Article

Not peer-reviewed version

Theoretical Proof of De Broglie's Wave Function

Sheng Qin *

Posted Date: 18 July 2024

doi: 10.20944/preprints202407.1504.v1

Keywords: de Broglie Wave Function; Matter Wave Function; Free Particle Wave Function; Spatial Distribution of Wave Function

Article

Theoretical Proof of de Broglie's Wave Function

Sheng Qin

Southwestern University of Finance and Economics,China,610000; qinsheng@smail.swufe.edu.cn

Abstract: This paper, based on the "Unified Theory of Forces," rigorously proves the formula of de Broglie's wave function. This helps us better understand the following important issues: 1) Theoretically prove and understand the essence of de Broglie's wave function; 2) Prove that when the particle's momentum P is determined, the greater the mass of the particle, the more concentrated its wave function distribution, and the weaker the interference effect; 3) Correct the spatial distribution of the wave function of free particles, proving that the wave function of free particles is strictly constrained within a finite spatial range, which is consistent with the facts we observe.

Keywords: de Broglie Wave Function; Matter Wave Function; Free Particle Wave Function; Spatial Distribution of Wave Function

1. Introduction

Since de Broglie proposed his theory of wave functions for particles in his 1925 doctoral thesis "On the Theory of Quanta," the theory has been verified by a large number of experiments. However, the author believes that the derivation process and assumptions of the theory, based on the theoretical conditions at that time, may not fully explain the essence of the wave function of free particles (may not fully explain the essence of the wave nature of free particles). At the same time, the author believes that de Broglie's theory on the spatial distribution of free particle wave functions is problematic and does not conform to the facts we observe. The relationship between particle mass, momentum, and interference effects in de Broglie's theory is also not clearly explained.

This paper, based on the author's "Unified Theory of Forces" [1], derives the formula of the wave function of free particles more concisely and rigorously, and imposes strict conditions on the spatial distribution of the wave function of particles.

2. Wave Function of Particles at Rest

Firstly, the motion of a particle should comply with the law of conservation of energy, and the probability of a particle appearing at a certain place in space should not violate the law of conservation of energy. According to the conclusions in the "Unified Theory of Forces," we know that all "forces" originate from the energy deficit $E_{Missing}$ between materials [1]. Therefore, the distribution of particles in space will be constrained by the "$E_{Missing}$," and they will not appear anywhere in space unless the particle obtains energy from the outside or from other internal particles.

Based on the formula for electric potential energy:

$$E_p = k\frac{Qq}{r}$$

We got,

$$r = k\frac{Qq}{E_p}$$

Based on our conclusions in the "Unified Theory of Forces," assuming the energy deficit between the electron and proton is $E^0_{Missing}$, then before the hydrogen atom releases energy to the outside, the equilibrium radius $\bar{r}$ of the electron and proton is:

$$\bar{r} = k\frac{e^2}{E^0_{Missing}}$$

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 July 2024 doi:10.20944/preprints202407.1504.v1

We have already proven that when the distance between the electron and proton is less than $\bar{r}$, there will be a repulsive force between the electron and proton, rather than an attractive force. This is the essence of the repulsive force between all particles at close distances [5].

When the hydrogen atom releases 13.6eV of energy (ground state hydrogen atom), we simply assume that we ignore the effect of the atomic nucleus, then according to the constraints of energy conservation, the motion radius of the electron cannot be greater than:

$$r_1 = k\frac{e^2}{13.6 \times 1.6 \times 10^{-19}}$$

$$= 8.99 \times 10^9 \frac{\left(1.6 \times 10^{-19}\right)^2}{13.6 \times 1.6 \times 10^{-19}} \approx 1.06 \times 10^{-10} m$$

Therefore, for the ground state hydrogen atom at rest, if it does not obtain external energy, the electron outside the nucleus cannot appear outside the atomic nucleus $r_1 \approx 1.06 \times 10^{-10} m$.

For the moving free particle, due to the asymmetry of motion [2] and according to the "prohibition of energy arbitrage" theorem [1], we have already proven that particles will produce Lorentz contraction effects symmetrically in all directions (not just in the direction of particle motion) [6].

Therefore, for free particles, taking the ground state hydrogen atom as an example, assuming the ground state hydrogen atom moves at a speed v, then its distribution in space will be confined to a finite range centered on the motion trajectory of the hydrogen atom nucleus r_v:

$$r_v \leq r_1 \sqrt{1 - \frac{v^2}{c^2}}$$

Where, $r_1 \approx 1.06 \times 10^{-10} m$

We have discussed in another article that matter, including photons and electrons, is composed of positive and negative charges through the method of energy deficit $E_{Missing}$ [5,6]. Therefore, for this type of free particles composed of positive and negative charges, their distribution in space is constrained by the above formula.

This is completely different from the wave function of free particles in traditional quantum mechanics (de Broglie wave function). The formula for the wave function of free particles in traditional quantum mechanics is:

$$\psi(\boldsymbol{r}, t) = \frac{A}{r} e^{i(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t)}$$

According to the interpretation of the wave function formula for free particles in quantum mechanics, the probability of a particle appearing in a space perpendicular to the direction of motion within an integer wavelength λ is the same. However, in fact, this is not consistent with all our experimental observations, nor does it conform to the basic law of conservation of energy.

We know that the wave nature of a particle only occurs after the interaction between objects, that is, wave nature needs material interaction as a medium condition. For example, diffraction, interference, double-slit interference, transmission, and reflection, etc. Therefore, before free particles interact with other materials, their spatial distribution is strictly limited, not uniformly distributed in the entire space.

3. The Essence of de Broglie's Wave Function

Theorem 1. The energy added by particles composed of positive and negative charges during motion is the accompanying energy field E_{follow}, which is equivalent in nature to photons or electromagnetic waves, and therefore has interference effects.

Proof:

For the accompanying energy field E_{follow} of moving charges , we have already argued about its size and nature in the "Unified Theory of Forces." The most powerful experimental evidence comes from synchrotron radiation experiments, where the radiated energy form is photons.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 July 2024 doi:10.20944/preprints202407.1504.v1

Therefore, we have sufficient evidence to prove that the energy form of the accompanying energy field E_{follow} is equivalent to photons.

The same conclusion applies to other ordinary particles and matter composed of positive and negative charges (including almost all matter except neutrinos).

We can conduct two thought experiments for demonstration.

The first thought experiment:

Due to the relative independence of space [2], we can actually regard matter as charged particles separated from each other by a long distance. Let's take hydrogen atoms as an example for proof.

Hydrogen atoms can be equivalently regarded as composed of protons and electrons that are far apart. So when we observe a hydrogen atom moving at a speed v (assuming the mass of the hydrogen atom in the stationary state is m_0^H), it is equivalent to observing the motion of a proton and an electron, and they will both produce an accompanying energy field E_{follow} (for simplicity, we assume that the total energy deficit of the entire moving hydrogen atom is E_{follow}^H).

According to the conclusions of special relativity, assuming the mass and momentum of the hydrogen atom moving at a speed v are: m_v^H and P_v^H respectively, we have:

$$m_v^H = m_0^H \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = m_0^H + \frac{\mathrm{E}_{follow}^H}{c^2} \quad (1)$$

$$P_v^H = m_v^H v = m_0^H v + \frac{\mathrm{E}_{follow}^H}{c^2} v \quad (2)$$

We find that the second term $\frac{\mathrm{E}_{follow}^H}{c^2}$ on the right side of equation (1) is actually equivalent in form to a photon, having an interference effect similar to that of a photon. However, if we look at the first term on the right side of equation (1), we find that this term still has momentum, corresponding to $m_0^H v$ in equation (2). Therefore, the second term $\frac{\mathrm{E}_{follow}^H}{c^2}$ on the right side of equation (1) is not the complete form E_{follow} of the moving hydrogen atom. Therefore, we need to find out the physical quantity that does not participate in the interference effect in the moving state, just as we observe the mass of the stationary particle, to determine the complete form of the accompanying energy E_{follow} of the hydrogen atom moving at a speed v.

Next, let's go back to a thought experiment in another paper of ours [3]:

Since any object can annihilate into two photons by matter-antimatter annihilation, in fact, any object is equivalent in form to two photons. A hydrogen atom moving at a speed v in the direction of the X-axis is equivalent to two photons emitted in the positive and negative directions of the X-axis. Due to the Doppler effect produced by the moving object emitting photons, the energies of the two photons are $\frac{1}{2}m_0^H c^2\sqrt{\frac{c+v}{c-v}}$ and $\frac{1}{2}m_0^H c^2\sqrt{\frac{c-v}{c+v}}$.

Then, the photon moving in the opposite direction of the X-axis will not participate in the interference effect on the positive direction of the X-axis. At the same time, it will also cancel out the energy of a part of the photons with equal energy and in the positive direction of the X-axis (equivalent to the energy of the particle in the stationary state). Therefore, we can calculate the part of the energy of the hydrogen atom moving at a speed v that does not participate in the interference effect and is equivalent to the energy of the hydrogen atom in the stationary state in terms of physical meaning: $2\left(\frac{1}{2}m_0^H c^2\sqrt{\frac{c-v}{c+v}}\right)$.

Thus, the part of the energy E_{follow}^H of the hydrogen atom moving at speed v that truly participates in the interference effect is:

$$\mathrm{E}_{follow}^H = m_v^H c^2 - 2\left(\frac{1}{2}m_0^H c^2\sqrt{\frac{c-v}{c+v}}\right)$$

$$= \frac{1}{2}m_0^H c^2\sqrt{\frac{c+v}{c-v}} + \frac{1}{2}m_0^H c^2\sqrt{\frac{c-v}{c+v}} - 2\left(\frac{1}{2}m_0^H c^2\sqrt{\frac{c-v}{c+v}}\right)$$

$$= \frac{1}{2}m_0^H c^2\sqrt{\frac{c+v}{c-v}} - \frac{1}{2}m_0^H c^2\sqrt{\frac{c-v}{c+v}} = \frac{m_v^H v}{c} = \frac{P_v^H}{c} \quad (3)$$

 doi:10.20944/preprints202407.1504.v1

We note that equation (3) is precisely the momentum form corresponding to the hydrogen atom moving at speed v, because this form of energy is equivalent to that of a photon, hence its energy and momentum relationship differs only by the speed of light C.

Therefore, we can draw the following conclusions:

Conclusion 1. The wave nature of moving particles is actually an effect caused by the accompanying energy field E_{follow}, which is equivalent to the wave function form of photons. Thus, its wavelength can be represented by $=\frac{h}{p}$.

Conclusion 2. Unlike the photon wave function, a part of the energy of moving particles does not participate in the interference effect, with the energy value is of $2\left(\frac{1}{2}m_0^H c^2\sqrt{\frac{c-v}{c+v}}\right)$. Therefore, we can speculate that with the particle's momentum P determined, the larger the mass of the particle, the weaker the interference effect due to the influence of this part of energy that does not participate in the interference effect, and its distribution will be more concentrated at the central position of the particle's direction of motion.

The second thought experiment:

We have conducted a similar thought experiment in the paper on the relative independence of space and have also discussed the asymmetry of motion [2]. Since the laws of physics are consistent in any uniform motion reference frame, we can also prove the fact that the increase in energy and other physical effects we see in moving objects are actually a kind of motion asymmetry effect, which is essentially caused by the relative independence of space, the accompanying energy field E_{follow}, and the prohibition of energy arbitrage, among other physical laws [1–3].

We will not elaborate further on this.

4. Discussion

Based on the "Unified Theory of Forces" [1–3], we have theoretically solved the essence of dark matter, theoretically proved the Lorentz contraction effect [4], proved the origin of the magnetic fields of neutron stars, the sun, and the Earth [7], and proved the essence and origin of the repulsive force between particles [5]. At the same time, this paper has also strictly proved de Broglie's wave function and corrected it through the "Unified Theory of Forces." This theory has many other conclusions and applications, which we will not discuss further. Because the theoretical basis of the "Unified Theory of Forces" is entirely based on rigorous theoretical derivation, and the number of physical problems that this theory can solve is so numerous, the author believes its correctness is beyond doubt.

5. Conclusion

In this paper, the author has re-explained and proved the theory of de Broglie's wave function, reaching the same conclusions in a more concise and rigorous manner. The author believes that this can truly help us understand the physical essence of the wave function of free particles. At the same time, we have corrected and constrained the spatial distribution of the wave function of free particles to better conform to our actual observations.

Additionally, the author has made up for the deficiencies in de Broglie's theory, deriving from theory the relationship between the strength of the interference effect of free particles and their mass and momentum. With the particle's momentum determined, the larger the mass of the particle, the weaker the interference effect will be, and the distribution will be more concentrated. This is the first time in physics that this has been theoretically proven, and I think this is very important.

References

1. Qin S (2022) Unified Theory of Gravity, Electromagnetic Force, Strong and Weak Forces and their Applications: Theoretical Explanation for Dark Matter. J Phys Chem Biophys. 12:335.
2. Qin S (2022) A Possible Explanation for the Twin Paradox and Action at a Distance: The Relative Independence of Space and the Absoluteness of Simultaneity. J Phys Chem Biophys. 12:332.
3. Qin S (2022) Derivation of Special Relativity Transformation Formulas without Time Delay Effect and Length Contraction Effect. J Phys Chem Biophys. 12:333.

 doi:10.20944/preprints202407.1504.v1

4. Qin S (2023) A Theoretical Explanation and Modification of the Lorentz Contraction Effect, and a Tentative Theoretical Explanation of the Planck Energy Formula. DOI: 10.20944/preprints202305.0221.v1
5. Qin S (2023, October 21). Theoretical Explanation and Computational Formulas for the Repulsion of Atomic Nucleus on Electrons and Strong Short-Range Repulsion. https://doi.org/10.31219/osf.io/ybrpg
6. Qin S (2023, May 4). A Theoretical Explanation and Modification of the Lorentz Contraction Effect, and a Tentative Theoretical Explanation of the Planck Energy Formula E=hω. https://doi.org/10.31219/osf.io/xdqr7
7. Qin S (2023, April 1). Theoretical explanation and experimental design of the origin of Earth's magnetic field, stellar magnetic field, and neutron star magnetic field. https://doi.org/10.31219/osf.io/sh8rd