01. The 2-Slit Experiment

What is the world made of?

(Dominant view late 17th, 18th cent) ⇒ (Newtonian “corpuscular” ontology)

lump of stuff

stable corpuscles of matter - held in place by forces

empty space

model - Newtonian gravity

Wave theory of light (minority view - Huygens 17th cent.)

light as corpuscles

endorsed by Newton - carried great authority

analogous to...

stone - source of water waves

spreading ripples

pond
Early 19th cent. Decision in favor of Wave Theory: Interference Phenomena

Wave theory provides natural explanation.
Corpuscle theory faces problems.

interference of water waves

constructive interference
destructive interference

where two crests meet = even higher crest

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Young's two slit experiment

observation screen

1st barrier produces point source

Corpuscle Theory
• should not expect to see bands
• expect uniform illumination
2-Slit Experiment for electrons (Davidson & Germer 1927)

Shoot electrons at double slits

All experiments reveal standard interference pattern (like Young’s experiment with light)

use crystal - slits must be atomic scale

Are they particles being “guided” through slits to hit screen in interference pattern? OR Are they really “waves”?

Shoot one through at a time

After many shots, still get interference pattern!

Which slit will it go through? Where will it hit?

Result of Experiment: No determinate prediction! Can only predict the probability of which slit it will go through and where it will hit!

Suggests “Probability Interpretation” of electron position...
Different ways to interpret the notion of probability

A. Objective Interpretation: Probability is a property of objects

1) Relative Frequency Account

Probability is a property of groups of objects

“Electron A has probability of $\frac{1}{2}$ of going through upper slit”

means

“As sample of electrons shot through slits increases, the frequency of the proportion that go through upper slit approaches $\frac{1}{2}$”

2) Propensity Account

Probability is a property of single objects

“Electron A has probability of $\frac{1}{2}$ of going through upper slit”

means

“Electron A has an intrinsic tendency (propensity) of $\frac{1}{2}$ of going through upper slit”

B. Subjective Interpretation: Probability is a property of our knowledge

Probabilities measure the state of our knowledge

“Electron A has probability of $\frac{1}{2}$ of going through upper slit”

means

“We lack enough knowledge to know definitely which slit Electron A will go through”

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\begin{align*}
\text{Probabilities in QM are } & \text{ objective } & \Rightarrow & \text{ QM description is complete. No theory can predict with certainty which slit electron will go through.} \\
\text{Probabilities in QM are } & \text{ subjective } & \Rightarrow & \text{ QM description is incomplete. Some other complete theory can predict which slit electron will go through.}
\end{align*}
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