

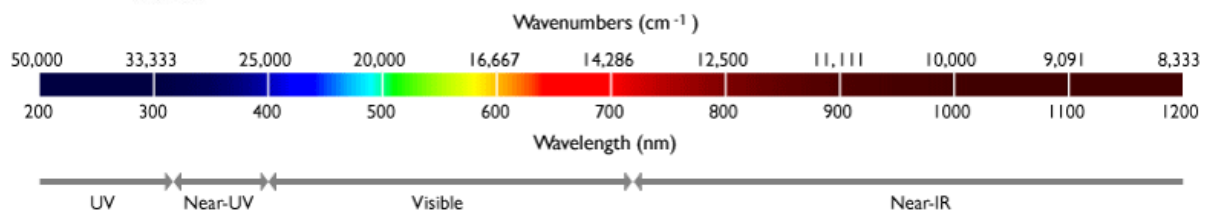


Technical Information:

Measuring Light with Wavelengths and Wavenumbers

The “color” of light is generally identified by the distribution of power or intensity as a function of wavelength λ . For example, visible light has a wavelength that ranges from about 400 nm to just over 700 nm. However, sometimes it is convenient to describe light in terms of units called “wavenumbers,” where the wavenumber w is typically measured in units of cm^{-1} (“inverse centimeters”) and is simply equal to the inverse of the wavelength:

$$w(\text{cm}^{-1}) = \frac{10^7}{\lambda(\text{nm})}$$



In applications like Raman spectroscopy, often both wavelength and wavenumber units are used together, leading to potential confusion. For example, laser lines are generally identified by wavelength, but the separation of a particular Raman line from the laser line is generally given by a “wavenumber shift” Δw , since this quantity is fixed by the molecular properties of the material and independent of which laser wavelength is used to excite the line.

When speaking of a “shift” from a first known wavelength λ_1 to a second known wavelength λ_2 , the resulting wavelength shift $\Delta\lambda$ is given by

$$\Delta\lambda = \lambda_2 - \lambda_1$$

whereas the resulting wavenumber shift Δw is given by

$$\Delta w = \left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right) \times 10^7 = - \frac{\Delta\lambda}{\lambda_1 \lambda_2} \times 10^7$$

When speaking of a known wavenumber shift Δw from a first known wavelength λ_1 , the resulting second wavelength λ_2 is given by

$$\lambda_2 = \frac{1}{1/\lambda_1 + \Delta w \times 10^{-7}}$$

Note that when the final wavelength λ_2 is longer than the initial wavelength λ_1 , which corresponds to a “red shift,” in the above equations $\Delta w < 0$, consistent with a shift toward smaller values of w . However, when the final wavelength λ_2 is shorter than the initial wavelength λ_1 , which corresponds to a “blue shift,” $\Delta w > 0$, consistent with a shift toward larger values of w .