

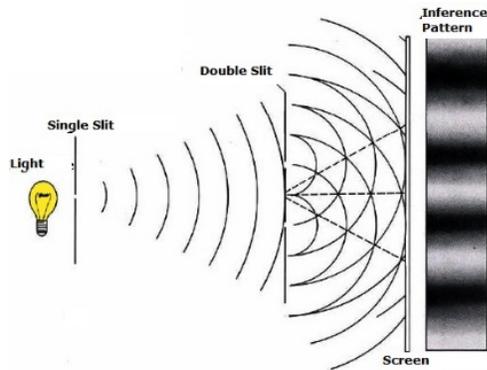
PH407H
Weird World of Quantum Mechanics
Dr. A. Stetz

Essay 1: T. Hellmuth et al, "Delayed-choice experiments in quantum interference," *Physical Review*

I embark on this essay heartened by the reassurance that logical contradictions abound in quantum mechanics. There are few certainties, and even an English undergraduate like myself might lean into imaginings of the significance of quantum mechanics. I am experiencing an interesting dualism as I progress through the readings in this course (not just a particle/wave duality). One part of me is overwhelmed and somewhat lost, while another part of me is genuinely excited by all the possibilities quantum mechanics offers. Like the tinman at the local YMCA trying yoga for the first time, I am trying to force my brain into the shapes required to understand what I am reading. What is difficult for me is visualizing the experiments and grasping their significance with my limited experience in physics. Like the tinman might, I have found some compromises that leave me feeling less sore. I skim the sections which have the highest proportion of squiggles (everything that resorts to algebraic language to describe processes and results) and head straight for words and pictures. However, it is my task in this essay to attempt to explain "the experiment, the technology, and the significance of the result."

In the article, "Delayed-choice experiments in quantum interference", Hellmuth et al begin by discussing Young's interference experiment: the original 'double-slit' experiment, as well as subsequent versions of the experiment. As far as I understand it, in Young's experiment a light source is directed toward a plate with a slit in it. This slit ensures that the light entering the experiment is originating from a single source. The light travels through the slit and encounters a plate with two parallel slits in it. The light passes through the two slits and can then be observed on a screen behind the plate. The light behaves like a wave, in that it splits into two to pass through the parallel slits and these two waves interfere with each other (cross) after passing through the slits, thereby producing bright and dark

bands on the screen. The light behaves like individual particles, in that it is absorbed by the screen at individual points and the interference pattern appears because of the varying density of these points.



What's more, when detectors are placed at the slits we find that individual photons pass through just one slit (as one would expect from a particle), and not through both slits (as would a wave). When observed, they change from exhibiting wave qualities to exhibiting particle qualities! The photons do *not* form the interference pattern if one detects which slit they pass through.

Apparently, it is only possible to “observe either the path or the interference of the photon but never both simultaneously.” This is due to the Heisenberg uncertainty principle, mathematical inequalities which assert that “the more precisely the position of some particle is determined, the less precisely its momentum can be known” (*Uncertainty Principle*, Wikipedia).

Hellmuth et al's article describes two delayed-choice interference experiments suggested by Wheeler to determine whether “the result of the experiment is changed if the decision for observation of either the path of the photon or interference is made *after* the photon has passed the slits”. One of the experiments is based in the spatial domain and the other is in the domain of time. In a very basic sense, the experiments indicated that even after a photon has passed through the slit, the wave function collapses once the decision for observation occurs. This seems to defy logic. It seems that the manner in which the photon traveled was decided only after it arrived. Interestingly, Wheeler has suggested that “No elementary phenomenon is a phenomenon until it is a recorded phenomenon”

which to me sounds a lot like the watcher is a required participant. Wheeler has also said, “the past has no existence except as it is recorded in the present.” This seems to me to hint that not only is the watcher a required participant, but he might *retroactively* participate.

Is there a potentiality for human awareness (consciousness) to influence ‘is-ness’? This would mean that consciousness allows a human being tremendous creative power and therefore responsibility. (“Walk softly on the Earth”, indeed...) It would mean that all sentient beings have value beyond an intrinsic value as isolated units. I am excited about what this might mean in terms of human connection across time and space. What if temporality isn’t linear? What if time travel isn’t about riding in a machine that allows you to turn the clock backward or forward (an entirely physical imagination of time-travel), but rather is a connectivity that reaches backward to ancestors and forward to descendants, a connectivity that is woven deeply into place? This seems as plausible to me as any other explanation.