

Corrections

- Compton's Exp \rightarrow Electron has $h\nu/c$ momentum

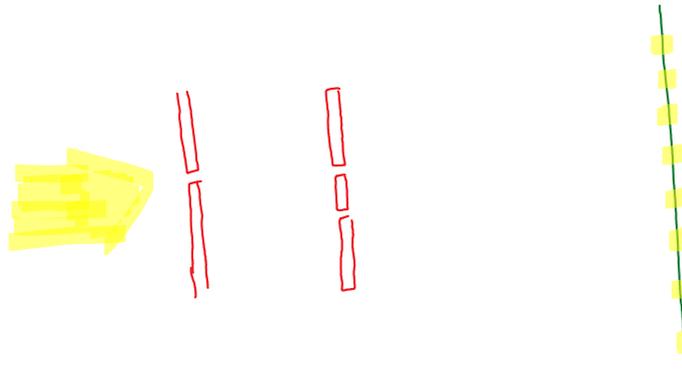
- De Broglie proposed his idea in 1923

but the Double-slit with electron was done in 1961.

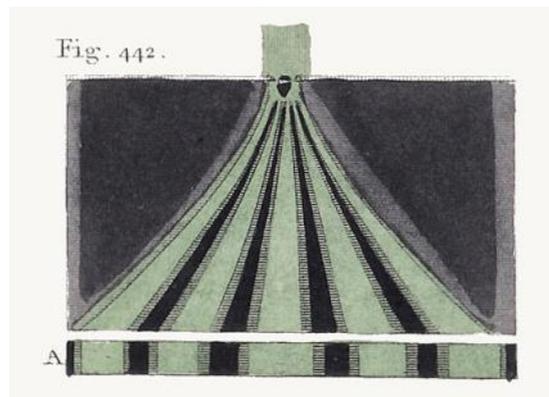
Plan

- Double slit exp
 - Normal light
 - Low intensity light
- Mach-Zehnder Interferometer
- Which way experiments & particle aspect
- Electron
 - Flow
 - Single particle
- Large objects

Double slit Exp. (DS)



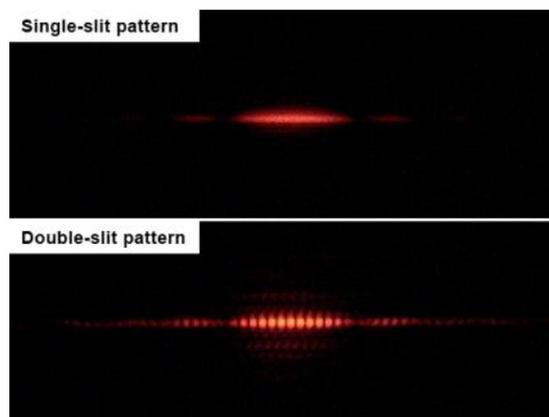
- Experiment → See if we can do it in the optics lab or in the class.
1800
Thomas Young



Original publication: A Course of Lectures on Natural Philosophy and the Mechanical Arts- YOUNG, Thomas Immediate source: https://en.wikipedia.org/wiki/Young%27s_interference_experiment#/media/File:Young-Thomas-Lectures1807-Plate_XXX-fig442-dbl_slit.jpg

To learn more about the history read this:
<https://www.aps.org/publications/apsnews/200805/physicshistory.cfm>

Actual experiment



The top one is from a single slit and the bottom one is from a double-slit.
The top one is due to the diffraction.
From: https://en.wikipedia.org/wiki/Double-slit_experiment
Do it yourselves:
<https://www.exploratorium.edu/snacks/two-slit-experiment>

- How can we check/double-check (Photoelectric + Compton)'s exp in this set-up? Is light comprised a bunch of particles?

Low intensity light \rightarrow Instead of single photon

$\frac{h\nu}{h\nu} \quad \frac{h\nu}{h\nu} \quad \frac{h\nu}{h\nu} \quad \dots$?

G. Taylor
1909

We know now that low-intensity light is not really a single particle of light. But it was a natural idea.

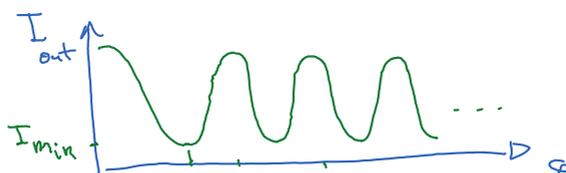
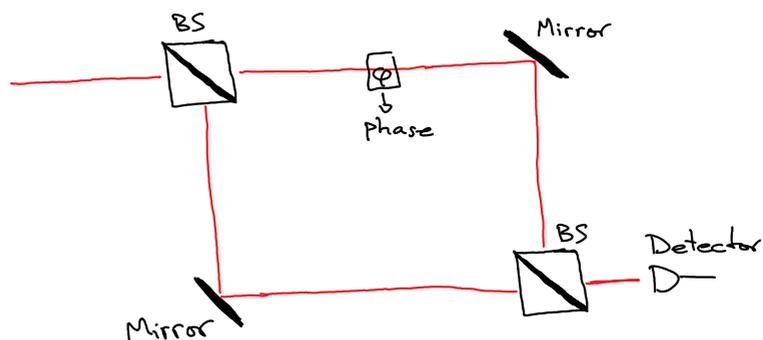
There are Fringes on the screen &

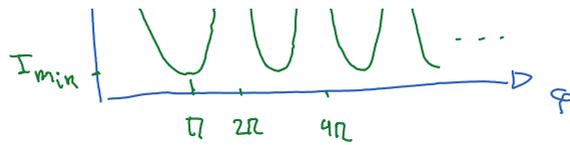
Still wave

What does this tell you?

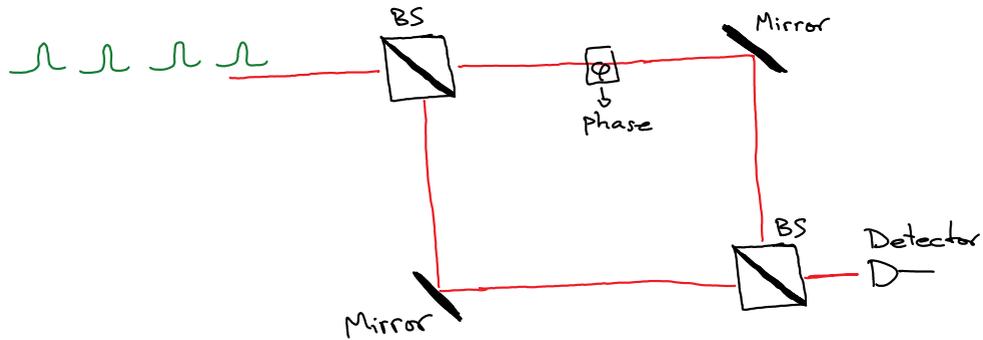
\hookrightarrow Is that the end of it?
Were they wrong?

Let's look at this in a different exp. the (MZI).



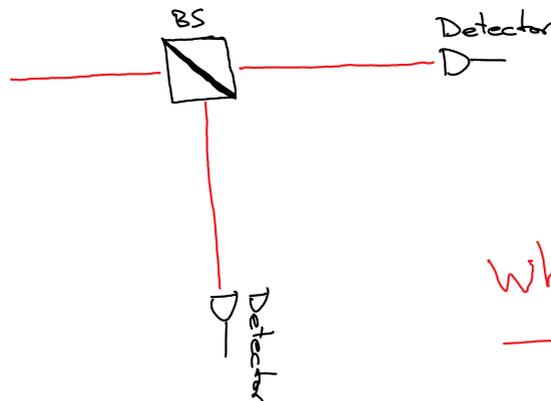


How can we check to see if light is comprised of particles?



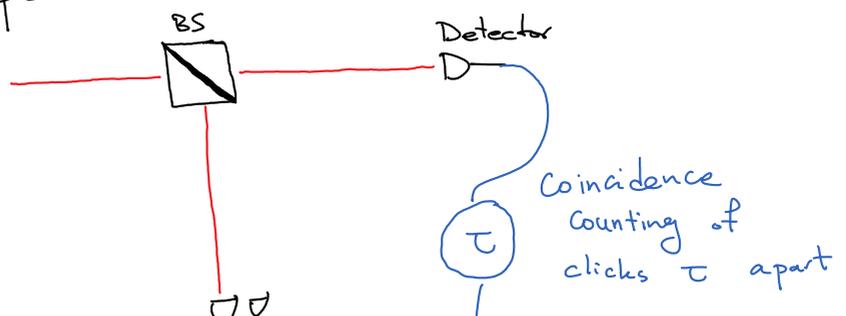
The result is the same. But what does that mean? If particle, who are they interfering with?

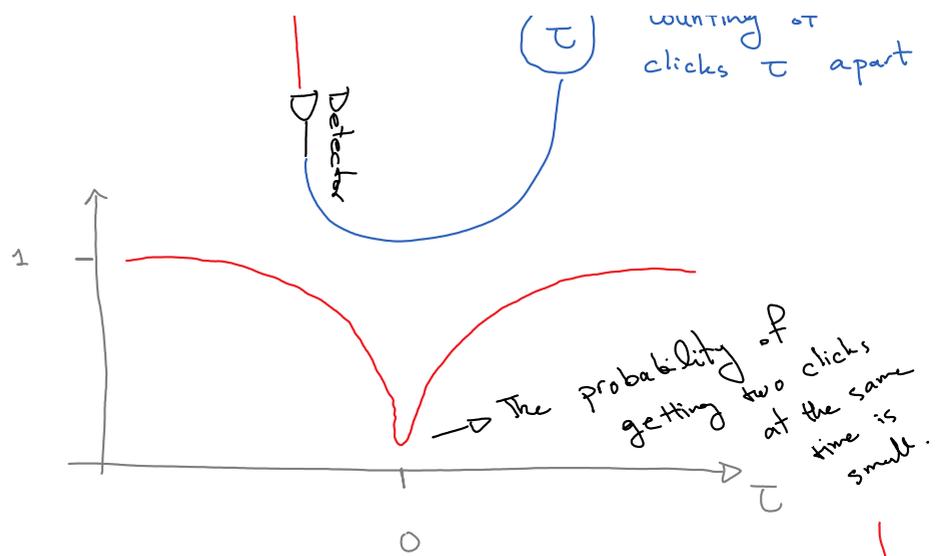
Now, let's ask them which path they took?



Which one clicks?

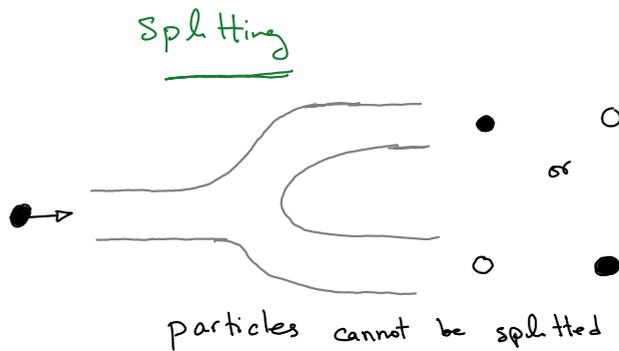
↳ This is the basics of Hanbury Brown-Twiss (HBT) experiment.





So, they are splitting → Maybe they are particles

Remember



Which one is it?

Both Neither ... ?

It seems that it depends on the question that we are asking from the light.

If we ask if it is light (does it interfere)

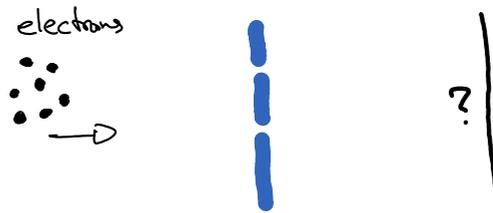
↳ Yes

If we ask if it is a particle (does it split)?

↳ It is a particle and does not split.

- Delayed Choice experiments

- How could we check de Broglie's proposal?



With ping-pong balls → particle behaviour

How about microscopic objects such as the electron?

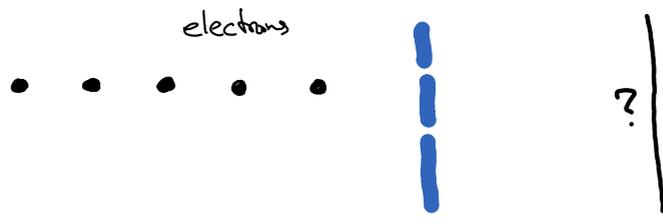
Behave like a wave

Claus Jönsson 1961

→ Seems like de Broglie was right

But

- How do we know that it is not the "flow" and the individual particles are acting as wave?
- How can we check if individual electrons act like wave and not the collection?



Pier Giorgio Merli, et al.
1974 \rightarrow Biprism

Frabboni 2012
 \rightarrow real (DS)

A5

- What's challenging with DS for electrons?
- How far apart should the slit be?
- How wide should the slit be?
- What's de Broglie wave-length of electron?
(Assume an electron gun of $V = 10 - 100$ volts)