

### Elastic versus Inelastic Scattering and Absorption:

We have considered elastic scattering of x-rays and light as the source of diffraction and scattering as defined by change in the momentum of the scattered radiation (direction) but not in the energy (wavelength). This allows for calculation of the d-spacing using Bragg's Law for instance. Dynamic scattering involves observation of elastically scattered light (generally) that is

### 3 Main Types of Interaction of Radiation with Matter

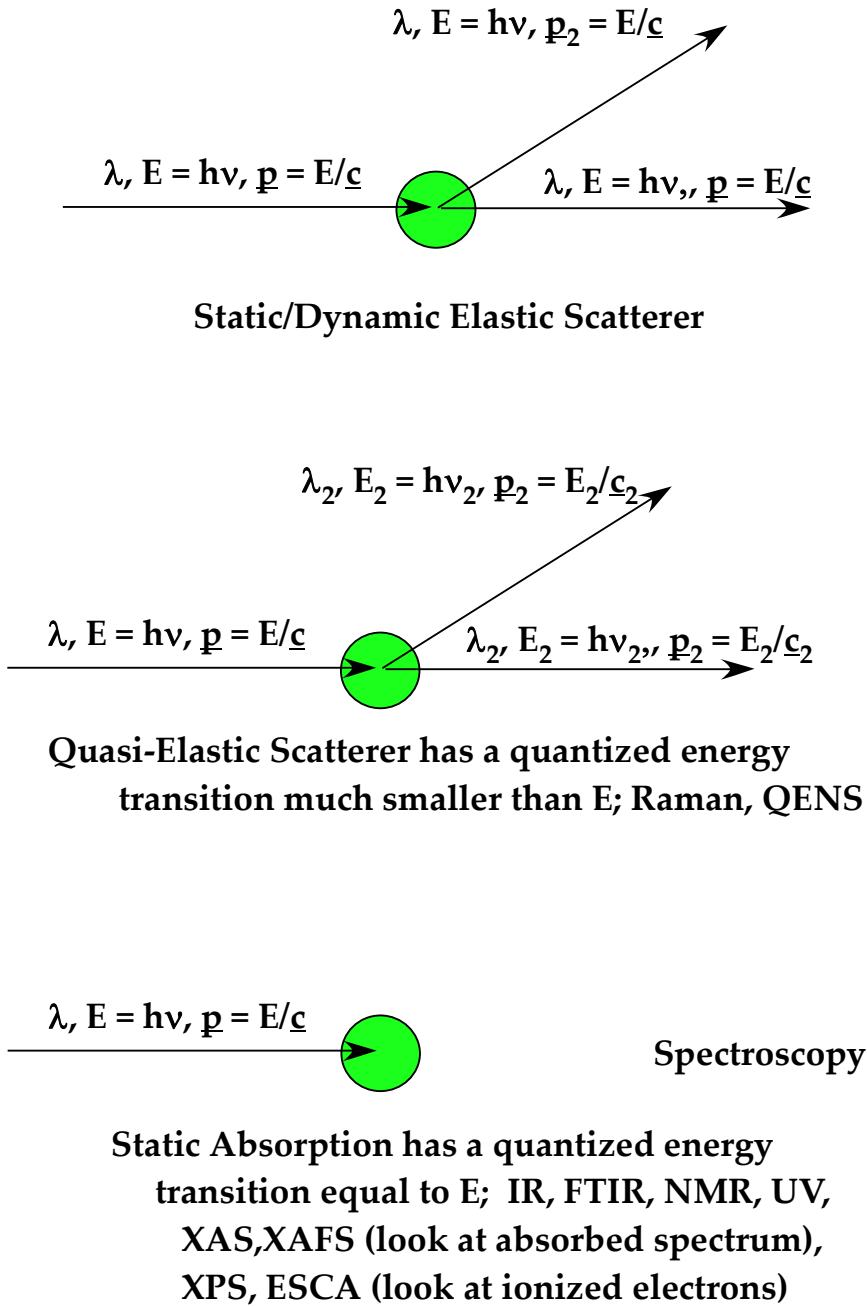


Figure 1. 3 types of interaction of radiation with matter.

observed as a function of time from a dilute solution of particles. As particles move in and out of the beam fluctuations in the scattered intensity are observed that relate to the thermal diffusion of the particles. Since thermal diffusion is related to size by Stokes law the particle size can be determined by consideration of the pairwise time correlation function of the scattered radiation. That is, if the particles move faster the fluctuations are faster and the time correlation function has a steeper decay that is associated with a smaller particle. This is called Dynamic Light Scattering. There are also analogues to this analytic technique using neutron scattering.

Inelastic scattering can be partial or total, that is we can observe either a small shift in the energy (wavelength) of the scattered photon, or total absorption of the incident energy. Partial absorption is used in Raman scattering where the thermal vibration of molecular bonds has an energy similar to but smaller than that for visible lasers. Two shifts in the wavelength spectrum are observed for addition and subtraction of a small amount of energy to the incident laser radiation. These are called the Anti-Stokes and Stokes lines respectively.

If a quantized transition occurs with the same energy as an incident electro-magnetic wave then absorption (totally inelastic scattering) is observed. This is the basis of a wider range of spectroscopies including XAS/XAFS electron orbital transitions and XPS/ESCA for electron ionization energy using x-rays, UV absorption spectroscopy for electron orbital transitions such as the  $\pi$  to  $\pi^*$  bond transition, IR spectroscopy for molecular bond vibrations especially in organic species and polymers, and NMR which uses absorption of radio-frequency EM radiation to observed nuclear spin transitions under a high magnetic field.