$$\boxed{\left(\frac{1}{E'}-\frac{1}{E}\right)=\frac{(1-\cos\theta)}{m_e c^2}}$$

In terms of wavelength

$$\left(\frac{\lambda'}{hc}-\frac{\lambda}{hc}\right)=\frac{(1-\cos\theta)}{m_e c^2}$$

$$E=h\upsilon=\frac{hc}{\lambda}$$

$$\lambda'-\lambda=\frac{h}{m_e c}(1-\cos\theta)$$

$$\boxed{compton\ shift, \Delta\lambda=\frac{h}{m_e c}(1-\cos\theta)}$$

$$\boxed{compton\ shift, \Delta\lambda = \frac{h}{m_e c}(1-\cos\theta)}$$

Eq. gives the changes in wavelength expected for a photon that is scattered Through the angle θ by the particle of rest mass m_e

This change is independent of wavelength λ of the incident photon

Compton wavelength λ_c = h/mc 2.426 X 10^{-12} m

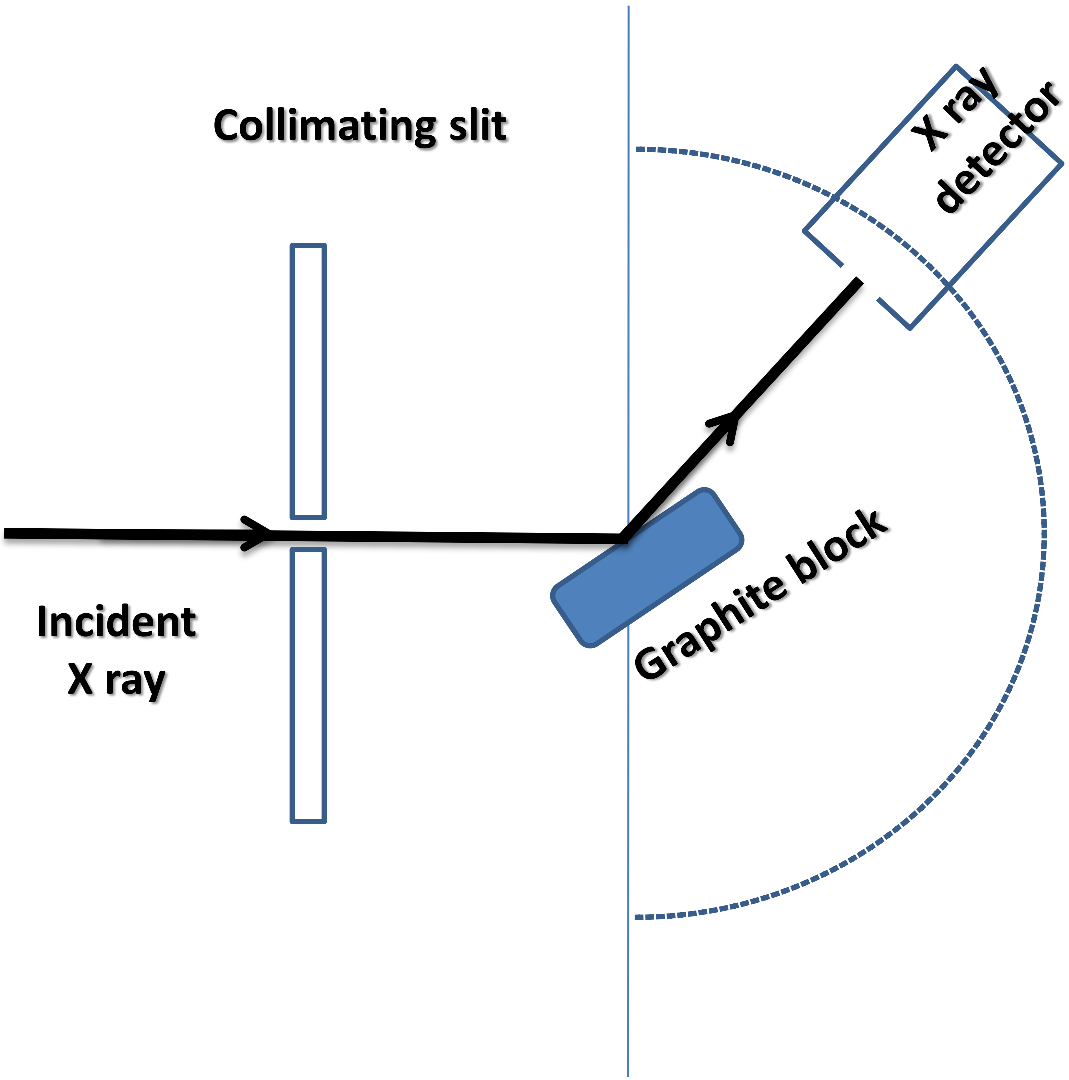
The greatest wavelength change is AT θ=180 °

$\Delta\lambda$ = 4.852 X10^{-12} m

This changes are observable in x-ray

Shift in wavelength for visible light is less than 0.01 percent of the initial wavelength

Compton Effect : Experimental setup



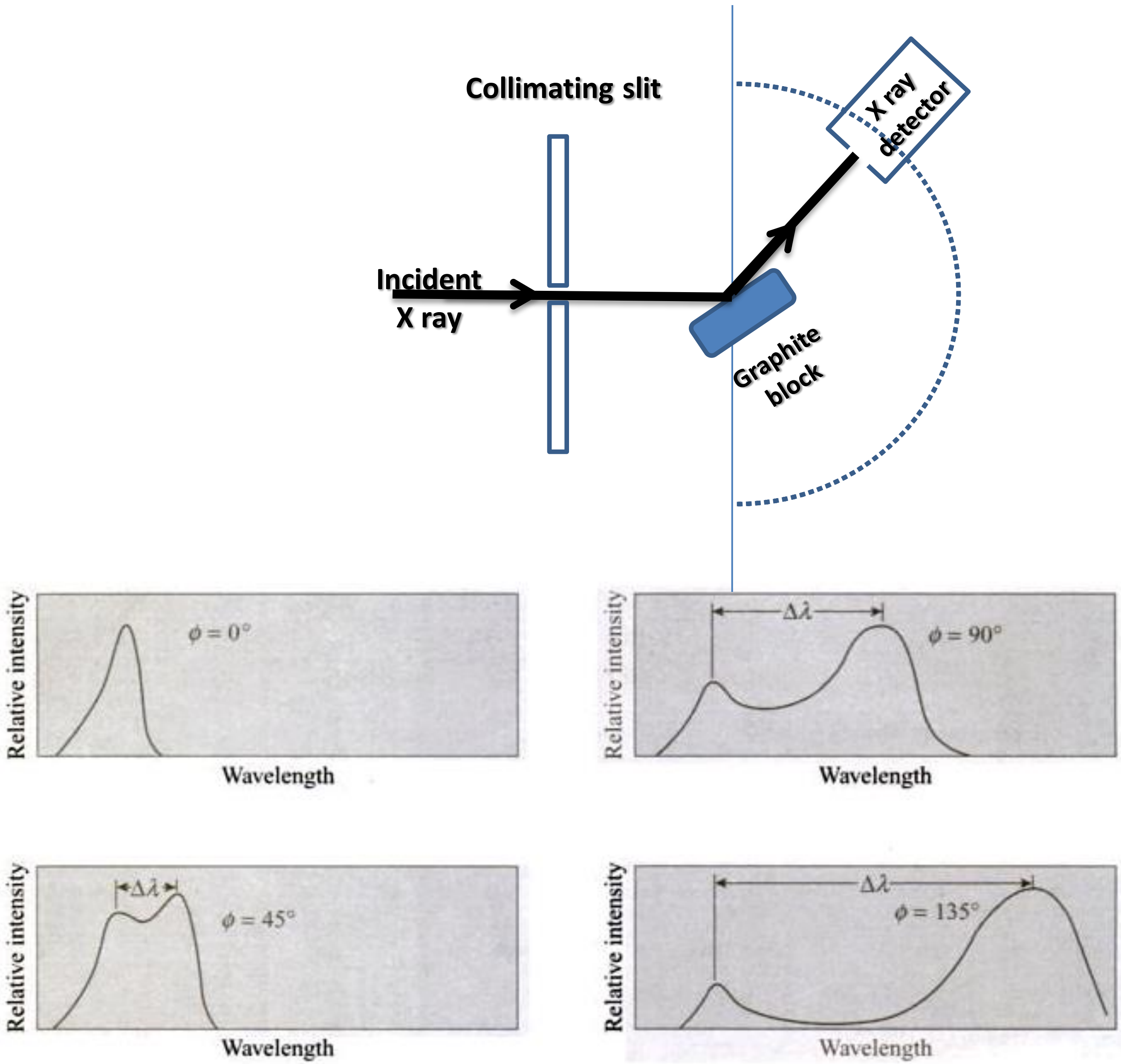


Fig. 2.24 *Experimental confirmation of Compton scattering. The greater the scattering angle, the greater the wavelength change, in accord with Eq. (2.21).*

The nature of light…….

- The birth of quantum mechanics is intimately linked with the theories and discoveries relating to the nature of light

- Is the nature of light that of a wave or a particle???

The story of light……..

- **Corpuscular theory (Newton)**
- **Wave nature (Huygens)**
- **Double-slit interference experiment (Young)**

The story of light (contd.)……..

- **Light is an electromagnetic wave (Maxwell)**
- **Photoelectric effect – existence of light quanta – photons (Einstein)**
- **Photons have momentum (Compton)…..**

Light has a dual nature

- **Wave** (electromagnetic) - Interference
  - Diffraction
- **Particle** (photons) - Photoelectric effect
  - Compton effect

Wave - Particle Duality for light

What about Matter?

If light, which was traditionally understood as a wave also turns out to have a particle nature, might matter, which is traditionally understood as particles, also have a wave nature?

Louis de Broglie's hypothesis

The dual nature of matter

A particle with momentum p has a *matter wave* associated with it, whose wavelength is given by

$$\lambda = \frac{h}{p}$$

The connecting link – Planck's constant

Dual Nature

Radiation

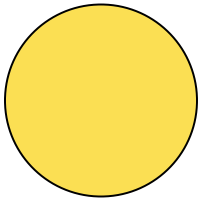
$$\boxed{E = h\nu}$$

Matter

$$\boxed{\lambda = \frac{h}{p}}$$

Particle

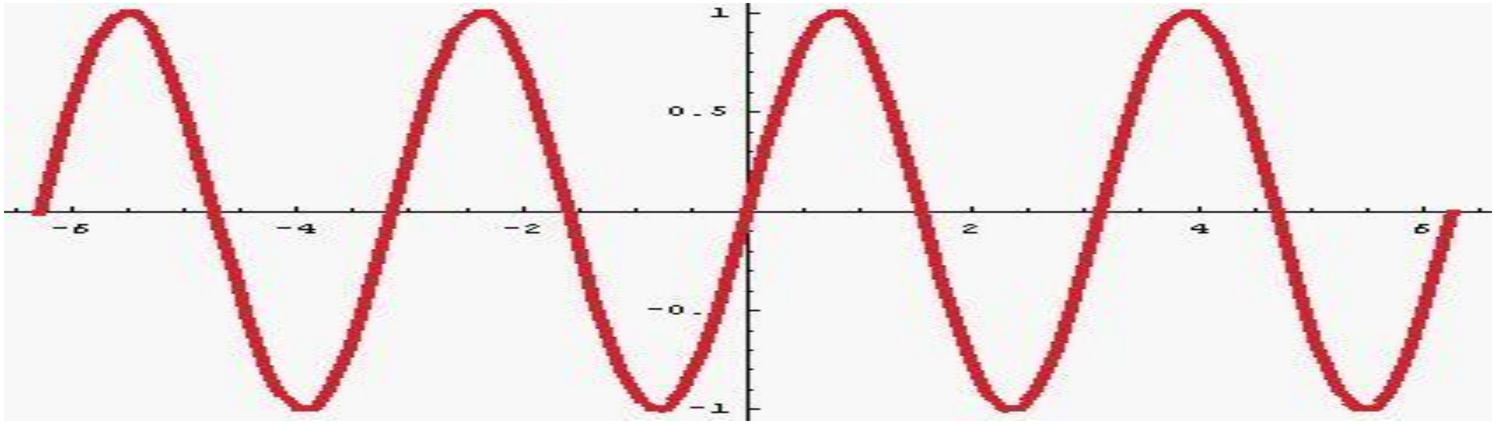
Our traditional understanding of a particle…



"Localized" - definite position, momentum, confined in space

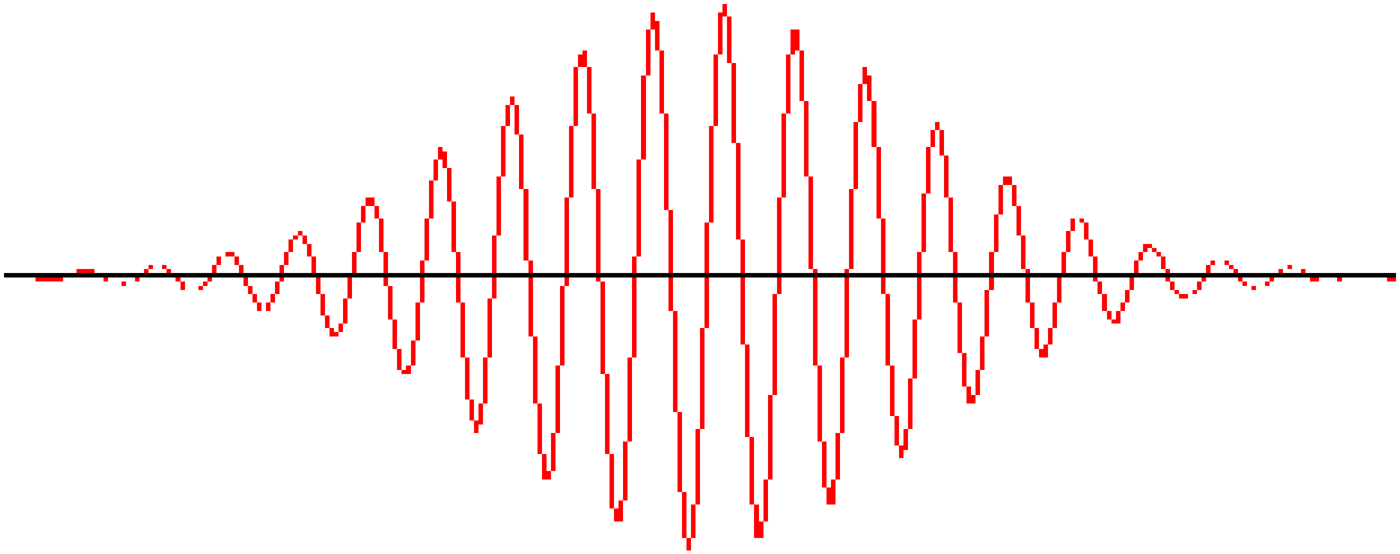
Wave

Our traditional understanding of a wave….



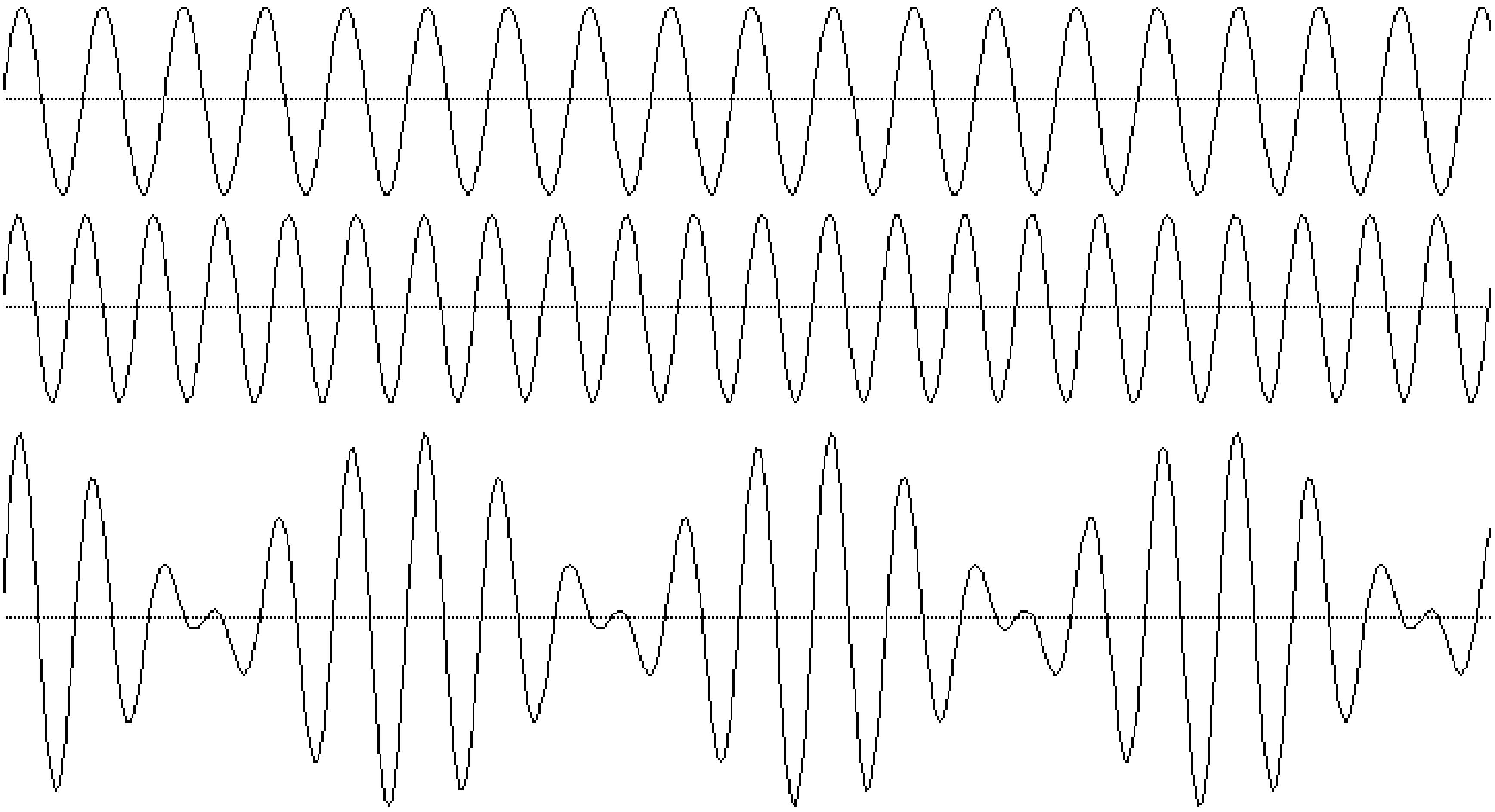
"de-localized" – spread out in space and time

A "Wave Packet"



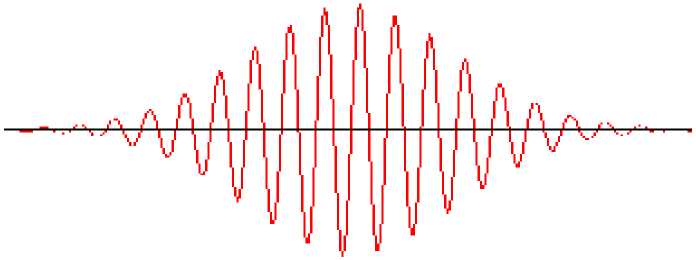
How do you construct a wave packet?

Adding up waves of different frequencies…..



Constructing a wave packet by adding up several waves ....

If several waves of different wavelengths (frequencies) and phases are superposed together, one would get a resultant which is a localized wave packet



A wave packet describes a particle

- **A wave packet is a group of waves with slightly different wavelengths interfering with one another in a way that the amplitude of the group (envelope) is non-zero only in the neighbourhood of the particle**

- **A wave packet is localized – a good representation for a particle!**

Characteristics of Matter Waves

- Only moving material particles exhibit matter waves.
- Smaller is the speed of the particle longer is the wavelength associated with it.
- Matter wave travels faster than the speed of light in vacuum as $v_p > c$
- Matter waves are not real waves and therefore cannot be represented by wave displacement. Variation of Ψ constitute matter waves. They are neither longitudinal nor transversion in nature.