Physics Experiments

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Background Radiation

Apparatus:

Timer-scaler

Geiger-Muller tube

Stop-watch

The purpose of this experiment is to find out the count rate of background radiation. Here we have a set of apparatus, the main ones include: a timer-scaler, a Geiger-Muller tube, and a stop-watch.

Firstly, I will connect the GM tube to the scaler.

As what we have to measure is the background radiation, we should not put any radioactive source near the GM tube.

Now I will switch on the scaler and set the voltage on the scaler to 450V.

Later on, I will note down the total number of counts in 10 minutes and work out its count rate.

Now, I am going to reset the reading on the scaler to zero.

With stop-watch, we can start to keep the time, 5…4…3…2…1.

10 minutes' time is about to pass, I will turn off the high tension supply and take the reading.

5…4…3…2…1.

In 10 minutes, the recorded total number of counts is 545. It means that the count rate of background radiation is about 0.9 counts per second.

<div align="center">**Ionizing Power of Radiation**</div>

Apparatus:

α source (americium-241)   Spark counter

β source (strontium-90)   EHT power supply

γ source (cobalt-60)

The operating principle of most radiation detectors is based on the ionizing power of radiation.

In this experiment, we would like to compare the difference between the ionizing power of α, β and

γ radiation.

The main apparatus for this experiment includes an α source - The α source we use today is

americium-241, an EHT power supply and a spark counter.

Here we have an EHT power supply and a spark counter.

To start with, I will connect the spark counter to the EHT power supply.

I will set the voltage on the spark counter to 4000V.

At such a high voltage, no sparking occurs.

Ionizing Power of α radiation

Now, I will hold an α source about 1cm above the wire gauze.

Can you all see and hear the spark?

I will then try to find out the range of α radiation. I will hold the α source about 1cm above the wire

gauze of the spark counter.

At that moment, sparking will take place.

After that, I will lift up the α source by 1cm each time.

Please pay attention to see whether sparking would still occur.

We found out that when the source is away from the wire gauze to a certain distance, no sparking will occur.

Do you all agree that the distance between the α source and the wire gauze is the range of α radiation in air?

Now, I will insert a piece of paper between the source and the wire gauze so that a part of the wire gauze is covered. It is discovered that if the wire gauze is covered, no sparking could occur. However, when the wire gauze is not covered, sparking continues to occur. Therefore, it is believed that the penetrating power of α radiation is extremely low and α radiation can be stopped by even one piece of paper.

Ionizing Power of β radiation

Now, let's go on to investigate the ionizing power of β radiation. I will use strontium-90 as the β source in this experiment.

The result shows that no sparking occurs for β radiation.

Ionizing Power of γ radiation

Lastly, I will use cobalt-60 as the γ source to repeat the same experiment.

For γ radiation, no sparking is produced as well

The amount of sparking tells the ionizing power of the radiation. The more sparking the radiation produces, the stronger its ionizing power is. Therefore, α radiation has the strongest ionizing power among α, β and γ radiation.

However, can anyone of you explain why placing the radioactive source near the wire gauze under extra-high voltage would help produce sparking?

Effectiveness of GM Tube and Timer-scaler

Apparatus:

β source (strontium-90)

Timer-scaler

Geiger-Muller tube

This experiment is conducted to find out the working voltage for the GM tube and scaler. When the working voltage is applied, the GM tube and scaler will be able to work at its highest efficiency.

Here are the apparatus needed for the experiment. They include a β source, while the β source we use in this experiment is strontium-90, a timer-scaler, a stop-watch and a GM tube.

I have already connected the GM tube to the scaler

And used a pair of forceps to put the β source on the cards,

which are placed 12cm from the GM tube.

This distance will remain the same throughout the whole experiment.

Please note that the source has to be pointing along the axis of the GM tube.

Also, we have to switch on the scaler and allow five minutes for it to warm up.

Now the experiment is about to begin. I will set the voltage on the scaler to 300V.

Then, I will gradually increase the high tension supply from 300V

to the point at which the scaler starts to register counts.

The voltage is now 350V. I will jot down the total number of counts in the coming 100 seconds,

At 350V, the total number of counts is 4442, therefore, the count rate is 44.4 counts per second.

I will repeat this experiment for several times. Every time I will increase the voltage by 25V. Then, I will note down the applied voltage and the recorded total number of counts, and work out the count rate afterwards.

This experiment will be repeated until the voltage reaches 500V.

At 375V, the total number of counts is 8535, the count rate is 85.4 counts per second.

At 400V, the total number of counts is 8897, the count rate is 89.0 counts per second.

At 425V, the total number of counts is 9071, the count rate is 90.7 counts per second.

At 450V, the total number of counts is 9532, the count rate is 95.3 counts per second.

At 475V, the total number of counts is 9855, the count rate is 98.6 counts per second.

At 500V, the total number of counts is 9923, the count rate is 99.2 counts per second.

Based on the date collected, we can plot a graph of count rate against applied voltage.

This graph shows a plateau with threshold voltage at about 400V and plateau length of about 100V.

According to the graph, above the threshold voltage, there is only a small increase in the count rate even though we further increase the voltage.

For this set of GM tube and scaler, the working voltage is taken as the threshold voltage plus 50V, that is 450V.

Diffusion Cloud Chamber

Apparatus:

Diffusion cloud chamber   Dry duster

Weak radium source   Alcohol

Dropper   Dry ice

Diffusion cloud chamber is a radiation detector based on the principle of ionizing power.

In this experiment, we will observe the tracks of α, β and γ radiation by using a diffusion cloud

chamber.

Here we have the set-up for the experiment. The main apparatus includes a diffusion cloud chamber,

a weak radium source, a bottle of alcohol, a dropper, a duster and dry ice.

Here you can see the cloud chamber that we use in this experiment.

Cloud chamber is a transparent, cylindrical container. A metal plate separates the upper part from

the lower part.

Here is a hole. Through this hole, we can insert a radioactive source into the cloud chamber.

At the bottom of the cloud chamber, there is a round foam pad.

Later on, I will put some dry ice on it and cover it with the foam pad,

then screw the base lid back on.

At the top of the upper part of the cloud chamber, there is a transparent lid. We can observe the

tracks of α, β and γ radiation through this lid.

There is a felt ring in the upper part of the cloud chamber, later on, I will use a dropper to add some

alcohol to it.

Now, I will insert the radium source into the cloud chamber through this hole.

I will also use a dropper to add some alcohol to the felt ring, and put the lid back. Now, let us

observe carefully the tracks produced inside the cloud chamber.

If necessary, we can rub the plastic lid of the chamber with a dry duster.

By doing so, charges will be produced on the plastic lid and can disperse the ions produced by

radiation.

Therefore, more ionization can be resulted.

As we can see, there are some broad and straight tracks scattering from the source. These are the

tracks of α radiation. They are about 3 to 5cm long.

If we want to see the tracks of β and γ radiation only, we need to place a tin foil in front of the

radium source.

It is because tin foil can effectively stop α radiation. Only β and γ radiation can successfully pass

through the tin foil. However, since the tracks of β and γ radiation are thinner and fainter, they

cannot be easily seen by naked eyes. As a result, we can only see few faint, thin and twisting tracks.

By using cloud chamber, we can distinguish α, β and γ radiation by observing the tracks produced

inside the chamber.

Magnetic Deflection of β particles

Apparatus:

Timer-scaler   2 lead blocks

Geiger Muller tube   A pair of slab magnets

β source (strontium-90)

Through this experiment, we can find out whether β radiation carries any charge and if so, investigate its polarity by observing its deflection in a magnetic field.

Here are the apparatus that we need for this experiment:
a timer-scaler, a Geiger Muller tube, a pair of slab magnets, 2 lead blocks, a β source – in this experiment, strontium-90 will be used, and a stop-watch.

Firstly, I will connect the scaler to the GM tube and place the β source about 15cm from the GM tube. Please make sure that the source is pointing along the axis of the GM tube.

We can start our experiment as soon as the set-up is ready.
Now, I will switch on the scaler and set the voltage on the scaler to about 450V.

At this moment, the reading on the scaler should show an increasing number of counts.

Then, I will place two lead blocks on the two sides of the radioactive source so that a narrow gap is formed right in front of the source.
Therefore, the emitted radiation can only pass through the narrow gap and travel straight towards the GM tube.
Otherwise, the β radiation emitted will spread through a wide angle, resulting in an inconspicuous magnetic deflection.

After forming the narrow gap, I will try to find out the count rate under the condition that β radiation is not deflected.

Firstly, I will reset the reading on scaler to zero. With the help of a stop-watch, I will note down the total number of counts on the scaler in the coming 100 seconds. 5…4…3…2…1…

In 100 seconds' time, the recorded total number of counts is <u>2619</u>, the count rate is <u>26.2</u> counts per second.

Now, I will place a pair of slab magnets between the GM tube and the β source. Do you notice that there is a great reduction in the count rate?

I am going to move the GM tube around until there is a great increase in count rate again.

Now, I will find out the count rate when β radiation is deflected in a magnetic field.

After resetting the reading on the scaler to zero, I will make use of a stop-watch and find out the total number of counts recorded in 100 seconds. 5…4…3…2…1…

In 100 seconds' time, the total number of counts is <u>2353</u> while the count rate is <u>23.5</u> counts per second.

The result shows that we have to move the GM tube to a specific position to obtain a count rate which is approximately close to the original count rate.

This experiment tells us that β radiation deflects in a magnetic field.

Now, we have already found out the direction that β radiation deflects,

can you work out whether β radiation carries any charge and deduce the charge it carries by using Fleming's left hand rule?

Penetrating Power of α, β & γ Radiation

Apparatus:

Timer-scaler	γ source (cobalt-60)
GM tube	Several sheets of paper
Stop-watch	Several aluminium sheets
α source (americium-241)	2 lead sheets
β source (strontium-90)	

Different types of radiation vary in their penetrating power.

In this experiment, we will compare the penetrating power of α, β and γ radiation.

Here we have the apparatus we need for the experiment. The main apparatus includes: a timer-scaler, a Geiger-Muller tube, an α source – today, we are using americium-241, a β source – the one we are using today is strontium-90, a γ source – the one we are using today is cobalt-60, several pieces of paper, aluminium sheets of different thickness, 2 lead sheets and a stop-watch for keeping the time.

In our surroundings, there exist a lot of weak radiation called background radiation.
To prevent the background radiation from affecting our experimental result,
we will first find out the count rate of background radiation before investigating the penetrating power of α, β and γ radiation.

Firstly, I will connect the scaler and the GM tube
Turn on the scaler, and set the voltage on the scaler to 450V.

As what we have to measure is the background radiation, we should not put any radioactive source near the GM tube.

I will then note down the total number of counts in 100 seconds.

Now I am going to reset the reading on the scaler to zero,

With the help of a stop-watch, I will start keeping the time, 5…4…3…2…1.

In 100 seconds' time, the recorded total number of counts is 98.

We have to repeat the above procedure for several times in order to find out the average count rate.

It is found that the count rate is about 1 count per second.

β radiation

Now, we will move on to find out the penetrating power of β radiation.

I will first put the β source 5cm from the GM tube.

Then, I will find out the total number of counts in 100 seconds and the count rate by using a scaler and a stop-watch.

Now I will start keeping the time, 5…4…3…2…1

100 seconds has passed, the recorded total number of counts is 41287. Therefore, the uncorrected count rate is 412.9 counts per second.

Later on, I will insert aluminium plates of different thickness between the radioactive source and GM tube.

Then I will try to find out the recorded total number of counts in 100 seconds and the count rate under the condition that radiation has passed through the aluminium plate.

Now, I am going to place a 0.1mm thick aluminium plate between the source and the GM tube.

After 100 seconds, the recorded total number of counts is 34541 while the count rate is 345.4 counts

per second.

Now, I am going to place a 0.25mm thick aluminium plate between the source and the GM tube. After 100 seconds, the recorded total number of counts is 28261 while the count rate is 282.6 counts per second.

Now, I am going to place a 0.4mm thick aluminium sheet between the source and the GM tube. After 100 seconds, the recorded total number of counts is 24321 while the count rate is 243.2 counts per second.

Now, I am going to place a 0.55mm thick aluminium plate between the source and the GM tube. After 100 seconds, the recorded total number of counts is 19846 while the count rate is 198.5 counts per second.

Now, I am going to place a 0.91mm thick aluminium plate between the source and the GM tube. After 100 seconds, the recorded total number of counts is 12342 while the count rate is 123.4 counts per second.

Now, I am going to place a 1.62mm thick aluminium plate between the source and the GM tube. After 100 seconds, the recorded total number of counts is 4354 while the count rate is 43.5 counts per second.

Now, I am going to place a 2.02mm thick aluminium plate between the source and the GM tube. After 100 seconds, the recorded total number of counts is 1869 while the count rate is 18.7 counts per second.

Now, I am going to place a 2.68mm thick aluminium plate between the source and the GM tube.

After 100 seconds, the recorded total number of counts is 478 while the count rate is 4.8 counts per second.

Now, I am going to place a 3.22mm thick aluminium plate between the source and the GM tube. After 100 seconds, the recorded total number of counts is 192 while the count rate is 1.9 counts per second.

Now, I am going to insert an aluminium plate of 5.24mm thick between the source and the GM tube.

After 100 seconds, the recorded total number of counts is 161 while the count rate is 1.6 counts per second.

According to the data collected, do you notice that when the thickness of aluminium plate reaches 5mm or above, the recorded count rate will reduce to approximately that of background radiation? Therefore, we can say that aluminium sheets of 5mm thick can completely block the β radiation.

γ radiation

Finally, I will try to find out the penetrating power of γ radiation.

I will place a γ source 8cm from the GM tube.

By using the scaler and the stop-watch, I will find out the total number of counts in 100 seconds and work out the count rate.

100 seconds has passed, the recorded total number of counts is 286. It means that the uncorrected count rate is 2.9 counts per second.

Now, I will place this 20mm thick lead block between the GM tube and the radioactive source. Let's see if there is any great change in the total number of counts within 100 seconds' time.

After inserting the lead block, the recorded total number of counts in 100 seconds is 156 while the count rate is 1.6 counts per second.

Now, I will insert another 20mm thick lead block between them.

After the insertion of two 20mm thick lead blocks, the recorded total number of counts in 100 seconds is 130. So, the count rate is 1.3 counts per second.

Based on the data collected, it is found that a 20mm thick lead block can reduce the strength of γ radiation by half. But 2 lead blocks of altogether 40mm thick cannot completely block the γ radiation.

Therefore, we can believe that a 25mm thick lead block can reduce the strength of γ radiation by half but it cannot completely block the γ radiation.

α radiation

After working out the count rate of background radiation, we can now move on to investigate the penetrating power of α radiation.

I will first place an α source 1cm in front of the GM tube

and start to measure the count rate for 100 seconds.

According to the scaler, it is found that the total number of counts recorded in 100 seconds is 2629 and thus the count rate is 26.3 counts per second.

Please keep in mind that the corrected count rate is only obtained if count rate of background radiation is subtracted from the measured count rate.

Now, I will insert a piece of paper between the GM tube and the radioactive source and pay attention to the effect on the count rate.

After inserting one piece of paper, the recorded total number of counts in 100 seconds is 2525. So the count rate is 25.3 counts per second.

It can be seen that the count rate doesn't change much after a piece of paper is inserted.
Now, I will insert one more piece of paper between them.

After inserting altogether 2 pieces of paper, the recorded total number of counts in 100 seconds is 2514, it means that the count rate is 25.1 counts per second.

It's quite surprising that there is not much change in the count rate after the insertion of 2 pieces of paper.
Now I will insert 2 more pieces of paper between them.
There are altogether 4 pieces of paper.
Let's see whether the count rate would greatly reduce.

After inserting 4 pieces of paper, the recorded total number of counts in 100 seconds is 2328, so the count rate is 23.3 counts per second.

Everyone of us may have expected that 4 pieces of paper is more than enough to stop α radiation.
However, a relatively high count rate is still obtained. What is the problem indeed?

Ah, we came to find that americium-241 is not a pure α source.
Besides α radiation, americium also emits γ radiation, whose strength is quite high indeed.
Therefore, we cannot just use several pieces of paper to stop the γ radiation emitted from

americium-241.

In fact, we cannot separate γ radiation from α radiation and use only α radiation to perform this experiment.