Physics 102 – October 12, 2009

- Exam 1 Wednesday Hoyt
- Bring Calculator
- 3x5 index card w/ 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

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

I hope this looks familiar!

Single e^- ATOM

Spherical geometry

+

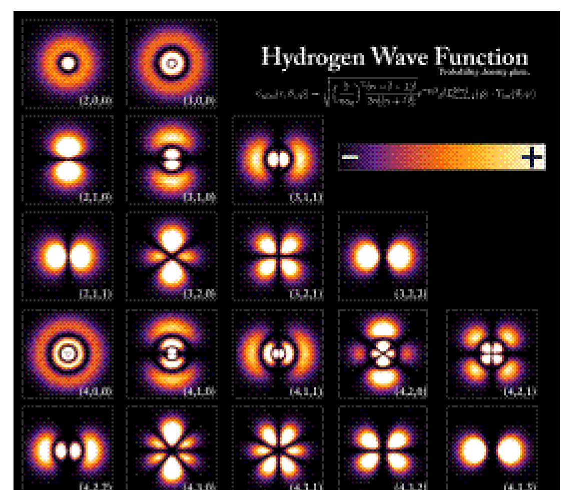
$$F = \frac{k q_1 q_2}{r^2}$$

"Coulombs law"

Quantized
Spatial locations
Energies
...

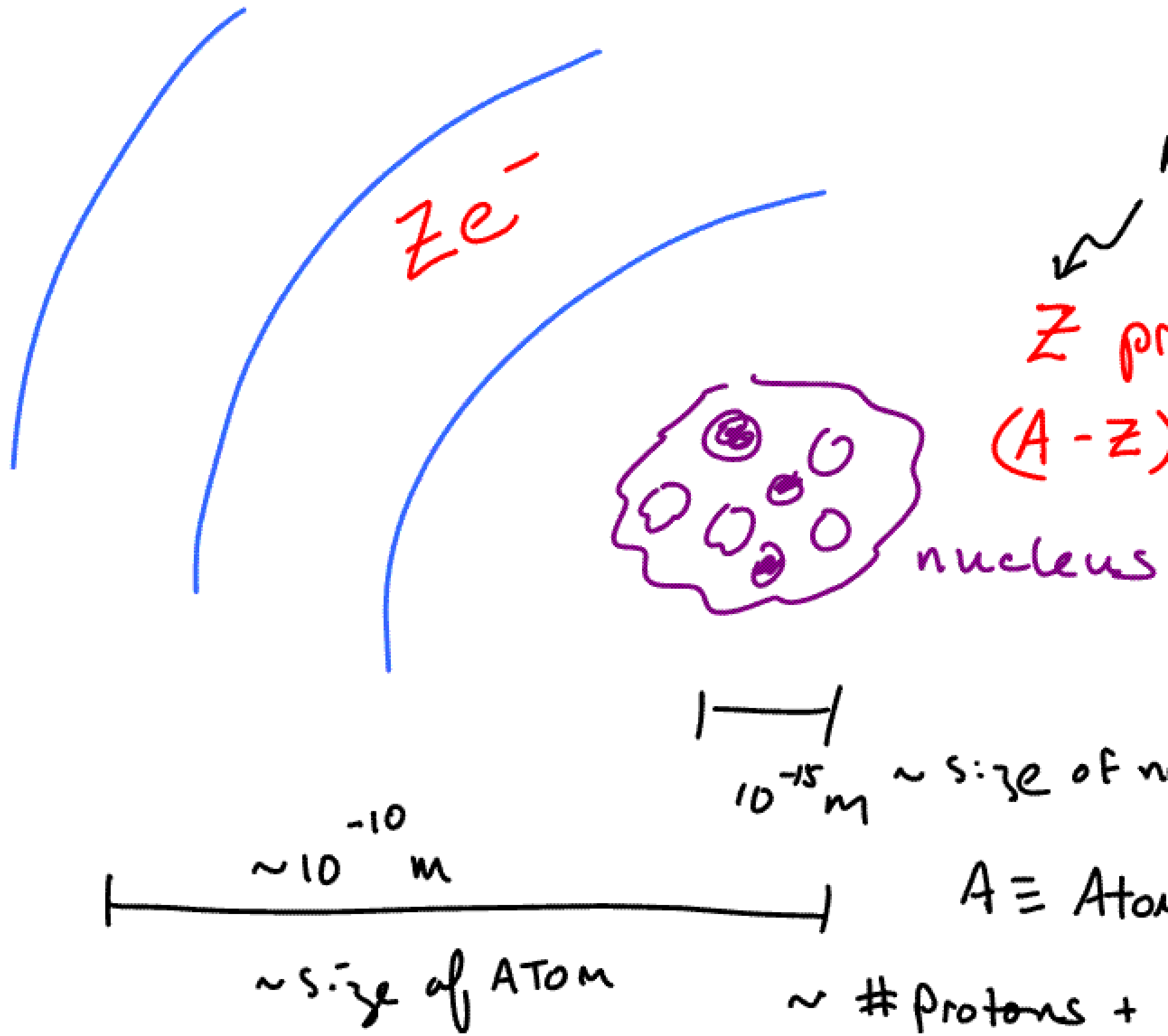
→

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

$A \equiv$ Atomic Mass

$\sim$ # protons + # neutrons

Different Z → Different # e^-
in neutral
ATOM

→ Different chemical
characteristics
+ Mass

"Elements"

Slightly over 100 elements in nature

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

No spin

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

Bosons - can share the same condo or quantum state

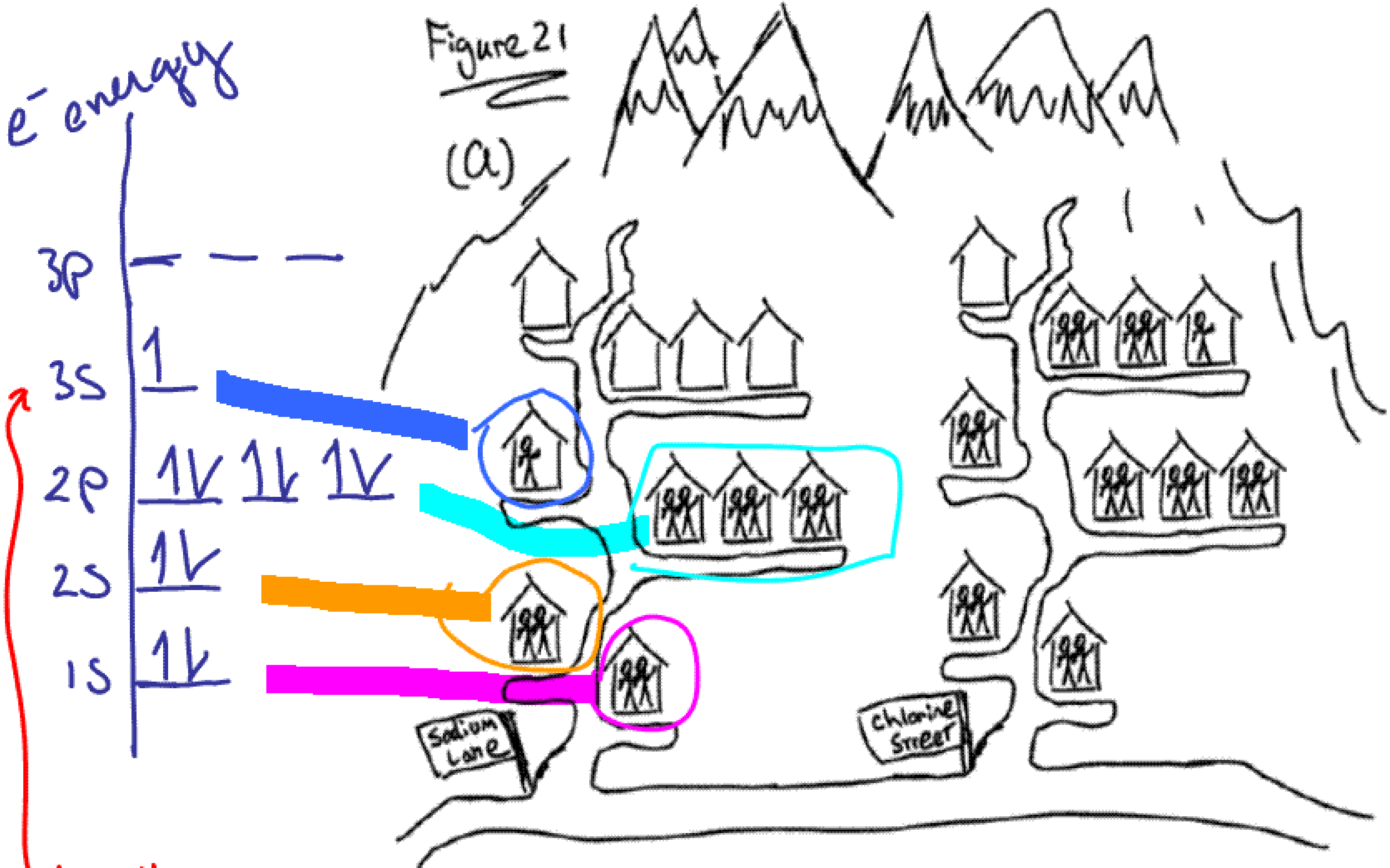
fermions - only 1 to a state

in each orbital on condo can have 2 e^-

one spin "up"

one spin "down"

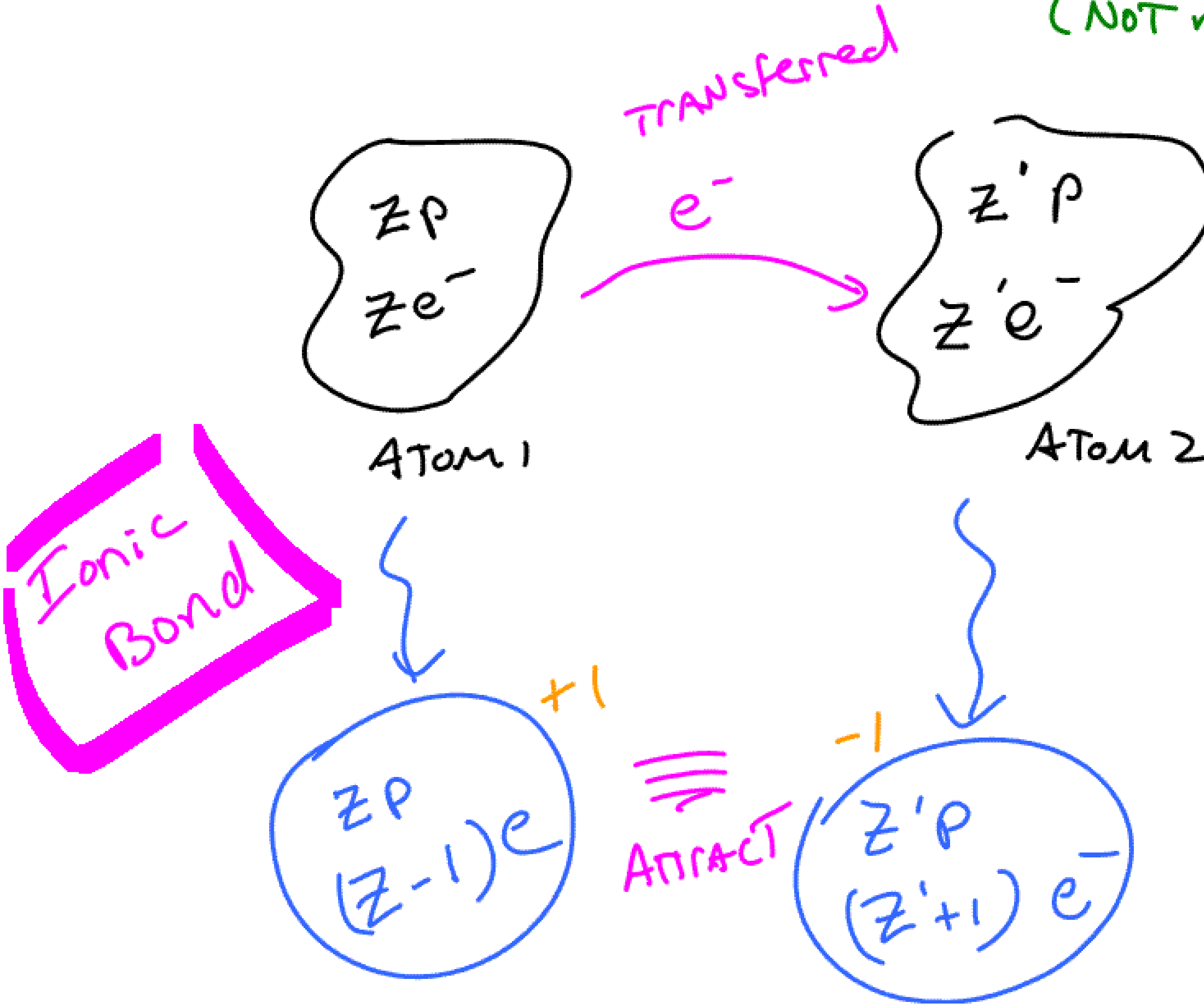
With spin included as part of quantum state → have only 1 e^- per state



"outer" electrons most important in determining size + chemical characteristics of atom

Chemical Bonds

Ions ≡ Atom w/ e^- added or removed (NOT neutral)




+ nucleus
e⁻
e⁻
+ nucleus
Covalent Bond
e⁻
e⁻

Periodic Table of the elements

John Newlands – English analytical chemist
(1837–1898) … Arranged table of elements
by ATOMIC Masses

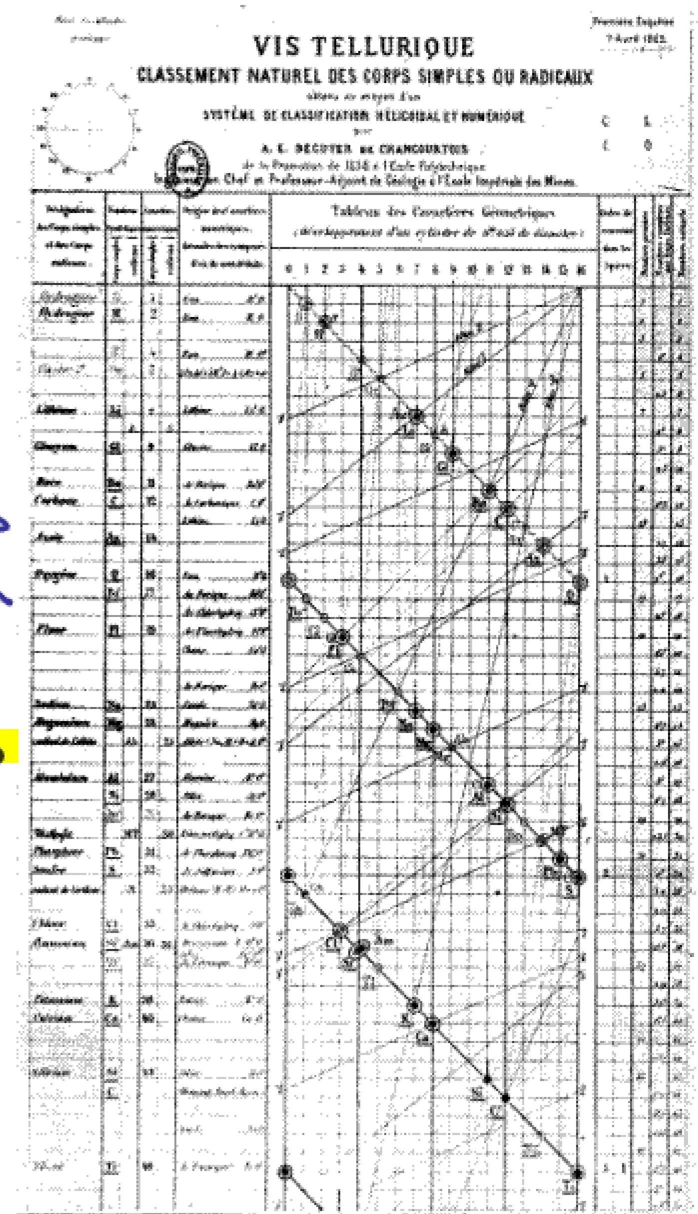
Antoine Lavoisier
France (1743–1794)

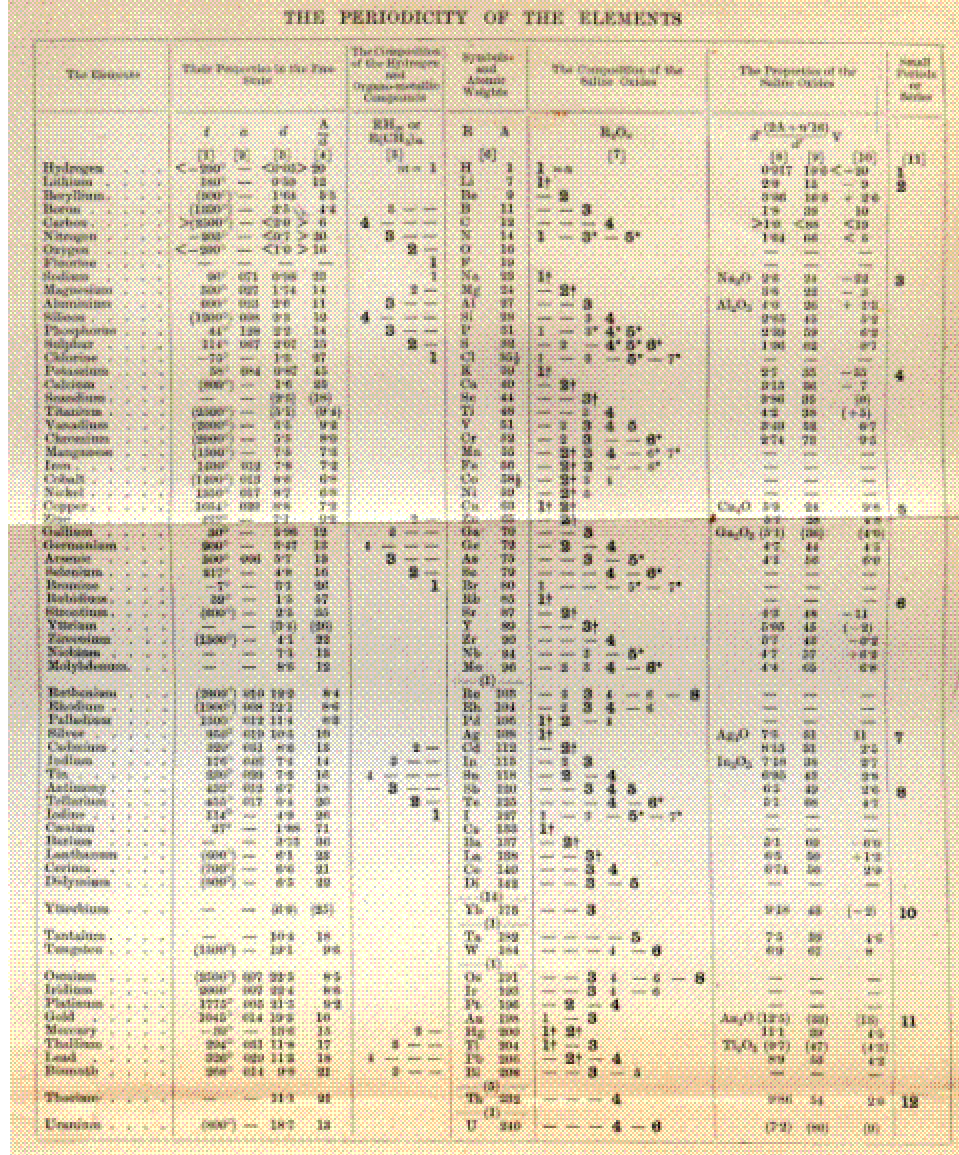
"Father of Modern
Chemistry"

quantitative Analysis

guillotined during French Revolution

Alexandre-Emile
Béguyer de Chancourtios
France (1820–1886)





THE PERIODICITY OF THE ELEMENTS

The Elements	Symbol
Hydrogen	H
Lithium	Li
Beryllium	Be
Boron	B
Carbon	C
Nitrogen	N
Oxygen	O
Fluorine	F
Sodium	Na
Magnesium	Mg
Aluminium	Al
Silicon	Si
Phosphorus	P
Sulphur	S
Chlorine	Cl
Potassium	K
Calcium	Ca
Scandium	Sc
Titanium	Ti
Vanadium	V
Chromium	Cr
Manganese	Mn
Iron	Fe
Cobalt	Co
Nickel	Ni
Copper	Cu
Zinc	Zn
Gallium	Ga
Germanium	Ge
Arsenic	As
Selenium	Se
Bromine	Br
Rubidium	Rb
Strontium	Sr
Yttrium	Y
Zirconium	Zr
Niobium	Nb
Molybdenum	Mo
Ruthenium	Ru
Rhodium	Rh
Palladium	Pd
Silver	Ag
Cadmium	Cd
Indium	In
Tin	Sn
Antimony	Sb
Tellurium	Te
Iodine	I
Caesium	Cs
Barium	Ba
Lanthanum	La
Cerium	Ce
Didymium	Di
Ytterbium	Yb
Tantalum	Ta
Tungsten	W
Osmium	Os
Iridium	Ir
Platinum	Pt
Gold	Au
Mercury	Hg
Thallium	Tl
Lead	Pb
Bismuth	Bi
Thorium	Th
Uranium	U

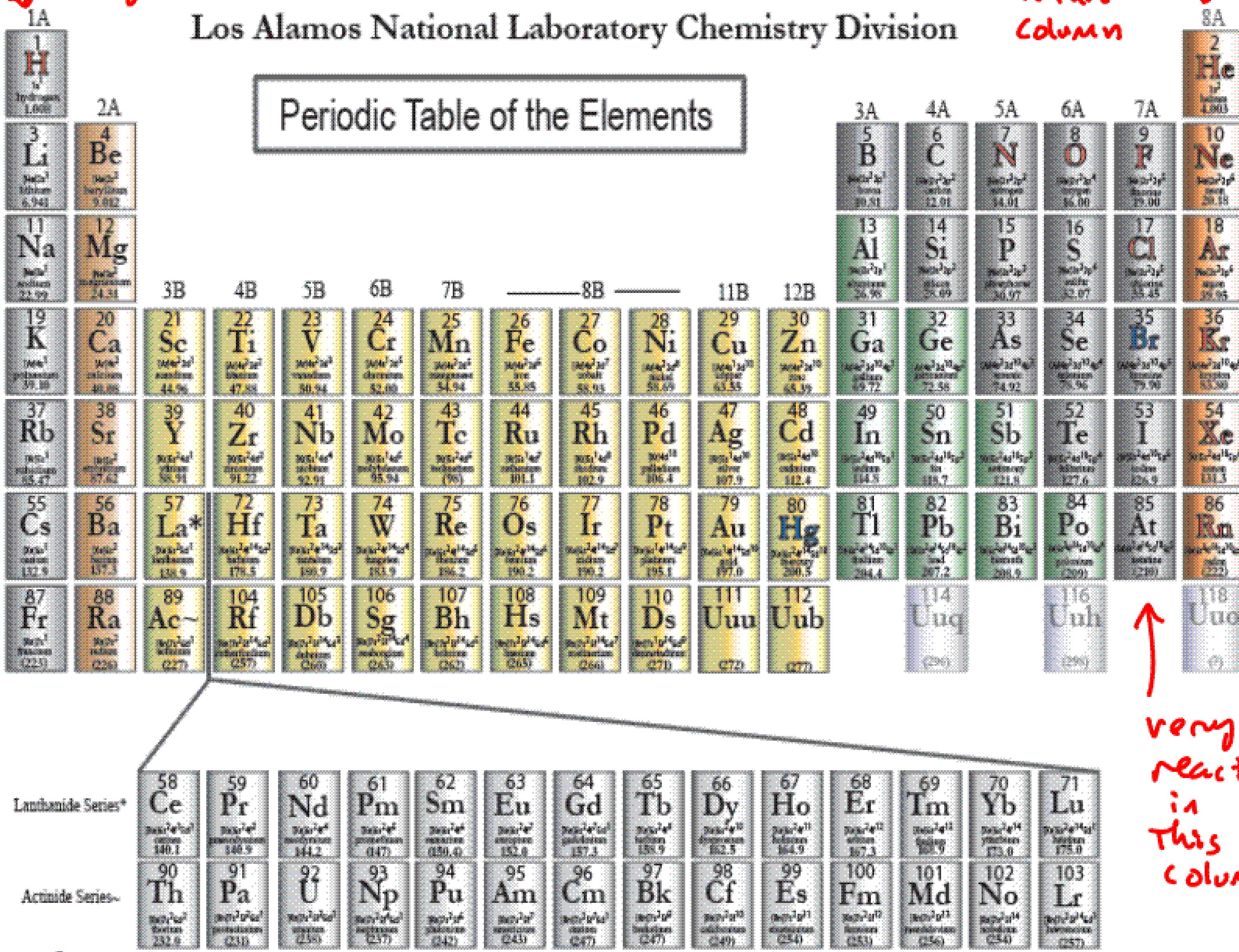
Dmitri Mendeleev

Russian (1834-1907)

when elements arranged by mass - see a certain periodicity in their chemical properties.

very reactive in this column

very inert in this column



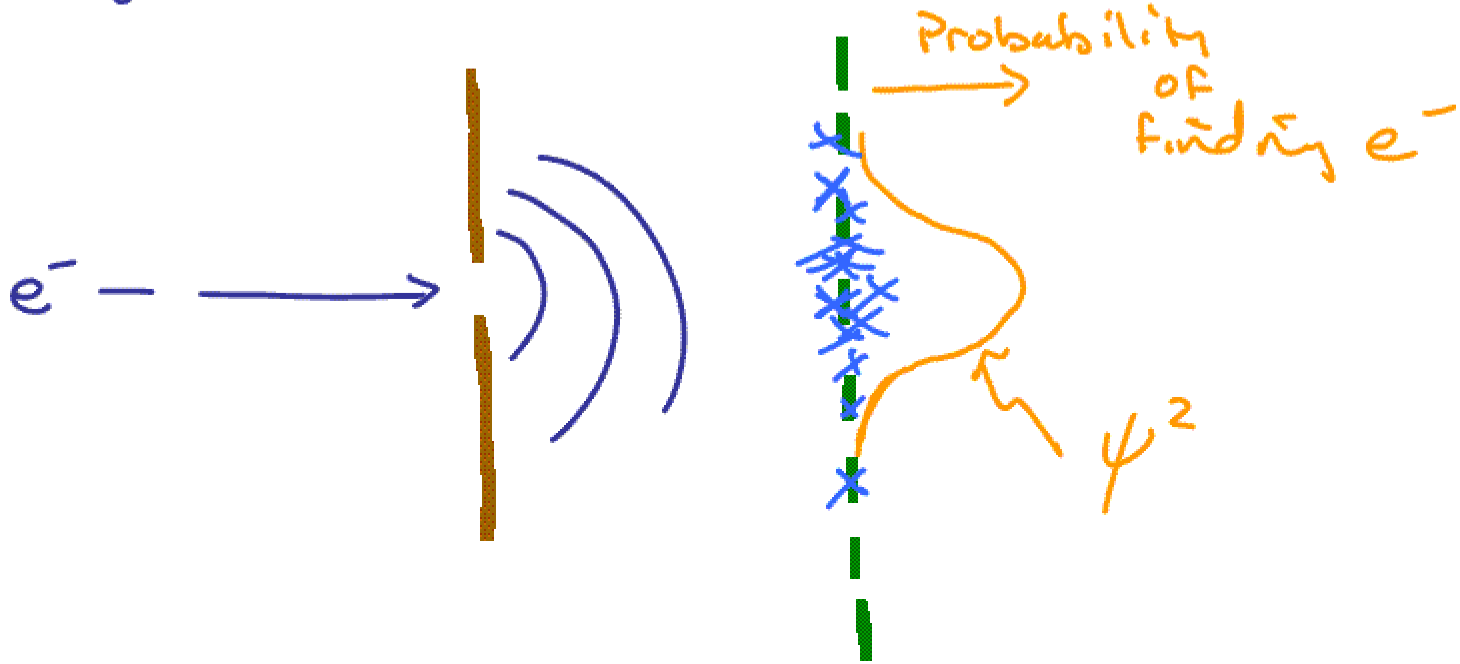
very reactive in this column

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

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.



$\psi(x)$ Not well defined

$\psi^2(x) \rightarrow$ probability distribution

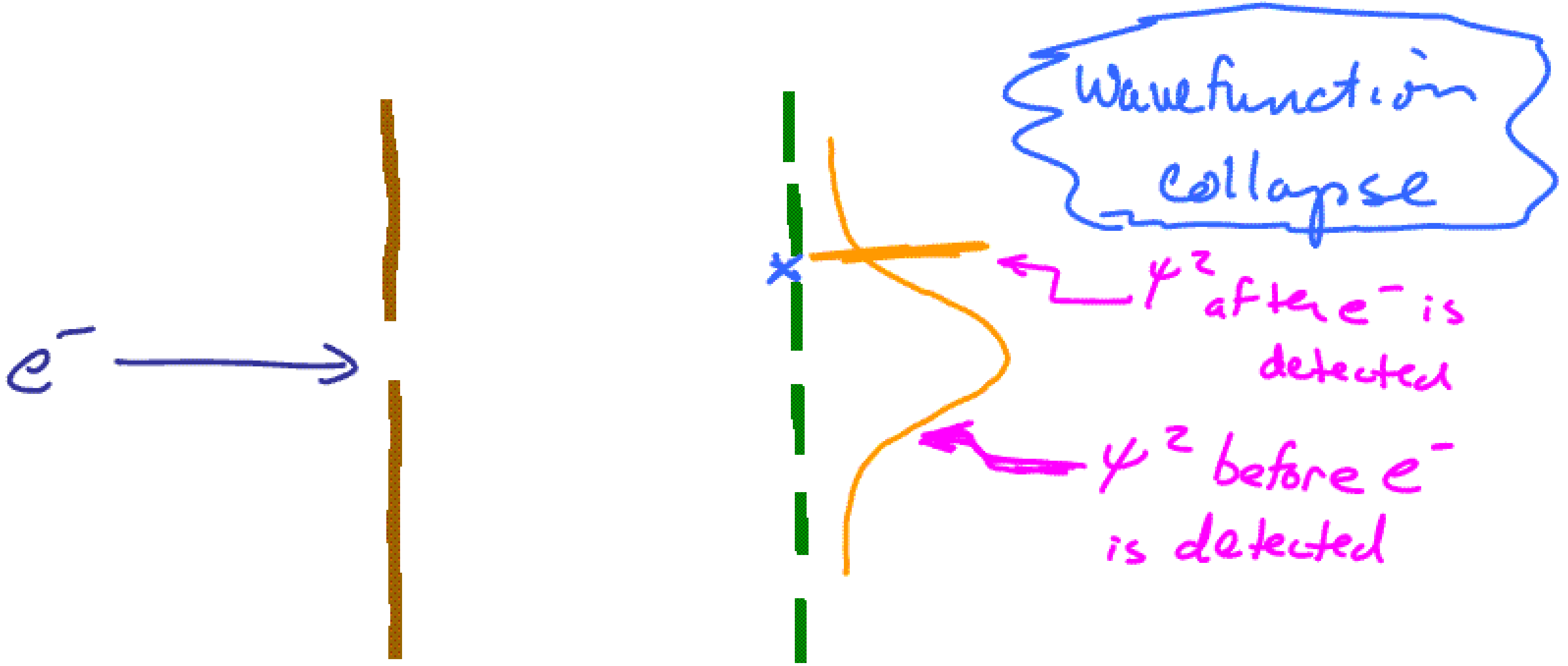
Max Born German (1882 - 1970)

1954 Nobel Prize in physics

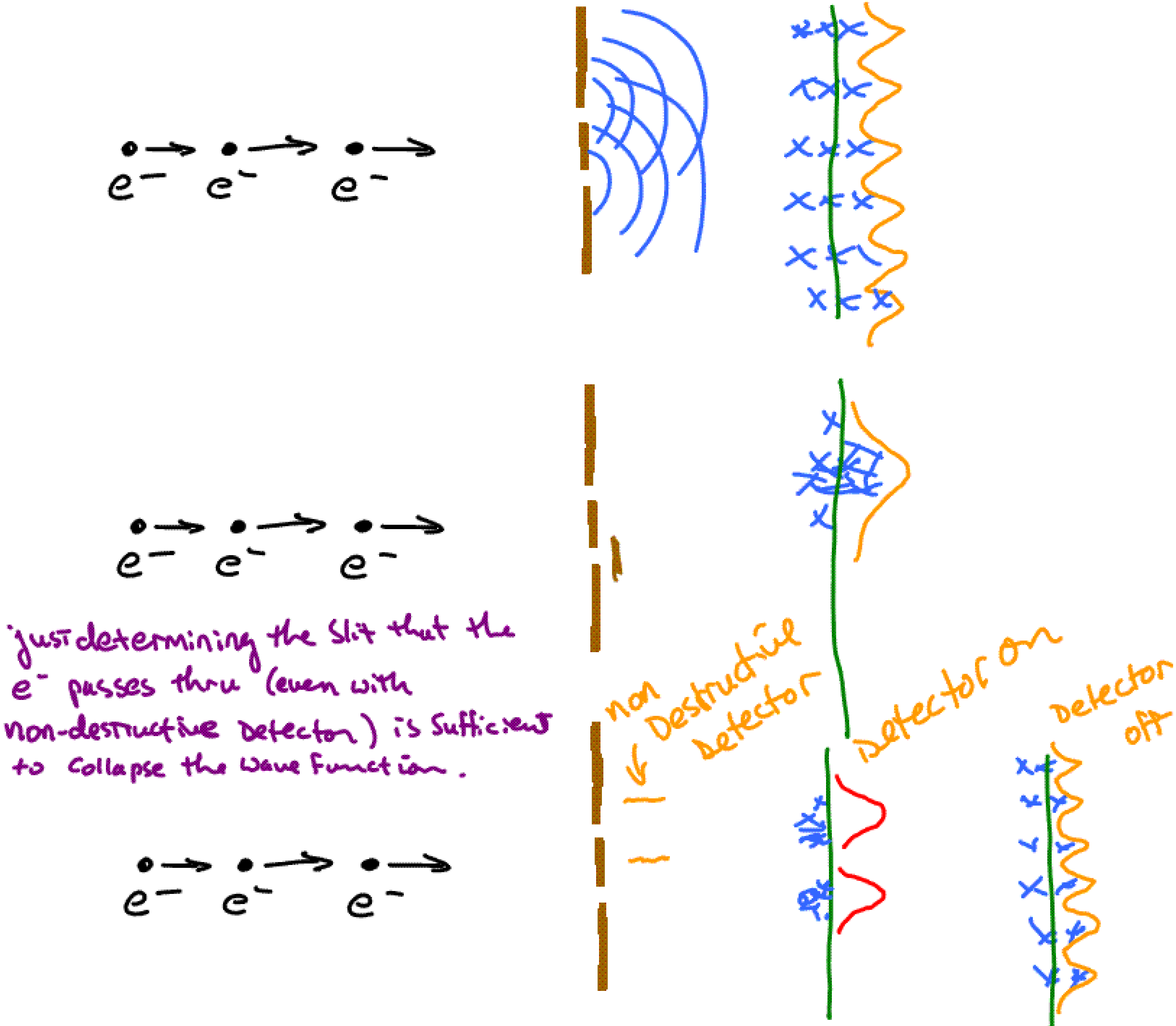
"For his fundamental research in quantum mechanics, especially for his statistical interpretation of the wavefunction"

$\psi(x)$ wave function

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

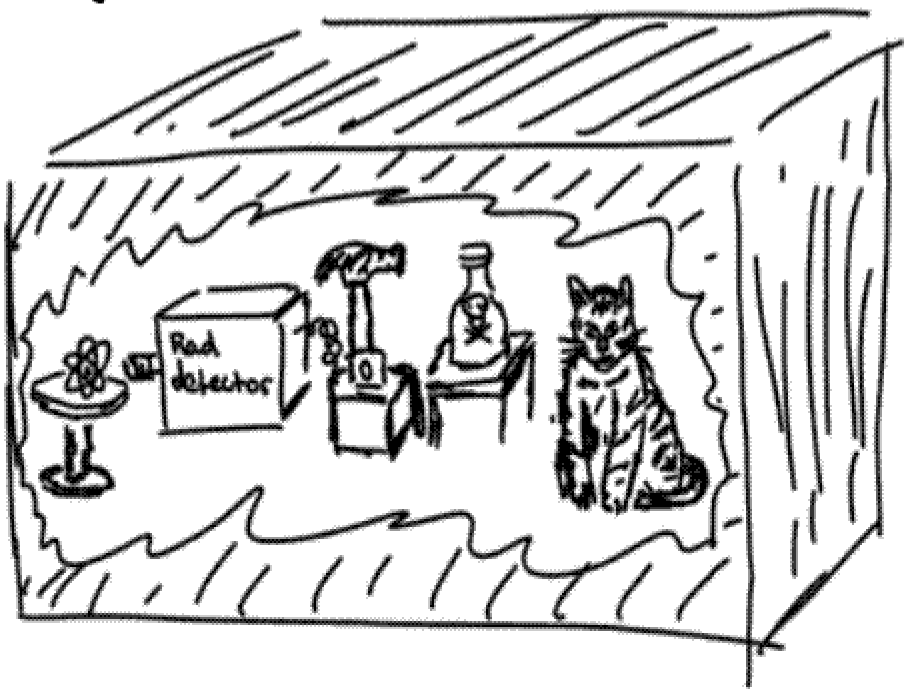


Once electron hits the film/Detector we know with 100% certainty where the electron hits
- so wavefunction has to "collapse"



e^- e^- e^-
e^- e^- e^-
just determining the slit that the e^- passes thru (even with non-destructive detector) is sufficient to collapse the wave function.
e^- e^- e^-
non Destructive detector
Detector on
Detector off

Schrödinger's Cat



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

Copenhagen Interpretation

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

$$\text{cat state} = \frac{1}{2}(\text{dead}) + \frac{1}{2}(\text{alive})$$

Hugh Everett (1957)

Bryce DeWitt 1960's + 70's → Many Worlds interpretation

Overall wavefunction does not collapse. It evolves in time. "Decoherence" forces wavefunction to evolve into different streams that do not interact.