Conjoined Spherical Triangles: A Tool for the Unification of General Relativity and Quantum Mechanics

Aswan Korula

April 9, 2025

Abstract

The Conjoined Spherical Triangle (CST) framework introduces a novel approach to unifying general relativity and quantum mechanics through the concept of a computationally aware space-time. This paper presents the CST as a geometrical model that integrates gravitational dynamics and quantum phenomena, treating space-time not only as a passive arena for physical processes but as an active, informationally dynamic system. We explore how the four laws of the CST—path law, area law, duality law, and entropy law—encode both space-time curvature and quantum state evolution. By embedding quantum information within the geometry of space-time, the CST framework offers a geometrically grounded interpretation of quantum entanglement, superposition, and the wavefunction collapse. Furthermore, the CST provides a pathway for addressing key challenges in quantum gravity, such as the black hole information paradox and the unification of quantum mechanics with general relativity. The potential applications of the CST extend to high-energy physics, cosmology, and quantum field theory, where it serves as a computationally aware medium for processing both gravitational and quantum information. This paper highlights the CST framework's potential to bridge the gap between gravitational systems and quantum states, offering a promising new direction for the future of theoretical physics.

1 Introduction

The pursuit of a unified theory of physics has been a central goal of theoretical research for over a century. While *general relativity* (GR) [1] provides an elegant description of the large-scale structure of the universe, encompassing the behavior of gravitational systems, it struggles to incorporate the *discrete and probabilistic nature* of *quantum mechanics* [2]. On the other hand, *quantum mechanics* successfully explains the interactions of particles at the smallest scales but does not account for the curvature of space-time.

A natural approach to solving this problem is to find a framework that integrates both theories, allowing them to coexist within a single, unified structure. In this paper, we propose the **Conjoined Spherical Triangle (CST)** as a new and powerful tool for this unification. The CST is based on simple *spherical geometry*, yet it provides a framework in which *information*, *curvature*, and *computation* are *intrinsically embedded* into the very fabric of space-time.

We show that the CST framework can explain key phenomena in both *general relativity* and *quantum mechanics*, bridging the gap between the *continuous geometry* of gravitational systems and the *discrete information* at the heart of quantum mechanics. Specifically, the CST:

- Models *free-fall* and *gravitational deformation* within the context of an *infalling object*, referencing points A and C to describe its motion.
- Provides a new *geometrical understanding of quantum entanglement*, using the *deformation parameter* to represent entangled states.
- Demonstrates how space-time itself can become *computationally aware*, allowing the CST to process *quantum information* and apply it to gravitational systems.

The CST, by unifying *geometry* and *information theory*, provides a *computationally aware space-time* framework that could serve as the cornerstone for a future theory of *quantum gravity*. In the following sections, we will explore the mathematical foundations of the CST, its application to gravitational systems, and its role in quantum information processing.

2 The Conjoined Spherical Triangle Framework

We now introduce the *Conjoined Spherical Triangle* (CST), a reversible geometric structure defined entirely on the surface of a unit sphere. The CST serves as a curvature-aware informational unit that encodes relationships among three geometrically significant points: an initial position, an evolving point, and a center point. This structure enables us to capture asymmetry, angular deformation, and entanglement-like constraints across evolving spin network configurations.

Definition and Setup

Let the points A, Q, and C lie on the surface of a unit sphere:

- A is a fixed reference point, analogous to an origin or initial location.
- C is another fixed point, interpreted as the target or geometric anchor.
- Q is a movable point on the arc between A and C, representing a dynamic evolution state.

Let B' be a fourth point such that both $\triangle AB'Q$ and $\triangle CB'Q$ are spherical triangles sharing the common side QB'. This segment QB' will be denoted by the symbol h, which we interpret as a hinge length:

$$QB' = h.$$

The two triangles are joined at the segment QB' and together define the Conjoined Spherical Triangle. Each triangle is described by its interior angles at the vertices:

- In triangle $\triangle AB'Q$, $\angle B'AQ = A$ (sight angle), $\angle AQB' = \theta$ (swing angle), $\angle AB'Q = i$ (angle of incidence).
- In triangle $\triangle CB'Q$, $\angle B'CQ = C$ (sight angle), $\angle CQB' = \pi - \theta$ (swing angle), $\angle CB'Q = r$ (angle of reflection).

The sides opposite to these angles are as follows:

- AB' and $B'C$ are opposite to angles θ and $\pi - \theta$ (under the symmetric path condition, $\theta = \pi/2$),
- Common hinge $QB' = h$ is opposite angles A and C (under symmetric swing conditions, $A = C$),
- AQ and QC lie along the arc between A and C and opposite to angles i and r (under combined symmetric conditions $AC = QC$ *and* $i = r$).

Derivation of Equation 1

We apply the spherical law of sines to both triangles [3]:

For triangle $\triangle AB'Q$:

$$\frac{\sin(AB')}{\sin(\theta)} = \frac{\sin(h)}{\sin(A)} = \frac{\sin(AQ)}{\sin(i)}.$$

For triangle $\triangle CB'Q$:

$$\frac{\sin(B'C)}{\sin(\pi - \theta)} = \frac{\sin(h)}{\sin(C)} = \frac{\sin(QC)}{\sin(r)}.$$

Under the single symmetry, $AQ = QC$, we divide these to obtain the key identity—Equation 1:

$$\frac{\sin(AB')}{\sin(B'C)} = \frac{\sin(i)}{\sin(r)} = \frac{\sin(A)}{\sin(C)} = 1. \tag{1}$$

This equation is the basis for all CST laws and characterizes perfect geometric symmetry across the CST independent of $h, AQ/h, \theta$.

Equation 1A: Path Law

From Equation 1, symmetry implies that the arc lengths satisfy:

$$AB' + B'C = \pi.$$

That is, the combined path length from A to C via the hinge at B' subtends a semicircle. Since the sphere has radius 1, this corresponds to a maximal straight-line path in spherical geometry. We interpret this as the unit CST encoding an entangled separation of π radians.

Equation 1B: Area Law

The area of a spherical triangle is given by the spherical excess:

$$\text{Area}(\triangle) = \angle A + \angle B + \angle C - \pi.$$

Applying this to both triangles and using the identity from Equation 1, we compute:

$$\text{Area}(\triangle AB'Q) + \text{Area}(\triangle CB'Q) = (A + i + \theta - \pi) + (C + r + \theta - \pi).$$

Substituting $A = \pi - C$ and $i = \pi - r$, and simplifying:

$$= [(\pi - C) + (\pi - r) + \theta - \pi] + [C + r + \theta - \pi] = \pi.$$

Thus, the combined CST encloses an area of π steradians on the unit sphere.

Equation 1C: Duality Law

From classical spherical trigonometry (Todhunter's polar triangle construction [4]), each triangle in a CST has a polar conjugate. Under inertial symmetry, the polar of triangle $\triangle AB'Q$ is triangle $\triangle CB'Q$, and vice versa. This duality implies a reversible angular mapping that preserves area and curvature under reflection across the hinge.

Equation 1D: Informational Tension Law

Define $h = QB'$ as the hinge segment of the CST. If we consider a wave of wavelength λ propagating along the spherical arc, then the informational tension across the hinge is defined as:

$$\mathcal{T}_{\text{CST}} = \frac{h}{\lambda}.$$

This is analogous to Planck's relation in wave dynamics and characterizes the CST's energy or information-bearing capacity under inertial conditions.

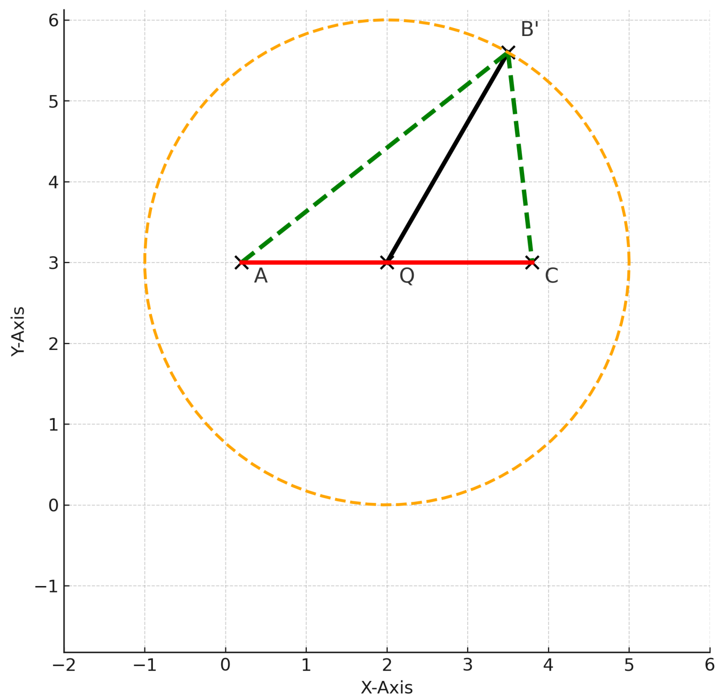

Figure 1: **Conjoined Spherical Triangle (CST) Diagram.** This illustration shows two spherical triangles joined at the common edge QB', forming a hinge structure with arc paths AB' and $B'C$. The midpoint Q of the great circle arc AC serves as the baseline symmetry point. This geometry encodes a fixed total arc length of π radians across the hinge, enabling invariant informational cycles. This diagram is limited to the domain $AC < 2h$.

3 Generalizing the CST with the Sine-Alpha Function

The inertial Conjoined Spherical Triangle (CST) represents a perfectly symmetric configuration in which the evolving point Q lies exactly halfway along the arc connecting points A and C. In this case, the path lengths AQ and QC are equal, and the four CST laws—path, area, duality, and informational tension—remain balanced and internally reversible.

However, in dynamic or non-inertial settings—such as those encountered in evolving quantum geometries—the point Q may shift asymmetrically along the arc from A to C. This introduces a curvature imbalance that must be regulated to preserve consistency across the CST structure. To accommodate such deformation, we introduce a continuous balancing mechanism: the *sine-alpha function*.

Defining the Asymmetry Parameter α

Let $AQ = L_1$ and $QC = L_2$. Define the asymmetry ratio as:

$$\alpha = \frac{L_2}{L_1} = \frac{QC}{AQ}.$$

Under inertial conditions, $\alpha = 1$, and the CST is symmetric. When $\alpha \neq 1$, the CST becomes asymmetrically stretched or compressed depending on the direction and magnitude of α. This parameter acts as a curvature-aware deformation variable and serves as the input to the sine-alpha function.

The Sine-Alpha Function

We generalise Bolyai [5] to define the sine-alpha function as a deformation of the classical sine function:

$$\sin_\alpha(x) = \sum_{n=0}^{\infty} \frac{(-1)^n \alpha^n}{(2n+1)!} x^{2n+1}.$$

This series retains the odd-parity structure of the classical sine function but introduces an exponential weighting of each term by powers of α. The function is designed to recover $\sin(x)$ when $\alpha = 1$, and to deform continuously for $\alpha \neq 1$. Its purpose is not to define a physical field, but to regulate asymmetry across the CST's internal structure.

Generalized CST Laws

We now generalize the four CST laws to account for the asymmetry introduced by arbitrary α.

Equation 1A (Generalized Path Law)

In the symmetric case, the arc lengths satisfy $AB' + B'C = \pi$. For $\alpha \neq 1$, the CST must adjust its total arc length to preserve internal curvature consistency. Define the generalized total arc length $\Phi(\alpha)$ as:

$$\Phi(\alpha) = \pi \cdot \frac{2\min(\alpha, 1)}{1+\alpha}.$$

Thus, the generalized path law becomes:

$$AB' + B'C = \Phi(\alpha).$$

This construction preserves the limiting case $\Phi(1) = \pi$ and ensures continuity and reversibility under asymmetric deformation.

Equation 1B (Generalized Area Law)

We define the generalized CST area using a curvature-regulated scaling function:

$$\Psi(\alpha) = \frac{4\alpha}{(1+\alpha)^2}.$$

Then the total area enclosed by the CST becomes:

$$\text{Area}(\triangle AB'Q) + \text{Area}(\triangle CB'Q) = \pi \cdot \Psi(\alpha).$$

This function is symmetric under $\alpha \to 1/\alpha$, reflecting geometric reversibility, and satisfies $\Psi(1) = 1$, reproducing the inertial CST area of π steradians.

Equation 1C (Generalized Duality Law)

The duality relationship between the triangles deforms with asymmetry. Define the duality modulation function:

$$\Omega(\alpha) = \frac{2\sqrt{\alpha}}{1+\alpha}.$$

Then the polar triangle relation generalizes to:

$$\text{Polar}_\alpha(\triangle AB'Q) = \triangle\widetilde{CB'Q}(\alpha), \quad \text{with conjugation factor } \Omega(\alpha).$$

This maintains reversibility and angle correspondence under deformation, with $\Omega(1) = 1$.

Equation 1D (Generalized Informational Tension Law)

The hinge length $h = QB'$ deforms with asymmetry. Define the general form of the informational tension:

$$\mathcal{T}_{\text{CST}} = \frac{h(\alpha)}{\lambda}, \quad \text{where} \quad h(\alpha) = h_0 \cdot \frac{1+\alpha^2}{2\alpha}.$$

This function is minimized when $\alpha = 1$ and increases with asymmetry in either direction, capturing the growth in internal tension due to curvature imbalance.

Interpretation

These four generalized laws preserve the structural integrity of the CST under deformation. The parameter $\alpha = QC/AQ$ serves as a geometric regulator, encoding how far the configuration has deviated from symmetry. The sine-alpha function governs the scaling of deformation effects across all four laws, ensuring internal reversibility and a continuous path back to equilibrium.

4 CST in General Relativity

In general relativity (GR), space-time is curved by the presence of mass and energy. The dynamics of objects in gravitational fields are governed by the curvature of space-time, which influences their trajectories. The Conjoined Spherical Triangle (CST) provides a new way of representing space-time by encoding the information and curvature directly into the geometry.

4.1 CST Geometry and Gravitational Systems

The CST geometry begins with three key points in space-time:

- A, a fixed reference point in space,
- C, the center of mass of a massive body (such as a black hole or a neutron star),
- Q, the position of a test mass (e.g., a particle or object falling towards the massive body).

In GR, an object falling under the influence of gravity follows a geodesic, a path determined by the curvature of space-time. The CST geometry represents this path as a spherical triangle with sides corresponding to the distances between A, Q, and C. The deformation parameter $\alpha = \frac{QC}{AQ}$ characterizes the degree of deformation in the CST system, where:

- $\alpha > 1$: Elongation (the test mass is far from the massive body).
- $\alpha = 1$: Neutral (the test mass is in an equilibrium state).
- $\alpha < 1$: Compression (the test mass is close to the massive body).

The CST thus provides a geometric description of gravitational deformation, where the path of an object falling into a gravitational field can be viewed as a symbolic deformation of the CST system.

4.2 The Four Laws and Gravitational Deformation

The four laws governing the CST are as follows:

- Path Law (1A): Describes how the deformation of the CST geometry affects the distances between points A, Q, and C as the test mass moves. The path length remains consistent for any change in α, reflecting the conservation of information in gravitational dynamics.

- Area Law (1B): The areas of spherical triangles formed within the CST geometry are invariant under changes in the deformation parameter α. This law reflects the conservation of gravitational energy and the way space-time curvature remains constant in certain systems.

- Duality Law (1C): Establishes the duality between different gravitational states, where elongation or compression corresponds to dual geometrical interpretations of the same system. This highlights the symmetry between different configurations of space-time.

- Entropy Law (1D): Describes how entropy behaves in the CST system. As a test mass approaches a massive body, the information encoded in the CST system grows, reflecting the increase in entropy as the system evolves towards a more disordered state.

These four laws, when applied to gravitational systems, offer new insights into the behavior of mass and energy in curved space-time. They allow us to model free-fall, black hole dynamics, and gravitational waves in a unified framework.

4.3 Sine Alpha Function and Gravitational Behavior

The sine alpha function, embedded in the CST structure, provides a measure of the deformation of space-time as an object falls towards a massive body. It captures the curvature induced by the presence of mass and encodes the gravitational interaction in a way that is consistent with general relativity.

The sine law for spherical triangles applied to the CST system is given by:

$$\frac{\sin(a)}{\sin(c)} = \frac{AQ}{QC} = 1$$

where a and c are the angles of the CST triangle corresponding to points A and C, and the distances AQ and QC correspond to the spatial intervals between the test mass and the central body.

This relationship ensures that the gravitational deformation is captured in a geometrically consistent way, allowing us to model geodesic motion in terms of the deformation of space-time, just as general relativity describes it.

4.4 Applications to Gravitational Systems

The CST framework provides a new approach to understanding gravitational systems, including:

- Free-fall motion: The CST can model how objects move under the influence of gravity, providing a geometrically aware description of free-fall trajectories.

- Black holes: The CST framework offers a new perspective on black hole dynamics, including the event horizon and singularity, through the geometry of space-time.

- Gravitational waves: By understanding space-time deformation through CST, we gain new insights into the behavior of gravitational waves as they propagate through curved space-time.

Thus, the CST structure is a powerful tool for describing and understanding gravitational phenomena in a unified and computationally aware framework.

5 CST in Quantum Mechanics

Quantum mechanics describes the behavior of particles at the smallest scales, where discreteness and probability play central roles. The Conjoined Spherical Triangle (CST) framework, through its geometric interpretation and symbolic states, provides a novel way to represent quantum systems. By embedding information within the very geometry of space-time, CST allows us to think about quantum entanglement, superposition, and wavefunction collapse in terms of geometrical deformation rather than abstract quantum states.

5.1 CST Geometry and Quantum Systems

At the quantum level, information is fundamental to understanding the behavior of particles. However, space-time and information are traditionally treated separately in quantum mechanics. The CST framework breaks this distinction by treating space-time itself as an informational medium. This means that quantum information is inherently encoded within the curvature of space-time, and the deformation of space-time reflects the evolution of quantum states.

The CST structure uses the deformation parameter $\alpha = \frac{QC}{AQ}$, where:

- Q represents the quantum system (e.g., a particle or field),
- A and C are reference points in space-time, akin to positions of particles or quantum states.

Because the CST equations are independent of H (the radius or scale of the system), the same framework applies across all scales of quantum systems, from the submolecular to the cosmological level. Whether describing particle interactions at the quantum scale or the global behavior of cosmological systems, the CST structure remains applicable, providing a unified geometrical and informational model.

5.2 The Four Laws and Quantum Behavior

As with gravitational systems, the CST operates according to its four fundamental laws. These laws offer insights into the evolution and dynamics of quantum systems, as they encode both geometric deformation and symbolic processing:

- Path Law (1A): Describes how the quantum state evolves as a function of the deformation parameter α. The quantum state corresponds to the geometry of the CST, with the deformation representing changes in the state over time.
- Area Law (1B): In the quantum context, the area law represents the conservation of quantum information. Just as the area of a spherical triangle remains invariant under deformation, the information encoded in a quantum system is preserved even as the system undergoes superposition or entanglement.
- Duality Law (1C): The duality law in quantum mechanics corresponds to the duality of quantum states—superposition and entanglement—where the CST geometry reflects these dualities as geometric deformations. Just as a particle can be in multiple states at once, the CST can represent multiple geometric states simultaneously.
- Entropy Law (1D): In quantum mechanics, entropy is associated with decoherence. The CST entropy law describes how the quantum system's information content changes as the system evolves, maintaining a balance between information preservation and information loss as systems collapse into more definite states.

5.3 Sine Alpha Function and Quantum Mechanics

The sine alpha function, $\sin(\alpha)$, plays a key role in understanding how quantum states evolve within the CST framework. Just as it describes the deformation in gravitational systems, in quantum mechanics it acts as a measure of the deformation of the quantum state. This deformation is akin to the wavefunction collapse in quantum theory.

For example, the entanglement of two quantum particles can be viewed as the spatial deformation of two CST units. As the deformation parameter α changes, the relationship between the two particles changes, reflecting the shift from entanglement to separation.

5.4 CST and Quantum Entanglement

One of the most profound implications of the CST framework in quantum mechanics is its potential to provide a geometric understanding of quantum entanglement. Traditionally, entanglement is understood as a non-local phenomenon, where particles become correlated in ways that defy classical explanations. However, within the CST framework:

- Entangled states can be modeled as deformation in space-time itself. The entanglement of two particles corresponds to the curvature deformation in the CST geometry.
- The symbolic states of CST units can represent different quantum states, such as superposition or entanglement.
- Changes in the deformation parameter α can correspond to quantum state evolution, such as wavefunction collapse or measurement.

This new perspective on entanglement allows us to visualize quantum interactions as spatially encoded deformations, rather than abstract correlations between distant particles.

5.5 CST as a Computational Tool for Quantum Gravity

The CST structure provides a promising framework for quantum gravity, offering a way to treat both quantum information and space-time geometry within a unified system. By embedding information processing directly into the curvature of space-time, the CST can describe quantum systems in a gravitational context, where both quantum mechanics and general relativity are simultaneously accounted for.

In this way, CST can help to solve key problems in quantum gravity, such as the black hole information paradox. The computationally aware space-time model allows for the tracking and processing of quantum information even in extreme gravitational environments, providing a potential solution to the issue of information loss.

5.6 Applications of the CST Framework in Quantum Mechanics

The CST geometry offers a fresh perspective on quantum phenomena:

- Quantum entanglement: By encoding entanglement as geometric deformation, the CST offers a spatially grounded model for quantum correlations.
- Wavefunction collapse: The CST's ability to collapse into different symbolic states corresponds to the collapse of a quantum wavefunction, providing a new interpretation of this process.
- Quantum information: The CST allows us to represent the flow of quantum information within space-time, opening up new avenues for quantum computing and quantum communication.

Thus, the CST structure serves as a versatile tool for unifying quantum mechanics with the geometric framework of space-time, and it provides a new foundation for studying quantum gravity and quantum information theory.

6 A Computationally Aware Spacetime

In this section, we explore how the Conjoined Spherical Triangle (CST) provides a new and unified framework for understanding both General Relativity (GR) and Quantum Mechanics (QM). The CST geometry encodes information and curvature directly within the structure of space-time itself, creating a computationally aware space-time [6]. This framework allows us to reconcile the continuous nature of space-time in GR with the discrete nature of quantum systems, offering a potential solution to the problem of quantum gravity.

6.1 CST Geometry and Gravitational Systems

In general relativity, the curvature of space-time describes the dynamics of massive bodies. The CST geometry uses the deformation parameter $\alpha = \frac{QC}{AQ}$ to represent the deformation in space-time. Here:

- A is a fixed reference point,
- C represents the location of the massive body,
- Q is the position of a test mass (or infalling object).

The CST framework models the gravitational deformation of space-time through changes in the distances between these points, encapsulating the spacetime curvature without requiring external forces or a detailed description of mass. The key to CST's role in GR is that it directly represents the geometry of space-time while maintaining the core principles of gravitational dynamics.

The deformation of space-time is governed by the four laws of CST:

- Path Law (1A): Describes how the distance between points in the CST geometry evolves as the test mass moves, maintaining the information about its gravitational trajectory.
- Area Law (1B): The area of spherical triangles formed within the CST geometry remains invariant under changes in the deformation parameter α, reflecting the conservation of gravitational energy.
- Duality Law (1C): The duality between elongation and compression of the CST geometry mirrors the duality in gravitational systems between stretched and compressed space-time regions, such as the space around a black hole and near a massive object.
- Entropy Law (1D): Describes the change in entropy (information content) as the system evolves, offering insights into the thermodynamic behavior of gravitational systems and black holes.

These four laws provide a geometrically grounded way to model the behavior of free-fall motion, black holes, gravitational waves, and other phenomena in general relativity.

6.2 CST and Quantum Mechanics

In quantum mechanics, the discreteness of nature and the probabilistic nature of quantum systems play a central role. However, quantum mechanics has historically treated space-time and information separately. The CST framework merges these two aspects by modeling quantum states as deformations in space-time itself, turning space-time into an information processor.

By embedding quantum information into the geometry of space-time, the CST framework offers a spatially grounded interpretation of quantum phenomena:

- Entanglement: The CST can model quantum entanglement by representing entangled quantum states as geometrically coupled deformations within space-time.
- Superposition: The CST can represent quantum superposition as a combination of multiple symbolic states (such as elongation and compression), all of which can exist simultaneously in the same spatial framework.
- Wavefunction Collapse: The CST framework can describe wavefunction collapse as a change in the symbolic state of the CST, corresponding to the quantum system's transition from a superposition of states to a definite state.

Thus, the CST enables us to geometrically represent quantum states, allowing space-time itself to process quantum information in the same way that it describes gravitational systems.

6.3 Sine Alpha Function and Computationally Aware Space-Time

The sine alpha function $\sin(\alpha)$ plays a crucial role in the CST framework by capturing the deformation of space-time in both gravitational and quantum systems. In the CST, the deformation parameter α encodes the curvature of space-time and also represents the evolution of quantum states.

For gravitational systems, the sine alpha function reflects the gravitational deformation due to the mass of a central object, affecting the motion of a test mass. In quantum mechanics, it describes the entanglement and superposition of quantum states, where the deformation of one part of the CST system affects the rest of the system.

The computationally aware nature of space-time comes from the fact that space-time itself, as encoded in the CST geometry, processes information and evolves according to both quantum dynamics and gravitational curvature. The sine alpha function ensures that this information flow and evolution occur in a consistent and predictable manner.

6.4 Unifying General Relativity and Quantum Mechanics

By embedding both gravitational deformation and quantum information within the same geometrical framework, the CST offers a potential solution to the long-standing problem of quantum gravity. The CST provides a way to describe quantum systems within the context of curved space-time, allowing us to model quantum states alongside gravitational dynamics.

This unification is crucial for understanding phenomena that exist at the intersection of quantum mechanics and general relativity, such as:

- Black holes: The CST framework provides a new way to model the event horizon and singularity of black holes, while also accounting for quantum effects near these extreme gravitational environments.
- Gravitational waves: The CST can describe the propagation of gravitational waves through space-time, modeling both the geometry of space-time and the information encoded in the waves.
- Quantum field theory in curved space-time: The CST framework offers a novel way to represent quantum fields in curved geometries, where the spacetime itself processes quantum information.

In this way, the computationally aware spacetime described by the CST offers a geometrically informed solution to the challenge of unifying general relativity and quantum mechanics, offering new pathways for further research in quantum gravity and the fundamental nature of space-time.

7 Conclusion

The Conjoined Spherical Triangle (CST) framework represents a new and revolutionary approach to understanding the fundamental aspects of physics. By combining general relativity and quantum mechanics into a unified computationally aware space-time, the CST offers a novel framework for addressing some of the most significant challenges in theoretical physics, including quantum gravity, black holes, and quantum information theory.

Through the four laws of the CST—path law, area law, duality law, and entropy law—we have demonstrated how this geometry encapsulates the core principles of both gravitational dynamics and quantum behavior. The CST's ability to model gravitational deformation and quantum states as geometrically encoded deformations allows us to understand the interplay between gravity and quantum mechanics in a unified framework.

The CST framework holds particular promise for the following key areas:

- Quantum Gravity: By embedding quantum states in the curvature of space-time, the CST provides a new perspective on quantum gravity, potentially offering a solution to the black hole information paradox and gravitational singularities.
- Quantum Information: The CST's ability to model quantum entanglement and superposition geometrically offers a fresh understanding of quantum information processing, allowing space-time to act as a computational medium for quantum systems.
- Cosmology: The CST framework provides a powerful tool for understanding the early universe, cosmic inflation, and dark matter and dark energy through a unified geometrical model that combines quantum mechanics and general relativity.
- High-Energy Physics: The CST can be applied to high-energy particle interactions in extreme gravitational fields, offering new insights into particle physics, string theory, and quantum field theory in curved space-time.

Despite the promising potential of the CST framework, there are still several areas requiring further exploration. Formalizing the CST model within existing quantum gravity frameworks, such as loop quantum gravity and string theory, will be crucial for its wider acceptance in the scientific community. Additionally, experimental verification of its predictions, particularly in gravitational systems and quantum information experiments, is necessary to test the validity and accuracy of the CST model.

As we move forward, the computationally aware space-time described by CST offers a new geometrical interpretation of both gravitational and quantum phenomena, potentially leading to breakthroughs in our understanding of space-time, quantum gravity, and the unification of physics. This approach provides a pathway toward resolving some of the most profound questions in modern physics and may offer the missing link between general relativity and quantum mechanics.

The CST framework opens up new possibilities for the study of space-time itself as an active, informationally dynamic system, suggesting that space-time may not merely be a passive stage for physical events but a computationally aware entity that processes both gravitational and quantum information simultaneously. This perspective could change the way we think about the fabric of the universe, laying the foundation for the next era of theoretical physics.

8 Funding Statement

No funding was needed for this submission.

References

[1] Albert Einstein. *Relativity: The Special and General Theory*. Henry Holt and Company, 1916. Translated by Robert W. Lawson.

[2] P. A. M. Dirac. *The Principles of Quantum Mechanics*. Oxford University Press, 1930.

[3] Arnold Sommerfeld. Über die zusammensetzung der geschwindigkeiten in der relativtheorie. *Physikalische Zeitschrift*, 10:826–829, 1909.

[4] Isaac Todhunter. *Spherical Trigonometry: For the Use of Colleges and Schools*. Macmillan and Co., London, 5th edition, 1886.

[5] János Bolyai. *The Scientific Work of János Bolyai: Appendix: The Theory of Space*. Cosimo Classics, 2004. Originally published 1832 as an appendix to a work by his father, Farkas Bolyai.

[6] Greg Egan. *Permutation City*. HarperPrism, 1994. Explores themes of computationally simulated consciousness and self-aware spacetimes.