PHONONS

The energy of an electromagnetic wave is quantized and this quantum of energy is called a photon. Similarly the energy of a lattice vibration or an elastic wave is also quantized and the quantum of this energy is known as phonon. All types of lattice vibrations in crystals comprise photons – thermal vibrations are thermally excited phonon, sound waves are acoustical phonons and excitation of the optical branch generate optical phonons. Most of the concepts which apply to photons are also valid for phonons. For example the concept of wave particle duality holds goods for phonons. Also the energy of a phonon is given by $\hbar\omega$ where ω is the angular frequency of mode of vibration the total energy of that mode is written as

$$\varepsilon = n\hbar\omega$$

where n can be zero or a positive integer. Since the number of phonons may change with temperature the average no. of phonons in a vibrational mode is given by

$$\bar{n} = \frac{1}{\exp\left(\frac{\hbar\omega}{k_B T}\right) - 1} \quad \text{— (1)}$$

where k_B is the Boltzmann's constant and T the absolute temperature of the crystal. Thus the no. of phonons can be increased or decreased by raising or lowering the temperature respectively. The frequency of phonon waves may from 10^4 to 10^{12} cps i.e the vibrational spectrum of phonon waves occupies a wide frequency range. The phonons being indistinguishable particles require Bose Einstein distribution function to describe their distribution in the allowed energy states of the system. Due to particle nature of phonons the interaction of a phonon with another phonon or an electron may be considered as a scattering collision between the two particles.

There is no direct experimental evidence of the quantizati
on of lattice ~~vibra~~ energy. However the following experi
mental facts of forcefully suggests the existence of phonons

i) The lattice of heat capacity approaches zero as the temperature approaches zero. This can be explained only if the lattice vibrations are quantized in terms of phonon. ~~This will be described later~~

ii) The crystal scatter x-rays and neutrons inelastically The change in momentum and energy during this process can be associated with gain or lose of one ~~electron~~ or more phonons. The properties of these photons can be determined by measuring the momentum and energy of the scattered x-rays or neutrons