The Delayed Choice Experiment

The aim of this experiment is to trick photons to explicitly “choose” whether to act like waves or particles at the start of a test—and then modify the experiment midway to see if this influences their identity (a). One type of delayed-choice experiment uses either one or two “beam splitters”—a kind of mirror that divides the light and sends it along two perpendicular paths—and a number of light detectors to tell you which path (or paths) the light took during the test. With only one beam splitter in the apparatus, the light will behave like a particle, moving along either one path 50% of the time or the other path 50% of the time, as in (a). But when two beam splitters are in play, the light acts as a wave, as in (b).

Particle behavior

(a) When light is fired at a beam splitter, it acts as though it is made up of a beam of indivisible photons. Each photon will travel along one path or the other, at random. So each of the two photon detectors registers a count 50% of the time.

Wavelike behavior

(b) When a second beam splitter is introduced, the light switches behavior. Each photon that enters splits like a wave—travelling down both paths. The two waves are recombined by a second splitter. They then add up constructively, on the path to one detector, but destructively along the path to the second detector, canceling out the signal. So, only one detector fires, 100% of the time.

Shifting behavior?

(c) You can switch set-up midway through the experiment to try and trick the light. Start with only one splitter and let a photon enter the apparatus. It should take only one path. Then suddenly add the second splitter. You will find that only one detector fires, implying that the photon was acting like wave all along—splitting, traveling along both paths and then recombining. But why would the photon ‘choose’ to act like a wave at the start? How could it ‘know’ that you would later change the experiment? The delayed-choice experiment suggests to some physicists that choices made by the experimenter later can affect the behavior of light at earlier times.