Advanced Topic: Blackbody Radiation

The classical theory of physics predicted that the power given off by a blackbody would be infinite. Thus, this prediction of classical physics, known as Rayleigh's law, was absolutely unable to describe the distribution of light from a blackbody. Planck examined the experimentally known blackbody curve that described the frequency dependence of the intensity of the radiation and empirically determined the form of the equation that fit the data. Then, in 1900, he found a simple derivation for the equation that involved the peculiar assumption that the energy levels of the blackbody that give off the radiation can only occur in discrete and equally spaced intervals. In other words, these energy levels were not continuous, but instead were quantized. His was the first correctly determined quantum mechanical formula and it gave birth to quantum mechanics and led to the demise of classical mechanics.

According to Planck's formula:

1. A blackbody at any temperature emits some radiation at all wavelengths, but not in equal amounts.
2. A hotter blackbody emits more radiation per unit area at all wavelengths than does a cooler blackbody.
3. A hotter blackbody emits the largest proportion of its energy at shorter wavelengths than a cooler blackbody does. This can be described quantitatively by Wien's law, which states that the wavelength at which a blackbody emits its maximum amount of radiation, λ_{max} times the temperature equals a constant or

$$\lambda_{max}T = 2.90 \times 10^{-3} \text{ m-K.} \quad (11)$$

These ideas are schematically shown in Fig. 1.

Note that for a typical filament that operates at a temperature of 3000K, the maximum amount of radiation is emitted at a wavelength of 9.7×10^{-7} m or nearly 1 micrometer, which is in the infrared regime. Thus, most of the light emitted by the filament is in the infrared, not the visible wavelengths.