THIS IS THE STORY OF A PHOTON…

Alain Aspect – This is the story of a photon, a single photon, a photon that has neither brothers nor sisters, and that arrives at a beam splitter. We all know an example of a beam splitter: the window on which a ray of sunlight arrives, and as everyone has seen, a part of the ray is reflected and a part of the ray is transmitted through the glass. Yes but...when the photon arrives on the glass, it cannot cut itself in two. So, what does it do? Either it will be transmitted, or it will be reflected. But light, as we have known since the beginning of the nineteenth century, is actually a wave! How do we know? Because Thomas Young in England and Augustin Fresnel in France have done many experiments showing diffraction and interference, properties that can only be explained by admitting that light behaves as a wave.To sum up: a *single* photon decides to go either on one side or on the other, which I can verify by putting a detector on each side, and observing that it is detected either on one side or on the other. And then I do a second experiment, in which I recombine the two sides of the beam splitter. There I observe interferences, that I only know one way of interpreting, that there was a wave, which was separated in two parts, and is recombined. Thus in the first experiment the photon behaves like a particle that can only go either on one side or another; and in the second experiment the photon behaves like a wave that is split. Weird, right? Yes, quantum mechanics is weird.

As it happens, this is the famous property of "wave-particle duality". It is perhaps less weird than it seems at first. As Niels Bohr taught us, the properties of microscopic objects depend on the type of measurement we do. So if I do a measurement to reveal wave properties, the photon responds like a wave. If I change the measurement apparatus, and take a measurement apparatus to reveal particle characteristics, the photon behaves like a particle. Well, a mischievous man, John Archibald Wheeler, imagined the following experiment. We will choose the measurement apparatus, which shows either wave or particle character, *after* the photon hits the first beam splitter. This means that at the very moment it arrives at the beam splitter, the photon — the object we are measuring — is not informed about the type of measurement that will be done on it later. Well, we continue to find (strangely!) that nevertheless, after everything is done, we continue to observe either wave behavior or particle behavior, depending on which measurement was done.

What can we conclude? This is one aspect of "quantum non-locality", in which it is only at the last moment, the moment we do the final measurement, when the photon is detected, that in some way the complete story will be frozen, including the past. Of course, this does not allow us to go backwards in time, but that does lead us, in our description of the world, to accept that from time to time there are strange things: it seems that the past is affected by the measurement we are doing in the present.

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