College Physics I
Lab 8: Nuclear Radiation

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Introduction

You will learn how to use a Geiger tube and a Geiger counter, and you will observe some of the properties of α, β and γ radiation. You will mainly be studying their ability to penetrate. Though ability to penetrate varies within a particular type of radiation depending on its energy, the three types differ qualitatively in their ability to penetrate materials.

Note: Throughout this lab, you will have the option of measuring number of counts per unit time (for example, number of counts in a minute), or amount of time for a number of counts (for example, the amount of time to get 100 counts). You can even let the counter do the arithmetic for you and have it give you counts per minute (cpm) or counts per second (cps) directly. The problem is that, if the sample is not very active, you will have to wait an awfully long time to get, say 100 counts. On the other hand, if the sample is very active, there is no point in waiting a long time when you will get plenty of counts in just a few seconds. You can set the counter to stop after a given number of counts, or you can set it to stop after a given number of seconds (or minutes). You will probably need to use both of those features, depending on what you are counting and how precise you want the result to be. Remember that radioactive decay is a random process, so don't expect your results to be consistent or repeatable unless you have gathered plenty of counts (about 100 to 1000 or more). As a general rule, try to gather at least 100 counts for each test, and then divide that by the time it took (in seconds or minutes, but be consistent). If things are so slow that it seems it will take forever to get 100 counts, then maybe you will have to settle for only 50, or 10. On the other hand, if it is a very active sample and you can quickly get around 1000 or more counts, do so. The more counts the better. The suggestions given here for how many seconds or how many counts for each activity are just suggestions; they may not be the best way to proceed. Pay attention to what is going on, and change how you gather data if you think that would be best.

Activity 1: Setting the voltage in the Geiger tube

I will explain to you how the Geiger tube and counter work. You can adjust the voltage on the tube from 0 to 1200 V, and you will need to find the optimum voltage. To do this, place the known β source in the top position, and take a reading for, say, 5 s, with the voltage set at 500 V, 600 V, . . . all the way up to 1200 V. Then make a careful graph of activity (in cps or cpm) versus voltage. The place where your graph just begins to flatten (usually around 900 V) is the voltage you should use for the rest of the experiment. This point is hard to recognize—ask me if you are not sure how to interpret your graph.

To hand in for Activity 1

- Graph of activity versus voltage, showing where you think the optimum voltage is,
- Data used to generate the graph mentioned above.

Activity 2: Estimating background radiation

With nothing in or near the counter, estimate the background radiation. Find the number of counts in 10 seconds 5 different times, and see if your 5 different results agree. Then find the number of counts in 1 minute 5 different times. Your five results will probably be more in agreement in this second case. At any rate, make some estimate of what you think the background radiation is in cpm or cps. You should keep your result for background radiation in mind when looking at data for the other parts of the lab.

To hand in for Activity 2

- Result for background activity, and how you arrived at that result.

Activity 3: Activity graph

You will be given a box of various plates. Though they are made of different materials, each plate is marked in kg/m^2 (or something with units of mass per unit area). This is called areal density. Basically, this tells you how much stuff there is per unit area that the radiation beam must penetrate—it measures how thick the plate is. Set up a sample with the plate between the sample and the Geiger tube. Get a reading of activity for each plate, and make a graph of activity versus areal density for that sample. Start by taking a data point with no plate. Then continue with the thinnest plate; if you are sure, after a few plates, that no radiation is getting through, then there is no need to check the activity for the thicker plates. Draw a line on your graph showing the background activity. Do this for the known α emitter and for the known β emitter, and for a third source you will be given.

To hand in for Activity 3

- 3 graphs of activity versus areal density,
- Data used to generate the above graphs,
- Comments, based on your observations, concerning α radiation's ability to penetrate compared to β radiation's ability to penetrate.
- Similar comments on the third source.