10.1 Optics in different regimes

- The electromagnetic spectrum

Radiobroadcasts ($\lambda \sim 100$ m), microwaves ($\lambda \sim$ mm), visible ($\lambda \sim 500$ nm), x-ray ($\lambda \sim 1$ nm), gamma-rays ($\lambda < 10^{-3}$ nm)

From: http://science.hq.nasa.gov/kids/imagers/ems/waves3.html
Classification of the optical regimes according to the detection systems

1. Geometrical optics
   a) The wavelengths $\lambda$ involved are small compared with the dimensions $d_{\text{apparatus}}$ of the apparatus involved: $\lambda \ll d_{\text{apparatus}}$.
   b) The photon energies $h\nu$ are small compared with the coarse energy sensitivity $\Delta E$ of the apparatus $h\nu \ll \Delta E_{\text{apparatus}}$.

Under these approximations we can make rough approximation by a method called geometrical optics, which practically omits the wave character of the electromagnetic radiation. That is $\lambda$ is considered practically equal to zero, $\lambda/d \to 0$.

Within this Geometrical Optics regime approximation, Light travels out of its source along straight lines or rays
Ray path along which light energy is transmitted from one point to another in an optical system.

2. Classical theory of electromagnetic radiation
   a) The wavelengths $\lambda \sim d_{\text{apparatus}}$
      (A bit difficult to do it with visible light, but easier to implement with microwaves)
b) The photon energies $h\nu$ are still small compared with the energy sensitivity $\Delta E$ of the apparatus ($h\nu \ll \Delta E_{\text{apparatus}}$).

In this case, a very useful approximation can be made considering wave theories, while still disregarding the quantum mechanics character of light. This is the realm of the classical theory of electromagnetic radiation.

3. Photon picture

a) For very short wavelengths (right side of the spectrum shown above) $\lambda \ll d_{\text{apparatus}}$

b) The photon energies $h\nu$ are large compared with the energy sensitivity $\Delta E$ of the apparatus ($h\nu \gg \Delta E_{\text{apparatus}}$).

This regime constitutes the realm of the photon picture of the light.