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RESEARCH ARTICLE

AN INNOVATIVE CONCEPT: THE DUAL (ENERGY) EQUIVALENCE PRINCIPLE, WHICH LEVERAGES FIBER CURVATURE TO CREATE A QUANTUM CHIP

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ABSTRACT

Building quantum chips entails a sophisticated, multi-phased fabrication process that integrates advanced concepts from quantum mechanics, materials science, semiconductor engineering, and nanotechnology. This research innovative idea can serve as the core processing units within quantum computers, utilizing quantum bits, or qubits, which make superposition and entanglement possible, to perform computation that surpasses classical limitations. The development involves precise control over qubit coherence, error correction mechanisms, and integration with classical control circuitry to enable reliable and scalable quantum information processing. This research explores an innovative method for developing quantum computing chips to facilitate industry integration and progress. The approach involves analyzing fabrication techniques, material properties, and strategies to preserve quantum coherence, aiming to enhance chip performance and scalability.

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INTRODUCTION

Quantum chips are considered difficult to develop in the computer industry because they are tied to traditional ways of thinking. This creates many constraints during manufacturing and design, which may prevent quantum chips from being built. To make quantum chips possible, we need to develop and innovate new approaches to solve these problems, so we can work together to make quantum chips a reality. Quantum computing hardware development, particularly quantum chips, encounters significant challenges primarily due to the entrenched paradigms rooted in classical computing architectures and methodologies. These conventional frameworks impose substantial constraints on fabrication processes, material selection, and design architectures, thereby impeding the realization of scalable, reliable quantum microchips. To advance the field, it is imperative to pioneer innovative engineering approaches and develop novel technological solutions. This may include redefining fabrication protocols, exploring alternative qubit materials, and designing architectures that are compatible with quantum mechanical principles. Such strategic advancements are crucial for translating quantum chip concepts from theoretical models to practical, deployable technologies. Collaborative efforts across multidisciplinary research domains are essential to overcoming these barriers, ultimately accelerating the transition of quantum chips from experimental prototypes to commercially viable components in quantum information processing systems. This research paper aims to explore an innovative methodology for developing quantum computing chips, with the goal of facilitating and accelerating technological integration and advancements within the computer industry.

The innovative proposed approach includes a comprehensive analysis of fabrication techniques, material properties, and strategies for preserving quantum coherence to optimize chip performance and scalability.

DISCUSSION

The concept was initially proposed by physicists, and the 2023 Nobel Prize in Chemistry was awarded to scientists who worked with quantum dots. Now, let's explore quantum dots in more depth. Compared to attosecond pulses, quantum dots are more accessible and could transform the world, so everyone should know about them. Some TV screens use quantum dot principles. Quantum dots are very small semiconductor materials, typically 1-10 nanometers, made of various elements like silicon or compounds such as cadmium sulfide, cadmium selenide, and zinc sulfide. More complex types include ternary quantum dots like cadmium sulfide selenide. They are called quantum dots mainly because of their tiny size. At 1 nanometer, there are a few hundred to a few thousand atoms; at 10 nanometers, hundreds of thousands or millions. This scale lets us analyze atoms directly. What's special? At these scales, quantum mechanics takes over, changing particle behavior from the macro world. In 1937, Herbert Fleulich predicted that particle behavior at the nanoscale would differ due to limited electron activity space, leading to the quantum confinement effect. [1,2,3] Quantum dots resulted from work by three 2023 Nobel laureates in Chemistry. In the 1980s, Mounqi, Louis Bruce and Alexei Yechivov independently synthesized quantum dots. In the early 1990s, Blind Qi Ba Wendi improved their manufacturing, making them potentially commercial. Their discovery relied on chemical methods, earning a Chemistry Nobel, while

physics provides the theoretical basis. When materials shrink to 1-10 nanometers, electrons exhibit wave-particle duality. In larger solids, electrons act as particles, but at nanoscales smaller than or equal to the de Broglie wavelength, wave properties are more evident. This wavelength, derived from experiments, indicates when the electron's wave nature must be considered due to confinement, causing quantized energy levels. For instance, an electron seems observed from afar because it's distant, but closer inspection shows it vibrating. Think of a long rope: if tied at both ends and flicked gently, ripples are hard to see from far away due to the length. Shortening the rope makes vibrations more noticeable as waves are confined. Similarly, in quantum dots, smaller size means larger electron energy band gap; bigger dots mean a smaller gap. The energy band gap is the energy needed for an electron to move from the valence to the conduction band, transitioning from low to free energy. The larger the gap, the more energy required. [2,3]

The smaller the gap, the less energy needed to overcome it. Imagine a wave string: plucking the whole string produces a lower frequency, while a shorter section results in a higher frequency. Frequency is inversely proportional to length, and here, it reflects the electron's energy. When electrons act as waves, higher frequency means higher energy. Similar to light, where higher frequency light has more energy. Quantum dots show this: their emitted light color varies with size. They emit light when electrons move from the valence to the conduction band after gaining energy, then return to a lower-energy state, releasing photons. The energy released equals the initial energy absorbed, matching a specific light frequency. Larger band gaps in smaller quantum dots mean they emit blue light, while larger dots emit red. Adjusting their size enables different colors, crucial for Samsung's Q LED display, which uses blue backlight and quantum dots of different sizes to produce red and green. Blue light's high energy is ideal, as quantum dots need only absorb part of it. Besides displays, quantum dots enhance solar cells by absorbing various light frequencies, improving performance in diverse lighting conditions.

In some quantum dot materials, multipole generation occurs, involving an electron and a hole—both carrying positive and negative charges. A single hydrogen atom can also be seen as a basis. For solar energy applications, we need to produce as many devices as possible to enhance photoelectric efficiency. When intense light strikes a photovoltaic cell, an electron is ejected. If the light's energy exceeds the band gap, the electron gains extra kinetic energy after overcoming the energy difference. This means the photon's impact is strong enough to eject the electron and send surplus energy flowing around. In traditional photovoltaic materials, because of their larger size, high-energy electrons tend to transfer their energy to the surrounding crystal lattice upon collision, converting kinetic energy into heat. Conversely, at the quantum dot level, an interesting phenomenon occurs. If the electron still has excess kinetic energy, it can eject its partner before colliding with the lattice. The remaining energy is sufficient for the electron to eject another electron, forming a new electron-hole pair—effectively creating a new machine. Therefore, using quantum dots in photovoltaic cells can significantly improve their efficiency.

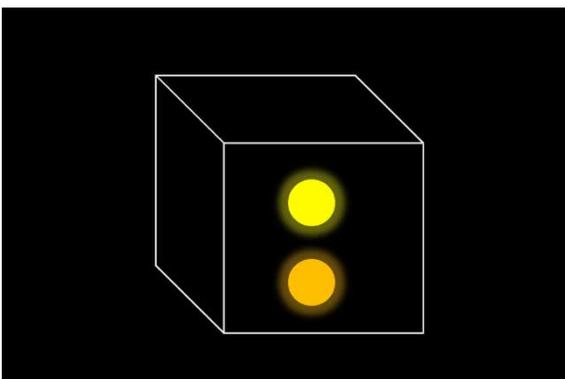


Figure 1. Dual Super-Position

Beyond the above-mentioned, as our innovative research paper suggested light can be considered as a form of energy type, which can exist in dual equivalence like wavelight when it is stated in the energy proposes. Our research suggested that, light energy and the physical properties of quantum wave-dots can be utilized in curvature type such as laser, which may provide 0 to 1 delivery simultaneously, and more. Our innovative concept can hold significant application potential in electronics, in the area of quantum chips, as well as in medi-tech innovation. The above literature review can well support our research paper's innovative idea concept, in applying the dual utilities in the property of wave-light properties, to fit in the curvature of the optical fiber device (quantum chips). Our innovative concept of idea can leverage quantum wave-dots to generate quantum bits, and these wavelight particles might also contribute to developing superconducting materials, especially quantum chips that work at room temperature.

Suggestion

Fabrication Curvature Method: Fabrication refers to the comprehensive process involved in the manufacturing and assembly of components and systems, typically encompassing steps such as material selection, machining, forming, joining, and finishing. This complex process is fundamental to producing precise and reliable products in various engineering disciplines, including electronics, mechanical systems, and materials science. Ensuring meticulous attention to detail and adherence to industry standards is critical to achieving desired specifications and performance outcomes. In the context of IEEE standards, fabrication procedures emphasize quality control, safety protocols, and compliance with operational benchmarks to facilitate the development of robust technological solutions. The initial phase of the process involves the careful selection of the qubit modality, with superconducting qubits—specifically those constructed from Josephson junctions—being the predominant choice due to their advantageous attributes. Alternative modalities such as trapped ions, semiconductor quantum dots, and spin-based qubits are also considered, each with unique operational characteristics. Superconducting qubits are favored in large-scale quantum computing architectures owing to their inherent scalability and compatibility with existing semiconductor fabrication techniques, facilitating integration into complex quantum circuits.

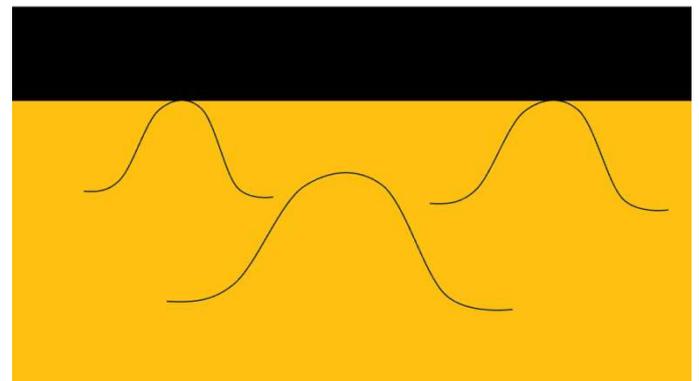


Figure 2. WaveLight State

Prior to the fabrication stage, comprehensive numerical simulations and advanced modeling techniques are employed to thoroughly analyze and predict qubit behavior under various operational conditions. These simulations are critical for optimizing key parameters including coherence times, which determine the qubit's durability; gate fidelities, essential for precise quantum operations; crosstalk mitigation strategies, to ensure minimal unwanted interactions; and scalability metrics, to assess the feasibility of extending the system to larger qubit arrays. Such pre-fabrication modeling ensures that the selected qubit design meets the stringent performance criteria necessary for practical quantum computing applications.

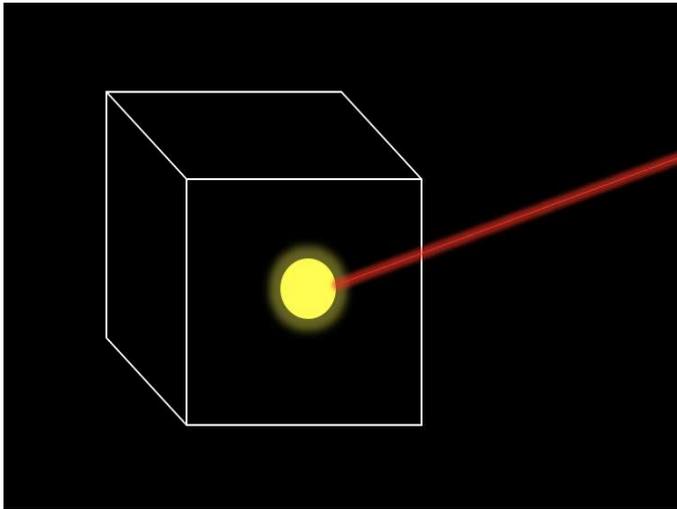


Figure 3. Suggested Laser Light Particle

Quantum computing chips are fabricated within specialized cleanroom environments that adhere to stringent contamination control protocols. The fabrication process employs state-of-the-art nanofabrication techniques, particularly electron-beam lithography (EBL), which enables direct-write patterning of the wafer surface with nanometer-scale precision. This process defines the intricate geometries required for superconducting circuits, including Josephson junctions—critical nonlinear elements—and microwave resonators essential for qubit readout and control. Multilayered architectures, which are fundamental for integrated qubit systems, are constructed through advanced thin-film deposition methods such as atomic layer deposition (ALD), ensuring conformal and uniform layers at atomic thicknesses. These multilayer structures are subsequently patterned and refined using reactive etching processes, including reactive ion etching (RIE), to achieve the desired nanoscale features necessary for high-performance quantum operations.

Innovative Insight:

Dual Equivalence (WaveLightCommonality Existence): Light can be regarded as a form of energy that exists in dual states, similar to wavelight when described in terms of energy. Our research suggests that light energy and the physical properties of quantum wave-dots can be used in curvature-based applications, which may deliver 0 to 1 signals simultaneously, among other functions. Our innovative concept has significant potential for applications in electronics, especially in the field of quantum chips.

WaveLight Commonality Existence

Dual Equivalence, also known as WaveLight Commonality Existence, refers to a theoretical framework in physics and engineering that examines the collective behavior and shared characteristics of wave phenomena within electromagnetic systems. This concept emphasizes the identification of commonalities among wave modes, which can be critical for developing advanced optical communication technologies, photonic devices, and electromagnetic compatibility solutions. In essence, Dual Equivalence involves analyzing the symmetry properties, modal correlations, and energy transfer mechanisms that underpin wave interactions at a fundamental level, often leveraging principles from wave theory, quantum mechanics, and electromagnetic field theory. This approach can lead to a more comprehensive understanding of wave propagation, interference, and coherence in complex systems, aligning with IEEE standards for technical rigor and precision.

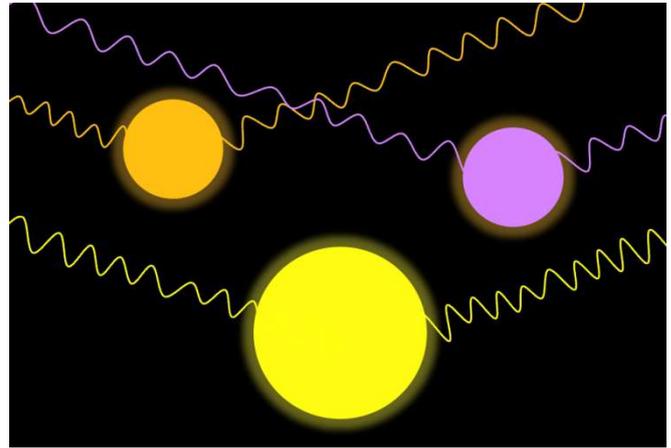


Figure 5. Wavelength form of electromagnetic

Light can be conceptualized as a form of electromagnetic energy that exhibits dual wave-particle properties, consistent with quantum electrodynamics principles. Its wave-like behavior can be described through a spectrum of energies characterized by frequency and wavelength, which influence its interaction with matter at the quantum level. Our research suggests that the energy inherent in light, combined with the quantum properties of nanostructures such as quantum dot arrays, can be engineered for curvature-based electronic applications. In the fiber curvature context. These applications include the potential to simultaneously transmit multiple binary signals (0 and 1) in fiber curvature superposition states, harnessing quantum coherence and entanglement phenomena. Our innovative idea concept can bring technological advancements that hold considerable promise for the development of high-speed, low-power quantum integrated circuits and neuromorphic computing systems, ultimately enabling more efficient and scalable quantum computing architectures in electronics. Our innovative idea concept can make the advanced computer device become possible, especially in the application of quantum chips.

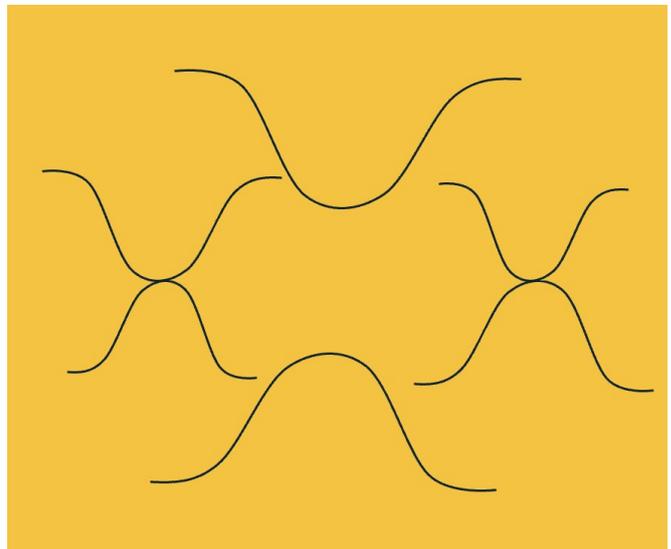


Figure 6. Dual wavelightproperties

So, in other words, these dual properties can be applied in the making of quantum chips, in the collimity state. When light bends in the curvature that is hit inside the fiber, it will behave as a wave of light in a certain state. When we create a wave of light that can bend in the curvature, the quantum dots will coexist at a certain level within the curved fiber. In the same time. This means that this methodology can be applied in the making of quantum chips.

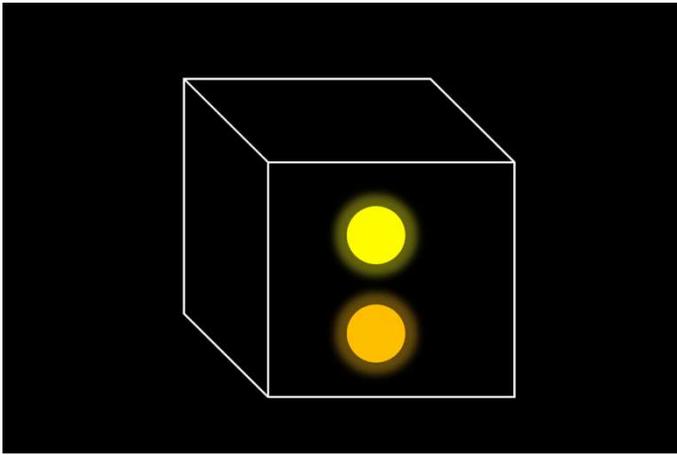


Figure 7. Dual properties—namely, the wave-like and particle-like behaviors

In essence, these dual properties—namely, the wave-like and particle-like behaviors—can be exploited in the development of quantum photonic chips operating in the collimated state. When light propagates through a curved optical fiber, the induced curvature causes the electromagnetic wave to undergo spatial modulation, resulting in wavefront bending governed by the principles of optical waveguide theory. Under such conditions, the light exhibits a behavior analogous to a coherent wave within a defined modal state. By engineering the wave packet to conform to the curvature-induced modal profile, quantum dots embedded within the fiber can maintain coherent quantum states at specific interaction levels. This facilitated coupling enables the integration of quantum dot emission and absorption processes into the fiber's photonic modes, potentially leveraging phenomena such as strong light-matter interaction and Purcell enhancement. Consequently, this methodology offers a promising pathway for the scalable fabrication of quantum photonic chips, wherein precise control over electromagnetic mode propagation and quantum dot integration within fiber geometries can enable advanced quantum information processing and quantum chips system.

CONCLUSION

This research paper aims to explore an advanced innovative methodology for the fabrication and development of quantum computing chips, with the primary objective of facilitating and accelerating the integration of quantum technologies into mainstream computational hardware, thereby propelling the progression of the computer industry. In utilizing the dual properties of Wavelight. This innovative proposed approach encompasses a comprehensive analysis of cutting-edge fabrication techniques, an in-depth consideration of the intrinsic material properties, and strategic methodologies for maintaining quantum coherence. These elements are critical for optimizing the operational fidelity, scalability, and robustness of quantum processors, ensuring their viability for practical applications. The study further emphasizes the importance of minimizing decoherence sources, controlling environmental interactions, and implementing error mitigation strategies to enhance quantum state preservation, which are pivotal for achieving reliable and high-performance quantum computing architectures.

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