THE FOUR LAWS OF RADIATION

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In order to best make use of the of information that comes to us via the electromagnetic spectrum, we need to understand some basic properties of radiation. For electromagnetic radiation, there are four "laws" that describe the type and amount of energy being emitted by an object.

Planck's Law

Planck's Law states that every object emits radiation at all times and at all wavelengths. In 1900, Max Planck postulated that the electromagnetic energy is emitted not continuously (like by vibrating oscillators), but by discrete portions or quantum. This law governs the intensity of radiation emitted by unit surface area into a fixed direction (solid angle) from the blackbody as a function of wavelength for a fixed temperature. This law can be expressed through the following equation:

$$E(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$

where k is the Boltzmann constant, h the Planck constant, and c the speed of light in the medium, whether material or vacuum.

Wein's Law

Wien's law, also called Wien's displacement law, relationship between the temperature of a blackbody (an ideal substance that emits and absorbs all frequencies of light) and the wavelength at which it emits the most light. Wein's Law states that the wavelength of peak emission is inversely proportional to the temperature of the emitting object.

Wien's Law tells us that objects of different temperature emit spectra that peak at different wavelengths. Therefore, hotter objects emit most of their radiation at shorter wavelengths; hence they will appear to be bluer and cooler objects emit most of their radiation at longer wavelengths; hence they will appear to be redder.

Formally, Wien's displacement law states that the spectral radiance of black body radiation per unit wavelength, peaks at the wavelength λmax given by:

$$\lambda_{\max} = \frac{2.8983 \times 10^{-3} K^{\circ} m}{T}$$

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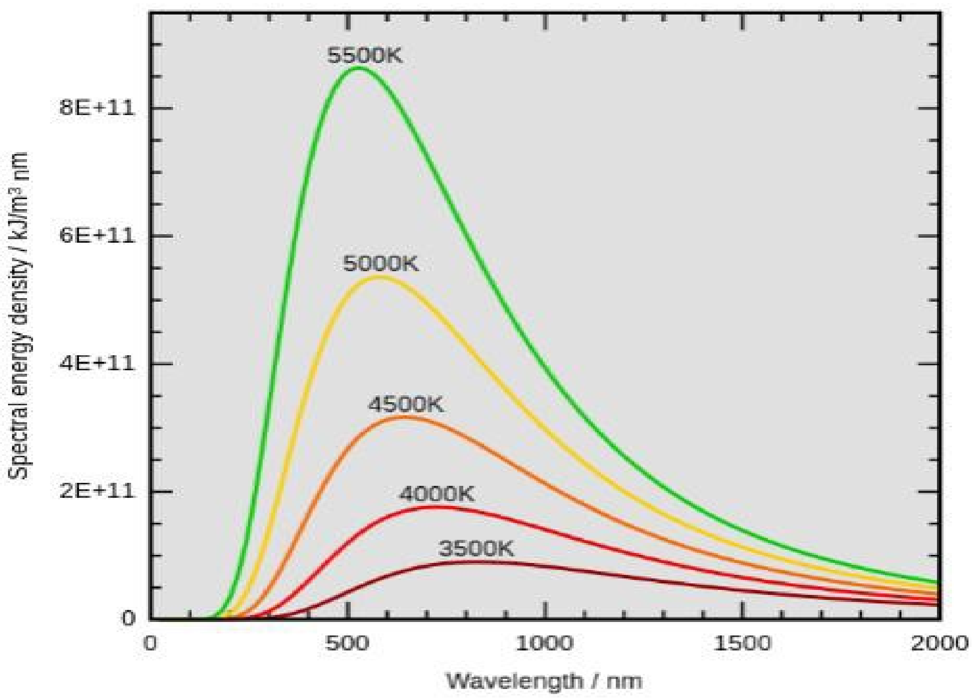

Stefan–Boltzmann Law

Stefan–Boltzmann law, states that the total radiant heat energy emitted from a surface is proportional to the fourth power of its absolute temperature. Therefore, if E is the radiant heat energy emitted from a unit area in one second and T is the absolute temperature (in degrees Kelvin),

then $E = \sigma T^4$

Here, the Greek letter sigma (σ) representing the constant of proportionality, called the Stefan–Boltzmann constant. This constant has the value 5.6704 × 10−8 watt per m2K4.

Kirchhoff's Laws

Kirchhoff's Law states that for an object whose temperature is not changing, an object that absorbs radiation well at a particular wavelength will also emit radiation well at that wavelength. The implication of Kirchhoff's law can be explained as if we want to measure a particular constituent in the atmosphere (water vapour for example), we need to choose a wavelength that is emitted well by water vapour (otherwise we wouldn't detect it). However, since water vapour readily emits at our chosen wavelength, it also readily absorbs radiation at this wavelength -- which is going to cause some problems measurement-wise.