Introduction to Quantum Mechanics

Gracie Conte

University of North Carolina, Chapel Hill
July 12, 2019

Classical vs. Quantum Mechanics

Classical Mechanics

- Describes the motion of macroscopic objects
- Position, momentum and energy move in smooth, orderly and predicable patterns
- Fairly simple

Classical vs. Quantum Mechanics

Classical Mechanics

- Describes the motion of macroscopic objects
- Position, momentum and energy move in smooth, orderly and predicable patterns
- Fairly simple

Quantum Mechanics

- Describes motion for particles of very small sizes
- Position, momentum and energy restricted to discrete values

Classical vs. Quantum Mechanics

Classical Mechanics

- Describes the motion of macroscopic objects
- Position, momentum and energy move in smooth, orderly and predicable patterns
- Fairly simple

Quantum Mechanics

- Describes motion for particles of very small sizes
- Position, momentum and energy restricted to discrete values
  - Discrete: It's like comparing a ramp and a staircase.
- Not very simple

Classical vs. Quantum Mechanics

Classical Mechanics

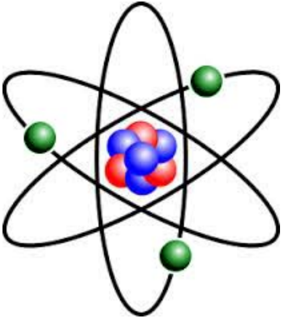
- Describes the motion of macroscopic objects
- Position, momentum and energy move in smooth, orderly and predicable patterns
- Fairly simple

Quantum Mechanics

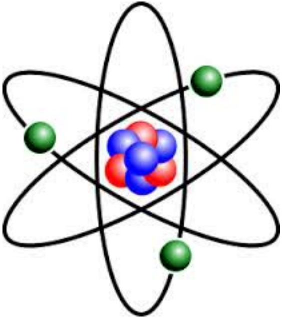
- Describes motion for particles of very small sizes
- Position, momentum and energy restricted to discrete values
  - Discrete: It's like comparing a ramp and a staircase.
- Not very simple

Conclusion: Classical Mechanics is too simple for extremely small particles moving at very high speeds.

Atoms

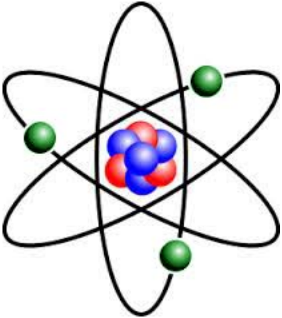


Atoms



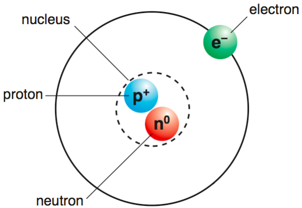
- Nucleus = protons + neutrons
- Atom = nucleus + electrons

Atoms

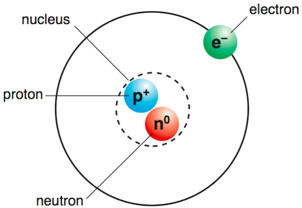


- Nucleus = protons + neutrons
- Atom = nucleus + electrons
- Protons have positive charge
- Nuetrons have no charge
- Electrons have negative charge

Atoms

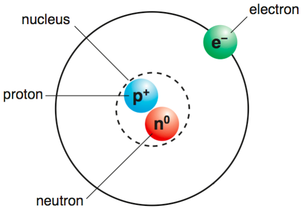


Atoms



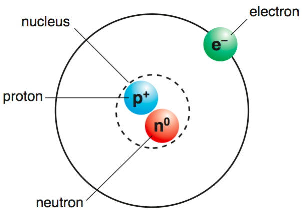
- Electrons are accelerating around the neucleus

Atoms



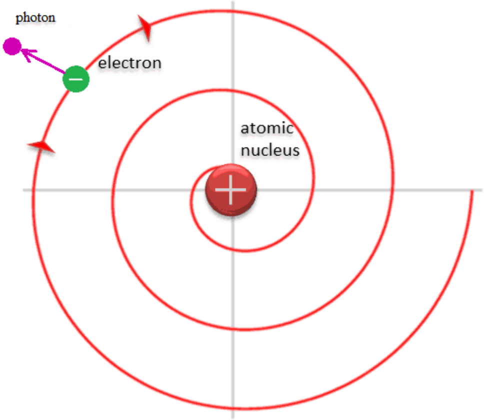
- Electrons are accelerating around the neucleus
- Acceleration = a changing electric field (photons should be emitted)

Atoms



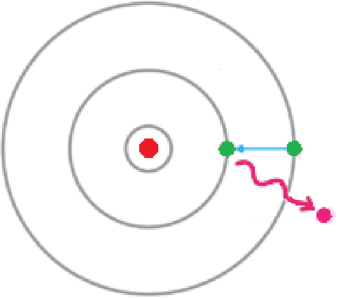
- Electrons are accelerating around the neucleus
- Acceleration = a changing electric field (photons should be emitted)
- Thus electrons should lose energy

Atoms



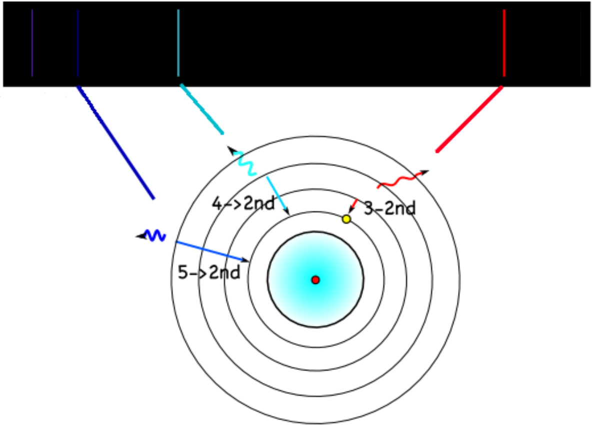
Atoms shouldn't even exist! (But they do.)

Quantum Leap

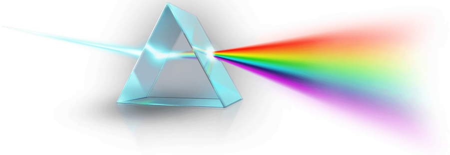


But can we verify this?

Emmision Spectra

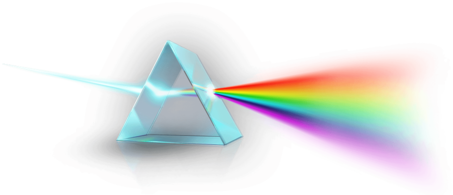


What is Light?



What is Light?

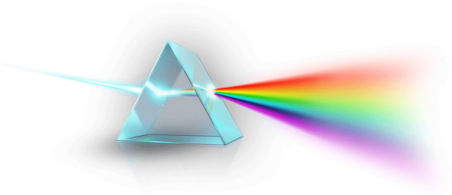
Newton: Light is made of particles



What is Light?

Newton: Light is made of particles

Huygens: Light is a wave

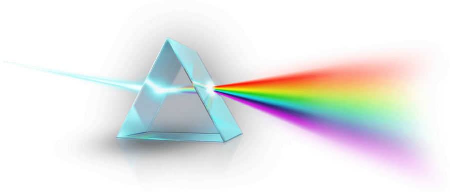


What is Light?

Newton: Light is made of particles

Huygens: Light is a wave

Light is made up of tiny little packets called photons that have no mass



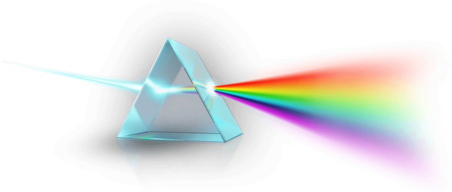
What is Light?

Newton: Light is made of particles

Huygens: Light is a wave

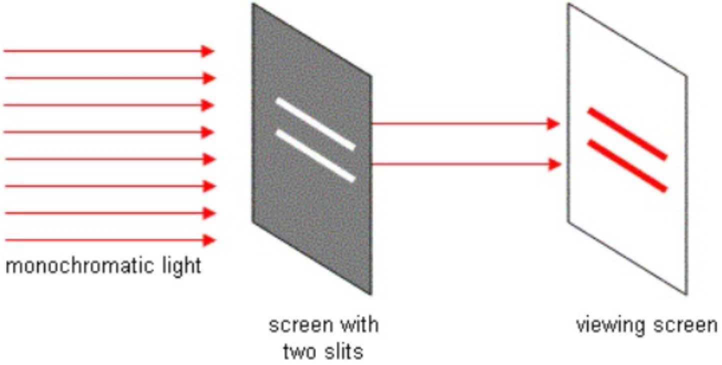
Light is made up of tiny little packets called photons that have no mass

So is light a wave or a particle?



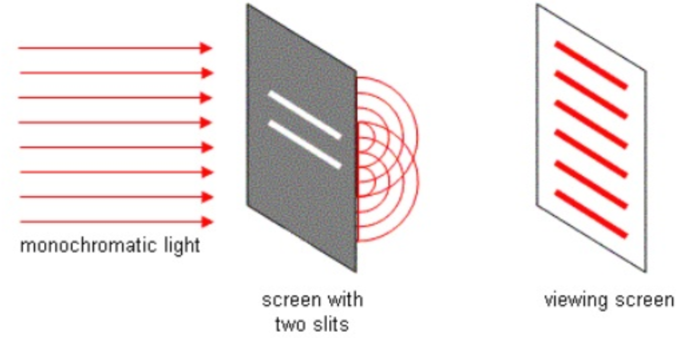
If light is made of particles...

...then we would see two spots that correspond with the rays that hit directly where the slits are located.

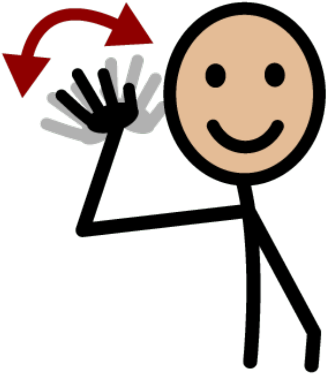


If light is a wave...

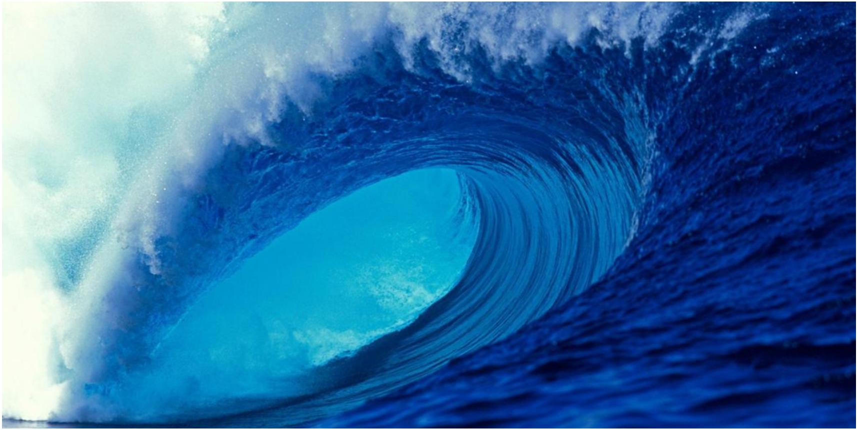
...then we would observe diffraction as we see it pass through the slits. We would be able to see an interference pattern from waves as they meet each other.



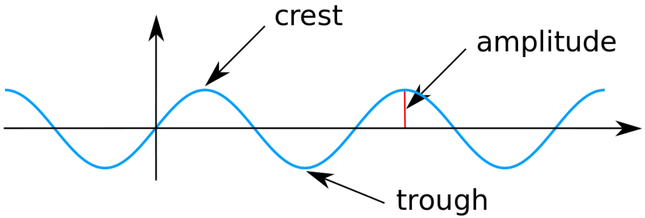
Waves



Waves



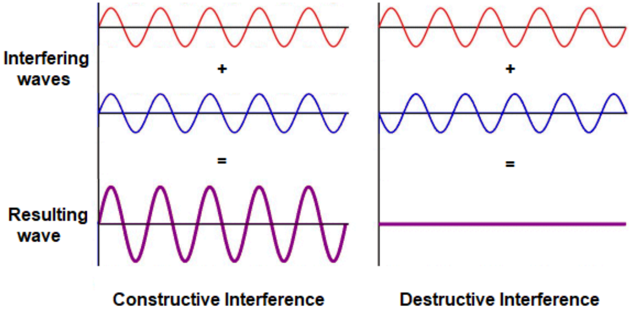
Waves



Waves

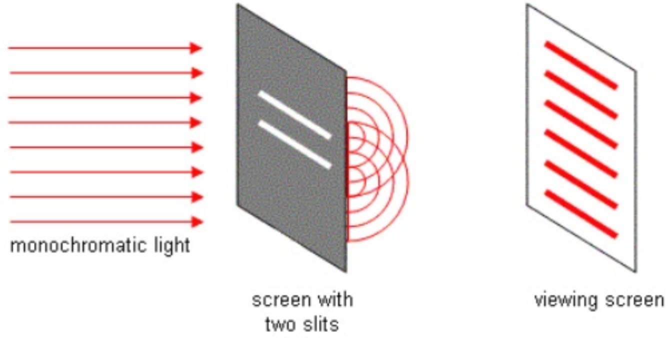
Waves

Waves - Interference



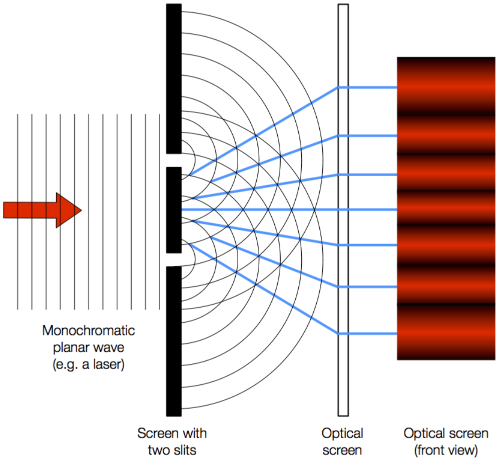
If light is a wave...

...then we would observe diffraction as we see it pass through the slits. We would be able to see an interference pattern from waves as they meet each other.



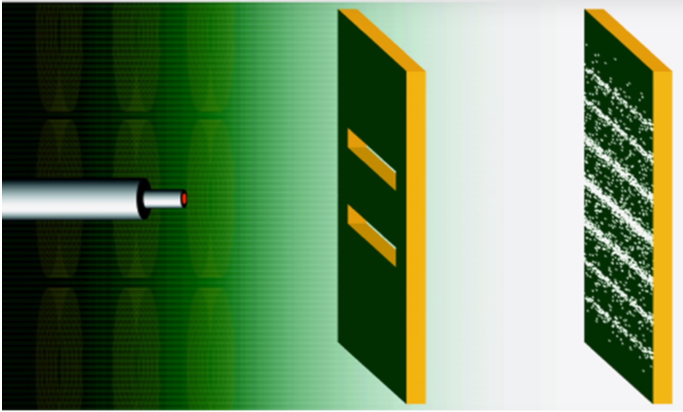
If light is a wave...

...then we would observe diffraction as we see it pass through the slits. We would be able to see an interference pattern from waves as they meet each other.

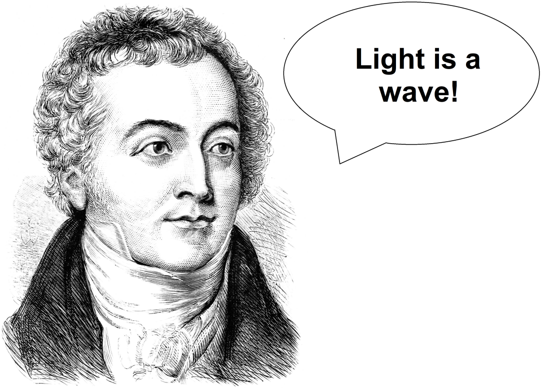


The Experiment

The Experiment

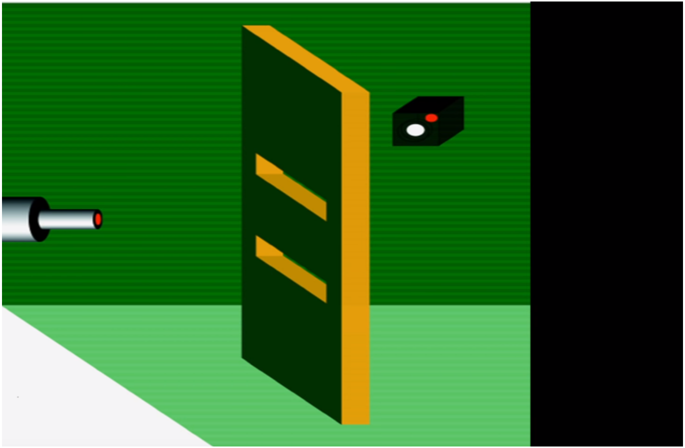


The Experiment

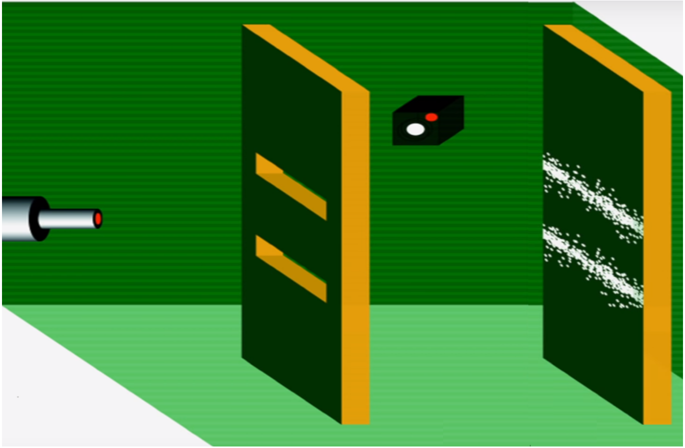


Thomas Young

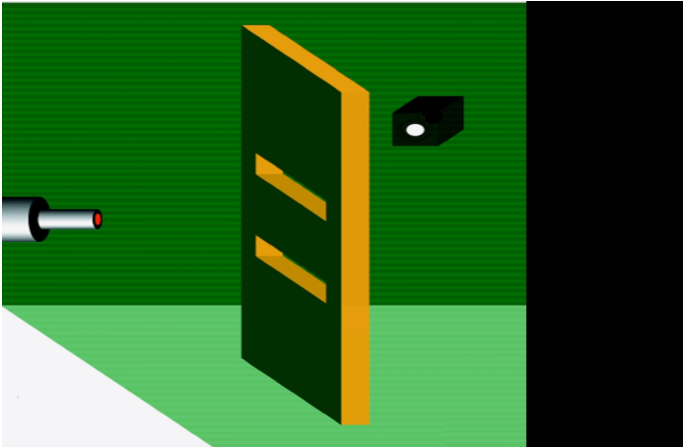
The Experiment with an Observer



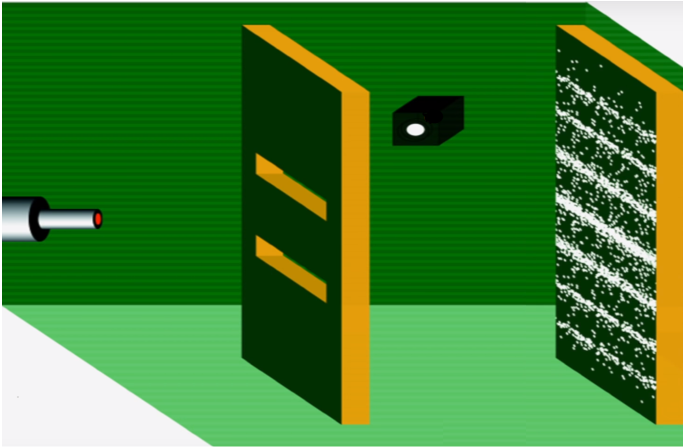
The Experiment with an Observer



The Experiment with an "Observer"



The Experiment with an "Observer"

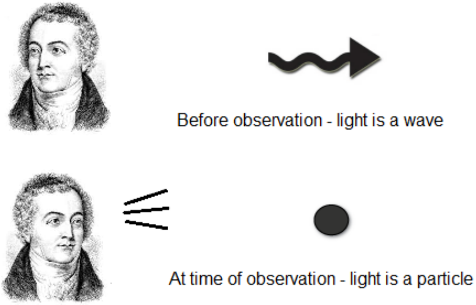


The Duality of Light

So is light a particle or wave?

The Duality of Light

So is light a particle or wave? It's both!



How is it that the photon simultaneously possesses two completely different properties?

Welcome to Quantum Mechanics!

There is still a lot we don't know.