Structural Regime Resolution at the Quanta Scale

Structural Regime Resolution Series — Paper IV

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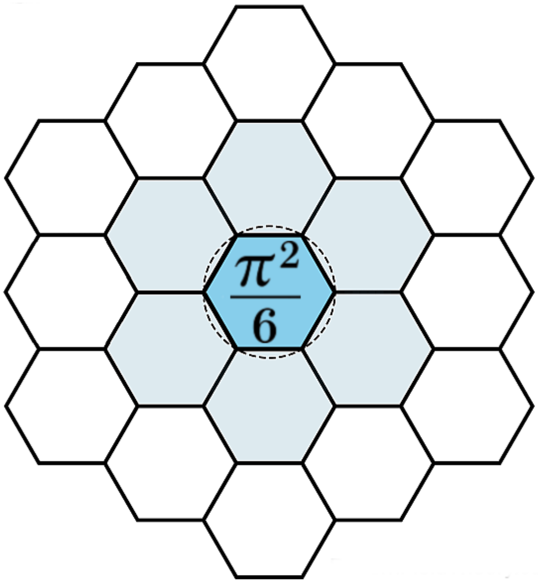
January 6, 2026



Abstract

This paper applies Structural Regime Resolution (SRR) to quanta-scale phenomena: atomic orbitals, tunneling, wavefunction tails, effective barriers, and minimal excitation domains. The central claim is that even at the single-particle or few-particle level, apparent boundaries, walls, and discrete jumps are low-SRR collapses of finite constraint transition zones. At high SRR, quanta occupy volumetric regions with structured probability, partial occupancy, and continuous constraint resolution. In Pattern Field Theory (PFT), these domains correspond to minimal coheron-scale constraint regions stabilized by Phase Alignment Lock (PAL) on the Allen Orbital Lattice (AOL). SRR unifies wave-particle duality, tunneling, and boundary conditions as description-dependent projections of volumetric constraint structure.

Quanta-Scale Structure under Structural Regime Resolution

Scope and Aim

Paper I introduced SRR. Paper II applied it to plasma dominion boundaries. Paper III applied it to quantum criticality and superconductivity. This paper applies SRR to the smallest operational scales:

- atomic orbitals and bound states,
- tunneling and barrier penetration,
- wavefunction tails and evanescent regions,
- effective point particles and boundary conditions.

The goal is to show that even "microscopic boundaries" are not primitive; they are SRR-dependent projections of finite constraint zones.

Quanta as Minimal Constraint Domains

Definition 1 (Quantum state (PFT))**.** *A quantum state is a minimal, PAL-stabilized constraint domain on the Allen Orbital Lattice, expressed as a structured volumetric coheron distribution rather than a point object.*

In PFT terms:

- the "particle" is not a point but a domain,
- localization is a constraint envelope, not a geometric delta,
- quantization arises from admissible standing constraint patterns.

Atomic Orbitals as High-SRR Objects

Standard quantum mechanics represents atomic orbitals as probability clouds, but many pedagogical models collapse them into discrete "shells" or radii.

Under SRR:

- **High SRR:** orbitals are volumetric regions with nodal surfaces, internal structure, and extended tails.
- **Low SRR:** orbitals are treated as discrete levels or sharp shells.

The nodal surfaces are not boundaries; they are internal constraint nulls inside a volumetric domain.

Barriers and Tunneling

Tunneling is usually described as penetration of a particle through an impenetrable boundary.

In SRR terms:

- **High SRR:** a barrier is a finite constraint region where admissible patterns decay but do not vanish.
- **Low SRR:** the same region is represented as a sharp wall with a discontinuous crossing probability.

Proposition 1 (Tunneling as volumetric constraint traversal)**.** *If a barrier has finite thickness δ, then at sufficiently high SRR the wavefunction must be represented as a continuous, decaying distribution across the barrier region. The notion of "crossing a wall" is a low-SRR projection.*

Wavefunction Tails and Evanescent Regions

Wavefunction tails are often treated as mathematical artifacts.

In PFT, they are:

- the physical expression of constraint gradients,
- the volumetric transition between admissible and forbidden ordering,
- minimal examples of dominion transition zones at the quanta scale.

There is no place where the wavefunction "ends"; there is only progressive constraint incompatibility.

Effective Point Particles

Point particles appear when SRR is very low relative to the system scale.

- **High SRR:** every excitation has finite spatial structure.
- **Low SRR:** this structure is collapsed into an effective point for kinematic convenience.

Remark 1 (Point particles as SRR artifacts)**.** *In Pattern Field Theory, point particles are not ontological primitives. They are low-SRR representations of minimal volumetric constraint domains.*

Boundary Conditions as SRR Collapse

Infinite potential walls, hard boxes, and perfect reflectors are idealizations.

In SRR terms:

- real systems always have finite transition regions,
- infinite or perfectly sharp boundaries are low-SRR limits,
- boundary conditions encode collapsed transition physics.

Discreteness and Quantization

Quantization does not arise from "jumps across boundaries" but from:

- admissible standing constraint patterns,
- PAL-stabilized resonant domains,
- AOL-supported discrete coherence modes.

The appearance of discrete jumps is a low-SRR temporal sampling of continuous reconfiguration.

SRR and Wave–Particle Duality

Wave–particle duality is reinterpreted as:

- **High SRR:** volumetric, distributed constraint structure (wave-like).
- **Low SRR:** collapsed, localized effective object (particle-like).

There is no duality in the underlying structure, only in the descriptive resolution.

Canonical Statement

Remark 2 (Quanta-scale SRR statement)**.** *In Pattern Field Theory, all quanta-scale boundaries, walls, and point particles are low-SRR projections of finite constraint transition domains. At sufficiently high SRR, every "particle" is a volumetric, structured, PAL-stabilized region of the Allen Orbital Lattice.*

Consequences

- No microscopic boundary is truly sharp.
- No particle is truly point-like.
- Tunneling is not exceptional; it is normal volumetric overlap.
- Quantization reflects admissible domain patterns, not surface crossing.

Conclusion

Structural Regime Resolution extends cleanly down to the quanta scale. It dissolves the conceptual tension between waves and particles, explains tunneling and boundary conditions as volumetric constraint phenomena, and frames quanta as minimal PAL-stabilized domains on the Allen Orbital Lattice. Together with Papers I–III, this completes the SRR framework across scales from cosmological dominions to single-quantum domains.

Glossary

Structural Regime Resolution (SRR) Resolution level controlling whether transitions are represented as volumes or boundaries.

Coheron Fundamental excitation and ordering carrier in PFT.

PAL Phase Alignment Lock, coherence stabilization mechanism.

AOL Allen Orbital Lattice, discrete substrate of PFT.

Constraint domain Finite region over which a particular ordering is sustained.

Tunneling Volumetric traversal of a finite constraint incompatibility region.

Boundary condition Low-SRR encoding of a collapsed transition region.

Document Timestamp and Provenance

This document is part of Pattern Field Theory (PFT) and the Allen Orbital Lattice (AOL). It applies Structural Regime Resolution (SRR) to quanta-scale phenomena, serving as Paper IV in the Structural Regime Resolution Series.

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