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Title: Dual Nature of Matter and Radiation

DUAL NATURE OF MATTER AND RADIATION

Matter and Wave Duality

Just as electromagnetic radiation shows both wave and particle behavior, de Broglie proposed that matter too should exhibit similar duality to maintain nature's symmetry. Hence, moving particles can display wave-like properties.

De Broglie Concept

De Broglie hypothesized that every moving particle is linked with a wave, called a matter wave or de Broglie wave. Its wavelength is:

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

Where m is the particle's mass, v is velocity, and h is Planck's constant.

For an electron accelerated by a voltage V:

$$\lambda = \frac{12.27 \text{ Å}}{\sqrt{V}}$$

This wave nature was confirmed by experiments: Davisson-Germer (slow electrons) and G.P. Thomson (fast electrons).

Electric Discharge

The flow of current through a gas (electric discharge) requires high voltage, typically around 20,000 V, to initiate visible sparking.

Photoelectric Phenomenon

This effect refers to the emission of electrons from a metal surface when illuminated with light of sufficient frequency. The released electrons are called photoelectrons, and the resulting current is termed photoelectric current.

Key Observations

1. **Intensity Influence:** Higher intensity increases photoelectric current proportionally.
2. **Anode Voltage Influence:** Increasing anode potential enhances current up to saturation.
3. **Frequency and Stopping Potential:** Stopping potential varies linearly with light frequency.
4. **Threshold Frequency (ν_0):** Below this, no photoelectrons are emitted, regardless of intensity.
5. Above ν_0, maximum kinetic energy depends on frequency, not intensity.
6. Photoemission is practically instantaneous.

Einstein's Equation for Photoelectric Effect

$$\frac{1}{2}mv^2 = h\nu - W_0 = h\nu - h\nu_0 = h(\nu - \nu_0)$$

Where:

- ν = incident photon frequency
- ν_0 = threshold frequency
- $W_0 = h\nu_0$ = work function

- v = photoelectron velocity
- m = electron mass

Stopping Potential (V_0)

This is the negative potential at which photoelectric current becomes zero.

$$eV_0 = K.E_{max} = h(\nu - \nu_0)$$

It depends on frequency and the metal, but not on intensity.

Photoelectric Cells

Devices converting light energy into electrical energy. Types include:

1. Photo-emissive cell
2. Photo-voltaic cell
3. Photo-conductive cell