

Quasiparticles as Rational Functions: Extending ODR to Condensed Matter

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2026-08-03

Abstract

The Ontological Distribution of Reality (ODR) framework identifies a particle with its Compton count $N_C = m/m_P \in \mathbb{Q}^+$, a dimensionless rational number whose prime factorization assigns it a fixed vertex on the Bruhat–Tits tree. This paper extends that framework to address a natural objection: what of quasiparticles — phonons, magnons, Cooper pairs, and dressed electrons — whose effective mass depends on the host material? We argue that a quasiparticle is not an invariant vertex but a context-dependent edge traversal: a rational function $N_C^*(\alpha) = f(N_C^{\text{bare}}, N_C^{\text{lattice}}, \dots)$ of the background Compton counts. This distinction recovers the intuitive hierarchy of condensed matter (bare particles as invariant substances, collective excitations as derived relations) within ODR's geometric ontology. We examine three test cases: electron effective mass in semiconductors, phonon dispersion, and the CMB as a thermodynamic ensemble, and provide falsifiability conditions for the core claim.

Keywords: Ontological Distribution of Reality, Bruhat–Tits tree, quasiparticles, effective mass, Compton frequency, p-adic valuation, place-democracy

1. Introduction

The Ontological Distribution of Reality (ODR) framework defines a particle as an invariant dimensionless rational number — its Compton count $N_C = m/m_P \in \mathbb{Q}^+$ — which assigns it a fixed coordinate on the Bruhat–Tits (BT) tree via its prime factorization. [established — ODR v3.0, <https://papers.qnfo.org/papers>]. This identification recasts the question "what is a particle?" from a spatial question (where is it?) to a combinatorial one (what is its ratio?).

A natural objection arises from condensed matter physics. The particles studied in solids — electrons, phonons, magnons, Cooper pairs — have effective masses m^* that depend on the host crystal, temperature, doping, and external fields. If a particle is defined by a constant Compton count, what is an entity whose Compton count changes with the environment?

This paper provides the ODR answer: a quasiparticle is not a fixed vertex on the BT tree but a rational function of background Compton counts. It lacks the "ontological permanence" of a bare particle because its prime factorization shifts with context. This is not a flaw in the framework — it is its precise account of why condensed matter physicists routinely distinguish "elementary" from "emergent" excitations.

We proceed through four stages. Section 2 reviews the Compton frequency in quantum field theory (QFT) and condensed matter. Section 3 examines three definitions of a "particle" (QFT, condensed matter, ODR) and their intertranslation. Section 4 resolves the priority question: is a particle more invariant than the cosmic microwave background? Section 5 formalizes the quasiparticle as a rational function and provides falsifiability conditions.

2. The Compton Frequency Across Disciplines

2.1 Quantum Field Theory: Intrinsic Oscillation

In quantum field theory, the Compton frequency is the intrinsic rest-frame oscillation of a free particle. For a particle of mass m , the angular frequency is:

$$\omega_C = \frac{mc^2}{\hbar}$$

In natural units ($\hbar = c = 1$), this reduces to $\omega_C = m$. The Compton frequency serves as the "clock rate" for quantum phase evolution [established — standard QFT]. For the electron, the cyclic Compton frequency is approximately 1.236×10^{20} Hz.

Historically, the Dirac equation's Zitterbewegung (trembling motion) was associated with frequency $2mc^2/\hbar$. However, this is understood in modern QFT as an interference artifact between positive- and negative-energy solutions that vanishes under second quantization — it is not a physical oscillation of the particle [established — standard QFT interpretation].

2.2 Condensed Matter: A Probe, Not a Parameter

In condensed matter physics, the term "Compton frequency" is rarely used as an isolated parameter. The focus is on **Compton scattering**: the inelastic scattering of X-rays or gamma rays off electrons to probe their ground-state momentum density. The central observable is the **Compton profile** — the spectral line shape encoding the electron momentum distribution [established].

Research emphasis falls on inhomogeneous systems (liquid metals), strong electron correlation effects, and high magnetic field influences on the Compton profile.

2.3 The ODR Bridge

ODR's contribution is to elevate the Compton frequency from a "property that a particle happens to have" to "what a particle is." The dimensionless Compton count:

$$N_C = \frac{m}{m_P} \in \mathbb{Q}^+$$

is the particle's identity. Its prime factorization determines its depth and position on the BT tree. All other properties (energy, wavelength, interaction strengths) are functions of this root number. [established — ODR v3.0]

3. What Is a Particle? Three Frameworks

3.1 Standard QFT: Field Excitation

In quantum field theory, a particle is a quantum excitation of an underlying field — a localized ripple in the electron field, photon field, or quark field [established]. It is defined by a set of conserved quantum numbers (mass, spin, charge) and is not a persistent "thing" in the classical sense: particle number is not conserved, and particles are created and annihilated in interactions.

3.2 Condensed Matter: Quasiparticle as Emergent Excitation

In condensed matter, the term "particle" takes on a pragmatic meaning. **Indivisible particles** (electrons, photons) exist but are "dressed" — an electron moving through a crystal drags a cloud of virtual phonons and other electrons, acquiring an effective mass m^* that can differ by orders of magnitude from the bare mass. For example, in GaAs, $m^* \approx 0.067 \times m_e$ [established].

Quasiparticles (phonons, magnons, electron holes) are collective excitations of many-body systems. They behave mathematically like elementary particles — carrying momentum, spin, and obeying quantum statistics — but are emergent: they do not exist outside the bulk material.

3.3 ODR / Bruhat–Tits Tree: Invariant Rational Number

In the ODR framework, a particle is a persistent ratio — a combinatorial coordinate on the BT tree, stripped of spatial extension, existing only as a prime-factorized relationship to the Planck scale [speculative — ODR v3.0].

The particle's identity is given entirely by its Compton count N_C . In the BT tree, this corresponds to a specific depth determined by the p -adic valuations of N_C . The electron is not a "thing" that has mass m_e ; it is the ratio $N_C \approx 4.185 \times 10^{-23}$. Since the BT tree has no absolute origin, a particle is purely a relational node — defined only by how its cycle-count compares to other cycle-counts.

4. Particle vs. CMB: A Question of Ontological Priority

4.1 Standard Physics: Particles Precede States

The cosmic microwave background (CMB) is a state of the photon field — a bath of approximately 4×10^{84} photons redshifted to a temperature of approximately 2.725 K [established]. In QFT, the underlying photon field is ontologically prior to any specific thermodynamic configuration. The CMB cannot exist without photons; therefore, the particle (field excitation) is more invariant than the state.

4.2 Frequency Stability

A single massive particle (such as an electron) has a strictly constant Compton frequency $\omega_C = m$. The CMB, in contrast, is a thermal blackbody spectrum — a continuous distribution of photon frequencies spanning from radio to infrared. Its "frequency" is a statistical average (the Wien peak in frequency is approximately 160 GHz at 2.725 K), not a sharp eigenfrequency [established].

Thus, even in standard physics, the particle has a precise, unchanging "note" while the CMB is a symphony of many notes.

4.3 ODR: The Coordinate Precedes the Cloud

In the BT tree, a particle is a single rational point — a specific depth defined by its prime factorization. The CMB is a thermodynamic ensemble: a Gibbs distribution over many possible rational coordinates (many different photon Compton counts) [speculative].

A coordinate system (the BT tree) is logically prior to a probability distribution over that system. The single, precise rational ratio is the primary object; the thermal bath is a derived, statistical artifact.

Furthermore, the CMB introduces an **Archimedean bias**. It has a specific temperature (2.725 K), which relies on the real-number continuum and thermal equilibrium. An isolated particle, with its exact Compton count, is purely combinatorial and place-democratic — its ratio is valid at every completion of $\mathbb{Q}$, not just the Archimedean one. In

dimensionless Planck units (per qnfo-core §0.7: $\hbar = c = G = k_B = 1$), $T = k_B T_{\text{phys}} / E_P \approx 1.92 \times 10^{-32}$ — itself a Compton count, but one that only makes sense as a Gibbs parameter, not as an invariant vertex.

5. Quasiparticles in the ODR Framework

5.1 The Challenge

The ODR framework identifies a particle with a constant Compton count $N_C = m/m_P$. A quasiparticle — an electron in GaAs with $m^* = 0.067 \times m_e$, or a phonon with frequency-dependent effective mass — appears to violate this identification. Its Compton count is not invariant:

$$N_C^* = \frac{m^*}{m_P} = \frac{m^*(\text{material}, T, \text{doping}, \omega)}{m_P}$$

If you change the host crystal, the number changes. Therefore, a quasiparticle does not occupy a **fixed, invariant vertex** on the BT tree.

5.2 Formal Definition

Definition. A quasiparticle is any state whose Compton count $N_C^*(\alpha)$ is a **rational function** of a set of background parameters α — including the Compton counts of the host lattice ions, the temperature, and the external fields — rather than an invariant constant.

$$N_C^*(\alpha) = f(N_C^{\text{bare}}, N_C^{\text{lattice ions}}, N_C^{\text{phonon modes}}, \dots)$$

A bare particle (such as the isolated electron) corresponds to the special case where f reduces to a constant. In all other cases, N_C^* is context-dependent, and its prime factorization shifts with the environment.

5.3 Geometric Interpretation on the BT Tree

Invariant particle (bare electron): A fixed vertex on the BT tree at depth determined by $\text{ord}_p(N_C^{\text{bare}})$. Its coordinates are the same in every completion of $\mathbb{Q}$ — it is place-democratic [speculative].

Quasiparticle (dressed electron, phonon): An edge traversal or local deformation of the tree caused by the collective motion of many vertices. It is a wave propagating across the tree, not a permanent vertex. When the quasiparticle decays (a phonon splits into two lower-energy phonons via anharmonicity), its Compton count reduces to a product of smaller background Compton counts — it disperses into the lattice.

CMB photon: A single coordinate sampled from a Gibbs distribution over photon Compton counts. Each individual CMB photon has a definite Compton count, but the ensemble is characterized by the temperature parameter, which is an Archimedean statistic, not a combinatorial invariant.

5.4 Distinction from Bare-Dressed Renormalization

There is a superficial resemblance between "quasiparticle effective mass" and "dressed particle mass in QFT." Both involve renormalization. The distinction is:

- **QFT renormalization:** The bare mass is a UV-divergent parameter; the dressed (physical) mass is what we measure. Both exist within the same underlying field theory.

- **ODR treatment:** The bare Compton count is the invariant identity. The dressed mass (quasiparticle effective mass) is a rational function of lattice parameters — a "derived" identity that changes with the host. In QFT terms, it is as though the renormalized mass depended on which laboratory you used [speculative].

5.5 Worked Example: Phonon Dispersion

Consider a monatomic linear chain with lattice constant a and spring constant K . The phonon dispersion is:

$$\omega(q) = 2\sqrt{\frac{K}{m}} \left| \sin\left(\frac{qa}{2}\right) \right|$$

The "effective mass" of the phonon depends on the frequency (or wavevector): $m^*(\omega) \propto 1/\omega$. Its Compton count:

$$N_C^{\text{phonon}}(q) = \frac{\hbar\omega(q)}{m_P c^2}$$

is a function of the lattice parameters (a, K, m) and the wavevector q . The 2-adic valuation $\text{ord}_2(N_C^{\text{phonon}})$ is not fixed — it varies with q . The phonon is a path on the BT tree, not a vertex.

When a zone-center phonon (Γ -point) decays into two zone-boundary phonons (K-point) via anharmonic coupling, the single rational function $N_C^\Gamma(0)$ decomposes into a product of two lower-frequency functions $N_C^K(q) \cdot N_C^K(-q)$. Geometrically, one edge traversal bifurcates into two.

5.6 Falsifiability

The characterization of quasiparticles as non-invariant rational functions would be disconfirmed if:

1. A quasiparticle were found whose effective mass m^* is **independent** of the host material, temperature, and external fields — i.e., if m^* were a universal constant. This has not been observed; the whole of condensed matter physics is organized around the material-dependence of effective masses [established].
1. A phonon mode were found with a Compton count whose p-adic valuations are invariant under changes to the lattice constant — i.e., if $\text{ord}_p(N_C^{\text{phonon}})$ were constant across all materials. This is testable via DFT calculations of phonon dispersions across different crystal structures.
1. A quasiparticle were discovered that survives the removal of its host medium — persisting as a free excitation after the lattice is dissolved. This would contradict the emergent character of all known quasiparticles.

6. Discussion

6.1 Substance vs. Relation in Geometric Form

The ODR treatment of quasiparticles recasts an ancient ontological debate — substance vs. relation — in geometric terms:

- **Invariant particle = substance:** Fixed BT-tree vertex, Compton count independent of context, prime factorization preserved across all completions.
- **Quasiparticle = relation:** Edge traversal, Compton count a function of background, prime factorization shifts with environment.

This is not dualism — the relation itself is a geometric object (a path on the tree). It simply lacks the compositional stability that distinguishes invariant vertices.

6.2 Anderson's "More Is Different" in ODR Terms

Anderson's 1972 dictum that emergent phenomena are "as real as" invariant ones is recovered in ODR without contradiction. A phonon is a real path on the BT tree — it is a genuine geometric object. It is simply not an invariant vertex. Anderson's insight that "more is different" can be reformulated as: compound systems produce rational functions whose properties are not reducible to those of the individual Compton counts.

6.3 Limitation: Finite Lifetime

A challenge not fully resolved: quasiparticles have finite lifetimes (linewidth Γ). The BT-tree formalism may need a complex-valued Compton count ($N_C + i\Gamma/m_P c^2$) to capture decay, analogous to the complex mass pole in scattering theory. This is left for future work.

6.4 Frontier Question

Is there a maximum "ontological distance" from a bare particle beyond which an emergent collective excitation can no longer be approximated as a quasiparticle with a well-defined $N_C^*(\alpha)$? This would correspond to a depth threshold on the BT tree where the rational function approximation's error exceeds the intrinsic width.

7. Conclusion

The ODR framework's identification of a particle with its Compton count $N_C \in \mathbb{Q}^+$ extends naturally — not awkwardly — to condensed matter. A quasiparticle is not an invariant vertex but a rational function of background Compton counts:

$$N_C^*(\alpha) = f(N_C^{\text{bare}}, N_C^{\text{lattice}}, N_C^{\text{temperature}}, \dots)$$

This formalizes the condensed matter physicist's intuitive distinction between "elementary" and "emergent" excitations within ODR's geometric ontology. The BT tree provides the coordinate system; invariant particles are fixed points on it; quasiparticles are paths between them; and the CMB is a probability distribution over many such points.

The framework makes a falsifiable prediction: no quasiparticle will ever be found with an invariant Compton count independent of its host environment. This prediction has held for the ~90 years since Landau's Fermi liquid theory, and it is the paper's central claim.

Declarations

Author Contributions

QNFO: conceptualization, formal analysis, writing.

Data Availability

No experimental data were generated. All cited values are from published sources.

Competing Interests

None declared.

Funding

None.

License

QNFO Unified License Agreement (QNFO-ULA).

AI Assistance Disclosure

This paper was drafted with AI assistance under human direction.

Peer Review

This preprint has not undergone formal peer review.

Errata

No errata at time of publication. Corrections will be tracked in GitHub at the project repository.

Version

v1.0, 2026-08-03.

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