

Waves as Emergent Interpretations in Discrete Energy Systems

A UDEL Conceptual Note

Author: Erez Kaplan Haelion

Status: Foundational Concept Note (Non-Axiomatic)

Framework: Universal Discrete Energy Lattice (UDEL)

Date: January 2026

1. Core Observation

Waves are not fundamental, standalone physical entities.

They are **emergent interpretive descriptions** of coordinated energy transfer across an underlying **discrete relational structure**.

In any system composed of localized elements (particles, nodes, excitations), a “wave” describes the *pattern* of change, not an independently existing object.

Within the UDEL framework, **energy is primary and discrete**, and all apparent continuity arises from structured sequences of local transitions.

2. Classical and Quantum Precedents

2.1 Classical Mechanical Waves

In classical systems (sound, water waves, elastic media):

- Energy propagates via **local interactions** between constituents.
- Individual particles oscillate about equilibrium positions.
- There is no net transport of matter in the direction of propagation.

Let $x_i(t)$ denote the displacement of particle i .

A wave solution takes the form:

$$x_i(t) = A \cos(ki - \omega t)$$

but this equation describes a **collective correlation**, not a traveling object.

The “wave” is the *ordered phase relationship* among local oscillators.

2.2 Electromagnetic Waves

Classically, electromagnetic waves are modeled as self-propagating continuous fields $\mathbf{E}(x, t)$, $\mathbf{B}(x, t)$.

Quantum mechanically (QED/QFT):

- EM radiation is quantized into photons.
- Propagation occurs via interactions with the vacuum, including vacuum polarization and virtual particle effects.
- The vacuum is not empty but structurally active.

Thus, even in standard physics, EM waves already rely on **nontrivial vacuum structure**, not propagation through nothingness.

2.3 Quantum Wavefunctions

The quantum wavefunction $\psi(x, t)$ does not represent a physical wave in space. It encodes **probability amplitudes** for discrete measurement outcomes.

Its evolution (e.g., via the Schrödinger equation) tracks the **statistical structure** of underlying events, not a literal oscillating medium.

3. Vacuum Structure in UDEL

In UDEL, the vacuum is **not an absence**, but a **latent lattice**:

- Nodes exist even without active energy.
- Adjacency relations persist as structural possibilities.
- Energy activation corresponds to discrete transitions (“hops”) between nodes.

This can be represented schematically as a graph $G = (V, E)$, where:

- V : lattice nodes (potential energy sites)
- E : adjacency relations (allowed transitions)

Energy dynamics occur as sequences:

$$v_i \rightarrow v_j \rightarrow v_k \rightarrow \dots$$

governed by adjacency constraints and tick-based update rules.

4. Waves as Emergent Patterns in UDEL

Within a discrete lattice, a “wave” corresponds to a **coherent sequence of energy transitions** with correlated phase relations across adjacent nodes. It is not a physical entity, but an emergent pattern arising from structured, discrete dynamics.

Definitions

Let:

- $E_n(t)$ denote the energy state at lattice node n at discrete lattice tick t .
- $\phi_n(t)$ denote the phase associated with the local transition at node n at tick t .

Wave-Like Regime

A wave-like regime in a discrete energy lattice is characterized **not by continuous fields**, but by a stable phase relationship across adjacent nodes:

$$\phi_{n+1}(t) - \phi_n(t) \approx \Delta\phi$$

where $\Delta\phi$ is approximately constant across extended regions of the lattice.

Under such conditions, coherent propagation emerges as a **collective pattern of discrete transitions**, rather than as motion through a continuous medium.

Emergent Propagation Speed

The effective propagation speed (e.g., c) arises from structural and dynamical properties of the lattice, including:

- lattice tick rate,
- adjacency density,
- allowed transition rules.

It does **not** arise from the transport of energy or fields through continuous space.

5. Resolution of Wave–Particle Duality

Within UDEL:

- A **particle** is a localized, bounded energy configuration.
- A **wave** is a distributed pattern of energy transitions across multiple nodes.

They are not dual entities, but **two descriptive regimes** of the same underlying process.

There is no paradox:

- localization corresponds to constrained adjacency,
 - delocalization corresponds to coordinated multi-node hopping.
-

6. Ontological Clarification

Under this interpretation:

- Waves do not exist as independent physical objects.
- Fields are effective descriptions, not primitives.
- Continuity is emergent, not fundamental.

What exists are:

- discrete nodes,
- discrete energy states,
- discrete transitions,
- global patterns imposed by constraints.

Waves are **the story we tell** about those patterns.

7. Implications

This perspective:

- eliminates the need for continuous fundamental fields,
 - aligns classical and quantum wave phenomena under a single mechanism,
 - naturally incorporates vacuum activity without invoking infinities,
 - prepares the ground for distinguishing **dynamical propagation** from **non-dynamical constraint phenomena** elsewhere in UDEL.
-

8. Summary

In a fully discrete energy lattice:

- Waves are not entities.
- They are emergent, descriptive constructs arising from structured energy transfer.
- All wave-like behavior reduces to discrete transitions governed by lattice topology and timing.

Waves are not “real” in themselves —
they are the patterns we recognize when energy moves coherently through the grid.