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INVESTIGATING THE CORRECTNESS OF BORN'S PROBABILISTIC INTERPRETATION OF WAVE-PARTICLE DUALITY USING THE PARTICLE COLLECTION DEVICE

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Abstract. *This paper explores the physical essence of the wave nature of microscopic particles. There is no doubt that microscopic particles are volatile. The microscopic particle beams in destructive interference correspond to the decrease of the amplitude of the matter wave function, which is macroscopically reflected in the reduction of the current value of charged particle flow, or the weakening of ionization of particles with other substances, or the lowering of X-ray intensity excited by the particle beam. This paper believes that for interference microscopic particle beams, the arrived microscopic particle numbers cannot be accurately measured by traditional current measurement method or by way of sensitizing the photographic negative. Only by use of the instrument specially designed for collecting microscopic particles or for accurately measuring the impulse, could the particle number be properly measured. Due to the incorrect interpretation of the measurement results of experimental instruments, a misunderstanding of the motion characteristics of microscopic particles has been generated. As a result, the microscopic particle is puzzling in many phenomena. In this paper, a new explanation of the wave nature of a microscopic particle is proposed, whose reasonability is justified by the analysis of an ideal experiment, and the design scheme of an experimental device that can accurately measure the particle number is described.*
Keywords: Microscopic particles, Wave-particle duality, Electronic interference experiment, Born's probabilistic interpretation

1. **Introduction.** When the study of physics reaches deeper into the microscopic, it encounters many perplexing phenomena. It is well known that light is an electromagnetic wave. By studying the frequency of light waves, interference and diffraction of light waves, reflection and refraction of light waves, physicists confirm that light is an electromagnetic wave. However, the results of many observation experiments clearly show that only by assuming that light wave is a kind of particle, which are endowed with the particle characteristics such as momentum and mass, can a reasonable and accurate explanation be given to the experimental results, and it is difficult to obtain a satisfactory explanation with wave theory and method. Besides, for all we know that electrons, protons, and neutrons are physical particles, whose particle characteristics are clearly demonstrated by the measurement of their masses, by the observation of collisions between particles and by observation and measurement of their trajectories in given electric or magnetic fields. However, the fluctuating characteristics of electrons are reflected in experiments such as the crystal scattering of electrons, and only when the electron flow is regarded as a kind of material wave, the variation law of the reflected current can be explained quantitatively

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by using de Broglie's wavelength formula and the wave interference principle. This is an archaic issue, as it has been nearly a hundred years since the discovery of the fluctuating phenomenon of electrons, but what the nature of the fluctuating nature of microscopic particles is still a debatable question.

Wave-particle duality is a property universally possessed by microscopic particles, as confirmed by a large number of well-designed physical experiments. The view that microscopic particles are both waves and particles poses a huge obstacle for people to understanding the microscopic world. It is desired to characterize the waves of matter of microscopic particles within an easily understandable framework. The properties of a wave are described by physical quantities such as amplitude, frequency, and speed of propagation. Waves exist in space in a diffuse state and are characterized by physical phenomena such as interference, diffraction, and the relationship between the wave and the propagating medium. Particle motion is characterized by physical quantities such as velocity, mass, density, and the geometry of the particle and by the collision of particles with other substances, the trajectory of the particle, the change of the state of motion of the particle after the force, the space occupied by the particle area, the inaccessibility and other physical phenomena are characterized.

Various doctrines have been proposed by physicists regarding the interpretation of the wave-particle duality of microscopic particles, and it is now generally accepted of Born's explanation of the probability of the wave-particle duality of microscopic particles. de Broglie first proposed the theory of wave-particle duality of microscopic particles [1]. Born argued that the square of the amplitude value of the wave function of matter at a point in space is proportional to the magnitude of the probability of the particle appearing in the region near that point. Bohr proposed the complementary principle of the microscopic world, and believed that due to the wave-particle duality, only by the use of both wave image and particle image which are two classical physical images opposite to each other, could a complete description of microscopic particles be made. Under some conditions wave image is used and under other conditions particle image is used. The two images are equally important, and their description of particles is complementary. Heisenberg introduced the measured inaccuracy relation in quantum mechanics, which has the physical meaning that microscopic particles cannot have both a deterministic position and momentum at the same time. However, physicists have not reached a consensus on the explanation of the wave-particle duality of microscopic particles. Einstein believed that there must be a deterministic description of microscopic particle motion. He raised doubts about Heisenberg's uncertainty principle and Born's probabilistic interpretation, which he thought was epistemologically unacceptable. Unable to design an ideal experiment that would overthrow the uncertainty relation and probabilistic interpretation, Einstein had to admit that they had no inherent contradiction. However, Einstein refused to accept the uncertainty relation and denied the completeness of the laws of quantum mechanics. The debate over the nature of wave-particle duality in microscopic particles has been going on for a long time, but it has become much calmer after Einstein. Despite the huge epistemological obstacle in understanding the wave-particle duality of microscopic particles, there is now a consensus on it in physical circles. And the uncertainty relation and probabilistic interpretation have become laws of quantum physics that are widely accepted [2-4]. The correctness of quantum mechanics has been verified by many precision experiments [5]. Until now, quantum mechanics is still an important research field of physics theory, and new results have been published continuously [6,7]. Einstein is one of the founders of quantum mechanics for his research in the theory of photoelectric effects and the theory of excited radiation, and his firm belief in a deterministic description of the motion of microscopic particles reminds us of the possibility of new progress in the relentless search for an explanation of the nature of wave-particle duality in microscopic particles.

Wave motions are dramatically different from physical particles in the macroscopic world. This great difference results in great obstacles for people trying to understand the nature of the wave-particle duality of microscopic particles, and also prevents people from developing a clear physical picture of the state of existence of microscopic particles in their minds that is consistent with the physical experience of the macroscopic world. The difference between a wave and a moving physical particle is also reflected in the presence or absence of material transport and transfer. In the macroscopic world, waves are simply vibrations propagating through a medium, while the motion of physical particles is the actual transport and transfer of material. It is believed that the same principle is applied to matter waves in the microscopic world as well. Theoretically, it is possible to collect charged physical particles using a specially designed device. The number of physical particles arriving at a certain time can be determined by measuring the amount of charge in the device. Alternatively, the momentum transferred by the collision of a particle and a substance can be measured with a specially designed precision device for measuring the accumulation of impulses in a certain time, thus to determine the number of physical particles arriving in the wave. In the case of a wave propagating vibration, there is no problem of collecting and weighing the waves arriving in a certain period of time. In this paper, the research is conducted along these principles.

In Chapter 2 of this study, the simple harmonic vibration hypothesis for microscopic particle matter waves is presented. Ideal experiments on coherent electronic waves are carefully analyzed in the third chapter. In Chapter 4, the capabilities of existing instruments for detecting the number of microscopic particles are questioned, and the design principle of an instrument which can accurately detect the particle number is described. Chapter 5 lists a number of issues for further exploration. The last chapter is a conclusion for this study.

2. **Hypothesis on Simple Harmonic Vibration of Matter Wave of Microscopic Particles.** The most important theory about matter wave of microscopic particles is Born's probabilistic interpretation. Born's theory has been controversial, and the author of this paper is skeptical of this theory. Based on the crystal scattering experiment of electron beams as well as other related investigations on the wave nature of microscopic particles, it is found that the problem may be caused due to people's excessive trust in the function of the detecting instrument. After deep consideration of the problem, a new explanation on the wave nature of microscopic particles is obtained, which includes the following three hypotheses.

1) When moving in vacuum, the microscopic particles are also in a state of simple harmonic vibration. The wavelength of the vibration is presented by the de Broglie wavelength formula.

2) When two beams of the same microscopic particles, at the same movement rate and toward approximate same direction, meet at a certain point in space, interference will occur due to different vibration phases. The interference obeys the wave interference principle.

3) The macroscopic effect of interference is manifested by the difference in the light amount on the photographic negative, or the difference in the intensity of the test current, or the difference in the intensity of X-rays excited in a certain substance. These measurements are proportional to the square of the amplitude of the wave function. However, when the interference of microscopic particles occurs, these measurements cannot be used to accurately reflect the number of particles.

Hypotheses 1) and 2) are based on the results of a large number of physical observation experiments; in particular, the results of the crystal scattering of electron beams are fully consistent with the quantitative interpretation using the wave interference principle. Hypothesis 3) is different from the probabilistic interpretation of matter waves, which is the main problem discussed in this paper. According to hypothesis 3), in the case of microscopic particles in fully destructive interference, although the amplitude of the wave function is 0, it does not mean there are no particles arriving. It is the detecting instrument that cannot find the particles. This paper does not believe that the light amount on the photographic negative can directly reflect the number of electrons at this place. When two beams of electrons with the same movement rate and toward the same direction meet somewhere in space and the phase difference of the vibration is π, the electron number cannot be measured by photographic method or by way of measuring current due to the destructive interference, while it is assumed that the electrons did arrive and pass through the point.

Perhaps the mysterious nature has played a joke with the physicists who intended to measure the number of electrons arriving somewhere in space by photographic negative or current checking, and they were convinced of the measurement results. However, in some cases, the electrons passed through the detecting instrument without leaving a trace. In other words, the electrons did pass through the detecting instrument, but the instrument clearly showed that no electrons arrived, which obviously indicated that there was something wrong with the detecting instrument. In this paper, the microscopic particle number measured by the existing methods is called observable values. The spatial density of microscopic particles determined by Schrödinger's equation is called the observable spatial density. If there are interference effects of microscopic particles, the observable value and observable spatial density should be smaller than the actual value.

The idea presented in this paper may be too radical. In other words, it doubts the precise and perfect detection methods of modern experimental physics in detecting microscopic physical quantities. These experimental studies have never stopped in the past 100 years, and the results of these precision experiments have undergone heavy scrutiny by generations of physicists. However, there is no doubt that the experimental result is the standard to verify whether the physical theory is right. If electrons, which have escaped from observations countless times before, can be detected by well-designed experiments, then it should be acknowledged and thus the theory should also be revised.

3. Theoretical Analysis on the Ideal Experiment of Coherent Electron Wave.

3.1. **Analyzing on the ideal experiment of coherent light wave.** A large number of well-designed experiments have confirmed that microscopic particles have wave nature which can be accurately measured and calculated by wave principle. The crystal scattering experiments of X-rays and of high-speed electrons are calculated by the same light wave interference principle. The theoretical calculation results are highly consistent with the experimental observation results, which fully show that the interference principle plays a decisive role. Next, an ideal experiment will be carefully analyzed to examine the interference of light waves and particle waves, to deduce what these ideal experiments should result and to compare the differences between light waves and particle waves.

It is assumed that α and β are two beams of coherent light wave, which meet at point C in space, as shown in Figure 1. The angle θ between the two beams is very small, so that the two beams are approximately parallel. The assumption is that the phase difference between the two beams of light wave at point C is π. From the interference principle of light wave, the light wave energy at point C is almost 0. If a light-receiving plate M is

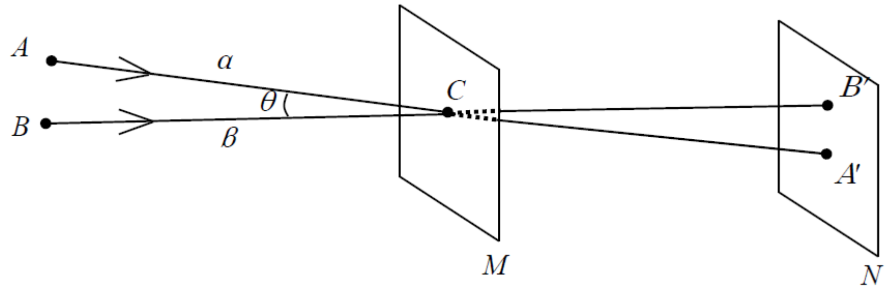

FIGURE 1. Diagram of the ideal experiment on interference of light wave

placed at C, there will be a dark spot at point C. In other words, the arrival of light wave can hardly be detected at point C. When the phase difference between the two beams of light wave is not π, for example, 0.25π or 0, then the energy of α and β which come from A and B can be detected at C.

Put a light-receiving plate N in front of the meeting point of α and β, and far away from C. It is assumed that α and β are thin enough and N is far enough away from M. A small notch is set at C to make α and β pass through completely, then the image point A' of α and the image point B' of β can be detected on the light-receiving plate N since point A and point B do not coincide. As A' and B' have been effectively separated in space, the light wave at A' and the light wave at B' have no interference effect, so no matter what the phase difference of α and β is, the energy of each of the two beams of light can be accurately detected on N. An interesting phenomenon will occur at this time. When the phase difference of α and β is π, the arrival of the light wave will not be found at point C (here photographic negative is used for detection or a light-receiving plate is placed and observed with the naked eye), because the energy of the light wave at the point C is almost 0. However, when setting a small notch to make α and β pass through completely and detecting with a light-receiving plate or photographic method at N, it will be found that α and β pass through point C without any hindrance. The sum of the energy of the incident light waves at A' and B' must be much greater than that at point C. According to the principle of wave propagation and the principle of wave interference, the above phenomenon is not surprising.

3.2. **Analyzing on the ideal experiment of coherent electron wave.** When the two beams of light α and β in the above experiment are replaced with two beams of coherent electrons, what conclusions could be expected? It is known that the interference of the electron beams completely conforms to the wave interference principle; the de Broglie wave vibration frequency ω and wavelength λ formed by electron beam are given by the de Broglie wavelength formula:

$$\lambda = h/(mV) \quad \omega = mV^2/h$$

where m, V and h represent the static mass of electron, the movement rate of electron and Planck constant. When the phase difference of two beams of coherent electron wave α and β at point C is π, theoretically, the arrival of the electrons cannot be detected at point C due to fully destructive interference, while the arrival of electrons will be detected at A' and B'. Since electrons possess the properties of particles, the electron beams from A to A' and from B to B' must be the flow of physical particles. How does the electrons pass through the small hole at C and arrive at A' and B'? According to Born's probabilistic interpretation, the probability of electrons appearing near point C is almost 0, while the observation result of the sum of number of electrons arriving at A' and B' per unit time must not equal that arriving at C per unit time, which is an obvious contradiction.

As the experimental results of the interference of electrons are in full compliance with the wave interference principle, the two beams of electrons must arrive at C independently without affecting each other, and they interfere at C. The situation above means that the meeting of them at C should be first confirmed; otherwise the situation is not related to wave interference. The contradiction is reflected in the following situation, on the one hand, when two beams of electrons meet at C in space, destructive interference will occur due to a constant phase difference π, and on the other hand, the interference result convinces us that the arrival of the two beams of electrons cannot be detected at C. To resolve the contradiction, it should be assumed that the two beams of electrons did pass through point C, but our detector did not find it. The idea that α and β arrive at A' and B' bypassing the small hole at C and going along another path is incredible.

In fact, the famous Davidson-Germer crystal scattering experiment of electron beams can illustrate the same issue. Taking electron beam as a plane wave, there are reflections of electron wave in the plane formed by the first layer of atoms in the crystal surface, and there are also reflections in the plane formed by the second layer of atoms in the crystal surface. In the area where electrons will arrive after reflection, the interference condition at a certain point is determined by the distance difference of the electrons. According to the de Broglie wavelength formula and the wave interference principle, the intensity of electron wave can be accurately calculated. Note that both of the two reflecting planes of the crystal reflect the electron wave, and the crystal also reflects the electron beam. The two beams of electrons meet in the reflection area should be first confirmed, which means that there are arrived electrons. While, if the current strength measured at a certain point is 0 and complete phase cancelling interference occurs, this situation is interpreted as no electrons arriving, which is obviously illogical.

3.3. **Questioning on the probabilistic interpretation of wave-particle duality.** It is impossible to observe the arrival of the electrons with the naked eye as the electrons are too small and move too fast. If the flow of electrons can be observed with the naked eye and the number of electrons can be clearly counted, then the problem can be solved. With the help of such a magical eye, it is possible to clearly answer whether Born's probabilistic interpretation is consistent with the facts, or whether the electrons have passed through the small notch at C in Figure 1. Unfortunately, humans' eyes cannot complete the task only by means of instruments.

It is worth pondering about Einstein's skepticism about the probabilistic interpretation of wave-particle duality. How can physicists admit that the electrons arrived at A' and B' miraculously in the experiment described above? Imagine that the small hole at C is sealed, it is obvious that no electrons will arrive at A' and B'. And then imagine that a small hole is opened near point C but not point C, there will be still no electrons detected at A' and B'. It actually implies that the two beams of electrons did pass through point C, but the instrument did not detect it. This is an audacious assumption which will be discussed in detail in next chapter.

4. **Experimental Assumption to Test the Nature of Wave-Particle Duality of Microscopic Particles.**

4.1. **Using specially designed electronic collection device to measure the number of electrons.** The instrument for detecting the flow of microscopic particles generally uses photographic method or current measurement method. The photographic method is based on the design of electrons with a certain speed hitting the photosensitive material to make it sensitive to the image. The current measurement method directly measures the current intensity formed by the moving electron beams, and the current value is used to reflect the number of electrons passing through per unit time. Therein lays the main problem. If two beams of electrons in fully destructive interference are incident on a photographic negative and cannot stimulate the expected chemical reaction, in other words, the incident electrons cannot sensitize the photosensitive material and it can be concluded that no electrons arrived. Similarly, if two beams of electrons in fully destructive interference cannot produce the expected magnetic field, in other words, the current detector shows there is no current passing when the electron beams pass through. It can also be concluded that no electrons arrived. Here the situation is presented that the electrons pass the test instrument, but the test instrument fails to monitor the electron.

The new interpretation proposed in this paper can be verified by the electron crystal scattering experiments described below. As presented in Figure 2, A stands for a beam of electrons with a certain speed, and M refers to the surface of a crystal. G is a device that measures the number of arriving electrons. The function of the device is to measure the number of electrons arriving at G in a certain period of time. The experimental device is basically the same as that in the electron scattering experiment of Davidson and Germer, but the device in this paper is not equipped with a galvanometer.

G in Figure 2 is a device to collect electrons, which is a hollow sphere with a small notch, as presented in Figure 3. The small notch is used to absorb electrons. Due to the small size of the notch, the collected electrons reflect the electron density at the position of the small notch. Moreover, as the notch is relatively smaller than the size of the hollow sphere, it is difficult for electrons to re-shoot out of the notch once entering the hollow sphere. It is required that the interior of the hollow sphere is a conductor, and its interior surface is rough and uneven. It is also required that its exterior surface is insulated from the interior, so that electrons hitting on the exterior surface will not enter the interior.

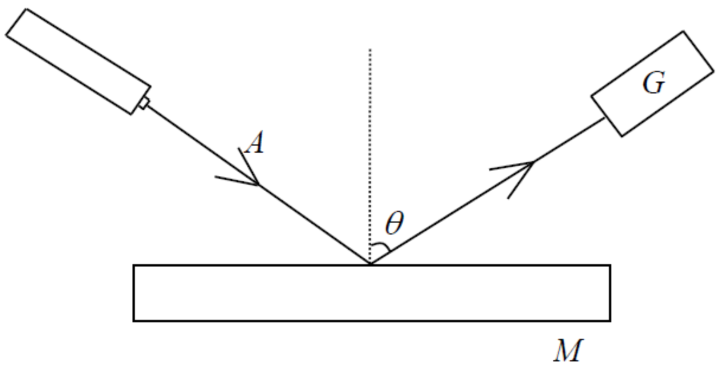

FIGURE 2. Diagram of crystal scattering experiment of electrons

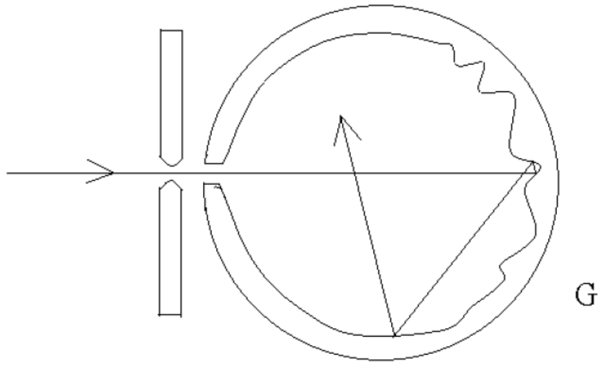

FIGURE 3. Diagram of electron collection device G

Place a thin baffle with a small opening in front of the small notch of the hollow sphere. The baffle is insulated from the sphere shell, and the two small openings are aligned and toward the direction of receiving electrons. The electric quantity carried by the sphere shell can be measured by electrostatic method.

Adjust the orientation of the electron beam so that it can shoot at the small notch of G according to the law of reflection. For the electron beams with different movement rates, the numbers of electrons that are shot into the small notch in a certain period of time are measured respectively, and their current value is measured by traditional galvanometer at the same position. The results of the comparative experiments will be used to verify the validity of the probabilistic interpretation of electron wave. According to the experimental results of the Davidson and Germer, if the traditional galvanometer method is used, the current arriving at G will vary periodically between a certain maximum value and minimum value with the increase of electron rate and the variation pattern depends on the lattice constant of the scattering crystal. The condition for the appearance of maximum current value is presented as follows:

$$a(\sin\theta)/k = \lambda, \quad k = 1, 2, \ldots$$

In the formula, a represents the lattice constant, θ representing the scattering angle, and λ representing the de Broglie wavelength. The device G designed in this paper is used to collect electrons. If the number of electrons ejected into a small hole in a fixed period of time increases monotonically with the rate of motion of the incident electrons, the interpretation of the probability of an electron wave is proved to be incorrect. The experiment can also be conducted as follows: using a galvanometer and device G separately near the scattering angle, select an electron beam of a fixed speed and detect the scattering angle when the current of electron beam reaches the maximum value using a galvanometer and continuously measure the current of the election beam and the number of electrons ejected into the aperture of G for a fixed period of time. A comparison of the experimental data measured by the two methods can be used to determine the conclusion.

G can also be an instrument to measure the tiny impact of a stream of microscopic particles and thereby determine the number of arrival electrons. Particle flow is a kind of matter flow with a certain mass and a certain speed. In this research, it is believed that the momentum of particle flow will not change whether the particle flow is in an interference state, so the number of particles can be measured by the momentum of the particle flow transferred to a fixed target. If G in the experiment shown in Figure 2 is replaced with an instrument that can accurately measure the impulse of the particles, it can be observed whether the number of electrons increases monotonically with the increase of speed of the electron beam A, so as to test the new explanation proposed in this paper. Theoretically, the number of electrons arriving at G in the experiment shown in Figure 1 has nothing to do with the interference of electron wave, so it is expected that the number of electrons will not be shown in a periodic change which is based on the condition for the interference of wave.

4.2. **Possible technical difficulties and solutions.** The collection device for electrons and the device for measuring the particle impulse can perform the intended function only under certain conditions of assumption. For a collection device for electrons, it is assumed that electrons entering the collection device do not escape unimpeded through the collection device and that the collection device can intercept the electrons. For instruments that measure particle impulse, we assume that the electron beam will not pass through the instrument unhindered and will not escape without transferring any momentum. In practice, the hypothesis raised may not be valid, because according to the argument presented, destructive interference electron beams would not be sensitive to light on the photographic film and would not generate a magnetic field in local space. It can be imagined that such electron beams (in fully destructive interference) have no electromagnetic interaction with other substances. It cannot be guaranteed that instruments designed by ordinary methods will certainly intercept these electrons, which also reminds us that the difficulties we might encounter should be considered when designing instruments for collecting electrons or measuring particle impulse.

The problem becomes more complicated once fully destructive interference electron beams can penetrate unimpeded through any material plate. It is possible to design instruments that collect electrons on a large spatial scale, since the interfering electron beams are not perfectly parallel and with a very small angle of intersection. The electron beam entering the electronic collection device is effectively separated away from the small entrance, and the electron beam that is effectively separated will definitely be effectively intercepted. A transverse scale of more than five times the de Broglie wavelength of the electrons can allow the interference beams to separate effectively. The electrons, which have been effectively separated, hit on the inner wall of the instrument and expend their energy through electromagnetic interaction and collision, and are eventually collected successfully. If a solid material plate is used to receive momentum from a phase-canceling interfering electron beam, there may be a situation where the electron beam penetrates the plate with essentially the same velocity, and very little momentum is transferred. To avoid such situation, the material plate can be placed away from the small inlet to receive the impact of the phase interfering electron beam, and when the electron beam is separated to a certain distance, the momentum can be effectively transferred to the intercepting material.

Experimental physicists had wrestled their brains in order to detect the amazing neutrinos released by the nucleus during β decay. Since the interaction between neutrinos and known materials is quite weak, it seems that neutrinos can penetrate any material of any thickness without hindrance. Such problems still cannot challenge the experimental physicist, so the phase cancelling interfering electrons will certainly not escape unnoticed by the elaborate apparatus designed by experimental physicists.

5. **Discussion.** Modern microscopic physics images of probability waves of microscopic particles have become widely accepted and deeply rooted in the last hundred years. If the arguments in this paper are confirmed by experiments, then the original probability wave images should be replaced by images that are more consistent with the real material world, thereby portraying the states of microscopic particles in a visual and accurate manner. The hypothesis can be stated that the wave function determined by the Schrödinger equation determines the observable density of a particle at a point in space around an atom. It is a challenging theoretical problem to determine the real spatial density distribution of the particle and to find the difference between the real density and the observed density of the particle and then theoretically explain the physical significance of the difference. In addition, the wave function determined by Schrödinger's equation does not reflect the true spatially distributed density of the particles, so the correctness of the Heisenberg-established mismeasurement relation needs to be re-examined.

In the new explanation on the wave-particle duality of microscopic particles, there are still some problems to be studied further. If the microscopic particles are in a state of vibration while moving, then what kind of vibration is it? Is it possible to describe it by the mode of vibration of macroscopic object? Why electron beams in destructive interference cannot leave traces on photographic negative and why they cannot be detected by a galvanometer? Is there any difference in the value of momentum between the interference matter waves of microscopic particles and the interference electromagnetic waves? In the study of physical theories, are there any other regions where the results given by the testing instruments are in fact inconsistent with the conclusions obtained by physicists? In other words, will the testing instruments deceive the physicists? What are needed to be updated for our understanding of the whole microscopic world? These questions are very important and deserve further study.

6. **Conclusion.** This research investigates the physical nature of particle fluctuations and proposes a simple harmonic vibration hypothesis for the fluctuations of microscopic particles. This research analyzes an ideal experiment to demonstrate the validity of the proposed hypothesis and to propose the design of an experimental setup that can correctly measure the number of arrivals of microscopic particles. Through an in-depth analysis of the electron crystal scattering experiments, we discovered that for phase interfering microparticle beams, the traditional methods of measuring current and exposing the photographic film to light do not accurately reflect the number of microparticles reaching the beam. The number of microscopic particles arriving can only be correctly measured with a specially designed instrument that collects microscopic particles or an instrument that precisely measures the microscopic particle impulse. The arguments presented in this paper refute Born's probabilistic interpretation of the volatility of microscopic particles.

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REFERENCES

[1] L. de Broglie, *The Current Interpretation of Wave Mechanics, A Critical Study*, American Elsevier, New York, 1964.
[2] W. H. Cropper, *The Quantum Physicists and an Introduction to Their Physics*, Oxford University Press, New York, 1970.
[3] K. W. Ford, *Classical and Modern Physics*, Xeror College Publishing, 1974.
[4] J. Mehra, *The Physicist's Conception of Nature*, 1973.
[5] G. W. Kaye and T. H. Laby, *Tables of Physical and Chemical Constants*, 16th Edition, Longman Group Limited, 1995.
[6] S. Sturm et al., High-precision measurement of the atomic mass of the electron, *Nature*, vol.506, no.27, pp.467-470, 2014.
[7] F. Heiße et al., High-precision measurement of the proton's atomic mass, *Physical Review Letters*, vol.119, no.3, 2017.
[8] X. Wang, A new study on the energy of microscopic particles concerning its matter waves, *International Journal of Innovative Computing, Information and Control*, vol.11, no.3, pp.999-1010, 2015.