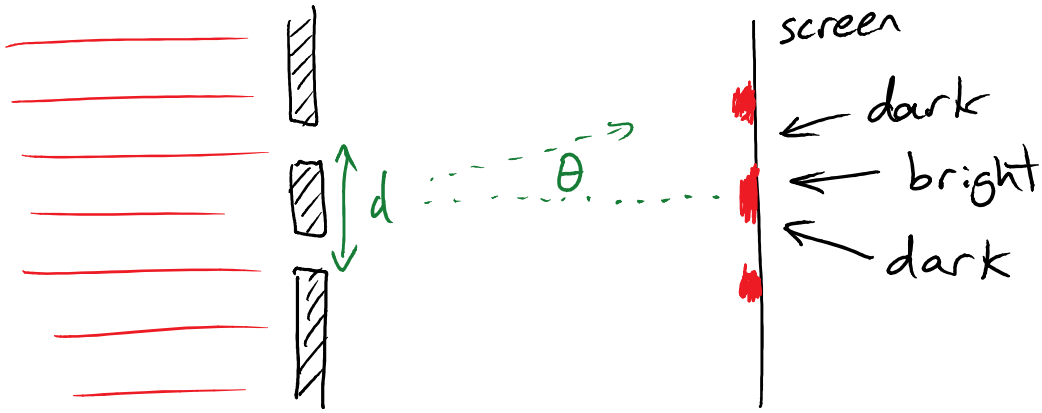
LAST TIME: Interference

- waves from 2 sources can cancel each other out if they arrive out of phase

e.g. DOUBLE SLIT EXPERIMENT

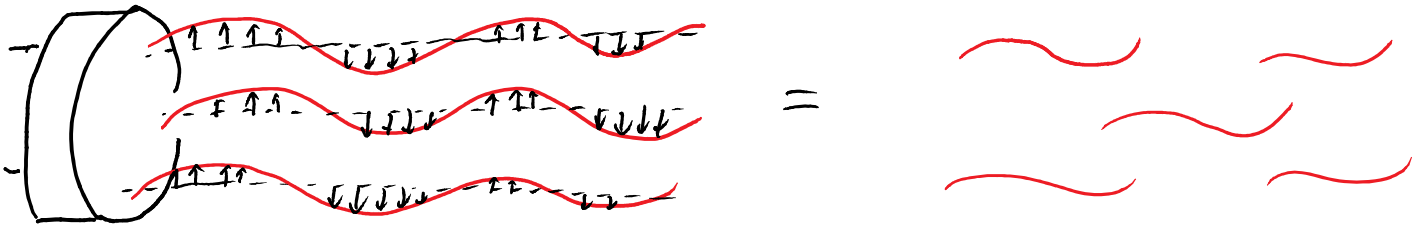


spacing: bright spots at $\sin\theta = \frac{\lambda}{d}, \frac{2\lambda}{d}, \ldots$

Q: Why is it bright in the middle?

- light is a wave
- 2 slits act as 2 in-phase sources
- interfere constructively in middle
- destructive interference ($\frac{\lambda}{2}$ path length difference) at dark spots

Einstein: light made of "lumps" = PHOTONS



frequency f

each photon has energy $\boxed{E = hf}$

present day: can "see" individual photons

Q2: What do we see if we fire individual photons at double-slit?

A: pattern of hits is same as intensity pattern from beam.

Related: similar pattern if we fire electrons or other particles through slits !! (get pattern for $\lambda = h/p$ ← momentum)

* $\lambda = \frac{h}{p}$ de Broglie wavelength *

BUT: classical explanation required interference of light from 2 slits!

Doesn't each particle have to go through one slit or the other?

TEST: cover one slit at a time & alternate

- if particles only see 1 slit, should see same pattern w. half as many particles.

RESULT: pattern changes to jelly bean pattern!

* Single particles go through both slits & interfere w. themselves *

BUT: still hit specific position on screen.

*even if we arrange all initial particles to be identical, they hit different positions on screen to build up interference pattern

observation: particles hit different locations on screen even if their initial states are identical.

explanation: initial state only determines PROBABILITIES for various outcomes

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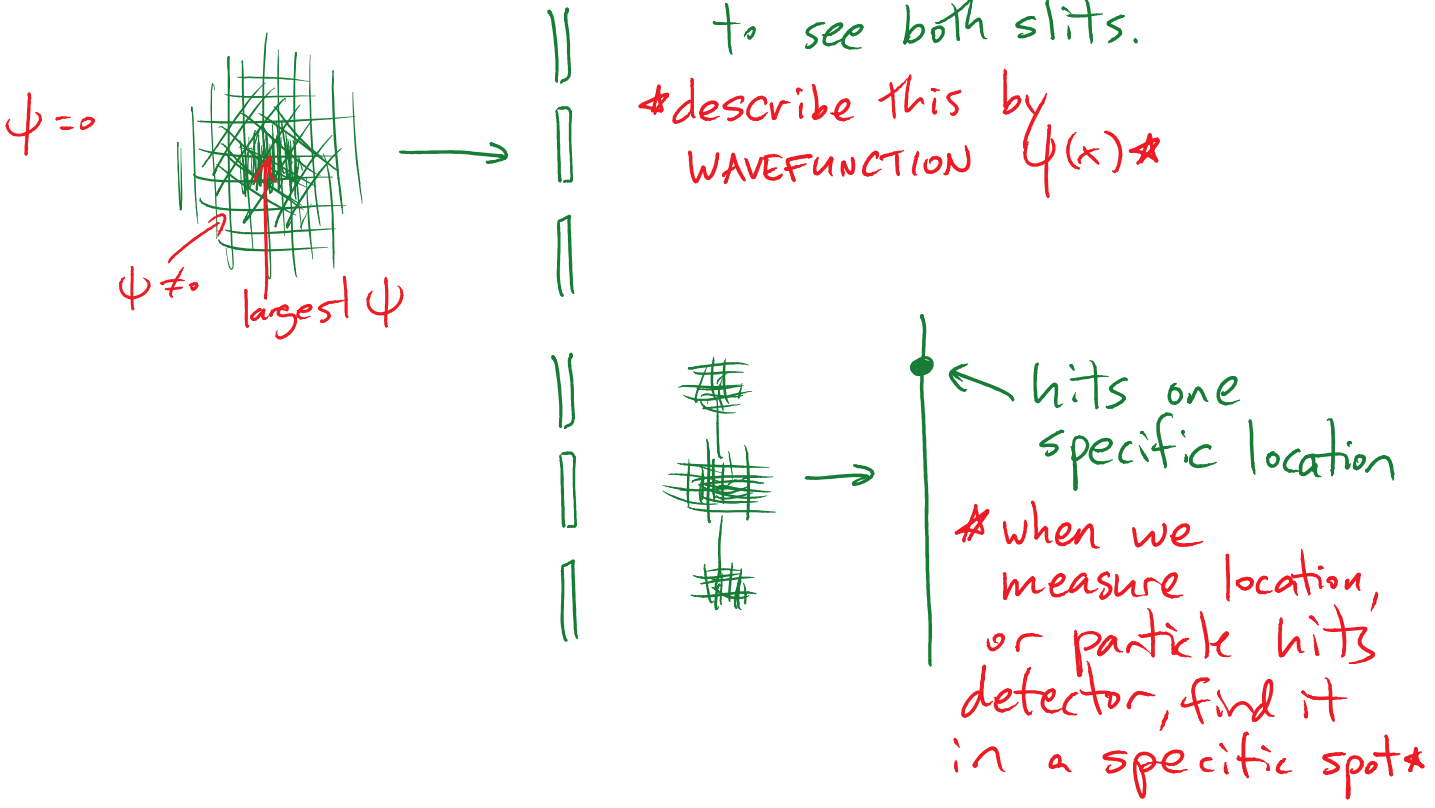
MODEL:

① traveling particles are actually spread out, big enough to see both slits.



Before this, particle has no definite location. $|\psi(x)|^2$ tells us PROBABILITY density for finding particle at x if we measure it.

This defines a QUANTUM SUPERPOSITION