

Bio-Inspired Platform for Enhanced Quantum Coherence

Cross-Reference to Related Applications

This application claims the benefit of U.S. Provisional Patent Application No. 63/751,887, filed January 31, 2025, which is incorporated herein by reference in its entirety.

Field of the Invention

[0001] The present invention relates generally to quantum computing and, more specifically, to bio-inspired platforms and methods for enhancing quantum coherence in quantum systems.

Background of the Invention

[0002] Quantum coherence is essential for the operation of quantum computers, sensors, and communication systems. However, maintaining coherence over extended periods remains a significant challenge due to decoherence caused by environmental interactions. Recent studies suggest that biological structures, such as neuronal microtubules, exhibit unique properties that may enhance quantum coherence through mechanisms like vibrational coupling, electron tunneling, and entanglement.

[0003] Despite these promising findings, there is a lack of practical platforms and methods for leveraging these bio-inspired mechanisms in artificial quantum systems. The present invention

addresses this gap by providing a comprehensive solution for enhancing quantum coherence using bio-inspired structures, synthetic systems, and hybrid approaches.

Summary of the Invention

[0004] The invention provides a bio-inspired platform and associated methods for enhancing quantum coherence in quantum systems. The platform incorporates structures derived from or inspired by biological components, such as neuronal microtubules, plant microtubules, bacterial cytoskeletons, or viral capsids, which exhibit properties conducive to sustaining quantum coherence. Additionally, the invention includes synthetic and hybrid systems designed to replicate these properties.

Key aspects of the invention include:

1. Bio-inspired structures capable of sustaining vibrational energy transfer at quantum-relevant frequencies.
2. Mechanisms for enhancing quantum coherence through phonon-mediated interactions, electron tunneling, and entanglement.
3. Applications in quantum computing, quantum sensing, and quantum communication.

Detailed Description of the Invention

Biological Structures

[0005] The invention utilizes biological structures known to exhibit quantum coherence-enhancing properties. These include:

- **Neuronal Microtubules:** Cylindrical protein polymers found in neurons that support coherent vibrational modes at terahertz frequencies.
- **Plant Microtubules:** Similar to neuronal microtubules but adapted for use in non-animal systems.
- **Bacterial Cytoskeletons:** Structural proteins in bacteria that may exhibit analogous quantum properties.
- **Viral Capsids:** Protein shells of viruses with geometric configurations that could support standing waves.

These biological structures are characterized by their ability to sustain vibrational energy transfer at quantum-relevant frequencies, which enhances quantum coherence through mechanisms such as phonon-mediated interactions, electron tunneling, and entanglement.

Synthetic and Hybrid Systems

[0006] The invention also encompasses synthetic and hybrid systems designed to mimic the quantum coherence-enhancing properties of biological structures. These include:

- Artificial nanotubes or graphene-based materials engineered to replicate the vibrational and electronic properties of microtubules.

- Hybrid systems combining bio-inspired components with synthetic materials to optimize coherence times.

Synthetic systems may be fabricated using advanced manufacturing techniques, such as molecular self-assembly or 3D printing, to achieve precise control over structural and functional properties.

Functional Mechanisms

[0007] The invention describes specific mechanisms by which quantum coherence is enhanced:

- **Vibrational Coupling:** Standing waves within cylindrical structures facilitate long-lived quantum states.
- **Electron Tunneling:** Enhanced probabilities of electron tunneling between adjacent sites.
- **Entanglement:** Entangled states sustained through vibrational and electromagnetic interactions.

These mechanisms are applicable across various quantum technologies, including quantum computing, quantum sensing, and quantum communication.

Practical Applications

[0008] The platform has applications in:

- **Quantum Computing:** Enhancing qubit coherence times and reducing error rates.
- **Quantum Sensing:** Improving sensitivity and resolution in quantum sensors.
- **Quantum Communication:** Enabling longer-distance entanglement distribution.

Claims

1. A bio-inspired platform for enhancing quantum coherence, comprising:
Structures capable of sustaining vibrational energy transfer at quantum-relevant frequencies, wherein said structures are derived from or inspired by biological components selected from the group consisting of neuronal microtubules, plant microtubules, bacterial cytoskeletons, and viral capsids.
2. The platform of claim 1, wherein the biological components are neuronal microtubules.
3. The platform of claim 1, wherein the biological components are artificially synthesized to mimic the properties of natural microtubules.
4. A synthetic platform for enhancing quantum coherence, comprising:
Artificially engineered structures configured to replicate the vibrational and electronic properties of biological components selected from the group consisting of neuronal microtubules, plant microtubules, bacterial cytoskeletons, and viral capsids.
5. The platform of claim 4, wherein the artificially engineered structures are nanotubes or graphene-based materials.
6. A hybrid quantum system for enhancing quantum coherence, comprising:
A bio-inspired component and a synthetic component, wherein said bio-inspired component enhances quantum coherence through mechanisms including vibrational coupling, electron tunneling, and entanglement.
7. The platform of claim 6, further comprising an error-correction module optimized for said hybrid quantum system.
8. The platform of claim 1, wherein the quantum coherence is enhanced through phonon-mediated interactions.

9. The platform of claim 1, wherein the quantum coherence is applied to quantum computing, quantum sensing, or quantum communication.

Abstract

A bio-inspired platform for enhancing quantum coherence using structures capable of sustaining vibrational energy transfer at quantum-relevant frequencies. The platform incorporates biological components, such as neuronal microtubules, plant microtubules, bacterial cytoskeletons, or viral capsids, as well as synthetic and hybrid systems designed to replicate these properties. The invention enhances quantum coherence through mechanisms including vibrational coupling, electron tunneling, and entanglement, with applications in quantum computing, quantum sensing, and quantum communication.