de Broglie (1923): Wave-particle duality

All material particles also display a dual wave-particle behavior with

$$\lambda = \frac{h}{p} \quad \text{and} \quad k = \frac{p}{\hbar}$$

where λ is the (de Broglie) wavelength and k is the (de Broglie) wavenumber of the material particle.

de Broglie wavelength

Electron 1 is accelerated from rest through a potential difference of 100 V.

Electron 2 is accelerated from rest through a potential difference of 200 V.

Afterward, which electron has the larger de Broglie wavelength?

(A) Electron 1

(B) Electron 2

(C) Both have same de Broglie wavelength

(D) Impossible to tell

de Broglie wavelength

Electron 1 is accelerated from rest through a potential difference of 100 V.

Electron 2 is accelerated from rest through a potential difference of 200 V.

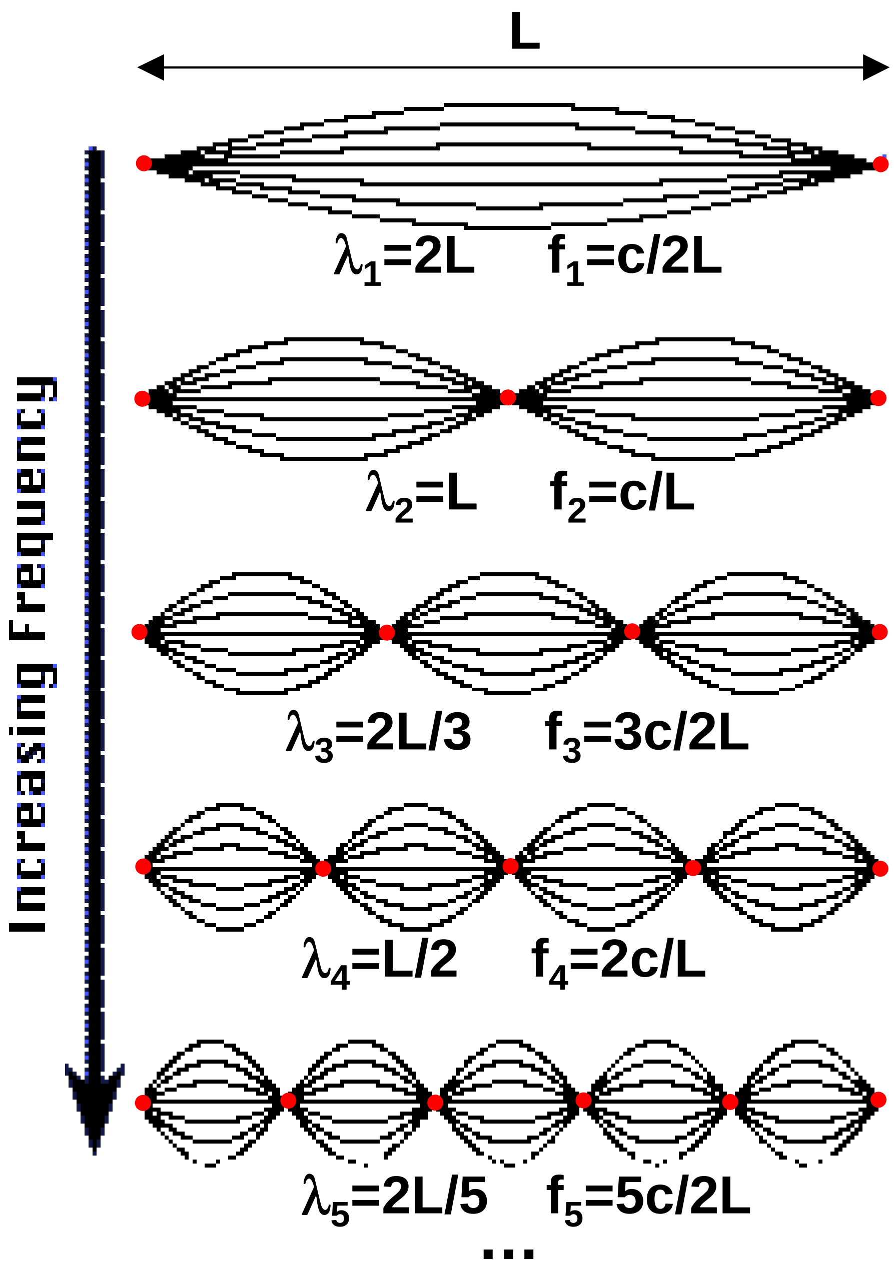
By how much is the de Broglie wavelength of electron 1 larger than that of electron 2

(A) $\lambda_1 = \sqrt{2}\lambda_2$ (B) $\lambda_1 = 2\lambda_2$

(C) $\lambda_1 = 4\lambda_2$ (D) some other relation

Standing waves:

For standing waves, boundary conditions mean that waves only have discrete modes.



Standing Waves on a Ring

What are the restrictions on the wavelength for a standing wave on a ring?

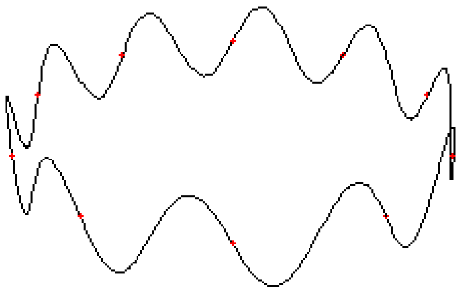
(A) $r = \lambda$

(B) $r = n\lambda$

(C) $\pi r = n\lambda$

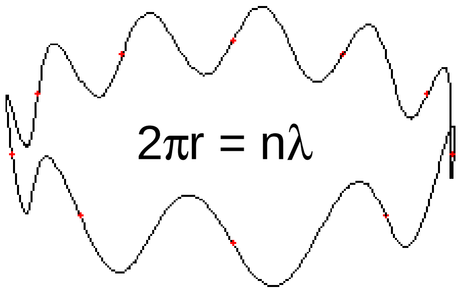
(D) $2\pi r = n\lambda$

(E) $2\pi r = \lambda/n$



Standing Waves on a Ring

What is n in this picture?



(A) 1

(B) 5

(C) 10

(D) 20

(E) impossible to tell

De Broglie wavelengths and stationary orbitals

Given the deBroglie wavelength (λ**=h/p**) and the condition for standing waves on a ring (**2πr = nλ**), what can you say about the angular momentum L of an electron if it is a deBroglie wave?

(A) $L = n\hbar/r$

(B) $L = n\hbar$

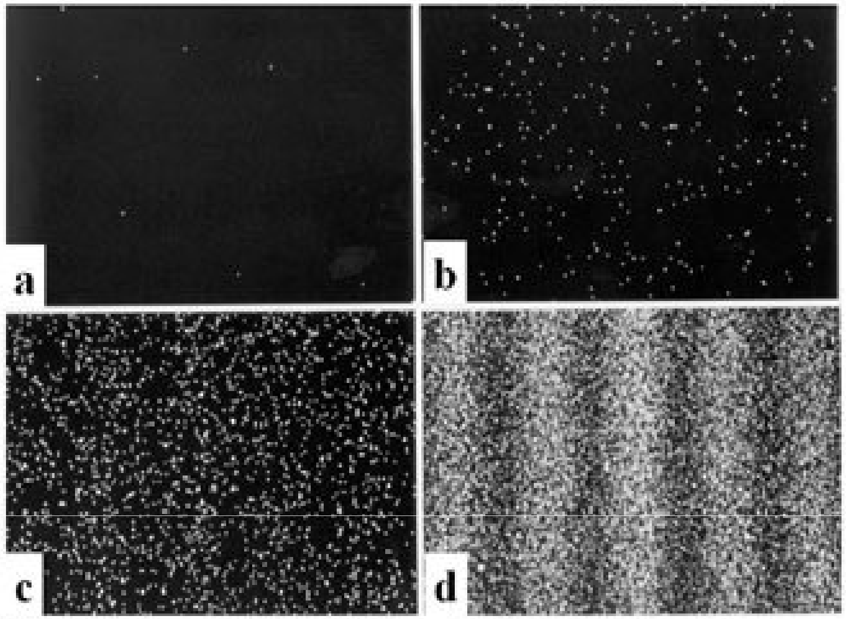
(C) $L = n\hbar/2$

(D) $L = 2n\hbar/r$

(E) $L = n\hbar/2r$

(Note: $\hbar = h/2\pi$)

Double slit experiments with electrons



Single-electron Build-up of Interference Pattern

1964: Claus Jönsson

Am. J. Phys. **42**, 4 (1974)

1976: Merli, Missiroli and Pozzi

Am. J. Phys. **44**, 306 (1976)

1989: Tonomura et al.

Am. J. Phys. **57**, 117 (1989)

Think about the following observations/questions:

- For each electron you see a single light flash. What does this tell you about the nature of the electron?
- Can you predict where the next light flash will be? What does this mean?