MODERN PHYSICS DAY 6: MATTER WAVES AND THE DE BROGLIE WAVELENGTH

CED 15.1 · Skill 2.B · FRQ: Multiple Representations

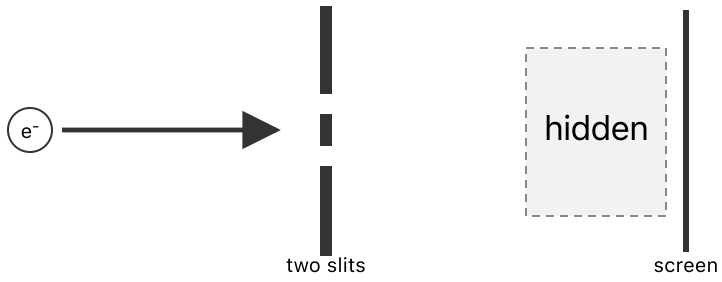
PREDICT

Electrons are sent one at a time toward a double slit. After many detections, what pattern will the screen show?

A. interference bands **B. exactly two bands** **C. one central spot** **D. a uniform random blur**

Commit before the screen result is revealed.

ELECTRON DOUBLE-SLIT SETUP



Distinguish the location of one detection from the distribution formed by many detections.

NOTES / REASONING

THE MATTER-WAVELENGTH RELATION

de Broglie associated a wavelength with particle momentum.

$$\lambda = \frac{h}{p} \qquad p = mv \text{ for a nonrelativistic particle}$$

A measurable diffraction pattern requires a wavelength comparable with a relevant spacing in the apparatus.

WE DO An electron moves at $2.00 \times 10^{6}\,\mathrm{m/s}$. Find its momentum and de Broglie wavelength. Use $m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$.

SAME RELATION, VERY DIFFERENT SCALE

LOGARITHMIC WAVELENGTH COMPARISON

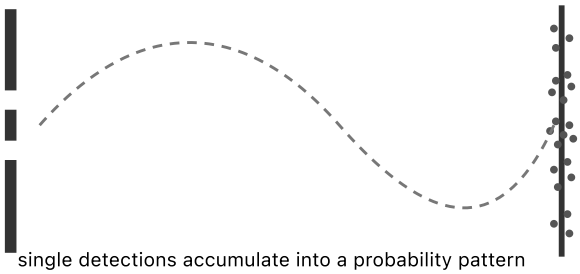
calculate and place the baseball

A $0.145\,\mathrm{kg}$ baseball travels at $40.0\,\mathrm{m/s}$. Calculate its wavelength and place it on the scale.

Explain why “the baseball has no wavelength” is different from “its wavelength is not experimentally relevant here.”

CONNECT WAVELENGTH TO A PATTERN

ACCUMULATED ELECTRON DETECTIONS



single detections accumulate into a probability pattern

1. If electron speed doubles, by what factor does its de Broglie wavelength change?

2. A crystal spacing is $0.250\,\text{nm}$. Compare it with the $0.364\,\text{nm}$ electron wavelength and predict whether diffraction is plausible.

3. Draw and label one localized electron event and the many-event interference envelope. State what each representation means.