Young's Double Slit Experiment

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Foundations of Physics 1 – related to today’s lecture

• Oscillations and Waves
  • Transverse and longitudinal waves
  • Analysis of wave equation

• Optics
  • Interference
  • Diffraction

• Electromagnetism
  • Maxwell’s equations
Recap 1: Wave Interference

Constructive interference dephasing by $n\lambda$, $n = 0, 1, 2, 3…$

Destructive interference dephasing by $(n+1/2)\lambda$
Recap 2: Single-Slit Wave Diffraction

- **Huygens principle**: each point on the wave front act as a fresh wave source
- A slit works like a “selector”
Recap 2: Single-Slit Wave Diffraction

- **Huygens principle**: each point on the wave front act as a fresh wave source
- A slit works like a “selector”
- Diffraction if slit width and wave length have similar size
Light: wave or particle?

Isaac Newton
1642-1726
Corpuscular theory of light (1672)

Thomas Young
1773-1829

Christiaan Huygens
1629-1695
Wave front theory (1678)
Young’s Double-Slit Experiment

Thomas Young
1773-1829

light source → double slit → screen
Young’s Double-Slit Experiment

If light is a particle…

If light is a wave…
Interference Pattern on the Screen

The screen features an alternation of constructive and destructive interference

\[ \Delta x = d \sin(\theta) \]

Constructive interference if:

\[ \Delta x = n \lambda \]

\(\lambda\): light wavelength
\(d\): slits separation
\(\theta\): incidence angle
\(n\): 0, 1, 2 …
$$\tan \theta = \frac{\Delta y}{L}$$

\(\theta\) : incidence angle
\(\Delta y\) : maxima separation
\(L\) : slits-screen distance

Interference Pattern on the Screen
Understanding the Equations

\[ n \lambda = d \sin \theta \]

\[ \tan \theta = \frac{\Delta y}{L} \]

- Why does sunlight form rainbows on the screen?
- What if I change the slits separation?
- What if I move the screen further away?

vsg.quasihome.com/interfer.htm
Why does light intensity decay with the angle?

- Interference between two slits
- Diffraction through each slit
- Combined effects
Why does light intensity decay with the angle?

Interference between two slits

Diffraction through each slit

Combined effects
Why does light intensity decay with the angle?

Check Jupyter notebook at degiacomi.org/teaching
1905: light as «quanta of energy»

- The **photoelectric effect** is explained by «light particles» hitting a metal surface
- Nobel Prize in 1921

Albert Einstein
1879-1955
1924: «matter waves»

- Particles as «waves that transfers energy and momentum»

\[ \lambda = \frac{h}{p} \]

\( \lambda \) : wavelength
\( p \) : momentum
\( h \) : Planck constant

- Davisson–Germer experiment: electrons diffract too!

Double-Slit Experiment with Molecules!

Phthalocyanine $C_{32}H_{56}N_8$

Further Information

• Book chapters:
  • 35.2: Two-source interference of light
  • 35.3: Intensity of interference patterns

• Double-slit experiment app:
  vsg.quasihome.com/interfer.htm

• Jupyter notebook on bands intensity in double-slit experiment:
  degiacomi.org/teaching

• Handouts on DUO
A laser pointer points towards two slits separated by 0.5 mm. A screen located at 1 m shows that the distance between the first two maxima is 1 mm. What is the color of the laser?
Is it a wave? Is it a particle?