Phys 100 2023
Lecture 38

Fri: Review Test 3

Test 3 covers – lectures 29-39 } Waves
– HW 8-11 } Quantum Physics

2021 Test 3 Q1-8, 10

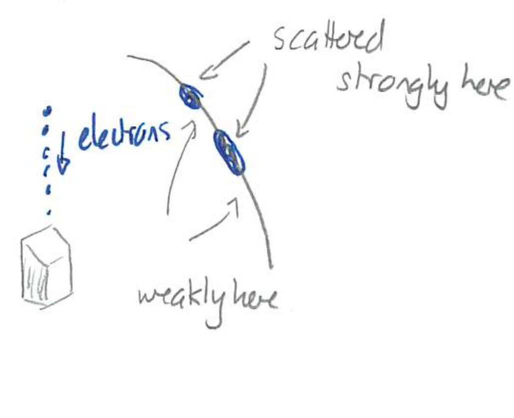
2022 Test 3 Q1-8, 11-13

Mon: Test 3

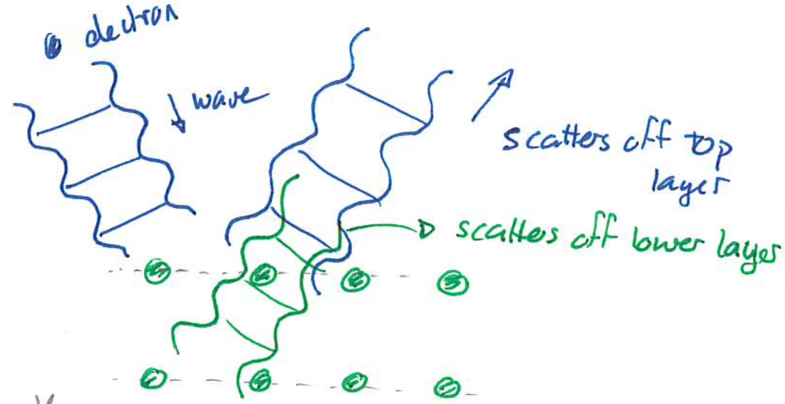
Evidence for wave nature of particles.

Experiments in which particles are fired through barriers and slits can be correctly explained by associating a wave with the particles. Such experiments were first performed in the 1960s. A much earlier set of experiments (1930s) demonstrated the wave behavior of particles. These involved scattering electrons off crystals. These were first performed by Davisson and Germer in the US (1926). This involved firing electrons at a nickel crystal and observing the scattered electrons. Using a classical particle model, we would predict that electrons are scattered randomly at all angles. The actual experiment revealed strong scattering at certain angles and weaker at others.

This could be explained by using a wave model for electrons and considering how it interacts with the atoms in the crystal



A simplified model is illustrated. Waves associated with the electrons will scatter off various layers inside the crystal. These will interfere constructively at some angles and destructively at others.



This process a pattern of highly likely angles and highly unlikely angles. Such patterns are routinely observed.

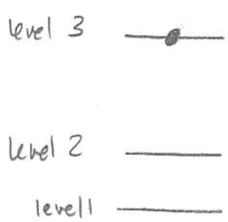
DEMO: * Electron Diffraction N/H

* Wikipedia Electron Microscopy Images

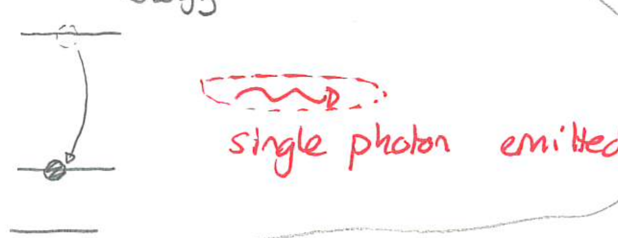
Emission and absorption of electromagnetic radiation by matter

Quantum theory explains how matter can emit radiation.

* Atom/Molecule ... has discrete energy levels



→ Matter changes state + loses energy



Then:

$$\text{energy lost by atom} = \text{energy of photon} = 6.63\times10^{-34} \times \text{frequency light}$$

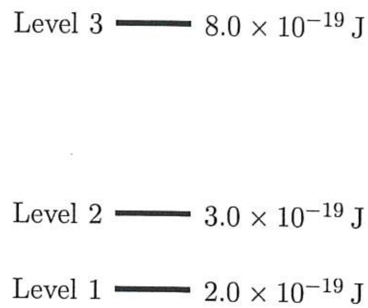
So we can get

$$\text{frequency light} = \frac{\text{energy lost by atom}}{6.63\times10^{-34}\,\text{J}\cdot\text{s}}$$

Quiz 1 80%

1 Emission spectrum

An artificial atom has three energy levels as illustrated.



a) List all possible jumps in energy that the atom could have that result in emission of electromagnetic radiation. For each case, determine the change in atom energy.

b) Determine all possible frequencies of the emitted light.

c) Determine all possible wavelengths of the emitted light.

How many distinct lines will the spectrum contain?

Answer a)

Jump levels	Energy change (lost)
3 → 2	5.0×10^{-19} J
3 → 1	6.0×10^{-19} J
2 → 1	1.0×10^{-19} J

b) For each $\text{frequency} = \dfrac{\text{energy lost}}{6.63 \times 10^{-34}\,\text{J}\cdot\text{s}}$

Jump	
3 → 2	$\text{freq} = \dfrac{5.0 \times 10^{-19}\,\text{J}}{6.63 \times 10^{-34}\,\text{J}\cdot\text{s}} = 7.5 \times 10^{14}\,\text{Hz}$
3 → 1	$\text{freq} = \dfrac{6.0 \times 10^{-19}\,\text{J}}{6.63 \times 10^{-34}\,\text{J}\cdot\text{s}} = 9.1 \times 10^{14}\,\text{Hz}$
2 → 1	$\text{freq} = \dfrac{1.0 \times 10^{-19}\,\text{J}}{6.63 \times 10^{-34}\,\text{J}\cdot\text{s}} = 1.5 \times 10^{14}\,\text{Hz}$

c) $\text{wavelength} = \dfrac{\text{speed light}}{\text{frequency}} = \dfrac{3.0 \times 10^{8}\,\text{m/s}}{\text{freq}}$

3 → 2 wavelength = 3.97×10^{-7} m

3 → 1 wavelength = 3.31×10^{-7} m

2 → 1 wavelength = 1.99×10^{-6} m

There are three!

Such discrete spectra frequently appear in nature

Quiz 2

DEMO: Spectra from JPL

DEMO: Spectrum tubes

- identify H, He.

Similar considerations apply to absorption of electromagnetic radiation. This will be absorbed one photon at a time. It is not possible to absorb a portion of a photon.

Quiz 3