Quantum Technologies - Exam Summary

Planck Hypothesis

EM Radiation is made of quanta with discrete energy levels:

$E = h\nu$ $\quad h$, Planck's constant $= 6.626 \times 10^{-34}$ Joule · Second

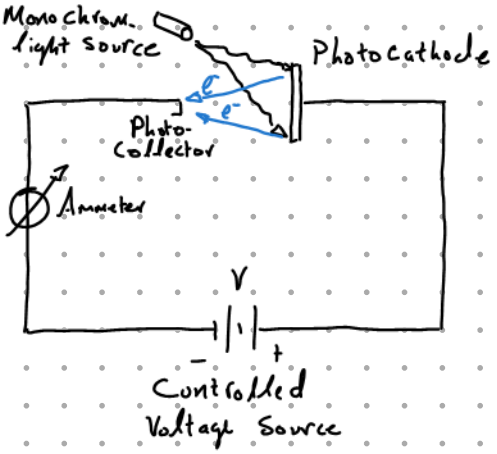
Meaning a beam of these particles has energy: $E_B =$ No. of photons $\times\ h\nu$

The Photoelectric Effect

Light is made of EM particles (photons) which have kinetic energy dependent on their frequency:

$h\nu = E_k + \Phi$

- $h\nu$: Energy of a single photon
- E_k: Kinetic energy of an electron
- Φ: The work function: Potential energy one must overcome



$\Rightarrow E_k = h\nu - \Phi$ $\quad (E_k$ cannot be negative$)$

$\therefore\ h\nu - \Phi \geq 0$

We can define a threshold voltage we must overcome:

$$V_{th} = \frac{\Phi}{h}$$

And to obtain the kinetic energy we measure the voltage at which electrons stop propagating:

$E_k = e \times V_{stop}$

Bohr's Model of the Hydrogen Atom

Electron orbits have a discrete energy level, radius, and velocity. When moving between these discrete energy levels a photon is emitted or absorbed.

Quantised Ang. Momentum, $L_\odot = \hbar n$ → Bohr's Hypothesis

Bohr's Radius, $r_\odot = \frac{\hbar^2}{m\,|e|^2}$ } Radius of the first energy level

Radius of energy level, n } $r_n = r_\odot \cdot n^2$

Linear Velocity of the Orbit $V_n = \alpha \cdot \frac{c}{n}$, $\alpha =$ fine structure $= \frac{1}{137}$

Contrary to classical orbits the electron moves slower the higher the orbit.

Classically:

$\vec{P} = m\vec{V}$ (momentum)

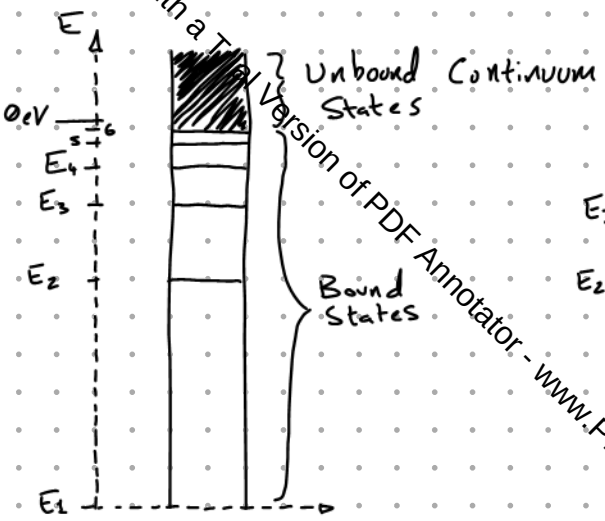
$\vec{L} = m \cdot v \cdot r \cdot \hat{O}$ (Ang. Momentum)

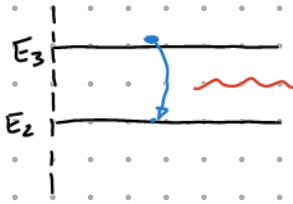
Energy of the qubit $E_n = -\frac{R}{n^2}$

Where R, the Rydberg Constant is:

$R = \frac{|e|^4 \cdot M}{2\hbar^2} = 13.6\ eV$

$(13.6 \times 1.602 \times 10^{-19}\ Joules)$





$E_3 - E_2 = h\nu_{32} = \frac{h \cdot c}{\lambda_{32}}$

$\lambda_{32} = \frac{h\,c}{-\frac{R}{9} + \frac{R}{4}} = \dots$

The Wave-Particle Nature of Matter