Electromagnetic (EM) waves are one of the best known and most commonly encountered forms of radiation that undergo scattering. Scattering of light and radio waves (especially in radar) is particularly important. Several different aspects of electromagnetic scattering are distinct enough to have conventional names. Major forms of elastic light scattering (involving negligible energy transfer) are Rayleigh scattering and Mie scattering. Inelastic EM scattering effects include Brillouin scattering, Raman scattering, and Compton scattering.

Light scattering is one of the two major physical processes that contribute to the visible appearance of most objects, the other being absorption. Surfaces described as *white* owe their appearance almost completely to the scattering of light by the surface of the object. The absence of surface scattering leads to a shiny or glossy appearance. Light scattering can also give color to some objects, usually shades of blue (as with the sky, the human iris, and the feathers of some birds), but resonant light scattering in nanoparticles can produce different highly saturated and vibrant hues, especially when surface plasmon resonance is involved.

Rayleigh scattering is a process in which electromagnetic radiation (including light) is scattered by a small spherical volume of variant refractive index, such as a particle, bubble, droplet, or even a density fluctuation. This effect was first modeled successfully by Lord Rayleigh, from whom it gets its name. In order for Rayleigh's model to apply, the sphere must be much smaller in diameter than the wavelength (λ) of the scattered wave; typically the upper limit is taken to be about 1/10 the wavelength. In this size regime, the exact shape of the scattering center is usually not very significant and can often be treated as a sphere of equivalent volume. The inherent scattering that radiation undergoes passing through a pure gas is due to microscopic density fluctuations as the gas molecules move around, which are normally small enough in scale for Rayleigh's model to apply. This scattering mechanism is the primary cause of the blue color of the Earth's sky on a clear day, as the shorter blue wavelengths of sunlight passing overhead are more strongly scattered than the longer red wavelengths according to Rayleigh's famous $1/\lambda^4$ relation. Along with absorption, such scattering is a major cause of the attenuation of radiation by the atmosphere. The degree of scattering varies as a function of the ratio of the particle diameter to the wavelength of the radiation, along with many other factors including polarization, angle, and coherence.

For larger diameters, the problem of electromagnetic scattering by spheres was first solved by Gustav Mie, and scattering by spheres larger than the Rayleigh range is therefore usually known as Mie scattering. In the Mie regime, the shape of the scattering center becomes much more significant and the theory only applies well to spheres and, with some modification, spheroids and ellipsoids. Closed-form solutions for scattering by certain other simple shapes exist, but no general closed-form solution is known for arbitrary shapes.

Both Mie and Rayleigh scattering are considered elastic scattering processes, in which the energy (and thus wavelength and frequency) of the light is not substantially changed. However, electromagnetic radiation scattered by moving scattering centers does undergo a Doppler shift, which can be detected and used to measure the velocity of the scattering center/s in forms of techniques such as LIDAR and radar. This shift involves a slight change in energy.

At values of the ratio of particle diameter to wavelength more than about 10, the laws of geometric optics are mostly sufficient to describe the interaction of light with the particle, and at this point the interaction is not usually described as scattering.

For modeling of scattering in cases where the Rayleigh and Mie models do not apply such as irregularly shaped particles, there are many numerical methods that can be used. The most common are finite-element methods which solve Maxwell's equations to find the distribution of the scattered electromagnetic field. Sophisticated software packages exist which allow the user to specify the refractive index or indices of the scattering feature in space, creating a 2- or sometimes 3-dimensional model of the structure. For relatively large and complex structures, these models usually require substantial execution times on a computer.

Rayleigh

Rayleigh is elastic scattering from small particles such as atoms or molecules, resulting in scattered radiation that occurs in all directions uniformly. Rayleigh scattering is wavelength

dependent with shorter wavelengths being more scattered. It is Raleigh scattering from molecules in the atmosphere which gives rise to the blue sky we see on a fine day. The blue light from the sun striking the upper atmosphere is scattered approximately 10 times more than red light so overhead the blue light is scattered into the eye of an observer while the red light goes largely unscattered and back out into space.

Debye or Mie

Debye or Mie is an elastic scattering mechanism which occurs from relatively large particles or molecules with dimensions comparable with the wavelength of the incident radiation or larger and the resulting scattered radiation is non-uniform. The effect is not very wavelength dependent. This process gives rise to the white scattered light seen in clouds or fog.