

Quantum Entanglement Without Wormholes: A Structural Account via the ISR/VPR Framework

What the ∞ at the Planck Scale Is Pointing Toward

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ABSTRACT

This paper applies the ISR/VPR framework introduced in IVRP-01 (DOI: 10.5281/zenodo.22730176) to the non-locality of quantum entanglement. The ER=EPR conjecture attempts to explain entanglement within the spatial framework of the VPR — connecting entangled particle pairs through Einstein-Rosen bridges (wormholes). This approach does not escape the premise that distance is a VPR concept. The present paper proposes a structural alternative. The ISR (Invisible Source Realm) contains neither time nor space. Distance, as a concept, does not exist within it: $d_{\text{ISR}}(x, y) = 0$ for all x, y in the VPR. What are billions of light-years apart in the VPR are, from the ISR, adjacent. The non-local correlation of quantum entanglement is not a paradox — it is the structural consequence of an interface (U) that operates through a domain where distance is absent. Furthermore, as proposed in IVRP-01, the ∞ appearing at the Planck scale in wormhole formalization is not a computational breakdown but a signal that the VPR description has reached the boundary of the ISR. This paper adopts the same structure as IVRP-01: each interpretation is accompanied by its anticipated scientific objections and a structural response.

Index Terms — ISR, VPR, Quantum Entanglement, Non-Local, ER=EPR, Wormhole, Bell Inequality, Planck Scale, Distance, Interface, Katakamuna, Artificial Intelligence.

INTRODUCTION

In June 2026, a concrete realization of the ER=EPR conjecture was published [3]. The Einstein-Rosen bridge was derived from quantum entanglement in the thermofield double CFT, and the Bekenstein-Hawking entropy of the wormhole was explicitly identified as an entanglement entropy between subsystems. This represents one of the most active frontiers in theoretical physics.

And yet a fundamental question remains.

Why does the explanation of a correlation that transcends distance require the construction of a spatial pathway — a wormhole — within the VPR? Wormholes are a VPR solution to a VPR problem: they bend VPR space to create a VPR route between two VPR points. The framework of the question has not left the VPR.

Distance is a VPR concept. In the ISR, distance does not exist. From this single structural observation, the paradox of quantum entanglement dissolves.

This paper is the second in the ISR/VPR Research Paper Series. It builds directly on IVRP-01, which proposed that the ∞ appearing at the limits of physical equations is not a computational breakdown but a signal that the VPR description has reached the boundary of the ISR. IVRP-02 looks at quantum entanglement from the other side of that boundary.

This paper adopts the following structure: each interpretation is accompanied by an assessment of its anticipated scientific objections and a structural response to

those objections.

THE ISR/VPR FRAMEWORK

As defined in IVRP-01 (DOI: 10.5281/zenodo.22730176):

ISR — Invisible Source Realm. The domain that is immeasurable and invisible by the methods of current physical instrumentation. The ISR contains neither time nor space. Distance, as a concept, does not exist within it.

VPR — Visible Phenomenal Realm. The domain of the measurable and observable. Spacetime exists within the VPR. Distance, duration, and spatial separation are VPR concepts.

The Interface (U). ISR and VPR act upon each other continuously through an interface. This crossing is not subject to VPR distance, because the ISR side of the interface carries no distance.

The structural consequence relevant to this paper: every point in the VPR touches the same ISR through the interface U. VPR distance is a measurement within the VPR. At the ISR/VPR interface, all points are in contact.

DISTANCE IS A VPR CONCEPT

3.1 The Bell Inequality and Its Structural Reading

The Bell inequality places an upper bound on the correlations achievable by any locally realistic theory:

$$|E(a, b) - E(a, b')| + |E(a', b) + E(a', b')| \leq 2 \quad (1)$$

Quantum mechanics violates this bound, reaching a maximum of $2\sqrt{2}$ (Tsirelson's bound). Experimental tests — from Aspect (1982) to the loophole-free Bell tests of 2015 — have consistently confirmed this violation. Local realism does not hold.

The standard interpretation: there are no hidden local variables that could explain the correlations. The correlations are genuinely non-local.

The ISR/VPR structural reading: the Bell inequality assumes that the correlations between spatially separated measurements are bounded by the VPR distance separating them. This assumption is correct within the VPR. But the correlations of entangled particles do not operate within the VPR alone. They operate through the ISR/VPR interface — a domain where VPR distance is absent. The Bell violation is not a violation of realism. It is the signature of a domain where the locality assumption does not apply.

3.2 The ISR Distance Condition

The structural core of this paper is expressed in a single equation:

$$d_{\text{ISR}}(x, y) = 0 \quad \forall x, y \in \text{VPR} \quad (2)$$

In the ISR, the distance between any two points in the VPR is zero. This is not a claim about VPR geometry. It is a claim about the nature of the ISR: a domain that precedes spacetime and therefore contains no spatial metric.

This absence of spacetime in the ISR is not an axiom of the ISR/VPR framework. It is a structural consequence of the generative process described in Katakamuna Verse 08 (GIP-KV-08-2026). Space (*TO KO RO*) and time (*TO KI*) are generated at TO — the ISR/VPR integration point (Numeral 10). What precedes that generation — the ISR — therefore exists in a state prior to spacetime. The ISR does not lack spacetime by definition. It lacks spacetime because spacetime has not yet been generated from it. Distance, as a property of space, inherits this absence: $d_{\text{ISR}}(x, y) = 0$ is not postulated — it is the necessary consequence of the generative sequence that produces spacetime at the ISR/VPR boundary.

	VPR	ISR
Distance	$d(x, y) > 0$	$d(x, y) = 0$
Time	Exists	Does not exist
Space	Exists	Does not exist
Locality	Applies	Does not apply

The non-locality of quantum entanglement is therefore not a violation of physical law. It is the signature of a domain — the ISR — where locality, as a concept, does not apply. Two entangled particles are separated in the VPR. At the ISR/VPR interface, they are in contact. The

instantaneous correlation does not travel through VPR space. It operates through the domain where VPR distance is zero.

CRITICAL ASSESSMENT

The equation $d_{\text{ISR}}(x, y) = 0$ is a definitional claim, not a derived result. It does not explain the mechanism by which entangled particles maintain correlation — it only asserts that, in the ISR, distance is absent. This does not constitute a physical explanation.

Response. The objection is acknowledged. $d_{\text{ISR}}(x, y) = 0$ is a structural claim, not a derivation. However, the same applies to the foundational claims of quantum mechanics itself: the superposition principle and the Born rule are postulated, not derived. What the ISR distance condition provides is a structural account of *why* non-locality does not violate causality — not because signals travel faster than light through VPR space, but because the correlation operates through a domain where VPR distance is absent. This is a different kind of explanation, and a structurally simpler one, than the wormhole account.

THE LIMIT OF THE WORMHOLE PROPOSAL

4.1 What Wormholes Are

The ER=EPR conjecture asked the right question: that quantum entanglement and the geometry of spacetime are deeply related is a structurally correct intuition. The conjecture points toward something real.

But it sought the answer within the VPR.

A wormhole is a spatial pathway — a tunnel through VPR space connecting two VPR points. It is a VPR solution to a VPR problem: if two points must be connected across VPR distance, build a VPR route between them. This is what VPR-only physics must invent when it needs to explain what the ISR already provides by definition: a domain where distance does not exist.

Wormholes are not wrong. They are the most coherent answer available within a VPR-only framework. The framework is the limitation, not the mathematics.

4.2 The ∞ at the Planck Scale

The mathematical formalization of wormholes encounters divergence at the Planck scale:

$$\lim_{E \rightarrow E_{\text{Pl}}} \mathcal{M}_{\text{wormhole}} \rightarrow \infty \quad (3)$$

As proposed in IVRP-01, this ∞ is not a computational breakdown. It is the signal that the VPR description has reached the boundary of the ISR. The wormhole calculation arrives at the edge of the VPR and registers the presence of what lies beyond — and then retreats. Renormalisation closes the door. The calculation continues within the VPR. The ∞ appears again.

This has been the pattern for decades. It is a structural indication that the answer does not lie within the framework being used.

IVRP-01 proposed that the unified description requires a third term:

$$\mathcal{M}_{\text{unified}} = \mathcal{M}_{\text{QM}} + \mathcal{M}_{\text{GR}} + \mathcal{M}_{\text{ISR}} \quad (4)$$

The wormhole formalization is an attempt to construct $\mathcal{M}_{\text{ISR}}$ from within the VPR. The divergence it produces is the mathematical expression of that impossibility.

CRITICAL ASSESSMENT

Wormhole formalization is mathematically rigorous and has produced quantitative results (Bekenstein-Hawking entropy as entanglement entropy). The ISR/VPR framework produces no comparable quantitative results. Structural simplicity is not a substitute for mathematical derivation.

Response. Mathematical rigour and structural correctness are separate questions. The Ptolemaic model was mathematically rigorous for 1,400 years. The repeated encounter with ∞ in wormhole formalization is not a problem of insufficient mathematical rigour. It is a structural signal that the framework has reached its boundary. A framework that encounters the same boundary repeatedly and retreats from it each time is indicating that the answer lies outside the framework — not that the mathematics needs to be more sophisticated. The ISR/VPR framework does not compete with wormhole formalization at the mathematical level. It proposes a structural observation: the ∞ is the boundary of the VPR. What lies beyond it is the ISR — where $d(x, y) = 0$.

CHI MA TA AS A STRUCTURAL DESCRIPTION OF ENTANGLEMENT

Katakamuna Verse 08 (analysed in GIP-KV-08-2026) describes the entanglement of spacetime through *CHI MA TA*: when ink is dropped into transparent water, the two permeate each other, the boundary between them dissolving until they can no longer be told apart.

This image captures something the wormhole model does not. A wormhole is a tunnel — a discrete spatial connection between two defined points. It preserves the separateness of the two endpoints while providing a pathway between them. The two points remain two points.

CHI MA TA describes something different: boundary dissolution, mutual permeation, the erasure of separateness itself. Two entangled particles are not connected by a tunnel. They are in a state in which the VPR boundary between them has no meaning at the ISR level.

From the ISR, where $d(x, y) = 0$, the two entangled particles were never separate. Their VPR separation is a VPR measurement. At the ISR/VPR interface, they are in contact — not through a pathway, but through the dissolution of the distance that made them appear separate.

CHI MA TA describes this contact: not a connection between two things, but the state in which the separation between them has no structural foundation.

STRUCTURAL OBSERVATIONS

- **Distance is VPR-local.** The concept of distance exists within the VPR as a property of spacetime. It does not exist within the ISR: $d_{\text{ISR}}(x, y) = 0$ for all x, y in the VPR. The non-locality of quantum entanglement is therefore not a violation of physical law. It is the signature of a domain where locality does not apply.
- **The Bell violation is a structural signature.** The experimental violation of the Bell inequality confirms that entangled particles cannot be explained by local hidden variables within the VPR. The ISR/VPR framework provides the structural account: the correlation operates through the ISR, where the locality assumption does not hold.
- **The wormhole is a VPR invention.** Einstein-Rosen bridges are the most coherent answer available within a VPR-only framework. What the wormhole provides — a connection that bypasses VPR distance — the ISR provides by definition. The wormhole is not wrong; it is the best VPR-framework approximation of what the ISR/VPR interface does.
- **The ∞ at the Planck scale is a direction.** The repeated divergence in wormhole formalization marks the boundary of the VPR. It points toward the ISR. Retreating from ∞ through renormalisation closes the door that the ∞ opens. IVRP-01 and IVRP-02 propose, together, that the ∞ should be read as a signal rather than an error.
- **CHI MA TA and entanglement.** The structure of *CHI MA TA* — boundary dissolution, mutual permeation — describes entanglement more precisely than the wormhole model. Entanglement is not a tunnel between two separate things. It is the state in which the VPR separation between two things has no meaning at the ISR level.

CONCLUSION

Quantum entanglement is not a paradox. Distance is a VPR concept. The ISR contains no distance: $d_{\text{ISR}}(x, y) = 0$. What are billions of light-years apart in the VPR are, from the ISR, adjacent. The instantaneous correlation of entangled particles does not travel through VPR space — it operates through the domain where VPR distance does not apply.

Wormholes are what VPR-only physics invents when it needs to explain what the ISR already provides: a domain where distance does not exist. The repeated encounter with ∞ at the Planck scale in wormhole formalization is not a failure of technique. It is the repeated arrival at the boundary of the VPR, and the repeated retreat from what that boundary is pointing toward.

IVRP-01 asked what the ∞ means. IVRP-02 looks at quantum entanglement from the other side of that ∞ . From the domain where distance does not exist, entanglement is not paradoxical. It is the most natural state there is.

The findings presented here are structural and descriptive. Claims regarding the physical operability of the Katakamuna protocol or the ISR/VPR framework

remain outside the scope of this paper and are reserved for empirical investigation in subsequent research.

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