What Compton's Experiment Reveals About How Light Works

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'The language of science is universal, and is a powerful force in bringing the peoples of the world closer together.'

Arthur Compton - Banquet speech for his Nobel Prize, 1927.

SETTING THE STAGE

Every day light bounces off the surfaces all around us and into our eyes. In 1905 **Albert Einstein** had introduced the theory of the Photoelectric effect, which was the first theory to explain light not only as a wave – *as illustrated by the artist 'Pro-Zak' (Fig 1)* - but as discrete parcels of waves with a finite energy known as '**photons**'. Einstein postulated that the visible light we see is made of **tiny packets** of energy known as photons**,** which our eyes and brain have evolved to see with. 15 years after Einstein's great insight, **Arthur Compton** *(Fig 3)*, devised and experiment that would dramatically confirm Einstein's theory. Compton predicted that if these small packets of light interacted with the world around them, they may change in some way after an interaction. If there was a change and it could be measured, then it would be confirmation that light did also travel as a particle.

THE EXPERIMENT

With excitement (and some trepidation!) we set up a small team to replicate this famous experiment and its revolutionary results. Collaborating in teams is essential in science, and the work of different peoples all pulling for the same result is very powerful.

Collaboration creates something better than any one person is capable of, and is one of the many aspects that makes doing science experiments so enjoyable. Reproducing previous landmark results yourself not only shows you how something was practically done, but helps animate dusty textbooks by bringing real science to life!

Our experiment fired **high energy X ray** photons (the packets of light we mentioned earlier) generated by a block of the radioactive element – Molybdenum in our case - at a Perspex target.

This experiment uses high energy **photons** to 'knock off' loosely held particles smaller than atoms in the plastic known as '**electrons**' (much like knocking coconuts off a stand at a fair with a tennis ball… except much much smaller!). After the collision we use detectors in different positions capture where the photon goes, known as the 'scattering angle' of the photon (aka tennis ball) goes after the collision.

In an ideal world, you would place detectors everywhere and could do the experiment as many times as you wanted, but the equipment available could only measure specific angles and the team had limited time with this incredible equipment. This is where the planning and teamwork really show, as the theoretical ideals meet the real world. Anticipating this we had already planned an efficient and timely sequence of angles to be measured to give us best spread of measurements we in the time slot we had available to mine for results. On the day of the experiment you need to be flexible and keep the main aim of the experiment in mind. Unexpected challenges in experiments with limited time and can beat any **theme park thrill ride!**

THE RESULTS

Although we knew what we should see, it is with relief and a strange fascination that we found the same results as Arthur Compton had found almost a century earlier… that photons lose differing amounts of energy when they collide with stationary electrons depending on what angle they are scattered by. The greater the angle of the scattered photon from its original path, the **greater the loss of energy.**

Showing that individual photons behave differently in a collision at different angles it shows that one photon is not linked in a wave to all the others that it was travelling with. This lays the foundation for the theory that all the technology used in the modern world is based on… the science of how very small things work known more famously as '**Quantum Mechanics**'.

WHAT'S NEXT

Quantum Mechanics completely revolutionised our understanding and it's continued study is still yielding ground-breaking practical insight into our world. Some of the biggest steps being taken are in the world of 'quantum computing' which has the potential of giving us incredibly fast computers for very low processing power (faster internet anyone?).

So whether its ground-breaking cancer treatment or harnessing energy in solar panels (*Fig 2*) understanding how the breakthroughs of yesterday were made gives us an insight into the **future technologies** of tomorrow.

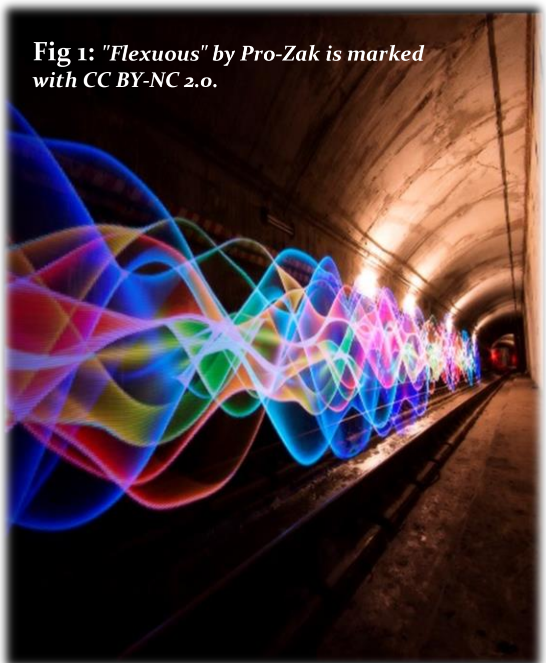

Fig 1: ***"Flexuous" by Pro-Zak is marked with CC BY-NC 2.0.***

(left) Fig 2: *"Solar panel on used for lighting village homes" by World Bank Photo Collection is marked with CC BY-NC-ND 2.0.*

***(Right)* Fig 3:** *"Compton,Arthur 1929 Chicago.jpg" by GFHund is marked with CC BY 3.0.*