The Production, Properties and Uses of X-Rays

Course: PHYS 2604

Date: 2016

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# **Purpose**

The purpose of this experiment is to become familiarized with the processes which create x-rays, and the uses for these x-rays in both a practical and laboratory manner. We are able to view some real life applications of the physical processes we describe by sometimes abstract physics equations.

# **Theory**

## Roentgen Observation

Performed in approximately 1895 German physicist Wilhelm Rontgen (Roentgen in English) was the first scientist to systematically study radiation of extremely call wavelengths deemed by him as x-rays. In Roentgen’s experiment he used a darkened room like the one used in the procedure below. In Roentgen’s experiment he set up a beam of x-rays and remarked that there was a shimmering from a barium platinocyanide screen he had been intending on using to test his idea. He speculated that this radiation must be coming from some new type of ray. He deemed this the x-ray. He won the first Nobel prize for physics in 1901.

## Spark Gap

A spark gap is two conducting electrodes that are separated by a small distance within a gas such as air. When the potential difference between the two electrodes is great enough the gas begins to ionize and there is a spark that flows between this process drastically can reduce resistance. Adding x-rays to the gas will allow for a quicker ionization of the gas within the chamber and therefore generate a slightly smaller value for the potential difference needed to create a spark gap.

## Geiger-Muller

In the 10 years since Roentgen discovered scientists were looking for protection from the harmful x-ray radiation that they wanted to study. and protect themselves from the invisible harmful effects of radiation. The invention of the Geiger counter was a scientific discovery used to further advance our understanding of the atom. Invented in 1911 by Hans Geiger, the very first Geiger counter could only detect alpha particles. However, years later with his doctoral student Walthur Muller, together they improved the counter and created the Geiger–Muller counter which we all know today. This device could detect multiple types of radiation and was much more efficient. This detector can count the number of counts/second of radiation from the x-ray machine used in this experiment.

## Inverse Square Law

The inverse square law is an explanation of how the intensity due to a radiating source drops off proportionally to the square of the distance from the source. This can be modeled using the counts/second vs. distance from the source data. In this portion of the experiment we will be measuring both the distance from the source and the counts/second of x-rays detected by the Geiger Muller counter.

## Ionization Chamber

The ionization chamber is the simplest of all gas-filled radiation detectors, and is widely used for the detection and measurement of certain types of ionizing radiation including but not exclusive to x-rays. It uses the discrete charges that are created by the interaction of incident x-rays and the gas within the ionisation chamber. The detector can track the movement of an incident radiation particle through and electric field. Creating a current which can then be measured.

## Photographic detection/Photographic Process/Rectilinear Propagation

Light travels in straight lines. This was known at the time of Roentgens discovery. What was not known is the fact that the x-rays that Roentgen was discovering were in fact a form of electromagnetic radiation. Therefore, these x-rays should therefore be able to travel straight and hit an object. However, when Roentgen performed the experiment and imposed different thicknesses of plates between the x-ray emitting device and a piece of photographic plate; he found that the photographic plate showed varying transparencies. He then produced this same process using his wife’s hand which revealed the shadows produced by her bones on the photographic plate. This was the first time the photographic process/photographic detection was shown using x-rays. It confirmed that x-rays and light rays had in common the ability of rectilinear propagation.

# **Apparatus**

-Cenco High Potential DC Power Supply

-Tel-X-Ometer, TEL. 580. (X-ray Production machine)

-Luminescent Screen

-Adhesive tape

-Film Cassete

-Auxillary Slide Carriage

-Ionisation Chamber

-Geiger-Muller Counter

-Screen for x-ray machine

-Metal Backstop with supporting wires for x-ray machine

-Small piece of to insert inside slit

-Two steel needles for Spark Gap and Rectilinear Propagation

-Pico-amplifier

-Voltage divider

- Kepco D.C power supply source

# **Procedure**

## Roentgen Observation

1. Insert the luminescent screen in slot 13.
2. Insert screen with metal gate facing towards x-ray machine
3. Observe the imagine of the metal gate and its supporting wires on the screen
4. Invert the fluorescent screen and repeat the process.

## Spark Gap

1. Attach two steel needles to the auxiliary carriage and hook the high voltage D.C power supply to either end of the needles to create a potential difference between the needles.
2. First observe the voltage required to create a spark gap without the presence of x-rays. By changing the voltage on the D.C power supply.
3. Turn x-rays on to 30Kv and change the voltage of the high voltage power supply. Until you observe the potential difference required to create a spark gap within the chamber.
4. Turn x-rays on to 20Kv and observe the potential difference required to create a spark gap within the chamber.

## Geiger-Muller Detection/Inverse Square Proportionality

1. Attach the Geiger-Muller counter to the reader
2. Insert the counter into a slot
3. Turn on x-rays and observe the counts/second at a certain distance
4. Move Geiger-Muller counter to 7-10 different slots and observe the counts/second
5. Make sure to record distance from source to the Geiger-Muller counter.

## Ionization Chamber

1. Mount the ionization chamber in slot 13.
2. Connect ionization chamber to the power supply to create a difference in between the cathode and anode.
3. Connect the rest of the circuit as modelled in figure 1.
4. Using logger Pro begin with the x-rays off and zero the readings on the lab-quest mini.
5. Switch the x-rays on and record the first position.
6. Start to increase the voltage supply at small increments of the voltage and record the current detected through the ionization chamber at these times
7. Curve fit the data with the appropriate curve fit

## Photographic Detection/Photographic Process/Rectilinear Propagation

1. Attach the steel needles length wise along the auxiliary slide. Opposite to the spark gap. 9 mm spacing between needles and 13mm from the bottom of auxiliary slide
2. Add film pack behind of the auxiliary slide in slot 14
3. Expose the film pack to x-rays for 2 seconds
4. Slide the film pack into slot 22, expose for 4 seconds to x-rays
5. Slide the film pack into slot 30, expose to x-rays for 6 seconds
6. Measure the distance between the slots.
7. Develop the film and measure the distance between the 3 needle points.
8. Construct a diagram of the experimental layout.

# **Analysis**

Roentgen Observation

The X-ray machine was turned on following the procedure outlined in 3.1. X-rays were then observed hitting the luminescent screen just as Roentgen observed these same X-rays light up the barium platinocyanide screen he was about to test. We then placed a metal backstop with supporting wires into a closer slit and observed the pattern of the backstop on the luminescent screen. These X-rays were exciting the luminescent screen so that it was giving off energy.

Spark Gap

Spark gap

Geiger-Muller Detection/Inverse Square Proportionality

Logger Pro File

Ionization Chamber

Logger Pro files

Photographic Detection/Photographic Process/Rectilinear Propagation

Photographic detection for this experiment was done using a chemical photographic detector. This detector is used to observe the radiation hitting the film pack because our eyes are unable to view x-rays. In our photographic detection case a silver halide molecule is split by the x-rays into it’s two daughter atoms. The developing liquid then only works on the particles of silver halides that have been exposed to light to develop the image created by the radiation (x-rays in our case). The x-rays were shot at the photographic detector at different distances for different amounts of time to allow for the same intensity of radiation to hit the photographic detector each time. This keeps all six pins on the photo look approximately the same intensity. To view the photograph detected by the detector, we need the process described below on photographic processing.

The Photographic process is really quite simple and for us only involved 5 steps.   
They are listed below.

1. The developer is injected into the packet and the hands are used to move the developer around to develop all of the film inside the film packet.
2. The developer is then poured out thoroughly and rinsed lightly
3. The fixer is then quickly injected into the film packet to make the image permanent
4. The image is cleaned in cold water to wash any residual developer or fixer away from the film’s image. Residual fixer may lead to a stained image.
5. The image can then be cut from the packet washed a little more if needed and can be viewed.

# **Discussion**

D1 – Roentgen Observation ( description and explanation ) -5

D2 - Spark Gap (explanation ) -10

D4 – Detection by Geiger- Muller counter ( brief explanation ) -5

D8 – Inverse Square Law ( calculated distances , record of GM counts, LoggerPro file and CurveFit ) -20

D3 – Ionization Chamber (a detailed circuit, Vp vs Ic for 30kV 50 A; 20kV 50 A; 30kV 20 A , tables, LoggerPro graphs , ) -20

D5 – Photographic Detection (describe and explain the procedure ) -5

D6 - Photographic Process ( brief explanation ) -5

D7 - Rectilinear Propagation ( diagram of the layout , table with distances and exposures, confirmation of the rectilinear propagation of X-rays ) -20

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# Appendix

# References

**There are no sources in the current document.**