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A New Paradigm for Single-Particle Double-Slit Interference: Cavity-Induced Nonlocal Quantized Momentum Transfer with no Need for Schrödinger's Wavefunction, Self-Interference, and Wavefunction Collapse

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Abstract: We propose a quantum framework where cavity-induced nonlocal stochastic quantized momentum transfer governs double-slit interference of single eelectrons, replacing self-interference, wavefunction collapse, and Schrödinger's wavefunction description. Using Heisenberg's operator formalism, we model the electron's interaction with the double slit as a quantized field potential. This approach explains interference via discrete momentum transfer through stochastic cavity modes. We explore its role as a non-local hidden-variable mechanism, predicting deviations in Bell violation, and finer discrete interference fringes in short cavity-mode wavelength regimes, opening new avenues for experimental verification. Our new interpretation of quantum dynamics sheds light on long-standing debates about quantum reality, hidden variables, wave-function superposition and Schrödinger's cat, the illusion of self-interference of a single electron, and instantaneous wavefunction collapse misconception in the measurements. Our theory possesses the deterministic description of an electron a stochastic yet nonlocal hidden variable characteristic of the quantized cavity modes. It meets Einstein's desire for a more complete theory and bridges the gap between physical reality and the incomplete conventional quantum theory that requires confusing Copenhagen or many-world interpretations.

Keywords: double-slit interference; self-interference; wavefunction collapse; Bell's inequality; non-local interaction; quantum reality

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This report presents a novel interpretation of double-slit interference based on quantized momentum transfer, offering a physically intuitive alternative to conventional wavefunction-based descriptions [1–5] of quantum theory [6–10]. Unlike the standard Schrödinger wavefunction approach, which treats the double slit as a classical object and interference as the self-interaction of a single electron's wave packet, our model assigns a quantized spacetime structure to the slit geometry. This introduces discrete cavity modes that govern the electron's interaction, leading to a stochastic yet well-defined excitation process.

A key prediction of our model is that when the electron's wavelength approaches the scale of a double slit with a sufficient gap width, the non-locality and discreteness of these cavity modes lead to deviations from the smooth continuum interference pattern expected in traditional quantum mechanics. This effect, arising purely from quantized momentum transfer, offers a testable signature requiring a highly coherent electron source and a stable slit structure. Additionally, our model naturally aligns with experimental violations of Bell's inequality [11–16], reinforcing the non-local aspects of quantum mechanics without invoking Einstein's hidden variables and questioning the quantum-mechanical description of physical reality [17].

By explicitly incorporating a quantized mechanism for the electron-slit interaction which has a nonlocal nature, our framework provides a deeper physical understanding of interference phenomena compared to interpretations such as Copenhagen, many-worlds, and Bohmian mechanics [18,19]. It not only preserves the realism Einstein advocated but also offers new insights into the interplay between quantum non-locality and spacetime structure, paving the way for further experimental verification.

According to Heisenberg's quantum operator formalism [20–22], the Hamiltonian of an electron interacting with the potential of a double slit is given by

$$H = \frac{{p_x}^2}{2m} + \frac{{p_y}^2}{2m} + V(x,y)$$
$$V(x,y) = V_0\delta(x)\left(1 - \delta(y - D/2) - \delta(y + D/2)\right) \tag{1}$$

where $\delta(x)$ is the Dirac delta function. The above potential wall of the double slit represents$V(x,y) = V_0, if x = 0, y \neq \pm D/2$, and $V(x,y)$ vanishes elsewhere. According to Heisenberg's matrix mechanics formalism, one has

$$\frac{d}{dt}p_x = F_x = -\frac{i}{\hbar}[p_x, H] = -\frac{\partial}{\partial x}V(x,y), \qquad \frac{d}{dt}x = \frac{p_x}{m}$$
$$\frac{d}{dt}p_y = F_y = -\frac{i}{\hbar}[p_y, H] = -\frac{\partial}{\partial y}V(x,y), \qquad \frac{d}{dt}y = \frac{p_y}{m} \tag{2A}$$

Where

$$F_x(x,y) = -V_0\left(\frac{d}{dx}\delta(x)\right)[1 - \delta(y - D/2) - \delta(y + D/2)]$$
$$F_y(x,y) = V_0\delta(x)\frac{d}{dy}[\delta(y - D/2) + \delta(y + D/2)]. \tag{2B}$$

Let us examine the trajectory of an electron initially at $y = 0, x = -\varepsilon$ before hitting the slit-wall at$t = 0$. One has the impulsive force $F = dp_x/dt = -V_0\, d\delta(x)/dx$ and the impulsive action from the slit-wall is given by$V_0 \int_{-\varepsilon}^{\varepsilon} dx\, d\delta(x)/dx = V_0$.If the potential energy V_0 is much greater than the incident kinetic energy, quantum tunneling is not permissible and the electron is reflected. Therefore, the electron can only pass through the potential wall via the double slits.

The slit gap D is the fundamental length unit, and the fundamental mode has 1/2 wavelength equal to D so that the wave has nodes at the slits. The allowed discrete modes have a frequency as an integer multiple of the fundamental mode. One has the following relations between wavelength $\lambda_c$of the fundamental cavity mode, wave vector k_y, and D as

$$D = \frac{\lambda_c}{2}, \qquad k_c = \frac{2n_c\pi}{\lambda_c} = \frac{n_c\pi}{D}, \qquad n_c^{'} = 0, \pm1, \pm2, \ldots.. \tag{3}$$

vc interpret, as an electron passes through either slit, it gains a y-component momentum, proportional ton_2/λvia absorbing or emitting a cavity quanta with the double-slit potential well, and a quantized field amplitude distribution $\boldsymbol{cos}(n_2\pi D/\lambda_c)$ and a probability of $\boldsymbol{cos}^2(n_2\pi D/\lambda_c)$, which leads to the same probability distribution for the dot-like interference signal when the electron hits the detector.

The above results indicate that when an electron passes through either slit, it interacts with the double slit and receives a kick, representing a quantized momentum transfer $\Delta p_y = \hbar k_y = n2\pi\hbar/\lambda$, from one of the cavity modes. This quantum of energy causes the electron to deflect from its original trajectory. As the deflected electron reaches the screen detector, it induces a dot signal. Each of the discrete multiple-mode force components in Equation (4) leads to a different dot signal on the screen, and as time evolves with more electron counts, an interference pattern emerges. The amplitude distribution of the n2-th mode is given by $\boldsymbol{cos}(n_2\pi D/\lambda_c)$. This value represents the field strength distribution of the cavity quanta, and its square represents the intensity or probability distribution of the cavity-mode quant. This leads to an interference pattern with an intensity proportional to $cos(n_2\pi D/\lambda_c)$. The y-component momentum change after the electron passes through the top slit is given by $\Delta\tilde{p}_y = n_c\hbar 2\pi/\lambda_c = 2n_cV_0\Delta t/\lambda_c$. Accordingly, one has

$$\boldsymbol{sin}\theta = \frac{\Delta p_y}{p} = \frac{n_c\hbar 2\pi/\lambda_c}{\hbar 2\pi/\lambda} = \frac{n_c\lambda}{\lambda_c} = \frac{n_c}{N},$$
$$\boldsymbol{sin}\theta = \frac{2n_cV_0\Delta t/\lambda_c}{\hbar 2\pi/\lambda} = \frac{n_c\lambda(v\Delta t/2)}{\lambda_c} = \frac{n_c\lambda}{\lambda_c}, \tag{4}$$

where$N \equiv \lambda_c/\lambda$, and the minimal Heisenberg's uncertainty principle of $V_0\Delta t/\hbar\pi = \hbar 2\pi v\Delta t/\hbar\pi = 1$ was used. Therefore, one has $n_c = Nn_2$. From Eqs. (5A) and (5A) the deflected electron angles due to the n-th electron passing through the upper beam or the m-th electron of the lower beam are given by

$$\boldsymbol{sin}\theta_t = \frac{y_n - D/2}{\sqrt{L^2 + (y - D/2)^2}} = \frac{n_c}{N}, \qquad \boldsymbol{sin}\theta_b = \frac{y_n + D/2}{\sqrt{L^2 + (y + D/2)^2}} = \frac{m_c}{N}. \tag{5}$$

Because of de Broglie's duality hypothesis, a quantum particle possesses a dual component which can be represented by a complex-value distribution function, and the probability is the squared magnitude. Accordingly, the overall interference intensity from those upper- and lower-beam electrons is given by

$$I_n \propto \boldsymbol{cos}^2(n_2\pi D/\lambda_c) = \boldsymbol{cos}^2(\pi D\,\boldsymbol{sin}\theta_t/\lambda) = \boldsymbol{cos}^2\left(\frac{\pi D(y + D/2)}{\lambda\sqrt{L^2 + (y + D/2)^2}}\right)$$
$$I_m \propto \boldsymbol{cos}^2\left(\frac{\pi D}{\lambda}\boldsymbol{sin}\theta_m\right) = \boldsymbol{cos}^2(\pi D\,\boldsymbol{sin}\theta_b/\lambda) = \boldsymbol{cos}^2\left(\frac{\pi D(y + D/2)}{\lambda\sqrt{L^2 + (y + D/2)^2}}\right), \tag{6A}$$

where Equation (5A) of $\boldsymbol{sin}\theta = n_c\lambda/\lambda_c$ is used. Because $N \equiv \lambda_c/\lambda$, the interference intensity of single electrons from the top and bottom beam is given by

$$I \propto \sum_n \boldsymbol{cos}^2\left(\frac{\pi D}{\lambda}\frac{y_n - D/2}{\sqrt{L^2 + (y_n - D/2)^2}}\right) + \sum_m \boldsymbol{cos}^2\left(\frac{\pi D}{\lambda}\frac{y_m + D/2}{\sqrt{L^2 + (y_m + D/2)^2}}\right). \tag{6B}$$

where y_n or y_m represents the location of the n-th upper-beam or m-th lower-beam electron's dot signal on the screen. Upon collecting the intermittent dot signals from arriving single electrons without knowing their trajectories, in the continuum limit of a large N, i.e., when the electron's wavelength is much shorter than that of the fundamental cavity mode, Equation (6B) can be reduced to the well-known formula [23] as

$$I(y) \propto \boldsymbol{cos}^2\left(\frac{\pi D(y - D/2)}{\lambda\sqrt{L^2 + (y - D/2)^2}}\right) + \boldsymbol{cos}^2\left(\frac{\pi D(y + D/2)}{\lambda\sqrt{L^2 + (y + D/2)^2}}\right). \tag{6C}$$

This interpretation provides a more physical picture of how single electrons, neutrons, atoms, or molecules can result in an interference pattern yet induce a dot-like signal on a detector screen. Our mechanism offers a better physical explanation to the quantum interference of single particles. With quantized momentum transfer, one can obtain a better picture of how an electron can be deflected from its initial trajectory. According to our mechanism, a single electron can only pass one of the double slits at a time, there is no need for the counter-intuitive wave splitting, self-interference, and then wave recombination of the wave-packet of the same electron before detection. Furthermore, there is no need of unphysical wavefunction collapse hypothesis of the Copenhagen interpretation of Schrodinger's wave-equation approach. According to our model, interference is caused by non-local interaction between the electron and the double-slit, and the interaction can be described as quantized momentum transfer from the double-slit cavity modes. The amplitude distribution of the n_2-th cavity mode is given by$\boldsymbol{cos}(n_2\pi D/\lambda)$, which leads to an interference pattern with an intensity proportional to $\boldsymbol{cos}^2(n_2\pi D/\lambda)$.

Now, let's consider a more realistic case where both slits have a finite width of B, then the potential becomes

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$$V(x,y) = V_0\delta(x)\left(1 - \Pi\left(\frac{y-D/2}{B}\right) - \Pi\left(\frac{y+D/2}{B}\right)\right), \tag{7}$$

where $\Pi(u) = 1$, if $|u| \leq 1/2$ and vanishes elsewhere. The corresponding force components are given by

$$F_x(x,y) = -V_0\left(\frac{d}{dx}\delta(x)\right)\left(1 - \Pi\left(\frac{y-D/2}{B}\right) - \Pi\left(\frac{y+D/2}{B}\right)\right)$$

$$F_y(x,y) = \left(\frac{V_0}{B}\right)\delta(x) \times \tag{8}$$

$$[\delta(y-(D+B)/2) - \delta(y-(D-B)/2) + \delta(y+(D-B)/2) - \delta(y+(D+B)/2)].$$

According to the above potential, with $\tilde{F}_x$and $\tilde{F}y$ defined in Eq, (4A), as a sum over the Fourier series components, it has

$$\tilde{F}_x(n_1,n_2) = i(V_0\, n_1/\lambda)[2\pi\delta(2n_1\pi/\lambda) - 2\boldsymbol{cos}(n_2\pi D/\lambda)\,\boldsymbol{cos}(n_2\pi B/\lambda)]$$

$$\tilde{F}_{xy}(n_1,n_2) = (V_0/\pi B)\boldsymbol{cos}(n_2\pi D/\lambda)\,\boldsymbol{sin}(n_2\pi B/\lambda) \tag{9}$$

$$= (V_0/\pi B)\boldsymbol{cos}(n_2\pi D/\lambda)\,\boldsymbol{sin}c(n_2\pi B/\lambda),$$

where $\boldsymbol{sin}c(u)$ is the sinc-function defined as $\boldsymbol{sin}(u)/u$. Equation (7) can be simplified and reduced to Eq (4) as B becomes 0. The overall interference intensity is given by

$$I \propto \sum_n \boldsymbol{cos}^2\left(\frac{\pi D}{\lambda}\frac{y_n - D/2}{\sqrt{L^2+(y-D/2)^2}}\right) \times \boldsymbol{sinc}^2\left(\frac{\pi B}{\lambda}\frac{y_n - D/2}{\sqrt{L^2+(y_n-D/2)^2}}\right)$$

$$+\sum_{m1}^{1} \boldsymbol{cos}^2\left(\frac{\pi D}{\lambda}\frac{y_m + D/2}{\sqrt{L^2+(y_m+D/2)^2}}\right) \times \boldsymbol{sinc}^2\left(\frac{\pi B}{\lambda}\frac{y_m + D/2}{\sqrt{L^2+(y_m-D/2)^2}}\right). \tag{10A}$$

After accumulating the intermittent dot signals of single electrons without distinguishing their trajectories, in the continuum limit of a large N, i.e., when the wavelength of the fundamental cavity mode is much longer than that of the electron, the above equation can be simplified to the well-known formula [23] as

$$I(y) \propto \boldsymbol{cos}^2\left(\frac{\pi D}{\lambda}\frac{y - D/2}{\sqrt{L^2+(y-D/2)^2}}\right) \times \boldsymbol{sinc}^2\left(\frac{\pi B}{\lambda}\frac{y - D/2}{\sqrt{L^2+(y-D/2)^2}}\right)$$

$$+\boldsymbol{cos}^2\left(\frac{\pi D}{\lambda}\frac{y + D/2}{\sqrt{L^2+(y+D/2)^2}}\right) \times \boldsymbol{sinc}^2\left(\frac{\pi B}{\lambda}\frac{y + D/2}{\sqrt{L^2+(y-D/2)^2}}\right). \tag{10B}$$

Equations (10A) and (10B) serve as the key formulas for double-slit interference with a finite slit width B. Without invoking the wave theory's counter-intuitive self-interference or the non-physical wavefunction collapse hypothesis, we re-derived the well-known interference formula which is a special case of our more general expression that predicts finer discrete fringes if the slit gap and the electron's wavelength become comparable. Incoherence in the electron source or instabilities in the experimental setup—arising from mechanical or thermal fluctuations—can degrade the observed interference pattern.

We propose in this work an alternative framework based on quantized momentum transfer to analyze the well-known double-slit interference involving single electrons. This approach offers a more physically intuitive picture by describing how an indivisible electron traverses only one slit, receives a discrete momentum transfer from the slit structure, and subsequently strikes the detector as a localized dot signal. Unlike the conventional Schrödinger approach and the Copenhagen

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interpretation of wavefunction collapse [24–28], our mechanism removes the counterintuitive notion of self-interference, where a single electron's wavefunction is presumed to split, traverse both slits simultaneously, recombine before detection, and collapse instantaneously upon measurement.

Our interpretation aligns naturally with Einstein's emphasis on physical reality and his critique of the incompleteness of the Copenhagen framework. While our stochastic discrete cavity-mode mechanism introduces a form of non-locality, it fundamentally differs from Einstein's hidden-variable theories [17], which rely on local realism. Instead, our model predicts a violation of Bell's inequality [11–16], in agreement with experimental results that challenge the classical notion of locality. This perspective provides deeper insight into the structure of quantum phenomena, where non-local interactions emerge from the quantized momentum transfer mechanism rather than from hidden variables.

A key prediction of our model is that when the electron's wavelength approaches the scale of the slit gap, the discreteness of the cavity modes in Eqs. (6B) and (10A) lead to deviations from the smooth continuum behavior described by Eqs. (6C) and (10B). This effect, arising directly from quantified momentum transfer, suggests that interference patterns at this scale should exhibit observable modifications. Testing this prediction requires an exceptionally coherent electron source and a structurally stable double-slit apparatus to prevent external perturbations from masking cavity-mode effects. Experimental verification of this phenomenon would provide direct evidence for the role of quantized spacetime structures in electron diffraction.

In conventional quantum mechanics, the Schrödinger wavefunction description treats the double slit as a classical object, and interference is understood as the self-interference of a single electron's wave packet. In contrast, our interpretation assigns a quantized spacetime structure to the double slit, where cavity modes arise naturally from its geometry. Rather than viewing the electron as a purely wavelike entity, our model treats it as a localized particle that interacts with the quantized cavity modes in a stochastic but well-defined manner. This perspective unifies particle-like and wave-like behavior while maintaining a physically realistic framework. It is interesting to point out that our approach of cavity-induced nonlocal quantized momentum transfer resembles the quantum electrodynamics for the interaction between an electron and an EM field [29–33].

By explicitly incorporating quantized momentum transfer, our theory provides a more intuitive and testable explanation of double-slit interference than interpretations such as Copenhagen, many-worlds, and Bohmian mechanics. Unlike these frameworks—which rely on abstract probability waves, parallel universes, or deterministic hidden variables—our approach attributes interference to a concrete physical mechanism rooted in the quantized structure of spacetime. This perspective eliminates the need for a single electron to exist in a superposition of paths, refuting the necessity of wavefunction overlap across multiple trajectories.

A crucial aspect of our model is its connection to Bell's inequality, a fundamental test of quantum correlations. Experimental violations of this inequality strongly support the nonlocal nature of quantum mechanics, aligning with our findings while providing a novel interpretation that dispenses with wavefunction collapse and self-interference. Future experiments could further distinguish our approach from conventional interpretations, potentially yielding new insights into the foundational nature of quantum reality. Moreover, our theory directly challenges the many-worlds interpretation, which posits that quantum superpositions lead to a continuous branching of the universe. While mathematically consistent, this idea introduces an unbounded proliferation of parallel worlds without direct experimental evidence. Our model, by contrast, maintains realism without invoking such an extravagant ontology, instead grounding quantum phenomena in discrete, testable momentum transfers. In this framework, Schrödinger's cat paradox [34] is no longer a paradox but a misinterpretation arising from an artificial insistence on wavefunction superposition as a physical reality rather than a calculational tool.

Furthermore, our theory, formulated within Heisenberg's operator framework, successfully reproduces the standard double-slit interference pattern, regardless of slit width. However, it does so without resorting to the elusive concept of single-electron self-interference or the unphysical notion of instantaneous wavefunction collapse. By providing a physically grounded account of an operator-based quantum theory, this work presents an interpretation of quantum mechanics that is experimentally testable and conceptually aligned with Einstein's vision of a comprehensible physical world.

References

1. Feynman, R. P., Leighton, R. B., & Sands, M. (1965). *The Feynman Lectures on Physics, Vol. 3*. Addison-Wesley.
2. Merli, P. G., Missiroli, G. F., & Pozzi, G. (1976). *On the Statistical Aspect of Electron Interference Phenomena*. *American Journal of Physics*, 44(3), 306-307.
3. Tonomura, A., Endo, J., Matsuda, T., Kawasaki, T., & Ezawa, H. (1989). *Demonstration of Single-Electron Buildup of an Interference Pattern*. *American Journal of Physics*, 57(2), 117-120.
4. Feynman, R. P. (2010). *QED: The Strange Theory of Light and Matter*. Princeton University Press.
5. Zeilinger, A. (2010). *Dance of the Photons: From Einstein to Quantum Teleportation*. Farrar, Straus and Giroux.
6. Bohr, N. (1949). *Discussions with Einstein on Epistemological Problems in Atomic Physics*.
7. Everett, H. (1957). *"Relative State" Formulation of Quantum Mechanics*. *Reviews of Modern Physics*, 29(3), 454. (Many-Worlds Interpretation)
8. Bohm, D. (1952). *A Suggested Interpretation of the Quantum Theory in Terms of "Hidden" Variables I & II*. *Physical Review*, 85(2), 166-193. (Bohmian Mechanics)
9. Dirac, P. A. M. (1981). *The Principles of Quantum Mechanics (4th ed.)*. Oxford University Press.
10. Wheeler, J. A., & Zurek, W. H. (1983). *Quantum Theory and Measurement*. Princeton University Press.
11. Bell, J. S. (1964). *On the Einstein Podolsky Rosen Paradox*. *Physics Physique Физика*, 1(3), 195-200.
12. Aspect, A., Dalibard, J., & Roger, G. (1982). *Experimental Test of Bell's Inequalities Using Time-Varying Analyzers*. *Physical Review Letters*, 49(25), 1804-1807.
13. Weihs, G., Jennewein, T., Simon, C., Weinfurter, H., & Zeilinger, A. (1998). *Violation of Bell's Inequality Under Strict Einstein Locality Conditions*. *Physical Review Letters*, 81(23), 5039-5043.
14. Hensen, B., Bernien, H., Dréau, A. E., Reiserer, A., Kalb, N., Blok, M. S., & Taminiau, T. H. (2015). *Loophole-Free Bell Inequality Violation Using Electron Spins Separated by 1.3 km*. *Nature*, 526(7575), 682-686.
15. Bell, J. S. (2004). *Speakable and Unspeakable in Quantum Mechanics (2nd ed.)*. Cambridge University Press.
16. Aspect, A., & Grangier, P. (2019). *Quantum Mechanics: From Basic Principles to Quantum Entanglement*. Oxford University Press.
17. Einstein, A., Podolsky, B., & Rosen, N. (1935). *Can Quantum-Mechanical Description of Physical Reality Be Considered Complete? Physical Review*, 47(10), 777-780.
18. Bohm, D. (1952). *A Suggested Interpretation of the Quantum Theory in Terms of "Hidden" Variables. I & II. Physical Review, 85*(2), 166–179 & 180–193.
19. Holland, P. R. (1993). *The Quantum Theory of Motion: An Account of the de Broglie–Bohm Causal Interpretation of Quantum Mechanics.*
   Cambridge University Press.
20. Heisenberg, W. (1925). *Quantum-Theoretical Re-Interpretation of Kinematic and Mechanical Relations*. *Zeitschrift für Physik*, 33(1), 879-893.
21. Sakurai, J. J., & Napolitano, J. J. (2017). *Modern Quantum Mechanics (2nd ed.)*. Cambridge University Press.
22. Griffiths, D. J. (2018). *Introduction to Quantum Mechanics (3rd ed.)*. Cambridge University Press.
23. Cohen-Tannoudji, C., Diu, B., & Laloë, F. (1977). *Quantum Mechanics* (Vols. 1 & 2).
   Wiley. ISBN: 978-0471164333 (Vol. 1), 978-0471164357 (Vol. 2).
24. Aharonov, Y., Albert, D. Z., & Vaidman, L. (1988). *How the Result of a Measurement of a Component of the Spin of a Spin-1/2 Particle Can Turn Out to Be 100*. *Physical Review Letters*, 60(14), 1351-1354.

25. Wiseman, H. (2007). *Grounding Bohmian Mechanics in Weak Values and Bayesianism*. *New Journal of Physics*, 9(6), 165.
26. Kocsis, S., Braverman, B., Ravets, S., Stevens, M. J., Mirin, R. P., Shalm, L. K., & Steinberg, A. M. (2011). *Observing the Average Trajectories of Single Photons in a Two-Slit Interferometer*. *Science*, 332(6034), 1170-1173.
27. Schlosshauer, M. (2007). *Decoherence and the Quantum-to-Classical Transition*. Springer.
28. Auletta, G. (2000). *Foundations and Interpretation of Quantum Mechanics*. World Scientific.
29. Haroche, S., & Raimond, J. M. (2006). *Exploring the Quantum: Atoms, Cavities, and Photons*. Oxford University Press.
30. Meschede, D. (1995). *Atoms and Quantum Mechanics in Cavities*. *Physics Reports*, 254(6), 315-364.
31. Dalibard, J., Raimond, J. M., & Haroche, S. (1992). *Wave-Particle Duality in a Cavity*. *Proceedings of the Royal Society A*, 435(1893), 173-178.
32. Haroche, S., & Raimond, J. M. (2013). *Exploring the Quantum: Atoms, Cavities, and Photons*. Oxford University Press.
33. Cohen-Tannoudji, C., Dupont-Roc, J., & Grynberg, G. (1992). *Atom-Photon Interactions: Basic Processes and Applications*. Wiley-VCH.
34. Schrödinger, E. (1980). *The present situation in quantum mechanics*. Proceedings of the American Philosophical Society, **124**(5), 323–338.