Pictures for Phys 217

- Photoelectric effect
Studying the PE effect
Some results
Actual data
EM spectrum
Compton effect
Compton results
Before collision: A photon of wavelength $\lambda$ approaches an electron at rest.

After collision: The electron scatters at speed $u$, angle $\phi$. A photon of wavelength $\lambda'$ scatters at angle $\theta$.

Boxes show momentum (top) and energy (bottom) expressions.

$h/\lambda$  
$hc/\lambda$  
$0$  
$m_ec^2$  
$h/\lambda'$  
$h/\lambda'$  
$\gamma_u m_ec^2$  
$\gamma_u m_ec^2$
Compton results
FIGURE 36-5 Diffraction represented schematically. For a given wavelength $\lambda$, the diffraction is more pronounced the smaller the slit width $a$. The figures show the cases for (a) slit width $a = 6.0\lambda$, (b) slit width $a = 3.0\lambda$, and (c) slit width $a = 1.5\lambda$. In all three cases, the screen and the length of the slit extend well into and out of the page, perpendicular to it.
Illustration of intensity

(a) Relative intensity $a = \lambda$

(b) Relative intensity $a = 5\lambda$

(c) Relative intensity $a = 10\lambda$
Electron diffraction
Equipment
Matter waves
Matter waves
Rutherford discovery

Curve proportional to $1/\sin^2 \theta$

Measurements

Curve expected from plum pudding model

Number of flashes seen on screen

Angle of deflection of alphas
• Possible to get a good charge density (preliminary)
What you “see” for Hydrogen
Electron potential in Hydrogen

\[ U(r) = -\frac{1}{4\pi\varepsilon_0} \frac{e^2}{r} \]

- \( E > 0 \rightarrow \) Unbound states
- \( E = 0 \)
- \( E < 0 \rightarrow \) Bound states
$E_1 = -13.6 \text{ eV}$

Lyman series ($n_f = 1$)

$E_2 = -\frac{13.6 \text{ eV}}{2^2} = -3.4 \text{ eV}$

Balmer series ($n_f = 2$)

$E_3 = -\frac{13.6 \text{ eV}}{3^2} = -1.5 \text{ eV}$

Paschen series ($n_f = 3$)

$E_4 = -\frac{13.6 \text{ eV}}{4^2}$

$E_5 = -\frac{13.6 \text{ eV}}{5^2}$

$E_6 = -\frac{13.6 \text{ eV}}{6^2}$

$E_n = 0$
More of the same
Frank & Hertz 1914

Mercury vapor

[Diagram of a circuit with labeled components: Heater, A, P, I, V, and a graph showing current (in milliamps) against voltage (in volts). The graph displays three peaks at specific voltage intervals.]
Spectrum Mercury

Continuum

2nd excited state

1st excited state

Ground state

\[ \varepsilon = -10.4 \text{ eV} \]

4.9 eV

6.7 eV
FIGURE 36-6 In Young’s interference experiment, incident monochromatic light is diffracted by slit $S_0$, which then acts as a point source of light that emits semicircular wavefronts. As that light reaches screen $B$, it is diffracted by slits $S_1$ and $S_2$, which then act as two point sources of light. The light waves traveling from slits $S_1$ and $S_2$ overlap and undergo interference, forming an interference pattern of maxima and minima on viewing screen $C$. This figure is a cross section; the screens, slits, and interference pattern extend into and out of the page.
\[ E = \frac{p^2}{2m} \]

\[ \frac{p^2}{2m} = E - V_0 \]

\[ E = \frac{p^2}{2m} \]
$$E = \frac{p^2}{2m}$$
$\Psi^*(x, t) \Psi(x, t)$  All $t$
\[ \psi_1(x) \]
\[ \propto \cos \left( \sqrt{\frac{2mE_1}{\hbar}} x \right) \]
\[ \propto e^{-\left( \sqrt{\frac{2m}{\hbar}} (V_0 - E_1) \right) x} \]
$|\psi(x)|^2$  Finite well  $\psi(x)$  

$\psi(x)$  Infinite well  $|\psi(x)|^2$
<table>
<thead>
<tr>
<th>Name of System</th>
<th>Physical Example</th>
<th>Potential and Total Energies</th>
<th>Probability Density</th>
<th>Significant Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero potential</td>
<td>Proton in beam from cyclotron</td>
<td>$E$</td>
<td>$\psi \cdot \psi$</td>
<td>Results used for other systems</td>
</tr>
<tr>
<td></td>
<td>Conduction electron near surface of metal</td>
<td>$V(x)$</td>
<td></td>
<td>Penetration of excluded region</td>
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<tr>
<td>Step potential (energy</td>
<td>Neutron trying to escape nucleus</td>
<td>$E$</td>
<td>$\psi \cdot \psi$</td>
<td>Partial reflection at potential</td>
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<tr>
<td>above top)</td>
<td></td>
<td>$V(x)$</td>
<td></td>
<td>discontinuity</td>
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<tr>
<td>Step potential (energy</td>
<td>$\alpha$ particle trying to escape Coloumb barrier</td>
<td>$E$</td>
<td>$\psi \cdot \psi$</td>
<td>Tunneling</td>
</tr>
<tr>
<td>below top)</td>
<td></td>
<td>$V(x)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barrier potential</td>
<td>Electron scattering from negatively ionized atom</td>
<td>$E$</td>
<td>$\psi \cdot \psi$</td>
<td>No reflection at certain energies</td>
</tr>
<tr>
<td>(energy above top)</td>
<td></td>
<td>$V(x)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finite square well</td>
<td>Neutron bound in nucleus</td>
<td>$E$</td>
<td>$\psi \cdot \psi$</td>
<td>Energy quantization</td>
</tr>
<tr>
<td>potential</td>
<td></td>
<td>$V(x)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infinite square well</td>
<td>Molecule strictly confined to box</td>
<td>$E$</td>
<td>$\psi \cdot \psi$</td>
<td>Approximation to finite square well</td>
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<tr>
<td>potential</td>
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<td>$V(x)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple harmonic</td>
<td>Atom of vibratign diatomic molecule</td>
<td>$E$</td>
<td>$\psi \cdot \psi$</td>
<td>Zero-point energy</td>
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<tr>
<td>oscillator potential</td>
<td></td>
<td>$V(x)$</td>
<td></td>
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