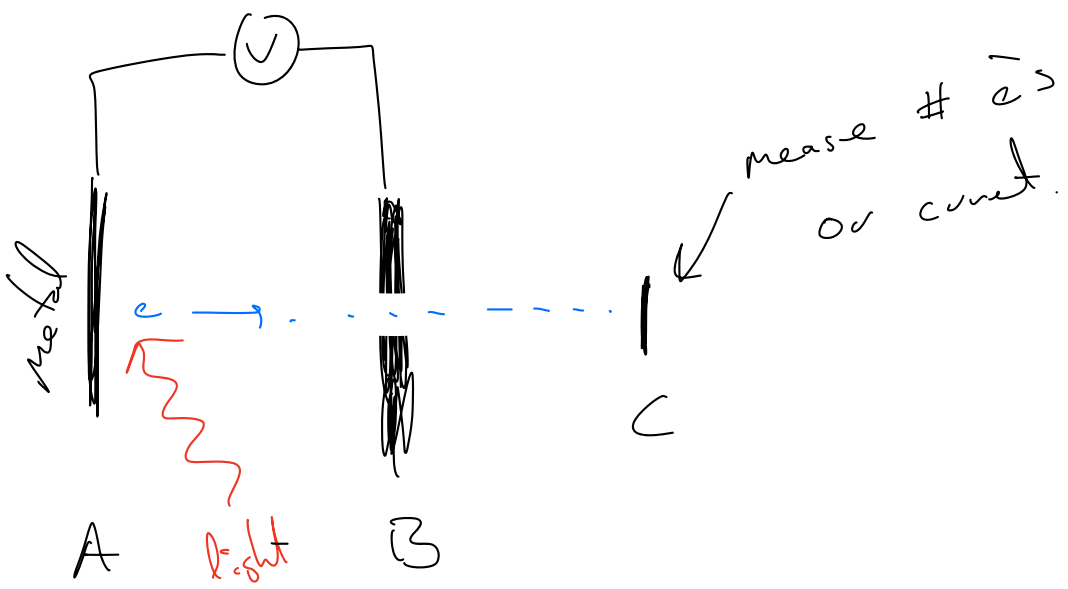
Photo electric Effect

Late 19C physicists observed "photo electric" effect

electric charge expelled from metal surface when exposed to light.

Measured to be electrons (e/m)

Bunch of experts:



Vary V & measure current at C

" light intensity " " " "

What was found was very confusing...

Results UV light

What makes sense

- More voltage more current. Ok
- Saturates at large V Ok
  (run out of e^-s)
- More light = more current Ok
- No current if V strictly negative Ok
  ↳ e^-s have limited KE, can't overcome E potential

What doesn't

-) Why does "stopping" voltage not depend on intensity?
Surely, the more intense the light, the more energy the e's should have?

=) Current seen ~instantly (no lag)
Classically would expect some significant delay ($\propto \frac{1}{I}$)

=) No e's come out if you use light of diff color!

No e's ejected unless the light frequency exceeds some minimum. If below no current no matter how intense the light!

Demo

Turns out to explain this need to take another radical step. (Einstein)

"Photons": (Motivated by Planck)

Assumes light quantised and each unit / particle has energy given by frequency

$$E = h\nu = \frac{hc}{\lambda} \qquad \frac{(1240\ eV\ nm)}{\lambda}$$

And these particles ("photons") are absorbed in discrete units

Note much more radical than Planks hypothesis

Planck: fundamentally silent of how light interacts with matter

(Complicated, full of potential discontinuities)

Einstein: Statement about light in & of itself

eg: Directly contradicts Maxwell's eqs

↳ much better understood.

"Second coming of h"

2nd revolutionary result had to QM.

How does this solve our problems?

Assume electron binding energy given by ϕ

If, $\gamma + e \rightarrow e$

$E_\gamma + -\phi \rightarrow KE$

$h\nu$

$E_\gamma = h\nu > \phi$ get electrons with $KE = h\nu - \phi$

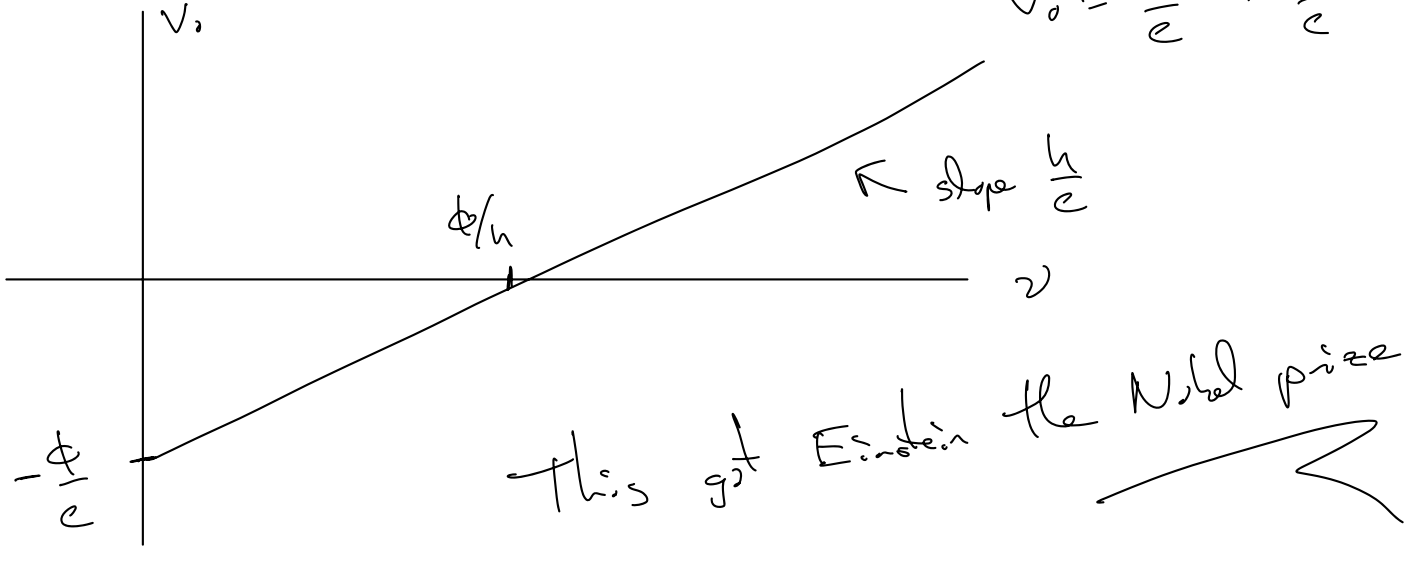
More intense light $\Rightarrow$ more $\gamma + e$ collisions, but not higher E photons!

Now if $h\nu < \phi$

$\Rightarrow$ no e's out

Prediction for V_0 "stopping" voltage $eV_0 = KE = h\nu - \phi$

$V_0 = \frac{h}{e}\nu - \frac{\phi}{e}$



this got Einstein the Nobel prize