It from Bit et al.; Revisiting the Assumptions.

Abstract: Some puzzles or paradoxes are sometimes solved by returning to the original assumptions for re-examination. The 2 slit experiment can be understood as a quantum phenomenon instead of a classical wave phenomenon. For this, the measurement problem is first described as stemming from a temporary quantization due to the constraint applied by the measuring instrument, creating a boundary condition on the probability distribution of the parameter being measured. After suggesting a soliton model for light, this temporary quantization is then applied to the 2 slit experiment. A non-classical explanation is offered for the "interference" pattern resulting in the 2 slit experiments.

The origin of Weeler's gedanken

The delayed choice experiment from which Wheeler's it from bit et al. is derived takes its source in the detection (appearance) of either a wave or a particle according to the choice of measurement in the double slit experiment. The "it from bit.." gedanken is a long way from this double personality presented by light under a choice of measurement on the part of the observer. In this essay, instead of tackling this gedanken, I will go back and address directly the assumptions at the source of this chain of reasoning. This assumption states that light is either a particle or a wave depending on the choice of experimental set-up. The chain of consequences and inferences that follow may be solid but no more than the initial assumptions at the source. By this I mean that, although light may offer under specific experiments two different appearances, wave or particle, it does not mean that in fact light has to be or change from a wave or (exclusive OR) to a particle. It is quite a metaphysical leap to infer from two appearances the existence of two mutually exclusive forms and thereby entities.

We will recall that a particle in motion exhibits both the properties of a particle and of a wave, the associated wave, offering two different appearances or behaviors for a single entity. There are other possibilities we may consider before giving up to quantum weirdness. Take for example, an electro-magnetic soliton wave that would behave in some experiment as a wave and yet would also carry a precise quantum of energy that a photoelectric detector would resolve as a particle. Under this soliton hypothesis, the two appearances of wave or particle are not only possible but also expected. This is, I believe, a far simpler and rational explanation than a double personality transformation defying simple logic. In other words, a soliton like hypothesis offers the double appearance or behavior of particle and wave without forcing an exclusive choice between two types of entities. The electro-magnetic soliton, essentially a quantized wave or a quantum of wave, would remain a wave whether we measure its wave property or its quantum property.

A soliton light wave could go through both slits and recombine on the other side of the slits while carrying its unchanged quantum of energy that would make it appear as a point particle to the proper integrating detector. Now with a soliton, without a true point particle at hand, the question of what slit it went through becomes irrelevant. This soliton light waves model is a simple explanation that could take away the wave-particle duality. A beam of soliton light would not produce interference in the 2 slit experiments. How else could we explain the pattern produced in these experiments? As we will see below, the explanation could rest with the solution to the "Measurement problem".

Quantum weirdness

There is another important component assumption at the source of the delayed choice experiment, notably, the "weird fact" that the observer appears to change the outcome, wave or particle, by his choice of measurement. This can be understood in two ways. Each instrument detects or reveals only the specific property it is intended to detect. So, ***in a first way,*** the observer does change the appearance of what he will detect or measure by his ***choice of instrument***, just like measuring a voltage with a voltmeter or a current with an ammeter from the same electric circuit.

The measurement Problem

But when talking about the quantum world, one has to admit that observation, no matter the choice of instrument, does change the system being observed. This is the ***second way*** in which the observer's ***choice to measure*** changes the observation. Let's see how this could be. When in nature a system applies a constraint on the freedom of one or more parameters of its components, it limits the number of possible states the parameters of these components may take. It is in effect forcing a quantization of the constrained parameters. Only a specific number of solutions of the wave function will emerge for these parameters. Electrons in an atom assume the quantized states created/allowed by the conjunction of multiple constraints within the structure of the atom. Similarly, the constraints we apply in measuring a quantum level system are no different. When the observer uses an instrument meant to detect a property of a quantum system, say Z, this property Z within the system will be constrained by the instrument and will become, as well, temporarily quantized under measurement. This is the same process as found in an atom, except that it is caused by, and will last just as long as the measurement itself. The observer does, by his choice to measure, change the system under observation and he chooses specifically which part or property of the system will be affected and therefore quantized. We may understand the process of temporary quantization as follow. The probability curve of any parameter (to which we assign here ontological existence) normally has tail ends going to infinities. When the measuring constraint is applied to the system, these infinities of the curve are replaced by certainties, like the walls of a box. The newly formed box forces quantization within these walls, allowing only a limited set of values to appear. This quantization lasts only as long as the measurement constraint does. Any measurement produces such a constraint on a system. That is, I believe, the source of the measurement problem.

Consequences

The observer abiding by this measurement limitation would know that under his observation he should expect a quantization of the property he is measuring in the system under observation and that, the part of the measurements that will be significant will be quantized. Although the property he is measuring may be generally understood as being continuously variable (and may even appear as such) he will accept only the quantized part of his results as valid.

For example, he could be using a pair of polarizers. In the usual setup, light goes through a polarizer and an analyzer. The polarizer is the measuring instrument applying a specific constraint onto the property of polarization of light. The system is now quantized and may only offer two possible results at the analyzer; light passes or it does not. All other angles of polarization exiting the analyzer, if any, are to be ignored!

Slit experiments

Now let us consider the "property" of direction of light as another example. Light may go in any direction and "any direction" means that "direction", as a property of light, is continuously variable, within its distribution curve. Now, let us send a collimated light beam through two slits... The apparatus applies constraint specifically on the property of direction. Should the direction taken by light exiting the two slits now be quantized? Why not? In theory, it should! Do we know for sure that the "interference" pattern is all and only a wave phenomenon, and not just (or partly) an example of temporary quantization of a continuous variable under the constraint of observation?

Suggested Explanation

We have seen above the explanation for the temporary quantization of continuously variable parameters under the constraint of measurement. The bell shape probability wave of light has tail ends with infinities. Once the wave goes through the slit, probabilities are constrained to a space of certainty. The new boundaries cause quantization of the wave's direction, which is the property affected by this experimental set-up. Only a certain number of ways to go through the slit will be allowed. This is a temporary and localized quantization of the probability wave of direction. In the case of a 1 slit set-up, the quantization of direction is contained within the slit's opening where the constraint lies. As the probability wave exits the slit, the freedom recovered allows the infinities back into the probability wave now adapted to the slit's opening. The direction light may take is any of a continuous centered distribution of directions. This results in the typical diffraction spread observed. In the case of the two 2 (or more) slits experiment, something different happens. The temporary quantization extends beyond the constraint of the slits. How is this possible? Right past the two slits, the recombining of the two lobes of the probability wave create a temporary barrier/wall to each other. This *constraint* causes the quantized directions to extend beyond the slit's opening. The protruding quantized directions now spread evenly by sharing freedom (and infinities) and each now is acting like a single slit opening that is diffracting.

Discussion

Above, I suggested that the use of a soliton wave model would support the wave-particle dual appearance of light without having to resort to an actual double state of wave and of particle. Since the soliton is essentially a quantum of wave, it is unlikely that is would produce interference patterns in the 2 slit experiments. Then, how would we explain the resulting pattern if the soliton model is considered? The 2 slit experiment resulting discrete pattern suggests that maybe a quantized scheme is involved.

This is where the measurement problem, explained in terms of temporary quantization, came to the rescue. But, admittedly, the concept of quantized “direction” is less than clear. Is the probability wave of the soliton quantized as it travels within the slit, or is the actual “roadway” within the slit already quantized/mapped? Or can we have both? Since the constraint is due to the small permanent opening of the slit, it would be logical to assume that the “roadway” within the slits is already and permanently mapped whether light is passing or not. Actually, some kind of light or vacuum fluctuations is continuously present within the slit, if we recall the conclusions of the Casimir (effect) experiment. This would mean that the interior of the slit is already mapped with some geodesic line that the soliton would follow. The quantized directions would still be protruding outside the slits due to the probability wave and cause a dispersion that could be matched to the wavelength. If this is true, the 2 slit experiments would have been showing a pattern revealing not so much the wave nature of light as the quantized nature of the space within the slits it travelled. This is just an idea. It would require a detailed theory and experimentations to validate the temporary quantization due to measurement, the soliton model and finally, the trajectory based pattern in the 2 slit experiments...

In this essay about Wheeler’s delayed choice experiment, I have chosen to address the assumptions at its source. This assumption pertains to the change of light from a wave to a particle or vice-versa following a choice of measuring instrument. I suggest that we don’t have to make an exclusive choice of states for light, between a wave or a particle, based on appearances of the two forms, wave or particle, when a possible structure like a soliton wave model for light could offers both appearances under the guise of only one state or entity. I explain that the *choice of the instrument* naturally determines what property will be detected. I also explain how, at the quantum level, the observer in his *choice to measure* a specific property does effectively affect that property of the system by the constraint applied on this property by the measuring instrument, and that the measurement of such property comes at the price of the quantization of the said property, within the system, to some extent, and in the significance of the results. These considerations require, I beleive, that we revisit some assumptions before addressing the Wheeler’s “it from bit...” gedanken.