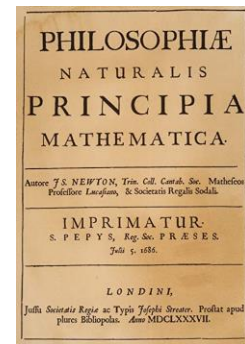


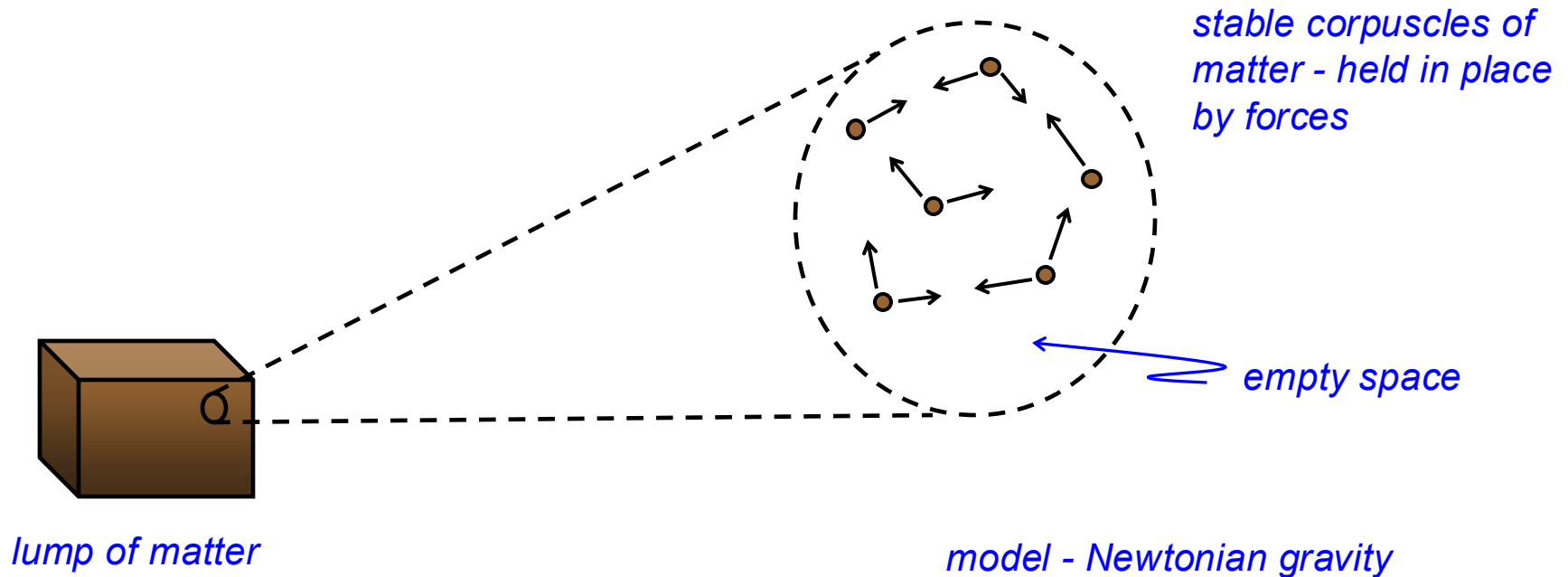
01. The 2-Slit Experiment

- *What is the world made of?*
- The dominant view in the 17th & 18th centuries:

Newtonian corpuscular ontology

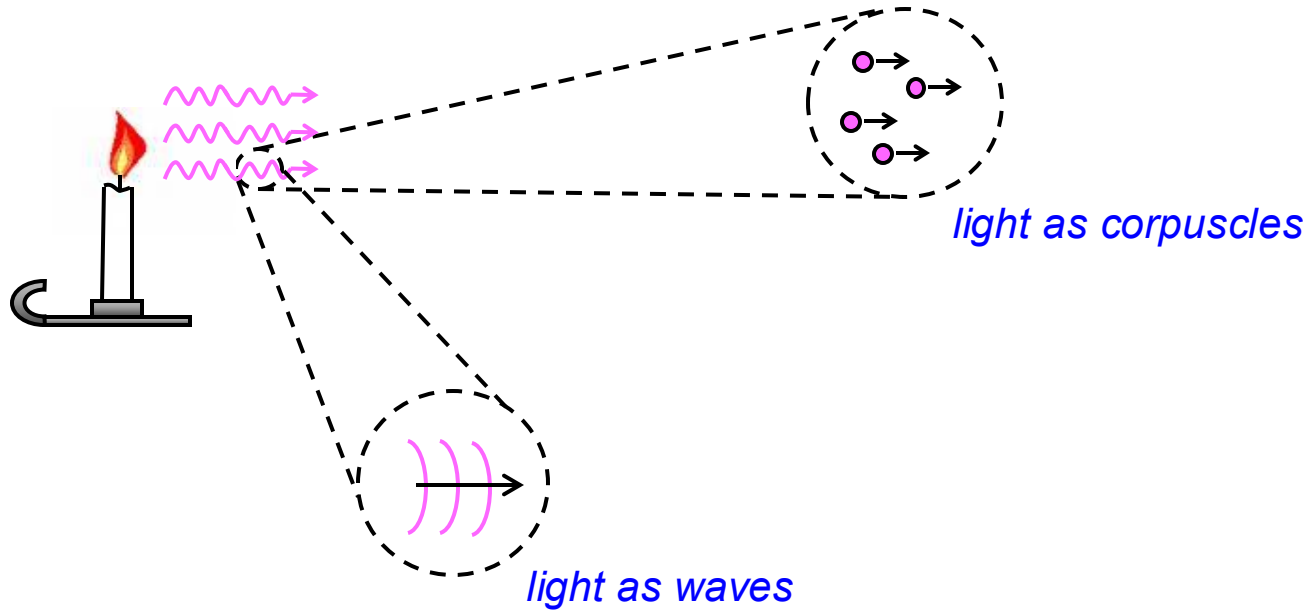
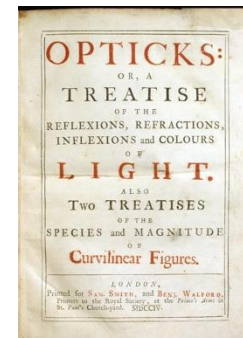


Isaac Newton
(1643-1727)



Extends to a theory of light...

- Corpuscular theory of light: Newton's *Optiks* (1704)



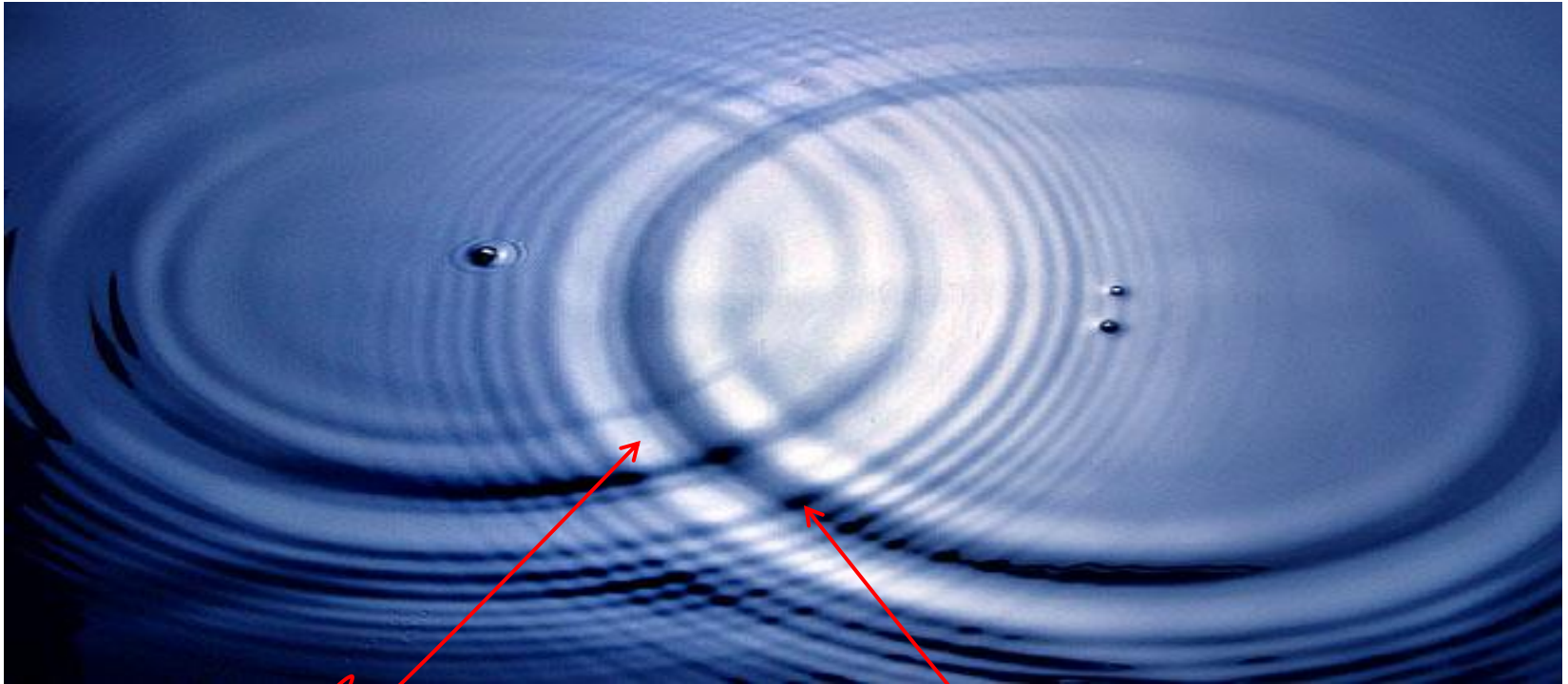
Christiaan Huygens
(1629-1695)

- Wave theory of light
 - minority view (Huygens 17th cent.)
 - candle = source of light waves
 - stone = source of water waves...



Decision in favor of Wave Theory: interference phenomena

interference of water waves



constructive interference

crest + crest = higher crest

$$\text{crest} + \text{crest} \Rightarrow \text{higher crest}$$

destructive interference

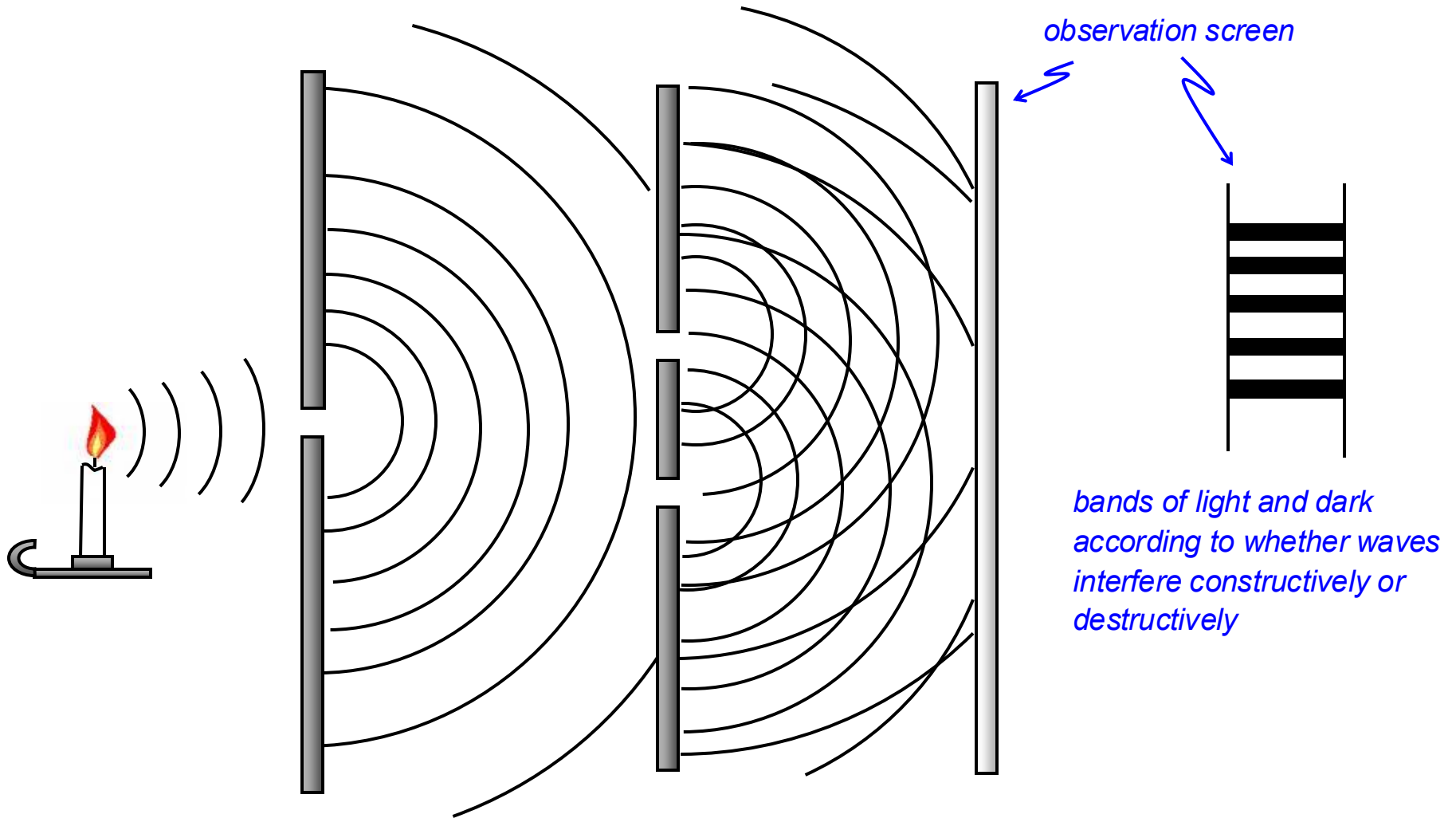
crest + trough = cancelation

$$\text{crest} + \text{trough} \Rightarrow \text{cancelation}$$

Thomas Young's 2-Slit Experiment (1800):



Thomas Young
(1773-1829)

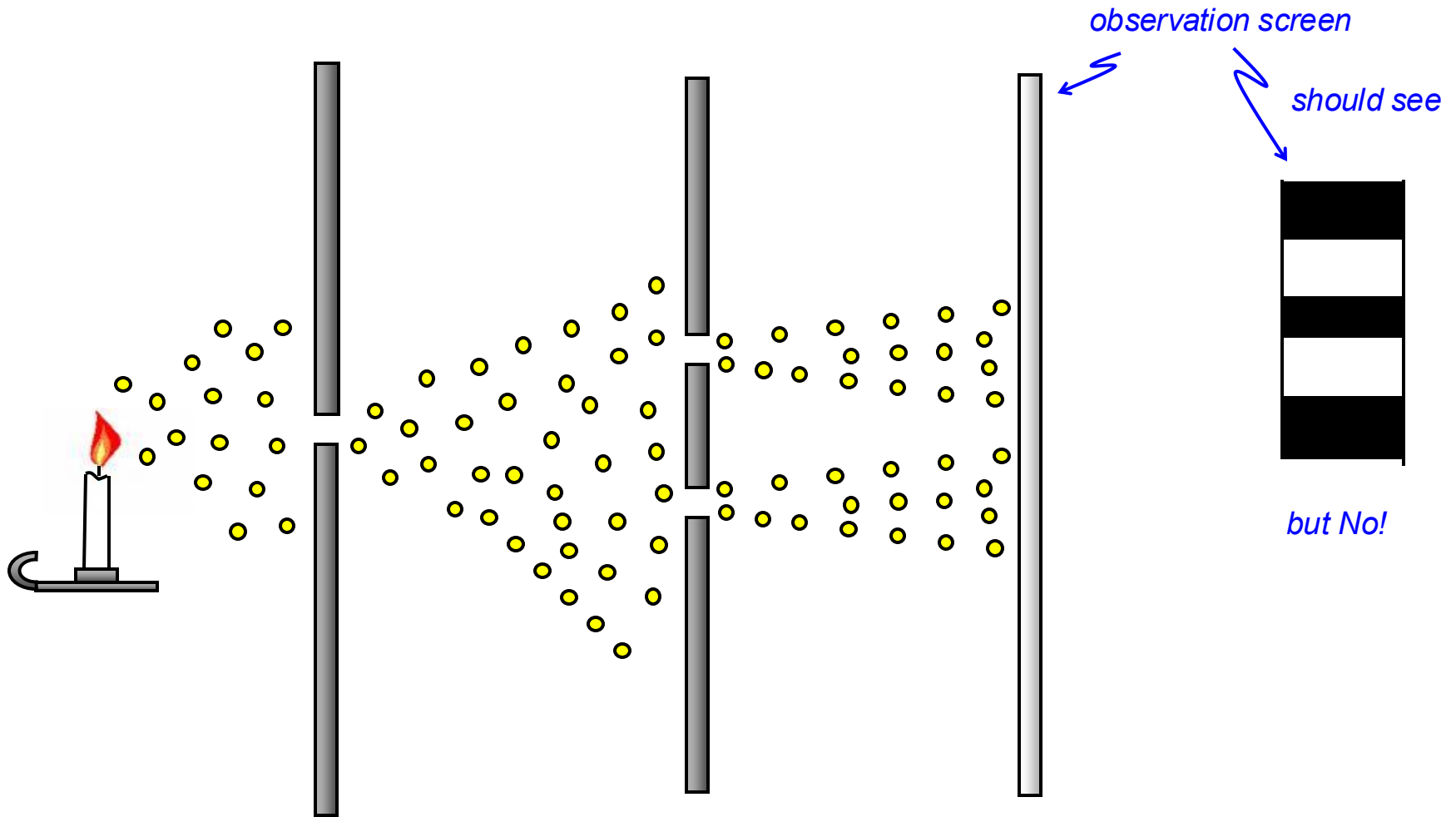


Thomas Young's 2-Slit Experiment (1800):

- If light consists of corpuscles, should see...



Thomas Young
(1773-1829)



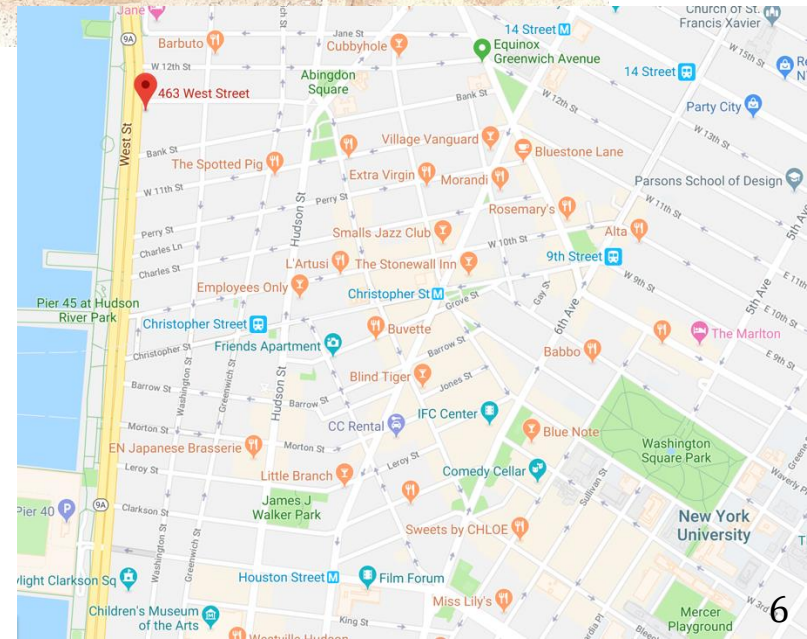
2-Slit Experiment for electrons (Davisson & Germer 1927)



At this site, the original location of Bell Telephone Laboratories, C. J. Davisson and L. H. Germer in 1927 performed the first direct demonstration of the wave-like behavior of elementary particles, predicted by L. de Broglie in 1923. The Davisson-Germer experiment provided crucial empirical evidence for the validity of the then rapidly evolving theory of quantum mechanics. In those years and subsequently many important scientific and technological discoveries were made at the same laboratory.

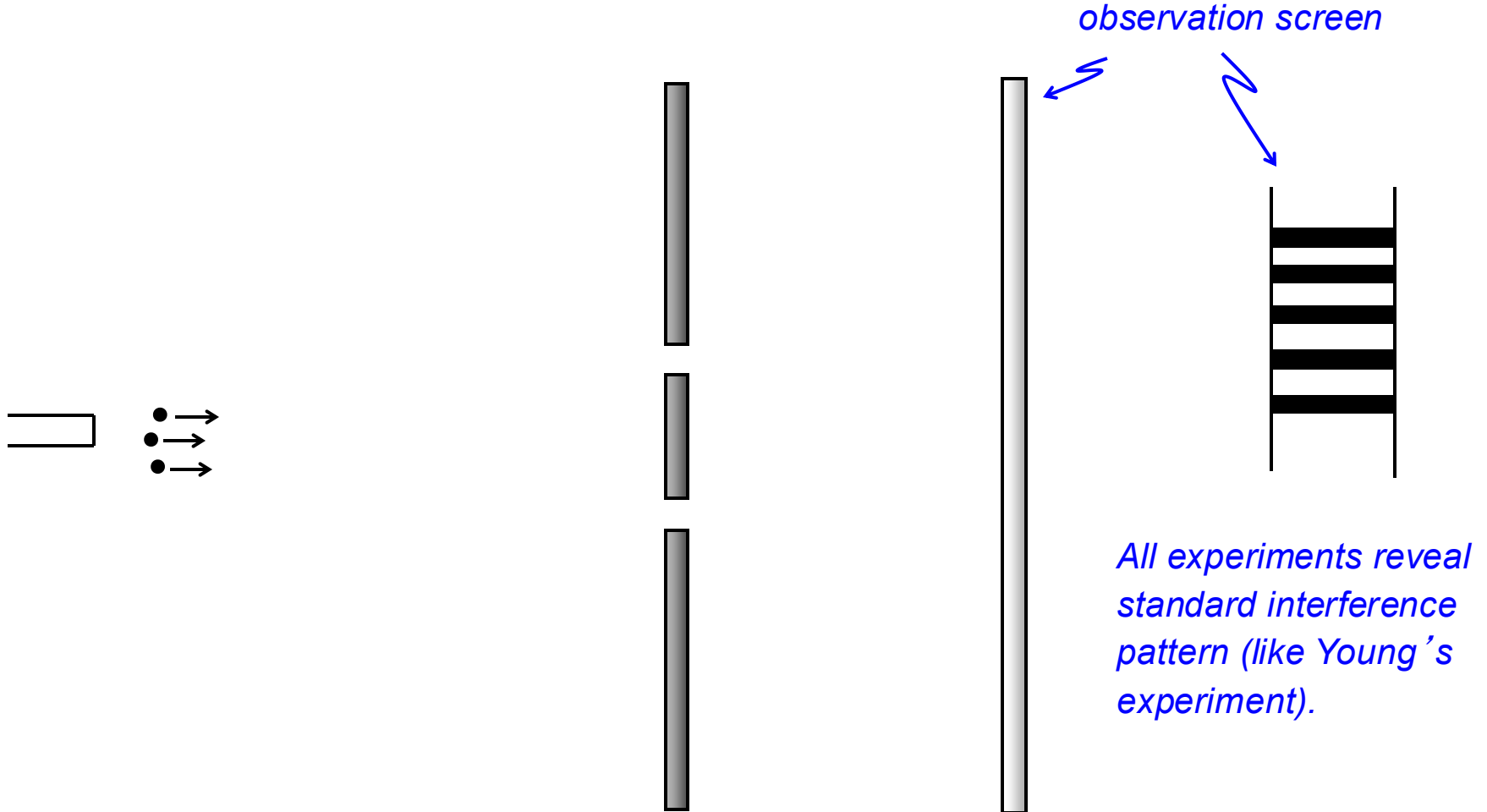
HISTORIC PHYSICS SITE, REGISTER OF HISTORIC SITES
AMERICAN PHYSICAL SOCIETY

*463 West Street
Between Bank St. and Bethune St.
Manhattan*



2-Slit Experiment for electrons (Davisson & Germer 1927)

- Shoot electrons at double slits...



Are they particles being guided through slits to hit screen in interference pattern?

OR

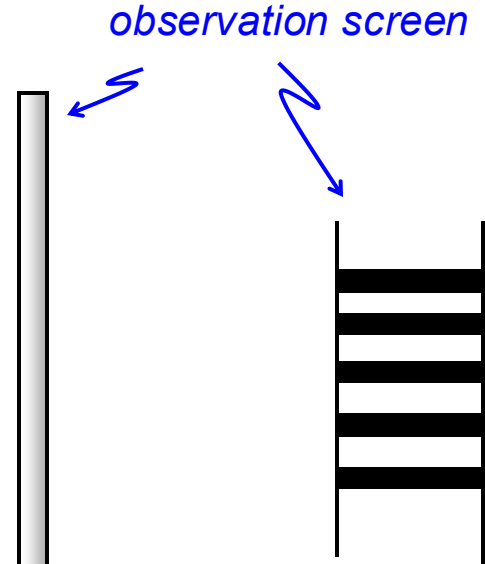
Are they really waves?

2-Slit Experiment for electrons (Davisson & Germer 1927)

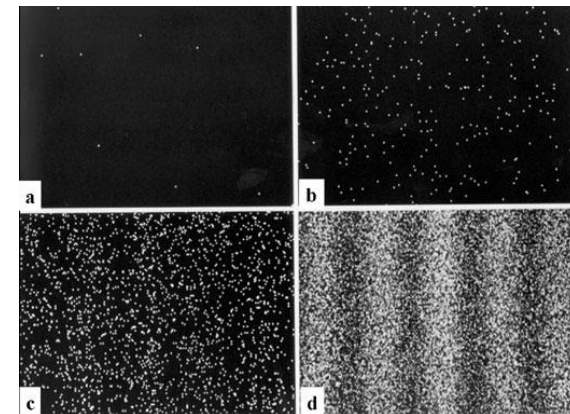
- Shoot one at a time...



Maybe they're waves...

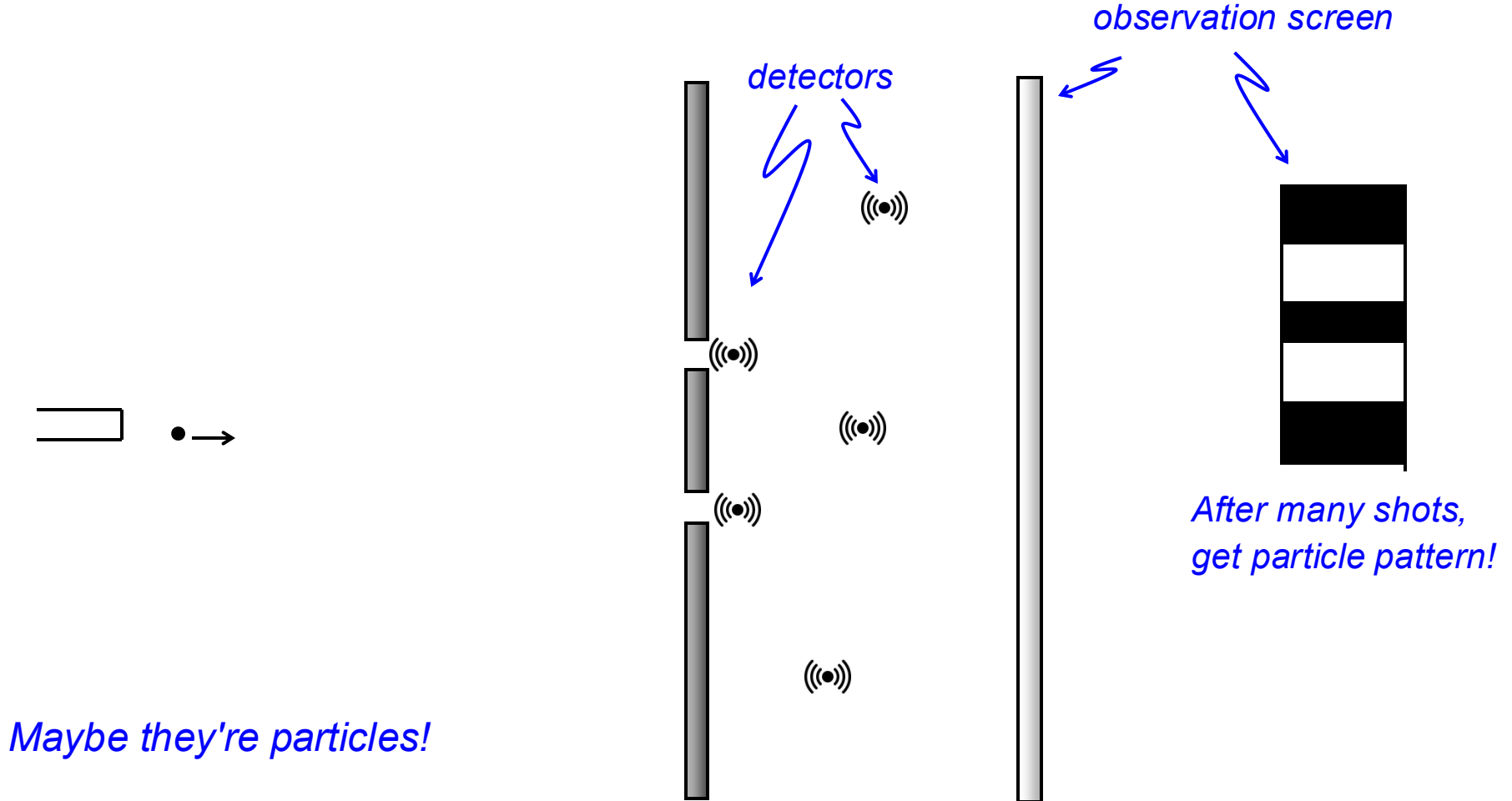


After many shots, still get interference pattern!



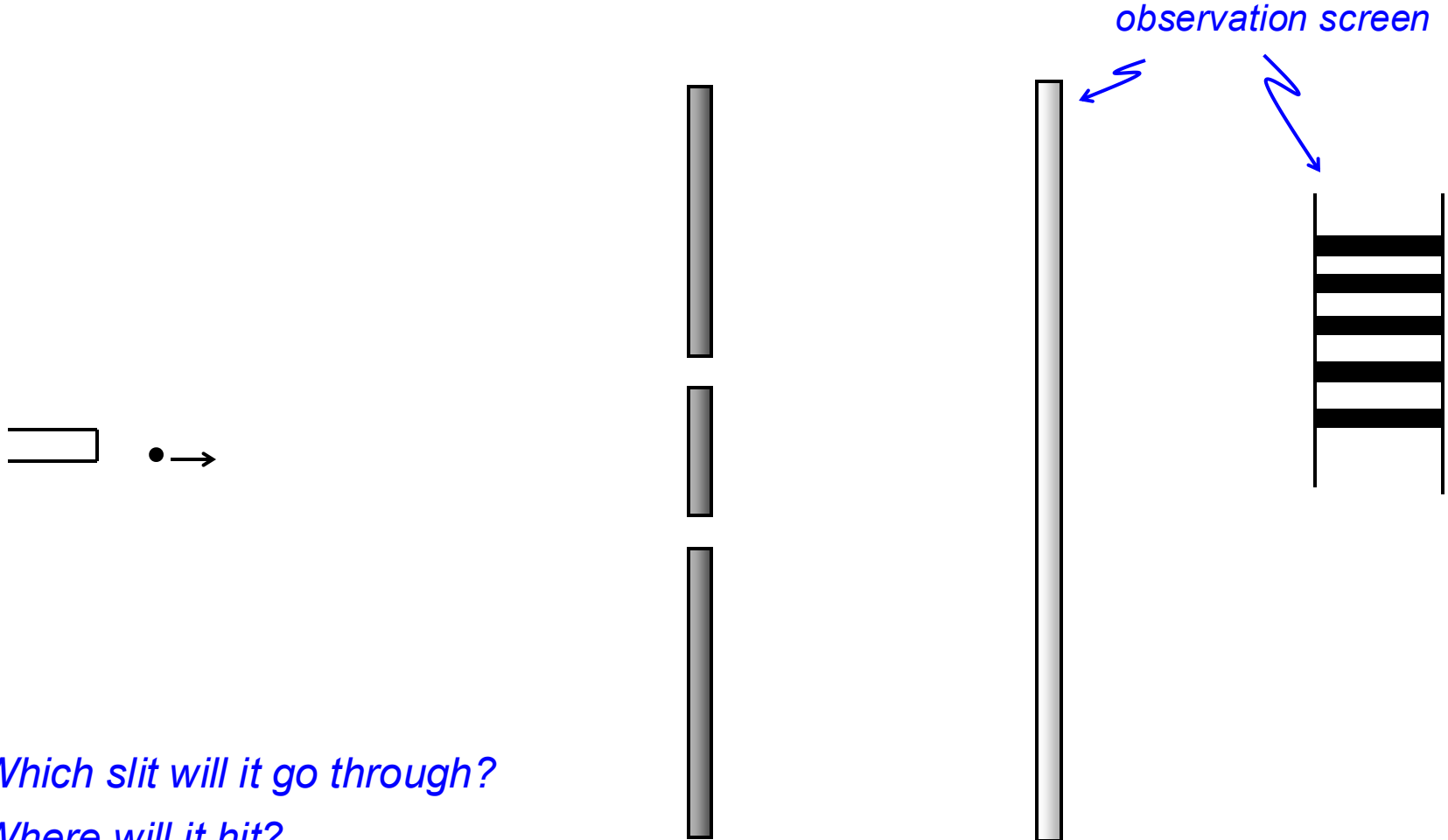
2-Slit Experiment for electrons (Davisson & Germer 1927)

- Shoot one at a time with detectors...



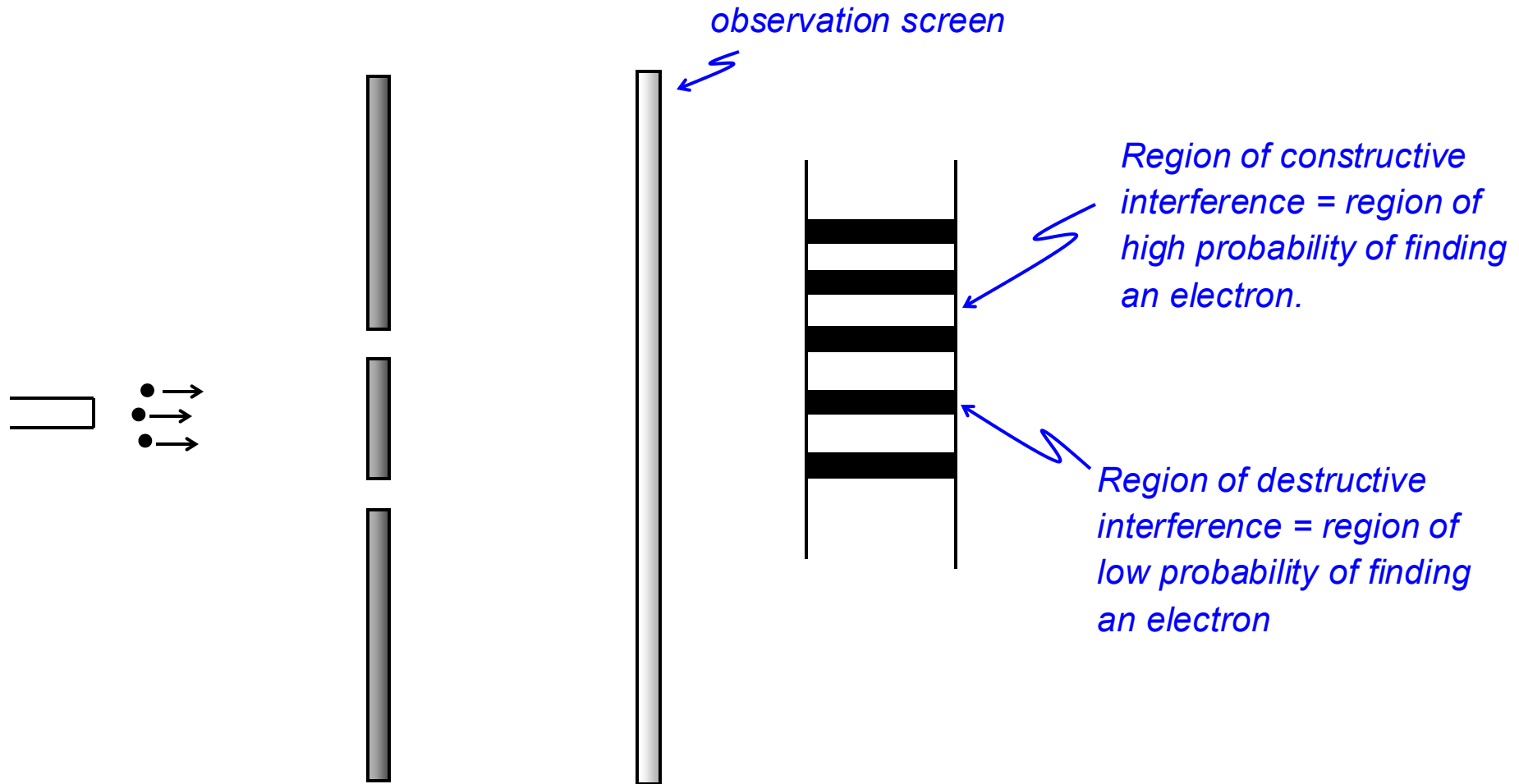
2-Slit Experiment for electrons (Davisson & Germer 1927)

- Without detectors:



- Without detectors: 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. Ontic Interpretation: A probability is a property of objects

(1) Relative Frequency Account

A probability is a property of a *group* of objects

"Electron A has probability of 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 1/2."

(2) Propensity Account

A probability is a property of a *single* object

"Electron A has probability of 1/2 of going through upper slit."

means

"Electron A has an intrinsic tendency (propensity) of 1/2 of going through upper slit."

B. Epistemic Interpretation: A probability is a measure of degree of belief

"Electron A has probability of 1/2 of going through upper slit."

means

"We lack enough knowledge to know definitely which slit Electron A will go through."

$\left[\begin{array}{l} \text{If probabilities in} \\ QM \text{ are } \textbf{ontic...} \end{array} \right] \Rightarrow \left[\begin{array}{l} \text{then } QM \text{ is } \textbf{complete}: \text{No theory} \\ \text{can predict with certainty which} \\ \text{slit electron will go through.} \end{array} \right]$

$\left[\begin{array}{l} \text{If probabilities in} \\ QM \text{ are } \textbf{epistemic...} \end{array} \right] \Rightarrow \left[\begin{array}{l} \text{then } QM \text{ is } \textbf{incomplete}: \text{Some } \textit{other} \\ \text{complete theory can predict which} \\ \text{slit electron will go through.} \end{array} \right]$