THE BLACKBODY PROBLEM

Based on our observations of heated objects we all know that they emit light when heated.

Ex. Red glow on an electric burner on a stove

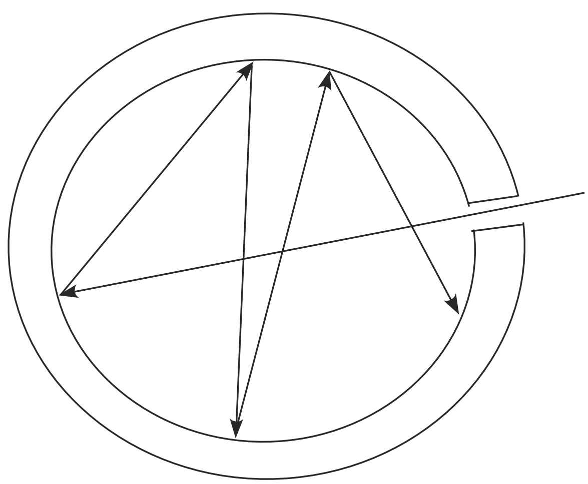
Ex. Bright white light from the tugsten wire in a light bulb.

The result is that the spectrum of light, and thus the wavelength, given off at a particular temperature is approximately the same for any object.

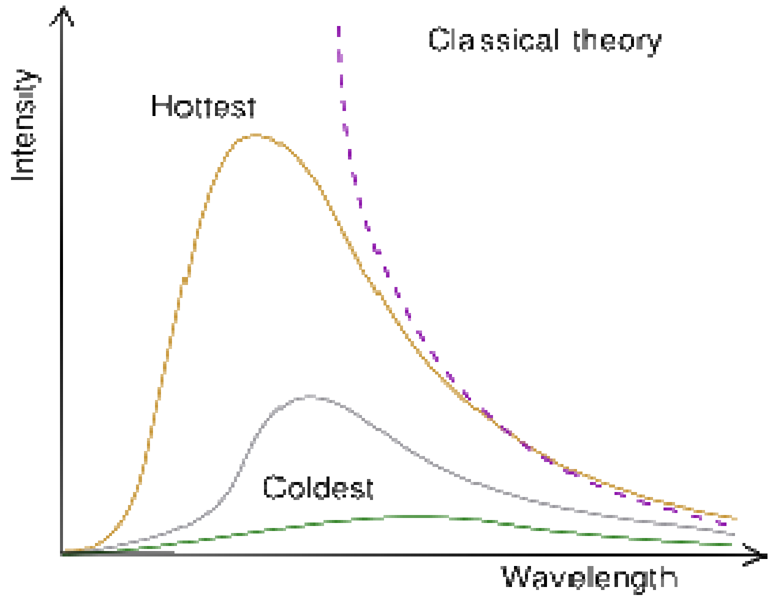
Quantum Physics began with the "BlackBody Problem".

Black Body Problem - To predict the radiation intensity at a given wavelength emitted at a specific temperature from a heated cavity (blackbody).

An object that absorbs all the radiation incident upon it is called a blackbody. A blackbody is a perfect observer and also an ideal radiator. A small opening to the cavity inside a body is a good approximation to a blackbody. Radiation entering the cavity has little chance of leaving the cavity before it is all absorbed. The radiation emitted through the hole is therefore characteristic of the temperature of the walls of the cavity.



Alternatively, the "blackbody" problem was to determine the mathematical function that would describe the experimental curve shown below.



There were several attempts in trying to solve the “blackbody” problem - To predict the radiation intensity at a given wavelength emitted at a specific temperature from a heated cavity (blackbody).

1. Stefan’s Law

$$e_{total} = \int_0^\infty e_f \, df = \sigma T^4$$

2. Wien’s Displacement Law

$$\lambda_{\max} T = 2.898x10^{-3} m \bullet K$$

3. Rayleigh-Jeans Law

$$I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$$

4. Plank’s Equation

$$u(f, T) = \frac{8\pi h f^3}{c^3}\left(\frac{1}{e^{\frac{hf}{k_B T}} - 1}\right)$$

In deriving the “blackbody” equation Max Plank made two “bold” assumptions concerning the nature of the oscillating molecules at the surface of the blackbody:

1. The molecules (resonators) can only have discrete values of energy given by:

$$\boxed{E = nhf} \qquad n = 1, 2, 3, \ldots$$

h = Plank’s constant = 6.626×10^{-34} J.s
n = positive integer called a quantum number
f = frequency of oscillation of the molecules

2. A molecule (resonator) can change its energy only by the difference ΔE:

$$\boxed{\Delta E = hf}$$

That is, a molecule cannot loose any fraction of its total energy!

- These 2 assumptions were the bold and radical ideas that Max Plank used to derive the blackbody problem.
- These assumptions contradicted Classical E&M because according to Classical E&M an oscillator can have any value of energy and loose any fraction of its energy.