

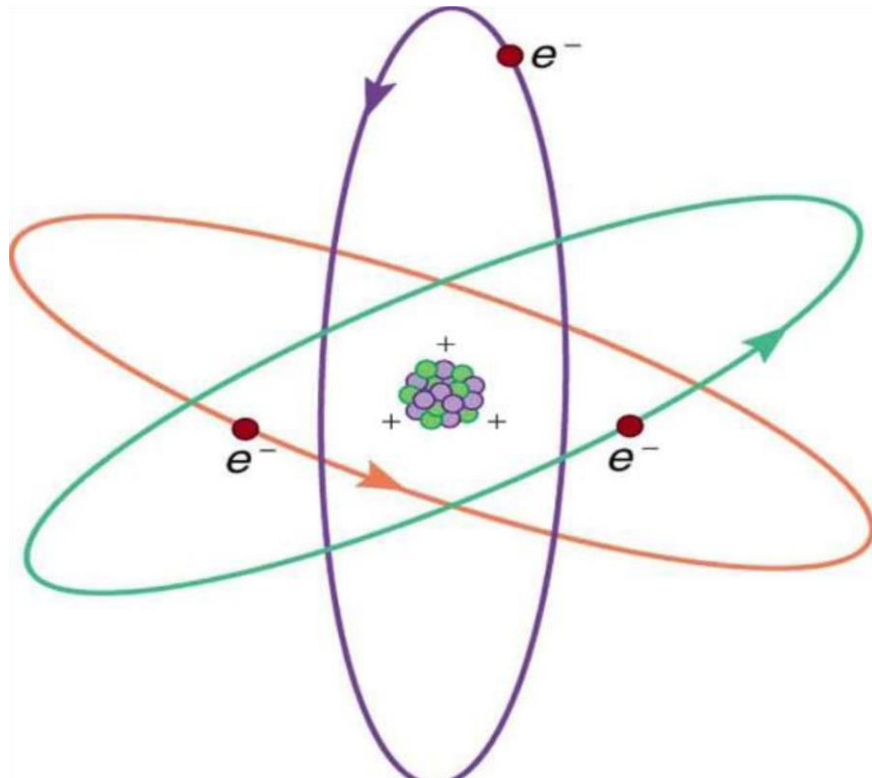
The Islamic University, Najaf

College of Medical Techniques

Department of Radiology Techniques



Atomic Physics / experiments
2022-2023
Lecture (2) / stage (1)
Photoelectric Absorption



Experiment 2

Photoelectric Absorption

OBJECTIVE

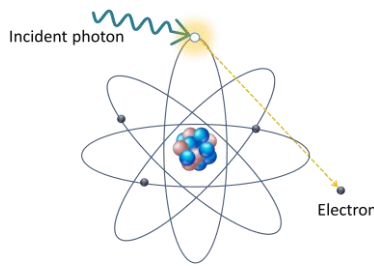
Collect gamma spectra from several commercial radioactive sources with single photo peaks and measure the gamma energies of the (photo effect) peaks, Compton backscattering peaks and the Compton edges. From these energies, the rest mass energy of the electron can be determined.

INTRODUCTION

The gamma rays interact with detectors and absorbers by three major processes: photoelectric absorption, Compton scattering, and pair production. In the photoelectric absorption process, the gamma ray loses all of its energy in one interaction. The probability for this process depends very strongly on gamma-ray energy E_γ and atomic number Z . In Compton scattering, the gamma ray loses only part of its energy in one interaction. The probability for this process is weakly dependent on E and Z . The gamma ray can lose all of its energy in one pair-production interaction .

Photoelectric absorption

A gamma ray may interact with a bound atomic, electron in such a way that it loses all of its energy and ceases to exist as a gamma ray . Some of the gamma-ray energy is used to overcome the electron binding energy, and most of the remainder is transferred to the freed electron as kinetic energy. A very small amount of recoil energy remains with the atom to conserve momentum. This is called photoelectric absorption because it is the gamma-ray analog of the process discovered by Hertz in 1887 whereby photons of visible light liberate electrons from a metal surface. Photoelectric absorption is important for gamma-ray detection because the gamma ray gives up all its energy, and the resulting pulse falls in the full-energy peak.



The probability of photoelectric absorption depends on the gamma-ray energy, the electron binding energy, and the atomic number of the atom. The probability is greater the more tightly bound the electron therefore, K electrons are most affected (over 80% of the interactions involve K electrons), provided the gamma-ray energy exceeds the K-electron binding energy. The probability is given approximately by Equation 1, which shows that the interaction is more important for heavy atoms like lead and uranium and low-energy gamma rays:

$$\tau \propto \frac{Z^4}{E^3}$$

where τ = photoelectric, mass attenuation coefficient. The energy of the photoelectron E_e released by the interaction is the difference between the gamma-ray energy E_γ and the electron binding energy E_b :

$$E_\gamma = E_e + E_b$$

In most detectors, the photoelectron is stopped quickly in the active volume of the detector, which emits a small output pulse whose amplitude is proportional to the energy deposited by the photoelectron. The electron binding energy is not lost but appears as characteristic x-rays emitted in coincidence with the photoelectron. In most cases, these x rays are absorbed in the detector in coincidence with the photoelectron and the resulting output pulse is proportional to the total energy of the incident gamma ray. For low-energy gamma rays in very small detectors, a sufficient number of K x-rays can escape from the detector to cause escape peaks in the observed spectrum; the peaks appear below the full energy peak by an amount equal to the energy of the x ray.