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Quantum Measurement Explained as Projected Probability from 4-D to 3-D

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Abstract: ***This paper builds on previous work and introduces a mathematical framework to address unresolved quantum mechanics phenomena, focusing on a dimensional reduction model that projects quantum states from 4-D to 3-D. Key quantum phenomena, including quantized energy, tunneling, destructive interference and entanglement are analyzed through this model, supported by the concept of a 4-D existence. The Theory of Space offers a cohesive paradigm, integrating quantum and classical physics while addressing the measurement problem, energy discreteness and the arrow of time.***

Keywords: Theory of Space, 4-D dimensionality, projected probability, quantum probability, measurement problem, quantum interval, quantum collapse, wavefunction collapse

1.Introduction

With the 100th anniversary of quantum formalism in 2025, this study addresses unresolved issues in quantum mechanics (QM). While the mathematical framework has been validated through numerous experiments and has led to significant technological advancements, the philosophical understanding of QM remains incomplete. This paper aims to address this gap by proposing a new model to explain phenomena such as the measurement problem, quantized energy, tunneling, non-locality of entangled particles, and the superposition of incompatible states.

The first step is to separate the passage of time or time events from the 4th dimension. In previous paper [1], the authors have proposed that the 4th longitudinal dimension Ct must be redefined. In 1908, Hermann Minkowski [2] gave birth to the four-dimensional space where the 4th dimension Ct links time events with space. That was a great contribution to introducing the concept of spacetime with a cone event for the past and the future. A step forward to Lorentz's and Poincare's contributions in the relativity theory.

This mathematical relation Ct is correct but the parameter of time as the passage of events is dependent on the initial time selected. Aside from the issue that its value is constantly growing with its intimate dependence on its previous and actual time dilation. Delta time or interval is a way to overcome this continuous and proper change but the question is what delta is the best one. And how this delta relates to the other physical quantities.

From the quantum perspective, Planck's periodic time τ is the appropriate delta time to consider, it will be a joining value between relativity and quantum theory which is at the core of nature. This $C\tau$ is the wavelength of energy λ! A novel 4th D following Einstein's General relativity that links energy with space. It also clears up Poincare's in variance (ΔR) ^2 + $(i \Delta C\tau)$ ^2 = constant. When the energy presence in a spatial zone is incremented, its $C\tau$ will be smaller and its space values will have a contraction. No more an arbitrary Minkowski interval but a *Quantum interval* with lots of physical meaning.

This 4-D as the longitudinal dimension of energy λ must be included whenever a spatial 3-D value is provided; the presence of energy completes the spatial information. Hamilton's quaternions can handle this 4-D relation; a scalar scale together with the three spatial vectors.

In other words, Einstein's spacetime values expressed in his General Theory of Relativity (GTR) are absolute; i.e., invariant under Lorentz's transformation. A gravitational effect that is independent of the frame of reference selected reinforces the intimate relation of spacetime plus mass with the presence of energy.

This will leave event time as the accumulation of quantum intervals. A relativistic parameter that depends on the 4th D in the same way that space and mass do; i.e., energy linked to space, time and mass. Schrödinger's Ψ wave equation [3] will evolve with the passage of time t. Dirac's relativistic equation [4] will also evolve with time t where its 4th D component represents energies wavelength.

Therefore, this study contributes to bridging theoretical gaps in quantum mechanics, offering novel insights for both foundational understanding and potential practical applications.

2.Physical existence in 4-D and its 3-D projected probability

Building on the concept of the quantum interval τ and the 4th dimension as energetic wavelength λ, the author proposes that any observation, measurement, or physical condition in 3-D projects the existence from 4-D into 3-D. This projection manifests as a single eigenvalue, eliminating the philosophical contradiction of simultaneous antagonistic states and aligning with the observed absence of superposition. The author has suggested that this manifestation is one of the core axioms of quantum mechanics (QM); a *Certainty principle.* Once the quantum system acquires this extra information, its future events will lose its versatility of eigenstates and will assume this new reality, i.e., following the collapse of the wavefunction.

The reduction from a higher dimension into the observable 3-D involves a random presence which is another core axiom of QM together with the concept of multiple eigenstates. That is, the superposition of multiple eigenstates at 4-D will manage the *deterministic* versatile existence of nature; a full description of the quantum system with no hidden variables issues. But its projected existence in 3-D will be randomly *poly-deterministic* followed by a probabilistic weight. This probabilistic presence in 3-D can be understood as a versatile existence with hidden values at 4-D.

For example, one 3-D dice contains six values, each one independent in its 2-D faces. A mono-deterministic or unique dice that can be poly-deterministic under a 2-D observation. This observation of its top face will reveal only one face with a probabilistic weight of occurrence but with 100% of its value. No average value nor a diffuse mixture of the superposition of its six values will be present at 2-D. The expectation value of different observations will evolve toward the average value of 3.5 dots (faces of: 1, 2, 3, 4, 5, 6 dots with equal probabilistic weight of 16.67%).

2.1 Physical existence resides in 4-D and is represented by the quantum pure state $| \Psi >$ in "Hilbert's linear mathematical space" (Hilbert's Cartesian coordinates), denoted as $\mathfrak{H}_{4D}$. Where:

$$< \Psi | \Psi > = 1 \tag{1}$$

This pure state is represented by an orthonormal basis $|\Phi_i >$ which correspond to the mathematical space at 3-D, i.e., in $\mathfrak{H}_{3D}$. This requirement for the orthonormal basis ensures that when some interaction or measurement or observation is done at 3-D, there won't be a mixture of eigenstates involved.

$$< \Phi i |\Phi j > = \delta\, i, j \tag{2}$$

2.2 This coexistence of basis states or superposition of eigenstates at 4-D contains a probabilistic distribution of each of them in such a way that c_{i} is a complex number that corresponds to eigenstate $|\Phi i>$. Where $c^*_{i} c_{i}$ provides its probabilistic weight or probability presence of this particular state at 3-D. Therefore, the pure state $|\Psi>$ can be expressed as:

$$| \Psi > = \Sigma_{i} c_{i} |\Phi i> \tag{3}$$

2.3 A Hermitian projection operator $\hat{\mathbf{O}}_{i}$ is associated with an eigenstate $|\Phi i>$.

$$\hat{\mathbf{O}}_{i} = |\Phi i><\Phi i| \tag{4}$$

The projected probability of a given state being involved in an interaction or measurement or observation is:

$$\mathbf{O}\,(\Phi i) = < \Psi |\hat{\mathbf{O}}| \Psi > = |c_{i}|^2 \tag{5}$$

Where:

$$c_{i} = \Sigma_{j} c_{i, j} \tag{6}$$

In other words, the probability of observing $|\Phi i>$ is:

$$\mathbf{P}\,(\Phi i) = \Sigma_{j} |c_{i, j}|^2 \tag{7}$$

Meanwhile, its overall existence at 4-D is 100%; a complete coexistence of observable:

$$\Sigma_{i} c^*_{i} c_{i} = 1 \tag{8}$$

2.4 Any physical conditioning like, interactions or measurements, etc. will provide extra information to the quantum system in such a way that its future quantum state will be the one involved in that event, that is, future $c_{i} = 1$; a $\mathfrak{H}_{3D}$. carrying this information.

2.5 Physical parameters contain poly-observable magnitudes which are represented by $\hat{A}$ an Hermitian operator acting over the variety of eigenstates of this mathematical space $\mathfrak{H}_{4D}$. The expectation value is the average eigenvalue A_{i} obtained through the multiplication of each eigenvalue with its probabilistic weight.

$$\hat{A}\, |\Phi i>= A_{i} |\Phi i> \tag{9}$$

$$< \Psi | \hat{A} | \Psi > = \Sigma_{i j} c^*_{i} c_{j} A_{i j} \tag{10}$$

As can be seen, this theory embraces actual quantum math, the only difference is in the way it's interpreted.

3.Existence at 4-D is continuous or intermittent

The projection from 4-D to 3-D offers a clear explanation for quantum observations post-interaction or measurement, addressing the measurement problem. However, the behavior of quantum systems during non-interaction and over the passage of time remains to be understood. Below is an analysis of whether quantum existence is continuous or intermittent, evaluating this in the context of various quantum phenomena.

3.1 The arrow of time:

A continuous existence in superposition will behave symmetric with time, there is no argument why time cannot be reversible. Meanwhile, an intermittent or quasi-3-D superposition approach will include the crucial randomness in QM. An alternating presence between 4-D and 3-D at the rate of its energetic frequency ($1/\tau$) will incorporate this memory-less presence. Every time its presence is at 3-D it will assume one of its eigenstates and that will exclude the reversibility in consecutive quantum intervals. An aleatory presence of individual eigenstates cannot be randomly reproduced backward. For further understanding and this random characteristic in entropy, read authors' previous paper [5]. Therefore, the intermittent or oscillating approach accomplished this understanding.

3.2 Energy presence in chunks

The first quantum equation was given by Max Planck [6] and it revealed that the presence in 3-D of energy is in a discrete form. The continuous alternative doesn't explain this important behavior of nature. The intermittent one does it because the fluctuation or oscillation between 4-D and our observable 3-D provides the understating of discreteness.

For a given action h, the time involved by the quantum system to be present at 3-D is inversely proportional to its energy ($E = h/\tau$). For example, a gradual or slow presence will imply a greater τ explaining why the presence of energy in 3-D is less, and vice versa.

3.3 Tunneling effect:

A continuous existence can explain how particles (compact entities and not pointy ones) pass through a potential barrier because of its existence in a higher dimension; i.e., out of 3-D avoiding the existence inside the barrier. On the other hand, an intermittent existence can manage the same concept; additionally, it can manage why there is a "collapse" when it is located on the other side. The particle is in one fluctuation at one side of the barrier and at the next fluctuation at the other side (quantum jump) creating a natural interaction that affects the system to resets. Like photons when passes through a polarized filter, it resets to the new phase. Both options explain the tunneling effect but the intermittent approach explains this phenomenon in a greater form.

3.4 Non-3-D locality of entangled particles:

The continuous existence at the 4-D provides a way of being *local* meanwhile their physical system is separated in 3-D. Idem with the intermittent approach. By existing in a higher dimension scenario, both alternatives solve the nonlocality issue; the great concern of Einstein [7] is finally overcome.

3.5 Vector addition of the 4th D component to the kinetic energy and to the angular momentum:

The famous relativistic equation used in quantum theory is $E = m_{r}C^2 = \gamma\, m_{o}\, C^2$ where m_{r} is the relativistic mass, m_{o} is the mass at rest, γ is Lorentz's gamma factor and C^2 is the speed of light squared. This energetic component is considered at the 4th D and added as a vector with the 3-D kinetic energy. A Cartesian coordinate with four axes, 0-1-2-3. Idem with quantum spin, an angular momentum at the 4th D which is added as a vector with the 3-D angular momentum **L**.

$$E^2_{4D} = (m_{o}C^2)^2 + p_{3D}^2\, C^2 \qquad (11)$$

$$\mathbf{J}_{4D} = \mathbf{S} + \mathbf{L}_{3D} \qquad (12)$$

This mathematical success summing them as vectors and not in a scalar way, reveals that all of them belong to the same type of energy and angular momentum respectively. The continuous approach can't explain why, meanwhile, the oscillatory approach does. It considers that the fluctuation travels at the speed C between 3-D and the 4th D carrying a kinetic value of $m_{o}C^2$ and an angular momentum of $\pm \hbar$ [8]. An additional argument in favor of the intermittent-oscillatory approach.

3.6 Quantum interference:

A continuous coexistence of states at 4-D can't infer how the interference is produced. A continuous existence do not embraces a phase criteria that is crucial to the interference phenomenon. In the intermittent approach, a fleeting passage through "3-D" in interaction with "out of 3-D" will involve a phase difference and explain a destructive interference. Like in the double slit experiment, where in the evolution of a divided quantum system, one part of its space is at "3-D" and gets in contact with the other part "outside 3-D"; a destructive interference is corroborated by the exclusive zones seen at the final detecting screen. Note that complex number manage quite well an existential phase.

3.7 The Uncertainty Principle:

A limit in handling some physical parameters. Only the intermittent approach can provide an explanation due to the different phase between some physical parameters. For example, momentum and energy are in different phase with position and time, so the order in which they are involved is determinant; i.e., non-commutative between them involving a limit that include Planck's action h.

3.8 Gravitational effect:

This last analysis is left for the gravitational effect, a physical phenomenon only understood under General Relativity. A continuous quantum existence at 4-D won't explain this universal phenomenon. An intermittent scenario where, in each fluctuation "out of 3-D", the space of the quantum system is replaced by the surrounding space producing a space flow towards the energetic source. When the energetic source is a non-charged, non-rotating and spherically symmetric body, the velocity of the flow is given by Schwarzschild's escaping speed [9]. An important insight that will exalt the 2025 anniversary and pave the path for future joining points between these two core theories of modern physics.

4. Conclusions

The Theory of Space provides a cohesive framework that unifies the dynamic nature of 3-D space, encompassing both quantum gravity and relativistic space-time, with the concept of multidimensional space energy. This theory addresses key quantum phenomena by positing a projection from a 4-dimensional existence to our observable 3-dimensional reality.

Through this model, we gain insights into the measurement problem, the nature of quantized energy, tunneling effects, entanglement, destructive interference and the arrow of time. The novel approach of considering the 4th dimension as an energetic wavelength ($\lambda = C\tau$) and understanding quantum intervals (τ) allows for a clearer interpretation of these phenomena.

The proposed intermittent or oscillating presence in 3-D provides a robust explanation for the discrete nature of energy, the locality of entangled particles at 4-D, and the vector addition of the 4th dimensional component to kinetic energy and angular momentum. Additionally, it offers a fresh perspective on the gravitational effect, suggesting a space flow mechanism towards energetic sources, consistent with Schwarzschild's escape velocity.

As we mark the 100th anniversary of quantum formalism, the Theory of Space stands as a promising paradigm, bridging gaps between classical and quantum physics, and providing a fertile ground for future research and experimental validation.

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Declarations

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Jose Oreste Mazzini (September, 2023) *A new interpretation of the Special of Special Relativity*, International Journal of Science and Research **12**, 9, 1509-1514. DOI: 10.21275/SR23918031232
[2] Hermann Minkowski (1907–1908), *Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern*, Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse: 53–111
[3] Erwin Schrödinger (1926). *Quantisierung als Eigenwertproblem*. Annalen der Physik. **384** (4): 273–376.
[4] Paul Dirac (February 1928). *The Quantum Theory of the Electron.* Proceedings of the Royal Society of London A. **117** (778): 610–24. DOI:10.1098/rspa.1928.0023.
[5] Jose Oreste Mazzini (December, 2024) *Exploring Entropy and time: Reversibility in the 4th Dimension*, International Journal of Science and Research **13**, 12, 386-390. DOI: 10.21275/SR241204184128.
[6] Max Planck (December, 1900). *Ueber das Gesetz der Energieverteilung im Normalspectrum* [On the law of the distribution of energy in the normal spectrum]. Annalen der Physik. 4th series (in German). **4** (3): 553–563.
[7] A. Einstein; B. Podolsky; N. Rosen (May 1935) *Can Quantum-Mechanical Description of Physical Reality be Considered Complete?* (PDF). Physical Review. **47** (10): 777–780. DOI:10.1103/PhysRev.47.777.
[8] Jose Oreste Mazzini (February, 2024) *The famous equation $E = mC^2$ and the spin, quantum momentum, are deduced from the dynamics of a fluctuation between 3-D and the 4th dimension*, International Journal of Science and Research **13**, 2, 1074-1079. DOI: 10.21275/SR24212193340.
[9] Jose Oreste Mazzini (November, 2024) *Quantum and Relativistic gravity: Understanding Potential energy through space flow kinetics*, International Journal of Science and Research **13**, 11, 337-341. DOI: 10.21275/SR241105050956.