

On the Single Electron Double Slit Experiment – A Randomly-Jumping Electron Approach

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Abstract

One of the greatest mysteries that has puzzled and seemingly hoodwinked our very understanding of nature is the single electron double slit experiment – one that Feynman termed the central mystery of quantum mechanics. At the heart of this mystery is how can an electron that is a physical particle exhibit a wave-like property? We’ve proposed a non-counterintuitive way to explain this phenomenon called the randomly-jumping electron hypothesis, in which the electron randomly “jumps” in discrete succession to specific points only and not others which is what causes the electron to indeed be a classical particle only but is able to produce a wave-like interference pattern. To provide supporting evidence for our hypothesis, we’ve developed a computer program to simulate the single electron double slit experiment by treating the electron as a classical particle while still exhibiting wave-like fringes in agreement with real-world observed data of the single electron double slit experiment performed. Our interpretation does not set out to “solve” the mystery of why an electron can produce a wave-like interference pattern once and for all, however our hypothesis is a monism ontological interpretation that does address some of the crucial debates that have remained unsolved for 100 years since the formulation of quantum mechanics.

Keywords: double slit, randomly-jumping electron, standard quantum theory, wave-particle duality, single electron interference pattern, quantum mechanics interpretation

1 Introduction

Standard quantum theory (“Copenhagen Interpretation”) [1-4] cannot answer a seemingly simple question regarding the very essence of what an electron is:

Is an electron a particle or a wave?

Particularly, in the context of the single electron double slit experiment [5], standard quantum theory cannot answer the following two questions:

Question 1: Is it even true that an electron only goes through either slit A or slit B?

Question 2: Is there any possible way to determine an electron’s trajectory?

Standard quantum theory outright refuses to provide an answer to the first question above, instead the approach has been to replace it with an abstract mathematical model (wave-particle duality), i.e. an electron is morphed into a “probability wave” that simultaneously passes through both slits which forms an interference pattern on the detector screen as (1).

$$\rho = \frac{1}{2}|A\rangle\langle A| + \frac{1}{2}|B\rangle\langle B| + \frac{1}{2}|A\rangle\langle B| + \frac{1}{2}|B\rangle\langle A| \quad (1)$$

Where the third and fourth terms are the quantum interference terms, in which the electron acts like a wave passing through both slits at the same time by forming the interference pattern on the detection screen. Once it can be confirmed if the electron passed through slit A (first term) or passed through slit B (second term), then the interference pattern ceases to exist on the detection screen, in which the electron starts to act like a particle.

Standard quantum theory also downright refuses to answer question 2, furthermore it

rejects the notion of the electron possessing any trajectory. After passing through the slit but before reaching the detection screen, an electron specters around like a wave in the vacuum between the two; once the electron reaches its final destination on the detection screen a non-localized wave-packet collapse happens – where the electron hits a singular point on the detection screen like a single particle; as to what happens in between from the moment the electron passes the slit and hits the detection screen on the other side no one knows – this is the notorious mystery of the single electron double slit experiment that Feynman termed the central mystery of quantum mechanics [6], and also more importantly the conundrum of the quantum measurement problem [7-9]. In the terms of standard mathematical formulation of quantum mechanics, the electron projects itself from a quantum pure state to a classical mixed state as in (2).

$$\rho \xrightarrow{\text{project}} \rho' = \frac{1}{2}|A\rangle\langle A| + \frac{1}{2}|B\rangle\langle B| \quad (2)$$

Repeated experiments have shown us that a single electron can only pass through one slit or another, it's not possible for it to pass through both, and it can only leave its mark at a singular point on the detection screen. As the very essence of quantum mechanics seems to be inherently conflicting, which manifests in the contradictory nature of wave-particle duality, this has led to the rise of many other interpretations of quantum mechanics such as the ontological Many Worlds interpretation [10-11] and the epistemological QBISM interpretation [12-14]. Alike with standard quantum theory, these interpretations also fail to provide adequate answers to the two aforementioned questions, either intentionally avoiding them or providing claims that cannot be scientifically proven. The crucial part that's overlooked is what happens in between when the electron is fired from the starting source to eventually being recorded on the detection screen; more importantly what trajectory does the electron take as it traverses through the slit(s) and makes it to the detection screen – which almost all of the current interpretations seemingly ignore [15-24].

Richard Feynman's semi-classical path integral approach [25] answered question 1 by clearly stating that the electron does indeed go through one slit only. He "imagined" that the electron could take multiple paths all at once, then by assigning a weight to each path, he was able to calculate the probability of the singular point where the electron would land on the detection screen. With his approach however, Feynman still avoided question 2, in which he doesn't pinpoint a trajectory for the electron.

Regarding the aforementioned questions 1 and 2, the only theory that has attempted to seek a reasonable answer is the De Broglie – Bohm pilot-wave theory [26-27]. In "Bohemian Mechanics", an electron is treated as a classical particle and can only parse through one slit or the other at a time (question 1), and the electron reaches a single point on the detection screen following a certain trajectory (question 2). The initial conditions of an electron under "Bohemian Mechanics" are uncertain, in which it can be described by a probability distribution of space, and therefore this leads to the formation of the interference pattern on the detection screen. However, there are still two unresolved issues of "Bohemian Mechanics":

1. "Bohemian Mechanics" requires a universal, global pilot-wave (nature's "invisible hand") to guide the electron's movement; under "Bohemian Mechanics" this requires invoking non-locality at a distance, something that should not be possible for a classical particle acting in accordance to Einstein's Theory of Relativity (Special).
2. According to the calculations of "Bohemian Mechanics", the electron will never cross over the midline of the double-slit apparatus; the electrons' paths will converge infinitely close to the midline but never cross over to the other side. However, conducted experiments have verified that the electron does indeed end up to the other side of whichever slit it passed through.

Standard quantum theory unequivocally rejects the idea of any trajectory the electron could take, and not only rejects that idea but they also don't ask what happens in between the electron being fired from the starting point to when it lands on the detection screen; and no one else is allowed to ask either.

Setting out from a logical perspective, a contradictory prerequisite will always produce a contradictory result. The study of physics, and physics itself as a whole cannot just be rooted in theoretical speculation (mathematical model and deductive inference), it has to be correlated with empirical data through experiments.

Since all experimentally verified results have shown that an electron indeed acts just

like a classical particle then we should just accept the fact that the electron is indeed a particle and not an entity with a “counterintuitive” wave-particle duality property. What needs to be done is how to reasonably explain why an electron, that has been proven is a particle and particle only, can somehow “mysteriously” produce an interference pattern synonymous with waves only.

At the microscopic level we know that energy is discrete; in this paper we propose that space is also discrete. We postulate that an electron doesn’t have to move in a continuous motion; and not only do we put forth the motion of an electron is discontinuous but also the electron randomly jumps in space. Simply put, we propose that an electron randomly jumps in successive intervals not equal to 0 in a 3-dimensional space; more importantly this means that an electron can only be in a specific point in space and not others.

In this paper we propose a randomly-jumping electron hypothesis that mainly postulates what happens in between when the electron leaves the starting source to it landing on the detection screen. We show that after the electron is fired, it starts to “jump” randomly; first it passes through either slit A or slit B completely random, then it randomly “jumps” successively through an uncertain trajectory between the slit and the detection screen, and finally it lands on a specific point on the detection screen and not somewhere else. The accumulation of all the individual “paths” taken by every electron is what produces the “mind-boggling” wave-like interference pattern on the detection screen.

The remainder of this paper is structured as follows. Section 2 is the model formulated to explain how an electron as a classical particle can produce a wave-like interference pattern. Section 3 are the results produced by a computer program simulating the single-electron double-slit experiment in correspondence to experimental data. Section 4 is the discussion summarizing our work, elaborating on some of the challenges faced by standard quantum theory, and potential further research.

2 Model

What we’ve proposed is an electron randomly “jumping” around with a specific step-length in 3-dimensional space as a particle though still exhibits a wave-like interference pattern at the detection screen. Although the electron has a coordinial position $r_k(x_k, y_k, z_k)$ at a given time t_k as it moves through space, its trajectory $\{r_1, \dots, r_k, \dots, r_n, \dots\}$ is not certain because it “jumps” around at random; thus, an electron can only occupy specific coordinates on the grid and not move in a continuous motion, therefore it has no instant velocity; otherwise, it would be possible to just describe the electron’s trajectory with a differential equation.

Jim Al-Khalili wrote “Everything that happens in the universe comes down to events that place somewhere in space and at some moment in time.” [28]; therefore, in the vast canvas of the sub-atomic world we can “paint” everything that happens as an event taken by mother nature – in which “she” can “choose” to randomly jump with a specific distance. Our proposed hypothesis is to transform the discrete movements of the electron’s trajectory $\{r_1, \dots, r_k, \dots, r_n, \dots\}$ into an event series $\{e_1, \dots, e_k, \dots, e_n, \dots\}$; where every event is as (3).

$$e_k \leftarrow (x_k: \rightarrow | \leftarrow, m_x; y_k: \uparrow | \downarrow, m_y; z_k: m_z) \quad (3)$$

Where event e_k representing at any given time t_k is located at (x_k, y_k, z_k) ; the electron only moves forward on the z-axis in a step-length of m_z ; the electron randomly moves left and right on the x-axis in a step-length of m_x ($\rightarrow | \leftarrow, m_x$); the electron randomly moves up and down on the y-axis in step-length of m_y ($\uparrow | \downarrow, m_y$).

Given the uncertain nature of the random jumps that the electron takes on the XY coordinate plane, the state of event e_k at given time t_k as (4).

$$|x_k\rangle = \frac{1}{\sqrt{2}}(|\rightarrow\rangle + |\leftarrow\rangle) \quad (4a)$$

$$|y_k\rangle = \frac{1}{\sqrt{2}}(|\uparrow\rangle + |\downarrow\rangle) \quad (4b)$$

The respective density operator (matrix) of the observable as (5).

$$\rho_x = |x_k\rangle\langle x_k| = \frac{1}{2}(|\rightarrow\rangle\langle\rightarrow| + |\leftarrow\rangle\langle\leftarrow| + |\rightarrow\rangle\langle\leftarrow| + |\leftarrow\rangle\langle\rightarrow|) \quad (5a)$$

$$\rho_y = |y_k\rangle\langle y_k| = \frac{1}{2}(|\uparrow\rangle\langle\uparrow| + |\downarrow\rangle\langle\downarrow| + |\uparrow\rangle\langle\downarrow| + |\downarrow\rangle\langle\uparrow|) \quad (5b)$$

Where the first and second terms represents there is a 50% chance of the electron randomly jumping to the right or left (x-axis) or up or down (y-axis). The third and fourth terms represent the movement is uncertain; and it is because of the uncertain “jumps” that the electron as a particle produces the interference pattern on the detection screen.

The density operator ρ_x, ρ_y determines the direction that the electron will jump towards on the x-axis and y-axis respectively; at any given time t_k , the electron’s position $r_k(x_k, y_k, z_k)$ can be iteratively determined as (6).

$$x_k = x_{k-1} + \text{sign}(\rho_x) * m_x \quad (6a)$$

$$y_k = y_{k-1} + \text{sign}(\rho_y) * m_y \quad (6b)$$

$$z_k = z_{k-1} + m_z \quad (6c)$$

Where;

$$\text{sign}(\rho_x) = \begin{cases} 1, & \text{electron jumps left;} \\ -1, & \text{electron jumps right;} \end{cases}$$

$$\text{sign}(\rho_y) = \begin{cases} 1, & \text{electron jumps up;} \\ -1, & \text{electron jumps down;} \end{cases}$$

It seems obvious that the function(s) of position and velocity can’t properly describe a randomly jumping electron (discrete movement); thus, a density operator (ρ_x, ρ_y) is required instead to first describe the direction of the electron’s movement and second calculate its position iteratively. Although it’s been proven that the electron is indeed a particle and moves like one, the wave-like interference pattern that it produces is the result of the uncertainty of the density operator as in (5)-(6). Instead of using traditional terms of position and velocity to describe exactly where the electron is at a given time, the density operator (matrix) is proposed to show that the electron can only appear at specific points on the grid and not be everywhere at once, which fully illustrates how the electron can produce a seemingly wave-like interference pattern yet be a particle.

How we’ve attempted to answer the two questions put forth in the beginning of the introduction is by utilizing a monism ontology (an electron is indeed a particle and a particle only):

- 1) The electron only physically passes through either slit A or slit B – not both;
- 2) As the electron traverses through the space between the starting source and the detection screen it randomly “jumps” through one of the slits and ends up at a specific point only on the detection screen forming a trajectory; and it’s the accumulation of all the electrons trajectories that manifests the seemingly wave-like interference pattern and allows the electron to exhibit wave behavior yet being a particle.

3 Results

The randomly-jumping electron hypothesis we’ve proposed fundamentally puts forth the notion that the electron produces the wave-like interference pattern on the detection screen despite being a particle.

For this paper, we’ve developed a computer program to simulate the single electron double slit experiment; this program simulates an electron being fired from the starting source, then randomly “jumps” through either slit A or slit B, followed by an uncertain trajectory, and finally it randomly lands on a specific grid point on the detection screen.

3.1 Setup

The setup metrics of the computer program simulating the double slit experiment is as follows, where the units are intentionally left out because this simulation is used to provide support to our proposed hypothesis; not to simulate a real experiment:

- (1) The coordinates of the firing source: $x = 0, y = 0, z = 0$;
- (2) The distance between the firing source and the obstruction board: $l = 500$;
- (3) The distance between the obstruction board and the detection screen: $L = 500$;
- (4) The obstruction board with the two slits and the detection screen is situated on the XY plane perpendicular to the z-axis;
- (5) The distance between the two slits: $d = 50$; slit width: $w = 6$; slit height: $h = 1000$;
- (6) The length of the jump: $m_x = 10 \pm 0.3$; $m_y = 10 \pm 0.6$; $m_z = 10$;

3.2 Simulated results of double-slit experiment

The simulated computer program was run multiple times; each time a single electron was fired from the starting source, it randomly passes through one of the slits, then randomly “jumps” in the space between the slits and the detection screen forming an uncertain trajectory, and finally randomly lands on one specific spot and that one spot only on the detection screen. A total of 7019 electrons’ trajectories were recorded; 3518 electrons passed through slit A and 3501 passed through slit B, in which it can be seen that the ratio of the electrons’ that passed through slit A or slit B is very close to 1 – meaning that it can be concluded that the electron indeed randomly passes through either slit and not both.

Figure 1 shows the wave-like interference pattern produced by the accumulation of where all 7019 electrons landed on the detection screen.



Fig. 1 The wave-like interference pattern (diffraction fringes) that is formed from the accumulation of all the 7019 electrons fired.

Figure 2 shows the normalized intensity of all the 7019 electrons corresponding to where they landed on the detection screen as calculated.

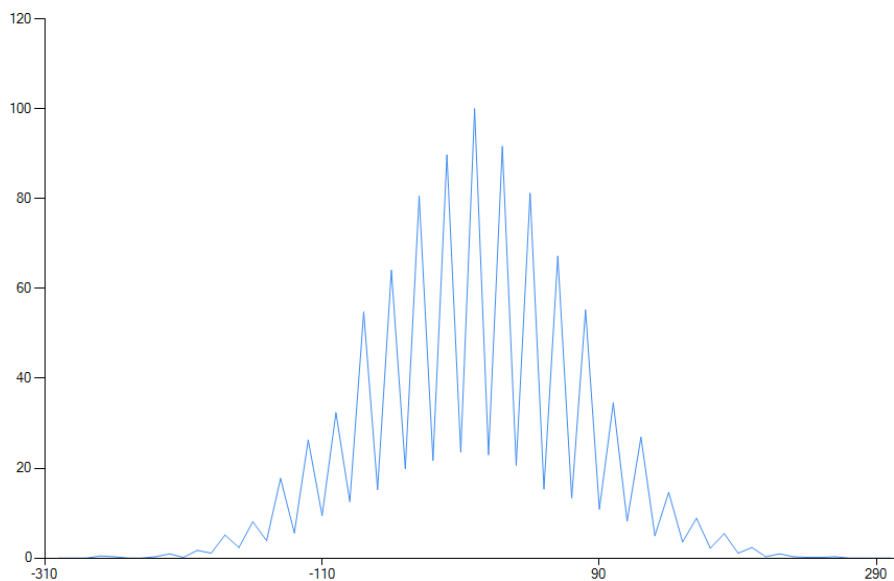


Fig. 2 The normalized intensity of all of the 7019 electron’s landing on the detection screen.

Figure 3(a) shows the accumulation of all 7019 single electrons’ trajectories,

where the blue lines are the ones that passed through slit A and the red lines are the ones that passed through slit B; 3(b) shows the spatial distribution of all 7019 single electrons', where the blue dots are the ones that passed through slit A and the red dots are the ones that passed through slit B; 3(c) shows the average trajectories of all 7019 electrons' where 3518 passed through slit A (blue lines) and 3501 passed through slit B (red lines); 3(d) shows the average trajectories of all 7019 electrons' without taking in consideration which slit it passed through.

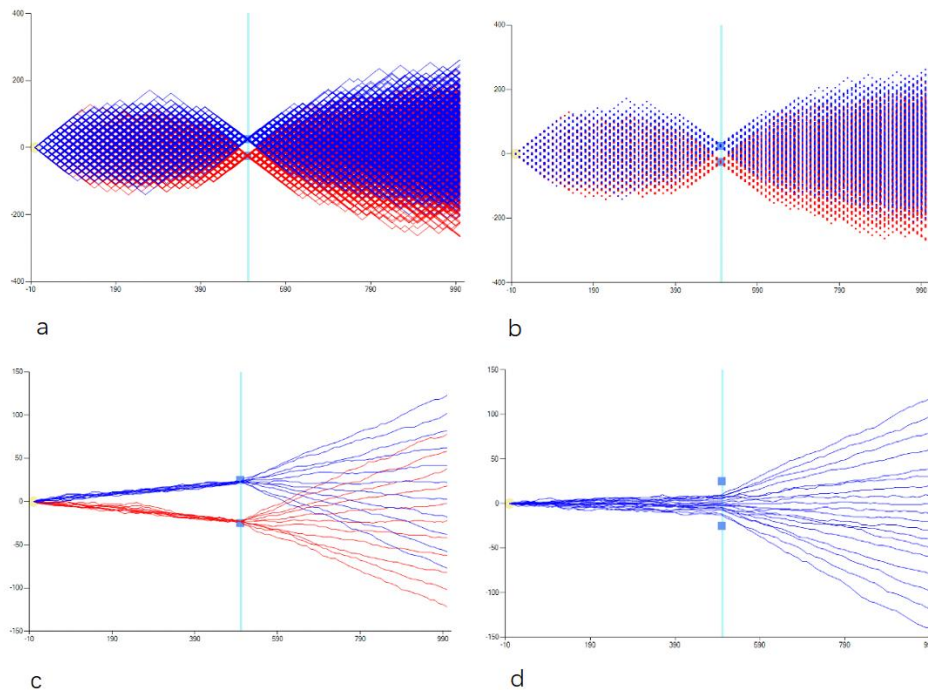


Fig. 3 The trajectories of all the electrons, the spatial distribution, and the average of the trajectories taking in and without consideration of which slit the electron passed through.

The simulation is conducted again with a further magnification of the central five interference fringes; intervals of 3, 7, 196, 888, and 5975 electrons are sent through and their intermediate build-up are recorded in five central “blobs” as shown in Figure 4, clearly showing the wave-like interference pattern.

Figure 4(a) shows 3 electrons; 4(b) shows 7 electrons; 4(c) shows 196 electrons; 4(d) shows 888 electrons; 4(e) shows 5975 electrons. In 4(a)-(b), since there are only a limited number of electrons starting off with 3 and 7, the hits appear to be completely random and “scattered” on the detection screen. In 4(c)-(d) as more electron hits accumulate to 196 electrons and 888 electrons the pattern becomes more discerning, where the interference pattern starts to slowly appear, but it is only once there are a huge significant number of electrons’ “hits” recorded of 5975 in 4(e) does the pattern become clearly visible, where the interference pattern is in complete agreement with the results of the single electron double slit experiment conducted.

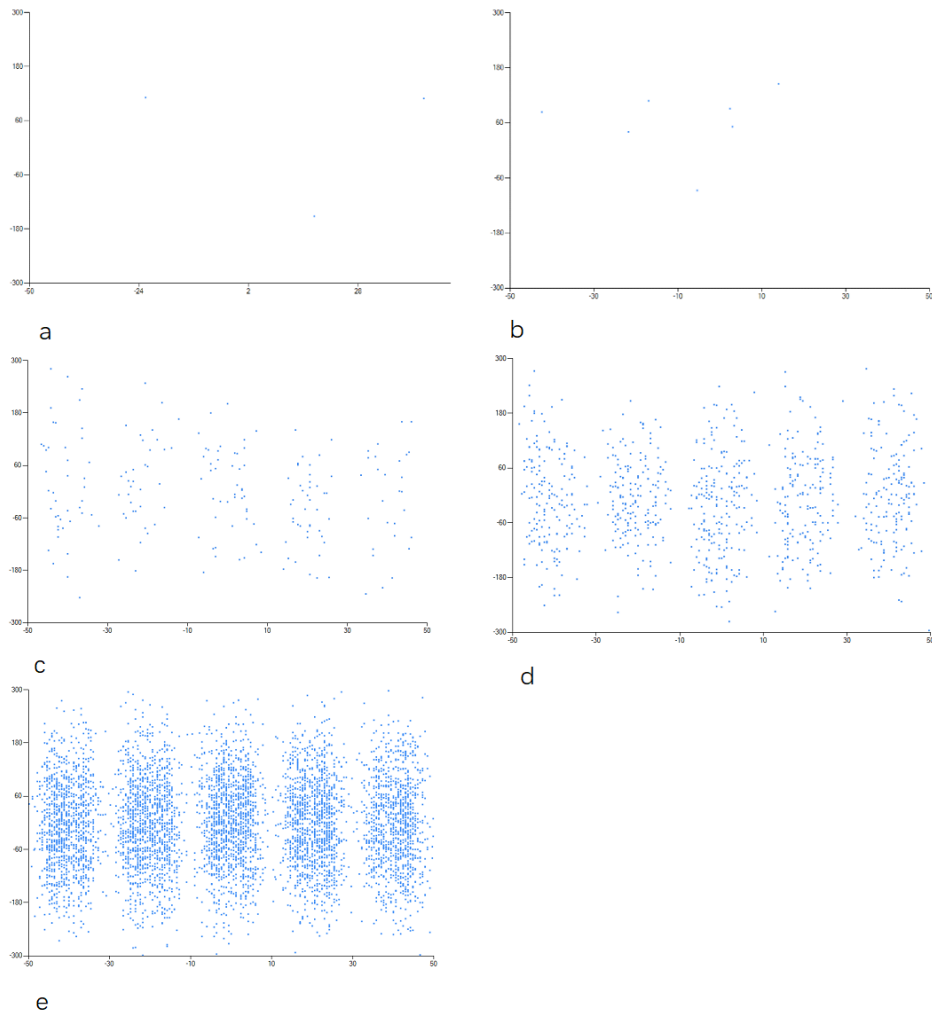


Fig. 4 Buildup of interference patterns (blobs) of the electron's intervals magnified from the central five interference patterns.

Figure 5(a) shows the trajectories of 3 electrons; 5(b) shows the trajectories of 7 electrons; 5(c) shows the trajectories of 196 electrons; 5(d) shows the trajectories of 888 electrons; 5(e) shows the trajectories of 5975 electrons. In 5(a)-(b) the single trajectories of the three and seven electrons can be seen clearly; all of the electron's individual paths are clearly "traceable" from being fired from the starting source to when it lands on the detection screen – fully "illuminating" its movements. In 5(c)-(e) as more electron's trajectories (196, 888, 5975) are recorded and start to "overlap" each single electron's trajectory becomes more "blurred" – leading to the electron's seemingly "wave behavior" as it disperses and smears out across space.

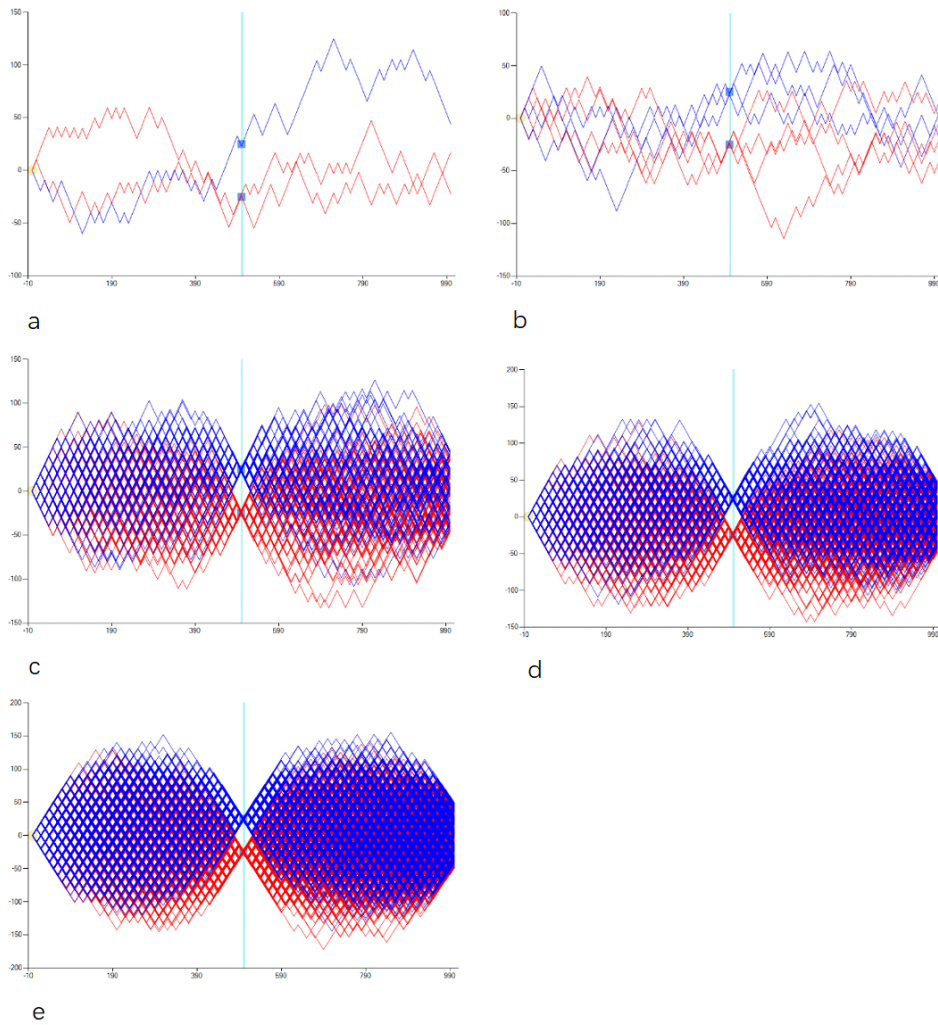


Fig. 5 The discrete trajectories of the 3, 7, 196, 888, and 5975 electrons intervals taking in consideration which slit the single electrons passed through; blue lines are the electrons that passed through slit A, red lines are the electrons that passed through slit B.

3.3 Results Analysis

Figure 1-5 shows that the results of the computer program simulated experiment are in agreement with the real-world observations of the single electron double slit experiment [29-41]. A cluster of “blobs” across the screen are more concentrated in the middle as shown in Figure 1. Figure 2 shows that the intensity of the corresponding “blobs” of electrons in the middle “peaks” is higher than those in the outlying sections of the detection screen – this also mirrors real-world experimentally verified data. Figure 3 shows that the electron can only land on a specific point and not somewhere else. Figure 4 shows the buildup of electrons intervals from 3, 7, 196, 888, 5975 showing the gradual build-up of the wave-like interference pattern. Figure 5 shows that when there are only 3 and 7 electrons trajectories recorded, even though its random yet still shows the trajectory of being a classical particle, however with the gradual increase in trajectories recorded (196, 888, 5975) the electron starts to exhibit more wave-like dispersion. In other words, as more trajectories of electrons are recorded it starts to “behave” more like a wave yet is still a classical particle.

The striking correspondence between the experimental data and our simulated experimental data for the single electron double slit experiment provides straightforward evidence to solidify the effectiveness of our proposed random-jumping electron hypothesis.

Given Figure 1 and 2, the path difference from the central point of the detection screen can be calculated as in (7).

$$\Delta r = \begin{cases} k(2m), k = 0,1,2, \dots, \text{"constructive interference" (bright fringes);} \\ \left(k + \frac{1}{2}\right)(2m), k = 0,1,2, \dots, \text{"destructive interference" (dark fringes);} \end{cases} \quad (7)$$

Where m is the step-length of the electron's jump. If we let the wavelength of the electron to be $\lambda = 2m$, then (7) in correspondence with the experimental data observed as in (8).

$$\Delta r' = \begin{cases} k(\lambda), k = 0,1,2, \dots, \text{"constructive interference" (bright fringes);} \\ \left(k + \frac{1}{2}\right)(\lambda), k = 0,1,2, \dots, \text{"destructive interference" (dark fringes);} \end{cases} \quad (8)$$

Based on the above analysis, using our monism ontological interpretation it can be said that the electron, as a classical particle, doesn't "posses" a wavelength because it's not a physical wave; the electron's wave-like behavior is the product of the successive "jumps" it "takes" of a specific step-length.

If we assume that the electron is accelerating with a velocity of $100v$ then its "wavelength" is $\lambda \approx 0.12nm$; therefore, the step-length of the electron's "jumps" is $m \approx 0.06nm$; the electron's average speed of ($\bar{v} = m/\Delta t$) can be calculated, and Δt is the electron's time of each jump. With $100v$ of energy for an electron $E = 100eV$, then using $E = h\nu$, $\nu \approx 2.5 \times 10^{16}$ can be obtained; in which if it's assumed that $\nu = 1/\Delta t$, the average velocity of the electron is approximately $\bar{v} \approx 3 \times 10^{16} m/s$; where the calculated average speed of our simulated experiment is close to the actual observed speed of $5.9 \times 10^{16} m/s$.

Two conclusions can be made from Figure 3 and Figure 5: 1) Bohr's complementary principle or wave-particle duality does not hold firm – with our proposed hypothesis it can be known which slit the electron goes through and also see the wave-like interference pattern that's formed; 2) The two unresolved issues of "Bohemian Mechanics" have been addressed – again, with our proposed hypothesis it can be seen that the electron does indeed crossover the midline and is a classical localized particle as Einstein had suggested.

Furthermore, the random "jumping" of an electron makes it impossible to know exactly where it is, because the electron's "jumps" are discrete and non-continuous it ceases to have an instant velocity – fundamentally, this puts forth a reasonable explanation of the Heisenberg Uncertainty Principle in physical terms.

4 Discussion

Our proposed monism ontological interpretation has attempted to answer the two questions aforementioned in the introduction: (1) The electron, as a classical particle, can only pass through either slit A or slit B and not both; (2) the electron randomly arrives at a specific spot on the detection screen after "jumping" through a random trajectory.

The whole why does an electron that is actually a physical particle but produces a wave-like interference pattern conundrum arises from one simple thing that has been overlooked for 100 years: it's been presumed by default that the electron will always move continuously in a straight line and not discretely "jump" randomly – the bright fringes are where many electrons "jumped" to and the dark fringes are where no electrons "jumped" to. The accumulation of all the electrons' marks through a gradual build-up leads to the wave-like interference pattern slowly forming on the detection screen.

The randomly jumping electron hypothesis we've proposed has attempted to answer some of the critical questions regarding the quantum mechanics interpretations of the past 100 years [42-51]:

- 1) Measurement problem (wave-packet collapse): The electron is a particle, at any given time an electron can only be at one place and that one place only, essentially even though the position is uncertain but when you "observe" it is just where it happens to be at that given time; which in our proposed hypothesis then there is no wave-packet collapse – thus there is no measurement problem.
- 2) Observer problem: The electron is a physical particle that randomly "jumps" through an

uncertain discrete trajectory, where the external observer has no effect on the electron's movement. Our proposed monism ontological hypothesis clearly puts forth the tenet that the objective external world is unequivocally independent of what we the observers' does and in no way can we influence and even alter the very essence of reality (the blinking of our eyes does not cause anything to change).

- 3) Boundary problem – where's the precise line between the classical and quantum world:
 - a) With our proposed hypothesis, there is no so-called boundary regardless if it's a micro electron or a macro bullet – they both “jump”. Taking the macro bullet for example, it doesn't exhibit any wave-like interference pattern because the “jump-lengths” are practically 0, therefore it fires in a completely straight line; while in the context of the micro electron its “jump-length” is “relatively” bigger thus it produces the wave-like interference pattern despite being a physical particle as well.
 - b) The step-length of the jump is $\approx 1/p$; where the mass of the bullet is about 10^{28} greater than that of an electron, and the velocity of a bullet is about 10^{-4} times slower than an electron; therefore, it can be calculated that the bullet's “jump-length” is approximately 10^{-35} meters, in which it is close to the Planck length. For our proposed hypothesis, as the “jump-length” bottlenecks down gradually becoming smaller and smaller the wave-like interference starts to disappear as the micro electron transitions from the quantum world to the macro bullet in the classical world.
 - c) We can “replicate” the double slit experiment in the macro world with a ball that could be manually setup to jump randomly; theoretically we could see the ball jumping through a random trajectory and then randomly land on a specific spot on the detection screen to produce a wave-like interference pattern. With an experiment set up accordingly like this, it can be shown that a macro-sized object such as a football can exhibit a wave-like property as being a classical particle.
- 4) Operator problem – what is the physical meaning of the operator in quantum mechanics: Since a classical particle's “jump-length” is approximately 0, its movement is continuous and a function of position, velocity, acceleration is sufficient enough to fully describe it; however because a micro-sized particle (electron) randomly “jumps at will”, where its jump-length is relatively larger than 0, which leads to its movement being completely discrete and non-continuous – where an operator is then needed to describe the electron's movements in two parts.
 - i. By formulating a possibility of which direction the electron will “jump” in;
 - ii. Iteratively calculate the electron's position, leading to an uncertain trajectory.
- 5) Born Rule problem: Based on our proposed hypothesis, the electron is randomly “jumping around” in space, therefore we can only calculate the probability of where it could “jump” to. Essentially this explains the essence of Born Rule's fundamental origin where it's the product of the electron randomly “jumping” discretely throughout space.
- 6) Electron Spin problem: Our speculation on why an electron spins is because at any given time when the electron “jumps” forward on the Z-axis while it can only randomly “jump” clockwise or counterclockwise to the closest adjacent point on the XY-plane from where it's currently at on the grid.

In conclusion, further research will include why the wave-like interference pattern disappears once the slit in which the electron passed through is illuminated by an external light source. Simply put, an explanation of why this happens is because the electron cedes to “jump” once it is “disturbed” by external light, i.e. once the light source illuminates the electron, it causes the step-length of the electron's “jumps” become close to zero, which then causes its trajectory to become a straight line, just like a bullet.

Declarations

Data availability. The authors confirm that all data that support the findings of this study are included within the main text and its supplementary materials. All data are also available from the corresponding author K.X., upon reasonable request.

Authors' contributions. All authors conducted the research and contributed to the development of the model. All authors reviewed the manuscript.

Conflict of interests. The authors declare that they have no competing interests.

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