Quantum Eraser

Anisha Yeddanapudi

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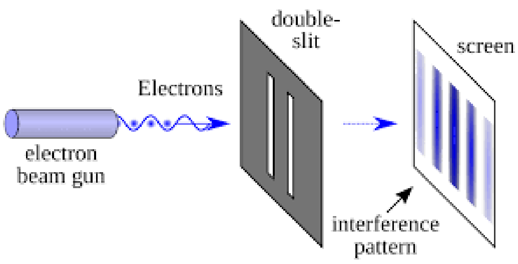
My goal here is to go over the quantum eraser experiment in better detail so that everyone is on the same page with what we're trying to do.

§1 Double Slit Experiment

We begin by understanding the general Young's double slit experiment. A source emits particles (electrons) towards a screen that has two slits. The electrons can pass through these two slits to a screen on the other side, where they make a mark depending on the slit they passed through. As more particles accumulate, they result in a interference pattern affirming the wave nature of quantum particles.



However, now let us assume that your place a detector at each of the slits which counts the number of individual electrons that pass through each slit. Would the interference pattern still be visible? No.

The reason for this has to do with the inherent nature of quantum superposition. As explained by Schrondinger's cat, when there is a lack of observation the cat is in a superposition of states (being alive and dead). However, once your open the box and take a 'measurement' of the cat, it's no longer alive. We destroy the superposition.

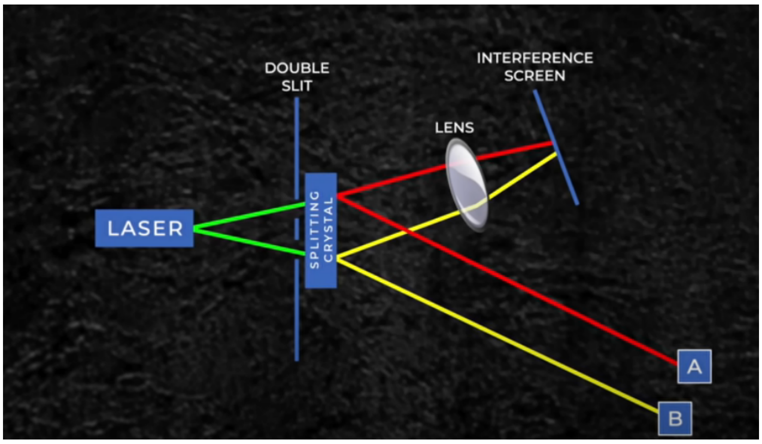
Same thing happens when adding this extra detector to the double slit, the paths that an electron can take to the screen are no longer indistinguishable. We have lost the superposiiton, and therefore, also lost any information that was associated with it (the intereference pattern).

§2 Quantum Eraser

There are multiple different variations to the quantum eraser experiment, we're going to be discussing just one which hopefully will give you some ideas as to how to conduct your own.

§2.1 Non-Temporal

Consider the following experimental set up. The splitting crystal creates two beams of entangled photons. The detectors A and B are used to determine which slits each of the photons traveled through. In this case, we place the detectors far enough such that the photons hit the screen before they are able to travel to the detectors.



What should we be seeing? Well, one might think that since we don't know which of the slits each of the particles travel through until AFTER they have already hit the screen an interference pattern should be visible. However, that is NOT the case, **we actually LOSE the wave pattern**.

> The particle or wave pattern is created by whether a detector in the future sees which slit the photon goes through.

This highlights the non-temporal aspects of quantum mechanics since we have basically rewritten the past from the future.

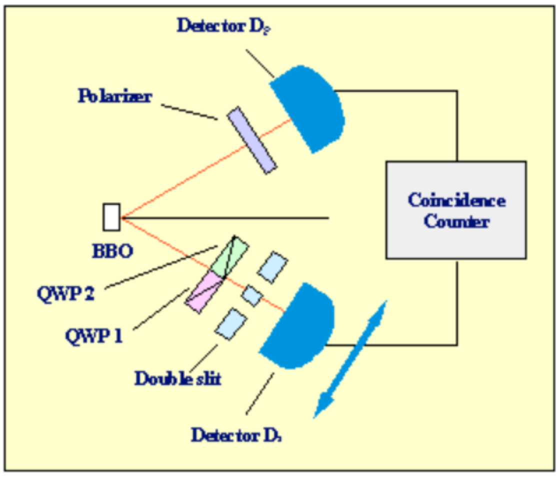
Delayed Choice

There is a way to add delayed erasure such that we measure the one beam of photons prior to the erasure of information regarding which slit the photon traveled through. What do we expect to see?
One would assume that since we still have the infromation regarding which slit the particle went through we should lose the interference pattern. However, that is not the case, somehow the particle is able to sense that the information will be lost in the future allowing us to regain the fringe pattern.

∼ ASIDE: "MANY-WORLDS" INTERPRETATION ∼
One interpretation of quantum mechanics that might succeed in helping us understand this is the many-worlds interpretation. An important thing to realize is that our understanding of the past is solely dependent on our view of the present.
For more details about this let me know!
∼ END ASIDE ∼

§2.2 Non-Locality

In general, we can create situations where we are able to determine or not determine which slit the photon goes through, and as a result, obtain a particle or wave pattern on a screen. We can add an additional metric to 'erase' the information we have about which slit the photon goes through.



There are a couple different ways to do this (in the video they use silvered mirrors and extra dectectors). The one I'd like to highlight was done in this paper I sent over a couple times. By adding a additional polarizer to the p beam such that all light of x and y combined polarization will pass through, causes us to lose the information of which slit the s photons passed through, regaining the interference pattern.

This means that there must be some level of 'communication' between the two photons which allows the p photon to tell the s photon whether or not to produce the interference pattern. This shows the inteherent non-local behavior of entangled quantum particles, as information is able to travel faster than the speed of light between p and s.

§3 Thoughts and Notes

If this is not making sense to you feel free to read through the various resources I sent and referenced here.