University of Zurich[UZH]

KT I Lab Course

Angular Correlation

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Contents

1 Introduction

The goal of this experiment is to measure the angular correlation function of γ-rays in a ^{60}Co decay and compare it to theoretical predictions.

1.1 The ^{60}Co Decay

^{60}Co is a synthetic isotope of cobalt with a half-life of 5.1 years. Through β^- decay it disintegrates into an excited ^{60}Ni atom with an energy of 2505 keV and l = 4 with positive parity. This nickel isotope thus emits two successive gamma rays with energies of 1172 keV and 1332 keV in order to reach its stable state of 0$^+$. Since the intermediate state (2$^+$) has a lifetime of around 1 ps, the two γ-rays can due to the finite experimental time resolution be treated as coincident. A schematic diagram of the ^{60}Co decay is provided in figure 1.

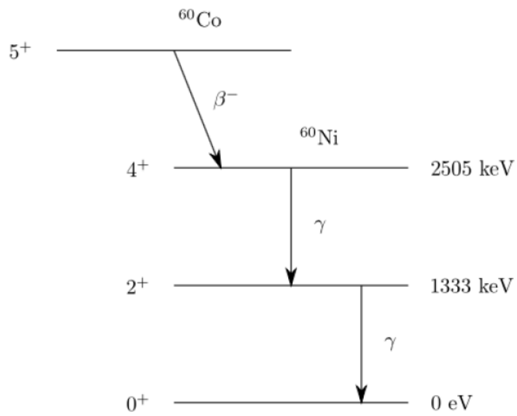

Figure 1: Schematic illustration of the ^{60}Co Decay. [**??**]

1.2 Angular Correlation

The two successive γ-rays are predicted to be emitted anisotropically relative to each other according to the general angular correlation function [**??**]:

$$W(\theta) = 1 + \sum_{1}^{l} a_i \cos^{2i}\theta \tag{1.1}$$

This function describes the probability for the latter gamma ray to be emitted at an angle θ from the first one. $2l$ is the order of the lowest multipole in the cascade. In case of the ^{60}Co decay, both gamma rays are emitted during a transision of Δl = 2 and positive parity, so the dominant contribution is the electric quadrupole and the correlation function reduces to:

$$W(\theta) = 1 + a_1 \cos^2\theta + a_2 \cos^4\theta \tag{1.2}$$

The coefficients a_1 and a_2 have been theoretically predicted by Dr. Hamilton for all combinations of angular momenta involved by consideration of state transitions using the Clebsch-Gordan-coefficients. These are summarized in figure 2

J_2	J_3	Multipoles	a_1	a_2
1	0	Dipole–Dipole	1	0
1	1	Dipole–Dipole	−1/3	0
1	2	Dipole–Dipole	−1/3	0
1	1	Quadrupole–Dipole	−1/3	0
1	2	Quadrupole–Dipole	3/7	0
1	3	Quadrupole–Dipole	−3/29	0
2	3	Dipole–Quadrupole	−3/29	0
2	2	Dipole–Quadrupole	3/7	0
2	1	Dipole–Quadrupole	−1/3	0
2	0	Quadrupole–Quadrupole	−3	4
2	1	Quadrupole–Quadrupole	5	−16/3
2	2	Quadrupole–Quadrupole	−15/13	16/13
2	3	Quadrupole–Quadrupole	0	−1/3
2	4	Quadrupole–Quadrupole	1/8	1/24

Figure 2: Coefficients a_1 and a_2 for different combinations of J_1 and J_2 for an atom deexciting into the ground state J_1 = 0 [**??**]

Since the angular monenta of J_3 = 4, J_2 = 2, J_1 = 0 are assumed for the ^{60}Co decay, the expected correlation function has the following explicit form:

$$W(\theta) = 1 + \frac{1}{8}\cos^2\theta + \frac{1}{24}\cos^4\theta \tag{1.3}$$

1.3 Experimental Concept

The experimental setup, more throroughly described in section **??**, consists of two scintillation counters that detect the coincident γ-rays from different and adjustable relative angles. The rate of detected events is then plotted and compared to the theoretical description from formula 1.3.

2 Measurement Principle

2.1 Experimental Set-Up

2.2 Electronic Modules

3 Energy Spectrum

4 Calibration