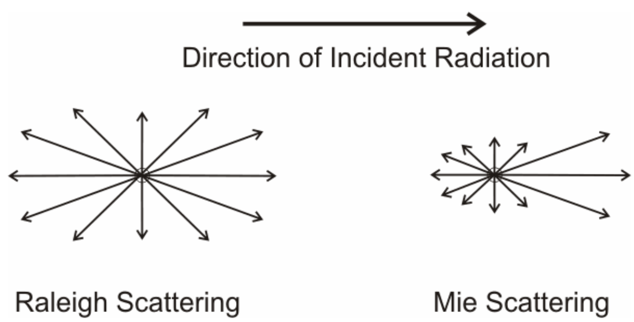
Rayleigh, Mie, and Optical Scattering

Note: There is a good explanation of Raleigh, Mie, and Optical scattering on the web at: http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/blusky.html.

Raleigh scattering occurs when the dimensions of the scatter is much smaller than the wavelength of the incident electromagnetic radiation. An example is when S-band radar waves are scattered by raindrops. Raleigh scattering exhibits a strong wavelength dependence. Mie scattering occurs when the dimensions of the scattered is much larger than the wavelength of the incident electromagnetic radiation. An example is when light is scattered by small water droplets in clouds.



The intensity of the scattered radiation for Raleigh scattering is

$$I = I_0 \frac{\left(1+\cos^2 q\right)}{2R^2}\left(\frac{2p}{l}\right)^4\left(\frac{n^2-1}{n^2+2}\right)^2\left(\frac{D}{2}\right)^6$$

Where n is the refractive indeed of the material, D is the diameter, and l is the wavelength, and q is the scattering angle. Note that the forward scatter equals the backscatters and at $q = 90^o$ scattering is half of the forward/back scatter. Integrating over a sphere surrounding the particle gives the Raleigh scattering cross section:

$$s = \frac{2p^5}{3}\frac{D^6}{l^4}\left(\frac{n^2-1}{n^2+2}\right)^2$$

Question: what are the units?

Note the strong dependence on wavelength and even stronger dependence on particle diameter.

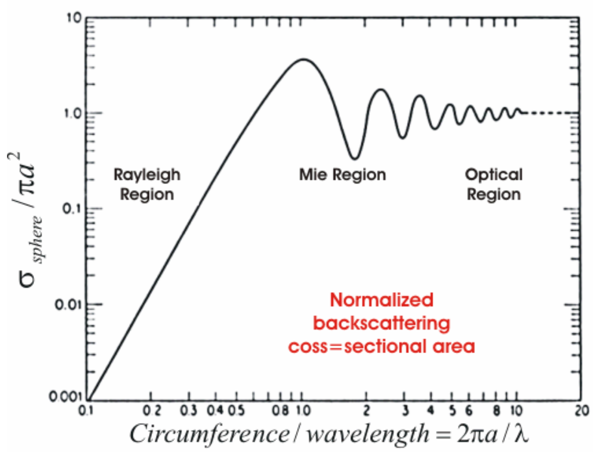


Figure 4.2 Normalized backscattering cross-sectional area of a sphere as a function of circumference normalized by radar wavelength λ. a = radius. From Skolnik, 1980, Introduction to Radar Systems, with permission of McGraw-Hill, Inc.

Back scatter from raindrop

$$s = \frac{p^5 |k|^2 D^6}{l^4}$$

Where $|k|^2$ is a parameter related to the complex index of refraction of the material. For water it is normally taken as 0.93, and for ice 0.197.

Radar reflectivity ($m^2\ m^{-3}$):

$$h = \sum_{Unit\ Volume} s_i = \frac{p^5 |k|^2}{l^4} \sum D^6 = \frac{p^5 |k|^2}{l^4} z$$

$$\boxed{h = \frac{p^5 |k|^2}{l^4} z}$$

Radar reflectivity factor (m^3)

$$\boxed{z = \sum_{Unit\ Volume} D^6}$$

Why do we need two factors?