

Matter Waves

- De Broglie stated that since EMR has momentum and acts like a wave, perhaps matter, which has momentum, also acts like a wave.
- • He used Compton's momentum of EMR formula, $p = h/\lambda$ and equated it to the formula for momentum of matter, $p = mv$

De Broglie wave equation

$$p = \frac{h}{\lambda} \quad \text{wave or photon momentum}$$

$$p = \frac{h}{\lambda} \quad p = mv \quad mv = \frac{h}{\lambda} \quad \therefore \lambda = \frac{h}{mv}$$

- De Broglie wavelength is more significant for small masses traveling at high speeds rather than large masses traveling at low speeds



Matter Waves

- This was not a popular idea. In fact, de Broglie's thesis was held up until Einstein reviewed his work and agreed with it.
 - To prove the existence of such waves is very difficult because they are so small.
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Solution

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{50\text{kg} \cdot 16\text{m} / \text{s}}$$

$$\lambda = 8.3 \times 10^{-37} \text{ m}$$



This means what?

- This wavelength (8.3×10^{-37} m) is about a billion, trillion times smaller than a hydrogen atom!
 - This wavelength is so small that it is completely unobservable.
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Examples

- Calculate the wavelength of an electron moving at 1.0×10^6 m/s.
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Solution

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{9.11 \times 10^{-31} \text{ kg} \cdot 1.0 \times 10^6 \text{ m/s}}$$

$$\lambda = 7.3 \times 10^{-10} \text{ m}$$



What does this mean?

- This wavelength ($7.3 \times 10^{-10} \text{ m}$) is in about the same wavelength of x-rays.
 - This is observable.
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Eg) Determine the De Broglie wavelength for an alpha particle traveling at $0.015c$.

$$p = \frac{h}{\lambda} \quad p = mv \quad mv = \frac{h}{\lambda} \quad \therefore \lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63 \times 10^{-34} \text{ Js}}{6.65 \times 10^{-27} \text{ kg}(0.015)(3.00 \times 10^8 \text{ m/s})}$$

$$\lambda = 2.2 \times 10^{-14} \text{ m}$$