A Plausible Explanation of the *double-slit* Experiment in Quantum Physics

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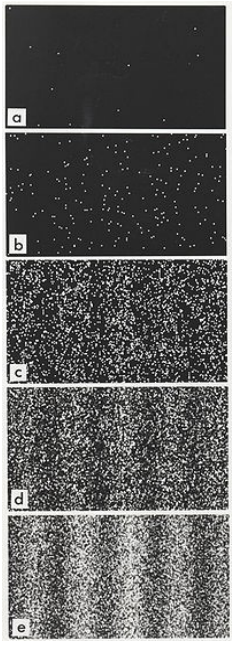
Abstract: A plausible non-Quantum Mechanical explanation to the *double-slit experiment* is considered. This is based on the view that globally energy propagates continuously as a wave while locally energy is manifested (measured or observed) in discrete units. The 1989 Tonomura 'single electron emissions' double-slit experiment is used as a backdrop to this discussion.

The 'double-slit experiment' (where a beam of light passes through two narrow parallel slits and projects onto a screen an 'interference pattern') was originally used by Thomas Young in 1803, and latter by others, to demonstrate the 'wave-nature' of light. This experiment came in direct conflict, however, with Einstein's *Photon Hypothesis* explanation of the Photoelectric Effect, establishing the 'particle-nature' of light. Reconciling these two logically antithetical views has been a major challenge for physicists. This self-contradiction in Physics lead Niels Bohr to formulate his *Complementarity Principle.* Stated for energy, this principle asserts that *energy can display both particle and wave properties, but not both simultaneously.* It does not, however, explain how this can be possible, only that it is so. The double-slit experiment embodies this quintessential mystery of Quantum Mechanics.

With the advent of more advanced technologies, recent experiments have only thrown more fuel to this raging controversy. There are many variations and strained explanations of this simple experiment and new methods to prove or disprove its implications to Physics. But the 1989 Tonomura 'single electron emissions' experiment is the clearest expression of this wave-particle enigma. In this experiment single emissions of electrons go through a simulated double-slit barrier and are recorded at a detection screen as 'points of light' that over time randomly fill in an interference pattern. The picture frames below illustrate these experimental results. We will use these results in explaining the *Double-Slit* Experiment.

Explanation of the Double-Slit Experiment:



The basic logical components of a *double-slit experiment* are the 'firing of an electron at the source' and the subsequent 'detection of an electron at the screen'. It is commonly assumed that these two events are directly connected. The electron emitted at the source is assumed to be the same electron as the electron detected at the screen. We take the view that this may not be so. Though the two events (emission and detection) are related, they may not be directly connected. That is to say, there may not be a 'trajectory' that directly connects the electron emitted with the electron detected. And though many explanations in Quantum Mechanics do not seek to trace out a trajectory, nonetheless in these interpretations the detected electron is tacitly assumed to be the same as the emitted electron. This we believe is the source of the dilemma. We further adapt the view that while energy propagates continuously as a wave, the measurement and manifestation of energy is made in discrete units (*equal size sips*). And just as we would never characterize the nature of a vast ocean as consisting of discrete 'bucketfuls of water' because that's how we draw the water from the ocean, similarly we should not conclude that energy consists of discrete energy quanta simply because that's how energy is manifested in our measurements of it.

The 'light burst' at the detection screen *(see figure)* in the Tonomura *double-slit experiment* may not signify the arrival of "the" electron emitted from the source and going through one or the other of the two slits as a particle strikes the screen as a 'point of light'. The 'firing of an electron' at the source and the 'detection of an electron' at the screen are two separate events. What we have at the detection screen is a separate event of a light burst at some atom on the detection screen, having absorbed enough energy to cause it to 'pop' (much like popcorn at seemingly random manner once a seed has absorbed enough heat energy). The parts of the detection screen that over time are illuminated more frequently by energy will of course show more 'popping'. The emission of an electron at the source is a separate event from the detection of a light burst at the screen. Though these events are connected they are not directly connected. There is no trajectory that connects these two electrons as being one and the same. The electron 'fired' is not the same electron 'detected'.

What is emitted when an electron is 'fired' is a burst of energy which propagates continuously as a wave and going through both slits illuminates the detection screen in the typical interference pattern. This interference pattern is clearly visible when a large stream of electrons or photons illuminate the detection screen all at once. If we systematically lower the intensity of such electron beam the intensity of the illuminated interference pattern also correspondingly fades. For small bursts of energy, the interference pattern illuminated on the screen may be so faded that may not be detectible and may not be manifested instantly, however. The 'burst of energy' going through the two slits gets distributed over large areas of the detection screen in the form of an interference pattern. Thus the accumulated energy locally may not be high enough for the interference pattern to be manifested.

If locally on the detection screen the accumulation of energy has not reached a *minimum threshold,* energy will not be manifested as a 'light burst'. If the bursts of energy 'fired' are very small (single electrons) and this energy is spread over large areas of the detection screen, the 'accumulation of energy' locally at various places on the detection screen will build up slowly -- but more so in certain parts of the screen where the projected interference pattern is more prominent. Thus, the interference pattern will emerge only after longer periods of time, as more atoms absorb enough energy to cause them to 'pop' more frequently at those locations of the screen. We have a 'reciprocal relation' between 'energy' and 'time'. Thus, 'lowering energy intensity' while 'increasing time duration' is equivalent to 'increasing energy intensity' and 'lowering time duration'. But the resulting phenomenon is the same: the interference pattern observed.

This explanation of the *double-slit* experiment is logically consistent with the 'probability distribution' interpretation of Quantum Mechanics. The view we have of energy propagating continuously as a wave while manifesting locally in discrete units (*equal size sips),* helps resolve the *wave-particle duality* and the *measurement problem.* Furthermore, following this view of the propagation and manifestation of energy, we demonstrate elsewhere (paper) that Planck's Law of black body radiation is an *exact mathematical identity* that describes the interaction of measurement.

Summary:

The argument presented above rests on the following ideas.

1) The 'electron emitted' is not be the same as the 'electron detected'.
2) Energy 'propagates continuously' but 'interacts discretely'.
3) Energy 'accumulation before manifestation'.

Our explanations of experiments are also guided by the following attitude of *physical realism*:

A) Changing our detection devices while keeping all other experimental apparatus the same can reveal something 'more' of the underlying physics but not something 'contrary'.

B) If changing our detection devices reveals something 'contrary', this is due to the display design of the detection device and not to a change in the experimental results.

Thus, using *physical realism* we argue that if we keep the experimental apparatus constant but only replace our 'detection devices' and as a consequence we detect something different, the nature of the double slit experiment does not change. The experimental behavior has not changed, just the display of this behavior by our detection device has changed. The 'source' of the beam has not changed. The effect of the double slit barrier on that beam has not changed. So if our detector is now telling us that we are detecting 'particles' whereas before using other detector devices we were detecting 'waves', *physical realism* should tell us that this is entirely due to the change in our methods of detection. For the same input, our instruments may be so designed to produce different displays.

In the Tonomura experiment we examined above, the 'single dot' detected after each 'single emission' may be produced by the display design of the detection screen used. Thus in keeping the device at a constant level of 'energy saturation', each additional electron energy radiated on the screen gets 'focalized' to the dot displayed, bringing the energy level of the screen back to equilibrium. This is somewhat analogous to a lightning flash at a specific point discharging the entire cloud. This would explain why we get only one dot for each electron emitted.

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