The double-slit experiment is not as mysterious

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Abstract

This paper presents a novel interpretation of quantum mechanics, specifically addressing the mysteries of wave-particle duality and the collapse of the wave function upon measurement. It challenges the notion that consciousness affects wave function collapse, proposing instead that nature inherently performs continuous, observer-independent measurements. The author argues for a universe that operates on a discrete, pixelated spacetime, contradicting traditional views of continuous models. This is based on the idea that the probabilistic nature of quantum mechanics implies a digital, computational framework for the universe, termed the "Random Machine."

The concept of the "Random Machine" is applied to explain quantum phenomena, such as the double-slit experiment and entanglement, suggesting that these events are determined by computational processes rather than physical properties. By reinterpreting these foundational experiments, the paper advocates for an indeterministic quantum universe, where events are outcomes of randomly made choices.

This approach redefines the understanding of quantum mechanics, proposing a shift from deterministic interpretations to a model where quantum events are dictated by a cosmic random mechanism. The manuscript offers significant implications for the conceptual underpinnings of quantum physics, advocating for a reconsideration of the nature of reality as fundamentally computational.

Unresolved mystery of contemporary physics is the so-called wave-particle duality and the related issue of the reduction of the quantum object's wave function due to measurement. There is an extreme view that it is not the act of measurement itself that causes the reduction of the wave function, but rather when the result reaches the observer's consciousness, the collapse of this function occurs. (This view was popularized by a thought experiment known as Schrödinger's cat paradox).

The simplest assumption is that Nature continuously performs an countless amount of measurements on itself, which cause the reduction of the wave functions of quantum objects, and the presence (or absence) of a conscious observer has no significance. Below is a proposal for the mechanism that Nature uses when making such "measurements".

The general belief is that the Universe is indeterministic, as evidenced by our deep conviction that we have free will, and this is confirmed by the probabilistic nature of quantum physics. Mathematics is considered to be the foundation of physics. It is even said that the Universe is mathematical, which is why the probabilistic aspect of our reality is described by probability theory, which is a fairly extensive branch of mathematics.

Let us consider what is the most important element of probability theory, what is its essence, and what is the reason for the emergence of this field of mathematics. This element is the "random machine". All probabilistic processes rely on the fact that there is a set of possible events (future states). The elements of this set exclude each other. In order for only one of these events to be realized, a draw must take place. The draw is a single act and is performed by a mechanism commonly known as a "random machine". The "random machine" must gather all possible states, each of which has a positive number assigned to it called probability. The sum of the probabilities of all events, for each draw, must be exactly equal to one.

In probabilistic phenomena, the "random machine" and the act of drawing are not always present in an obvious and explicit manner, as in the case of flipping a coin or rolling a die. Sometimes these elements are disguised, and we may not even be aware that they actually exist.

The problem when applying probability theory is calculating the probability for individual elements of the set of possible events. It is not always possible to determine it precisely, as in the case of a coin toss or a dice roll. However, in quantum mechanics, there is a so-called wave function, which is a solution to the Schrödinger equation. The wave function is a function that assigns a complex number $\boldsymbol{\Psi}(\vec{\boldsymbol{r}}, \boldsymbol{t})$ to the particle's position $\vec{\boldsymbol{r}}$ at time $\boldsymbol{t}$, in the case of a single particle. The square of the modulus of this function determines the probability density for finding the particle at point $\vec{\boldsymbol{r}}$ at time $\boldsymbol{t}$. Since we are dealing with probability, the wave function must be normalized to one, i.e., the integral over the entire volume of the Universe:

$$\int_{-\infty}^{+\infty} |\boldsymbol{\Psi}(\vec{\boldsymbol{r}}, \boldsymbol{t})|^2 d\vec{\boldsymbol{r}} = \mathbf{1} \tag{1}$$

The wave function is precisely defined at every point in space, so there is no problem with calculating the probability in a limited volume of space.

The wave function has been applied in quantum mechanics for several decades and has accurately predicted the results of experiments conducted on subatomic particles. Unfortunately, the probability densities resulting from this function cannot be directly loaded into a "random machine" because it is a finite device. This means that the set of possible events must be finite, so the space from equation (1) must be finite and its volume divided into standard chunks (pixels). In this situation, one should abandon continuous space and replace it with a discrete space composed of points (pixels) arranged, for example, at a Planck distance from each other. The fact that the "random machine" is finite also means that it can only perform a finite number of draws. This implies that time in the wave function cannot be continuous either. In quantum physics, there is the so-called Planck time, which is the shortest meaningful time interval.

Therefore, the probabilistic nature of quantum mechanics implies that the spacetime is not continuous, but is discrete and bounded. In this situation, it is necessary to modify the wave function slightly. The square of the modulus of this function cannot represent the probability density, but rather the probability value at specific points (pixels) in space. After all these changes, the normalization to unity of the new discrete wave function, denoted by the symbol $\boldsymbol{\Psi_d}$, should look as follows:

$$\sum_{i=1}^{n} |\Psi_d(\vec{r}_i, t_j)|^2 = 1 \tag{2}$$

where $\boldsymbol{n}$ is a finite number of pixels for which there is a defined probability $|\Psi_d(\vec{r}_i, t_j)|^2$ of a particle being present in the pixel $\boldsymbol{r_i}$ during the quantum time interval $\boldsymbol{t_j}$.

The point particle does not to move zigzag through pixels because it would violate the conservation of momentum. Instead, particles move as a discrete wave function, or probability cloud, where the probability of the particle being in a particular pixel near a hypothetical continuous trajectory is assigned.

If such a cloud representing one particle overlaps with the probability cloud of another particle, then the probabilities of both particles will be contained in the same pixel. The probability that these particles will collide precisely in that pixel is the product of these two probabilities. There can be a large number of such pixels with multiplied probabilities. In this situation, in order to select the pixel in which a collision may occur, a "random machine" must be launched, which means that all of these multiplied probabilities must be "inputted" into it, and if the sum of probabilities does not equal one, it must be completed with empty lottery tickets. When a pixel is drawn, the wave functions collapse, and a collision occurs precisely in that pixel. However, if an empty lottery ticket is drawn, no collision occurs, and the wave functions of these particles continue to propagate.

> *Attention! The use of the idea of a wave function in quantum physics automatically excludes the principle of conservation of information, and thus the symmetry with respect to time reversal, because the collapse of the wave function of a subatomic particle destroys information about the shape of this function, i.e. destroys information about the past of this particle. Therefore, in the Standard Model, there is no principle of conservation of information. (For example, in a quantum computer, random collapse of the entanglement function destroys the entire computational process and need to enter the input data again).*

The wave functions are not observable in spacetime, but propagate in the so-called configuration space. In spacetime, we observe only the places where the particles have interacted.

What is configuration space? It is an abstract mathematical space supplemented with additional dimensions such as momentum, energy, etc. This space consists of points and is discrete. So where are these configuration spaces of particle wave functions located? Where is the "random machine"? Where are all the necessary calculations and randomizations performed?

Everything indicates that the Universe possesses a kind of computational superstructure in the form of a powerful, digital mathematical machine that creates (animates) our reality. It is in the memory of this machine that configuration spaces are found, it is within this machine that all necessary calculations and drawings take place. From this point, the mechanism that draws individual events from probable events, we will call the Drawing Machine, written in capital letters.

> *Note: In quantum physics, there is a concept of so-called virtual bosons that carry interactions over distance. The term "virtual" used here suggests that these are objects belonging to the digital space and only carry (at the speed of light) information from the past about interaction charges. This information includes the value of the charge, its position, velocity vector, and acceleration. Based on this information, (virtual) potential fields of individual interactions are created, which by necessity are also just information contained in the digital space of the Supercomputer. By using this information and established physical laws, the Supercomputer creates our reality. The universe is therefore mathematical in order to be computable.*

Earlier it was stated that in spacetime we only observe points where particle interactions have occurred, therefore everything we see, touch, etc. is a place of particle interaction. These places were chosen by the Random Machine. The objects we see are areas where photons have interacted with the outer electron shells of atoms on the surface of the object. As a result of these interactions, new photons of colors dependent on the chemical composition of the surface layer are generated, which then interact with the retina of our eye, next a whole cascade of interactions related to the biochemistry of our body occurs, resulting in an abstract image of the object in our brain. In turn, electrons from the outer orbitals of atoms on the soles of our shoes interact with the outer electrons of atoms on the surface of the floor, and so on. All these interactions are related to the operation of the Random Machine and the collapse of the wave functions of particles.

Let us attempt to analyze the famous double-slit experiment based on the concept of the Random Machine presented here. Let the particles that we will be passing through the slits be electrons. (It does not matter which subatomic particles we use, all behave similarly in this experiment).

We have in a vacuum chamber an electron gun (a small linear accelerator) and two screens placed one after the other. The first screen, counting in order from the electron gun, has two narrow slits cut into it. The screens are coated with a phosphor, which enhances the interaction effect with the electron and leaves visible traces on these screens of the places where the electrons hit. We "shoot" single electrons from the electron gun towards the screens with a certain kinetic energy. As we mentioned earlier, an electron in a vacuum chamber is unobservable until it collides with another subatomic particle, because it spreads in the configuration space in the form of a wave function in the memory of a supercomputer, i.e., in a digital machine that creates our reality.

In the first stage of the experiment, both slits are open. The electron is accelerated to the appropriate velocity, and its wave function is dispersed over a larger area before it reaches the first screen. (*Note! By using a properly shaped magnetic field, the electron's wave function can be focused on a very small surface area. Additionally, with an electric field, this focal point can be shifted. This occurs, for example, in various types of accelerators or cathode ray tubes. Therefore, through appropriately shaped magnetic and electric fields, we could focus the electron's wave function on either of the two slits.*) When subatomic elements begin to appear in the configuration space of this function on the first screen, the Random Machine must be activated to determine the location on the screen where the interaction will occur. At this point, the electron's wave function collapses, and a trace of the impact appears on the screen. However, if all the randomizations regarding the first screen result in the selection of an empty outcome, it means that the wave function has passed through both slits.

Beyond the slits, the wave function undergoes further scattering and interference, resulting in probability distributions for interaction with the second screen that form characteristic fringes. A collision point on the screen belonging to one of these fringes is determined by the Random Machine. With a sufficient number of electrons that have reached the second screen, an interference pattern emerges, resulting in an interferogram.

In the next stage of the experiment, we first cover one slit, and then the other. On the second screen, we observe two slightly dispersed fringes directly behind the slits. The interference pattern disappears.

In the third stage of the experiment, both slits are open, but a detector is placed next to one of them, which will detect the electron with 100% efficiency. The detector only slightly disturbs the electron's trajectory, but in order for the particle to be "seen," it must interact with the detector sensor, otherwise it will not be detected. Now, when the electron's wave function reaches the first screen, one of three possibilities can be selected by the randomization process: 1. The screen is selected. 2. The detector is selected. 3. An empty selection is made. An empty selection means that the wave function passed through the slit to the other side of the screen where there is no detector. The remaining part of the wave function will not be found behind the second slit, because the detector, which detects the electron with 100% efficiency, acts as the same obstacle as the screen (the detector, like the screen, participated in the randomization, but was not selected). However, if interaction with the detector is selected, the electron's wave function collapses, so it cannot appear behind the second slit. A new wave function is generated from the point of detection. Ultimately, on the second screen, we obtain the same image as in the second stage of the experiment, when we covered one slit at a time.

The above indicates that saying, in connection with this experiment, that an electron is in two places at once is incorrect. As long as the electron exists in the form of a wave function contained in the configuration space, it does not exist in spacetime, so it is difficult to say that it is in multiple places at once. It can only appear in spacetime as a result of randomization and collapse of the wave function. The Random Machine always determines only one location (pixel) where the electron appears.

The idea of the existence of an informational superstructure can also explain the phenomenon of "spooky action at a distance" concerning entanglement, where two subatomic particles separated by even a significant distance have some quantum parameter described by the same wave function. When the Random Machine is activated for one of these particles and the entanglement function collapses, the result of the random draw will affect both particles. The other particle will "learn" about the result of the random draw immediately, regardless of the distance between them, because in digital space, distance is only a number. In addition, tests of Bell's inequalities, which were conducted on quantum objects, also confirm the existence of the Random Machine.

Now let's zoom in on a single atom of a radioactive element. The moment it decays is entirely unpredictable, yet we can accurately determine the time after which half of the atoms of this element will decay when dealing with a sample containing a significant number of atoms. This is another evidence for the existence of the Drawing Machine because in the configuration space of the wave function of the nucleus of a radioactive element, there always exists a point (or points) where there is some non-zero probability of interaction resulting in the decay of that nucleus. Therefore, in every quantum of time, the Drawing Machine must be activated, which may eventually draw that point, and the atom will decay. Knowing the probability of decay of a single atom, thanks to the law of large numbers, one can predict after how much time (after how many quantum of time) half of the large pool of atoms of this element will decay. This is another evidence that time cannot be continuous.

The Schrödinger's cat paradox can also be explained by the concept of the Random Machine. The paradox aims to illustrate the postulate that until a measurement is made, the cat as a quantum object (or rather, the radioactive atom used in this thought experiment) is in a superposition of two states: the cat being alive or dead. According to the concept of the Random Machine, there is no such thing as a superposition of quantum states, only probabilities of different states occurring in the future. It is the Random Machine that determines which state will be realized, independently of the presence of an observer making a measurement. It is the Random Machine, not the observer measuring the system, that determines when the cat will be killed. By the way, Schrödinger could have come up with a less gruesome thought experiment to justify his postulate.

Bibliography

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