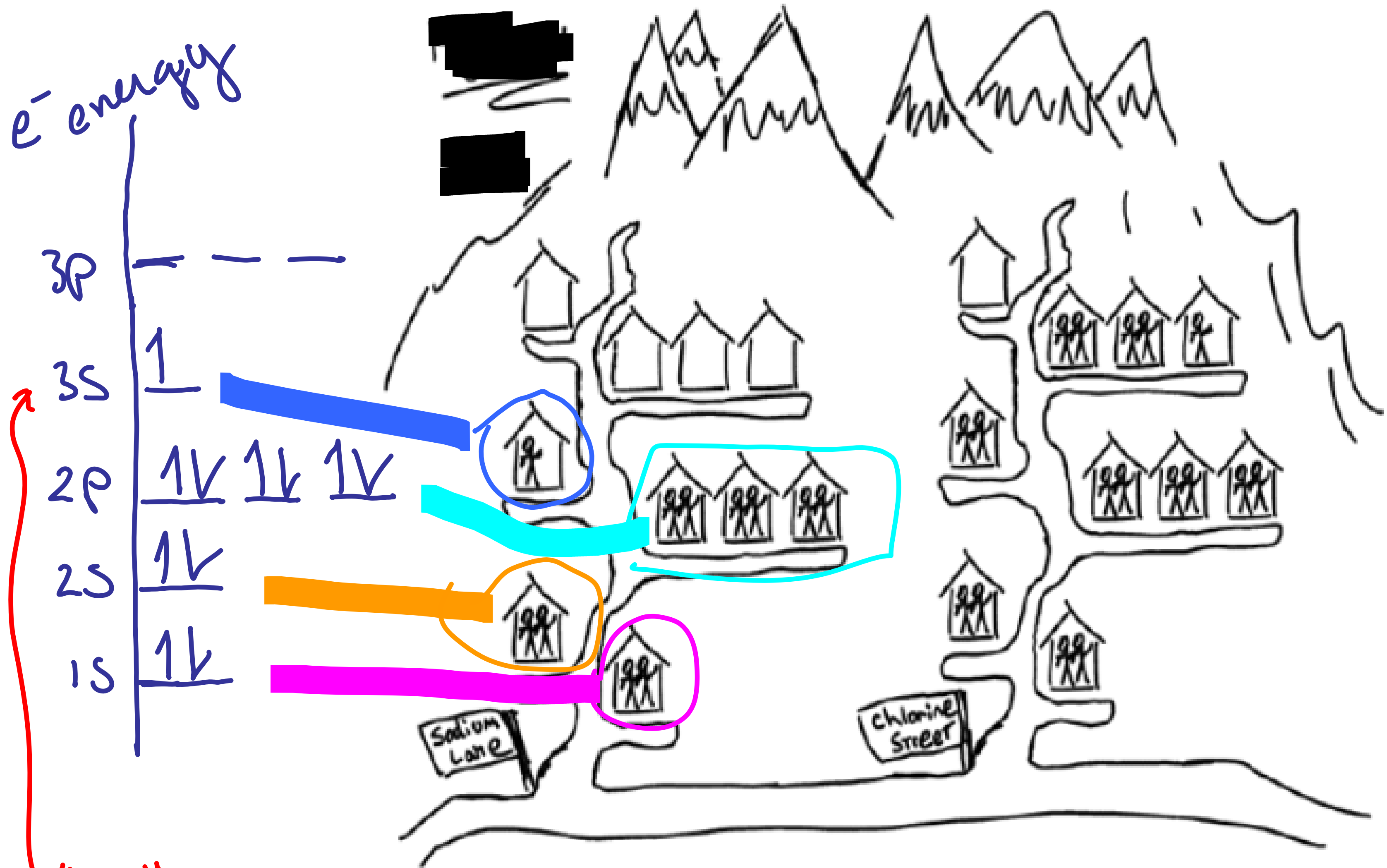
half integer spin $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}$ . . . Fermions

only 1 particle per quantum state

Promiscuous

happily share quantum state,

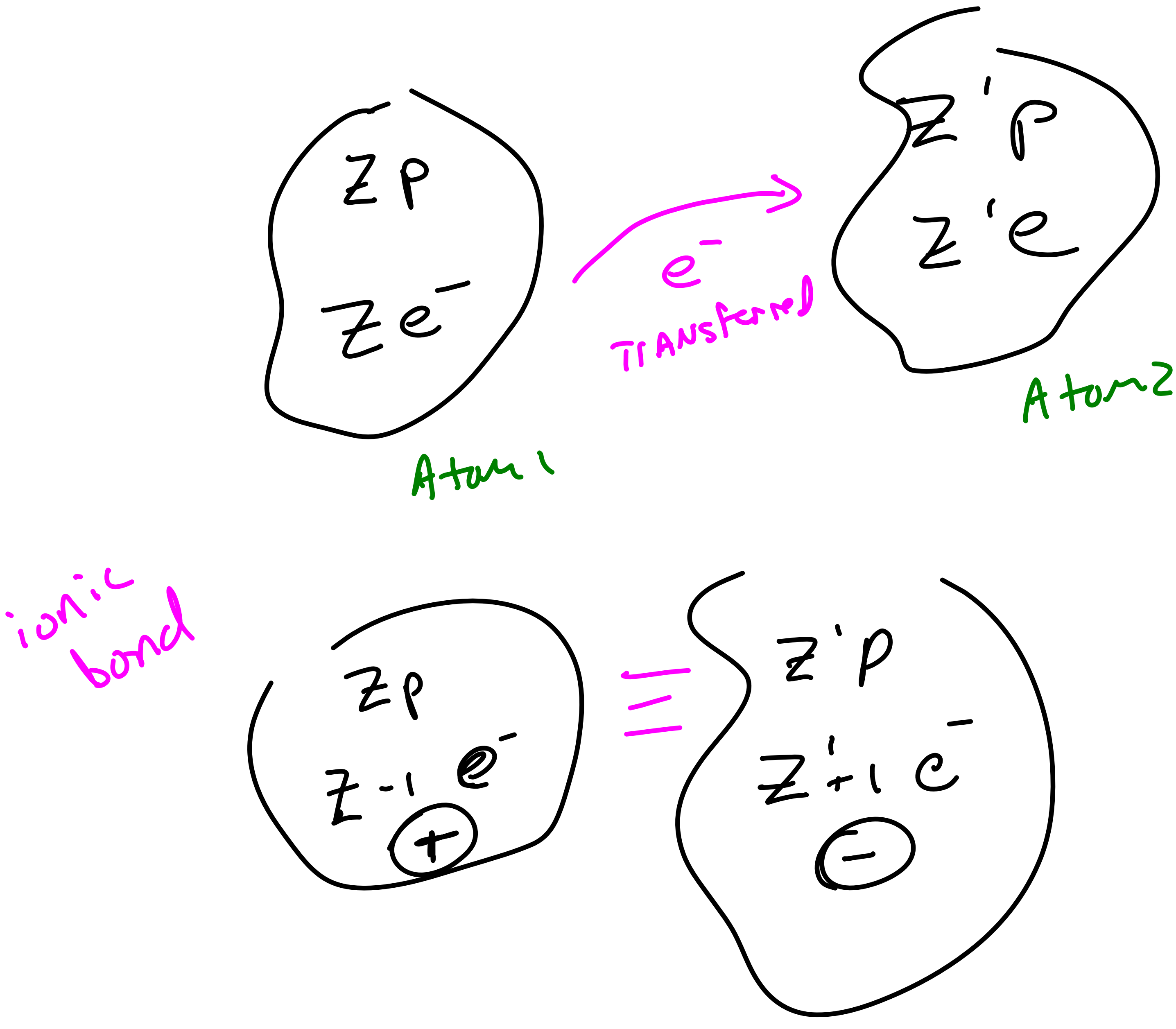
electrons have spin ½ - fermions

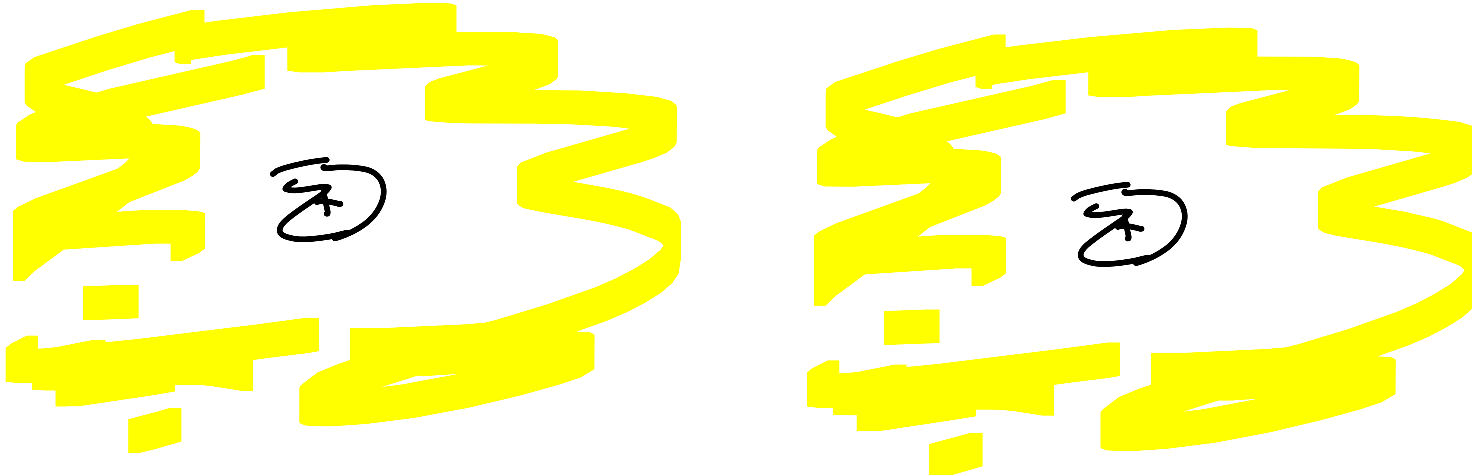



"outer" electrons

most important

in determining size + chemical characteristics of atom


Zp
Ze⁻
Atom 1
e⁻
TRANSferred
Z'p
Z'e
Atom 2
ionic bond
Zp
Z-1 e⁻
+
Z'p
Z'+1 e⁻
−



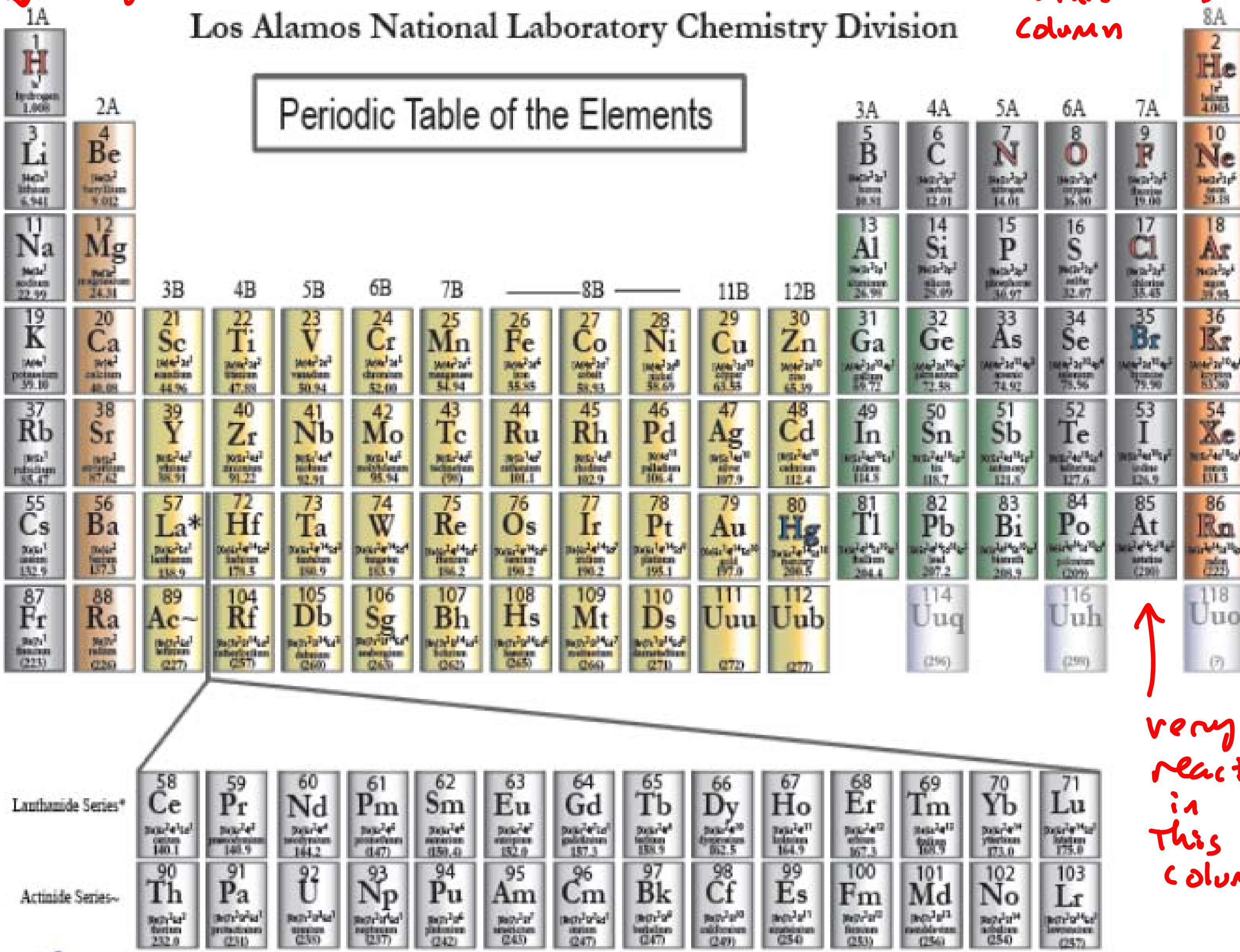

e⁻e⁻
covalent
bond

very reactive in this column

very inert in this column

# Los Alamos National Laboratory Chemistry Division

## Periodic Table of the Elements

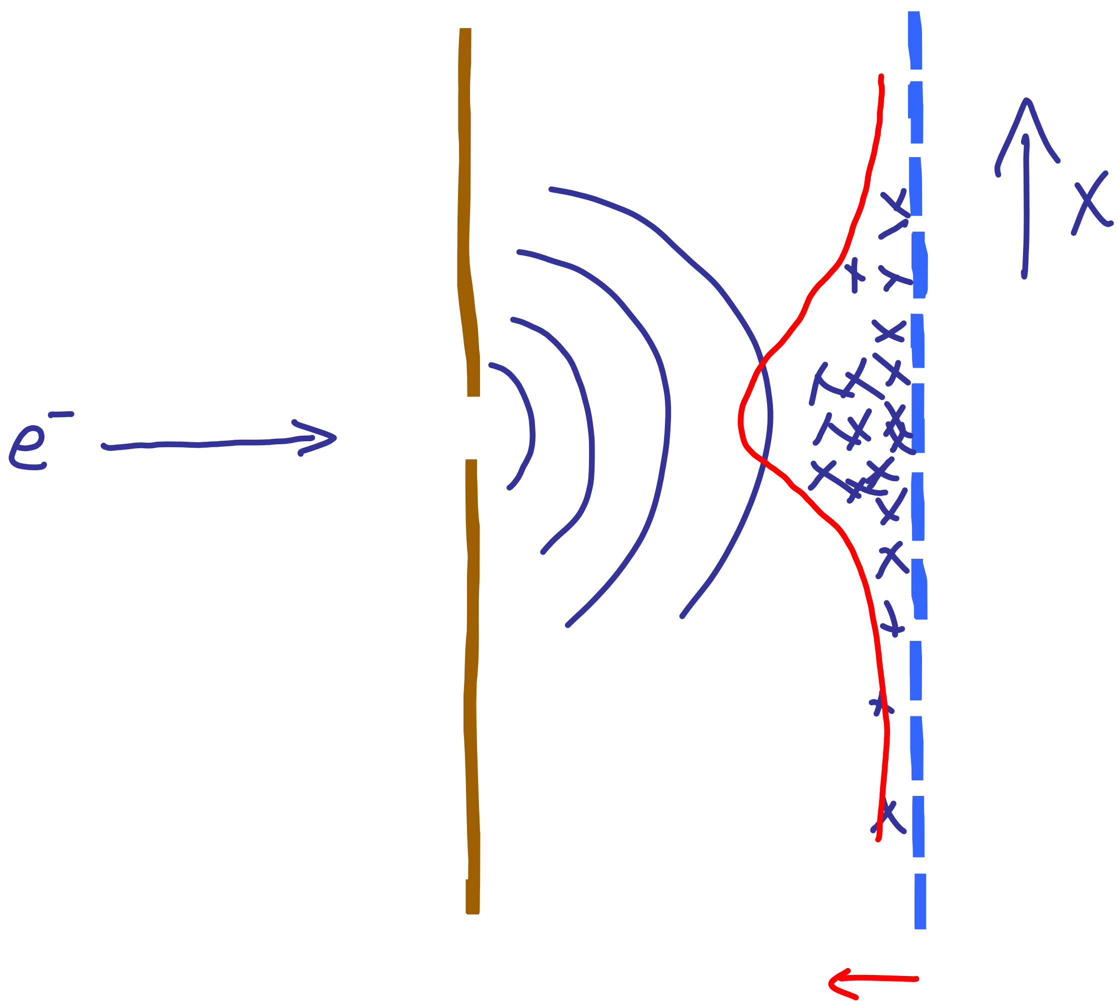



very reactive in this column

Los Alamos NATIONAL LABORATORY

CHEMISTRY

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




$\psi(x)$ not well defined

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

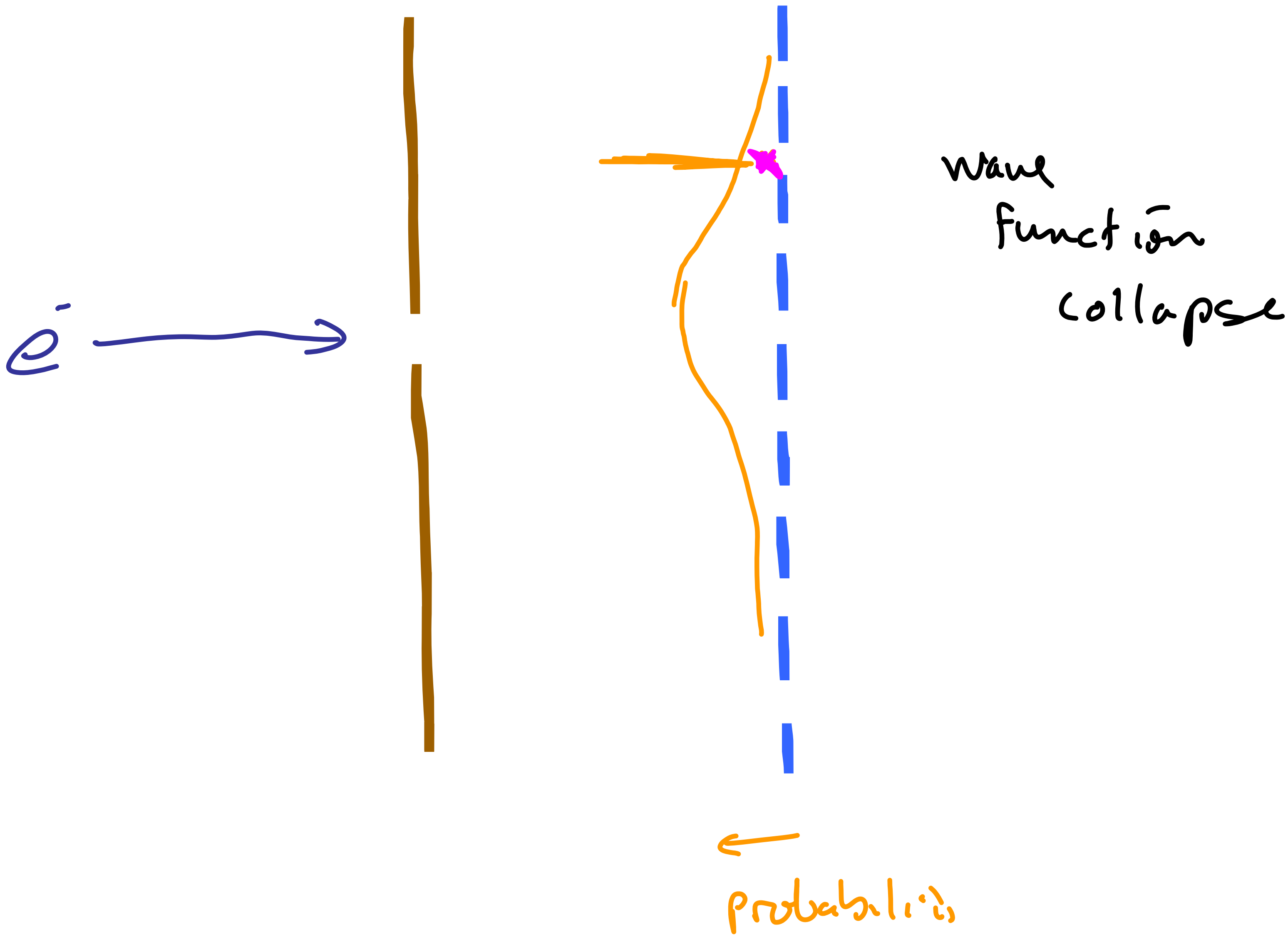
# Max Born German (1882-1970)

1954 Nobel Prize in physics

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

$\psi(x)$ wave function

$\psi^2_{(x)}$ ~ probability of finding particle in region of space



e-
wave function collapse
probability