Photonics

Lecture 3

Scattering of Light

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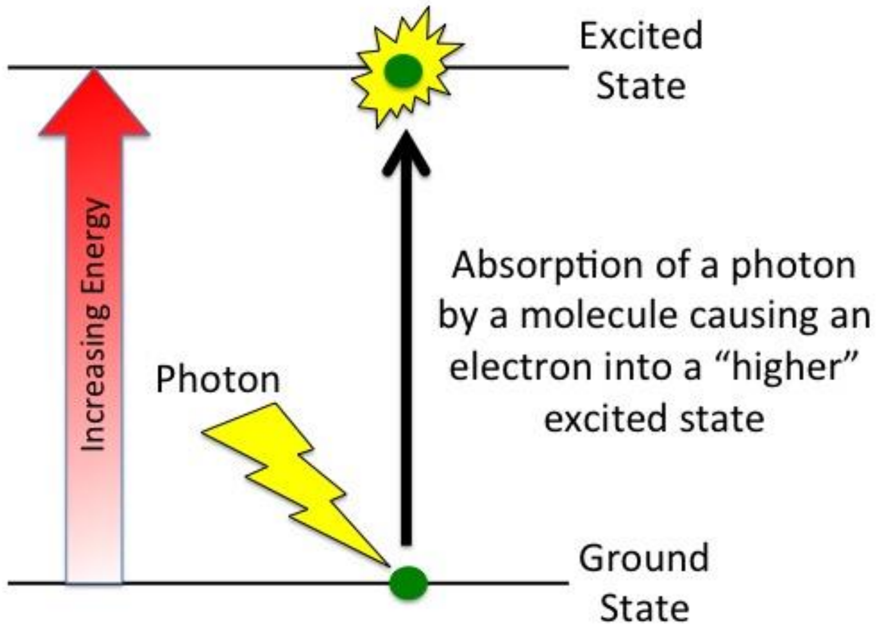
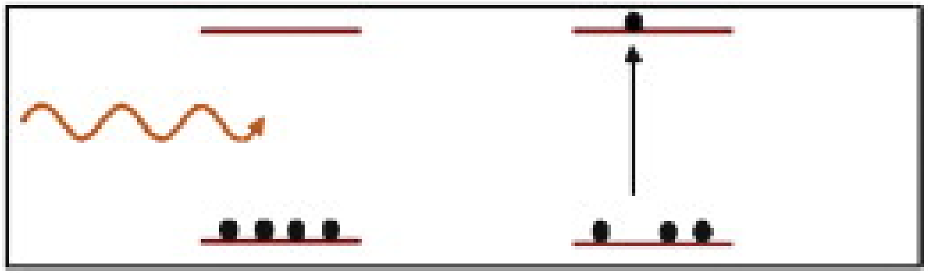
Absorption of light

Absorption of light takes place when matter captures electromagnetic radiation, converting the energy of photons to internal energy.

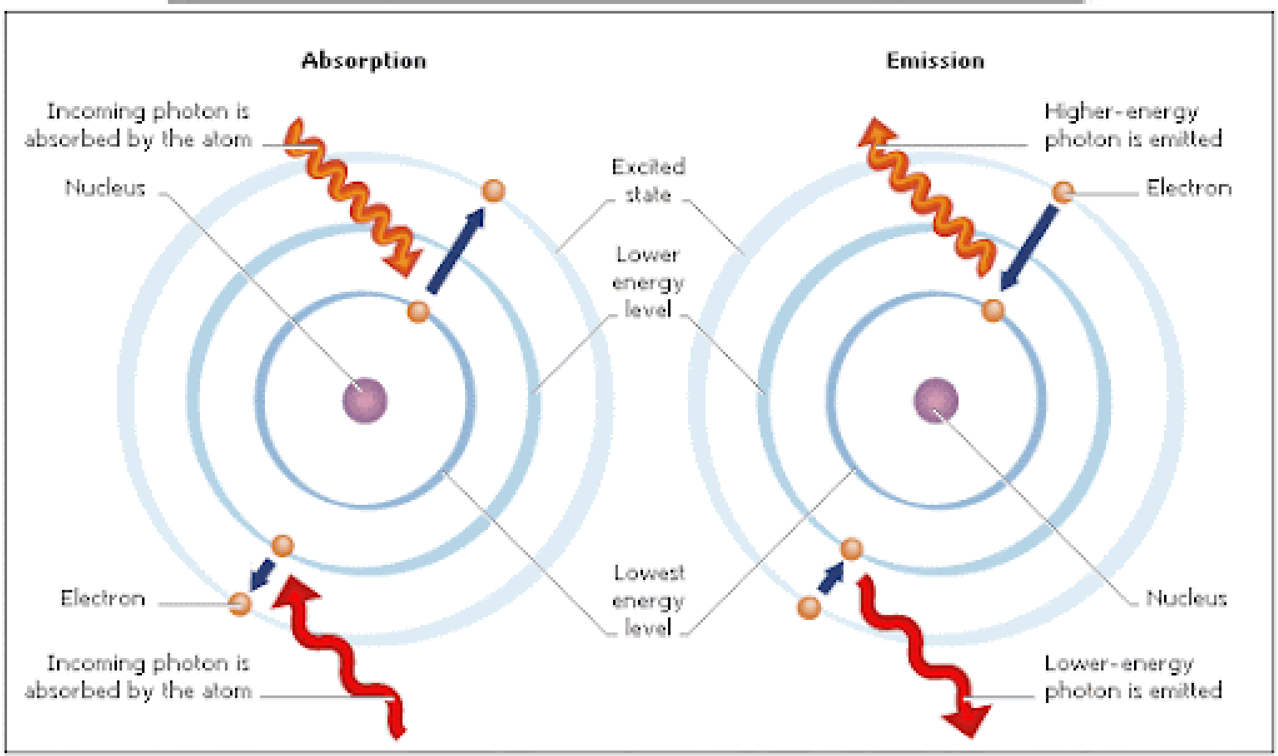


The Effect of Light Absorption on Matter

Since the energy levels of matter are quantized, only light of energy that can cause transitions from one existing energy level to another will be absorbed.

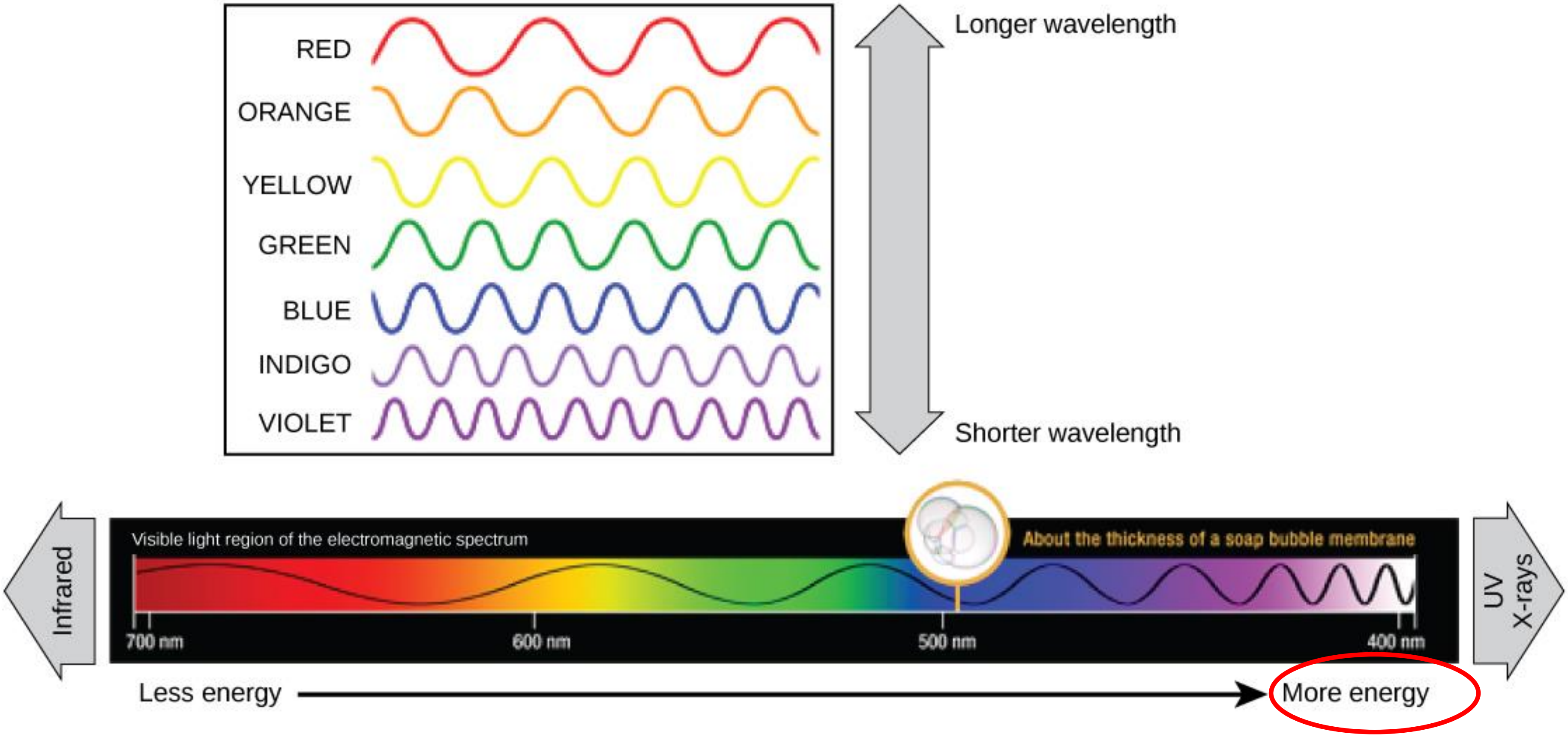


Absorption



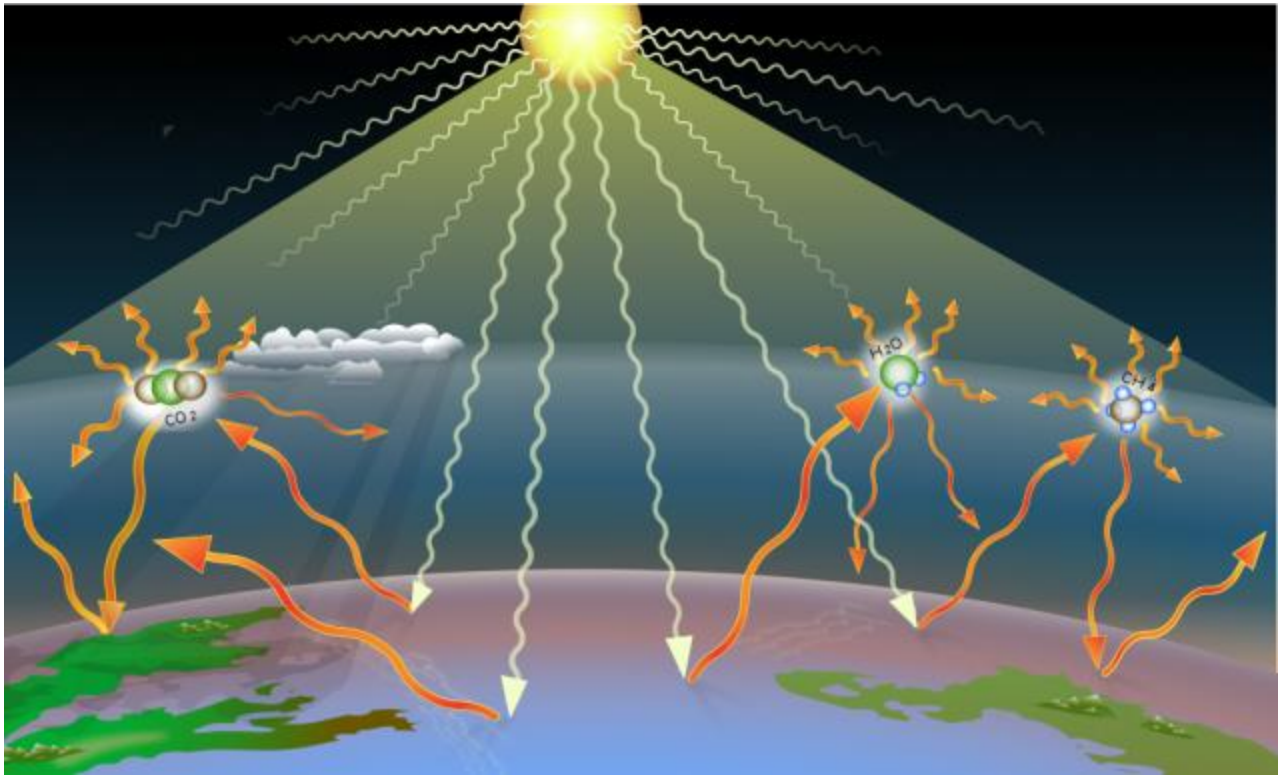
The Effect of Light Wavelength

The amount of energy carried by a light photon depends on its wavelength. The shorter the wavelength, the higher the energy



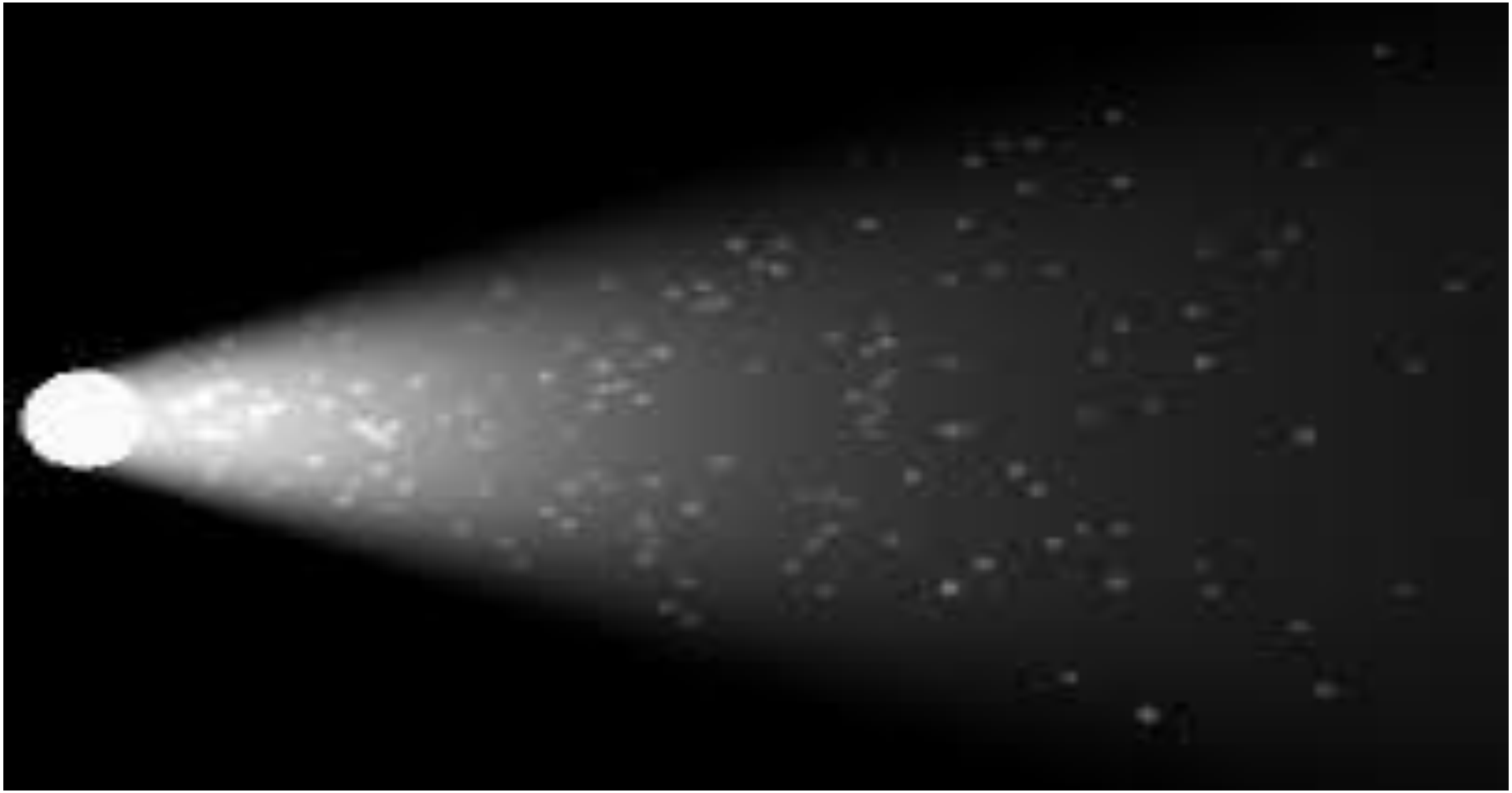
Scattering of Light

When sunlight enters the atmosphere of the earth, the atoms and molecules of different gasses present in the air absorb the light. Then these atoms re-emit light in all directions. This process is known as the Scattering of light.



This phenomenon is easily observed from everyday experiences. For example, a shaft of sunlight illuminating an otherwise darkened room is an example.

The light beam (or shaft of light) is clearly visible via the dust or smoke particles that scatter the light. Depending on the level of dust in a movie hall, one can see the path of the light from the projector, again due to dust scattering it.



How would one distinguish scattering from absorption of light?

the absorbed light is invariably converted into heat energy by the absorbing molecules, and, the absorbed photons are lost forever. In the case of scattered light, the photons are redirected and removed from the beam.

$$I = I_0 e^{-(\alpha_a + \alpha_s)x}$$

where αa is the absorption coefficient and αs is the scattering coefficient. We must know the contributions from absorption and scattering. In some cases, absorption is more significant than scattering (i.e. αa >> αs); in other cases, absorption may be small compared to scattering (i.e. αa << αs). In the previous section, we assumed the former case to be true in order to solve problems.

Example

A 25 cm long glass tube is filled with smoke particles. An incident beam of light of irradiance 10 mW/cm2 strikes the tube at one end and 6.43 mW/cm2 is measured as the irradiance of the transmitted beam. What is (a) scattering coefficient.

The general equation that applies for combined absorption and scattering is

$$I = I_0 e^{-(\alpha_a + \alpha_s)x}$$

or

$$\alpha_a + \alpha_s = \frac{1}{x} \ln[I_0 / I]$$

We will solve for part (c) of the problem first, using this equation, as

$$\alpha_a + \alpha_s = \frac{1}{25} \ln[10/6.43]$$

$$= \mathbf{0.0177\ cm^{-1}}$$ **Answer**