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Article

# The IN/OUT Wave Mechanism: A Non-Local Foundation for Quantum Behavior and the Double-Slit Experiment

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## Abstract

This work extends the framework developed in "The Vibrational Fabric of Spacetime" [1] by detailing the **IN/OUT wave mechanism**. It provides a detailed, step-by-step explanation of how particles, as self-trapped wave packets, interact non-locally with their environment. We focus on applying this mechanism to the double-slit experiment, offering a mechanical and intuitive explanation for quantum interference and the role of the environment. The principle of "source subtraction" is introduced as a fundamental geometric method for determining allowed particle paths. This exposition demonstrates how quantum behavior emerges from the inherently extended nature of particles defined by their wave-mediated connection to the universe.

**Keywords:** IN/OUT wave mechanism; Pilot Wave Theory; de Broglie-Bohm Theory; double-slit experiment; quantum foundations; emergent quantum mechanics; non-locality; wave-particle duality; transactional interpretation; measurement problem; photon mass mechanism; vibrational spacetime

## 1. Introduction: The Monistic Paradigm of Vibrational Reality

The paradigm presented in the main article [1] posits a fundamental unity to physical reality: there is only one primordial constituent in the universe—**Space itself**. What we perceive as distinct entities—matter, fields, and forces—are but different manifestations of space in a state of vibration.

In this framework:

- **Space is the medium:** It is not a passive void but a dynamic, vibratory network capable of supporting wave propagation.
- **Waves are vibrating space:** Electromagnetic waves, and indeed all fundamental waves, are nothing more than specific vibrational modes of the spatial medium.
- **Matter is trapped vibration:** Particles are stable, self-sustaining wave packets—standing waves or solitons—localized within the medium through non-linear effects.

This monistic view resolves the ancient duality between the container (space) and the contained (matter).

### Fundamental Reference Frame

**Important Clarification:** Throughout this article, when we refer to a particle's velocity or state of motion (e.g., "at rest", "moving with velocity  $v$ "), we mean specifically **its velocity relative to the spatial medium itself**. This is a fundamental reference frame defined by the network of vibrating space. The laboratory frame, while practically useful for measurements, is derivative and often in motion relative to this fundamental medium. This distinction is crucial for understanding how the internal wave structure of particles adapts to their motion through space.

It provides a natural explanation for why a particle at rest relative to the medium can exist: its internal energy consists of standing waves forming **closed loops** within the spatial network. The mass-energy equivalence ( $E = mc^2$ ) corresponds to the energy of these circulating waves. When the

particle moves, these internal closed loops transform into **helical paths** from the perspective of the medium, while remaining closed loops in the particle's own rest frame. This geometric insight clarifies how the internal structure of a particle is intrinsically linked to its state of motion, addressing the relativistic requirement that there is no privileged absolute frame—the particle's properties are defined relative to the medium with which it interacts.

It is from this foundational principle that the IN/OUT wave mechanism naturally emerges, providing a mechanical basis for quantum behavior and non-locality.

## 2. The IN/OUT Wave Mechanism: A Self-Sustaining Feedback Loop

The stability of a particle—a self-trapped wave packet in the elastic spacetime network—is not a static state but a dynamic, self-sustaining process. This process is governed by a fundamental feedback loop between outgoing (OUT) and incoming (IN) waves.

### 2.1. A Closed Loop of Vibration

The mechanism is fundamentally circular, forming a closed loop:

1. The particle's core emits an outgoing spherical wave, the **OUT wave** ( $\psi_{\text{OUT}}$ ), into the surrounding elastic medium.
2. This OUT wave propagates radially, exciting the vibrational degrees of freedom of space itself throughout its journey.
3. Each point in space, thus excited, becomes a secondary source that scatters a wavelet. The coherent sum of all these scattered wavelets, with appropriate time delays, forms a converging spherical wave—the **IN wave** ( $\psi_{\text{IN}}$ ).
4. Crucially, this IN wave, upon reaching the particle's core, does not simply interfere with it. It **drives and sustains** the very oscillation that generates the OUT wave.

This creates the fundamental self-sustaining loop:

$$\text{Core Oscillation} \rightarrow \psi_{\text{OUT}} \rightarrow \psi_{\text{IN}} \rightarrow \text{Core Oscillation} \rightarrow \dots \quad (1)$$

The particle exists as a **stable resonance** in this loop. The OUT wave is the source of the IN wave, and the IN wave is the source of the OUT wave. This closed loop is only possible because space is elastic and can support this continuous energy exchange.

### 2.2. Mathematical Framework of the Feedback Loop

The process can be conceptualized through a wave equation with a source term that depends on the incoming wave:

$$\square \psi_{\text{OUT}}(\vec{r}, t) = S(\psi_{\text{IN}}(\vec{r}_{\text{core}}, t)) \quad (2)$$

where  $\square$  is the wave operator, and the source term  $S$  at the particle's core location  $\vec{r}_{\text{core}}$  is a function of the IN wave amplitude and phase. The stability condition requires that the phase of  $\psi_{\text{IN}}$  at the core matches the phase of the core's oscillation, creating constructive reinforcement:

$$\phi_{\psi_{\text{IN}}}(\vec{r}_{\text{core}}, t) = \phi_{\text{core}}(t) + 2\pi n, \quad n \in \mathbb{Z} \quad (3)$$

This phase coherence condition across the entire extended structure is what gives rise to quantum behavior.

### 2.3. The Particle as a Non-Local Standing Wave

A stable particle corresponds to a standing wave pattern formed by the IN/OUT loop. The particle is not merely *at* a location; it is **extended over** the region where this coherent feedback occurs. Its "position" is simply the focal point where the IN wave converges to drive the oscillation most effectively.

This explains non-locality inherently: the particle's properties depend on the entire configuration of the IN/OUT wave field, which extends throughout space and encodes information about the environment.

### 3. Connection to de Broglie's Pilot Wave and Wheeler's Transactions

The IN/OUT wave mechanism provides a physical realization and extension of several foundational quantum interpretations.

#### 3.1. de Broglie-Bohm Pilot Wave Theory

In de Broglie-Bohm theory [2,3], a particle is guided by a wave function  $\Psi$ . Our model makes this guidance mechanism concrete:

- The converging IN wave ( $\psi_{IN}$ ) is the physical pilot wave. It guides the particle by determining the locations where phase coherence (and thus stable existence) is possible.
- The model answers the question of the wave's origin: the pilot wave is generated by the particle itself through its interaction with the environment.
- The guidance is not an external force but an internal requirement for maintaining the self-sustaining feedback loop.

#### 3.2. Wheeler's Transactional Interpretation

The continuous two-way process closely resembles Wheeler's transactional interpretation [4,5]:

- The OUT wave corresponds to the *offer wave*.
- The IN wave corresponds to the *confirmation wave*.
- The stable particle is the completed *transaction*.

The key difference is that our mechanism operates through standard retarded waves and feedback within an elastic medium, without requiring advanced waves or backward-in-time causation.

## 4. The Particle in Motion: Sailboat on a Self-Generated Wave Field

#### 4.1. Velocity as a Deformed Wave Pattern

When a particle moves with constant velocity  $\vec{v}$  relative to the medium, the spherical symmetry of the IN/OUT field is broken. The particle maintains a permanently deformed configuration:

- **In the direction of motion:** OUT waves are Doppler-shifted to shorter wavelengths, and IN waves from ahead are more intense.
- **Behind the particle:** OUT waves are stretched, and IN waves from behind are less intense.

This asymmetry creates a stable pseudo-stationary wave pattern that moves with the particle.

#### 4.2. Inertia as Resistance to Wave Pattern Reconfiguration

Acceleration requires changing this stable deformed state. The physical mechanism involves:

- The applied **force** manifests as the sum of all momentum exchanges between the particle's core and the IN/OUT wave field.
- Each local interaction with the pseudo-stationary waves contributes an impulse  $\Delta\vec{p}$ .
- To accelerate, the particle must reconfigure its entire extended wave structure to match the new velocity state.
- This requires working against the "elastic memory" of the medium that resists this change.

Mathematically, the force  $\vec{F}$  is the time derivative of the total momentum transfer from the wave field:

$$\vec{F} = \frac{d}{dt} \sum_i \Delta\vec{p}_i^{(\text{wave-core})} \quad (4)$$

where the sum runs over all local interactions with the IN/OUT wave structure.

Thus,  $F = ma$  describes the net force needed to overcome the collective resistance of the wave pattern reconfiguration. The inertia is the manifestation of the energy required to reshape this non-local wave structure.

#### 4.3. The Physical Origin of Momentum

In this framework, the particle's momentum is not an abstract quantity but the integrated effect of the momentum density carried by its extended wave field. When external forces act on the particle, they essentially modify the boundary conditions for the IN/OUT wave solution, forcing a transition between different stable wave configurations corresponding to different velocities.

### 5. The Double-Slit Experiment: A Wave-Geometric Explanation

#### 5.1. The Source Subtraction Principle

A fundamental principle in this wave-based paradigm is that an **absence of a source is equivalent to a negative source**. This is not a mathematical trick but a physical reality stemming from the linearity of wave equations (for the low-energy perturbations we consider).

Consider a partition (the slit screen). Its effect on an incoming OUT wave ( $\psi_{\text{OUT}}$ ) is to act as a new source of IN waves. Every atom in the partition, when excited by  $\psi_{\text{OUT}}$ , becomes a source of a scattered wavelet.

Now, imagine cutting two slits in the partition. The resulting wave field is identical to the field that would exist if the partition were solid, **minus** the field that would be emitted by the two "plugs" of material that were removed.

Mathematically, if  $\psi_{\text{INsolid}}$  is the IN wave from a solid screen, and  $\psi_{\text{INplug1}}$ ,  $\psi_{\text{INplug2}}$  are the IN waves that the two plugs would emit if they were present, then the actual IN wave is:

$$\psi_{\text{INwith slits}} = \psi_{\text{INsolid}} - (\psi_{\text{INplug1}} + \psi_{\text{INplug2}}) \quad (5)$$

The solid screen typically produces a simple, perhaps even blocked, wave field. The interesting part is the term  $-(\psi_{\text{INplug1}} + \psi_{\text{INplug2}})$ . The **absence of the plugs** acts as sources of **negative wave activity** (phase-inverted relative to the solid screen's reflection). It is these "negative sources" that are responsible for creating the complex interference pattern.

#### 5.2. Building the Interference Pattern

The two plugs, were they in place, would be excited coherently by the same incident OUT wave from the electron. They would thus act as two coherent sources of IN waves, emitting spherical waves. According to the principle above, the actual setup is equivalent to having these two coherent sources emitting **with a negative amplitude**.

The interference of these two effective negative sources creates a pattern of wave crests and troughs (phase coherence and anti-coherence) behind the screen. This pattern is the famous interference pattern.

#### 5.3. Particle Guidance: The Principle of Phase Coherence

The electron (the self-trapped wave packet) does not "choose" a path. Instead, its stable existence *requires* it to position itself within the wave field where it can maintain a coherent feedback loop.

- The allowed paths for the electron's core are the **ridges of constructive interference** in the total IN/OUT field. On these paths, the IN wave returning to the electron is in phase with its own vibration, providing reinforcing feedback.
- If the electron's core were to wander into a zone of destructive interference (a trough in the pattern), the IN wave would be out of phase. This would create a destabilizing force, a "phase conflict," pulling the core back towards a zone of coherence. The particle is dynamically guided by the need to maintain this non-local resonance.

Therefore, the electron passes through “both slits” in the sense that the wave field that defines it and guides it is shaped by the absence of material in **both** locations. The particle’s trajectory is a property of the entire extended system (electron + screen), not just the electron alone.

#### 5.4. *The Effect of Measurement and the Role of the Observer*

What happens if we try to detect which slit the electron goes through? Such a detection requires a strong local interaction (e.g., hitting the electron with a photon near one slit). This interaction violently disturbs the delicate, coherent IN/OUT wave field. It is like dropping a rock into a pond where a stable standing wave pattern exists. The coherence is destroyed.

The measurement apparatus itself becomes a dominant new element in the environment. The IN wave field is now shaped primarily by this local interaction, collapsing back to a much simpler configuration—perhaps one corresponding to a single, localized source (one slit). Without the complex interference pattern to guide it, the electron behaves like a localized particle and the interference pattern disappears.

The “collapse” is therefore not a mystical event triggered by consciousness or observation, but the **physical disruption of the non-local wave structure** that constitutes the particle’s quantum state. The observer is not special; any physical interaction that is strong enough to decohere the IN/OUT wave field will produce the same effect.

## 6. Photons as Massless Guided Excitations

The IN/OUT mechanism applies universally to all physical entities. The fundamental distinction lies in how different types of particles allocate energy between internal vibration and translational motion:

- **Massive particles (electrons, protons, atoms, etc.):** Can dynamically allocate energy between internal loops and translation.
  - **At rest relative to the medium:** 100% of the wave activity maintains internal closed loops, creating rest mass.
  - **In motion:** A portion of the energy is devoted to translation, transforming internal loops into helical paths. The percentage allocated to translation increases with velocity.
- **Photons (massless excitations):** Allocate 100% of their energy to translation. They lack any internal closed-loop structure that could allow them to be at rest relative to the medium. This explains why photons **cannot be at rest** in any reference frame—their very nature is pure propagation.

Despite this fundamental difference, both massive particles and photons generate and are guided by their IN waves. The interference phenomena observed in the double-slit experiment—whether with electrons, atoms, or light—are therefore of the same nature: they result from the guidance of excitations by environmentally-shaped wave fields. Each particle follows paths of maximum phase coherence in the IN wave field created by its own OUT wave interacting with the experimental setup.

## 7. Discussion: Connections and Future Developments

This conceptual framework naturally connects to established physical theories while opening new research directions:

- **Special Relativity Connection:** The velocity-dependent deformation of the IN/OUT wave patterns provides a natural mechanism for relativistic phenomena. A forthcoming publication will demonstrate how the complete mathematical formalism of Special Relativity emerges naturally from this paradigm as an **observational theory** describing how particle dynamics appear in different reference frames moving through the vibrational medium.
- **Mathematical Formalization Path:** The clear physical picture presented here provides a solid foundation for developing the precise wave equations governing the IN/OUT mechanism. Future

work will focus on deriving the Schrödinger and Dirac equations as effective descriptions of this underlying mechanism.

- **Experimental Discriminators:** This model makes distinctive predictions about the role of environmental boundaries in quantum behavior, suggesting novel interference experiments where the global geometry is systematically varied.

The framework demonstrates remarkable explanatory power while providing clear pathways for further development.

## 8. Conclusions: A Unified Non-Local Reality

The IN/OUT wave mechanism provides a coherent foundation for quantum phenomena:

- **Non-locality** is inherent in the extended wave structure.
- **Wave-particle duality** resolves to waves with stable foci.
- **Quantum guidance** emerges from phase coherence requirements.
- The environment actively participates in defining particle behavior.

This model transforms quantum paradoxes into natural consequences of a unified vibrational reality. The successful application to the double-slit experiment demonstrates the framework's explanatory power, while the natural emergence of relativistic behavior from wave deformation patterns points toward a comprehensive foundation for modern physics.

## References

1. G. Furne Gouveia. *The Vibrational Fabric of Spacetime: A Model for the Emergence of Mass, Inertia, and Quantum Non-Locality*. Preprints 2025, 2025090184. <https://doi.org/10.20944/preprints202509.0184.v1>
2. de Broglie, L. *Journal de Physique et le Radium*, 1927, 8, 225. (The original presentation of the pilot-wave concept at the 1927 Solvay Conference).
3. Bohm, D. *Physical Review*, 1952, 85, 166. (The seminal paper developing the de Broglie-Bohm pilot-wave theory).
4. Cramer, J. G. *Reviews of Modern Physics*, 1986, 58, 647–687. (The transactional interpretation of quantum mechanics).
5. Wheeler, J. A. *Phys. Rev. D*, 1990, 41, 431. (Information, physics, quantum: The search for links).

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