Black body radiation

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- When light wave interact with matter ,it may be absorbed,reflected or transmitted by the matter.
- The light wave of which wavelength is reflected that is treated as its colour.
- When a metal piece is heated it emits radiations of frequencies which change with temperature .
- As the temperature increases ,ie the metal becomes hotter and hotter it radiates visible light changing from red ,orange ,to yellow and then white.
- These radiations may also contain other frequencies which are not in visible region.
- All objects emits radiations continuously,where the frequency of dominant radiation depends on the temp. at which the emission occurs.
- At room temp.most of the radiations are in IR region,Hence not visible

- A body which is in thermal equilibrium with its surroundings absorbs energy from the surroundings at the same rate as it emits radiations into the surroundings.
- A body not in thermal equilibrium with surroundings ,but at a temp.greater than surroundings,will emit more energy than it absorbs from the surroundings.
- This will decrease the temperature of the body and it finally attains the temperature of the surroundings.
- A body stops radiations only at absolute zero.

Black body

An ideal body which can absorb all the radiations incident on it ,regardless of the frequency or angle of incidence of the radiations is called a black body.

The radiations emitted by a black body when it is heated to a constant temperature are called blackbody radiations.

Thus a blackbody is a source of thermal radiations.

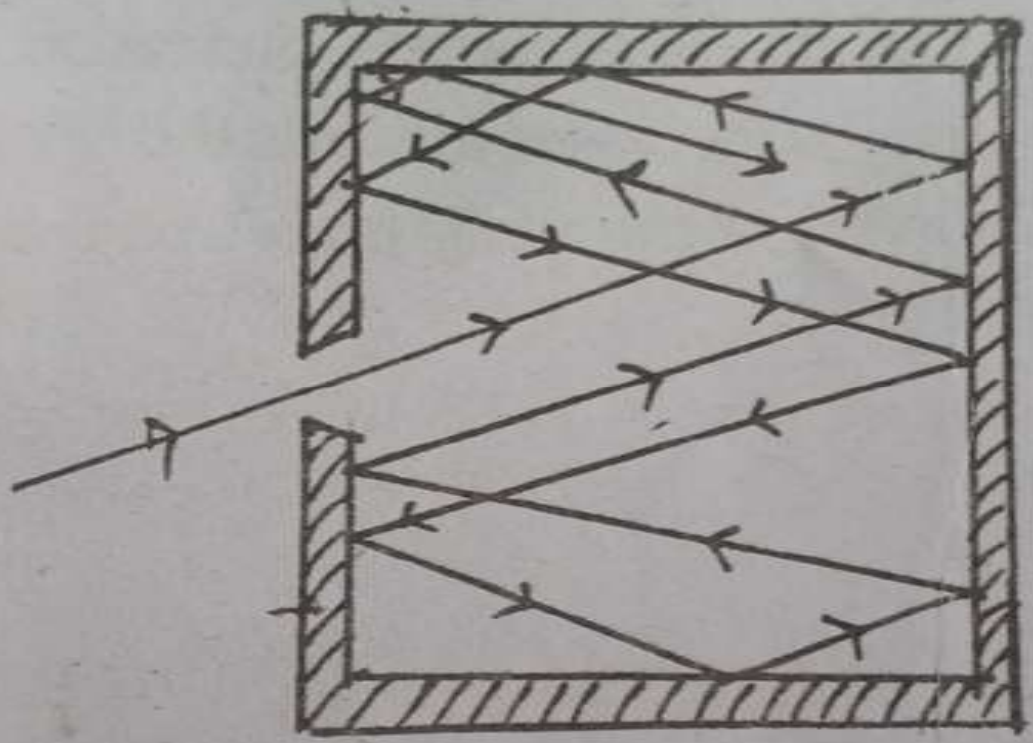

Fig (4)

Any radiation striking on the hole will enter into the cavity and will undergo multiple reflections and finally absorbed by the atoms of the same wall.

At thermal equilibrium with the surroundings ,the atoms of the walls of the black body emit radiations and at the same time these radiations get absorbed by the atoms on the same walls.

When the blackbody is heated to a higher temperature than that of its surroundings ,then it emits more radiation than it absorbs.These radiations will emerge out of the hole on the blackbody.

Lord Rayleigh and James Jeans Used the wave nature of radiation to study the blackbody spectrum of radiations inside the cavity at a constant absolute temp. T.

They considered the radiations as a series of standing waves formed by the superposition of reflected from the inner walls of the cavity ,just as standing waves formed on a stretched string.

To form a standing wave at any direction nodes should be formed at each reflecting surfaces on the opposite sides.

The condition for forming forming standing waves in a cavity along any direction is that the pathlength in that direction between the reflecting surfaces should be $n\lambda/2$ where n=1,2,3,.....

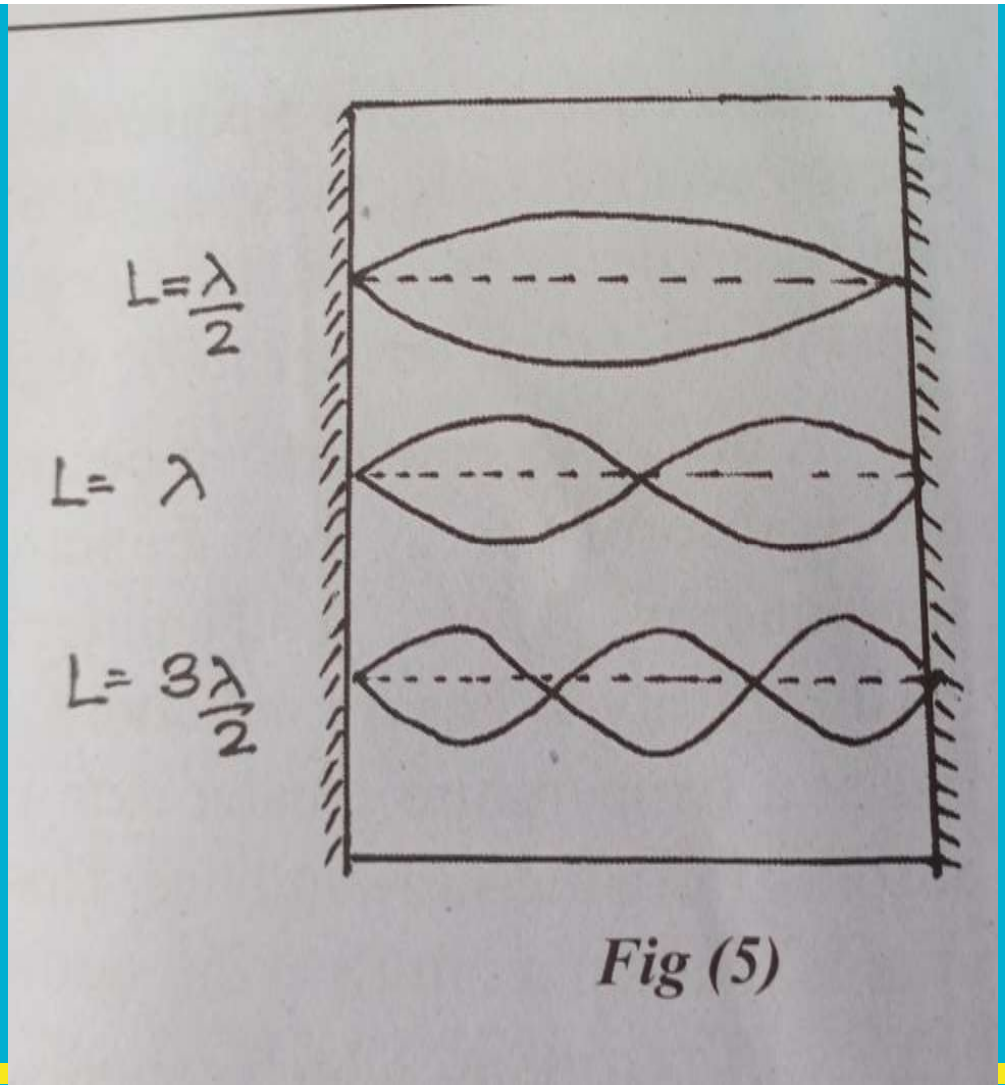

Fig (5)

The total energy per unit volume or energy density in the cavity within the ~~freq~~uency range υ and $\upsilon+d\upsilon$ at temperature T is

Where K is the Boltzmann constant and c is the speed of light in free space.This formula is called Rayleigh-Jeans formula.

$$u(\nu)d\nu = \frac{8\pi kT}{c^3}\nu^2 d\nu$$

According to above equation as the frequency increases towards UV end of the spectrum,the energy density should increase as υ^2.For infinitely high frequencies ,the energy density should go to infinity.

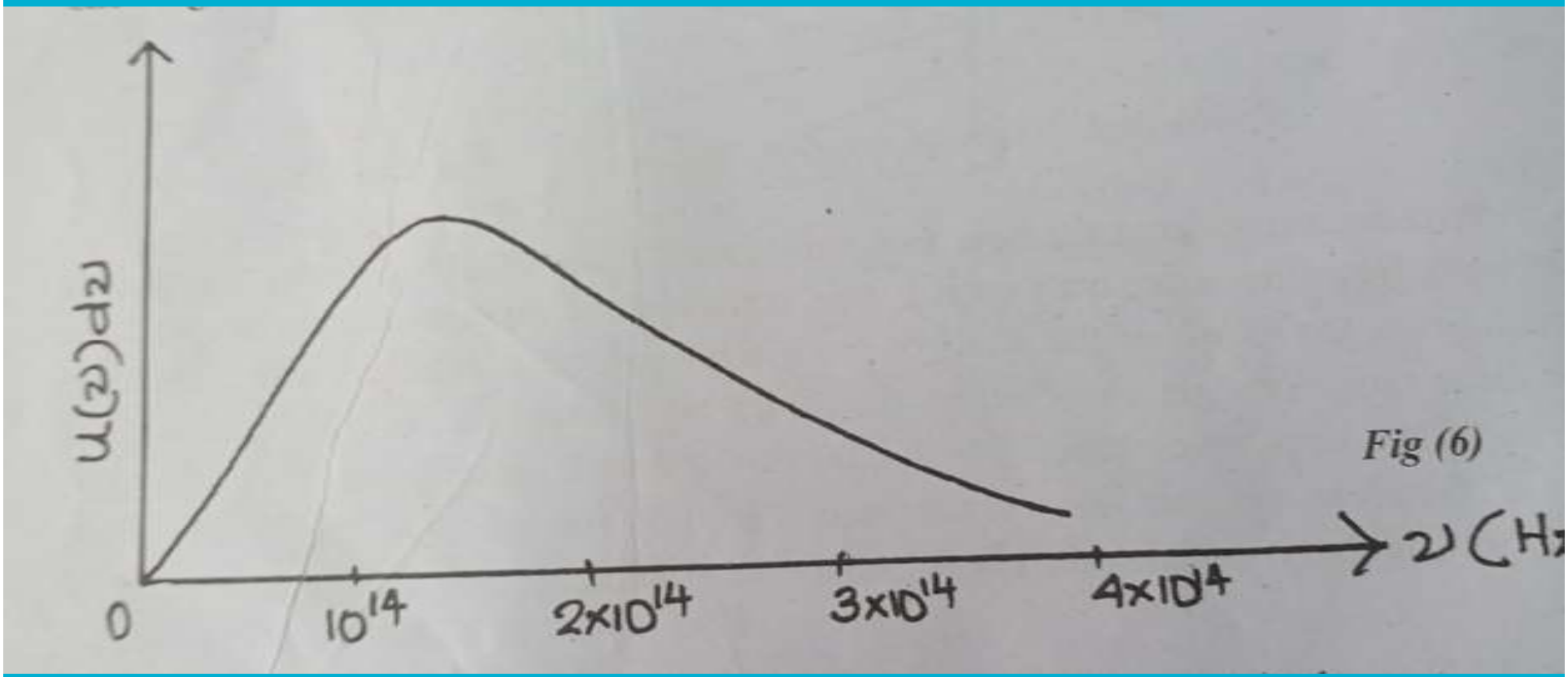

Fig (6)

The graph shows that energy density falls to zero as the frequency tends to infinity.

Thus Rayleigh Jeans law diverges from the observations as the frequency of radiation approaches infinite region of electromagnetic spectrum

This discrepency at higher frequencies or lower wavelength in UV region of energy emitted by an ideal body is known as Ultraviolet catastrophe.

These discrepancy of ultraviolet catastrophe was studied by Max Planck suggesting that radiations are emitted and absorbed as discrete packets called quanta and each ~~qua~~ntum having energy $E=h\upsilon=hc/\lambda$,where h is the Planck's constant.

Later Einstein postulated that these quanta are real physical particles called photons.

Acc.to classical theory ,the atoms on the walls of the cavity inside the black body are oscillators which emit and reabsorb radiation continuously.

But acc. to Planck's theory the oscillators in the cavity cannot have a continuous distribution of energy but can exchange energy with the standing waves in cavity only in quanta of $h\upsilon$.

Thus the interactions of electromagnetic radiations with matter suggests that electromagnetic radiations are composed of discrete energy particles.