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## 6 The Ultraviolet Catastrophe

Rayleigh-Jeans law agrees well with the [exper]imental results at low frequencies but near the [max]imum in the spectrum and at higher frequencies it is [v]iolent disagreement (Fig. 8.9).

According to this law the energy density will be

$$E_\lambda \, d\lambda = \frac{8\pi kT}{\lambda^4} d\lambda$$

or

$$dE = \frac{8\pi kT}{c^4} \times \nu^4 \times \frac{c}{\nu^2} d\nu$$

$$\left(\because \lambda = \frac{c}{\nu}, d\lambda = \frac{c}{\nu^2} d\nu\right)$$

$$dE = \frac{8\pi \nu^2 kT \, d\nu}{c^3}$$

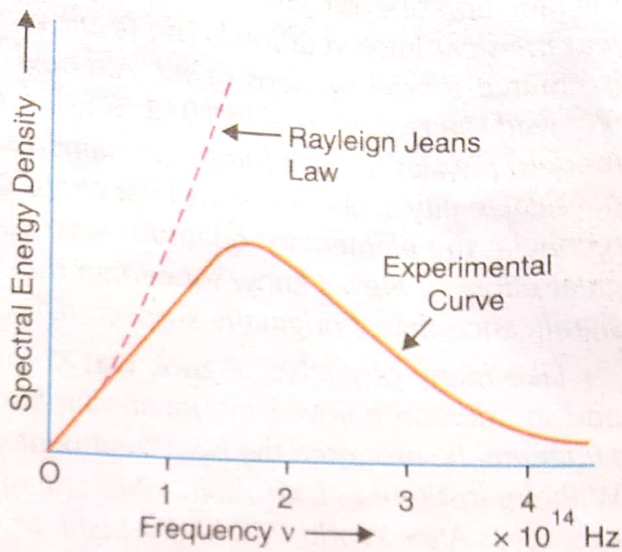



Fig. 8.9

The energy density will continuously increase with increase in frequency $\nu$ and approaches $\infty$ [wh]en $\nu \to \infty$.

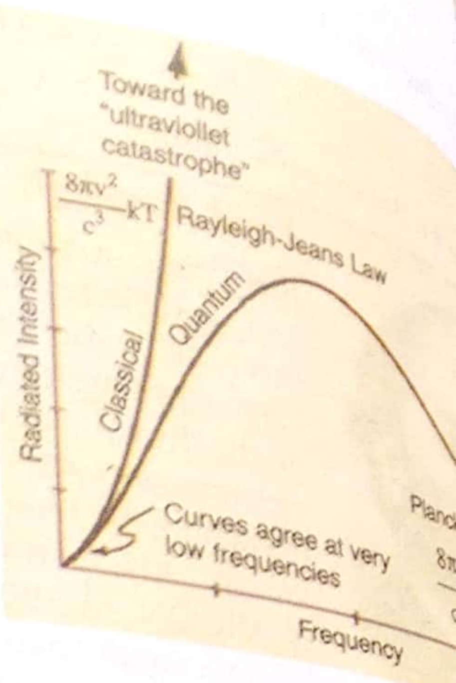
This is in contradiction to observed results. This fatal objection to the law has been known as [ult]raviolet catastrophe.

Further, at any temperature $T$, the total energy of radiation,

$$E = \int_0^\infty \frac{8\pi \nu^2 kT \, d\nu}{c^3}$$

is predicted to be infinite which is against the Stefan's law.

Figure 8.9 shows the comparison of the Rayleigh-Jeans formula for the spectrum of the radiation from a black body at 1500 K with the observed spectrum. This discrepancy known as **ultraviolet catastrophe** (energy density increasing continuously with frequency) was the fatal failure of classical physics. This failure of classical physics led Planck (in 1900) to the discovery that radiation is emitted in quanta whose energy is $h\nu$. In 1900, the German physicist Max Planck used "Luck guesswork" (as he later called it) to come up with a formula for the spectral energy density of black body radiation as




$$E_\nu \, d\nu = \frac{8\pi h}{c^3} \frac{\nu^3 d\nu}{e^{h\nu/kT} - 1}$$

Here $h$ is Planck's constant whose value is $h = 6.626 \times 10^{-34}$ J.S.