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THE CONNECTION BETWEEN SCHRÖDINGER EQUATION AND QUANTUM FIELD THEORY

Hashim Gad Elseed[1], Haj hamed Diab Aljaly[2], Mohammed Hashim Albashir[3]
[1.2.3] *Department of Physics, Nile Valley University, Sudan*

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ABSTRACT

The purpose of this research review is to examine the connection between the Schrödinger equation and quantum field theory. The method used in this review is a literature review of existing research on the topic. The results of the review indicate that the Schrödinger equation, which is a fundamental equation in quantum mechanics, can be derived from the principles of quantum field theory. This connection highlights the underlying unity of the two theories and helps to further our understanding of the behavior of subatomic particles. Additionally, it has been found that the Schrödinger equation is useful in describing the behavior of systems with a small number of particles, while quantum field theory is more appropriate for systems with a large number of particles.

Research in this area has led to the development of new methods for solving the equation, such as the path integral approach, which provides a powerful tool for studying quantum systems with a large number of degrees of freedom. Additionally, the Schrödinger equation has led to the discovery of new symmetries and conservation laws, such as the AdS/CFT correspondence, which connects quantum field theory in anti-de Sitter space with a conformal field theory on the boundary of that space. Theoretical frameworks such as quantum field theory in curved spacetime and the holographic principle have also been developed to unify quantum mechanics and general relativity, and to understand the thermodynamic behavior of quantum systems and their behavior in extreme conditions. The study of quantum systems in non-equilibrium conditions is an active area of research and continues to yield new insights and discoveries.

Overall, the research reviewed in this study suggests that the Schrödinger equation and quantum field theory are closely related, and that a deeper understanding of one can lead to a deeper understanding of the other.

KEYWORDS: ***Schrödinger equation, quantum field theory, general relativity, quantum systems***

INTRODUCTION

The Schrödinger equation is a fundamental equation in quantum mechanics that describes the time evolution of a quantum mechanical system. It is used to calculate the probability of finding a particle in a certain location at a certain time. On the other hand, quantum field theory is a theoretical framework that describes the behavior of subatomic particles in terms of fields, such as the electromagnetic field. It is particularly useful in describing the behavior of systems with a large number of particles, such as in high-energy physics[1-7].

The connection between the Schrödinger equation and quantum field theory, as well as the connection between quantum mechanics and general relativity, has been the subject of much research in recent years. The purpose of this research review is to examine these connections, providing a clear explanation of the Schrödinger equation and its implications. The review will also discuss how quantum field theory builds on or extends the principles of quantum mechanics described by the Schrödinger equation and how the principles of general relativity may be applied to the study of quantum mechanics. The review will further explore the connection between the Schrödinger equation and other areas of physics, such as quantum field theory and general relativity[8].

The method used in this review will be a literature review of existing research on the topic. This will include a systematic search of academic journals and other sources for relevant studies, as well as a critical analysis of the findings presented in these studies. The results of the review will be presented in a clear and concise manner, highlighting the key findings and their implications for our understanding of the connection between the Schrödinger equation and quantum field theory, as well as how it relates to other areas of physics such as general relativity.

The Schrödinger equation and quantum field theory are two of the most fundamental theories in physics, used to describe the behavior of subatomic particles and the universe as a whole. The

Schrödinger equation is a wave equation that describes the time evolution of a quantum mechanical system, while quantum field theory is a theoretical framework that describes the behavior of subatomic particles in terms of fields, such as the electromagnetic field. Despite their apparent differences, there is a connection between these two theories that has been the subject of much research in recent years.

The purpose of this research review is to examine the connection between the Schrödinger equation and quantum field theory. The review will focus on recent research that has been published on the topic and will explore the ways in which the Schrödinger equation can be derived from the principles of quantum field theory, as well as the implications of this connection for our understanding of the behavior of subatomic particles. The review will also explore the ways in which the two theories can be used together to provide a more complete understanding of the universe.

1- Schrödinger equation and its role in quantum mechanics:

The Schrödinger equation is a fundamental equation in quantum mechanics that describes how a quantum system changes over time[1]. It is a partial differential equation that describes the evolution of a wave function, which represents the state of a quantum system. The wave function, represented by the Greek letter psi (ψ), is a complex function that encodes all the information about the quantum system, including its position and momentum[2]. The Schrödinger equation describes how this wave function changes over time, and it is the basis for understanding the behavior of quantum systems such as atoms, molecules, and subatomic particles. The Schrödinger equation plays a fundamental role in the understanding of quantum mechanics and is used to calculate the properties of a wide range of physical systems[3].

specifically, the Schrödinger equation is used to calculate the energy levels and wave functions of a quantum system, which can then be used to predict the behavior of the system. It is also used to understand the nature of quantum phenomena such as superposition and entanglement, which are key features of quantum mechanics that distinguish it from classical mechanics. The Schrödinger equation is a central equation in the field of quantum mechanics, and it is used extensively in the study of quantum physics and in the development of new technologies such as quantum computing and quantum cryptography[4].

The development of new methods for solving the Schrödinger equation in quantum field theory, such as the path integral approach, which provides a powerful tool for studying quantum systems.

2-Exploring Quantum Systems: The Path Integral Approach to Solving the Schrödinger Equation in Quantum Field Theory:

One powerful method for solving the Schrödinger equation in quantum field theory is the path integral approach. The basic idea behind this method is to represent the evolution of a quantum system by a sum over all possible paths that the system can take. The paths are weighted by a phase factor that depends on the action of the system, which is a functional of the fields. The path integral approach is particularly useful for studying quantum systems in the presence of interactions, where traditional methods, such as the perturbation theory, can become intractable[5].

The path integral approach can be used to compute various quantities of interest, such as the partition function, correlation functions, and transition amplitudes. The path integral approach can also be used in combination with other methods, such as the renormalization group, to study the behavior of quantum systems at different scales[6].

The path integral approach has been applied to a wide range of quantum field theories, including quantum electrodynamics, quantum chromodynamics, and quantum gravity. It has also been used to study the behavior of quantum systems in condensed matter physics and statistical mechanics [7].

Overall, the path integral approach is a powerful tool for studying quantum systems and provides a probabilistic interpretation of quantum mechanics. It allows for a non-perturbative treatment of quantum systems and provides a way to compute non-perturbative quantities of interest.

The discovery of new symmetries and conservation laws in quantum field theory that are related to the Schrödinger equation, such as the AdS/CFT correspondence [8].

3-Symmetries and Conservation Laws in Quantum Field Theory: The Role of the Schrödinger Equation:

Symmetries and conservation laws play an important role in quantum field theory, as they provide a way to simplify the behavior of quantum systems and relate different physical phenomena. Some symmetries and conservation laws are related to the Schrödinger equation and can be used to study the behavior of quantum systems in different regimes [9].

One example of a symmetry related to the Schrödinger equation is the AdS/CFT correspondence, also known as the gauge-gravity duality. This correspondence states that certain quantum field theories in flat spacetime can be mapped to quantum gravity theories in a curved spacetime with a negative cosmological constant. The Schrödinger equation can be used to study the behavior of quantum systems in the flat spacetime, while the AdS/CFT correspondence provides a way to understand the behavior of the same systems in the presence of gravity [10].

Another example is the conformal symmetry, which is a symmetry that relates to the scale invariance of a theory. The conformal symmetry is related to the Schrödinger equation because the Schrödinger equation is invariant under scale transformations, and the conformal symmetry can be used to simplify the behavior of quantum systems in certain regimes [11].

Conservation laws such as energy-momentum conservation are also related to the Schrödinger equation, as the Schrödinger equation preserves the total energy of the system. This is an important property of the Schrödinger equation, as it ensures that the total energy of the system is conserved over time.

In summary, the Schrödinger equation is related to various symmetries and conservation laws in quantum field theory. These symmetries and conservation laws provide a powerful tool for understanding the behavior of quantum systems in different regimes and relating different physical phenomena. The AdS/CFT correspondence and the conformal symmetry are some examples of symmetries that are related to the Schrödinger equation and have been an active area of research [12].

4-Connection between the Schrödinger equation and quantum field theory and general relativity:

The development of new theoretical frameworks, such as quantum field theory in curved spacetime, which attempt to unify quantum mechanics and general relativity.

The development of new theoretical frameworks that attempt to unify quantum mechanics and general relativity is an active area of research. One of the most promising frameworks in this area is quantum field theory in curved spacetime (QFTCS)[13].

QFTCS is a theoretical framework that combines the principles of quantum field theory with those of general relativity. It attempts to describe the behavior of quantum systems in the presence of strong gravitational fields, such as those found near black holes or in the early universe. The theory is based on the idea that the properties of a quantum system are determined by the geometry of spacetime, and that the dynamics of the system are governed by the Schrödinger equation in curved spacetime [14].

One of the key challenges in developing QFTCS is reconciling the principles of quantum mechanics and general relativity. Quantum mechanics describes the behavior of matter and energy at the microscopic level, while general relativity describes the behavior of matter and energy at the macroscopic level. The two theories have different mathematical structures and make different predictions about the behavior of matter and energy in certain regimes. Therefore, unifying them requires a theoretical framework that can reconcile these differences [15].

One of the main approaches to QFTCS is based on the path integral approach to quantize gravity. This approach is based on the idea of summing over all possible geometries of spacetime, which is similar to the path integral approach used to solve the Schrödinger equation in quantum field theory. The hope is that by combining these two approaches, a consistent theory of quantum gravity can be obtained [15].

In summary, QFTCS is a theoretical framework that attempts to unify quantum mechanics and general relativity by describing the behavior of quantum systems in the presence of strong gravitational fields. It is based on the Schrödinger equation in curved spacetime and one of the main challenges is reconciling the principles of quantum mechanics and general relativity. The path integral approach to quantize gravity is one of the main approaches to QFTCS [16].

5- The relation between the thermodynamic behavior of quantum systems and the Schrödinger equation:

The understanding of the relation between the thermodynamic behavior of quantum systems and the Schrödinger equation through the holographic principle.

The holographic principle is a principle in theoretical physics that relates the thermodynamic behavior of quantum systems to the behavior of gravity in certain regimes. The principle states that the information content of a region of spacetime is proportional to the area of its boundary, rather than its volume. This principle is closely related to the Schrödinger equation, as it provides a way to understand the behavior of quantum systems in the presence of gravity [17].

One of the key implications of the holographic principle is the holographic entropy bound, which states that the entropy of a quantum system is bounded by the area of its boundary in Planck units. This bound is closely related to the Schrödinger equation, as it provides a way to understand the behavior of quantum systems in terms of their entropy [18].

Another key implication of the holographic principle is the AdS/CFT correspondence, also known as the gauge-gravity duality. This correspondence states that certain quantum field theories in flat spacetime can be mapped to quantum gravity theories in a curved spacetime with a negative cosmological constant. The Schrödinger equation can be used to study the behavior of quantum systems in the flat spacetime, while the AdS/CFT correspondence provides a way to understand the behavior of the same systems in the presence of gravity [17].

The holographic principle also has implications for the study of quantum systems in the presence of black holes. The thermodynamic behavior of a black hole can be related to the behavior of a quantum system in a lower-dimensional space via the holographic principle. The study of quantum systems in the presence of black holes is an active area of research and is closely related to the Schrödinger equation.

In summary, the holographic principle is a principle in theoretical physics that relates the thermodynamic behavior of quantum systems to the behavior of gravity in certain regimes. It is closely related to the Schrödinger equation, as it provides a way to understand the behavior of quantum systems in the presence of gravity. The holographic entropy bound and the AdS/CFT correspondence are key implications of the

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holographic principle, and their study is an active area of research.

6- Behavior of quantum systems in extreme conditions, or high temperatures, by using the Schrödinger equation

The Schrödinger equation is a fundamental equation in quantum mechanics that describes the time evolution of a quantum system. It can be used to study the behavior of quantum systems in a wide range of conditions, including in the presence of strong gravitational fields or high temperatures [20].

In the presence of strong gravitational fields, the Schrödinger equation can be used to study quantum systems in the context of quantum field theory in curved spacetime (QFTCS). This is a theoretical framework that combines the principles of quantum field theory with those of general relativity. It attempts to describe the behavior of quantum systems in the presence of strong gravitational fields, such as those found near black holes or in the early universe. The theory is based on the idea that the properties of a quantum system are determined by the geometry of spacetime, and that the dynamics of the system are governed by the Schrödinger equation in curved spacetime [19].

In high temperatures, the Schrödinger equation can be used to study the behavior of quantum systems in the context of quantum statistical mechanics. This is an area of physics that studies the behavior of quantum systems in thermal equilibrium. It can be used to study the behavior of quantum systems in high-temperature regimes, such as those found in the early universe or in the cores of stars. In this context, the Schrödinger equation can be used to study the behavior of quantum systems in terms of their entropy, which is a measure of the disorder of a system [21].

In summary, the Schrödinger equation is a powerful tool that can be used to study the behavior of quantum systems in a wide range of conditions, including in the presence of strong gravitational fields and high temperatures. In the presence of strong gravitational fields, the Schrödinger equation can be used to study quantum systems in the context of QFTCS. In high temperatures, it can be used to study the behavior of quantum systems in the context of quantum statistical mechanics.

7- Properties of the quantum systems in non-equilibrium conditions by using the Schrödinger equation

The Schrödinger equation is a fundamental equation in quantum mechanics that describes the time evolution of a quantum system in equilibrium conditions. However, many physical systems are not in equilibrium and the study of their properties is an active area of research. To study the properties of quantum systems in non-equilibrium conditions, researchers use extensions of the Schrödinger equation or other theoretical frameworks [7-9].

One such extension is the Schrödinger-Langevin equation, which describes the time evolution of a quantum system in the presence of an external noise. This equation is used to study the behavior of quantum systems in non-equilibrium conditions, such as in the presence of decoherence or dissipation. By solving the Schrödinger-Langevin equation, researchers can study the properties of quantum systems in non-equilibrium conditions, such as their stability and response to external perturbations [20].

Another extension is the time-dependent Schrödinger equation, which describes the time evolution of a quantum system in non-equilibrium conditions. This equation is used to study the behavior of quantum systems in the presence of time-dependent Hamiltonians, such as in the presence of a time-varying external field or in the presence of a time-dependent potential. By solving the time-dependent Schrödinger equation, researchers can study the properties of quantum systems in non-equilibrium conditions, such as their dynamics and response to external perturbations [10].

Another theoretical framework is the density matrix formalism, which is a generalization of the wave function and it can be used to study the properties of quantum systems in non-equilibrium conditions. This approach allows to study the density matrix of a system, which encodes all the information about the state of a system, including the probabilities of its subsystems to be in a certain state, and it can be used to study the properties of quantum systems in non-equilibrium conditions, such as their stability and response to external perturbations [21].

In summary, The study of the properties of quantum systems in non-equilibrium conditions is an active area of research. To study the properties of quantum systems in non-equilibrium conditions, researchers use extensions of the Schrödinger equation, such as the Schrödinger-Langevin equation, time-dependent Schrödinger equation and the density matrix formalism. These extensions and frameworks allow researchers to study the properties of quantum systems in non-equilibrium conditions, such as their stability, dynamics, and response to external perturbations.

Overall, the connection between the Schrödinger equation and quantum field theory is a rich and active area of research that continues to yield new insights and discoveries.

CONCLUSION

The research review concludes that the Schrödinger equation, a fundamental equation in quantum mechanics, can be derived from the principles of quantum field theory. This connection highlights the underlying unity of the two theories and helps to further our understanding of the behavior of subatomic particles. The Schrödinger equation is useful in describing systems with a small number of particles, while quantum field theory is more appropriate for systems with a large number of particles. Research in this area has led to the development of new methods for solving the equation, such as the path integral approach, and the discovery of new symmetries and conservation laws. Theoretical frameworks have also been developed to unify quantum mechanics and general relativity, and to understand the thermodynamic behavior of quantum systems in non-equilibrium conditions. Overall, the research suggests that a deeper understanding of one theory can lead to a deeper understanding of the other.

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