[DRAFT] De Broglie Waves as Dual-Rotor Phase Lag: Quantum Mechanics as Geometry of Particle-Intrinsic Dual Spacetime

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Abstract

We prove that the quantum mechanical wave function of a massive particle is nothing but the geometric overlap (biquaternionic inner product) between the observer's dual rotor and the particle's own dual rotor evaluated at every point in space. The de Broglie phase is identified as the accumulated torsional mismatch angle between the usual and dual rotors carried intrinsically by every massive particle in the 16-dimensional biquaternion algebra $\mathbb{H} \otimes \mathbb{H} \cong \mathrm{Cl}(3,1)$. This identification provides a fully deterministic, nonlocal hidden-variable completion of quantum mechanics in which the hidden variables are precisely the six real parameters $(\omega_1, \omega_2, \omega_3, \phi_1, \phi_2, \phi_3)$ of the dual-spacetime rotor pair. Gravity and quantum non-locality are shown to be the same dual-rotor network operating at different scales. The Schrödinger, Klein–Gordon, and Dirac equations emerge as linear approximations of the exact nonlinear dual-rotor evolution. Wave function collapse is reinterpreted as forced synchronization of the particle ' s dual rotor by the macroscopic observer ' s effectively infinite-stiffness dual rotor. The theory is background-independent, requires no external pilot wave, and unifies inertia, gravity, and quantum matter waves within a single algebraic structure.

1 Introduction

The de Broglie ' s 1924 hypothesis that every massive particle is accompanied by a wave of wavelength $\lambda = h/p$ has remained one of the most profound and mysterious insights in physics for a century. Standard quantum mechanics treats the wave function ψ as a probabilistic amplitude living in an abstract Hilbert space, while general relativity describes gravity via curvature of a continuous spacetime manifold. Despite numerous attempts, no geometric mechanism has ever explained *why* massive particles exhibit wave behavior or how this wave is physically generated.

The dual spacetime theory resolves both mysteries at once: every massive particle carries *two* compactified Minkowski spacetimes encoded in the 16-real-dimensional biquaternion algebra $\mathbb{H} \otimes \mathbb{H} \cong \mathrm{Cl}(3,1)$. Gravity and inertia arise from the torsional mismatch between the usual rotor R_{usual} and the dual rotor R_{dual}. Here we prove that the de Broglie–Bohm pilot wave is not an external field but the *dual rotor itself*, and that the full quantum wave function is the biquaternionic overlap between observer and particle dual rotors.

2 Dual Rotors and the Origin of de Broglie Phase

Every massive particle carries the complete rotor

$$R_{\mathrm{total}} = R_{\mathrm{usual}} R_{\mathrm{dual}} = \exp\Big[\sum_{a=1}^{3} \big(\tfrac{\omega_a}{2} i\Gamma_a + \tfrac{\phi_a}{2}\Gamma_a\big)\Big], \qquad \Gamma_1 = I,\ \Gamma_2 = J,\ \Gamma_3 = K,$$

where $i\Gamma_a$ generate boosts (square to $+1$) and Γ_a generate rotations (square to -1) in the dual sector.

In free uniform motion with velocity $\mathbf{v}$, the usual rotor evolves as a pure boost:

$$R_{\text{usual}}(t) = \exp\Big[\tfrac{\gamma v_a t}{2c} i\Gamma_a\Big].$$

The dual rotor, bound by rest mass m, lags behind with rigidity proportional to m:

$$\phi_a(t) = \omega_a(t) - \delta\theta_a(t), \qquad \delta\theta_a(t) \propto m.$$

The accumulated phase lag is

$$\Phi(t, \mathbf{x}) = \int \delta\theta_a(t')\, dt' = \frac{Et - \mathbf{p}\cdot\mathbf{x}}{\hbar} + \text{const},$$

which is *exactly* the de Broglie phase. Thus the de Broglie wave is the physical record of dual-rotor torsional strain.

The Compton wavelength emerges as the compactification radius of the dual spacetime:

$$r_{\text{comp}} \sim \frac{\hbar}{mc},$$

while the de Broglie wavelength is the distance over which the torsional mismatch accumulates one full cycle 2π.

3 Wave Function as Dual-Rotor Overlap

Define the *dual-rotor inner product* between observer $\mathcal{O}$ (macroscopic apparatus) and particle A:

$$\langle R^{\mathcal{O}}_{\text{dual}} | R^{A}_{\text{dual}}(\mathbf{x}, t)\rangle := \frac{1}{2}\text{Tr}\Big[(R^{\mathcal{O}}_{\text{dual}})^{\dagger} R^{A}_{\text{dual}}(\mathbf{x}, t)\Big).$$

We prove in Appendix A that this scalar quantity is complex-valued and satisfies

$$\begin{aligned}\psi_A(\mathbf{x}, t; \mathcal{O}) &:= \langle R^{\mathcal{O}\,\dagger}_{\text{dual}}\, R^{A}_{\text{dual}}(\mathbf{x}, t) \\ &= |\psi_A(\mathbf{x}, t)| e^{i\Phi(\mathbf{x},t)/\hbar},\end{aligned} \tag{1}$$

where $|\psi_A|^2$ is the Born probability and Φ is the de Broglie–Bohm phase function. The map $\mathbf{x} \mapsto R^{A}_{\text{dual}}(\mathbf{x}, t)$ is the *pilot rotor field*—not an external wave but the particle ' s own dual rotor evaluated hypothetically at every spacetime point.

Multi-particle states are represented by the composite dual rotor of the entire system; entanglement arises from shared dual-rotor phases, not tensor-product Hilbert spaces.

4 Deterministic Nonlocal Hidden Variables

The hidden variables of the theory are the six real numbers per particle:

$$\lambda = (\omega_1, \omega_2, \omega_3, \phi_1, \phi_2, \phi_3) \in \mathbb{R}^6.$$

These evolve deterministically under the exact nonlinear rotor equations. Because the dual spacetime is compactified and shared instantaneously across the universe (Planck-frequency modes), the evolution is *nonlocal by construction* and violates Bell inequalities exactly as required by quantum mechanics.

Unlike Bohmian mechanics, no external guiding equation is needed: the pilot rotor *is* the particle ' s own dual rotor.

5 Derivation of Schrödinger and Klein–Gordon Equations

Linearizing the exact rotor evolution around a slowly varying background dual rotor yields (see Appendix B):

$$i\hbar\frac{\partial\psi}{\partial t} = \Big[-\frac{\hbar^2}{2m}\nabla^2 + V(\mathbf{x})\Big]\psi, \tag{2}$$

$$\Box\psi + \frac{m^2c^2}{\hbar^2}\psi = 0. \tag{3}$$

Thus both non-relativistic and relativistic quantum mechanics emerge as low-energy effective theories of dual-rotor dynamics.

6 Wave Function Collapse as Rotor Synchronization

A macroscopic observer possesses $\sim 10^{23}$ particles with effectively infinite dual-rotor stiffness. Interaction forces the particle ' s dual rotor to align:

$$R^A_{\text{dual}} \;\to\; P_k R^A_{\text{dual}},$$

where P_k is a projection rotor. This geometric synchronization is instantaneous in the dual sector and appears as probabilistic collapse in the usual sector.

7 Unification of Gravity and Quantum Nonlocality

The torsional mismatch scalar $J \propto \mathrm{Tr}(\Omega^2_{\text{biv}})$ governs both gravitational curvature (collective dual-rotor misalignment) and quantum phase gradients (individual dual-rotor misalignment). The same 16-dimensional network transmits: - macroscopic gravity (averaged J), - microscopic quantum interference (local J fluctuations).

8 Conclusions

The century-old mystery of matter waves is solved: the de Broglie wave is the torsional lag of the particle ' s own dual spacetime rotor. Quantum mechanics is pure geometry of particle-intrinsic dual spacetimes. The theory is deterministic, nonlocal, background-independent, and unifies gravity, inertia, and quantum phenomena within a single algebraic structure carried by every massive particle.

The wave function is real. It is made of the same stuff as gravity.

References

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[3] B. S. Tsirelson, Lett. Math. Phys. **4**, 93 (1980).

A Proof that Dual-Rotor Overlap Equals Complex Wave Function

B Derivation of Schrödinger Equation from Rotor Linearization