Lecture:02

Inedequences of Classical Mechanics:-

In C.M, we can find inedequences / errors of such kinds:-

i) Stability of Matter:-

In an Ionic material, ions are in motion. Electrons revolves around nucleous of an atom. Electrons constantly accelerate if they emit radiation (radiation ⇒ a charged particle emits light when it accelerates.) This radiation cannot seen. When electrons continuously emit radiation, they should fall in nucleous in the time of order of 10^{-10} m. Such a collapse would be catastrophic for the chemical behaviour of the atoms. So classically stability of matter was not observed. Which was later discussed by Q.M currently.

2) Optical Spectra:-

Simply In simple wording seven colour strip is optical spectra

Radiation emitted from elements heats up the material or an electrical discharge takes place in gaseous form, it is found to have continuous range of frequencies. If allowed frequencies are $\omega_1, \omega_2, ---$ then formula for observed frequencies is

$\omega = n_1\omega_1 + n_2\omega_2 + ---$

This is in linear combination

where $n_1, n_2, ...$ are integers.

But after experiments, results couldn't match, but with Ritz combination

⇒ Spectral lines of any element include frequency that is sum/diff of two other lines.

Now let's allowed frequencies are $\omega_1', \omega_2', ...$ then observed freq is

$\omega = \omega_n' - \omega_m'$

So optical spectra is also obtained by wave mechanics not by e.M. Difference is clear by obtaining observed frequencies.

Principle of equipartition of Energy:-

E = energy, T = Temperature

$E \propto T = E = KT$, K is Boltz-man constant.

Wave Number:-

It is defined as:-

wave Number = $\frac{\text{No of cycles}}{\text{length}}$

wave No = k

length = L, $k = \frac{2\pi n}{L}$

unit = cycle/m.

Raleigh-Jeans formula:-

Black body Radiation:-

If an enclosure is in equilibrium in radiation with surroundings, called black body radiation

Perfect Black Body:-

If a hole in enclosure observes

radiation but not escapes it, Then such body is called perfect black body.

Formula:-

let 'l' be the length of box containing radiation, then each allowed frequency occured in the form of $e^{ik\cdot r}$,

where $k\cdot r = k_x x + k_y y + k_z z$

In order, that the wave ~~ra~~ remain in the box, being reflected back & forth from the walls ~~as~~ it is necessary that it have the same value at on wall as opposite one. so that the values of k

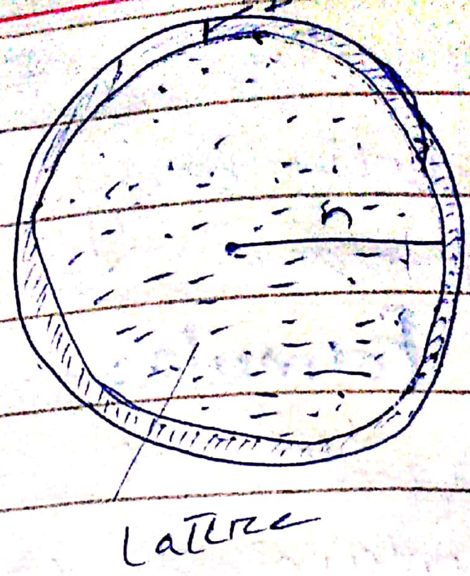
$$k_x = \frac{2\pi}{l} n_1, \quad k_y = \frac{2\pi}{l} n_2, \quad k_z = \frac{2\pi}{l} n_3$$

$$k = \frac{2\pi}{l}(n_1, n_2, n_3) \quad \text{where}$$

$$n^2 = n_1^2 + n_2^2 + n_3^2$$

we want to calculate no of allowed values of k.

we will regard 'n' put in a lattice, we consider a shell having radius 'n' & thickness 'Δn' which is equal to vol of shell.



vol = (area) Δn
$= 4\pi r^2 \Delta n$

$n = 4\pi n^2 \Delta n$

(n, Δn are not so small)

Simply we write formula of wave numbers as

$k = \frac{2\pi}{L} n \Rightarrow n = \frac{Lk}{2\pi}$

we form our formula in wave form per unit volume when k lies b/w k & k+dk

$|n| = 2 \cdot \frac{1}{L^3} 4\pi \left(\frac{Lk}{2\pi}\right)^2 d\left(\frac{Lk}{2\pi}\right)$

(we multiplied due to polarization by 2).

$n = 2 \cdot \frac{1}{L^3} 4\pi \left(\frac{L}{2\pi}\right)^3 k^2 dk$

$f = \frac{v}{\lambda} \Rightarrow v = f\lambda$ — ①

$\omega = \frac{c}{\lambda} \Rightarrow c = \omega\lambda$ — ②

$\lambda = L$ If $n = 1$

Q2) $c = \omega L \Rightarrow \omega = \frac{c}{L} = \frac{kc}{2\pi}$

$\Rightarrow k = \frac{2\pi}{c}\omega$

Now we form our formula when n is dependent on ω & change in freq changes from ω to $\omega + d\omega$

$$n(\omega)\,d\omega = 2 \cdot \frac{1}{L^3} 4\pi \left(\frac{L}{2\pi}\right)^3 \left(\frac{2\pi}{c}\omega\right)^2 d\left(\frac{2\pi}{c}\omega\right)$$

$$= 2 \cdot \frac{1}{L^3} 4\pi \frac{L^3}{8\pi^3} \left(\frac{2\pi}{c}\right)^3 \omega^2 d\omega$$

$$n(\omega)\,d\omega = \frac{8\pi}{c^3}\omega^2 d\omega$$

as formula of equipartition of energy is of one wave is kT. We can get Total energy of all particles

$$E(\omega)\,d\omega = \frac{8\pi\omega^2 d\omega}{c^3} \cdot kT$$

$\Rightarrow$ for low frequencies, but not for higher. But Total energy of radiation per unit vol of enclosure is $\int_0^\infty E(\omega)\,d\omega$, which would be infinite. Indeed Total energy must be finite.