Gamma Activity #2: Identification of Mystery γ-ray Sources

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August 12, 2019

1 Introduction

In this activity, you will measure the γ-ray spectrum of several unidentified radioactive sources using a high purity germanium (HPGe) detector. Using these measurements and a database of nuclear decay schemes, your task will be to identify each source.

2 Getting started

Verify that the HPGe detector is ready to take data and is properly calibrated. If needed, repeat the energy calibration procedure from Gamma 1 using some check sources provided by the TA.

Once you are confident that the HPGe detector is accurately calibrated, ask the TA to place the first mystery sample in the detector. The TA will explain the process of matching the γ-ray lines to known decays in the decay scheme database, and he or she will work together with you to identify the first mystery sample. The TA will not intervene nearly as much for the later samples, so be sure to ask any clarification questions that you may have during this step.

After your group has correctly identified the first sample with the TA's help, you're ready to try assaying some samples on your own. Before moving on, however, discuss the following questions with your group and the TA:

- What are common backgrounds for an HPGe detector? What can be done to mitigate them?
- Although the mystery samples used for this activity typically have peaks that are easily seen, what could be done if you couldn't see any peaks above background?
- How were you able to identify the peaks for the first mystery source? How good is the detector's current energy calibration?
- In addition to the photopeaks, what other features do we expect in the sample spectra that are absent in background spectra? What is the physical explanation for these features?
- **Advanced** If time is available, use one of the photopeaks to estimate the activity of the sample. Approximate the detector efficiency using one of your measurements from Gamma 1. Your TA can provide you with a background spectrum if needed. How does your measured activity compare to the activity predicted using the initial activity, half-life, and branching ratio for your chosen photopeak?

3 Assay of unknown samples

The TA will now place a new sample in the detector for your group to identify. You may ask the TA for hints or more substantial help if you get really stuck, but try as much as possible to identify the sample in your group using the procedure that you learned earlier.

As you form hypotheses about the origin of each gamma line, consider the following questions:

- What is the intensity of the γ line in your proposed match? Is it plausible that you would see it after a few minutes of counting in the HPGe detector? What other lines from the same nuclide are intense enough that you would expect to see them also?
- What is the half-life of your proposed nuclide? If it is short, is there a process that might be occurring within the sample that could explain its presence? If so, what other γ lines would you expect to see from that process?
- All of the mystery samples were made using naturally occurring substances. Can your proposed γ-emitting nuclide be found in nature, or must it be created artificially?
- Are there any strong lines in the background spectrum that might be mistaken for γ lines from the sample? You may ask your TA for a background spectrum or measure it as a group.

4 Finishing the activity

Continue taking γ-ray spectrum data and consulting the decay scheme database until you have identified all of the mystery samples. If time is running out, the TA will help you save your data for later. You will have some extra time in Gamma 3 to finish any remaining identifications.

Useful references

- Table of Radioactive Isotopes: http://nucleardata.nuclear.lu.se/toi/index.asp
- Table of γ-ray lines: http://atom.kaeri.re.kr:8080/gamrays.html
- Article from Idaho State about "Radioactivity in Nature": http://www.physics.isu.edu/radinf/natural.htm