Note Title 8/16/2018

Learning Outcome: Identify the fundamental principles of photon optics & quantify photon properties

* Light as electromagnetic waves
  - satisfy Maxwell eqn.
  - represented by wave eqn.

$$\nabla^2 \vec{E} + k^2 \vec{E} = 0 \qquad \nabla^2 \vec{H} + k^2 \vec{H} = 0$$

* For a given structure, only specific field configurations are allowed

⇒ Eigenmodes or Modes of the structure

$$\nabla \cdot \vec{D} = \rho_v$$

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{H} = \vec{J}_c + \frac{\partial \vec{D}}{\partial t}$$

$$\vec{D} = \epsilon \vec{E}$$

$$\vec{B} = \mu \vec{H}$$

For a plane EM wave propagating in +z direction

$$\vec{E} = \left(\hat{a}_x E_x + \hat{a}_y E_y e^{j\phi}\right) e^{-jkz}$$

If $\phi = 0$ ⇒ linear polarization

If $\phi = \pm \pi/2$ ⇒ circular polarization, $E_x = E_y$

Any other ⇒ Elliptical polarization

Photon Optics

$E = h\nu$

$= \frac{hc}{\lambda}$

$h = 6.63 \times 10^{-34}$ J-s

$c = 3 \times 10^{8}$ m/s

$1eV = 1.602 \times 10^{-19}$ J

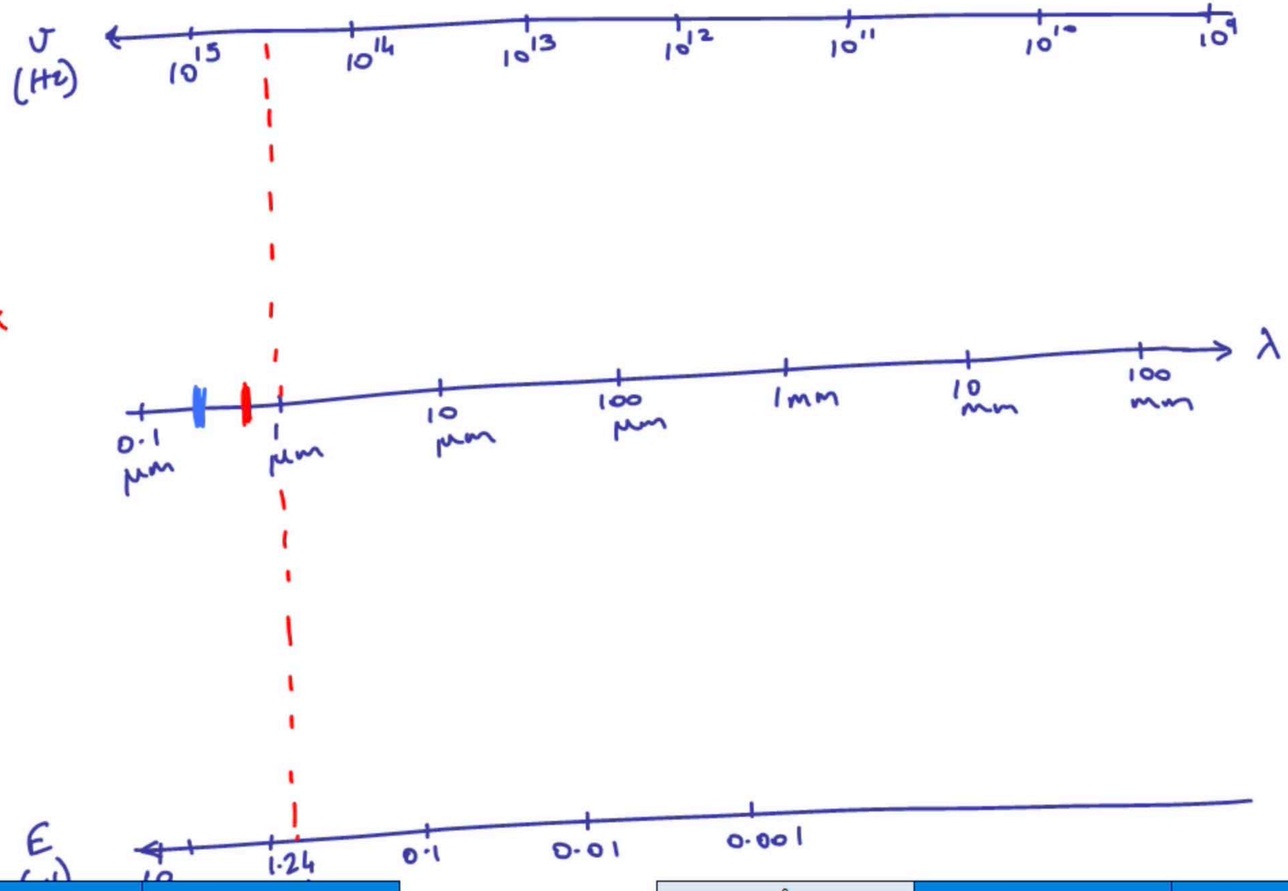
Wavelength (μm), $\lambda = \frac{1.24}{E(eV)}$

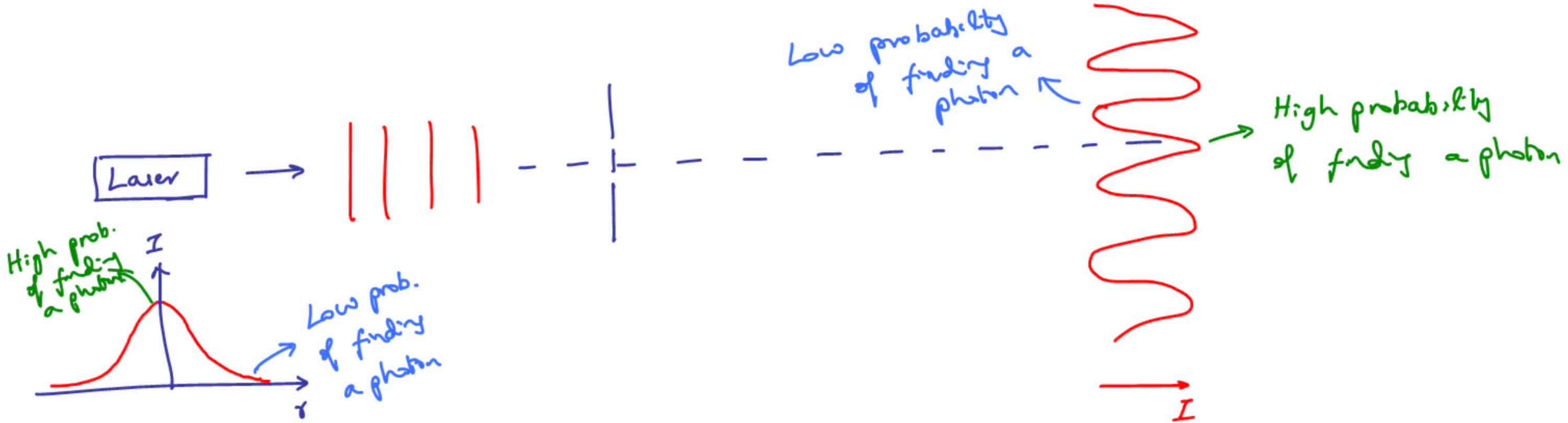
Photons have zero rest mass

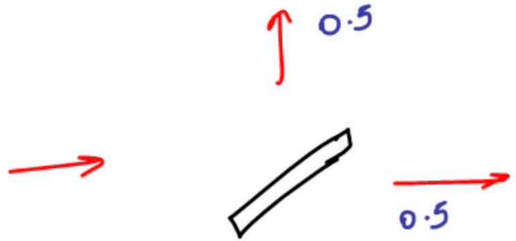
Photon momentum, $p = \frac{E}{c} = \frac{h}{\lambda} = \hbar k$ ($\hbar = h/2\pi$)

Photon probability

$p(r)\,dA \propto I(r)\,dA$

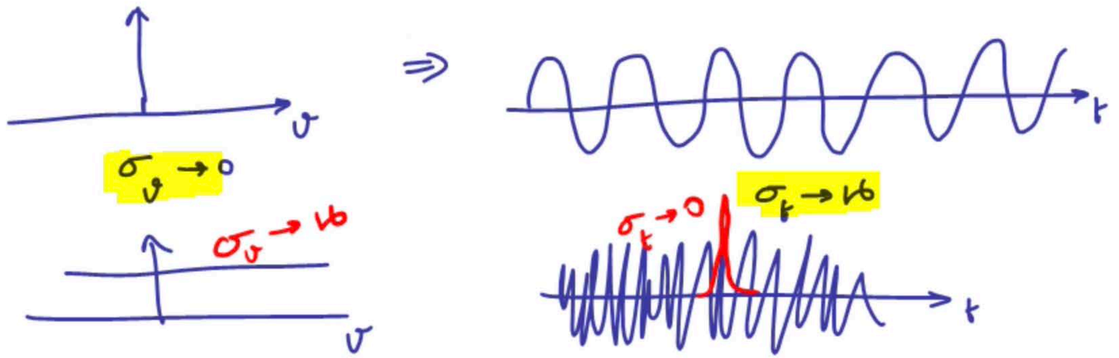




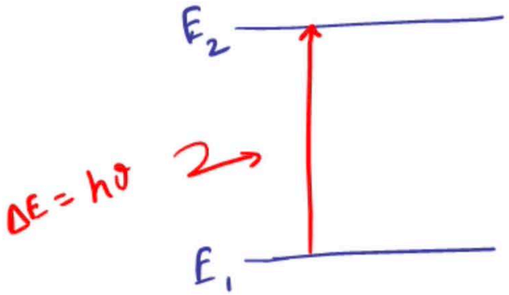


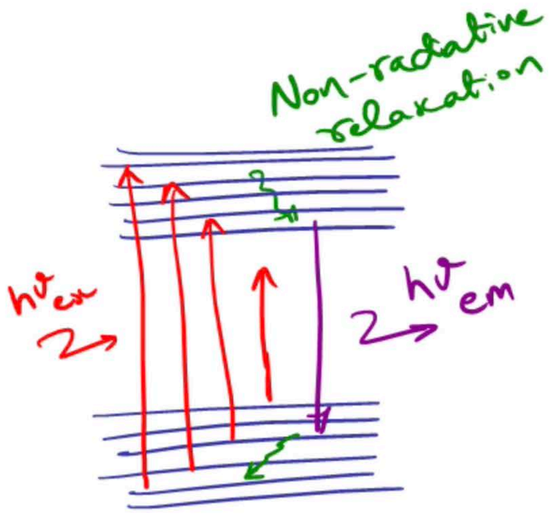
Photon uncertainty

$$\sigma_E \cdot \sigma_t \geq \frac{\hbar}{2}$$

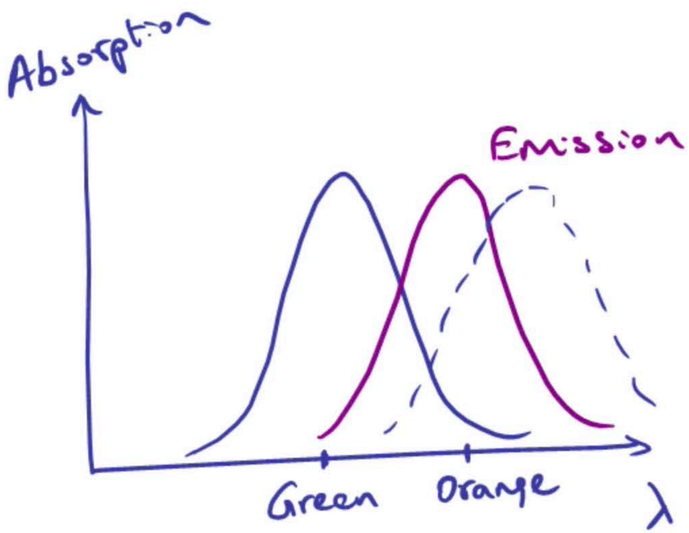


Photon Absorption:





$\nu_{ex} > \nu_{em}$



Rhodamine 6G

Photon Polarization:

Colour Filters

Photon spin → LCP, RCP

⇒ Spin angular momentum

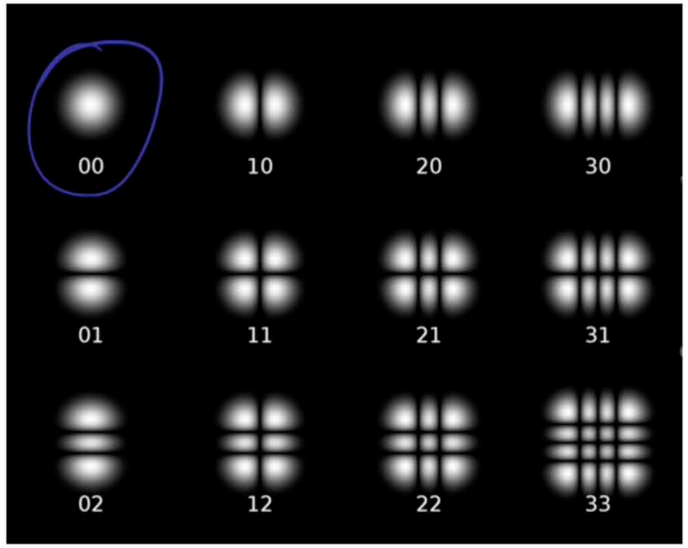
$s = \pm \hbar$

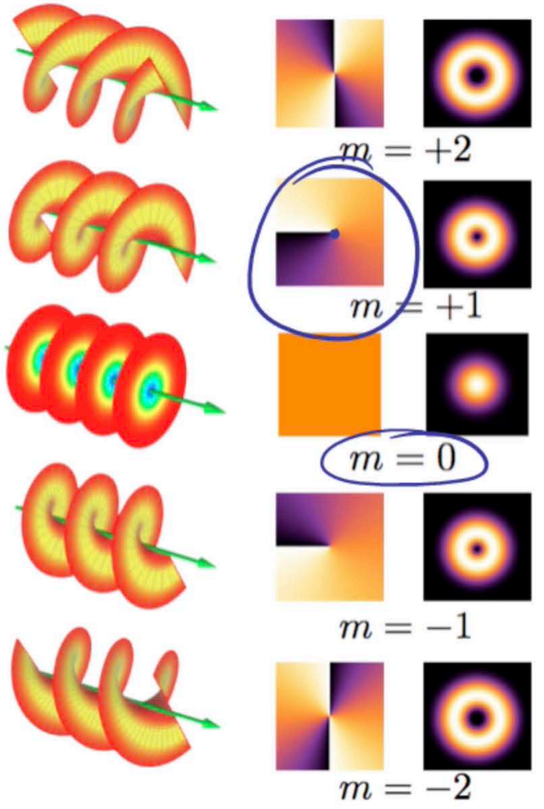
Orbital angular momentum, $L = l\hbar$ $l \rightarrow$ charge

$$\nabla^2 \vec{E} + k^2 \vec{E} = 0$$

Cartesian

Cylindrical





$$\nabla^2 \vec{E} + k^2 \vec{E} = 0$$

Cartesian → Hermite – Gaussian

Cylindrical → Laguarre Gaussian