$\frac{1}{2}$ Lecture. 1^{st} $\frac{1}{2}$ on Exam #2

Recap: The world is quantized!

Atoms are useful, atoms are real.

Something goes wrong when trying to describe thermal radiation from "Black Bodies"

→ thermally clean

→ Stat Mech + E.M fields

Goofy idea that the Amplitudes are quantized seems to describe the data ...

More on early atomic theory

Already indications atoms had to have some substructure

- Spectra: Characteristic λ's "finger print" atoms
- Electrons: $m_e << m_1$ $10^{-3}\, m_1$
  - $\longrightarrow$ But they seem to come out of metals
- Radioactivity

(1895)

X-rays – Come back to these later...

Actually discovered 1^{st}, before electrons (Not thought to be a particle)

Start of wild times. (Sci-fi like stuff)

Seeing into the body ... seeing bones.

Originally thought to be related to phosphorescence.

(Red Herring) But led to discovery of Radiation.

<u>1896</u> Henri Becquerel

Turns out really good at making Uranium Salts
↳ Phosphores

Plan: Expose salts to sun ("Activate them") then
see if later they give off x-rays

(Expose photograph wrapped in dark paper)

Sure enough they do. Even after not being "Activated"!

<u>Very Suprising!</u> Some materials that just emit stuff.

Opened a huge field of Physics + Chemistry

α - radiation $\Rightarrow$ + Easy to stop $q/m \sim \frac{1}{2}\frac{e}{m_1}$

β - radiation $\Rightarrow$ − Hard to stop $q/m \sim \frac{e}{m_e}$

γ - " 0 Very hard to stop

Place in $\left|\begin{array}{l} B \\ E \end{array}\right.$ field, see what happens

Try to stop it ... thats basically it

<u>1897</u> Discoverd electron

Once got good at experiments can ask about the Energy
(Before relativity)

α, γ - radiation most of the time very well-defined E

β - Very long story

<u>γ - Radiation</u> will come back to later

Photon, same as X-rays (Much more energetic)

<u>α - Radiation</u>

Soon linked to He Atoms   1868 (Solar eclipse)
1895 Uranium Ore

He only discovered <u>on earth</u> few years before

$$\frac{q_\alpha}{m_\alpha} = \frac{2 q_1}{4 m_1} = \frac{1}{2} \frac{q}{m_1}$$

Doubly charged

Eventually found He gas in sample that was spitting out α's

Again, Big hint for sub-structure to atoms

$E_\alpha \sim 10^6 E_{\text{chemical reactions}}$!

β – Radiation

- Quickly discovered that it is electrons
- Spectrum: Discrete vs Continuous?

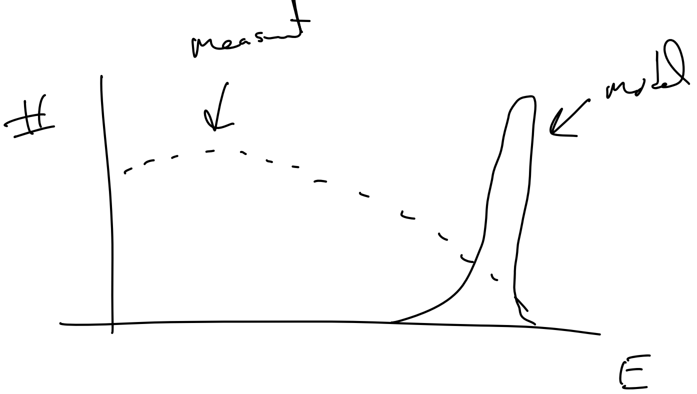
Naive Expectation: Bunch of Discrete lines.

Why? "This is what spectra look like"
That's what they do. (atoms, α, γ ...)

Experimentally not sure if D or C for ~15 y.

1914 (Chadwick) Series of experiments that convinced everyone
the β-decay was continuous.

People were unhappy ... (Worried if this is what was going
on or an artifact of measurement



What happened?
Obvious answer: you have losses somewhere.

Clever experiments convinced everyone this was not the case
- Thin targets   Measure if target heats up

$\Rightarrow$ fundamental Spectrum Continuous.

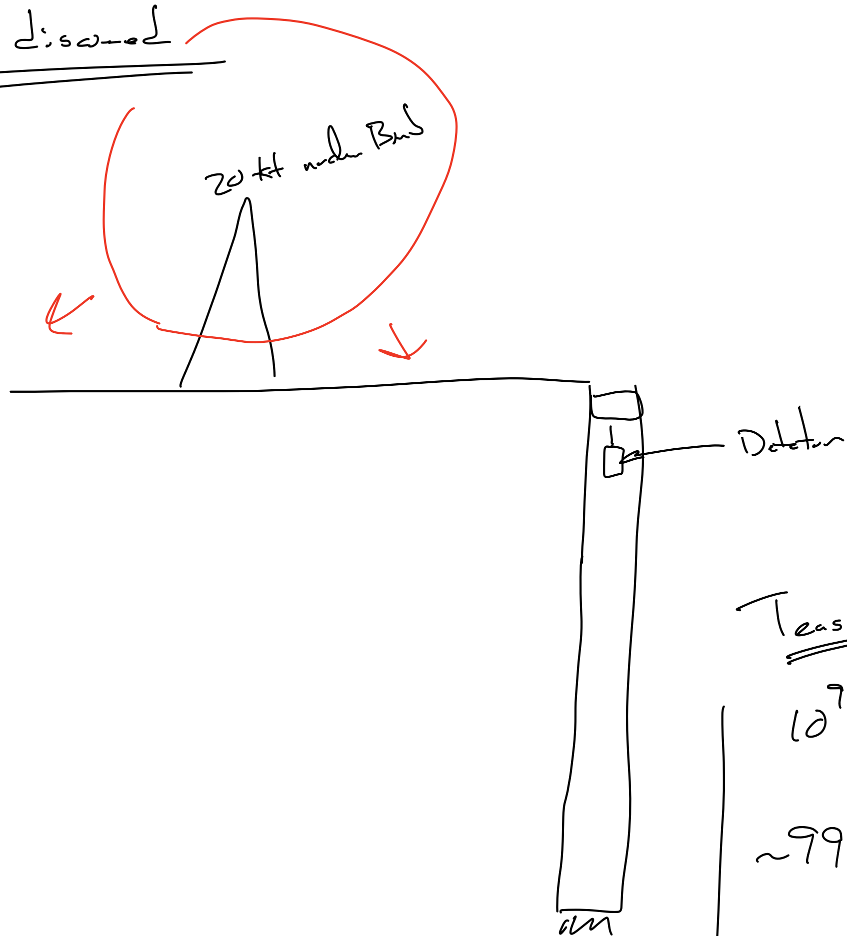
1930: Pauli invents the ν

$A \to A' + e$ (Predicts Discrete Spectrum)

$A \to A' + e + \nu$ ← neutral & light

E not Discrete B/c you miss ν's E

ν's discovered



Reasons

- $10^9:1$ ratio of ν's to other matter particles
- $\sim 99\%$ fraction of Energy carried away by ν's in Supernova
- 10^{38} ν's/s Produced by sun $\Rightarrow 10^{11} \frac{\nu\text{'s}}{cm^2\, s}$ at earth
- 10^6 ν/day from Bananas (K)

$$\boxed{\mu\text{'s} \quad \frac{1}{cm^2\ min} \sim 10^{-2} \frac{\mu\text{'s}}{cm^2\, s}}$$