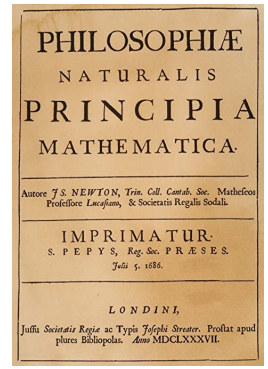
01. The 2-Slit Experiment

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


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

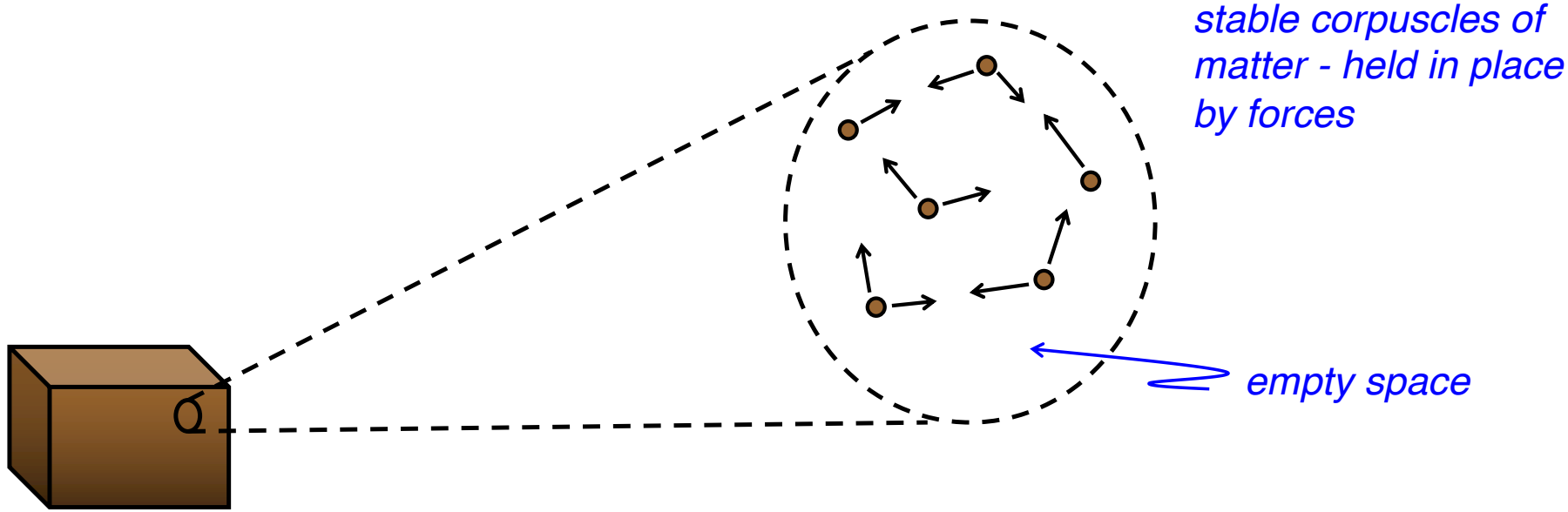
Autore J S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

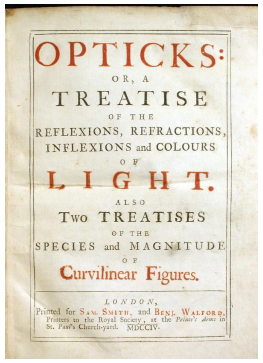
Isaac Newton
(1643-1727)

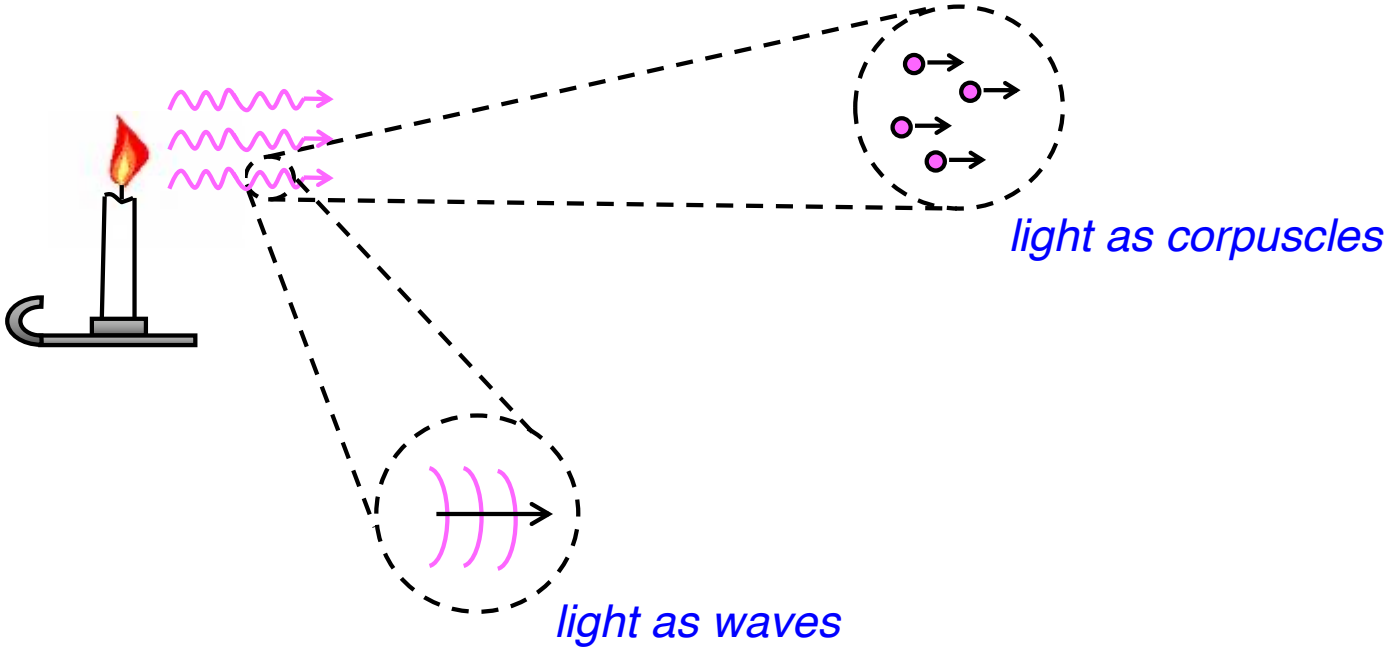
Newtonian corpuscular ontology



Extends to a theory of light...

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


OPTICKS:
OR, A
TREATISE
OF THE
REFLEXIONS, REFRACTIONS,
INFLEXIONS and COLOURS
OF
LIGHT.
ALSO
Two TREATISES
OF THE
SPECIES and MAGNITUDE
OF
Curvilinear Figures.
LONDON,
Printed for SAM. SMITH, and BENJ. WALFORD,
Printers to the Royal Society, at the Prince's Arms in
St. Paul's Churchyard. MDCCIV.

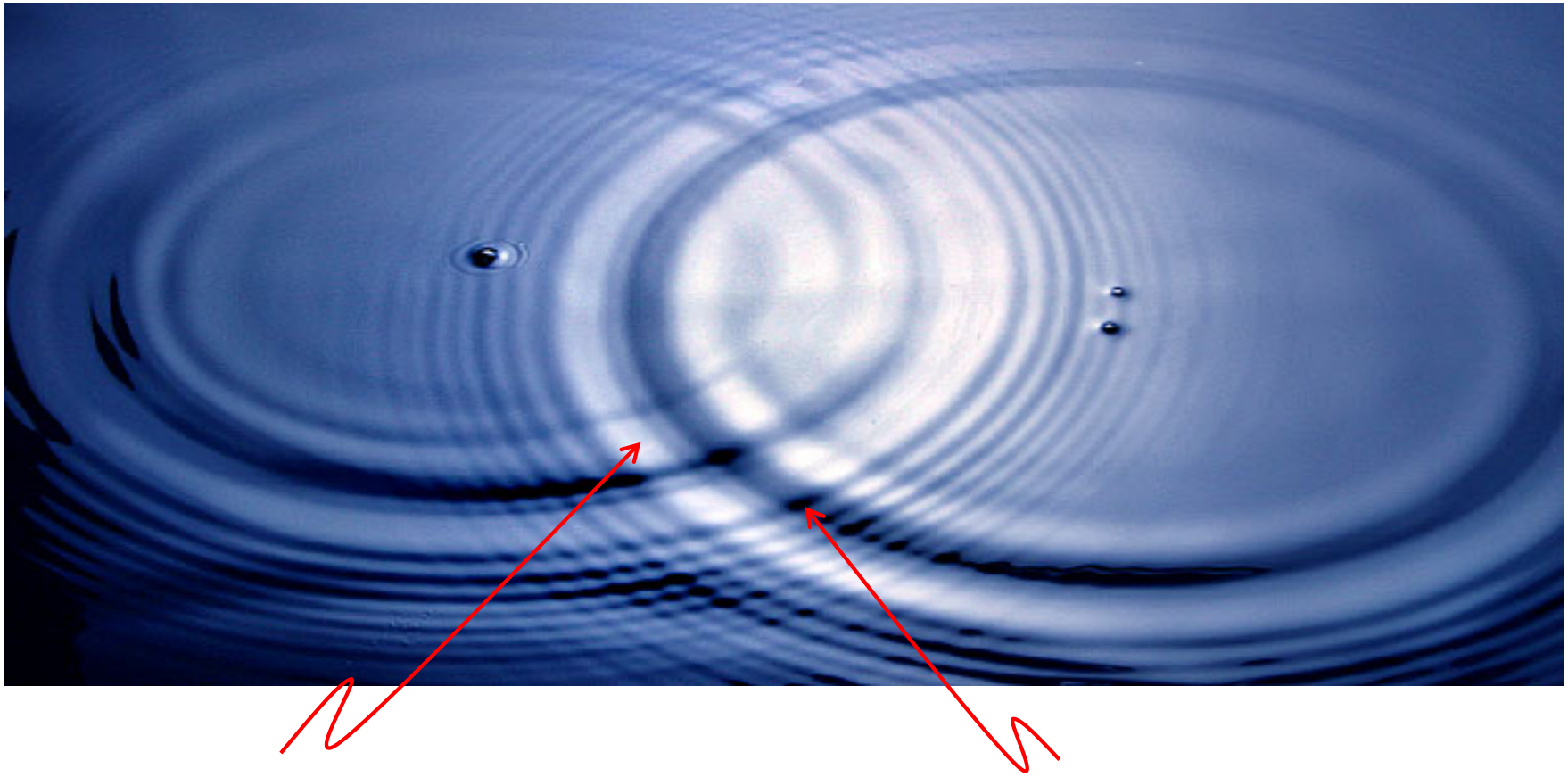


Christiaan Huygens
(1629-1695)

- *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

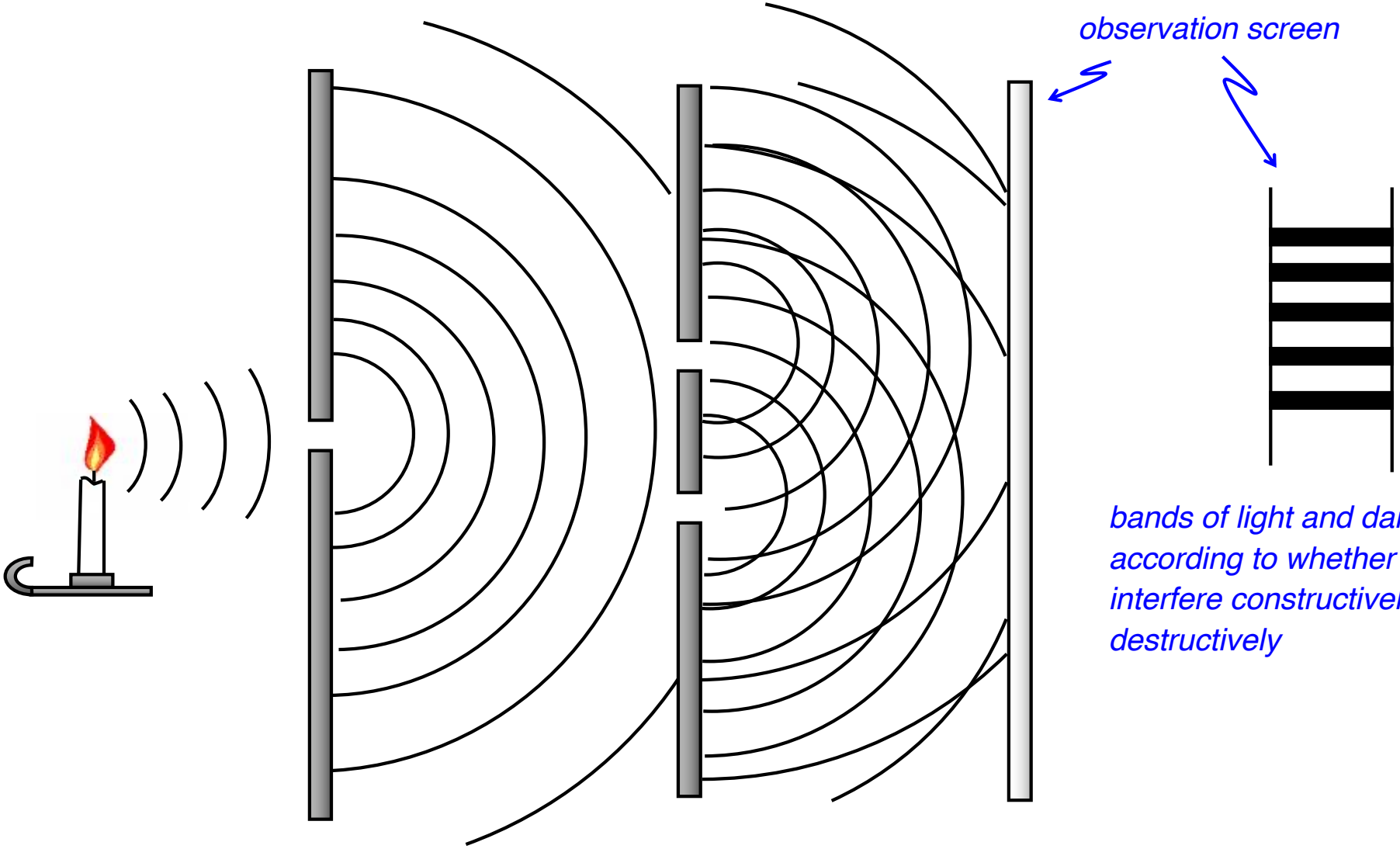
$crest + crest = higher\ crest$

destructive interference

$crest + trough = cancelation$

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

Thomas Young
(1773-1829)

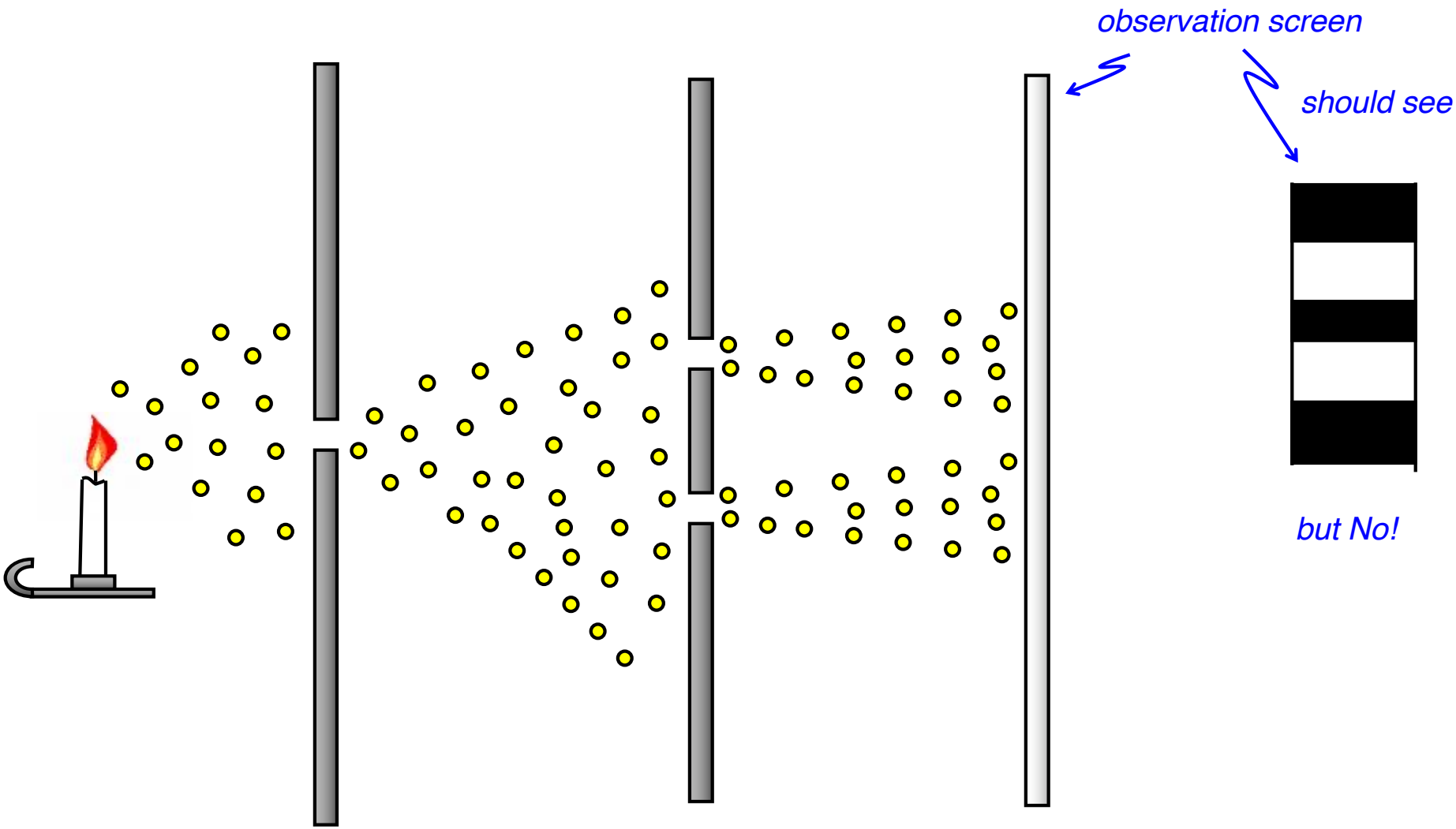


bands of light and dark according to whether waves interfere constructively or destructively

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

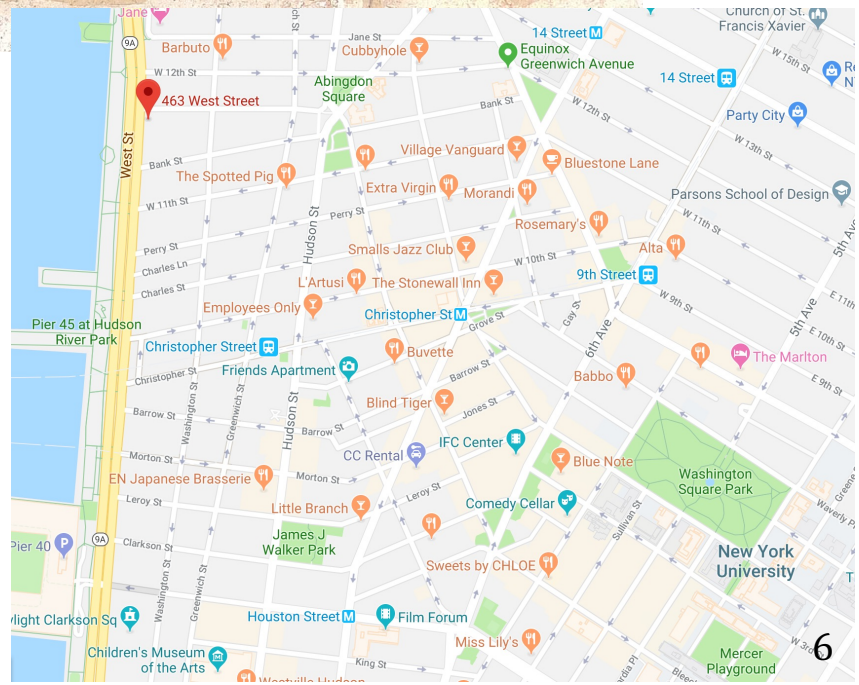
- If light consists of corpuscles, should see...

Thomas Young
(1773-1829)



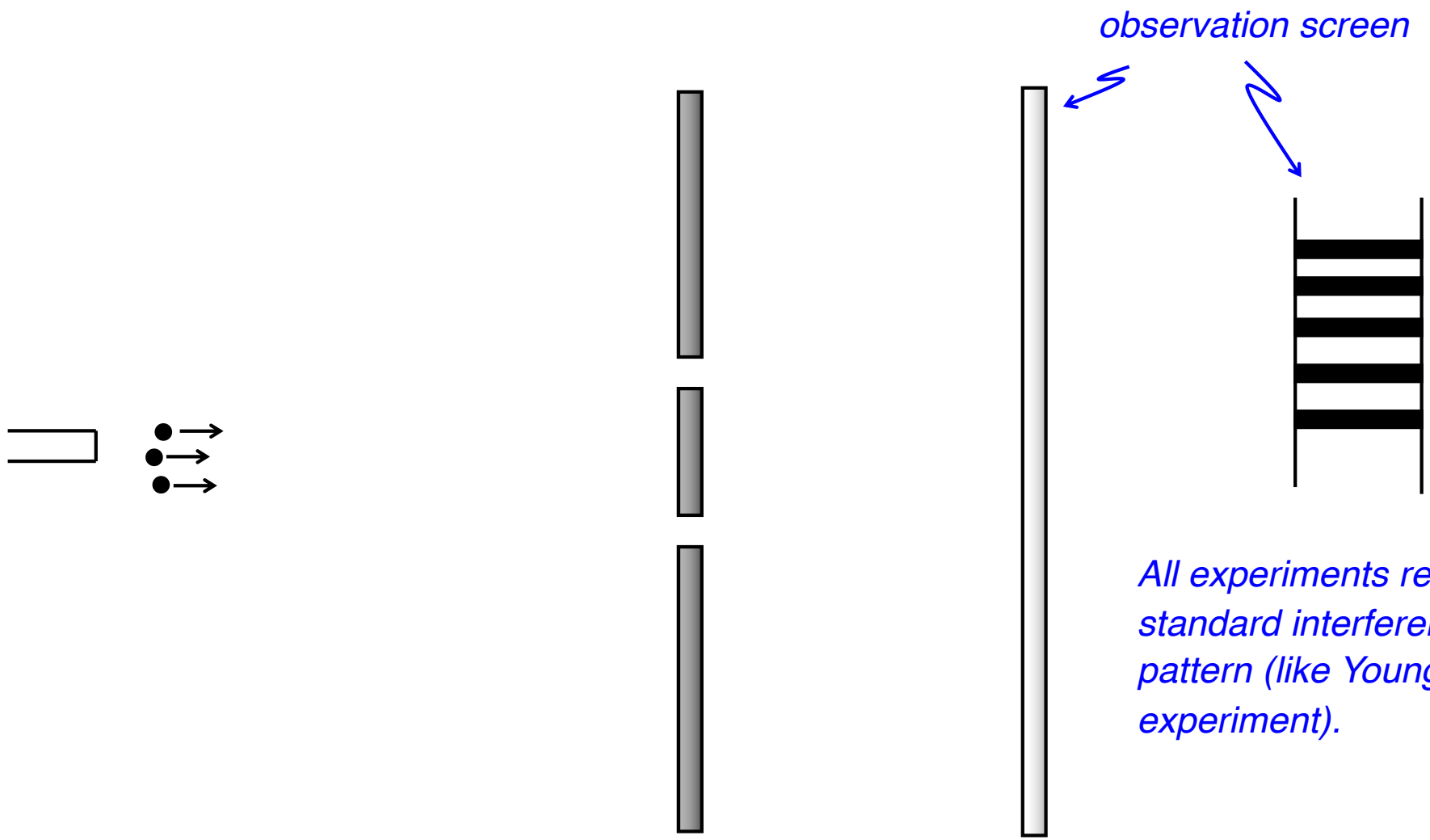
2-Slit Experiment for electrons (Davisson & Germer 1927)

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



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

- Shoot electrons at double slits...

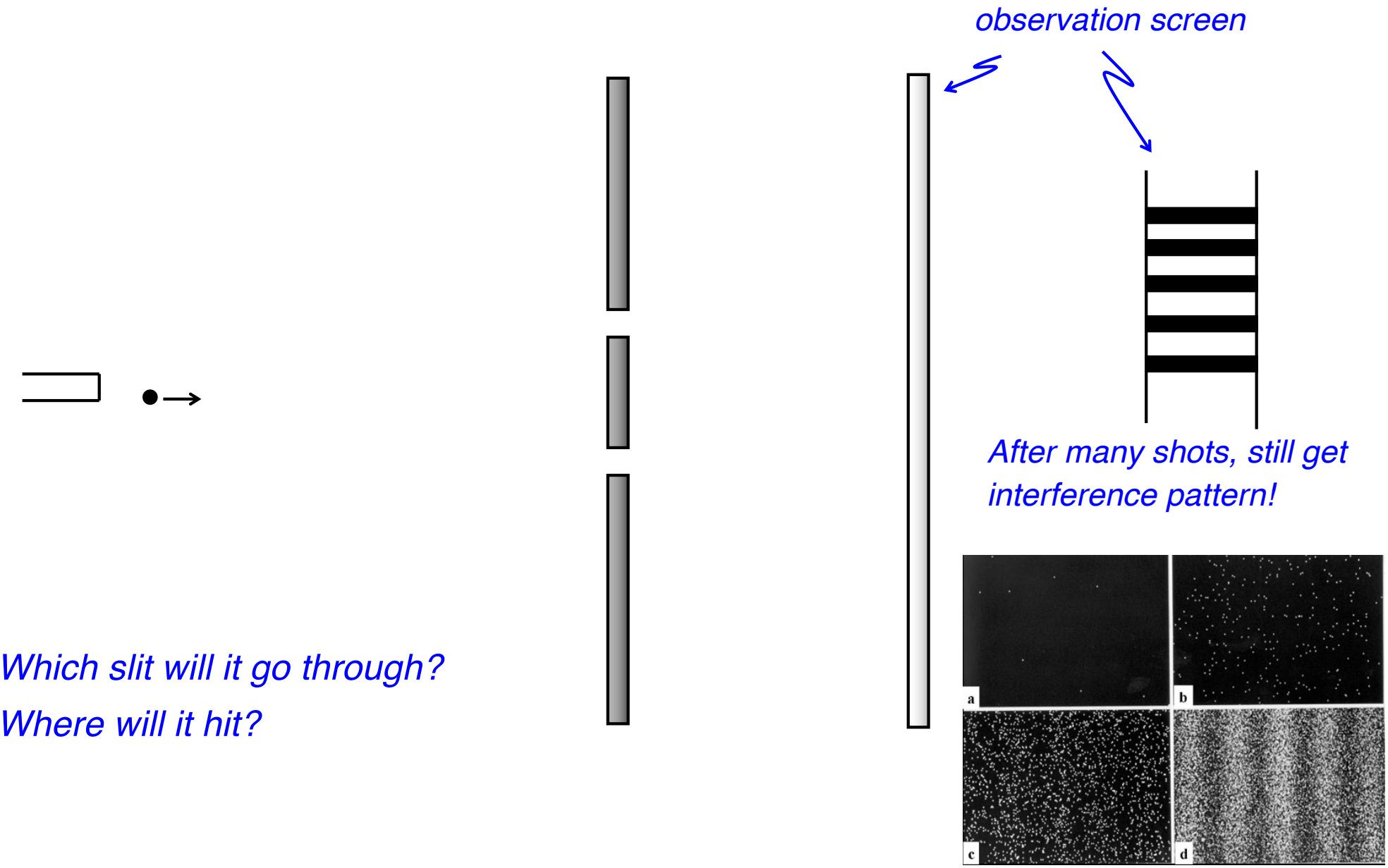


All experiments reveal standard interference pattern (like Young's experiment).

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

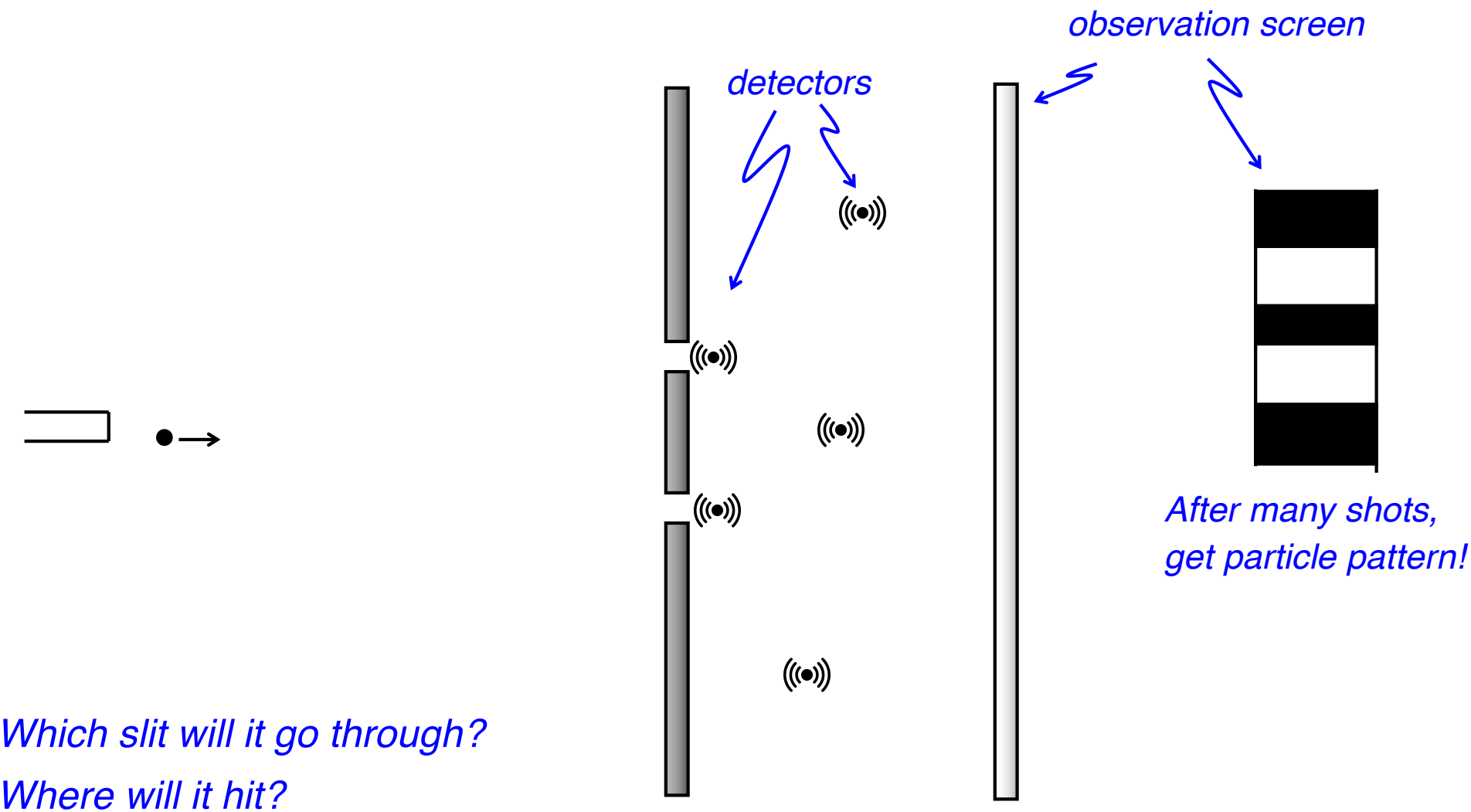
2-Slit Experiment for electrons (Davisson & Germer 1927)

- Shoot one at a time...



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

- Shoot one at a time with detectors...

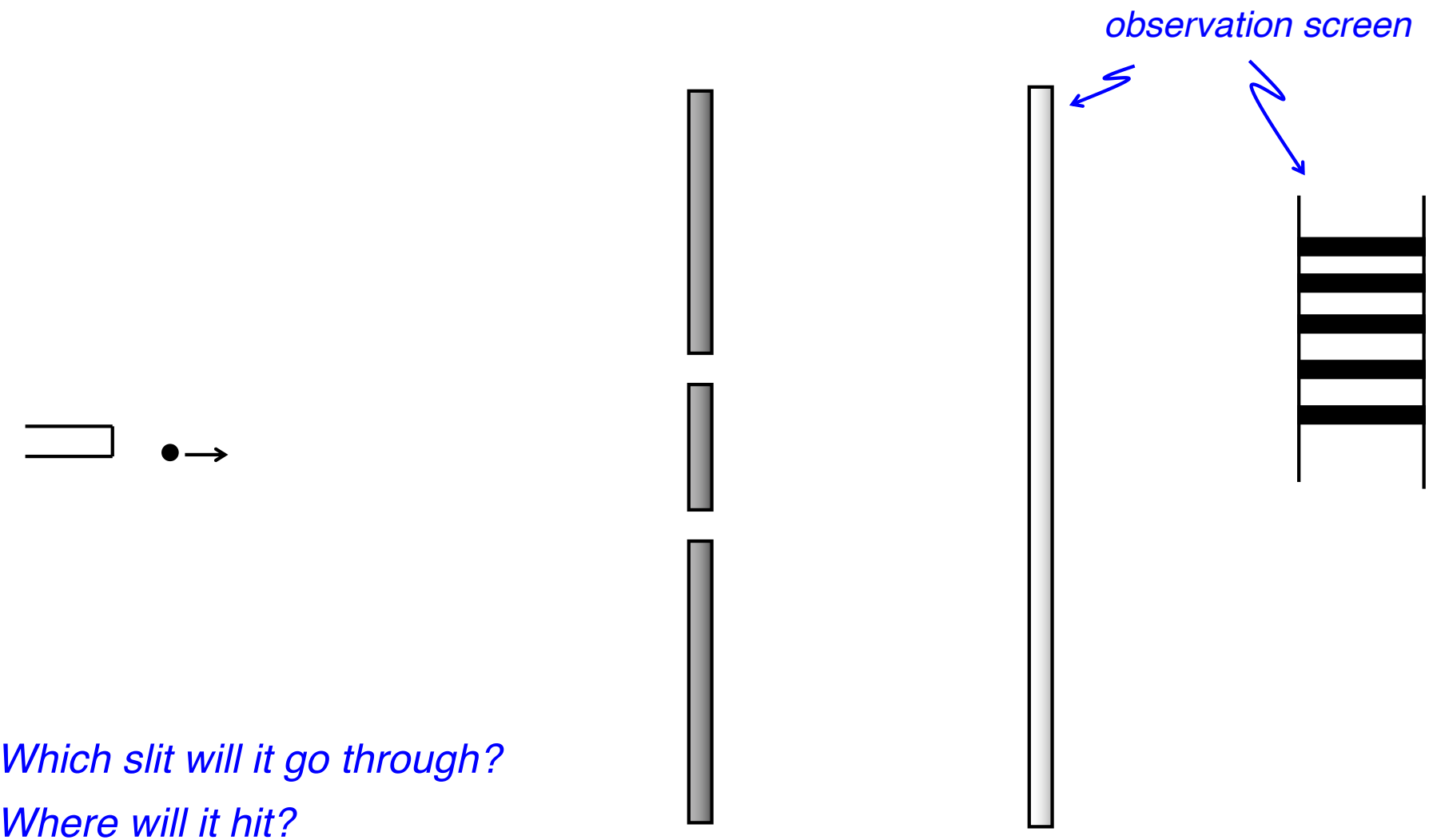


Which slit will it go through?

Where will it hit?

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

- Without detectors:

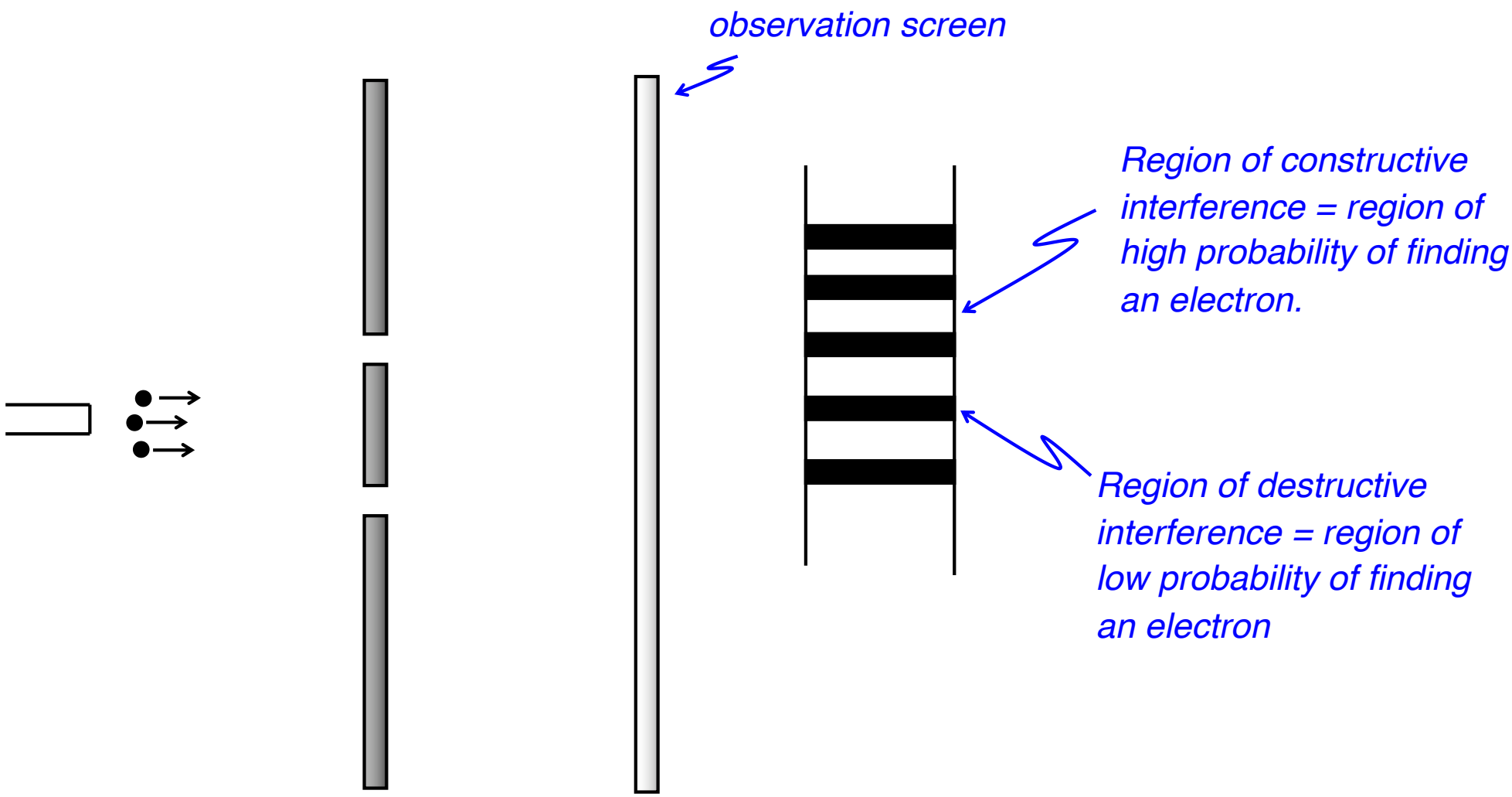


Which slit will it go through?

Where will it hit?

- *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."*

(If probabilities in *QM* are ***ontic***...) $\Rightarrow$ (then *QM* is ***complete***: No theory can predict with certainty which slit electron will go through.)

(If probabilities in *QM* are ***epistemic***...) $\Rightarrow$ (then *QM* is ***incomplete***: Some *other* complete theory can predict which slit electron will go through.)