University of Tikrit

Collage of science

Department of physics

A scientific article

Scattering Cross Sections

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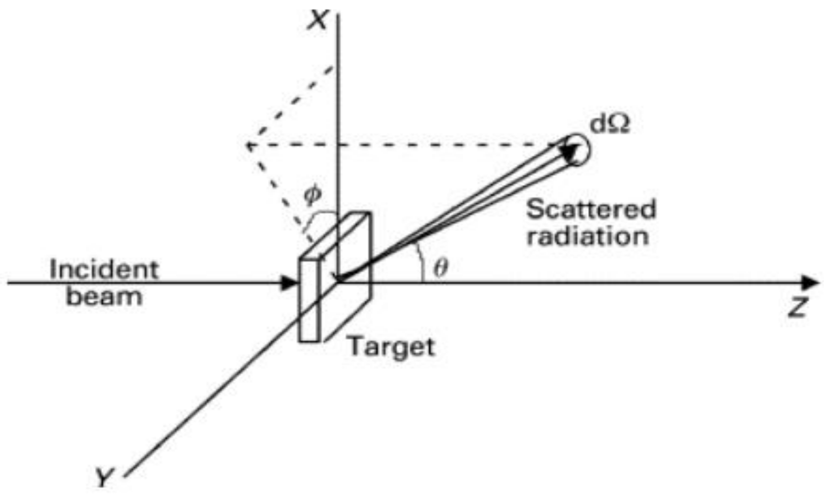
Scattering Cross Sections:

A scattering cross-section, σ, is a quantity proportional to the rate at which a particular radiation–target interaction occurs. More specifically, if the incoming radiation is considered as being composed of quanta or 'particles' (for example, photons or neutrons), a cross-section is a scattering rate (number of scattering events per unit time) per unit incident radiation flux, where the latter is the number of incident particles striking the target surface per unit time per unit area. In cases where the radiation is being treated as a continuous classical wave, as in the case of long-wavelength electromagnetic radiation, scattering cross-sections are determined by dividing the power of the scattered wave by the intensity of the incident wave. Dimensionally, Although the SI unit of total cross sections is m^2, smaller units are usually used in practice .In nuclear and particle physics, the conventional unit is the barn b, where 1 b = 10^{-28} m^2 = 100 fm^2 Smaller prefixed units such as mb and μb are also widely used. Correspondingly, the differential cross section can be measured in units such as mb/sr.[1]

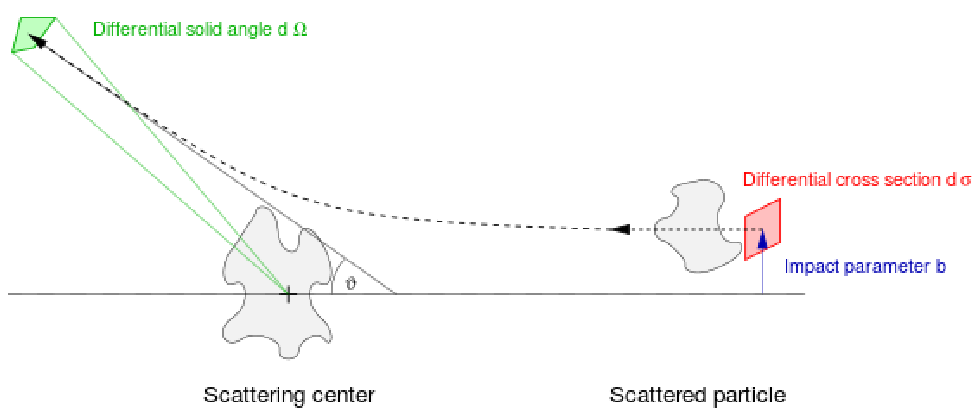
A scattering cross-section should not be interpreted as a true geometric cross-sectional area, but as an effective area that is proportional to the probability of interaction between the radiation and target.



Standard scattering geometry for measuring differential scattering cross-section

The incident beam travels in the positive z-direction and one considers the radiation scattered into a differential solid angle dΩ at polar angle θ and azimuthal angle ϕ . Some of the most famous cross sections are conic sections, cross sections are created by slicing a right cone in various ways. There are four types of conic sections , a circle, an ellipse, a parabola, and a hyperbola. [2]

Differential cross-sectional : Consider a classical measurement where a single particle is scattered off a single stationary target particle. Conventionally, a spherical coordinate system is used, with the target placed at the origin and the *z* axis of this coordinate system aligned with the incident beam. The angle θ is the scattering angle, measured between the incident beam and the scattered beam, and the φ is the azimuthal angle.



The impact parameter *b* is the perpendicular offset of the trajectory of the incoming particle, and the outgoing particle emerges at an angle θ **.** [3]

The cross-sectional area: is important when looking at nuclear reactions. The cross-section of some nucleus is used to define the effective size of a nucleus, and thus this value can be used to express the probability of some nuclear reaction taking place.[3] As well, the neutron cross section is particularly

important as it expresses how likely a reaction between a neutron and a target nucleus is, the basis for nuclear fission.

Backscatter Cross Section :

The scattering cross section C_{sc} (λ, r) (m^2) of an atmospheric particle (molecule, aerosol, water drop, or ice crystal) determines how much radiation is scattered in all directions by the particle. Here λ is wavelength and r is the particle dimension. Consider a uniform light beam of irradiance I (W m) incident on a particle of area of geometric cross section A (m). The particle scatters an amount of power W (W) into all directions**.** [4]

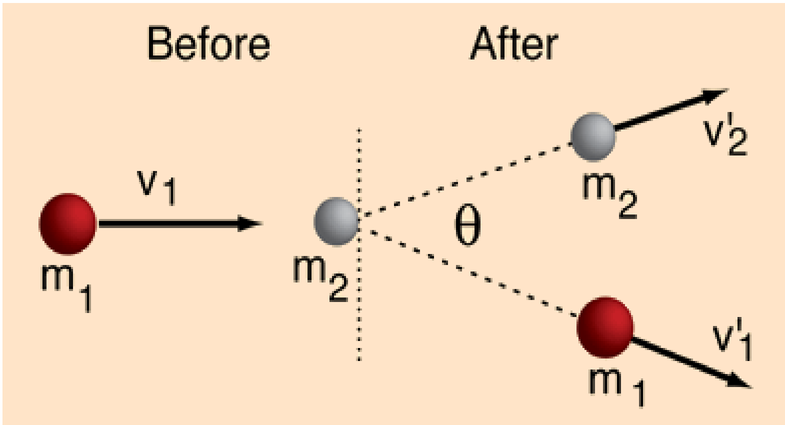
Efficiency: The scattering efficiency, Q_{sc} (λ, r), is defined as the ratio of the scattering cross section to the geometric cross section.

Elastic and Inelastic Collisions

A perfectly elastic collision is defined as one in which there is no loss of kinetic energy in the collision. An inelastic collision is one in which part of the kinetic energy is changed to some other form of energy in the collision. Any macroscopic collision between objects will convert some of the kinetic energy into internal energy and other forms of energy, so no large scale impacts are perfectly elastic. Momentum is conserved in inelastic collisions, but one cannot track the kinetic energy through the collision since some of it is converted to other forms of energy. Collisions in ideal gases approach perfectly elastic collisions, as do scattering interactions of sub-atomic particles which are deflected by the electromagnetic force. Some large-scale interactions like the slingshot type gravitational interactions between satellites and planets are perfectly elastic.

Collisions between hard spheres may be nearly elastic, so it is useful to calculate the limiting case of an elastic collision. The assumption of conservation of momentum as well as the

conservation of kinetic energy makes possible the calculation of the final velocities in two-body collisions. [5]



Elastic collisions, target at rest

"Collisions" in which the objects do not touch each other, such as Rutherford scattering or the slingshot orbit of a satellite off a planet, are elastic collisions. In atomic or nuclear scattering, the collisions are typically elastic because the repulsive Coulomb force keeps the particles out of contact with each other.

Collisions in ideal gases are very nearly elastic, and this fact is used in the development of the expressions for gas pressure in a container.

Cross section of the solid :

If a plane intersects a solid (a 3-dimensional object), then the region common to the plane and the solid is called a cross-section of the solid. A plane containing a cross-section of the solid may be referred to as a cutting plane.

The shape of the cross-section of a solid may depend upon the orientation of the cutting plane to the solid. For instance, while

all the cross-sections of a ball are disks, the cross-sections of a cube depend on how the cutting plane is related to the cube. If the cutting plane is perpendicular to a line joining the centers of two opposite faces of the cube, the cross-section will be a square, however, if the cutting plane is perpendicular to a diagonal of the cube joining opposite vertices, the cross-section can be either a point, a triangle or a hexagon. [6]

Plane sections

A related concept is that of a plane section, which is the curve of intersection of a plane with a surface. Thus, a plane section is the boundary of a cross-section of a solid in a cutting plane. If a surface in a three-dimensional space is defined by a function of two variables , i.e., $z = f(x, y)$, the plane sections by cutting planes that are parallel to a coordinate plane (a plane determined by two coordinate axes) are called level curves . More specifically, cutting planes with equations of the form $z = k$ (planes parallel to the xy-plane) produce plane sections that are often called contour lines in application areas .A plane section of a probability density function of two random variables in which the cutting plane is at a fixed value of one of the variables is a conditional density function of the other variable (conditional on the fixed value defining the plane section). If instead the plane section is taken for a fixed value of the density, the result is an iso-density contour. For the normal distribution, these contours are ellipses.

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