Exercise J7 - Determination of the manganese content of a steel sample with neutron activation analysis

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1 Introduction

The goal of this exercise is to determine the manganese content of a steel sample. The sample, along with a sample of pure manganese, is activated with thermal neutrons. The γ radiation being a result of activation is measured with a germanium detector.

2 Required reading

1. Interaction of γ-rays with matter: photoelectric absorption, Compton scattering, pair production ([1]-2.III.A).
2. Beta-decay, energy conditions ([2]-1.3).
3. Radioactive decay law, half-life ([2]-1.11)
4. Principles of operation of semiconductor germanium detectors ([1]-12.II.C, 12.III.A, 12.IV.A)
5. Electronic signal processing (preamplifier, amplifier, multichannel analyzer) ([2]-14.1, 14.2, [1]-16.III, 18-III).
6. Energy resolution, energy calibration, efficiency calibration ([1]-4.V, 4.VI)
7. Statistical and systematical uncertainties in radiation measurements ([1]-3.II).
8. Decay schemes ([2]-1.1, 1.3).
9. Pu-Be neutron source, neutron moderation ([1]-1.V).
10. Neutron activation. How does sample activity depend on the time of activation? What is the optimal activation time?

3 Outline

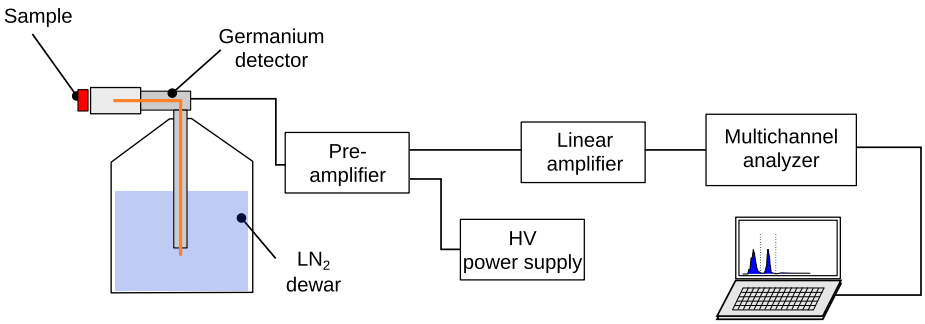

Figure 1: Overview of the experimental setup

1. Introduction to experimental setup: neutron source, calibration sources, detectors, HV power supplies, amplifiers, analyzer and computer program.
2. Optimalization of impulse shaping time.
3. Energy calibration of the detector.
4. Weighing of the steel and manganese samples. The box for the manganese sample weighs 6 g.
5. Measurement of the background γ radiation for both samples before activation.
6. Simultaneous activation of both samples in the neutron source.
7. Measurement of the γ spectra for activated samples. To determine the half-life several spectra must be measured, for each the start time and length of measurement must be written.

4 Data analysis

A laboratory report is a kind of essay, and it should be written with correct spelling and grammar. It should follow logical reasoning, keeping in mind that a person that never done the exercise before, should understand what were the objectives, methods and results.

It should be structured with sections like introduction, methods, results, and conclusions. The introduction should define the purpose of the experiment, put possible hypotheses to be tested, refer to previous studies, and briefly describe the method to be used. The main part, consisting of a more detailed description of the procedure and results, should include figures, and schemes, clearly presented, including labels, legends, units, and other elements. It is not needed to copy textbook knowledge, instead, it is better to select the key information on used methods and equipment and focus on the actual experiment and results. Numerical values should be presented with uncertainties. In the conclusions,

one should discuss whether the result confirms expectations or predictions, how it compares to the literature, what is the source of discrepancies, or the main component of uncertainty, if something could be improved, etc.

Main analysis steps

1. Energy calibration of the detector.
2. Identification of γ rays from decay of ^{55}Mn, and their half-lives.
3. Determination of the Mn content, based on γ intensity for the pure sample and the steel sample.
4. Experimental uncertainty analysis.
5. Comparison of the results with literature data and discussion

References

[1] G. Knoll "Radiation detection and measurement", ed. III or IV, J. Wiley and Sons

[2] C. Leo, "Techniques for Nuclear and Particle Physics Experiments" ed. II, Springer 1994

[3] S. Brandt "Data analysis", ed. IV, Springer 2014

[4] Chart of Nuclides, www.nndc.bnl.gov/nudat3/