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Rayleigh Scattering

Why is the sky blue? This question has probably pervaded the minds of human beings since the dawn of mankind, but the true scientific explanation has only been understood in more recent history. The short answer is a phenomenon called Rayleigh Scattering which is named after the man who first described it: English Physicist Lord John Rayleigh. Before going into too much detail however, we must first explore the work of someone else...

In the 1860's English Physicist John Tyndall (1820-1893) worked on disproving the spontaneous generation of life theory through a process of sterilizing known as Tyndallization. He was trying to show that bacteria in the air was the source of mold growth, and for his experiments he wanted to compare boiled meat broth in two groups: one which was exposed to room air and another that was exposed to pure air.

His method for producing pure air was to coat the inside of a box with glycerin to cause any particles to settle and stick to the sides. In order to check the level of particles still floating around inside, he would shine a powerful light through a hole cut into the side. Any dust or other particulates would sparkle, letting him know that the air was still impure. While this happened, he observed that the light that scattered off of the air particles was mostly blue tinted whereas the light that passed through was mostly red tinted. He described the light scattering off of particles in such colloidal suspension as Tyndall scattering, and in 1869 applied this idea to explain how it affected the color of the sky and sunset.

Rayleigh expanded upon these ideas and in 1871 published "On the light from the sky, its polarization and colour" and "On the scattering of light by small particles" which provided a mathematical expression to describe the phenomenon.

When an electromagnetic wave interacts with a small particle, the oscillating electric field creates an oscillating dipole when the electrons are moved back and forth. The oscillating dipole radiates at the same frequency as the incident radiation, which causes scattering. The main difference between Tyndall Scattering and Rayleigh Scattering is that the latter accounts for light scattering particles which are smaller than the wavelength of light. Atmospheric molecules in air such as Oxygen, Carbon Dioxide, and atoms such as Nitrogen are all smaller than 40nm and behave differently than particles colloidal suspension.

To account for this, Rayleigh balanced the exponents on both sides of Tyndall's equation and derived an inverse fourth power dependence on scattered light to incidence wavelength. He also published other papers on this phenomenon where he "derived the expression for the incident wavelength, the intensity and degree of polarization of the scattered light as a function of wavelength, angle and refractive index of the scattering particles."

Since the scattering intensity of the wavelength is proportional to &lambda; <sup>-4</sup>, a wavelength at 400nm (blue light) is scattered a factor of ~7 times as efficient as a wavelength of 650nm (red light) The sky therefore appears to be blue on Earth because blue light is scattered more efficiently than red light in our atmosphere.