Resonance Quantum Theory (RQT): A Framework for Resonance, Structure, and Spatial Realization Conceptual Foundations and the Roton Quantum Model

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Abstract

The Resonance Quantum Theory (RQT) is a conceptual framework that interprets physical structure, interaction, and persistence as consequences of resonance organization rather than as properties imposed through fundamental particles, fields, spatial geometry, or independent quantization rules. At its fundamental level, RQT describes a Resonance Space of resonance-capable identities and dynamically maintained relationships characterized by recurrence, phase, coherence, and closure. Spatial position, distance, direction, and dimensionality are not assumed as fundamental properties of this description.

Observable physical entities are interpreted as persistent resonance identities. Persistence arises when mutually compatible resonance relationships establish recurrent structures that partially close onto themselves and thereby become increasingly decoupled from the surrounding resonance environment. Such structures may retain open resonance capacity and participate in further relationships, allowing higher-order resonance identities and hierarchical organization to emerge.

Physical space is proposed to arise as a realization of these underlying resonance relationships. A resonance state may admit a well-constrained spatial realization, while another may remain compatible with multiple spatial realizations. Consequently, a definite state in Resonance Space need not imply a definite spatial position or trajectory. RQT investigates whether this distinction can provide a common physical basis for persistent matter, quantum delocalization, interaction, and the emergence of classical spatial structure.

Quantization and characteristic physical structures are proposed to arise through the restricted resonance configurations capable of maintaining coherent recurrence and closure. Interaction corresponds fundamentally to the formation, accommodation, and reconfiguration of resonance relationships; familiar spatial interactions and geometries are treated as observable realizations of this deeper relational dynamics.

To facilitate visualization, analysis, and numerical investigation, the Roton Quantum Model (RQM) is introduced as an explicitly three-dimensional geometric realization of selected RQT resonance structures. RQM represents resonance relations through spatial channels, distances, directions, and rotational planes, providing a tractable model for investigating possible spatial realizations without requiring these geometrical properties to be fundamental in Resonance Space.

The purpose of this paper is to establish the conceptual foundations of RQT, introduce Resonance Space and spatial realization, define the principles of resonance closure and hierarchical identity, clarify the relationship between RQT and RQM, and develop a framework in which familiar physical structure may be investigated as an emergent manifestation of resonance organization.

1 Introduction

Nature exhibits persistent structure across an extraordinary range of scales. Atomic systems form stable molecules, molecules organize into complex materials, and larger structures emerge through increasingly intricate patterns of interaction. Despite their diversity, such systems share

a common characteristic: they maintain coherence, stability, and recognizable identity while continuously interacting with their surroundings.

Modern physics provides highly successful mathematical descriptions of these phenomena. Quantum theory, quantum field theory, and relativity accurately predict a vast range of experimental observations and have established a remarkably consistent framework for understanding physical behavior. At the same time, many fundamental properties of physical systems are introduced through independent postulates, parameters, symmetries, or interaction rules. Stability, quantization, binding, charge, and long-range interaction are typically described within specialized theoretical frameworks, each optimized for a particular domain of observation.

This raises a broader conceptual question: might these apparently distinct phenomena arise from a common underlying organizational principle? Rather than beginning with particles, fields, forces, or even spatial geometry as fundamental entities, one may instead ask whether physical structure emerges from the formation and persistence of relationships between resonating systems.

The Resonance Quantum Theory (RQT) explores this possibility. At its most fundamental level, the framework assumes that resonance relationships can form, persist, combine, and close into recurrent structures. A sufficiently persistent resonance organization may itself acquire an effective identity and participate as a unit in further resonance relationships. Physical systems are therefore understood not primarily as isolated objects, but as dynamically maintained resonance identities embedded within a larger network of relationships. Stability, interaction, and hierarchy are interpreted as consequences of the organization and closure of these relationships across different spans.

This perspective does not require spatial position, distance, direction, or dimensionality to be fundamental properties of the underlying resonance description. RQT instead introduces a *Resonance Space* in which physical identity is determined by resonance organization and relationships. Familiar spatial structure is proposed to arise through realizations of these relationships. A well-defined resonance state may admit a sharply constrained spatial realization, while another may remain compatible with several possible spatial realizations. The consequences of this distinction for localization, interaction, and quantum behavior are developed in the following sections.

The purpose of RQT is not to replace successful physical descriptions by assumption, but to investigate whether a common resonance-based framework can provide a deeper conceptual basis from which their observed structures and behaviors may emerge. The theory therefore focuses on the formation of persistent resonance structures, resonance closure, the development of interaction channels, and the mechanisms through which increasingly complex identities can arise from comparatively simple assumptions. Importantly, a resonance identity need not represent a fundamental indivisible object: what appears as a single resonance node at one span may itself consist of organized resonance relationships at lower spans.

To facilitate visualization and quantitative exploration of these concepts, the Roton Quantum Model (RQM) is introduced later in this work. RQM provides an explicitly three-dimensional geometric realization of selected RQT resonance structures. It represents resonance relationships through spatial channels, directions, distances, and rotational planes, allowing possible spatial manifestations of RQT structures to be investigated without requiring these geometrical properties to be fundamental in Resonance Space.

The following chapters develop the fundamental concepts of the theory, introduce Resonance Space, resonance channels and closure, examine the emergence of persistent and hierarchical resonance identities, and investigate how spatially observable physical structure may arise from the organization of resonance relationships.

2 Conceptual Foundations

The conceptual foundation of RQT is intentionally minimal. Rather than beginning with particles, fields, forces, or a predefined spatial geometry, it starts from the possibility that oscillatory

relationships can form, persist, and become mutually organized. When such relationships establish sufficiently recurrent and self-consistent structures, they may acquire persistent identity. Once an identity has formed, it may itself participate in further resonance relationships, allowing increasingly complex structures to arise through repeated application of the same principle.

RQT refers to the relational domain in which these resonance structures exist as *Resonance Space*. Resonance Space is not assumed to be a hidden geometrical space underlying ordinary three-dimensional space. It denotes the organization of resonance-capable identities and their possible and realized relationships. Spatial position, distance, direction, and dimensionality are therefore not required as initial properties of the framework.

Figure 1 summarizes the recursive principle of resonance identity formation that is developed throughout the remainder of this section.

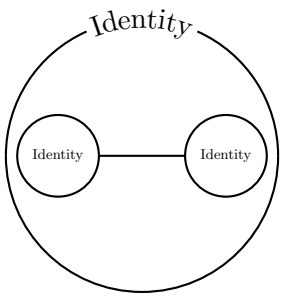

Figure 1: Recursive Formation of Identity

The remainder of this section develops the individual conceptual elements of this recursive process.

2.1 Resonance Space

RQT does not assume that resonance occurs within a pre-existing three-dimensional arena. At its most fundamental level, the framework requires only the possibility of distinguishable oscillatory behavior and of persistent relationships between such behavior.

The term *Resonance Space* denotes this relational domain. Its structure is determined by resonance possibilities and realized resonance relationships rather than by spatial coordinates. Frequency, recurrence, relative phase, coherence, and closure can therefore characterize a physical state without first assigning positions or distances to the participating identities.

A resonance-capable identity within this description will be referred to as a *Resonance Node* or *Reson*. The term does not imply a fundamental or indivisible constituent. A node is simply an identity that, at the span under consideration, can participate as a unit in further resonance relationships. Its internal organization may itself consist of resonance structures belonging to lower spans.

This allows the same organizational principle to operate recursively:

$$\text{resonance organization} \longrightarrow \text{closure} \longrightarrow \text{persistent identity} \longrightarrow \text{node for further resonance.}$$

RQT does not require that a lowest span has already been identified. A structure treated as elementary within one description may therefore reveal further resonance organization when examined at a deeper level.

2.1.1 Spatial Realization

Spatial geometry enters RQT only as a possible realization of resonance relationships. A sufficiently constrained resonance structure may admit a representation in which its relationships appear as positions, distances, directions, and geometrical configurations.

Schematically,

$$\mathcal{R} \xrightarrow{\mathcal{P}} G,$$

where $\mathcal{R}$ denotes a state in Resonance Space and G denotes one of its possible spatial realizations.

The framework does not require this realization to be unique. A definite resonance state may remain compatible with several spatial realizations,

$$\mathcal{P}(\mathcal{R}) = \{G_1, G_2, G_3, \ldots\},$$

so that

$$\boxed{\text{definite resonance state} \not\Rightarrow \text{definite spatial realization.}}$$

RQT therefore distinguishes physical definiteness in Resonance Space from spatial localization. A resonance identity need not possess a continuously defined position or trajectory merely because it can participate in spatially localized interactions.

The familiar three-dimensional physical world is proposed to represent a particularly persistent class of such spatial realizations. RQT investigates whether the organization of stable resonance relationships naturally favors realizations with three independent spatial degrees of freedom. This dimensionality is therefore not assumed as a fundamental property of Resonance Space, but is treated as a property that should ultimately emerge from the resonance organization itself.

The Roton Quantum Model introduced later in this work begins at this projected level. RQM provides an explicitly three-dimensional realization in which resonance relationships can be represented through spatial channels, distances, directions, and rotational planes. These geometrical quantities are therefore properties of the RQM realization and should not automatically be interpreted as fundamental properties of Resonance Space.

2.2 Persistence and Self-Resonance

Before a structure can interact, it must first persist.

Within Resonance Space, oscillatory behavior alone does not constitute a persistent structure. Oscillations may arise, change, interfere with other resonance activity, or disappear without establishing any lasting organization. Of particular interest to RQT are configurations whose evolution repeatedly returns to states compatible with their preceding resonance conditions.

Such recurrence provides the first requirement for persistence. Rather than requiring an oscillatory state to remain unchanged, RQT requires that its evolution repeatedly re-establish compatible resonance conditions. Persistence is therefore associated not with static structure, but with reproducible oscillatory organization.

At the conceptual level adopted here, the simplest form of such behavior is referred to as *self-resonance*. A self-resonant configuration forms a recurrent cycle in which its continuing evolution remains compatible with the conditions required for its own continuation. The recurrence need not represent a closed trajectory or loop in physical space. It is first of all a closure in resonance evolution: a return to compatible resonance states.

Schematically,

$$\text{oscillatory behavior} \longrightarrow \text{recurrence} \longrightarrow \text{self-resonance} \longrightarrow \text{persistence}.$$

Persistence becomes particularly significant when recurrence allows part of the resonance evolution to close onto itself. Instead of remaining entirely dependent on continuously changing resonance relations with the surrounding environment, an increasing fraction of the required oscillatory conditions can then be maintained within the recurrent structure itself. In this sense, resonance closure provides a mechanism for partial decoupling from the surrounding resonance environment.

This decoupling is not assumed to be absolute. A persistent configuration may remain capable of participating in external resonance relationships while maintaining sufficient internal recurrence to preserve its organization. The balance between internal closure and externally realizable resonance relations becomes important for the formation of stable identities and their subsequent interactions.

The precise internal form of the simplest self-resonant configurations is not specified at this stage. Nor does RQT require them to represent a fundamental lowest level of physical structure. A configuration treated as self-resonant at one span may itself arise from a more detailed organization of resonance relationships at a lower span.

The significance of self-resonance therefore lies not in identifying a particular fundamental object, but in providing the minimal mechanism by which transient oscillatory behavior can acquire persistence. Once such persistence is established, resonance closure can produce increasingly distinct identities, which may themselves participate in further resonance relationships and higher-order organization.

2.3 Stability and Identity

Persistence allows oscillatory behavior to remain. Stability allows it to become structure.

A persistent resonance configuration does not necessarily remain unchanged. Ongoing accommodation, competing resonance relationships, and changes in its surrounding resonance environment may continuously influence its evolution. Within RQT, stability therefore does not imply rigidity or immutability. A resonance structure is considered stable when its evolution remains within a sufficiently compatible range of recurrent states to preserve its characteristic resonance organization.

Stability is closely related to resonance closure. As recurrent relationships increasingly accommodate one another within a structure, the configuration becomes less dependent on specific external resonance conditions for its continuation. Sufficient closure therefore allows a persistent resonance structure to become partially decoupled from its surrounding resonance environment while remaining capable of further external resonance relationships.

A sufficiently stable and closed resonance structure can acquire a persistent *resonance identity*. This identity does not require a fixed internal composition or permanent spatial geometry. It is defined by the continued recurrence of characteristic resonance properties, such as phase relationships, resonance modes, closure conditions, and externally realizable resonance capacity.

The distinction between structure and identity is important. Internal resonance relationships may continuously adjust while the higher-order resonance organization remains recognizable. Identity is therefore associated with the persistence of an organized resonance pattern rather than with the preservation of every individual internal state.

The continuing evolution of a resonance identity also retains information about its preceding states. This information is not regarded as a separately stored quantity. It is embodied in the present resonance configuration itself: phase relations, active modes, closure conditions, and other state variables constrain which subsequent resonance states can be reached. The present state therefore carries forward distinctions established through the preceding resonance evolution.

Once a resonance identity has formed, it may itself participate as a unit in further resonance relationships. At the span under consideration, such an identity may therefore be treated as a *Resonance Node*, irrespective of whether it contains further resonance organization at lower spans.

This establishes the recursive principle underlying the RQT hierarchy:

resonance relationships $\longrightarrow$ recurrence $\longrightarrow$ closure and stability $\longrightarrow$ resonance identity $\longrightarrow$ Resonance No

Stable resonance identities therefore provide the building blocks of larger resonance networks without requiring any particular level of that hierarchy to be fundamentally elementary.

2.4 Interaction and Relationship Formation

Interaction creates relationships. Persistent relationships can create shared identity.

Resonance identities do not exist in complete isolation. A structure that is not fully closed retains the capacity to participate in resonance relationships beyond its own internal organization. When two or more resonance identities establish mutually compatible resonance conditions, their subsequent evolution becomes partially interdependent. Within RQT, this establishment or modification of a shared resonance relation constitutes an *interaction*.

Interaction therefore does not require a separate fundamental mechanism acting between otherwise independent objects. It is expressed directly through the resonance relationships that participating identities are able to establish, maintain, modify, or lose. The relevant physical process is the mutual accommodation of their resonance states.

A resonance relationship may involve characteristic frequency, relative phase, recurrence, and other compatibility conditions. Once established, the relation constrains the subsequent states available to all participating identities. Their evolution can therefore no longer be described entirely independently.

The formation of a relationship does not necessarily imply the immediate formation of a new identity. Relationships may differ greatly in coherence, persistence, and the degree to which the participating resonance states become mutually constrained. Some relationships may remain transient or weakly coupled, while others may develop persistent shared recurrence and increasing resonance closure.

When such shared organization becomes sufficiently stable, the combined resonance structure may itself acquire a higher-order resonance identity while its constituent identities remain distinguishable at a lower span. The same recursive principle that allows an individual resonance identity to become a Resonance Node can therefore operate on interacting groups of nodes:

$$N_1 + N_2 + \cdots + N_m \longrightarrow \text{shared resonance} \longrightarrow \text{shared recurrence} \longrightarrow \text{closure} \longrightarrow N_{\text{higher}}.$$

The resulting higher-order identity is not simply the sum of its constituents. It includes the persistent resonance relationships through which those constituents become organized. From the perspective of a higher span, the complete organization may therefore participate as a single Resonance Node in further relationships.

Relationships need not possess equal strength, duration, or structural significance. These distinctions are not introduced as fundamentally different types of interaction, but arise from differences in resonance compatibility, persistence, closure, and the extent to which the participating states constrain one another.

Interaction thus provides the mechanism through which Resonance Space develops structure beyond isolated persistent identities. Resonance Nodes establish relationships; persistent relationships form larger resonance organizations; sufficiently closed organizations acquire higher-order identity; and those identities may again participate in further resonance relationships.

This recursive process provides the foundation for the hierarchical organization discussed in the following section.

2.5 Emergence and Hierarchical Organization

Every stable organization becomes a candidate for higher-order organization.

The formation of a resonance relationship does not necessarily produce a new persistent identity. Many relationships remain transient, while others persist without becoming sufficiently closed to behave as a coherent unit. Within RQT, higher-order organization emerges when a group of resonance identities and their relationships achieves sufficient recurrence, stability, and closure to participate in further resonance processes as a distinguishable identity in its own right.

The persistence of such organization depends on compatibility between the participating resonance states. Compatibility is not regarded as a binary property. Through continued interaction,

the participating states may mutually accommodate their phases, recurrence conditions, and other resonance properties. Such accommodation may increase or decrease the coherence of the shared organization and thereby determine whether the relationship remains transient or develops into a persistent structure.

When sufficient closure is achieved, the resulting higher-order identity is not simply the sum of its constituents. The relationships between its constituent identities become part of the state of the new organization itself. Consequently, the higher-order structure may possess resonance capabilities, characteristic modes, recurrence periods, and possibilities for interaction that none of its constituents possesses independently.

This introduces an important distinction between internal resonance organization and externally realizable resonance relationships. Resonance capabilities that previously participated directly in the surrounding network may become accommodated within the closure of the new structure. From outside the structure, these relationships may consequently become reduced, concealed, or no longer independently accessible, while other resonance capabilities remain available or emerge only at the level of the combined identity.

Emergence therefore changes not only the number of participating identities, but the structure of what can resonate with what. A higher-order identity presents a new set of resonance possibilities to its environment while internally maintaining the lower-level relationships required for its own persistence.

The process can be expressed schematically as

$$\{N_i\} \longrightarrow \{R_{ij}\} \longrightarrow \text{shared recurrence} \longrightarrow \text{closure} \longrightarrow N_{\text{higher}},$$

where the resulting identity may again participate in relationships at another level of organization:

$$N_{\text{higher}} \longrightarrow R_{\text{higher}} \longrightarrow N_{\text{higher}+1} \longrightarrow \cdots$$

RQT refers to these successive regimes of resonance organization as *spans*. A span does not primarily denote a spatial size or distance. It identifies a level or regime in which persistent resonance identities participate as effective nodes in further resonance relationships. Structures belonging to different spans may coexist and overlap, and a single physical organization may simultaneously participate in resonance processes associated with several spans.

There is no requirement within RQT that the lowest possible span has already been identified. A Resonance Node treated as elementary at one level may contain further resonance organization at lower spans, while a complex structure may itself become a node at a higher span. The distinction between "elementary" and "composite" is therefore relative to the resonance organization being considered.

Hierarchy is consequently not introduced as an additional organizing principle. It follows recursively from resonance itself:

resonance → recurrence → closure → identity → new resonance capability → higher-order resonance

The same organizational principle can therefore, in principle, operate repeatedly across different spans without requiring a new class of fundamental mechanism at each level.

2.6 Accessible and Enclosed Structure

Closure creates enclosure. Enclosure creates selective accessibility.

The emergence of higher-order resonance identities introduces an important distinction between the internal organization of a structure and the resonance capabilities it presents to its surroundings. Within RQT, a stable identity is not expected to expose every aspect of its internal resonance organization equally. As resonance relationships become incorporated into recurrent

and increasingly closed structures, some of these relationships become internally accommodated while others remain available for further resonance formation.

Enclosure therefore follows naturally from resonance closure. A resonance condition that is repeatedly satisfied within the internal recurrence of a structure becomes less dependent on compatible relationships with the surrounding resonance environment. The corresponding part of the structure's resonance organization can then become effectively enclosed within the persistent identity.

This does not require complete isolation. A resonance structure may be strongly closed with respect to some of its internal relationships while remaining externally accessible through others. Enclosure is therefore generally partial and selective rather than absolute.

The distinction can be expressed schematically as

$$\text{resonance capacity} \longrightarrow \begin{cases} \text{internally accommodated,} \\ \text{externally available.} \end{cases}$$

An externally available resonance capacity does not necessarily imply that an external relationship is currently realized. It indicates only that the structure remains capable of participating in a compatible resonance relation. When such compatibility is established with another resonance identity, an external relationship may form.

It is therefore useful to distinguish between

$$\boxed{\text{enclosed relation} \neq \text{available capacity} \neq \text{realized external relation.}}$$

This distinction becomes important when describing interaction channels. A structure may possess the capacity to establish a particular resonance relationship without such a relationship presently existing, while another resonance relation may already be actively maintained with an external identity.

Selective accessibility allows a higher-order identity to present a comparatively simple resonance behavior while retaining substantially richer internal organization. From the perspective of another structure interacting at the same or a higher span, the detailed lower-span organization need not be independently accessible. What becomes relevant is the set of resonance relationships that the combined identity can externally realize.

The internal organization nevertheless remains physically significant. Enclosed relationships maintain the recurrence, closure, and stability of the identity and may influence how the structure responds when its externally realized relationships change. External interaction can therefore lead to accommodation within the internal resonance organization without requiring every internal relationship to become directly accessible.

Enclosure also provides a natural selection mechanism for persistent structure. Configurations whose continuation depends strongly on many incompatible external resonance conditions are more readily disrupted by their resonance environment. Structures capable of accommodating a greater fraction of their recurrence internally can persist with less dependence on particular external conditions. Stable resonance identities therefore tend to be associated with substantial, though not necessarily complete, closure.

The boundary of a resonance identity should consequently not be understood as a spatial surface. At the level of Resonance Space, it is a boundary of *resonance accessibility*: it distinguishes relationships incorporated into the recurrent organization of the identity from resonance capacities through which that identity can participate in its surrounding resonance network.

A spatial boundary may emerge later as one possible realization of this organization, but enclosure itself is fundamentally relational rather than geometrical.

RQT therefore regards accessibility and enclosure as complementary consequences of resonance closure. Higher-order organization does not merely combine lower-level structures. It reorganizes which resonance relationships remain externally realizable and which become incorporated into the persistent internal recurrence of the new identity.

2.7 Framework Assumptions and Scope

Complexity is not introduced. Complexity is accumulated.

The preceding sections establish the minimal conceptual foundation upon which the Resonance Quantum Theory is developed. Rather than beginning with particles, fields, forces, or a predefined spatial geometry, RQT begins with the possibility of oscillatory distinction, recurrence, and the formation of persistent resonance relationships. It then asks how much physical organization can arise through repeated application of these principles.

At this level, RQT assumes only that resonance-capable states can establish relationships whose evolution may become recurrent and mutually compatible. Recurrent resonance organization can acquire persistence; increasing closure can partially enclose such organization from its surrounding resonance environment; and sufficiently stable organization can acquire a resonance identity. A persistent identity may then participate as a Resonance Node in further relationships, allowing the same process to recur at higher spans.

The conceptual progression can therefore be summarized as

$$\boxed{\text{resonance} \rightarrow \text{recurrence} \rightarrow \text{closure} \rightarrow \text{persistent identity} \rightarrow \text{further resonance}}$$

without requiring any particular level of this hierarchy to constitute a fundamental lowest span.

RQT does not assume that every possible resonance configuration persists. Persistence is itself a non-trivial outcome of resonance organization. Configurations that fail to maintain sufficient recurrence or compatibility may dissolve into the surrounding resonance activity, while configurations capable of maintaining recurrent and partially enclosed organization can continue to participate in subsequent relationship formation.

Complexity can consequently accumulate recursively. Higher-order structures need not require new organizing principles at each level. A resonance identity formed at one span may become a participant in resonance relationships at another, where further recurrence, closure, and identity formation become possible.

Within this framework, *Resonance Space* denotes the relational organization of these resonance states and their possible and realized relationships. RQT does not assume that Resonance Space possesses ordinary spatial geometry. Position, distance, direction, trajectory, and dimensionality are therefore not fundamental prerequisites of the description. Spatial geometry is instead proposed to arise through realizations of sufficiently constrained resonance relationships.

This distinction allows a resonance state to be definite without requiring its spatial realization to be unique:

$$\text{definite resonance state} \not\Rightarrow \text{definite spatial realization.}$$

The framework therefore intentionally refrains from introducing particles, fields, forces, charge, mass, spacetime geometry, probabilistic state descriptions, or specific interaction laws as fundamental starting assumptions. Where RQT is intended to describe phenomena conventionally expressed through such concepts, their observed behavior must ultimately be recovered from, or shown to correspond to, the underlying resonance organization.

This places an important constraint on the scope of the theory. A resonance-based interpretation alone is not sufficient. The framework must progressively demonstrate that its minimal assumptions can reproduce established physical behavior and, where possible, lead to additional quantitative or experimentally distinguishable consequences.

The purpose of RQT is therefore not to add another elementary constituent to existing physical theories, but to investigate whether persistent physical structure and its observable spatial realization can arise from a smaller set of relational resonance principles. The following sections develop this framework in greater detail and examine how resonance modes, channels, closure, spatial realization, and specific physical structures may be represented within it.

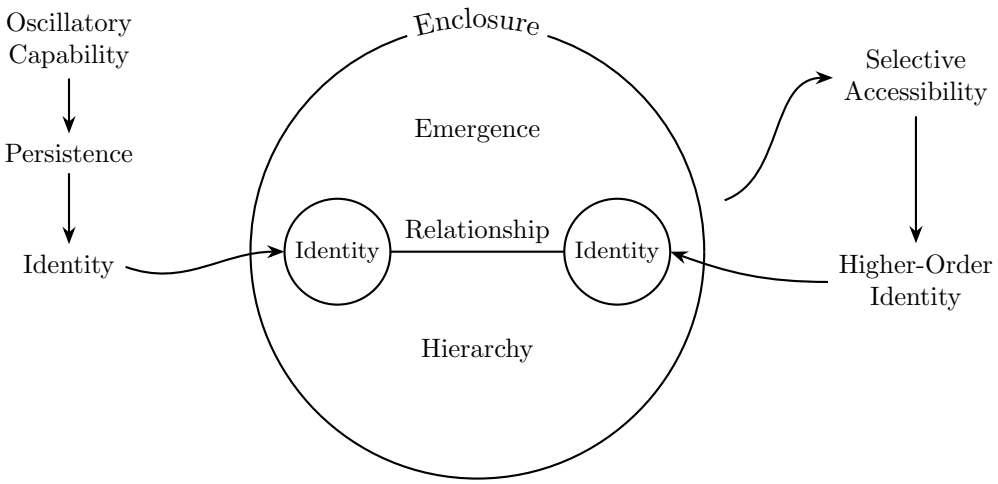

Figure 2: Conceptual foundations of the Resonance Quantum Theory

3 The Resonance Quantum Theory

Resonance does not take place in space. Spatial structure is one possible realization of resonance.

The conceptual foundations introduced recurrence, closure, persistent identity, and hierarchical organization without requiring a particular physical geometry. The Resonance Quantum Theory develops this relational description further by asking what characterizes the state of a resonance identity, how distinct identities can remain separated without assuming spatial distance, and under which conditions resonance relationships admit a spatial realization.

At this level, RQT remains independent of any particular geometric or discrete representation. A Resonance Node does not require a position, direction, trajectory, or spatial neighborhood. Instead, its physical state is characterized by its oscillatory modes, phase development, recurrence history, and its realized or available resonance relationships with other identities.

This introduces a fundamental distinction between *Resonance Space* and its observable spatial realizations. Resonance Space describes which resonance states exist and which relationships between them are compatible. Spatial realization describes how sufficiently constrained parts of this relational organization may appear as positions, distances, directions, trajectories, and geometrical structures.

The following subsections develop this distinction through the concepts of resonance state, phase, winding, resonance separation, and spatial realization.

3.1 Resonance State, Phase, and Winding

A resonance state requires a history of recurrence, not a position in space.

A Resonance Node is an identity capable of participating as a unit in resonance relationships at the span under consideration. Its state need not contain spatial coordinates. Instead, the simplest oscillatory description may be expressed through a characteristic mode or frequency together with its phase development.

For a periodic resonance mode, the instantaneous phase may be written as

$$\phi(t) \in [0, 2\pi).$$

Instantaneous phase alone, however, does not preserve the complete recurrence history. After every completed period the same phase is reached again, although the resonance process has

continued to evolve. RQT therefore distinguishes the cyclic phase ϕ from an accumulated or unwrapped phase Φ,

$$\Phi(t) = 2\pi W(t) + \phi(t),$$

where W represents the accumulated winding of the resonance evolution.

The winding records how recurrence has developed beyond the present cyclic phase. Two resonance states may consequently possess the same instantaneous phase while differing in their accumulated resonance history:

$$\phi_A = \phi_B, \qquad W_A \neq W_B.$$

Phase and winding should not be interpreted as spatial coordinates. They describe the state and history of recurrence within Resonance Space. Their significance is relational: resonance becomes possible when the evolving states of two or more identities satisfy sufficiently compatible phase, frequency, winding, and recurrence conditions.

A Resonance Node may participate simultaneously in several resonance modes. Its complete state may therefore require a corresponding set of phase and winding relations,

$$\mathcal{S}_i = \left\{ (f_k, \phi_i^{(k)}, W_i^{(k)}, \ldots) \right\},$$

together with the resonance relationships in which the identity currently participates. RQT does not assume that every physical system can ultimately be represented by a single phase or winding coordinate. Rather, it investigates how little resonance information is required to determine the relationships and realizations available to a given identity.

This provides a description of physical state that precedes spatial localization. A node need not carry three spatial coordinates specifying where it is. It must carry sufficient resonance information to determine which relationships it can presently maintain or establish.

3.2 Resonance Separation

Separation can exist before spatial distance exists.

If spatial distance is not fundamental, RQT requires another way to describe why two resonance identities that once participated in a common state may subsequently cease to be directly compatible.

The proposed primitive concept is *resonance separation*.

Consider two resonance identities A and B that initially participate in a compatible resonance relation. Their subsequent resonance evolution may accumulate differently. For a single mode, a simple measure of this divergence can be expressed through their unwrapped phase difference,

$$\Delta\Phi_{AB}(t) = \Phi_A(t) - \Phi_B(t),$$

or, equivalently, through differences in cyclic phase and winding,

$$\Delta\Phi_{AB} = 2\pi\Delta W_{AB} + \Delta\phi_{AB}.$$

This quantity should not initially be interpreted as a geometrical distance. It represents separation in resonance history: the degree to which two states have accumulated different recurrence development relative to a previously compatible condition.

Winding therefore carries a form of relational history. If two identities separate from a common resonance condition, their subsequent phase and winding development retains information about that separation even when their instantaneous cyclic phases later become similar again.

For systems containing several simultaneous resonance modes, resonance separation may require several such relations rather than a single scalar quantity. The precise measure of separation

in the general case remains to be developed. The essential proposal is more fundamental: *distinction and separation do not require a pre-existing spatial metric.*

Spatial distance may instead arise later as one realization of resonance separation,

$$\Delta\Phi_{AB},\, \Delta W_{AB},\, \ldots \quad \xrightarrow{\mathcal{P}} \quad r_{AB}.$$

The familiar distance r_{AB} would then belong to a spatial realization of the resonance relation rather than to its fundamental RQT description.

3.3 Resonance Proximity and Re-Coupling

To interact again, resonance identities need not first meet in fundamental space. They must again become mutually realizable.

Resonance separation does not imply permanent disconnection. As resonance states continue to evolve, previously separated identities may again approach conditions under which a compatible shared resonance relation can be established.

RQT refers to this condition as *resonance proximity*. Resonance proximity does not denote geometrical closeness. It describes the degree to which the current states of two resonance identities permit a mutually compatible resonance relation.

Schematically,

$$\mathcal{S}_A(t) \sim \mathcal{S}_B(t) \quad \Longrightarrow \quad R_{AB} \text{ may become realizable.}$$

Compatibility may depend on frequency, relative phase, winding, existing resonance relationships, available resonance capacity, and the surrounding resonance organization. Two identities may therefore become close in Resonance Space without the concept of a prior geometrical trajectory being required.

When sufficient compatibility is restored, a new shared resonance relationship may form. This process is referred to here as *re-coupling*. Re-coupling does not require the two identities to have traversed a fundamental spatial distance toward one another. Spatial proximity may instead be the geometrical realization associated with their renewed resonance compatibility.

This reverses the conventional order of explanation:

$$\text{spatial proximity} \rightarrow \text{interaction}$$

is replaced at the fundamental RQT level by

$$\text{resonance compatibility} \rightarrow \text{shared realization} \rightarrow \text{spatially localized interaction.}$$

In ordinary stable matter these descriptions may become almost indistinguishable because strongly constrained resonance networks produce persistent spatial relations. Their distinction becomes important when a resonance identity does not possess a unique spatial realization.

3.4 Spatial Realization and Projection Allowance

A definite resonance state need not specify one definite place.

RQT proposes that spatial geometry arises when resonance relationships admit a mutually consistent geometrical realization. The mapping from a resonance state $\mathcal{R}$ to its possible spatial realizations may be represented schematically by

$$\mathcal{P}(\mathcal{R}) = \{G_1, G_2, \ldots\}.$$

The set $\mathcal{P}(\mathcal{R})$ may be regarded as the *projection allowance* of the resonance state: the set of spatial realizations compatible with its current resonance constraints.

For strongly constrained resonance structures, the projection allowance may become narrow,

$$\mathcal{P}(\mathcal{R}) \approx G_{\text{unique}},$$

producing an effectively localized and geometrically stable object.

For other resonance states, several spatial realizations may remain compatible,

$$|\mathcal{P}(\mathcal{R})| > 1.$$

The underlying resonance state may nevertheless remain definite. RQT therefore distinguishes uncertainty or multiplicity of spatial realization from indefiniteness of the underlying resonance state:

$$\boxed{\text{definite resonance state} \not\Rightarrow \text{definite spatial realization.}}$$

A spatial probability cloud or delocalized state need therefore not be interpreted as a localized object whose true position is merely unknown. It may instead describe a resonance identity for which no unique spatial realization is determined by the presently realized resonance relationships.

Spatial localization then becomes a relational property. Additional compatible resonance relationships can constrain the projection allowance until a particular spatial realization becomes effectively unique. Conversely, loss of such constraints may allow the projection allowance to broaden again.

In this view, the transition between localized and delocalized behavior is not necessarily a transition between existence and non-existence of a physical identity. It is a change in how strongly the resonance state constrains its possible spatial realizations.

3.5 Propagation Without Continuous Spatial Position

A resonance identity can persist between spatial events without continuously occupying the space between them.

The distinction between resonance state and spatial realization has a direct consequence for propagation.

Consider an interaction at A that produces a persistent resonance identity and a later interaction at B in which that identity participates again. A conventional spatial description naturally suggests a trajectory connecting the two events,

$$\mathbf{x}(t) : A \longrightarrow B.$$

RQT does not require such a trajectory to exist at the fundamental level.

The interaction at A establishes a resonance state with a particular phase and winding history. This state may continue to evolve in Resonance Space without possessing a unique intermediate spatial realization. A later interaction becomes possible when the evolved resonance state becomes compatible with another resonance structure and a shared spatial realization can be established.

The fundamental sequence is therefore represented more naturally as

localized interaction at $A \longrightarrow$ resonance evolution $\longrightarrow$ compatible re-coupling $\longrightarrow$ localized interaction at B

A photon provides an important candidate for such behavior. RQT proposes that a photon need not be interpreted as a localized object continuously travelling through successive points of three-dimensional space. Its resonance state may instead retain the phase and winding information required to determine where subsequent compatible interactions can occur.

Several geometrical paths may consequently remain compatible with the same underlying resonance evolution. These paths need not represent several simultaneously traversed trajectories. They may instead represent alternative spatial realizations permitted by the same resonance state.

This interpretation is particularly relevant to interference, diffraction, and other phenomena in which assigning a unique intermediate trajectory is neither required by quantum theory nor experimentally justified.

At this stage, RQT does not claim that this qualitative interpretation alone reproduces quantum propagation. A complete theory must derive the allowed spatial interaction distributions, including their phase dependence and observed probabilities, from the underlying resonance evolution.

3.6 Accommodation, Splitting, and Merging

A Resonance Node is persistent, but it is not fundamentally indivisible.

A resonance identity persists only while its internal recurrence can accommodate the resonance relationships in which it participates. External relationships may modify phase conditions, recurrence modes, and other aspects of its internal organization without necessarily destroying its higher-order identity.

Such adjustment is referred to as *resonance accommodation*. Within a viable range, the internal resonance structure reorganizes while preserving sufficient closure for the identity to persist.

There may, however, be limits to this accommodation. If simultaneously imposed resonance conditions become too incompatible to be maintained within one recurrent closure, the existing identity may cease to be the most persistent organization available.

One possible reorganization is *splitting*,

$$N \longrightarrow N_1 + N_2 + \cdots ,$$

in which resonance organization previously maintained as one identity becomes distributed across two or more independently persistent identities.

Conversely, two or more resonance identities whose states become sufficiently compatible may establish shared recurrence and closure such that their previous distinction is no longer maintained independently. This process is referred to as *merging*,

$$N_1 + N_2 \longrightarrow N.$$

Splitting and merging are therefore not introduced as fundamental creation or destruction operations. They represent changes in how resonance organization partitions itself into persistent identities.

Schematically,

$$\boxed{\text{identity} = \text{a persistently maintained partition of resonance organization.}}$$

The number of effective Resonance Nodes may consequently change while the underlying resonance evolution remains continuous at a deeper span.

This principle also reinforces the relative meaning of a Resonance Node. A node is not required to be ontologically elementary. It is an organization that presently maintains sufficient recurrence and closure to participate as one identity in further resonance relationships.

The detailed conditions under which accommodation leads to deformation, mode change, splitting, merging, or loss of identity remain to be developed quantitatively. These processes provide an important link between the abstract dynamics of Resonance Space and the discrete structures explored later through the Roton Quantum Model.

3.7 Distinct Resonance Structures

The first observable property of a resonance structure is not its location, but its persistent distinction.

The existence of a resonance continuum alone does not imply the existence of distinguishable structures. Many oscillatory configurations may remain transient, continuously emerging and dissolving without establishing persistent organization. RQT therefore distinguishes between arbitrary oscillation and oscillatory organization that becomes sufficiently persistent to form a distinct resonance structure.

A distinct resonance structure is not initially defined by position, geometry, dimensionality, or physical extent. Instead, it is defined by the continued persistence of its oscillatory organization and by its distinguishability from the surrounding resonance continuum. Distinction therefore precedes localization. Only after stable relationships emerge may geometric descriptions become meaningful.

Persistent distinction also implies continuity. A resonance structure possesses both a history and the potential for continued evolution, not because information is explicitly stored, but because its oscillatory organization remains continuously connected to its own past. The present state is therefore understood as the ongoing evolution of the same resonance process rather than as a sequence of independently recreated states.

From the perspective of RQT, a resonance structure remains part of the observable resonance organization only insofar as this continuity persists. A structure that became completely disconnected from all continuing resonance relationships would cease to participate in the same observable organization. Whether such complete decoupling is possible remains an open question. Everyday physical structures, however, exhibit persistent relationships over extended periods, suggesting that stable resonance organization generally preserves continuity rather than abandoning it.

RQT begins not with localized objects, but with persistent distinction. Identity emerges from the continued existence of a persistent resonance organization. Interaction, separation, and geometry emerge only thereafter through the relationships established between such structures.

Distinct resonance structures therefore provide the first entities capable of participating in persistent interaction. The following section examines how these structures influence one another, adapt through resonance, and establish the relationships from which increasingly organized physical systems emerge.

3.8 Resonance Interaction

Interaction begins whenever the continued evolution of one distinct resonance structure influences that of another.

The existence of distinct resonance structures inevitably allows the possibility of interaction. Whenever two structures participate in one another's continued evolution, they no longer develop independently. Their oscillatory organization begins to adjust through mutual influence, giving rise to resonance interaction.

Interaction should not be understood as a discrete event but as a continuous process. Some interactions remain transient, producing only temporary adjustments before the participating structures continue independently. Others persist, allowing the interacting structures to accommodate one another over extended periods. Resonance interaction therefore represents a dynamic process whose consequences depend on the continued compatibility of the participating structures rather than on the mere occurrence of a single encounter.

Accommodation does not necessarily imply observable change. Highly compatible resonance structures may remain in continuous interaction while exhibiting little or no apparent evolution because their oscillatory organization is already mutually consistent. Interaction therefore exists whenever resonance structures contribute to one another's continued organization, regardless of whether this contribution manifests as rapid adaptation or as stable equilibrium.

The degree to which an interaction contributes to the continued organization of the participating structures determines its significance within the evolving resonance system. Persistent interactions gradually become part of the resonance organization itself, while transient interactions

leave little lasting influence. The following sections investigate how such persistent interactions organize into stable resonance relationships and eventually give rise to the structured resonance pathways that characterize stable physical systems.

3.9 Distinct Resonance Structures

The first observable property of a resonance structure is not its location, but its persistent distinction.

The conceptual foundations identified persistent resonance identity as the first form of organization capable of participating as a unit in further resonance relationships. At the level of RQT, such an identity is not initially defined by position, geometry, dimensionality, or physical extent. It is defined by the persistence of a distinguishable resonance organization.

Distinction therefore precedes localization. A Resonance Node may possess a definite resonance state even where that state does not admit a unique spatial realization. Its identity resides in the continuity of its resonance organization, including its characteristic recurrence, phase development, winding history, internal closure, and externally available resonance capacities.

Persistent distinction also provides continuity through resonance evolution. The present state is not regarded as an independently recreated configuration, but as the continuation of preceding resonance states. Phase and winding provide a minimal description of this history for individual resonance modes, while more complex structures may retain such continuity through several mutually organized modes and relationships.

A distinct resonance structure remains part of a wider resonance organization through the relationships in which it participates. Complete resonance closure would, by definition, remove all externally realizable relationships and make the structure inaccessible from the surrounding resonance network. Whether absolute closure is physically realizable remains an open question. Observable physical identities necessarily retain sufficient resonance accessibility to participate in subsequent interaction.

RQT therefore begins its description of physical identity with persistent distinction rather than spatial localization. Position and geometry become relevant only where resonance relationships constrain a corresponding spatial realization.

3.10 Resonance Interaction

Interaction begins when resonance evolution becomes mutually constrained.

Within RQT, interaction is not introduced as an additional process acting between otherwise independent objects. It occurs when two or more Resonance Nodes establish or modify a shared resonance relationship such that their subsequent evolution can no longer be described independently.

An interaction may be transient or persistent. A temporary compatibility may alter the participating resonance states without establishing lasting shared organization. Where compatibility can be maintained, however, the relationship itself becomes part of the continuing resonance evolution of the participating identities.

Interaction is therefore not restricted to discrete encounters. A stable resonance relationship may represent continuous interaction even when little observable change occurs. In such a case the participating resonance states already satisfy one another sufficiently well that only limited further adjustment is required.

The significance of an interaction depends on how strongly it constrains the future resonance states available to its participants. Weak or transient relationships may leave little persistent organization, whereas strongly maintained relationships may become integral parts of a larger resonance identity.

At the level of Resonance Space, no spatial mechanism of influence is required in this definition. Interaction describes the establishment and evolution of a resonance relation itself. A spatial

pathway or localized encounter belongs to a possible realization of that relation rather than to its fundamental definition.

3.11 Resonance Accommodation

Interaction becomes organization when resonance states accommodate one another.

A resonance relationship does not generally connect otherwise unchanged identities. Because the relation constrains the states available to its participants, continued interaction may require their resonance organization to adjust. RQT refers to this mutual adjustment as *resonance accommodation.*

Accommodation may involve changes in relative phase, characteristic periods, winding development, active resonance modes, closure conditions, or the distribution of resonance relationships within the participating structures. No particular geometrical displacement is implied at the fundamental RQT level, although such changes may acquire spatial realizations.

Successful accommodation allows a shared resonance relation to remain compatible with the continuing evolution of its participants. Where little adjustment is required, the relation may appear macroscopically stable. Where larger mismatch is introduced, the participating structures may redistribute the required adjustment through their internal and external resonance organization.

Accommodation is generally constrained by several simultaneous relationships. A change that improves compatibility with one resonance relation may increase mismatch with another. The evolution of a Resonance Node is therefore determined not by an isolated pairwise optimization, but by the collection of resonance conditions in which the identity participates.

RQT does not assume that this organization performs a global optimization or searches purposefully for a preferred state. Rather, resonance configurations capable of maintaining mutually compatible recurrence remain persistent, while configurations that cannot accommodate their competing relationships tend to weaken, reorganize, split, merge, or cease to persist in their previous form.

Accommodation therefore describes the dynamical mechanism through which resonance interaction can become persistent organization.

3.12 Stability and Accommodation Limits

Stability is the ability of a resonance identity to change without ceasing to be itself.

A resonance organization is stable when changes in its participating states and relationships can be accommodated without destroying the recurrence and closure by which the higher-order identity persists. Stability therefore denotes neither rigidity nor absence of change.

A stable resonance identity may undergo continuous internal reorganization. Phase relations may shift, subordinate modes may adjust, and external relationships may change while the higher-order organization remains recognizable. Stability at one span may consequently depend upon substantial dynamical freedom at lower spans.

External or internal changes may introduce resonance mismatch into an existing organization. Where sufficient accommodation capacity remains available, this mismatch can be redistributed among participating modes and relationships while preserving the identity as a whole.

There are, however, limits to such accommodation. If mutually imposed resonance conditions can no longer be maintained within the existing closure, the organization may undergo a more fundamental reconfiguration. Depending on the available resonance possibilities, this may include a change of mode, loss or formation of relationships, splitting into several persistent identities, merging into a more coherent identity, or dissolution of the previous organization.

Schematically,

$$N \xrightarrow{\text{accommodation}} N'$$

describes continued identity under changing resonance conditions, whereas

$$N \longrightarrow \{N_1, N_2, \ldots\}$$

represents a change in the partition of resonance organization itself.

Separation or splitting should therefore not automatically be interpreted as failure of resonance dynamics. It may constitute the available reorganization through which incompatible resonance requirements are redistributed into structures capable of renewed persistence.

Persistence and stability consequently describe related but distinct properties. Persistence denotes continued resonance identity; stability describes the range of changing resonance conditions across which that identity can continue to be maintained.

3.13 Resonance Distribution Across Hierarchies

Accommodation at one span can be distributed through resonance organization at others.

A Resonance Node may simultaneously constitute a higher-order identity and contain subordinate resonance organization. It may also participate in several relationships belonging to the same or other spans. Accommodation therefore need not remain confined to the relationship in which a change first appears.

A change introduced through one resonance relation may alter the internal conditions of the participating identity. The resulting mismatch can be distributed among subordinate modes and relationships, while changes arising internally may conversely modify the resonance capacities and relationships externally available to the higher-order identity.

The response of a resonance system consequently depends upon the distribution of its available accommodation capacity. Some changes may be absorbed predominantly within a local mode or relationship. Others may require coordinated adjustment across several parts of the organization. If the existing closure cannot accommodate the imposed conditions, the reorganization may reach the resonance-accessibility boundary of the identity and alter its external relationships.

This redistribution is fundamentally relational rather than geometrical. It does not require a disturbance to propagate along a predefined spatial pathway. It follows the network of realized resonance relationships and the modes through which compatible accommodation remains possible. A geometrical propagation pathway may emerge as a spatial realization of this underlying process.

Higher-order stability may therefore coexist with substantial lower-span reorganization. The persistence of the higher-order identity depends not on the immutability of its constituents, but on whether their combined evolution continues to satisfy the recurrence and closure conditions through which the larger identity is maintained.

Because every resonance identity may participate in several mutually constraining relationships, accommodation is inherently contextual. A configuration compatible with one relation may be incompatible with another, and the viable evolution of the structure reflects the combined resonance organization in which it participates.

Where accommodation produces sufficiently coherent shared recurrence, previously distinct identities may become incorporated into a higher-order organization. Where the existing organization can no longer be maintained, relationships may be released, identities may separate, or new resonance partitions may form.

Resonance distribution across hierarchies thus connects local resonance interaction with the persistence and transformation of larger structures. It also prepares the transition to *resonance channels*, which provide a more explicit description of persistent and externally realizable resonance relationships.

4 Resonance Channels and Closure

Persistent resonance relationships become structure.

The preceding sections described resonance identities through their recurrence, phase and winding history, resonance separation, interaction, and accommodation. As resonance organization becomes increasingly complex, however, following the complete evolution of every participating state becomes impractical. RQT therefore introduces a compact relational description of those interactions that become sufficiently persistent to constitute recognizable parts of a resonance organization.

The central concepts are *resonance channels*, *closure*, and *enclosure*. These do not introduce additional physical ingredients. A resonance channel denotes a persistent and distinguishable resonance relation. Closure describes the degree to which such a relation has become internally accommodated within a larger resonance identity, while enclosure describes the higher-order organization sustained by predominantly internalized relationships.

At the level of RQT, a resonance channel is not a material conduit and does not possess a fundamental spatial path, direction, or length. Its state may instead be characterized by resonance quantities such as mode, relative phase, winding history, compatibility, and the identities participating in the relation.

Only through spatial realization may a channel acquire a geometrical representation,

$$R_{ij} \quad \xrightarrow{\mathcal{P}} \quad C_{ij}^{(3D)},$$

where the RQT relation R_{ij} is represented in RQM by a spatially realized channel $C_{ij}^{(3D)}$ with properties such as separation, direction, and geometrical organization.

The distinction is fundamental to the relation between the two frameworks:

$$\boxed{\text{RQT channel} = \text{persistent resonance relation}}$$

whereas

$$\boxed{\text{RQM channel} = \text{three-dimensional realization of such a relation.}}$$

The following subsections develop the general RQT concepts first. Their particular geometrical realizations and structural restrictions are introduced later through the Roton Quantum Model.

4.1 Resonance Channels

A resonance channel is the persistent organization of a distinguishable resonance relation.

Resonance interaction may be transient, distributed, or continuously changing. Where an interaction becomes sufficiently persistent and distinguishable to contribute to the continuing resonance organization of its participants, RQT represents that relation as a *resonance channel*.

The interaction and the channel should not be understood as two separate physical processes. Interaction denotes the mutual constraint of resonance evolution; the channel denotes the persistent relational organization produced when that interaction becomes sufficiently established.

For two Resonance Nodes N_i and N_j, a realized channel may be represented schematically as

$$N_i \;\; R_{ij} \; N_j.$$

At the RQT level, R_{ij} need not possess geometrical length, orientation, curvature, or a trajectory through space. Its relational state may instead depend on quantities such as relative phase and winding,

$$\Delta\Phi_{ij} = 2\pi\Delta W_{ij} + \Delta\phi_{ij},$$

together with the modes, recurrence conditions, and wider resonance relationships of the participating identities.

This connects resonance channels directly to the previously introduced concept of resonance separation. A persistent channel maintains a compatible relation between resonance histories. Changes in phase and winding may therefore alter the channel state and, where a spatial realization exists, may correspond to changes in projected separation or geometry.

A realized channel need not remain permanently associated with an unchanged pair of lower-span constituents. What persists at a given span is the distinguishable resonance relation and the organization it supports. Internal reorganization may alter the lower-span realization while preserving the higher-order channel or identity.

Several channels may coexist where their resonance requirements remain mutually compatible. Their combined organization constrains the subsequent states available to the participating identities and may establish a higher-order resonance structure.

4.2 Channel Capacity, Realization, and Closure

The possibility of a relationship is not yet the relationship itself.

At the level of a selected resonance identity, RQT distinguishes between externally accessible resonance capacity and a distinguishable resonance channel realized with a particular counterpart. This distinction is relative to the resonance enclosure under consideration.

An *available resonance capacity* denotes resonance organization through which an identity can establish or strengthen an external relationship. It should not necessarily be interpreted as a physically unused connection. Within the complete resonance network, such capacity may already participate through many weak or distributed relationships with the surrounding resonance environment.

When one compatible resonance relation becomes sufficiently dominant and persistent to be distinguishable as an organized relationship, it may be represented as a realized resonance channel:

$$\text{distributed or available external resonance} \longrightarrow \text{dominant realized channel.}$$

A realized channel may remain strongly exposed to the wider resonance organization or become increasingly incorporated into the internal recurrence of a larger identity. This latter development constitutes *closure*:

$$\text{realized channel} \longrightarrow \text{increasing accommodation} \longrightarrow \text{closed channel.}$$

Closure does not terminate the interaction. It changes its role. A relationship that previously remained externally negotiable becomes increasingly sustained by the recurrent organization of the combined system.

The terminology is therefore partly dependent on the boundary chosen for the system under consideration. A relationship incorporated into the selected identity is internal or closed, while a relationship crossing that boundary is external or open. Where no dominant external counterpart is resolved, externally accessible resonance may be represented effectively as residual resonance.

Whether a relation is regarded as internal or external also depends on the span under consideration. A channel may be closed within one resonance enclosure while the resulting higher-order identity retains open or residual relationships at another span.

4.3 Residual Resonance

Residual resonance is externally accessible resonance organization that is not dominated by a distinct closed relationship.

When a resonance enclosure is considered as a distinct identity, not all of its externally accessible resonance organization need be concentrated into distinguishable partner-specific channels.

Some may remain distributed across many weak relationships with the surrounding resonance network. RQT refers to this externally accessible remainder as *residual resonance*.

Residual resonance should therefore not be interpreted as a literal channel connected to nothing. At sufficiently detailed resolution, it may correspond to a collection of weak resonance relationships between the selected identity and its environment. Schematically,

$$R_{\mathrm{res},i} \sim \sum_{k \in \mathrm{environment}} R_{ik}^{\mathrm{weak}}.$$

This expression is conceptual rather than a proposed quantitative summation law. Its purpose is to emphasize that residual resonance represents unresolved or distributed relationship rather than absence of relationship.

A compatible external identity may reorganize part of this distributed resonance into a dominant distinguishable channel,

$$R_{\mathrm{res},i} \longrightarrow R_{ij}^{\mathrm{dominant}},$$

while weakening, reopening, or loss of such a dominant relationship may return its resonance organization to a more distributed residual state.

Residual resonance may also remain when a relationship is predominantly internalized but its closure is incomplete, dynamically varying, or continuously coupled to wider resonance organization. Residual resonance is therefore not a single microscopic mechanism, but a relational description of externally accessible resonance that has not become completely confined to a particular closed organization.

At the general RQT level, no inverse-distance law or geometrical distribution is assumed for residual resonance. Such behavior requires spatial realization and must therefore be derived or represented at the RQM level.

This distinction becomes important when familiar long-range interactions are later considered. RQT may interpret an observed long-range effect as a spatial realization of residual resonance, but the corresponding geometrical law is not a primitive property of Resonance Space.

4.4 Resonance Closure

Closure turns externally negotiated resonance into internally sustained organization.

Resonance closure occurs when a persistent relationship becomes sufficiently accommodated within the recurrence of a larger resonance organization that its continued existence is predominantly sustained internally.

Closure therefore concerns more than the persistence of an individual channel. It changes the organization of the identities participating in it. Resonance conditions that previously depended upon external compatibility become incorporated into the recurrent state of the combined structure.

As closure increases, previously available resonance capacities may be reduced, redirected, or reorganized. New collective modes may simultaneously become possible. Closure therefore changes the future compatibility landscape of the resulting identity.

A useful schematic representation is

$$\{N_i, R_{ij}\} \longrightarrow \text{shared recurrence} \longrightarrow \text{closure} \longrightarrow N_{\mathrm{higher}}.$$

Closure does not imply perfect isolation. A closed organization may retain residual resonance, available capacity, and realized external channels. What has changed is the distinction between relationships that predominantly sustain the identity internally and those through which it remains accessible to the wider resonance network.

Closure is therefore one of the central mechanisms through which RQT converts relationship into persistent higher-order identity.

4.5 Resonance Locking and Stabilization

Closure describes organization; locking describes dynamical retention.

During accommodation, a shared resonance mode may become increasingly resistant to departure from its established relation. RQT refers to this dynamical retention as *resonance locking*.

Locking and closure are related but not synonymous. Closure describes how strongly a relationship has become incorporated into the internal organization of an identity. Locking describes how strongly the continuing dynamics retain that relationship near its established resonance mode.

A relation may therefore be strongly locked while remaining only partially closed, or strongly closed while environmental changes make it comparatively easy to reopen or reorganize.

Resonance stabilization may arise through several forms of organization. Persistent locking may reduce continuing accommodation demands; closure may internalize previously exposed relationships; and internal mode reorganization may replace several competing relationships by a new collective resonance mode.

At the RQT level these processes are described through changes in resonance organization. Particular geometrical mechanisms, such as rotational decoupling, directional channel arrangements, or spatially constrained modes, belong to their possible RQM realizations and are introduced only where such a representation is explicitly adopted.

4.6 Channel Availability and Saturation

A resonance identity can realize only those relationships compatible with its existing organization.

Channel availability describes the externally accessible resonance organization through which an identity can establish or strengthen additional persistent relationships.

Realizing a dominant channel changes the resonance state of the participating identity. Closing that channel may reorganize it still further. Consequently, the formation of one relationship may preserve, reduce, redirect, or remove the compatibility required for another.

Several realized channels can coexist only where their combined resonance conditions remain mutually accommodatable. An identity is said to be *saturated* with respect to a particular resonance mode when its present organization no longer permits an additional distinguishable channel of that mode to be realized.

Saturation is therefore relational and state-dependent rather than a fixed numerical property assumed by general RQT. Reopening, mode change, splitting, merging, or other reorganization may alter the externally accessible resonance capacity.

Specific channel counts and geometrical arrangements belong to particular RQM structures rather than to the general RQT ontology.

4.7 Resonance Enclosure

An enclosure is a boundary of resonance accessibility, not fundamentally a boundary in space.

A *resonance enclosure* is a persistent higher-order identity whose recurrence is substantially sustained by relationships that have become internal to its organization.

The subordinate identities participating in an enclosure need not cease to exist. Their resonance possibilities are constrained and reorganized by the combined structure, while the enclosure itself acquires resonance properties and capacities through which it can participate as a higher-order Resonance Node.

The boundary of an enclosure is not fundamentally a spatial surface. It is a boundary of resonance accessibility:

internalized resonance organization	externally realizable resonance organization.

Only through spatial realization may this relational boundary correspond to a geometrical extent, surface, orbital region, or other spatial structure.

Formation of an enclosure does not end accommodation. Internal relationships may continue to redistribute phase, winding, modes, and closure conditions while the higher-order identity remains persistent. Such reorganization may change its residual resonance and externally available channel capacities without destroying the enclosure itself.

An enclosure may consequently retain realized external channels, residual resonance, and additional available capacities. It may therefore participate as a Resonance Node in another enclosure at a higher span.

Resonance enclosure thus completes the recursive transition

identity → relationship → channel → closure → enclosure → higher-order identity.

4.8 Channels in the Roton Quantum Model

RQM gives geometrical form to resonance relationships that are not fundamentally geometrical in RQT.

The preceding descriptions concern resonance channels at the general level of RQT. The Roton Quantum Model introduces an additional representational step by realizing these relationships within an effective three-dimensional geometry.

A realized RQT relationship

$$R_{ij}$$

may therefore be represented in RQM by a geometrical channel

$$R_{ij} \xrightarrow{\mathcal{P}} C_{ij}(r_{ij}, \hat{\mathbf{r}}_{ij}, \ldots),$$

where r_{ij} denotes projected separation and $\hat{\mathbf{r}}_{ij}$ its projected direction. Depending on the RQM structure under consideration, additional geometrical properties such as rotational planes, characteristic channel arrangements, or directional constraints may be introduced.

These quantities belong to the RQM realization and should not be interpreted as fundamental coordinates or distances of Resonance Space. In particular, the geometrical channel length r_{ij} represents a spatial realization of the underlying resonance separation rather than defining that separation fundamentally.

The distinction between internal, external, and residual channels is made relative to the resonance enclosure under consideration. A channel whose relationship is incorporated into the recurrent organization of the enclosure is represented as closed or internal. A persistent distinguishable relationship crossing the chosen enclosure boundary is represented as an open external channel.

Where no dominant external counterpart is resolved, the corresponding externally accessible resonance organization may be represented by RQM as a residual or freely available channel. Such a residual channel should not be interpreted as a literal connection to nothing. It is an effective geometrical representation of weak or distributed resonance relationships between the selected identity and the surrounding resonance network.

The geometrical RQM representation provides an additional interpretation of this condition. A channel whose external realization is not constrained by a specific dominant relationship has no uniquely determined spatial direction. Its geometrical realization may therefore remain orientationally unconstrained.

RQM may represent such a channel as continuously changing, rotating, precessing, or otherwise varying through its allowed spatial orientations. Over timescales large compared with this variation, the externally accessible resonance capacity may consequently appear spatially distributed rather than directed toward a particular counterpart.

Schematically,

$$\text{no dominant RQT counterpart} \longrightarrow \text{non-unique spatial channel realization} \xrightarrow{\text{RQM}} \text{varying or rotating channel}$$

This interpretation preserves the RQM picture of a freely rotating open or residual channel while changing its ontological status. The rotation is not assumed to constitute a fundamental motion of a physical arm through Resonance Space. It is a three-dimensional representation of resonance organization whose spatial direction is not uniquely constrained.

Once a compatible external identity establishes a sufficiently dominant relationship, the projection allowance of the channel becomes more restricted. In the RQM representation, the previously distributed or rotating channel can then acquire a preferred orientation toward the spatial realization of its interaction partner:

$$\text{distributed residual relation} \longrightarrow \text{dominant resonance relation} \longrightarrow \text{constrained RQM orientation.}$$

Conversely, weakening or loss of the dominant relationship may broaden the allowed spatial realization again, returning the channel to a more freely varying or rotationally distributed RQM state.

Rotation should not necessarily be interpreted as uniform rotation through all spatial directions. Depending on the particular RQM structure, the projected channel may rotate within a plane, precess, oscillate between orientations, or participate in a more complex geometrical mode. The essential property of an unconstrained residual channel is not a particular rotational law, but the absence of a uniquely fixed spatial orientation.

Rapid variation of such an orientation may additionally reduce the ability of another spatially realized structure to maintain a persistent geometrical lock with the channel. In particular RQM structures, rotational or orientational dynamics may therefore contribute to effective decoupling. This constitutes an RQM mechanism rather than a fundamental requirement of the underlying RQT relation.

The RQT and RQM descriptions can consequently be summarized as

RQT:	The external resonance relation has no uniquely constrained spatial realization.
RQM:	The projected channel has no fixed direction and may vary or rotate spatially.

The RQM terminology of closed, open, and residual channels is therefore partly relative to the enclosure boundary and spatial resolution chosen for the model. The underlying RQT description remains a network of resonance relationships whose relative organization, concentration, closure, and spatial realizability may continuously change.

5 Relational Separation and Emergent Geometry

Separation can exist before distance. Geometry emerges when resonance separation becomes consistently projectable.

The preceding sections described how persistent resonance relationships may become organized into channels, closures, and higher-order resonance enclosures. Such organization, however, does not require every participating identity to become internalized within a common enclosure.

Distinct Resonance Nodes may remain individually recognizable while participating in persistent relationships within a shared resonance network.

Such networks introduce relational position and separation without requiring a pre-existing spatial metric. The participating identities remain distinguishable through differences in their resonance states, histories, and relationships, while persistent compatibility allows them to participate in a common organization.

Resonance separation was introduced previously through differences in accumulated phase and winding. This provides a relational distinction between resonance identities before any geometric distance is assigned to them. Where a sufficiently constrained collection of resonance relationships admits a mutually consistent spatial realization, this separation may become projectable as geometric distance, direction, neighbourhood, and eventually dimensional structure.

The purpose of this section is therefore not to introduce geometry as an additional background in which resonance occurs. It examines how persistent resonance relationships can acquire the ordered and repeatable spatial realizations recognized as physical geometry.

5.1 Relational Position

A Resonance Node has a position in the resonance network before it necessarily has a position in space.

A resonance identity acquires a relational position through the pattern of resonance relationships in which it participates. This position is initially defined not by coordinates, but by which identities constrain it, which resonance histories it shares with them, and which further relationships remain compatible with its state.

Two otherwise equivalent identities may therefore occupy different relational positions because they participate in different channel configurations or possess different phase and winding relations to the surrounding resonance network. Their distinction does not require them first to occupy different points in a geometric space.

Relational position should therefore not be confused with spatial position. It describes the role and constraint state of an identity within Resonance Space. Only where these relationships sufficiently restrict the projection allowance does relational position acquire a corresponding spatial realization.

Schematically,

$$\text{resonance state} \longrightarrow \text{relational position} \longrightarrow \text{projection constraints} \longrightarrow \text{spatial position}.$$

The final step need not always occur uniquely. A strongly constrained relational position may admit only a narrow range of spatial realizations and therefore appear as a localized object. A less constrained state may admit several positions or an extended region of compatible realization.

Neighbourhood, direction, and location are consequently not assumed as primitive properties of Resonance Space. They emerge where persistent relational positions become sufficiently constrained to support repeatable spatial organization.

5.2 Resonance Separation

Resonance separation records how resonance histories have become distinct.

Resonance separation was introduced previously as the divergence of resonance histories between identities. In the simplest single-mode representation, this distinction may be expressed through the accumulated phase difference

$$\Delta\Phi_{ij} = \Phi_i - \Phi_j = 2\pi\Delta W_{ij} + \Delta\phi_{ij}.$$

The cyclic phase difference $\Delta\phi_{ij}$ describes the present relative position within the recurring resonance mode, while ΔW_{ij} retains the accumulated winding difference associated with its preceding evolution. Resonance separation therefore contains relational history that is lost if only the instantaneous cyclic phase is considered.

This separation exists independently of a spatial metric. Two identities may possess a definite resonance separation without requiring coordinates or a geometrical distance between them.

Where several modes participate simultaneously, resonance separation may require a corresponding set of phase and winding relations rather than a single scalar quantity. RQT does not presently assume a unique general metric for this higher-dimensional resonance-state relation. The essential requirement is only that sufficient information remains available to distinguish resonance histories and determine their compatibility with subsequent relationships.

Within a persistent resonance network, resonance separation becomes constrained by several simultaneous relationships. Where these constraints admit a stable spatial realization, the underlying resonance separation may become represented by a projected geometric distance,

$$\Delta\Phi_{ij},\, \Delta W_{ij},\, \ldots \quad \xrightarrow{\mathcal{P}} \quad r_{ij}.$$

The mapping need not be unique. Several geometric separations may satisfy the same underlying resonance constraints, while sufficiently constrained networks may reduce the projection allowance to a narrow or effectively unique value of r_{ij}.

Geometric distance is therefore not identified directly with winding or phase difference. Rather, phase and winding provide resonance-state information from which spatial separation may become realizable.

Greater spatial proximity consequently need not imply greater resonance compatibility. If one projected separation produces incompatible resonance demands, another spatial realization may provide a more persistent accommodation. Geometric distance is thus treated as an outcome of resonance compatibility rather than as its fundamental cause.

5.3 Phase Compatibility and Relational Propagation

Propagation is first an evolution of resonance state; spatial propagation is its realization.

Structural similarity alone does not guarantee that resonance identities can sustain a shared relationship. Their recurring evolution must also meet in sufficiently compatible relative states. RQT refers to this relational condition as phase compatibility.

Phase is not introduced as an absolute temporal coordinate. It describes the state of an identity within a recurring resonance mode and, through relative phase, its compatibility with other resonance identities. Winding extends this description by retaining accumulated resonance history across repeated cycles.

A persistent channel therefore constrains not only which identities participate in a relation, but how their phase and winding states may continue to evolve relative to one another. Changes in one part of a resonance organization may consequently alter the compatible evolution of other participating identities.

At the fundamental RQT level, this continued evolution does not require an influence to traverse a sequence of intermediate spatial positions. Relational propagation describes the continuation and redistribution of resonance state through the network of realized relationships.

Schematically,

$$\text{resonance evolution} \quad \xrightarrow{\mathcal{P}} \quad \text{spatial propagation}.$$

Where the resonance organization possesses a strongly constrained spatial realization, relational propagation may appear as an influence travelling continuously through geometric space. Where the projection allowance remains broad, however, no unique intermediate spatial trajectory need exist.

This distinction is particularly relevant to resonance identities such as photons, for which RQT does not require continuous localization between emission and subsequent interaction. The resonance state may continue to evolve through phase and winding while several spatial realizations remain compatible with that evolution. A later localized interaction occurs where the evolved resonance state can establish a compatible relationship with another resonance identity.

Several geometrical paths may therefore correspond to the same underlying resonance evolution. Conversely, a sufficiently constrained resonance network may restrict the projection so strongly that propagation appears to follow a well-defined spatial path.

Propagation in RQT is consequently fundamentally relational. Spatial transit is one possible realization of that continuing resonance evolution.

5.4 Projected Distance Locking

A stable resonance relation may repeatedly project to a stable geometric separation.

Where a persistent resonance relation repeatedly admits the same or a narrow range of spatial realizations, its projected separation may become effectively locked. RQT refers to this condition as *projected distance locking*.

Distance locking is therefore not introduced as an independent mechanism forcing two objects to maintain a preferred geometric interval. It is the spatial manifestation of a resonance relation whose phase, winding, recurrence, and surrounding resonance constraints repeatedly select compatible realizations within a limited range.

Schematically,

$$R_{ij}^{\text{stable}} \quad \xrightarrow{\mathcal{P}} \quad r_{ij} \approx r_{ij}^{*}.$$

A locked distance need not be rigid or exact. The underlying resonance relationship may tolerate a range of phase and winding variation, while other relationships in the surrounding network may alter the projection constraints and shift the preferred spatial realization.

The participating identities may therefore move relative to one another in the projected geometry while their underlying resonance relationship remains intact. Conversely, a sufficiently large change in resonance separation may cause the previously stable spatial realization to become incompatible and require reorganization of the relationship.

Projected distance locking differs from resonance closure. Closure describes the incorporation of a relationship into the recurrent organization of an enclosure. Distance locking describes the repeated geometrical realization of a resonance relation as a stable separation. A relationship may therefore exhibit stable projected distance without becoming fully internalized within a higher-order enclosure.

5.5 Lateral Resonance Networks

Geometry becomes collective when several resonance separations must be realized simultaneously.

When several identities establish mutually compatible channels without losing their distinguishable identities, their relationships form a lateral resonance network. Additional identities may join such a structure at the same organizational span provided that the resulting resonance demands remain jointly compatible.

The stability of such a network cannot generally be reduced to isolated pairwise relations. Each identity may participate simultaneously in several channels, each carrying its own phase, winding, recurrence, and compatibility conditions. A spatial realization of the network must therefore accommodate several resonance separations at once.

Adjusting one relationship may improve its local compatibility while disturbing others. This produces *resonance frustration* where no available organization can simultaneously satisfy all individually preferred relations.

The network may respond through changes in phase relations, winding development, active modes, channel organization, or resonance separation. Where a spatial realization exists, these changes may appear as modifications of distance, angle, neighbourhood, or overall geometry.

Stable network geometry therefore represents an accommodated realization of several mutually constraining resonance relationships rather than the independent repetition of preferred pairwise distances.

Resonance frustration may also affect projectability itself. Where several geometrical arrangements remain compatible with the same underlying resonance organization, the network may possess a broad projection allowance and no unique spatial configuration. Additional relationships may progressively constrain this allowance until a sharply defined geometry emerges.

A lateral resonance network therefore provides the first setting in which geometry becomes a collective property of resonance organization rather than a property assigned independently to individual relationships.

5.6 Emergent Geometry

Geometry emerges where many resonance relationships admit a common spatial realization.

Persistent resonance relationships do not merely occur within geometry. RQT proposes that sufficiently constrained collections of such relationships make stable geometry possible.

An individual resonance state or relation may admit many spatial realizations. Each relationship therefore contributes constraints to a corresponding projection allowance. As additional mutually compatible relations are established, their allowed spatial realizations must become mutually consistent.

This may be represented schematically as

$$\mathcal{P}(\mathcal{R}_1) \cap \mathcal{P}(\mathcal{R}_2) \cap \cdots \cap \mathcal{P}(\mathcal{R}_n) = \mathcal{G},$$

where $\mathcal{G}$ denotes the set of geometrical realizations compatible with the combined resonance organization.

If $\mathcal{G}$ remains broad, the resonance organization does not determine a unique geometry. If continuing relationships constrain it increasingly,

$$\mathcal{G} \longrightarrow G_{\text{stable}},$$

the network acquires a repeatable and effectively definite spatial realization.

Geometry can therefore be understood as the common projection allowed by a sufficiently constrained resonance network.

Within such a realization, persistent resonance separations may appear as geometric distances, distinguishable relational arrangements may appear as directions and angles, and stable patterns of compatibility may define neighbourhood and topology.

The dimensionality and metric properties of this geometry are not assumed by general RQT. They must arise from the number and organization of independent relational constraints that can be simultaneously and persistently realized.

This also explains why spatial geometry may be extremely stable for ordinary macroscopic matter while remaining ambiguous for less constrained quantum states. Dense and persistent resonance networks can impose a large number of mutually reinforcing projection constraints, narrowing the available geometry until alternative realizations become negligible. More weakly constrained identities may retain substantially broader projection allowances.

The Roton Quantum Model adopts a three-dimensional realization of such resonance organization and represents it through nodes, projected channel directions, characteristic separations,

rotational modes, and concrete network geometries. These RQM structures should therefore be understood as spatial realizations of the more general relational organization described by RQT.

5.7 Dimensional Selection

Three-dimensionality is an observed property that RQT must explain, not an assumption it may quietly inherit.

The emergence of geometric organization does not by itself determine why persistent physical systems are observed through three independent spatial dimensions. Within RQT, dimensionality is therefore treated as a property that must arise from the projectability and stability of resonance networks rather than as a primitive characteristic of Resonance Space.

The relevant question is not initially why Resonance Space itself should possess three dimensions. Resonance Space is not assumed to possess ordinary spatial dimensionality at all. The question is instead why the stable external realizations of physical resonance organization predominantly admit three independent geometric degrees of freedom.

Three-dimensional geometry may represent a particularly stable or broadly realizable solution to this constraint problem. A given number of spatial degrees of freedom determines which combinations of resonance separations, neighbourhood relations, channel arrangements, and closures can be represented simultaneously without persistent incompatibility.

Demonstrating that three dimensions are preferentially selected, however, requires analysis of the resonance structures and projection constraints supported by candidate networks. General RQT does not yet provide such a derivation, and dimensional selection therefore remains an open quantitative task of the framework.

This does not imply that all resonance organization must be reducible to three independent degrees of freedom. Resonance identities may contain additional internal modes, phase relations, winding structures, and hierarchical organization that do not appear as independent external spatial dimensions.

A complex internal resonance state may therefore project into a comparatively simple three-dimensional external geometry:

$$\mathcal{R}_{\text{complex}} \quad \xrightarrow{\mathcal{P}} \quad G_{3D}.$$

The distinction between internal resonance freedom and external geometric dimensionality is essential. Additional resonance degrees of freedom need not correspond to hidden spatial dimensions.

RQT consequently treats observed three-dimensional space as a persistent property of spatial realization. Explaining why this particular dimensional organization dominates stable physical structure constitutes a constraint on the further development of the theory rather than an initial postulate.

6 Information, Persistence and Inertia (RQM View only)

A persistent resonance identity does not exist as a sequence of independently recreated states. Its present organization continues from its previous organization and thereby carries the constraints of its own history. Phase relations, channel configurations, closures, and ongoing transitions together determine which further developments remain compatible with the identity.

RQT therefore does not treat information as an additional substance stored within a resonance structure. Information is expressed by the organization that persists and by the alternatives that this organization permits or excludes. The state of a resonance system is informative because it influences how the system can continue.

6.1 Information as Persistent Organization

A resonance identity preserves information through the continuity of its internal and relational organization. Its present state reflects earlier accommodation processes and cannot generally be changed without affecting the relationships through which the identity remains coherent.

This information need not correspond to a static record. It may be carried by recurring phase relations, ongoing transitions, closed channels, or stable patterns of redistribution. A resonance structure therefore retains its history dynamically: the past remains effective through the organization that continues into the present.

Persistence does not require every internal state to remain unchanged. Subordinate relationships may oscillate, reopen, redistribute, or reorganize while the higher-level identity remains distinguishable. What persists is the continuity of the organization that connects these changing states.

6.2 Resistance to Reconfiguration

Because a persistent resonance system is relationally organized, a change imposed upon one part cannot always remain local. Altering a phase relation, channel state, or internal configuration may change the compatibility demands placed upon other parts of the structure.

The system must then redistribute the resulting resonance mismatch until a new coherent organization is established. Where this redistribution involves many mutually constrained relationships, the response cannot occur as an independent and instantaneous change of a single component.

RQT identifies the resulting resistance or lag as inertia. Inertia is therefore not initially defined as resistance to motion through space, but as resistance to the reconfiguration of an established resonance organization.

The strength of the inertial response depends on how extensively the imposed change must be accommodated. A local adjustment that remains compatible with the surrounding structure may produce little resistance. A change that requires coordinated reorganization across many channels, closures, or subordinate identities produces a greater system-wide response.

Inertia does not prevent change. It expresses the continuity that must be preserved while change proceeds. The existing organization constrains the path by which the system can reach another coherent state.

6.3 Inertia Across Resonance Hierarchies

A resonance identity may contain subordinate structures while participating in larger resonance organizations. Reconfiguration can therefore be distributed across several hierarchical levels.

An imposed change may be absorbed within a local relationship, redistributed through the internal organization of an enclosure, or transferred to the higher-level identity as a whole. Which response occurs depends on the available accommodation modes and on the stability of the relationships involved.

A higher-level identity may remain persistent while substantial reorganization occurs internally. Conversely, a disturbance that cannot be accommodated within subordinate structures may alter the organization of the entire enclosure or propagate into its external relationships.

Inertia is therefore relative to the identity level under consideration. What appears as internal adaptation at one level may appear as delayed response, reorientation, or structural change at another.

The persistence of a resonance identity and its inertia are thus closely connected. Persistence carries an established organization forward; inertia expresses the resistance encountered when that organization must be changed.

A locally imposed phase change may therefore spread through the resonance organization as a sequence of accommodation demands rather than being adopted

simultaneously by the entire structure.

7 Hierarchical Resonance Structures

Persistent resonance organization may be represented at different levels of structural detail. A higher-level identity can be treated as a coherent unit while its internal resonance organization remains hidden, or it can be expanded into the subordinate identities and channels through which it is sustained.

This hierarchical representation does not introduce additional physical entities. It provides a way to describe the same resonance organization at different levels of resolution. At each level, internally coherent structures may be represented as nodes, while their persistent same-level relationships are represented as resonance channels.

7.1 Resonance Nodes

A resonance node is a distinguishable resonance identity represented at a chosen organizational level by the channels through which it participates in a wider resonance network.

A node is not necessarily elementary and should not initially be understood as a geometric point. It may represent a minimal resonance identity, a resonance enclosure containing subordinate structures, or a larger coherent system whose internal organization is not relevant at the level currently examined.

The node representation compresses this internal organization while preserving the resonance properties required for its external relationships. These may include its present phase state, available and realized channel modes, closure conditions, and compatibility with neighbouring nodes.

Channels connected to a node are not attached to a passive junction. The node accommodates the relational conditions imposed by its incident channels, and its own resonance state constrains which relationships can remain compatible. A change in one relationship may therefore alter the accommodation demands placed upon the others.

Nodehood is relative to the chosen level of description. A structure represented as one node in a higher-level network may itself be expanded into an internal network of subordinate nodes and channels. Conversely, a persistent lower-level network may be represented as one higher-level node once its combined organization becomes sufficiently coherent to participate externally as a unit.

Links between hierarchy levels should not be interpreted as additional resonance channels. They express that a higher-level node is realized by, and remains consistent with, a subordinate resonance network. Changes in the higher-level identity therefore correspond to redistributed phase or resonance conditions within the lower-level organization, without requiring a separate cross-level channel.

The Roton Quantum Model later assigns concrete internal structures, channel types, and geometric representations to particular nodes. At the general level of RQT, the node remains a scale-dependent representation of persistent resonance identity.

7.2 Resonance Networks

A resonance network is a same-level organization of resonance nodes connected by realized resonance channels. It represents a set of persistent relationships between comparable identities at a chosen level of description.

The nodes of a resonance network are not passive points. Each node carries its own resonance state and accommodates the relational conditions imposed by its incident channels. A change in one channel may therefore alter the compatibility demands placed upon neighbouring channels and nodes.

The channels of a resonance network represent realized resonance relationships. At this level, a channel does not need to be treated as an independently evolving object. It expresses the compatibility relation through which the states of two nodes remain mutually constrained. In particular, phase may be understood primarily as a property accommodated by the participating nodes, while the channel defines the relational condition under which their phases can remain compatible.

A resonance network may contain many mutually dependent relationships. Its stability cannot generally be reduced to isolated pairwise channels, because each node may need to accommodate several resonance conditions at once. Adjusting one relationship may therefore stabilize one part of the network while disturbing another.

For this reason, resonance networks can exhibit frustration, redistribution, and reorganization. Where all relevant channel conditions can be accommodated together, the network may persist as a coherent structure. Where they cannot, the network may shift its phase relations, alter its channel availability, separate into more compatible subnetworks, or form a higher-level enclosure.

A resonance network should be distinguished from residual resonance influence. Residual influence may affect a network from outside or remain available for future interaction, but it becomes part of the network only when it forms a persistent realized channel contributing to the organization under consideration.

Different channel types or span-regimes may require distinct but related network descriptions. In such cases, the same underlying identities may participate in more than one resonance layer, while each layer preserves its own channel logic. The relation between such layers is not itself an ordinary resonance channel, but belongs to hierarchical realization or inter-span transition.

7.3 Coherent Subnetworks and Clusters

A resonance network need not be equally coherent throughout. Some regions may contain relationships that are more mutually compatible, more persistent, or more strongly accommodated than their connections to the surrounding network. RQT refers to such regions as resonance clusters.

A resonance cluster is therefore a coherent subnetwork within a larger resonance network. Its internal channels contribute to a shared local organization, while its external relationships remain comparatively weaker, less stable, or less fully accommodated.

A cluster is not automatically a separate higher-level identity. It may remain an identifiable region of a network without possessing sufficient internal closure to act as an independent resonance structure. Its boundary is therefore not absolute, but reflects the relative persistence of internal relationships compared with external ones.

Clusters may respond to resonance mismatch by redistributing accommodation demands internally. If this redistribution remains bounded, the cluster may persist as a stable subnetwork. If its internal organization becomes sufficiently self-sustaining and externally distinguishable, it may form a resonance enclosure and later be represented as a higher-level node.

Resonance clusters thus provide an intermediate concept between loose network organization and nested resonance identity. They describe how local coherence can emerge before full enclosure or higher-level identity is established.

7.4 Emergent Hierarchies

The concepts introduced above allow resonance organization to be described as a hierarchy of increasingly coherent identities. A resonance network may contain locally coherent subnetworks. Such subnetworks may form clusters, clusters may develop internal closure, and sufficiently persistent enclosures may become representable as higher-level nodes.

This hierarchy is not a simple stacking of independent layers. A higher-level identity remains realized by the lower-level resonance organization that sustains it. Its state therefore constrains,

and is constrained by, the phase relations, channel configurations, closures, and accommodation processes of its subordinate structure.

At the same time, the external resonance expression of a higher-level identity need not reproduce its internal organization directly. Internal channels may close, become redirected, or participate in inter-span transitions, while only certain resonance properties remain available to the surrounding network. The current exposure of an identity may change as channels are realized, while its overall external expression can remain stable.

Emergent hierarchy therefore combines three aspects: internal realization, inter-span transition, and external resonance expression. Internal realization describes how a higher-level identity is sustained by subordinate resonance organization. Inter-span transition describes how resonance changes are re-expressed across different span-regimes within the same identity. External resonance expression describes how the resulting identity remains available for further interaction.

This framework prepares the later transition from general RQT concepts to the concrete structures of the Roton Quantum Model. There, particular resonance trajectories, channel types, closures, and residual expressions will be used to construct increasingly complex physical identities, from elementary resonance structures to nuclei, atoms, molecules, and macroscopic matter.

8 From Relational Resonance to the Roton Quantum Model

The preceding sections developed RQT as a relational description of resonance organization. Identities, channels, closures, networks, and hierarchies were introduced without assuming a pre-existing spatial geometry. Position, separation, and direction were treated as consequences of persistent resonance relationships rather than as primitive background properties.

The Roton Quantum Model introduces a more concrete representation of these ideas. It models stable or quasi-stable resonance organization as explicit three-dimensional geometry. Resonance identities are represented as nodes or rotative structures, persistent relationships as channels, and stable relational separations as geometric distances.

This transition does not replace the relational foundation of RQT. It adds modelling assumptions that allow resonance organization to be drawn, compared, and eventually calculated. RQM therefore treats geometry as the stable form of resonance organization, while dynamic behaviour is described through deviations from that geometry, such as phase difference, distance variation, axis reorientation, propagation delay, and torque-like accommodation demands.

8.1 From Relational Position to Directionality

In RQT, a resonance identity acquires relational position through the pattern of relationships in which it participates. Such position is not yet a coordinate in space. It describes the role of an identity within a resonance network and the distinguishable relations by which it differs from other identities.

Directionality begins when these relations become repeatable and comparable. A single dominant relation may establish an axial tendency, but it does not yet define a fully stable spatial orientation. Several mutually compatible relations are required before angular structure, orientation, and robust directionality can become meaningful.

RQM represents these persistent relational differences as geometric directions and rotational axes. A stable channel may therefore be drawn as connecting distinct locations, while a stable rotative identity may be represented through one or more characteristic axes. These axes do not precede resonance organization; they express stable patterns of resonance recurrence and accommodation.

In this sense, directionality is not imposed from outside. It emerges when resonance relations remain sufficiently persistent for their differences to be represented geometrically. The RQM description begins precisely at this point: where relational position has become stable enough to be modelled as direction, axis, and spatial arrangement.

8.2 From Resonance Separation to Geometric Distance

In RQT, separation describes the relational distinction required for resonance identities to remain distinguishable while still participating in shared organization. In RQM, this separation is projected into explicit geometric distance.

Geometric distance is therefore one of the central modelling foundations of RQM. It represents the equilibrium form of a resonance relation: the point at which identity separation, phase relation, preferred channel span, and rotational propagation are mutually compatible.

Resonance mismatch is then expressed geometrically and dynamically. A phase deviation may appear as distance variation, axis reorientation, altered coupling, or delayed transition through the surrounding network. Conversely, a change in distance implies a required accommodation of phase and channel conditions.

RQM thus treats distance not as empty background space, but as the spatial representation of stable resonance separation and its possible deviations.

8.3 From Channels to Spatial Representation

In RQT, a resonance channel represents a persistent resonance relationship between identities. It need not initially possess geometric length, width, direction, or shape. Its essential role is relational: it expresses a realized compatibility through which participating identities remain mutually constrained.

RQM projects such channels into spatial representation. A channel may be drawn as an edge, span, tube, or directed relation between distinct locations, depending on the level of detail required. These geometric features do not replace the resonance relation; they provide a modelling language for its equilibrium distance, phase condition, coupling strength, and possible deviation.

The spatial form of a channel may therefore encode more than simple connection. Length can represent preferred resonance separation, orientation can represent shared axis alignment, and width may later be used to visualize channel capacity, phase load, or subordinate span structure.

Not every relation in a hierarchical diagram is a channel. Hierarchical realization, inter-span transition, residual expression, and enclosure boundaries require distinct representation. RQM may draw these relations in the same figure, but they should remain conceptually separate from ordinary realized resonance channels.

8.4 Model Scope and Additional Assumptions

The Roton Quantum Model is a concrete modelling layer built upon the relational concepts of RQT. It assumes that sufficiently stable resonance organization can be represented as explicit three-dimensional geometry. Resonance identities become nodes or rotative structures, channels become spatial spans, and stable resonance separations become geometric distances.

This representation is intentionally simplifying. RQM projects resonance organization into three dimensions and separates complex trajectories into rotational contributions, characteristic axes, phase relations, and distance-locked structures. Dynamic behaviour is represented by deviations from equilibrium geometry, including phase mismatch, distance variation, axis reorientation, coupling strength, propagation delay, and torque-like accommodation demands.

The model therefore describes stable or quasi-stable resonance states together with the tensions that may disturb them. A structure remains stable as long as its internal accommodation can absorb external channel demands. If the imposed mismatch exceeds this capacity, the structure may reorganize, release channels, or dissolve into another configuration.

RQM does not claim that every relational feature of RQT is automatically geometric. Hierarchical realization, inter-span transition, residual expression, and external resonance exposure require additional modelling conventions. These conventions will be introduced only where needed for concrete physical structures.

The scope of RQM is therefore constructive: it provides a geometric and mechanical representation from which specific resonance identities, channel types, enclosures, and residual effects can be modelled and compared with physical systems.

8.5 From Relational Resonance to Directionality

RQT does not begin with space, direction, or dimensionality. It begins with identities and resonance relationships. A resonance channel is therefore not yet a line in space, but a relational constraint between identities. Distance, direction, and geometric alignment only become meaningful once such relational constraints are realized as a persistent structure. This is the conceptual bridge from the resonance theory (RQT) to a concrete model (RQM).

A whole nucleus could, in principle, be described as a pure resonance graph without assigning any three-dimensional position to its nodes. Geometry only enters when such a graph is projected into a spatial model. This raises a natural question: if stable resonance graphs are later mapped into space, which dimensionality would they prefer? Would the most stable realization be three-dimensional, four-dimensional, or even higher-dimensional? RQT itself does not postulate the answer. It only provides the relational structure.

The first important observation is that pure phase accommodation on a graph does not by itself select a preferred dimensionality. Simple simulations of resonance networks with identity nodes, channel nodes, local phase states, and inertial phase accommodation show that many symmetric topologies can settle into coherent oscillatory states. This suggests that dimensionality is not selected by topology alone. A graph can distribute phase, but it does not yet know what it means for two channels to be parallel, opposite, or linearly aligned.

The missing concept is not dimensionality itself, but directionality. In RQM, directionality appears through axial rotations and the alignment of resonance projections along shared axes. This axial alignment was previously postulated as part of the 3D model. From the RQT perspective, however, such alignment can be motivated by coherent propagation through the relational graph. A graph may possess entry and exit nodes such that resonance entering at one location can split into several equivalent paths, propagate through the structure, and recombine at a distinct opposite location. In that case, the graph has a directional propagation property before any geometric direction has been assigned.

This changes the interpretation of linear alignment. Linearity is not fundamental in RQT. Instead, it is the RQM realization of coherent relational propagation. When a resonance can pass through a structure and reappear at a distinguished opposite node with minimal internal accommodation, the later geometric embedding naturally represents this as an effective direction. Thus, what appears in RQM as a straight resonance axis is, at the RQT level, a stable entry–propagation–recombination path through the graph.

This also clarifies why some graph structures are nucleus-relevant while others are not. A proton-like isolated structure (e.g. tetrahedron) may expose residual channels, but it does not yet provide a strong global entry–exit propagation axis. A neutron-like isolated structure (e.g. triangular dipyramid) may have one weak linear possibility, but lacks stable topological continuation as an isolated object. A deuteron-like structure (e.g. octahedron) already offers several propagation axes, while an alpha-like structure has a much richer set of coherent propagation possibilities. In an icosahedral interpretation of the alpha particle, there are naturally six antipodal directions through which resonance can enter, circulate through multiple paths (around the sphere), and recombine. This gives the alpha particle a strong resonance potential in several directions.

The emergence of 3D can then be understood as an economy of resonance realization. Higher-dimensional regular structures, such as the 16-cell or 24-cell, provide elegant symmetry extensions. However, higher symmetry alone is not sufficient. A structure is favourable only if it increases coherent internal propagation while reducing exposed residual dependency. If a 4D extension adds many additional vertices and channels without improving the charge–mass–residual-channel

economy, then combinations of 3D structures may be more efficient. In this sense, nature need not maximize dimensionality. It may instead maximize reusable coherent resonance per exposed dependency.

RQM is therefore not introduced as an arbitrary 3D assumption, but as the dominant geometric realization of resonance structures whose relational propagation already contains effective directions. The RQT graph supplies coherence paths; RQM realizes them as axial resonance channels in 3D. Linear resonance alignment is then not merely a geometric convenience, but the visible projection of stable relational propagation. This provides a foundation for the central RQM idea that normal matter is built from aligned rotational resonance structures in three-dimensional space.

9 Local Resonance Optimization

9.1 What Does a Resonance System Optimize?

Standard physical descriptions commonly characterize stable systems as configurations of minimal energy. A transition toward a more stable state is therefore described as a descent toward a lower energy level, accompanied by the release of excess energy.

Within Resonance Quantum Theory, this description is inverted. A stable system is not regarded as a system that has merely lost energy. It is a system that has found a configuration in which a larger portion of its available resonance capability can be maintained within persistent, mutually compatible resonance relations.

The local optimization problem is therefore not primarily the minimization of an abstract energy quantity. It is the search for a reachable configuration in which the remaining externally exposed resonance capacity is reduced relative to the resonance capability maintained by the system.

A resonance structure is locally improved when it can:

- close more of its internal resonance channels,
- reduce the strength or number of externally exposed residual channels,
- distribute unavoidable mismatch across larger relational distances,
- maintain its resonance structure over longer temporal intervals,
- or separate a poorly accommodated substructure from the remaining enclosure.

The locally preferred state is therefore not necessarily the globally most enclosed state. A system can only enter configurations that are dynamically reachable through its presently available resonance channels.

This distinction is important for metastable structures and isotopes. An isotope need not be intrinsically unstable in an absolute sense. It may persist indefinitely as long as no nearby and dynamically accessible configuration offers a substantially improved resonance enclosure.

A decay process becomes possible when the existing structure encounters a pathway toward a configuration with lower residual exposure. Such a pathway may depend on internal oscillations, environmental coupling, nearby identities, or temporary resonance mismatches.

The optimization principle may therefore be stated as follows:

> Local resonance dynamics favor reachable configurations that maintain the greatest resonance capability while exposing the least residual channel capacity to their surroundings.

9.2 Resonance Capability and Residual Exposure

Let a resonance enclosure possess a total effective resonance capability

$$\mathcal{R}, \tag{1}$$

representing the amount of resonance activity that can be maintained, transferred, circulated, or committed to resonance channels.

This quantity should not yet be identified directly with conventional energy. It represents the ability of a structure to sustain resonance relations and to participate in further resonance formation.

A portion of this capability is committed to internally maintained resonance structures. We denote this part by

$$\mathcal{R}_{\text{enc}}, \tag{2}$$

whereas the externally exposed channel capacity is denoted by

$$\mathcal{C}_{\text{res}}. \tag{3}$$

The residual capacity includes all resonance channels that remain externally accessible, insufficiently matched, only temporarily answered, or dependent on the surrounding resonance landscape.

A first non-normalized measure of enclosure quality is then

$$\mathcal{Q}_{\text{enc}} = \frac{\mathcal{R}_{\text{enc}}}{\mathcal{C}_{\text{res}}}. \tag{4}$$

The quantity $\mathcal{Q}_{\text{enc}}$ may be called the *Resonance Enclosure Quotient*.

A structure improves its local resonance condition when

$$\mathcal{Q}_{\text{enc}} \to \text{maximum}. \tag{5}$$

The quotient is deliberately not normalized. A normalized ratio would conceal an important limiting behavior. If the residual channel capacity approached zero,

$$\mathcal{C}_{\text{res}} \to 0, \tag{6}$$

then

$$\mathcal{Q}_{\text{enc}} \to \infty. \tag{7}$$

Complete closure on all resonance spans would therefore correspond to an infinite limiting value rather than an ordinary physical state.

This suggests that absolute resonance closure is not a realizable configuration. A structure may strongly reduce its residual channels, but it cannot remove its resonance capability from the relational universe altogether.

A fully closed structure would possess no remaining channel through which it could:

- interact,
- propagate,
- be distinguished,
- be localized,
- or participate in a higher-level resonance identity.

Absolute closure would therefore remove the relational conditions under which the structure could remain part of physical reality.

This leads to a possible RQT interpretation of energy conservation:

> Resonance capability may be redistributed, enclosed, propagated, or transferred, but it cannot be removed from relational availability altogether.

Full closure is not a state available to an object within the universe; it is the defining boundary condition of the universe as a whole.

The enclosure quotient is meaningful only for substructures embedded in a larger resonance environment. Applied to the universe as a whole, it loses its comparative meaning: the universe has no external residual channels not because it has optimized them away, but because no external reference domain exists. The universal enclosure is therefore not an optimized object, but the boundary condition within which all local resonance optimization takes place.

9.3 Resonance-Residual Ratio

For comparisons between structures, a complementary quantity may be useful. The *Resonance-Residual Ratio* describes the residual channel capacity relative to the resonance capability maintained by the enclosure:

$$\mathrm{RRR} = \frac{\mathcal{C}_{\mathrm{res}}}{\mathcal{R}_{\mathrm{enc}}}. \tag{8}$$

The Resonance-Residual Ratio is the inverse of the Resonance Enclosure Quotient:

$$\mathrm{RRR} = \frac{1}{\mathcal{Q}_{\mathrm{enc}}}. \tag{9}$$

A low RRR indicates that a large amount of resonance capability is maintained with comparatively little external exposure. A high RRR indicates that the structure remains strongly dependent on external coupling or carries substantial unresolved resonance mismatch.

The optimization principle may therefore be written equivalently as

$$\mathcal{Q}_{\mathrm{enc}} \to \text{maximum}, \tag{10}$$

or

$$\mathrm{RRR} \to \text{minimum}. \tag{11}$$

The positive formulation is conceptually preferred:

> Nature locally maximizes resonance enclosure.

The minimization of residual exposure is then a consequence rather than the primary description.

9.4 Environmental Dependence of Channel Closure

Whether a channel is open, residual, reactive, or effectively closed cannot generally be determined from the subsystem alone.

A potential channel may remain unanswered in one environment and become fully accommodated in another. An externally extending channel is not necessarily residual if it participates in a stable higher-level resonance enclosure.

Accordingly, the effective residual capacity should be written as a function of both the subsystem S and its resonance environment $\mathcal{E}$:

$$\mathcal{C}_{\text{res}} = \mathcal{C}_{\text{res}}(S, \mathcal{E}). \tag{12}$$

The enclosure quotient is therefore also relational:

$$\mathcal{Q}_{\text{enc}} = \mathcal{Q}_{\text{enc}}(S, \mathcal{E}). \tag{13}$$

The same internal structure may consequently be stable in one environment and unstable in another.

This provides a natural interpretation of environmental decay, catalysis, induced transitions, and resonance competition. The surrounding structure does not merely add external energy. It changes which resonance channels can be answered and which alternative enclosures become reachable.

A channel may be considered effectively accommodated when it is:

1. internally closed within the subsystem,
2. persistently coupled to a compatible external identity,
3. integrated into a stable higher-level enclosure,
4. or maintained through a temporally coherent oscillatory relation.

A channel remains residual when no sufficiently compatible continuation is available within the relevant resonance distance and time.

9.5 Decay as Resonance Reorganization

Consider an initial resonance structure S that transforms into a remaining enclosure E and an emitted structure X:

$$S \to E + X. \tag{14}$$

In conventional language, the system releases energy and falls into a lower-energy state.

In RQT, the process is interpreted as a redistribution of resonance capability:

$$\mathcal{R}_S = \mathcal{R}_E + \mathcal{R}_X, \tag{15}$$

subject to the appropriate resonance relations between the resulting structures.

The transformation becomes locally favorable when the remaining structure achieves an improved enclosure quotient:

$$\mathcal{Q}_{\text{enc}}(E) > \mathcal{Q}_{\text{enc}}(S). \tag{16}$$

The emitted structure carries away resonance capability that could not be maintained efficiently within the previous enclosure. Its emission allows the remaining resonance pattern to reduce mismatch and to close a greater portion of its available channels.

The system has not become stable merely because it contains less conventional energy. It has become stable because the remaining resonance capability is organized more effectively.

This may be summarized as follows:

> A resonance enclosure may discard part of its structure when separation allows the remaining resonance capability to achieve a more complete local enclosure.

Matter–antimatter annihilation illustrates a more subtle aspect of this principle. The mutually compatible residual channels of the two material structures may allow an extremely rapid closure event. In RQT terms, this can be interpreted as an *enclosure snap-in*: a transition in which previously exposed complementary channels collapse into a far more complete internal resonance closure.

However, such a snap-in cannot remove all relational continuity with the surrounding universe. The residual resonance capability associated with the former material structures must remain represented within the accessible resonance landscape. Radiation is therefore not merely the leftover of an incomplete cancellation. It is the required outward continuation of those resonance components that cannot be absorbed into the snap-in quickly or symmetrically enough.

The emitted photons carry the residual channel structure that preserves relational continuity while the material enclosure itself disappears from the material sector.

9.6 Propagation as Temporal Channel Closure

The enclosure principle also applies to propagation.

A freely propagating structure reduces its effective exposure to a local environment by shortening the interval during which its residual channels remain accessible at any one location.

The effective residual capacity may therefore depend not only on structural channel strength, but also on local exposure time:

$$\mathcal{C}_{\mathrm{res}}^{\mathrm{eff}} \sim \mathcal{C}_{\mathrm{struct}}\, \tau_{\mathrm{exp}}, \tag{17}$$

where $\mathcal{C}_{\mathrm{struct}}$ represents the intrinsic residual coupling capability and τ_{exp} the duration of local accessibility.

A propagating structure can improve its enclosure condition by reducing

$$\tau_{\mathrm{exp}}. \tag{18}$$

Propagation is therefore not merely displacement through an already existing space. It can serve as a form of *temporal channel closure*.

A freely propagating photon may represent an extreme realization of this principle. Its internal resonance structure achieves its strongest enclosure when it propagates at the maximal coherent Sonon transition rate.

The photon does not eliminate all external channels. Otherwise, it could never be emitted, absorbed, or scattered. Instead, it reduces their local temporal accessibility.

A photon interacts again when a sufficiently compatible material or radiative resonance structure occupies the same local resonance region and can open a new channel configuration.

The transition may be represented schematically as

$$\text{free propagative enclosure} \rightarrow \text{temporary channel opening} \rightarrow \text{coupled transition structure} \rightarrow \begin{cases} \text{absorption}, \\ \text{scattering}, \\ \text{re-emission}. \end{cases} \tag{19}$$

During absorption, the free photon identity does not first become a slower photon. Its propagative enclosure opens and its resonance capability becomes integrated into the receiving system.

9.7 The Sonon Origin of the Local Propagation Limit

Within the Roton Quantum Model, the maximal propagation speed is not introduced as an abstract prohibition. It is associated with the geometry and period of the fundamental Sonon process.

Let

$$T_s \tag{20}$$

denote the characteristic Sonon period, and let

$$\ell_s \tag{21}$$

denote the maximal coherent transition length that a Sonon-based resonance structure can bridge during one period.

The maximal coherent propagation speed is then

$$c_s = \frac{\ell_s}{T_s}. \tag{22}$$

In the simplest geometric interpretation, ℓ_s may be related to the characteristic Sonon diameter:

$$\ell_s \approx d_s. \tag{23}$$

This yields

$$c_s \approx \frac{d_s}{T_s}. \tag{24}$$

The relevant length is not necessarily the complete rotational circumference. It is the maximal displacement over which the resonance structure can maintain cyclic self-closure between successive states.

For a propagating Sonon structure with velocity v, temporal closure requires

$$vT_s \leq \ell_s. \tag{25}$$

If

$$vT_s > \ell_s, \tag{26}$$

the next state lies beyond the coherent continuation range of the previous state. The resonance structure can no longer maintain its identity and must reorganize or disintegrate.

The local speed c observed in the measurable universe may therefore correspond to

$$c = c_s. \tag{27}$$

In this interpretation, c is the maximal coherent propagation speed of Sonon-based identities.

It appears universal because all presently measurable matter and radiation either consist of Sonon structures or interact through Sonon-compatible resonance channels.

The statement is therefore not necessarily that no imaginable structure could propagate faster than c. Rather:

> No freely propagating Sonon-based resonance identity can exceed the maximal transition rate at which its cyclic structure remains self-consistent.

9.8 Why Not Every Sonon-Based Structure Moves at c

The fact that the Sonon process defines a maximal transition rate does not imply that every Sonon-based identity must propagate at that rate.

A resonance enclosure may use its available resonance capability for different forms of closure:

- axial propagation,

- internal rotation,
- orthogonal oscillation,
- standing resonance,
- coupling to neighboring structures,
- or integration into a higher-level identity.

For a photon, maximal axial propagation may offer the most effective enclosure. Its freely propagating structure therefore assumes

$$v_\gamma = c. \tag{28}$$

For an electron or another inertial enclosure, a substantial part of the resonance capability is maintained within internal circulation and persistent external channel structures. Its center of identity is therefore not required to propagate at c.

A neutrino-like structure may contain an additional weak orthogonal oscillation. If the total Sonon transition capability remains bounded by c, one may write schematically

$$v_\parallel^2 + v_\perp^2 = c^2. \tag{29}$$

Its forward propagation speed would then be

$$v_\parallel = \sqrt{c^2 - v_\perp^2}, \tag{30}$$

and therefore slightly below c.

The additional oscillatory structure would simultaneously create a more complex resonance footprint, reducing its compatibility with ordinary material resonance channels.

This remains a conceptual RQM interpretation and requires further geometric development.

9.9 Resonance-Distance Landscape

RQT does not begin with geometric distance as a fundamental quantity. Distance must emerge from the difficulty of establishing or maintaining resonance relations between identities.

The relational distance between two structures A and B may be represented by the minimal cumulative mismatch required to connect them through an admissible resonance path:

$$d_R(A, B) = \min_{\mathcal{P}: A \to B} \sum_{e \in \mathcal{P}} \mu_e, \tag{31}$$

where

- $\mathcal{P}$ is a possible sequence of resonance transitions,
- e denotes one transition within this sequence,
- and μ_e is the mismatch or transition cost associated with that step.

The apparently empty universe is therefore not devoid of relational structure. It forms a low-density resonance landscape shaped by the residual channels of all existing identities.

Large accumulations of matter contain vast internal resonance capability and correspondingly large distributions of residual mismatch. This mismatch must be accommodated through relational distance and through the surrounding transition landscape.

At this stage, no gravitational interpretation is required. The relevant claim is more primitive:

Concentrated resonance enclosures alter the surrounding distribution of resonance compatibility and resonance-distance requirements.

A propagating photon must continuously fit its resonance structure into this existing distance landscape.

It does not require a permanently closed long-range channel to a predetermined destination. Instead, it maintains its identity by realizing a sequence of locally compatible transitions.

The photon creates a propagative resonance line through the continued preservation of:

- frequency,
- phase relation,
- polarization,
- propagation orientation,
- and temporal closure.

A possible receiving structure becomes relevant only when its local resonance channels provide a more favorable continuation than free propagation.

9.10 Why Photon Propagation Remains Three-Dimensional

A photon originates from a material resonance structure with a three-dimensional extension and orientation.

Its initial resonance configuration therefore inherits compatibility with the shared three-dimensional resonance landscape established by material identities.

Higher-dimensional internal excursions are not necessarily prohibited. A resonance structure may locally use additional dimensions for:

- compactification,
- orthogonal oscillation,
- temporary channel rearrangement,
- or internal rotational closure.

However, long-range propagation requires continued compatibility with the surrounding resonance-distance landscape.

A persistent drift into an unsupported higher-dimensional direction would accumulate mismatch because the surrounding long-range resonance structure does not provide an equally continuous set of compatible transitions.

The propagating identity therefore tends to return to the dominant three-dimensional continuation.

This can be expressed conceptually as

$$\text{long-range propagation} \rightarrow \text{maximum compatibility with the shared 3D resonance landscape.} \tag{32}$$

Three-dimensional propagation is thus not imposed as an external geometrical rule. It emerges as the most broadly supported long-range resonance continuation.

Lower-dimensional internal structures may remain preserved within the propagating identity. Rotational planes, phase surfaces, and polarization structures can retain two-dimensional characteristics while the complete photon remains embedded in the shared three-dimensional landscape.

This provides a conceptual bridge between RQT and the geometric structures introduced by RQM.

9.11 Nonlocal Resonance Without Direct Signal Transfer

Consider a higher-level identity

$$C = A + B, \tag{33}$$

formed by a resonance relation between two spatially separated substructures A and B.

The identity C is not merely a communication line between two otherwise independent objects. It is a single higher-level resonance enclosure whose local manifestations appear at A and B.

The relation can dissolve only when both sides can enter alternative resonance configurations.

Schematically,

$$C(A, B) \to C'(A', B'). \tag{34}$$

At A, the transition appears as a local change in environmental compatibility. At B, it likewise appears as a local change in environmental compatibility.

Neither side must observe a signal arriving from the other. Each side only observes that the previous higher-level identity can no longer be maintained and that a new local continuation has become available.

The transition is therefore locally causal at both ends while remaining globally constrained by the existence of the higher-level identity.

The nonlocal relation does not necessarily transmit freely selectable information. Instead, it restricts which local continuations can be jointly realized.

A measurable residual effect may appear in the switching inertia of the local structures. The time required for B to abandon its former channel and couple to a nearby structure B' may depend on whether the complete identity C remains capable of preserving its previous enclosure.

This could reveal information about the persistence or adaptability of the shared resonance relation, but not necessarily a freely encoded message sent from A.

The distinction may be summarized as follows:

> A nonlocal resonance channel does not primarily transmit information between its endpoints. It defines the temporal and structural conditions under which both endpoints may continue to participate in the same identity.

9.12 Temporal Extension and Bi-Temporal Compatibility

No resonance exists at a dimensionless instant.

A realized resonance must persist across a finite temporal interval and maintain compatibility between preceding, present, and possible subsequent states.

A resonance identity should therefore not be represented solely as

$$R(t), \tag{35}$$

but more generally as a temporally extended structure

$$R[t_0, t_1]. \tag{36}$$

Its existence requires compatibility across both relational distance and relational time.

This does not imply that future events rigidly predetermine the present. The future acts not as a fixed destination, but as a constraint on which present resonance structures possess viable continuations.

The concept may be described as *pre-possibility constraint* rather than predestination.

A present resonance configuration is realizable only if it can be continued into at least one temporally compatible resonance history.

In this sense, the complete RQT description is bi-temporal:

$$R(t - \Delta t) \leftrightarrow R(t) \leftrightarrow R(t + \Delta t). \tag{37}$$

Forward causality remains the practical local description of physical change. Bi-temporal compatibility expresses the deeper requirement that a resonance identity must remain coherent across its complete temporal extension.

The principle may be stated as follows:

> No resonance exists only at one place or one instant. Every realized resonance extends across resonance-compatible distance and resonance-compatible time.

9.13 Summary

Local Resonance Optimization replaces the image of physical systems descending toward abstract lower-energy states with the image of resonance structures searching for improved enclosure.

A locally favorable configuration maintains substantial resonance capability while reducing the capacity of externally exposed channels.

The central non-normalized quantities are

$$\mathcal{Q}_{\text{enc}} = \frac{\mathcal{R}_{\text{enc}}}{\mathcal{C}_{\text{res}}}, \tag{38}$$

and

$$\text{RRR} = \frac{\mathcal{C}_{\text{res}}}{\mathcal{R}_{\text{enc}}}. \tag{39}$$

The local dynamics tend toward

$$\mathcal{Q}_{\text{enc}} \to \text{maximum}, \tag{40}$$

or equivalently,

$$\text{RRR} \to \text{minimum}. \tag{41}$$

Complete closure is an unreachable limit because it would remove a structure from all relational participation.

Propagation can itself improve enclosure by reducing temporal exposure. For photons, maximal coherent propagation may therefore represent a form of temporal channel closure.

The measurable speed c is interpreted as the maximal coherent Sonon transition rate,

$$c = \frac{\ell_s}{T_s}, \tag{42}$$

rather than as an unexplained external restriction.

Distance emerges from resonance mismatch and transition cost. The apparently empty universe forms a resonance-distance landscape through which propagating identities must continuously maintain compatible closure.

Three-dimensional propagation remains dominant because long-range resonance continuation is most strongly supported within the shared three-dimensional structure inherited from material identities.

Finally, nonlocal resonance relations need not constitute direct information channels. They define higher-level identities whose local continuations must remain mutually compatible across both relational distance and temporal extension.

The combined principle is:

> Physical structures persist by maximizing the enclosure of their resonance capability across compatible distance and compatible time.

RRRR QQQ M M R R Q Q MM MM RRRR Q Q M M M R R Q QQ M M R R QQQQ M M

10 The Roton Quantum Model

The Roton Quantum Model (RQM) is the geometric projection layer of Resonance Quantum Theory. It does not replace the relational formulation of RQT, but provides a discrete spatial representation in which resonance identities, channel alignments, closure patterns, and residual couplings can be modeled as rotative structures.

In this model, stable identities are represented as rotating resonance enclosures composed of nodes, channels, centers, and phase relations. The purpose of RQM is not to derive all physical constants from first principles, but to provide a compact geometric language for comparing resonance structures, identifying closure conditions, and approximating interaction capacity.

10.1 Purpose of the Model

The Roton Quantum Model (RQM) is the geometric projection layer of Resonance Quantum Theory. It translates the relational concepts of RQT, such as identity, coupling, separation, and closure, into a discrete spatial model of rotating nodes and linear resonance channels.

RQM maps resonance mismatch into geometric distance, phase displacement, coupling alignment, and transition capacity. Its purpose is to make resonance organization geometrically visible and to prepare a later framework in which matter formation, charge, and inertia may be described quantitatively.

The model is intentionally built from only a few intuitive primitives:

- localized resonance nodes,
- directed resonance channels,
- rotational closure.

Stable particles are modeled as resonance enclosures. Interactions are modeled as resonance channel relations between such enclosures, including the residual openness that remains after internal closure.

RQM is therefore not a separate ontology, but a compact construction language for RQT. It describes matter as an emergent geometry of placed nodes, aligned channels, closed rotations, and remaining interaction capacity.

10.2 Model Scope and Interpretation

RQM should be read as a simplified geometric representation of resonance organization. Its nodes, channels, centers, and rotations are not introduced as classical mechanical objects, but as spatial projections of relational resonance structure.

The model therefore does not claim that matter is made from small solid bodies connected by physical tubes. Instead, it represents resonance identities as localized structures, resonance relations as directed channels, and stable configurations as rotationally closed enclosures.

Geometric distance in RQM is the projected form of resonance separation in RQT. Likewise, alignment, phase displacement, and residual openness are geometric expressions of resonance compatibility, mismatch, and remaining interaction capacity.

The scope of RQM is constructive and interpretive: it provides a compact language for modeling stable particles, interactions, and composite matter, while the deeper ontological foundation remains the relational framework of RQT.

In this interpretation, matter begins when resonance stops being only an open propagation and becomes a stable rotational closure.

10.3 Rotons

A *Roton* is a rotational resonance structure in RQM. [1] As a pure prototype, it can be imagined as two compatible resonance identities rotating around a shared center, forming one closed circular relation rather than two independent objects. A Roton marks the transition from open resonance propagation to closed or partially closed identity.

In its simplest geometric image, a Roton is depicted as a circle with its 3D symmetry axis as the rotation axis. In this sense, the term Roton must be read as a recurring structural pattern: a primary constructive pattern of matter formation. It is not the smallest element of the model and does not refer to any fixed size or scale.

Inspired by the physical concept of entanglement, RQM treats stable particles and composite structures as internally closed resonance relations. Such structures can align, combine, and expose external channels through which further interaction remains possible.

Terminology note. The term *Roton* is already used in physics for a quasiparticle excitation, most prominently in superfluid helium. RQM does not adopt this term in that established technical sense. Instead, it uses Roton as a model-specific name for a rotationally closed resonance pattern. The shared intuition is rotational and collective, but the definition within RQM is distinct.

10.4 Sonons

While the Roton describes a closure pattern between compatible resonance identities, the *Sonon* denotes the smallest resonance polarity from which such identities may be constructed.

A Sonon is the smallest rotationally resonant object considered in RQM. It is not a Roton in the strict sense, because it is not composed of two compatible resonance identities rotating around a shared center. Instead, it represents the minimal internal polarity of resonance itself.

Geometrically, a Sonon may be pictured as a rotating crest–trough relation: two opposite aspects of one resonance expression. In RQM this is projected as a planar rotation with a minimal three-dimensional extension, rather than as a compound structure made from smaller identical parts.

The Sonon therefore serves as the fundamental resonance object of the model. The smallest Roton is not the Sonon itself, but a closed rotational relation between two Sonons. Larger particles and composite structures are then built from Roton patterns formed by such elementary resonance objects.

Terminology note. The term *Sonon* is used here in a model-specific sense. While related terms occur in phonon-like, sound-like, or quasiparticle-inspired contexts, RQM defines the Sonon specifically as the smallest rotationally resonant object: a minimal crest–trough polarity projected into rotation.

10.5 Resonons

A *Resonon* is a stable resonance structure that is not self-stable as an isolated rotational identity. Unlike a Roton, it does not form a closed identity by itself, but remains stable only as part of a larger compound configuration.

In RQM, the term is used for shared resonance patterns that are maintained by the surrounding structure. A Resonon may therefore be understood as a dependent resonance stability: real within the compound, but not separable as an isolated independent particle-like enclosure.

The concept becomes relevant whenever a resonance relation is stable enough to shape a structure, but not closed enough to exist on its own.

[1] The term *Roton* already exists in physics e.g. in context of superfluid helium. RQM uses the word in a different, model-specific sense.

10.6 Resonance Positions: Nodes and Centers

RQM uses the terms node and center for localized resonance positions. They are not different geometric objects, but different roles of the same type of position.

A node is such a position within a structural graph, grid, channel network, or compound geometry. A center is the same position when it acts as the rotational, coupling, or balance point of a Roton or larger resonance structure.

The distinction is therefore functional rather than spatial: nodes describe structure, centers describe rotation and coupling.

10.7 Roton Orientation, Axis, and Phase

In geometric form, a Roton can be represented by a center, a rotation plane, and a normalized axis vector perpendicular to that plane. Its rotating sub-structure is described by a characteristic radius around the center. The axis gives the Roton an orientation, and relative to this orientation the Roton may be compared with other Rotons as parallel, anti-parallel, or misaligned.

A Roton also carries a phase state. When two Rotons enter a resonance relation, their axes first define the compatibility of their rotation planes. Within such an aligned channel, their phase relation defines the distances at which the channel can become stable.

In RQM, stable distance is the spatial expression of phase compatibility. Equal parallel-aligned Rotons may lock at multiples of a characteristic length, including zero. If the phases do not match, the distance cannot remain fixed and drifts until a compatible phase-distance condition is reached.

This can be pictured as nuts on a long screw thread: stable positions exist only where the nut phase matches the thread. Dynamic configurations may therefore change distance until their phases lock again. In later applications, the remaining mismatch of such a phase-distance condition will be interpreted as the source of directed motion or acceleration.

10.8 Linear Resonance Channels

A linear resonance channel is the simplest geometric representation of a resonance relation in RQM. It is modeled as a directed connection between two localized resonance positions.

Such positions may be called nodes when they are considered as parts of a structural graph, or centers when they act as rotational or coupling centers. The geometric point is the same; the distinction only describes its role in the model.

The term linear does not imply that resonance is a classical straight object. It means that, within the geometric projection of RQM, the relation is approximated by a direct alignment between the participating structures. A channel may connect Sonons, Rotons, Resonons, nodes, centers, or larger compound structures, depending on the scale of description.

The presence of a channel is determined by the compatibility of its participating resonance endpoints and their ability to share an axis. Once present, the channel constrains these endpoints to a required relation of axis, position, phase, and distance. A channel is therefore not only a connection, but also a geometric constraint.

10.9 Channel Stabilization Modes

A resonance channel does not determine by itself whether a structure becomes rotational, static, or externally open. The resulting mode depends on axis orientation, phase relation, distance, and the available closure geometry.

In RQM, a channel may support several modes of stabilization. Anti-parallel orientation may lead to rotational closure, where two structures form a higher-level Roton. Parallel orientation may instead support distance locking, where structures remain at a preferred resonance distance and contribute to a static compound geometry.

If no stable rotational closure or distance locking is available, the channel remains externally open. Depending on context, such openness may appear as a short-range realized interaction, a long-range channel relation, or a residual channel after incomplete closure.

10.10 Model Limitations

RQM should not be read as a literal mechanical model. Its nodes, centers, axes, channels, and rotations are geometric projections of resonance relations, not small solid bodies or physical tubes.

The model primarily describes stable relational geometry. It is therefore most useful for configurations involving rotational closure, phase locking, distance locking, and persistent channel relations. Transient, chaotic, thermal, or dense many-body processes may require additional dynamical assumptions.

RQM also remains incomplete as a quantitative framework. While it prepares a language for describing charge, inertia, coupling, and acceleration, the exact mapping from RQM geometry to measured physical constants and observables is not yet fully established.

For this reason, every RQM construction must remain open to comparison with standard physical results, including spectra, masses, decay behavior, conservation rules, and interaction patterns.

These limitations do not reduce the intended scope of RQM, but define its current status: a minimal geometric language for stable resonance organization.

11 Elementary Resonance Structures

11.1 Basic Channel Relations

Before applying RQM to specific structures, a few rudimentary channel relations can be stated symbolically. These expressions are not yet complete physical laws, but define the geometric quantities used later.

An externally residually open channel between two resonance endpoints (i) and (j) may be represented by

$$E_{ij}(r) = \frac{\rho_i \rho_j}{r_{ij}^2},$$

where $(\rho_i) and (\rho_j) denote endpoint resonance capacities and (r_{ij}) is their geometric distance. If such openness re$

The relative axis orientation of two Rotons can be written as

$$s_{ij} = \hat{a}_i \cdot \hat{a}_j,$$

where $(_i) and (\hat{a}_j) are normalized axis vectors. Values near (+1) describe parallel alignment, values near (-1) an$
$parallel alignment, and values near (0) misalignment. In RQM, anti-parallel alignment is associated with rotatio$

For a realized or locked channel, distance and phase are linked. With $(k = 2\pi/\lambda)$, $stable channel distances satis$

$$\Delta\phi_{ij} = k r_{ij} \mod 2\pi,$$

or

$$r_{ij}^{(n)} = \frac{2\pi n + \Delta\phi_{ij}}{k}.$$

A deviation from this condition defines a phase-distance mismatch,

$$\epsilon_{ij} = \text{wrap}\, 2\pi (krij - \Delta\phi_{ij}).$$

In dynamic situations, this mismatch produces a channel drive,

$$C_{ij} = -\kappa_{ij}\epsilon_{ij},$$

where $(\kappa_{ij}) describes the effective coupling stiffness of the channel. The term (C_{ij}) is not introduced as a classic$

11.2 Photons

In RQM, a photon is modeled as the simplest propagating resonance enclosure. It is interpreted as a closed relation of two opposite Sonon aspects, forming a neutral rotating structure that can travel as a stable phase relation.

Unlike a material Roton, the photon does not form a distance-locked structure with external matter. Its internal closure is stable, but its external position remains open. It therefore appears not as a resting object, but as a propagating resonance identity.

The photon can be emitted when an existing resonance structure releases a closed channel relation, and it can be absorbed when another compatible structure opens or resolves such a relation. In this sense, photons are exchanged between resonance systems rather than merely shot through empty space.

Its frequency describes the recurrence rate of the internal closure. Its wavelength describes the phase-distance condition of its propagation. Its energy expresses the capacity of this travelling closure to change the resonance state of the structure that absorbs it.

The effective Photon consisting of two Sonons has an initial and final rotation radius and speed. Given the Bohr-Radii of two electron excitation levels and assuming the standard physics electron rotation speed, the Roton radius of an atom emmited photon might by approximated via the formula ... to ... for a d3-d2 transition giving a ratio to the Bohr radius of: ... comparing some balmer line photon frequencies.

11.2.1 Photon Propagation

In RQM, a free photon propagates because its internal resonance closure cannot form a stable external rest-locking relation. Remaining fixed would expose compatible external channels and destabilize the photon as an independent travelling closure. Propagation is therefore its stable external mode.

Geometrically, the photon is treated as an almost planar resonance enclosure. Its dominant structure is a two-dimensional rotating relation, while its three-dimensional extension is limited to the small rotation radius of the underlying Sonon aspects. This further limits external coupling.

The value of this propagation speed is not defined by the photon itself, but inherited from its underlying Sonon structure. A Sonon can propagate only as fast as its own rotational resonance can return to itself. If translation outruns this recurrence, the Sonon can no longer maintain its oscillatory coherence.

Therefore (c) is interpreted as the limiting propagation rate of the Sonon layer,

$$c = \frac{\lambda_s}{T_s} = \lambda_s f_s,$$

where $(\lambda_s), (T_s), and (f_s) describe the characteristic propagation length, period, and frequency of the underlying$

In matter, photons may propagate with an effective speed below (c) because their resonance closure repeatedly couples to the surrounding material structure. This coupling changes the effective propagation mode and shortens the propagation wavelength, while the photon frequency and its characteristic internal Roton scale remain fixed.

11.2.2 Photon internal Roton scale

As an exploratory RQM interpretation, the emitted photon may be assigned an effective internal Roton scale in addition to its longitudinal wavelength. The wavelength $(\lambda_\gamma) remains the phase -$

$return length of the expelled photon during propagation at (c). The internal Roton scale, however, can be back-calculated from the transition frequency and the Bohr-like circulation speeds of the participating atomic clevels.$

For a hydrogen transition (m→ n), $using (v_n = \alpha c/n), this gives the effective photon-Roton diameter$

[$D_\gamma^{(m\to n)}$

$2mn\overline{m-na_0.}]$

For Balmer transitions (m→ 2),

[$D_\gamma^{(m\to 2)}$

$4m\overline{m-2a_0}$

$m\overline{m-2r_2.}]$

Thus, the internal photon scale is not identified with the wavelength. Rather, RQM proposes that the characteristic Roton scale of a photon can be derived from the geometric conditions present during its creation process. This scale is obtained from the same transition frequency that later defines the propagated wavelength, but it appears as an internal rotational scale inherited from the participating atomic resonance levels. The photon wavelength, by contrast, describes the longitudinal phase-return of the released closure during propagation.

The photon wavelength and the internal photon-Roton scale are separated by a large factor. For hydrogen transitions, the ratio between wavelength and internal Roton diameter is governed mainly by the inverse fine-structure constant, with an additional rational factor determined by the participating resonance levels:

[$\lambda_\gamma \overline{D_\gamma}$

$2\pi \overline{\alpha \frac{mn}{m+n}.}]$

For Balmer-like electron transitions from (m=3,. . . ,6) to (n=2), this exploratory estimate gives

[$\lambda_\gamma \overline{D_\gamma \approx 1034...1293.}]$

Thus, the characteristic internal Roton scale of the emitted photon remains close to the atomic resonance geometry, while the photon wavelength is much larger and describes the longitudinal phase-return length of the released closure during propagation.

11.3 Electrons

An electron is a three-Roton enclosure with a shared center and spatial channel accommodation.

$$\text{Electron}_{\text{RQM}} = 3\,\text{Sonons at one resonance position with mutually perpendicular axes}$$

In RQM, an electron is modeled as three Sonons sharing the same resonance position. Their axes are oriented perpendicular to one another, so that the electron is the first structure whose resonance closure reaches a genuinely three-dimensional form.

The electron is therefore not a point-like particle. Its center may appear point-like to external interactions, because the available e-span channels originate from a common resonance position. However, the structure itself is not concentrated in a mathematical point. Its identity lies in the closed self-resonance of three mutually accommodating rotational components.

In equilibrium, the three Sonon phases are identical. The three axes expose six symmetric channel directions, while handedness describes the internal orientation relation of the Sonon rotations. Phase differences occur only during accommodation, when an external coupling or torque displaces one component and the other components must adjust.

This is the first RQM structure in which inertia appears. A photon can propagate as a two-Sonon closure, but an electron must continuously accommodate several spatial channel directions at once. Coupling to one channel therefore affects the whole enclosure. A torque or phase displacement temporarily increases the required internal resonance space until the three-channel configuration returns to equilibrium.

If the required accommodation exceeds the stable internal resonance space, the electron enclosure can no longer remain intact. In the symmetric case, such a disintegration would release photon-like closure structures.

Thus, the electron is the first stable three-dimensional resonance enclosure of RQM: not a singular object, but a compact self-resonant structure with three perpendicular Sonon axes, common phase in equilibrium, and exposed e-span channels.
[2]

11.4 Electron Interactions

Because an electron has a three-dimensional inertial character, it is not reducible to a single open channel. It is a compact e-span enclosure whose exposed channel directions can enter distance, phase, handedness, and alignment relations with similar resonance structures.

Before moving to more complex matter structures, RQM first tests whether the Roton hierarchy can continue in the simplest possible way. If an electron-like enclosure is a stable three-Sonon structure, the next question is whether two compatible e-span enclosures can form a higher-level Roton.

This motivates the discussion of complementary electron-like structures and their compounds. The purpose is not to import the standard concept of electric charge into RQM. At this stage, RQM speaks only about resonance channels, phase relations, handedness, alignment, and closure. What standard physics describes as opposite charge is here treated as complementary e-span orientation and handedness compatibility. This is first an attribute of the realized channel relation, not a primitive property assigned to an isolated particle.

11.4.1 Electron Interaction Modes

At short distances, RQM proposes that electron-like enclosures may align along phase-matched distance-locking positions. In such cases, their e-span channels can remain mutually phase-aligned by occupying compatible geometric separations. This regime belongs mainly to nuclear-level interactions, where direct e-span channel relations may still become relevant.

At atomic scales, stationary e-span nodes may provide anchors for stable rotational orbitals. These configurations also correspond to mutual channel accommodation at the e-span level, but through a larger compound structure rather than direct electron-electron closure.

At longer distances, only residual e-span exposure remains. Two same-class electron-like enclosures do not normally form a closed higher-level Roton. Their exposed channels compete for compatible resonance space, and the required phase accommodation tends to increase their separation until the residual mismatch is reduced. In standard physics this appears as electron-electron repulsion; in RQM it is interpreted as unresolved interaction between same-class e-span enclosures.

Macroscopic repulsion experiments do not isolate two electron-like objects. Charged bodies involve conductors, surfaces, air, supports, and the surrounding material environment. Their observed separation may therefore be read not as primitive mutual repulsion, but as collective relaxation of accumulated e-span exposure toward less saturated accommodation regions.

Thus, what standard physics describes as repulsion between like charges may correspond in RQM to attraction toward better available accommodation space.

11.5 Complementary Electron Modes

In RQM, a positron is introduced only as a standard-physics reference to a complementary electron-like mode. It has the same basic three-Sonon organization as the electron, but its internal

[2] In RQT, the electron may be interpreted as a single three-dimensional resonance trajectory with dedicated rotational structure. RQM separates this compound trajectory into three perpendicular Sonon-Roton components in order to model its geometry explicitly.

handedness and phase-orientation relations are compatible in the opposite way.

Like the electron, such a complementary e-span object consists of three co-located Sonon components with mutually perpendicular axes. It exposes the same type of e-span channel structure. The relevant difference is not expressed as a separate sign property, but as the way its internal Roton handedness aligns with other electron-like structures.

At this stage, RQM does not specify whether a standard-physics positron differs from an electron beyond this complementary coupling behavior. RQM therefore uses the general term electron-like e-span object unless the standard distinction is explicitly relevant. This reflects the fact that charge is not a base concept of RQM; possible standard-physics charge effects are introduced only later as projections of different e-span channel properties.

11.6 Two-Electron e-span Compounds

A two-electron e-span compound is the first test of whether electron-like enclosures can act as components of a higher-level Roton hierarchy. In the simplest case, two complementary electron-like enclosures align and form a positronium-like Roton compound.

In this compound, one e-span channel closes into a shared rotational relation. However, each component carries three e-span axes. After one channel pair has closed, four e-span channel directions remain only partially accommodated. The compound is therefore not fully self-stable: it forms a higher-level Roton locally, but does not close all exposed lower-layer channels.

This corresponds to the short lifetime of positronium in standard physics. Depending on its spin configuration, ground-state positronium survives about (0.124,ns) as para-positronium or about (142,ns) as ortho-positronium in vacuum. In matter, the lifetime can be further shortened by interaction with the surrounding medium.

From the RQM perspective, the distinction between para-positronium and ortho-positronium may indicate two different rotatory closure modes of a two e-span system. Since RQM does not treat charge as a primitive property at this stage, the positronium-like compound may be modeled as two complementary electron-like enclosures whose shared channel relation cancels the external e-span projection of the closed channel. One of the standard positronium states may therefore correspond to a two-electron-like rotatory system with no net external e-span exposure along the realized channel.

Thus, two-electron e-span compounds show that higher-level rotation does not guarantee higher-level enclosure. The remaining e-span openness leaves the compound susceptible to decay into photon-like closure structures, depending on its internal symmetry and environment.

The next possible hierarchy level would be a Roton compound of two positronium-like structures. Such a structure could partially accommodate additional residual e-span channels, but would still not necessarily become a stable matter-building block.[3]

In asymmetric decay cases, not all remaining resonance structure must be released as purely photon-like closure. A residual propagating structure with slight three-dimensional imbalance may remain. This motivates the following discussion of neutrino-like structures.

11.7 Neutrino-like Structures

In RQM, a neutrino-like structure may be interpreted as an asymmetric residual of an incomplete e-span compound decay. Unlike a photon-like closure, which remains nearly planar and propagates as a clean two-Sonon relation, a neutrino-like residual would retain a small three-dimensional imbalance.

This imbalance can be pictured as a weak wobble or precession of an otherwise photon-like propagation structure. It prevents the residual from becoming a standard photon-like closure,

[3]Standard physics knows molecular positronium, or di-positronium, ($Ps_2 = (e^-e^+)(e^-e^+)$), $a short-lived bound system of two positronium atoms. In RQM this corresponds to a higher compound of two partially closed two-electron-span systems. Its measured lifetime remains extremely short, of order (0.22, ns), suggesting partial additional closure rathe$

but also makes it poorly compatible with ordinary atomic e-span channels. As a result, such a structure would interact only weakly with matter.

The neutrino-like object is therefore not introduced here as a stable matter enclosure. It is a propagating residual: sufficiently closed to persist over long distances, but geometrically mismatched to most available resonance channels. In standard physics comparison, this corresponds to the weakly interacting character of neutrinos.

12 Nuclear Resonance Structures

12.1 Channel Types and Endpoint Constraints

Before introducing proton-like structures, RQM needs a short distinction between channel modes and endpoint constraints. A channel may be open, realized, distance-locking, rotationally enclosed, or residual. Open channels describe available resonance exposure; realized channels are active relations; distance-locking channels stabilize preferred separations; rotationally enclosed channels form higher-level Rotons; residual channels remain after incomplete closure.

An anchored channel is a realized resonance relation whose endpoint is constrained by a larger resonance structure. The constraint may appear as positional restriction, phase restriction, axis alignment, or distance locking. These aspects are not sharply separated in RQM; anchoring usually combines them with different weights.

Thus, a free electron-like enclosure is mainly phase-constrained by its own internal Roton state, while a proton-side e-span endpoint is mainly position-constrained by the proton geometry. In a realized proton-electron channel, both constraints act together.

12.2 Resonance Structure Notation

As resonance identities become more complex, their internal structure and external coupling properties are difficult to describe repeatedly in prose. RQM therefore uses a compact structural notation that distinguishes the resonance relations forming an identity from the resonance properties exposed to higher structural levels.

$$\underbrace{[\text{resonance structure}]}_{\text{identity}} \;\Big|\; \underbrace{\text{external resonance signature}}_{\text{higher-level interaction}}$$

The structural part describes how lower-level resonance entities combine into a higher-level identity. Square brackets denote the identity currently represented, while parentheses may be used for enclosed lower-level substructures. A dash denotes direct mutual resonance closure,

$$e - e,$$

whereas the symbols $<$ and $>$ indicate directed structural anchoring between different resonance levels.

Subscripts indicate multiplicity. Thus q_3, e_2, and s_2 denote three q-span, two e-span, and two s-span contributions respectively. For orbital spans, the resonance family is included in the symbol itself, for example o1, o2, and o3, while a subscript continues to indicate multiplicity.

The external resonance signature contains only properties relevant outside the represented identity. Entries without further marking denote resonance channels that remain available for higher-level coupling. A superscript r denotes *residual exposure*,

$$q_{12}^{r},$$

which contributes externally but does not represent independently addressable channel potential. New channel closures may nevertheless become available if the underlying resonance structure is reorganized under sufficiently close and compatible coupling conditions.

The notation is intentionally structural rather than exhaustive. Internal closure mechanisms that have already been defined for a lower-level entity are normally omitted unless they are relevant to the current discussion.

Notation	**Meaning**
$[\cdots]$	resonance identity currently represented
$(\cdots)$	enclosed lower-level substructure
$-$	direct mutual resonance closure
$<,>$	directed structural anchoring
^{n}	multiplicity of equivalent span contributions
^{r}	residual external exposure; no directly addressable channel
$\Big\vert$	separates internal structure from external resonance signature
$s, e, q, \mathrm{o1}, \mathrm{o2}, \ldots$	Sonon-, electron-, quon-, and orbital-span types
p_λ	photon identity characterized by wavelength λ

Table 1: Compact syntax used for RQM resonance structure notation.

For example, a photon formed from two mutually closed Sonon contributions may be written as

$$\boxed{p_\lambda = [s - s]}$$

where the wavelength λ characterizes the resulting photon resonance.

A proton may be represented schematically as

$$\boxed{P = (e < q_3) \,\Big|\, e,\ q_3^r}$$

indicating one externally available e-span channel together with residual exposure originating from three q-span contributions.

The notation therefore serves as a compact structural identity card rather than as an equation of motion. It will be used throughout the following sections to summarize the internal resonance organization and externally relevant resonance signature of particles, atoms, and molecules.

12.3 From Electron-like Enclosures to e-span Nodes

The previous discussion used electron-like enclosures as the first stable examples of e-span structures. For the following construction, however, RQM no longer treats the participating objects as free electrons or orbital electrons. Once e-span structures become confined inside a higher resonance geometry, their role changes.

RQM therefore switches to the more general term *e-span node*. An e-span node is a localized resonance component that can participate in e-span channel relations without being identified with a free electron. It may retain e-span compatibility, but its identity is now defined by the compound structure in which it is embedded.

This distinction is essential for nuclear-level geometry. The e-span components of a proton-like structure are not electrons placed at fixed corners. They are confined e-span nodes forming new internal resonance modes. Only one resulting e-span relation may remain externally available as an open channel for later electron-proton coupling.

12.4 From Rotons to Distance-Locked Geometry

The electron-positron case shows that a simple two-object Roton hierarchy does not automatically produce stable higher-level matter structures. A shared rotational channel can form, but remaining e-span channels prevent complete enclosure. RQM therefore next considers a different construction principle: distance-locked channel geometry.

Lower-level e-span relations allow e-span nodes to enter distance-locked arrangements and form new composite structures. These composites no longer behave like isolated electron-like enclosures. Their nodes are confined by the compound geometry and may support new resonance modes within the whole structure.

If e-span channels can stabilize a preferred distance, then multiple e-span endpoints may arrange into spatial structures with approximately equal channel lengths. This opens the geometric layer of RQM. The simplest primitives are the line segment, the equilateral triangle, and the tetrahedron. The tetrahedron is the first fully three-dimensional equal-edge enclosure and therefore becomes the natural first candidate for a stable nuclear-level geometry.

Higher regular structures, such as the octahedron and icosahedron, may provide further symmetric arrangements of distance-locked channels. Cubic and dodecahedral forms may also appear as compound or dual geometries, but they are not the first primitives of equal-distance closure.

Such node structures need not remain stationary. Once several distance-locked channels coexist, the nodes themselves may begin to rotate or oscillate while preserving their channel relations. RQM interprets this as the transition from static e-span geometry toward higher-level rotating node systems. These confined rotating node relations will later be described as q-span structures.

The proton will therefore not be introduced as an isolated point-like object, but as a proposed tetrahedral resonance geometry: the first compact nuclear-level enclosure built from distance-locked e-span relations.

12.5 Toward Proton Geometry

The previous sections introduced e-span nodes as confined resonance components rather than free electrons. This distinction becomes essential for the proton. A proton-like structure must not be understood as an electron-like object with opposite sign, but as a different resonance identity that nevertheless exposes an e-span-compatible endpoint.

This requirement explains why RQM constructs the proton from lower-level e-span geometry. An electron-like enclosure and a proton-like enclosure could not form a stable atom-like channel as whole objects unless the proton contained a substructure capable of presenting an e-span relation to the outside. The proton must therefore provide an anchored e-span node: a channel endpoint constrained by the internal proton geometry, but still compatible with an external electron-like e-span enclosure.

The smallest candidate for such a structure is a symmetric tetrahedral arrangement of four e-span nodes. One node remains comparatively stationary and provides the externally available e-span endpoint. The remaining three nodes enter a confined oscillatory resonance mode. In the proton model, these three oscillating nodes are called q-span nodes, or quons.

The role of the tetrahedral geometry is to keep the internal e-span channel lengths nearly equal while allowing the three q-span nodes to oscillate with identical radius around the stationary p-node relation. This produces a compact nuclear-level enclosure whose externally available e-span endpoint is position- and phase-constrained by the whole structure.

Thus, the proton is introduced in RQM as the smallest stable resonance geometry that can anchor an e-span channel for electron coupling.

Basic RQM notation. For the structural notation used below, s denotes the elementary resonance mode, or *sonon*. A photon is represented as a linear two-sonon resonance,

$$\boxed{p_\lambda = (s - s)}$$

whereas the electron is modeled as a multidimensional sonon enclosure,

$$\boxed{e = [sss]}$$

with several available e-span coupling directions. The symbols s and e provide the basic resonance notation required for the composite structures introduced below.

12.6 Protons

Before introducing the proton structure, we briefly state the elementary RQM notation used below. The symbol (s) denotes the elementary resonance mode, or *sonon*. A photon is represented as a linear two-sonon resonance,

$$[\ \boxed{p_\lambda = (s - s)}\ ]$$

while an electron is modeled as a multidimensional sonon enclosure,

$$[\ \boxed{e = [sss]}\ ]$$

capable of realizing multiple e-span couplings.

Within a distance-locked compound, an e-type node may enter a confined self-rotating state. Such a node is termed a *quon* and is represented schematically as

$$[\ \boxed{q = [e^{\circlearrowleft}]}\ ]$$

where $(\mathrm{e}^{\circlearrowleft})$*denotestheself−rotatinge−typeresonancestate*, *thebracketsindicatethatthestateisnotanindepen*
spannodewhosestableexistencedependsonthesurroundingcompoundgeometry.

Using this notation, the proton is represented by

$$[\ \boxed{P = (e < q_3)}\ ]$$

where the enclosing parentheses denote the proton as a composite resonance structure, (e) denotes its comparatively stationary anchored e-span node, and (q_3)*denotesthethreeconfinedq−spannodesformingtheremainingverticesofthetetrahedralgeometry*.

Where the externally available resonance character is relevant, the structural expression may be supplemented by its external resonance signature,

$$[\ \boxed{P = (e < q_3); |; e, ; q_3^r}\ ]$$

where the vertical separator distinguishes the internal structural identity from the resonance character presented by the completed structure. The (e)-term denotes the available anchored e-span channel, while (q_3^r)*denotesresidualq − spanexposureoftheconfinedquonstructure*.

In RQM, the proton is therefore modeled as a tetrahedral e-span enclosure consisting of one comparatively stationary e-span node and three oscillating q-span nodes. The quons are not self-sustained free particles; their resonance state exists only within the distance-locked proton compound.

Each quon performs a mostly circular oscillation along a toroidal resonance path centered on its corresponding (eq)-axis. The three quon motions remain phase-related so that the internal e-span channel lengths stay nearly balanced. The proton is therefore not a static tetrahedron, but a rotating and oscillating resonance enclosure whose stability depends on symmetric channel accommodation.

Relation to standard-physics concepts. In RQM, the inertia and gravitational effect associated with the proton are attributed primarily to the confined quon oscillations and, to a lesser extent, to the surrounding tetrahedral resonance lattice. Its externally available e-span character is associated with the anchored (e)-node and corresponds phenomenologically to what is described as electric charge in standard physics.

For conceptual comparison, the confined quon modes are related to the role attributed to quarks, while the resonance lattice plays a role broadly comparable to the gluonic binding structure. These correspondences are not intended as one-to-one identifications. In RQM, neither the quons nor the connecting resonance lattice are treated as independently extractable components; they are internal modes and relations of the proton resonance geometry.

Importantly, the quon was not introduced in order to reproduce the quark concept. It emerged from the internal requirements of the RQM construction itself. Starting from distance-locked resonance grids, additional structural latitude was introduced by allowing confined grid nodes

to enter oscillatory and rotational modes while remaining bound to the surrounding geometry. This additional degree of internal resonance freedom became necessary when constructing stable proton, neutron, and later alpha-cluster geometries. Only retrospectively does the resulting threefold confined structure show a conceptual resemblance to the quark description of the proton.

12.6.1 Electron Coupling

The anchored (p)-node provides the proton-side endpoint of an e-span channel. Because this endpoint is constrained by the proton geometry, an external electron-like enclosure can adjust its phase and distance relation to it. The atom-like relation is therefore not a whole-object coupling between electron and proton, but a realized e-span channel between an electron-like enclosure and the anchored (p)-node of the proton. The p-node does not expose three external e-span channels: three e-span relations are already internally occupied by the proton geometry, leaving only one further channel available to the outside.

The orbital axis may be modeled as aligned with the tetrahedral symmetry axis through the (p)-node. Small precessional motion of the (p)-node and the electron-like enclosure may then accommodate residual momentum and phase mismatch without destroying the proton enclosure.

The (p)-node has internal graph degree three within the tetrahedral proton geometry. These three internal e-span relations constrain the node and define the proton enclosure. This does not mean, however, that the (p)-node is limited to exactly three possible resonance channels in the RQT sense. In RQT, an identity may in principle couple to any number of resonance channels, provided the channel influences remain compatible. RQM represents only the dominant geometrically constrained channels. The tetrahedral structure mainly constrains the (p)-node along one effective external e-span axis, leaving further compatible e-span relations possible through this exposed channel direction.

Thus, the externally available proton channel should not be read as an additional rigid graph edge, but as the residual compatible e-span accessibility of the anchored (p)-node.

In this minimal sense, the first hydrogen-like atom has already appeared: an anchored proton-side e-span endpoint coupled to an external electron-like enclosure.

12.6.2 Experimental Validation

Relation to physical observations. The proton construction also provides simple RQM interpretations for several standard-physics observations:

- **Why a tetrahedral geometry?** The tetrahedron is the smallest fully three-dimensional equal-edge structure. A line segment is one-dimensional, and a triangle remains planar. The tetrahedron is therefore the first geometry that can confine e-span nodes into a compact 3D enclosure. This makes it the natural first candidate for a proton-like resonance structure.

- **Why three quons?** If one e-span node acts as the externally available anchored p-node, the remaining three nodes form the minimal symmetric support around it. Their oscillation allows the internal e-span channel lengths to remain nearly balanced. This gives the proton a stable internal resonance mode instead of a static point-like identity.

- **Why are quons not free electrons?** A quon is not a self-sustained electron-like enclosure. It is a confined e-span node whose resonance mode exists only inside the proton geometry. If removed from the compound, it would not remain the same object; it would have to reorganize into another available e-span structure or the compound would decay. In standard physics comparison, this corresponds to the fact that quarks are not observed as isolated free particles.

- **Why does electron scattering reveal proton substructure?** An incoming electron-like probe can couple to e-span-compatible internal nodes of the proton. The scattering

pattern therefore does not need to reflect a point-like proton, but can reveal internal rotating resonance components. In standard physics comparison, this corresponds to deep inelastic scattering and the observation of quark-like partonic structure inside the proton.

- **Why does the proton bind an orbital electron?** The stationary p-node provides an anchored e-span endpoint exposed to the outside. An orbital electron-like enclosure can phase-align and distance-lock to this endpoint. In standard physics this appears as attraction between proton and electron; in RQM it is a realized e-span channel between a dynamically accommodating electron-like enclosure and an anchored proton-side node.

RQM did not want to have quarks, they nevertheless emerged constructively

RQM did not introduce quark-like components as primitive assumptions. They emerge constructively when the model attempts to build the smallest stable three-dimensional e-span enclosure with one externally available anchored channel. The resulting tetrahedral geometry requires three confined oscillatory nodes, the quons. In standard physics comparison, these quons resemble quarks, but in RQM they arise from resonance geometry rather than from an imported particle classification.

12.7 Proton Extension and Deuteron-like Structures

The next constructive step after the proton is not yet a general neutron, but a direct extension of the proton geometry. If a second tetrahedral unit is placed in mirrored orientation on the proton-side (p)-node, the two pyramidal structures can share or align their central e-span relation and more importantly provide symmetric q-span channels.

This adds three further quon-like nodes to the proton geometry. The resulting compound contains six q-span nodes and retains one externally available e-span channel. In standard physics comparison, this corresponds to the deuteron: a proton-neutron bound state with one net externally visible e-span relation.

In RQM, the deuteron-like structure is therefore not simply a proton with an isolated neutron attached. It is a continued q-span stacking of the proton geometry. Its additional three quon-like nodes provide further q-span closure capacity without adding a second open e-span endpoint.

This structure also prepares the later neutron concept. The neutron-like role appears here as the added q-span completion that stabilizes the proton extension while keeping only one external e-span channel exposed.

12.8 Neutrons

Neutron-like structures provide q-span closure capacity without adding further externally exposed e-span channels.

RQM introduces neutron-like structures as a consequence of q-span closure. A proton-like structure already provides three q-span endpoints through its internal quon motion, but further nuclear growth requires additional q-span compatibility without simply adding more externally available e-span anchors.

In its minimal role, a neutron-like structure may be understood as a three-quon rotational triangle. Such a triangle can complement proton-like q-span structures, but it is not necessarily self-stable as an isolated object. Without additional anchoring, compensation, or embedding, the three quon axes cannot maintain a fully symmetric resonance relation.

This is why RQM does not introduce the neutron as one fixed geometry. Instead, neutron-like behavior depends on how the three-quon triangle is stabilized. Depending on context, this stabilization may be achieved by internal e-span compensation, by pair-stacking in a deuteron-like compound, or by embedding into a larger q-span lattice.

Thus, RQM distinguishes at least three neutron representations: isolated, deuteron-bound, and lattice-bound. They are not different particles in the standard sense, but different resonance

realizations of the same role: a three-quon structure contributing q-span closure while avoiding an additional externally exposed e-span anchor.

12.8.1 Isolated Neutron

An isolated neutron must provide its own compensation, because no surrounding nuclear structure is available to stabilize its three-quon triangle. In RQM, it may be modeled as an octahedral or double-pyramidal extension of the proton-like tetrahedron, with two opposite compensating e-span nodes. Schematically, this may be written as

$$n_1 qqq n_2,$$

where n_1 and n_2 denote compensating e-span nodes inside the isolated neutron enclosure. They should not be read as free proton or electron objects.

The three q-nodes remain the main inertial drivers of the structure. The opposite compensating nodes may close their channel directly or enter a mutual precessional compensation. Because this compensation is not perfectly symmetric with respect to the q-span rotation, the isolated neutron remains metastable.

In RQM terms, neutron decay occurs when this internal compensation can no longer remain closed. One side settles into a stable anchored state, while the opposite e-span component is expelled as an electron-like structure. Any remaining asymmetric resonance imbalance may leave as a neutrino-like residual.

12.8.2 Deuteron-bound Neutron

A neutron in a deuteron is not modeled as an isolated neutron placed next to an isolated proton. Instead, RQM treats the deuteron as a shared two-body q-span enclosure. It is a substantially different compound structure, not merely a proton-neutron pair in contact.

Geometrically, the deuteron-like structure may be imagined as two pyramidal resonance structures meeting at, or sharing, one central e-span anchor. This adds three further quon-like nodes to the first proton-like geometry and forms a six-quon compound with one externally available e-span anchor.

In this configuration, opposite quon rotation planes can align. This allows three new higher-level Roton relations to form at approximately twice the e-span length. The resulting structure may relax toward an octahedral geometry if these new q-span alignments become more stable than the original separated e-span relations.

The deuteron-bound neutron is therefore pair-compensated. Its three-quon triangle is stabilized by the shared deuteron geometry rather than by fragile internal compensation. In RQM terms, this explains why a deuteron can remain stable while an isolated neutron cannot.

Starting from the deuteron, the neutron-like part is therefore not a full isolated neutron hidden inside the compound. It is a three-quon contribution whose missing stabilization is provided by the shared q-span enclosure. The deuteron is thus not simply $P + N$, but a six-quon resonance structure with one externally available e-span anchor.

12.8.3 Lattice-bound Neutron

In larger nuclei, a neutron becomes even less like an isolated object. RQM interprets it as a local q-span configuration embedded in a larger resonance lattice. Instead of carrying its own complete compensation structure, it may remain as a three-quon triangle within the surrounding nuclear geometry.

In this case, the neutron is lattice-compensated. Its e-span exposure is not externally available because the surrounding q-span network absorbs and balances the relevant channel relations. The neutron-like role is therefore defined by the larger compound rather than by a self-contained neutron enclosure.

This representation becomes especially important for alpha-like clustering and later icosahedral stacking. In such structures, neutrons are expected to appear less as independent objects and more as internal resonance triangles that complete, stabilize, or redirect the q-span geometry of the nucleus.

Experimental implications. If RQM is correct in treating neutrons as context-dependent resonance realizations, then neutron properties should not be interpreted only as properties of a universal isolated particle. The isolated neutron, the deuteron-bound neutron, and lattice-bound neutrons should differ in their effective geometry and response to probes.

This suggests several qualitative expectations. Free neutron decay should reflect failure of internal e-span compensation. Deuteron structure should show signatures of shared q-span geometry rather than two independent nucleons. In larger nuclei, neutron contributions should depend strongly on local clustering and q-span embedding. Scattering experiments should therefore reveal different effective neutron responses depending on whether the neutron is isolated, weakly pair-bound, or deeply embedded in a nuclear lattice.

12.9 Orbital Pairing and Nuclear Anchors

In RQM, an orbital electron is not treated as part of a diffuse cloud. It forms realized e-span relations to nuclear resonance anchors. For the first hydrogen-like case, a single proton-side anchor is sufficient:

$$e \leftrightarrow A_e.$$

Beyond this first case, RQM no longer treats the nucleus as a collection of proton objects. The relevant concept becomes the number and geometry of available e-span anchors. These anchors must be held by an internal q-span structure that can keep their position, phase, and orientation stable enough for orbital coupling.

A paired orbital configuration requires two such anchors. The two electron-like enclosures are not independent cloud elements; they form a paired resonance relation while also coupling to the nuclear anchor structure:

$$e_1 \leftrightarrow A_e^{(1)} \qquad A_e^{(2)} \leftrightarrow e_2,$$

with an additional pair relation

$$e_1 \leftrightarrow e_2.$$

A simple linear arrangement,

$$e_1 - A_e^{(1)} - A_e^{(2)} - e_2,$$

may express the minimal pairing idea, but it is not a stable general solution for nuclear geometry. A stable nucleus must hold its e-span anchors inside a symmetric q-span enclosure rather than merely placing them on a line.

12.10 Deuteron-like Bridge Structures

The deuteron-like structure is the first bridge between a single e-span anchor and a paired anchor system. In RQM it is not introduced as a proton with a neutron attached, but as a continued q-span extension of the first proton-like geometry.

Geometrically, it may be imagined as two pyramidal resonance structures sharing or aligning through a central e-span relation:

$$\triangle_q \; - \; A_e \; - \; \triangle_q.$$

This adds three further quon-like nodes to the original proton-like structure and creates a six-quon compound. The result is still strongly axial, but it shows how a nuclear structure can grow by adding q-span closure capacity without simply adding another exposed e-span anchor.

In this sense, the deuteron-like structure is a transitional geometry. It demonstrates that nuclear growth must proceed by organizing q-span nodes around controlled e-span anchors. However, it does not yet provide the compact spherical enclosure needed for stable orbital pairing in larger atoms.

12.11 The Alpha Particle

The alpha particle is the first RQM structure that can anchor an orbital electron pair without becoming a line. It is introduced as the smallest stable q-span cage providing two internal e-span anchors:

$$A_e^{(1)}, A_e^{(2)}.$$

Its role is not to combine proton objects, but to hold two e-span anchor positions inside a compact and highly symmetric q-span enclosure. This allows paired orbital coupling of the form

$$e_1 \leftrightarrow A_e^{(1)} \qquad A_e^{(2)} \leftrightarrow e_2,$$

while the paired electrons may also remain mutually related:

$$e_1 \leftrightarrow e_2.$$

RQM models this enclosure as an icosahedral q-span structure. The icosahedron is the next natural triangular cage after the tetrahedral proton-like geometry. Its symmetry allows many q-span relations to close while keeping the overall structure nearly spherical.

The two internal e-span anchors arise from the central frustration of the geometry. If tetrahedral extensions are continued inward from opposite triangular regions of the icosahedral cage, their ideal centers do not collapse into one point. Instead, they form two nearby anchor positions:

$$\triangle_q^{(1)} \to A_e^{(1)} \qquad \triangle_q^{(2)} \to A_e^{(2)}.$$

This gives the alpha particle its special role in RQM. It is the smallest stable q-span cage that can provide two internally held e-span anchors for paired orbital coupling. In standard physics comparison, this corresponds to the exceptional stability of the helium nucleus, but RQM describes it as a geometric closure condition rather than as a sum of proton and neutron objects.

Discussion The alpha particle is therefore the first major closure result of RQM. It is not introduced as an additional assumption, but emerges as the necessary solution to the paired-anchor problem. Without a symmetric q-span cage capable of holding two internally rotating e-span anchors, the model could not support paired orbital coupling and would stop at single-anchor structures.

The same construction also yields the expected structural count. The icosahedral alpha model contains twelve quon nodes, matching the $2p + 2n$ helium-core count in standard physics comparison. In RQM, however, this count is not imposed from nucleon terminology; it follows from the smallest stable two-anchor q-span cage.

12.12 Nuclear Resonance Networks and Clustering

The preceding constructions show that RQM does not treat nuclei as collections of fixed proton and neutron objects. Instead, nuclear structures are modeled as resonance networks of q-span nodes, e-span anchors, and channel closures.

At this stage, however, the construction changes scale. The internal e-span grid of proton-like, deuteron-like, or alpha-like structures does not simply continue unchanged through the whole nucleus. After the alpha-like icosahedral cage has formed, its outer quons already oscillate with axes oriented outward from the cage. Additional e-span nodes placed by continuing the earlier tetrahedral e-span pattern would no longer align naturally with these q-span motions.

Such added e-span nodes would need to keep their e-channels phase-compatible with several existing q-span directions and distances at once. Their axes would not match the already established outward quon geometry, and phase accommodation would not be able to stabilize all relevant resonance distances simultaneously. As in the isolated neutron case, such an unsupported e-span node would tend to lose stable integration rather than extend the structure coherently.

RQM therefore does not continue nuclear growth by extending the original e-span tetrahedral grid. Instead, compact core structures become the next building blocks, and nuclear growth proceeds mainly through q-span clustering between them. The first such core structures are the proton-like tetrahedral geometry, the deuteron-like bridge, the triangular neutron-like q-span unit, and especially the alpha-like two-anchor cage.

These structures may combine through q-span bridges and shared resonance directions. The resulting nucleus is therefore not a uniform e-span grid, but a cluster network of compact resonance cages and connecting q-span relations. Alpha-like structures act as primary nuclear clusters. Their q-span directions can extend outward from the cage and form bridges to neighboring clusters.

Neutron-like triangular units may occupy gaps between such clusters, where they can align their three q-nodes with available q-span directions and increase closure. Proton-like anchor units may also appear where an additional externally available e-span anchor is structurally required.

This distinction becomes important for larger nuclei. Nuclear stability is not determined only by counting available e-span anchors or quon nodes. It also depends on whether neighboring core structures can form enough q-span bridges, whether gaps are symmetrically occupied, and whether residual frustration remains.

The alpha particle is therefore not merely a stable small nucleus, but the first reusable nuclear cluster. Larger nuclei can be interpreted as arrangements of alpha-like cages, proton-like anchors, deuteron-like bridges, and triangular neutron-like stabilizers. The geometry of these cluster networks determines which additional neutron-like structures are helpful, where they can stabilize gaps, and why some apparently simple alpha-stacked arrangements remain unstable.

This prepares the transition to atomic structure. Orbital electrons couple to available nuclear e-span anchors, while the internal q-span cluster network determines how these anchors are held, paired, oriented, or shielded by the nucleus.

12.13 Closure Types and Binding

In RQM, binding is interpreted as the observable consequence of resonance closure. A structure becomes more stable when its available channel relations are internally accommodated and fewer residual channels remain exposed. However, closure is not only a matter of quantity. A channel relation contributes to stability only if its phase, axis, distance, and geometry remain compatible with the surrounding resonance structure.

Several closure types must therefore be distinguished. Internal e-span closure stabilizes the small core structures themselves. Q-span closure stabilizes the oscillatory quon network inside and between such structures. Anchor closure determines how e-span anchors remain available, paired, shielded, or compensated. Cluster closure describes the additional stability gained when several compact core structures form q-span bridges with one another.

This also means that incomplete or incompatible closure can destabilize a structure. A channel may be present but geometrically frustrated; it may reduce one residual exposure while increasing phase mismatch elsewhere. Such frustrated closure can appear as instability, decay tendency, deformation, or the need for additional neutron-like stabilizers.

Binding in RQM is therefore not simply the result of adding more nodes or more channels. It depends on the quality of closure: how many relations can be held simultaneously without forcing the q-span grid, e-span anchors, or cluster geometry out of symmetry. A compact q-span cage with well-aligned oscillations and symmetrically held anchors can be more stable than a larger but poorly accommodated structure.

In standard physics comparison, strongly bound nuclei correspond to configurations where RQM expects high internal closure, strong q-span compatibility, and low residual exposure. The alpha particle is the first major example. Later alpha-cluster nuclei are expected to show additional stability when their cluster geometry allows symmetric q-span bridging.

A later quantitative version of RQM may relate closure quality to measured binding energies. At this stage, however, binding is used only as a comparison term for the degree to which resonance channels are internally closed, stabilized, and protected from residual external coupling.

Additional neutron-like units are stabilizing only when they occupy geometrically useful positions. They do not merely add material. They provide q-span closure in gaps where alpha-like or proton-like clusters would otherwise leave unresolved resonance directions. If no compatible gap exists, an additional neutron-like structure may increase frustration rather than stability.

Take-away Nuclear stability in RQM is not determined by the number of components alone, but by the quality of resonance closure. Stable nuclei arise when e-span anchors, q-span oscillations, and cluster bridges can be held in compatible phase, distance, and symmetry relations.

12.14 Isotope Geometry as a Qualitative Check

The cluster picture also gives RQM a first qualitative way to compare with isotope patterns. Extra neutron-like structures are not expected to stabilize a nucleus merely because they add further nodes. They should be stabilizing only when they can occupy geometrically useful gaps, align their three q-nodes with available q-span directions, and reduce residual frustration between existing clusters.

This gives a different interpretation of isotope stability. In RQM, additional neutron-like units are not passive fillers. They are triangular q-span stabilizers. Their effect depends on whether the surrounding cluster geometry provides three compatible attachment directions. If such directions are missing, the additional structure may reduce symmetry or increase frustration rather than closure.

The instability of a simple two-alpha arrangement is therefore significant. A system made from two alpha-like cages may appear close to a natural next step, but it provides too few symmetric q-span bridges to become a stable general building block. In standard physics comparison, this corresponds to the instability of ^{8}Be.

More stable alpha-cluster arrangements appear when several cages can mutually support their q-span directions. The nuclei ^{12}C, ^{16}O, and ^{40}Ca are therefore natural qualitative check-points for RQM. They correspond to arrangements in which alpha-like clustering can provide especially symmetric closure.

The oxygen isotopes provide an additional test case. In RQM terms, ^{16}O may be interpreted as a highly closed alpha-cluster arrangement. Extra neutron-like structures become useful only when they can align their three q-nodes with available gaps in this geometry. The existence of stable heavier oxygen isotopes, such as ^{18}O, is therefore interpreted as evidence that some additional neutron-like units can stabilize specific q-span gaps rather than merely adding material.

At larger scale, ^{40}Ca provides another geometric marker. It may be modeled as a highly symmetric arrangement of ten alpha-like clusters. In this picture, the absence of a stable next pure alpha extension is not arbitrary: the remaining central or inter-ring positions become geometrically frustrated. Additional neutron-like structures may then become preferred because they can occupy and stabilize such gaps without requiring another externally anchored e-span structure.

These examples do not yet constitute a quantitative isotope theory. They serve as qualitative checks on the RQM construction principle: stable isotopes should correspond to cluster geometries with high q-span closure, well-positioned e-span anchors, and low residual frustration, while additional neutron-like units should appear where they improve the closure of specific geometric q-span gaps.

12.15 Alpha-Cluster Stacking and Isotope Geometry

After the alpha particle has emerged as the first reusable q-span anchored structure, RQM can extend nuclear construction by stacking alpha-like clusters. In this layer, the construction no longer continues the original e-span grid uniformly. Instead, alpha-like Q-structures, neutron-like q-span triangles, and occasional proton-like anchor structures become the effective building blocks of larger nuclei.

For this purpose, an alpha-like q-span icosahedral structure will be denoted by Q.

A Q-cluster usually corresponds to an alpha-like structure, but in rarer contexts it may denote a related twelve-quon structure with different internal e-span anchoring. Its defining feature is not a conventional particle label, but its icosahedral q-span organization.

For geometric stacking, it is often more intuitive to use the dual dodecahedral representation. In this view, each dodecahedral face corresponds to a q-span rotational plane, and opposite or parallel faces indicate possible q-span channel directions. The Q-clusters can then be arranged as dodecahedral building blocks whose face relations make the available resonance alignments visible.

The natural stacking of such structures follows dodecahedral and icosahedral geometry. In an idealized shell picture, the number of available Q-positions appears in layers such as

$$1, \quad 12, \quad 20, \quad 30, \quad 12, \ldots$$

These spherical layers should not be read as rigid shells that must be filled one after another. RQM allows partial, overlapping, and laterally extended cluster arrangements whenever they provide better q-span closure and lower frustration. Nevertheless, the shell counts mark natural geometric capacities of the dodecahedral stacking pattern.

Geometric frustration becomes important as the clusters grow. Alpha-like Q-structures are not rigid polyhedra; their q-span relations may adapt by small angular and distance accommodations. Such deformations can allow neighboring clusters to remain compatible even when the ideal dodecahedral geometry is not exact. However, this accommodation has limits. In particular, central or inter-ring gaps may not provide enough symmetric space for another full Q-structure. These gaps are natural candidates for neutron-like triangular stabilizers or, in some cases, proton-like anchor patches.

This gives RQM a geometric interpretation of isotope variation. The structural count A is associated primarily with the amount of q-span structure that must be arranged, while the realized e-span anchor count is treated as a state of that arrangement. A nucleus is therefore not described only by how many anchor nodes it contains, but by whether its geometry favors a given node as anchored, compensated, or non-exposed.

12.15.1 Isomers and Transition Paths

In this view, nuclei with the same structural count A and the same externally open e-span anchor count may still correspond to different q-span gap fillings and internal geometries. In standard physics language, this means that nuclei with the same proton number Z and neutron number N may nevertheless occur in different internal states.

RQM expects a range of possible resonance geometries with the same number of q-nodes and externally realized e-span anchors. In standard physics comparison, this corresponds to nuclear

isomers: nuclei with the same conventional composition, Z and N, but different internal resonance geometries.

Standard physics describes the preferred transition as a decay toward a lower-energy state. RQM describes the same process as a relaxation toward higher internal resonance closure and lower residual mismatch. The nucleus keeps the same structural count and the same external e-span anchor count, but its internal q-span channel organization improves.

Such a transition may occur in different ways. If the internal q-span geometry improves while the realized orbital e-span channels remain compatible, the released correction can leave as photon-like radiation, corresponding to gamma emission in standard physics.

If, however, the rearrangement changes which internal anchor position is realized toward the orbital structure, the previous electron-core channel may no longer remain compatible. The released correction can then be transferred into the coupled orbital electron, which is expelled. In standard physics comparison, this corresponds to internal conversion: Z, N, and A remain unchanged, but the atom becomes ionized.

Beta decay is a different class of transition. There the anchoring state of the core changes more deeply: a neutron-like role may become proton-like, or a proton-like role may become neutron-like. In standard physics this changes Z and N. In RQM it corresponds to a different isotope decay path through the resonance-geometry landscape.

The same coupling principle also works in the opposite direction. If an ion captures a new electron, or if orbital electrons shift between resonance states, the external e-span environment of the nucleus changes. RQM therefore expects weak but genuine feedback from the atomic electron structure into the internal nuclear resonance geometry.

γ-emission	:	same Z, N, A; q-span correction leaves as photon-like radiation
internal conversion	:	same Z, N, A; q-span correction ejects an orbital electron
β-decay	:	Z, N change; anchoring state changes through the isotope landscape
recombination / orbital shift	:	electron environment changes; core may re-accommodate

12.15.2 Notation

A useful structural notation is Q_n^m, where n denotes the number of alpha-like Q-clusters and m denotes additional four-neutron-like stabilizing clusters, denoted schematically by ν. For example, a double ring of ten alpha-like clusters with one central four-neutron-like stabilizer may be written as Q_{10}^1.

This notation is only structural. It does not define a quantitative mass model. Its purpose is to describe how q-span structures and neutron-like stabilizers may occupy the same geometric cluster network. The Q-cluster core might be extended with $\mathrm{P}_n and N_n giving the additional number of separate Proton-Like anchor points and Neutron-Like resonance endpoints with no long time stable anchoring node. The option D_n m typically occupying frustrated dodecahedral allocations e.g. intehcenter of a Q_1 0 core). In this way one Isomere Ca-28 can be written as Q_1 0^1 N_4. A more structural sequential form : N_2/Q_5/N_4/Q_5/N_2. This notation base sonthetriad quon cap with no (stable) central anchor.$

12.15.3 Qualitative Isotope Checks

Several qualitative comparisons follow. A two-alpha arrangement is not expected to be generally stable, because a single q-span bridge between two Q-structures might be too weak to saturate internal or orbital electron momentum. This corresponds to the instability of the ^{8}Be-like configuration. Larger arrangements become more stable when several alpha-like Q-structures form mutually supporting q-span bridges.

The ^{40}Ca-like closure provides a simple example: ten alpha-like Q-structures may form a symmetric double-ring arrangement, each ring consisting of 5 Q-clusters. In RQM terms, this

is a strong q-span closure point, as many linear q-span resonance chains exist in this geometry. The remaining central region in contrast is geometrically frustrated (too small) and might not naturally accept another full alpha-like Q-structure. Additional neutron-like structures may therefore become preferred in later nuclei because they can stabilize such gaps without adding further externally exposed e-span anchors.

At larger scale, shell-like dodecahedral cluster counts suggest possible structural limits. A completed sequence such as

$$(1 + 12 + 20 + 30 + 12)Q$$

would contain $75Q$ cluster positions. Since each Q-cluster corresponds to a twelve-quon structure, or four nucleon-like structural units in standard comparison, this gives a rough upper structural scale near

$$75 \cdot 4 = 300.$$

This is not presented as a precise prediction, but as a geometric scale marker. It is notable that the upper region of known nuclei lies close to this order of magnitude.

Another important comparison point is the ^{208}Pb-like region. Its structural count corresponds to

$$208 = 52 \cdot 4,$$

which lies close to the combined $20 + 30$ dodecahedral layer count. In RQM terms, such a configuration may represent a highly developed outer cluster closure, after which further growth becomes increasingly frustrated and may have to proceed inward or through asymmetric stabilizing additions.

These examples are not yet a quantitative isotope theory. They indicate how RQM intends to read the isotope map geometrically: stable or long-lived nuclei should correspond to cluster arrangements with strong q-span bridging, symmetric gap stabilization, and low residual frustration. Extra neutron-like structures are expected where they improve q-span closure without requiring additional externally visible e-span anchors.

12.15.4 Decay Sequences

The same geometry gives a possible reading of broader decay sequences. Beta decay may be interpreted as a transition in which the nucleus changes the anchoring state of one e-span-related node in order to reach a more stable q-span arrangement. What standard physics describes as conversion between neutron-like and proton-like roles is, in RQM, a reconfiguration of whether a local gap-filling structure gains or looses internal resonance anchor character - which indicates whether a core-structure is externally anchored, internally compensated, or non-exposed.

At the outer ranges of smaller isotopes, added neutron-like or proton-like structures may appear as less integrated surface additions. In such cases, n, p, $2n$, or $2p$-like fragments may separate more easily, because they are not yet absorbed into a symmetric q-span closure. Alpha-like loss can occur when an entire Q-structure occupies an asymmetric or weakly integrated position.

For very large Q-networks, the geometry may become increasingly hollow or shell-like. Around the $Q \approx 50$ region, corresponding roughly to the combined $20 + 30$ outer shell count, excess neutron-like stabilizers may begin to occupy both inner and outer seats. Such configurations can become vulnerable to large-scale rearrangement or fission-like transitions, because central voids and shell frustration make the cluster network easier to split or collapse into alternative closures.

Take-away. In RQM, isotope structure is treated as a geometric matching problem. The structural count A determines how much q-span organization must be arranged, while the realized e-span anchor count describes which nodes become externally anchored within that geometry. Stable isotopes correspond to optimal resonance arrangements for a given A. Such optima may be supported by strong internal q-span bridging, cascaded channel closure, symmetric distribution of e-span anchors, low overall residual e-span exposure, and low dodecahedral geometric frustration.

13 Atomic and Molecular Structure

The preceding sections constructed nuclear resonance structures from e-span anchors, q-span nodes, and cluster closures. These structures are not complete atoms. An atom appears only when electron-like enclosures form realized e-span relations with the available anchors of a nuclear core.

RQM therefore does not begin atomic structure with a diffuse electron cloud. It begins with channel geometry. Orbital electrons are modeled as electron-like enclosures whose motion, phase, and distance relations are constrained by the e-span anchors of the nucleus. The resulting orbital is not a material path in the classical sense, but a stable resonance-matching trajectory in the geometric projection of RQM.

This also means that a bare nucleus and an electron-enclosed nucleus are not resonance-identical. Once orbital electrons are present, their realized e-span channels feed constraints back into the nuclear anchor structure. Atomic stability is therefore a coupled property of the nuclear core and its surrounding electron relations.

The same language naturally extends toward molecules. If an orbital electron can couple to one nuclear core, it may also enter shared relations between two cores, especially when its trajectory can remain phase-compatible with both anchor structures and, in paired cases, with a second electron-like enclosure. Molecular binding is therefore introduced as a continuation of atomic channel geometry rather than as a separate mechanism.

This section develops that transition: from anchored electron-core relations, to orbital pairing, to shared electron trajectories between nuclear cores.

In this view, atoms and molecules are not built by placing electrons around fixed nuclei. They are resonance compounds in which nuclear anchors, electron-like enclosures, and shared channel trajectories co-determine the stable geometry.

13.1 Atoms

Orbital Closure. In RQM, an orbital electron is not held around the nucleus by a balancing force. Its orbital state is a recurring resonance structure in which at least one electron channel remains phase-locked to an anchored e-span node of the atomic core. Orbital distance and period therefore emerge from the closure itself.

In the strict RQM representation, an electron provides up to three directional e-span channels. Once one channel participates in a stable orbital closure, however, the resulting trajectory can constrain or effectively enclose the remaining channel capacity. These channels are therefore not independently available at all times. RQT itself does not require a fixed number of possible resonance relations; three channels are a sufficient geometric representation within RQM.

A single orbital electron can already form a stable core coupling while retaining *open resonance capacity*: its existing resonance relations may still reorganize if additional compatible partners allow a more complete closure. This is distinct from a geometrically open channel.

Paired orbital electrons provide a particularly favorable case. The two electrons can couple mutually while locking symmetrically into corresponding core anchors. Alpha-like core structures are especially suitable for such paired closure, since their internally displaced e-span anchors allow symmetric dynamic distance and direction.

This double locking is not restricted to a simple circular orbit. Any recurring trajectory that preserves the required phase relations and symmetry can contribute to the same closure. More complex orbital structures therefore become possible when several compatible resonance periods or spatial components participate.

Geometric channel relations and *open resonance capacity* should thus be distinguished: the former describe represented resonance directions, while the latter describes the ability of an already stable structure to enter a different or more complete closure.

Orbital Resonance Hierarchies. RQM begins with the simplest stable orbital resonance available to the current atomic configuration: a planar electron–core resonance with characteristic period (T_1).*Apairedelectronconfigurationcanclosesymmetricallyintocorrespondinge* − *spananchorsofthecoreandtherebyestablishaparticularlystableorbitalrelation.Additionalelectronsdonotnecess*

The resulting orbital hierarchy is therefore not assumed in advance. It develops from a set of mutually compatible principal resonance periods, $[\,T_1, ; T_2, ; T_3, \ldots,]$*whoseabsoluteperiodsandcorrespondingspa*

Multi-Period Orbital Structures. Once more than one principal orbital resonance is available, a stable electron trajectory may combine several directional resonance components. RQM represents such a trajectory by its dominant Roton decomposition, $[\,T{=}(T_x, T_y, T_z),]$*whereeachcomponentdescr*

The simplest planar orbital may therefore be represented schematically as $[\,(T_1, T_1, 0),]$*whileahigherplanarre* *closingtrajectoriesmaycombinetheprincipalperiods*, $[(T_1, T_1, T_2), \quad (T_1, T_2, T_1), \quad (T_2, T_1, T_1),]$*andanalogo* *ordercombinations.Noteverymathematicalcombinationisexpectedtoclose* : *realizableorbitalstructuresarerest*

A three-dimensional orbital is therefore not introduced as a new primitive shape, but as the combined trajectory of simpler directional Rotons. The same structure can be viewed either as a set of rotational resonance planes or as the resulting repeating electron trajectory. In the latter representation, different component periods can generate elongated or multi-lobed projections resembling the spatial orbital families used in conventional atomic descriptions. In RQM these lobes are projections of the underlying phase-dependent trajectory rather than separate regions that the electron must occupy independently. The Roton representation is particularly useful because its planes and exposed o-span directions remain directly available when later considering atomic and molecular resonance coupling.

Paired and Unpaired Orbital Electrons. Electron pairing introduces an additional level of closure. A paired orbital does not merely contain two electrons following compatible trajectories: each electron can retain a specific resonance relation to a corresponding core e-span anchor while the pair simultaneously contributes to a symmetric combined closure. Such symmetry is favorable because asymmetric orbital coupling would require additional compensation within the core and the surrounding resonance structure.

These electron–core relations remain structurally identifiable even when equivalent electrons may exchange their roles. In RQM, exchanging such roles therefore corresponds to opening and re-establishing resonance closures rather than to a purely formal relabeling. The associated closure transition is expected to require a finite snap-in or snap-out energy, although this scale is not quantified in the present model.

Unpaired orbital electrons retain greater open resonance capacity. Their existing electron–core closure may remain stable while alternative channel relations can still become favorable when compatible resonance partners are introduced. Paired electrons, in contrast, generally achieve a more complete local enclosure through their mutual and symmetric core relations. This distinction later becomes important when atomic orbital structures reorganize into shared multi-nuclear resonance structures during molecular binding.

Atomic Resonance Latitude. A stable atomic structure is not characterized only by how completely its present resonances are enclosed. It may also retain different possibilities for realizing additional or alternative closures when suitable resonance partners become available. RQM

refers to this structural freedom as *resonance realization latitude*, or more briefly *resonance latitude*.

Resonance latitude is not a scalar quantity and is not identified with a fixed number of unused channels. It depends on the geometry, period, phase, orientation, and enclosure of the existing resonance structure. An unpaired electron may provide an obvious possibility for further coupling, but whether this possibility can be realized depends equally on the supporting core geometry and on the availability of compatible resonance partners.

Additional latitude can also emerge from improved internal organization. Electron pairing may establish a tighter and more symmetric e-span closure to the core, while multi-period orbital trajectories can distribute resonance relations over several compatible directions and periods. A structure that is more completely enclosed locally may therefore support more stable resonance possibilities elsewhere rather than simply having less remaining capacity.

Residual exposure does not itself constitute an available channel. It may, however, contribute to a restructuring when several identities enter sufficiently close and compatible resonance conditions. In such cases previously internal, residual, or externally available relations may reorganize into a new higher-level closure.

Resonance latitude therefore describes the set of resonance improvements that a structure can still realize while preserving or replacing its current enclosure with a more favorable one. It is distinct from *resonance accommodation capacity*, which describes how much perturbation an existing resonance structure can absorb or redistribute before its closure is lost.

Transition to Molecular Binding. The orbital structures described above are local resonance solutions of an isolated atom. They are therefore not assumed to remain unchanged when another atomic structure enters effective coupling range. Once compatible core anchors, orbital spans, or residual resonance relations become accessible, the closure problem changes: resonance relations that were previously optimal within one atom may reorganize into a more favorable multi-atomic structure.

Molecular binding primarily exploits the *resonance realization latitude* retained by the participating atoms. Electron pairing, redistribution of orbital resonance components, and the ability of individual electrons to establish compatible relations with several cores or partner electrons provide the principal routes by which separate atomic closures can reorganize into a shared molecular resonance structure.

Existing electron–core closures may remain largely intact, shift in period or orientation, or become components of shared trajectories involving several nuclei. RQM can represent this transition in two complementary ways. The Roton representation retains the principal orbital planes and emphasizes the newly established coupling relations between atoms, while the resonance-trajectory representation follows the resulting combined electron path through the multi-core structure.

Molecular binding is therefore treated as the formation of a higher-level resonance closure from the realization latitude of its constituent atoms, rather than as an additional force acting between otherwise unchanged atomic structures.

13.2 Molecular Binding

From Atomic to Shared Resonance Closure. When two atoms enter effective coupling range, their previously separate orbital closures become part of one combined resonance problem. Molecular binding primarily realizes resonance latitude already present in the participating atomic structures: available electron channels, compatible core anchors, and orbital relations capable of entering a more favorable collective closure. The electrons are not assumed to remain assigned to their original atoms. Where the participating cores are equivalent, a shared electron resonance couples symmetrically to both; where their core structures differ, the resulting closure must accommodate the corresponding anchor geometry, periods, and phases.

The simplest molecular closures arise when one electron or an electron pair establishes compatible e-span relations with more than one core. Protonic cores provide individual e-span anchors, whereas alpha-like cores can support symmetrically paired anchor relations. In more complex molecules, the contributing electrons may become integrated into shared multi-period trajectories rather than remaining in recognizable atomic orbitals. Molecular binding is therefore treated as a reorganization of atomic resonance closures into a new multi-core identity, not as an additional interaction placed between otherwise unchanged atoms.

Single-Electron and Paired-Electron Closure. The simplest multi-core resonance may be formed by a single electron coupling symmetrically to two equivalent protonic anchors. In such a structure, the electron is not assigned preferentially to either core. Its recurring trajectory must instead maintain compatible phase and distance relations with both. This provides a possible RQM representation of a one-electron molecular ion such as H_2^+, although the resulting trajectory need not be identical to the orbital of an isolated hydrogen atom.

A more complete closure becomes available when two electrons participate. The electrons can establish a mutual e-span relation while each remains symmetrically coupled to both cores. Schematically, this may be represented as

$$C_1 - (e - e) - C_2.$$

The electron–electron closure adds a relation that is absent from the single-electron case and may therefore favor a different period, scale, or trajectory geometry. In the simplest Roton representation, the pair forms a shared planar double-orbital closure around the internuclear axis. In the trajectory representation, the same structure corresponds to a combined repeating path whose time-averaged exposure is concentrated between or around the two cores. The trajectory is typically modelled as an intermediate planar circle, while excited molecular states may realize multi-period trajectories around the two cores.

The stability of such a molecular closure depends on the compatibility of all participating relations rather than on electron attraction toward a particular nucleus. Equivalent cores favor symmetric coupling, while unequal cores may shift the shared trajectory without requiring the electrons to retain fixed atomic ownership.

Core-Anchor Symmetry and Multi-Period Molecular Closure. More complex molecular structures arise when the participating atomic cores provide several geometrically related e-span anchors. A protonic core offers a single dominant anchor relation, whereas an alpha-like core provides a paired anchor geometry that can only be used consistently through a correspondingly symmetric electron arrangement. A molecular closure involving such a core must therefore preserve the internal $e - \alpha - e$ axial symmetry rather than attach an isolated electron to only one side of the core structure.

The contributing electrons need not remain confined to separate bond-like trajectories between pairs of nuclei. Where the core geometry permits it, they may enter a shared multi-period molecular trajectory that includes several anchors and cores within one repeating closure. In this representation, conventional valence electrons are understood as those electrons whose existing orbital relations retain sufficient resonance realization latitude to participate in the larger molecular structure. The resulting closure is constrained not only by the number of available electrons, but also by whether their periods, phases, and anchor symmetries can be combined into a self-consistent trajectory.

Representative Molecular Closure Types.

Why Can One Electron Bind Two Proton Cores? The molecular ion H_2^+ represents the simplest shared resonance closure. A single orbital electron simultaneously realizes compatible

e-span relations with two proton cores. The electron cannot remain stationary between the two cores, since orbital motion is required to maintain the characteristic electron–proton distance. Instead, the shared trajectory remains centred on the middle plane between the two proton anchors.

Structurally, the simplest realization may be represented as

$$p \; - \; e_{\mathrm{rot}} \; - \; p$$

or, more explicitly,

$$(q_3 < e) \; - \; e_{\mathrm{rot}} \; - \; (e > q_3),$$

where the rotating electron belongs symmetrically to both proton cores.

Why Do Two Hydrogen Atoms Form a New Molecular Identity? The hydrogen molecule H_2 introduces a second type of resonance closure. Besides maintaining shared e-span relations to the two proton cores, the two electrons also establish a mutual e-span closure within the middle plane. The electron pair therefore becomes a new resonance identity rather than two independent electrons occupying neighbouring trajectories.

A simple model realization is a planar paired-electron trajectory around the proton–proton axis,

$$p \quad \begin{matrix} e \\ | \\ e \end{matrix} \quad p$$

or schematically

$$p - (e - e) - p.$$

The shared proton closure and the internal electron-pair closure are realized simultaneously. The resulting paired-electron trajectory possesses different resonance realization latitude and potentially exposes a different o-span characteristic than a single rotating electron.

Why Does Helium Realize a Different Closure? Helium does not extend the hydrogen concept. Its alpha core provides a different resonance topology. The two electrons realize a symmetric planar closure around the alpha center,

$$e \quad \alpha \quad e,$$

forming an internally completed structure without requiring a second atomic core.

Accordingly, the relevant question is no longer how a paired electron could couple to another alpha core, but whether the available core topology supports such a realization. Within the present RQM model, no nucleus with separate two proton structure became available. The alpha-centered closure is therefore the only known double e-span anchor core. This enforces trajectorial limits to the orbital electrons.

With this reasoning, a $He_2 molecule would not find an axially symtric combined electron closure. A He-atom will rather start using it's single o-span channel to interact with other He-Atom creating a He-Liquid.$

This distinction becomes particularly apparent in molecules such as Li_2, where proton- and alpha-centered closure principles coexist within the same molecular structure. There, alpha–proton coupling is mediated through neutron-supported dodecahedral resonance geometry, combining internal alpha closure with externally shared proton closures.

Li_2

$$\begin{array}{c|ccccccccc|c} e & a & - & p & e & p & - & a & e \\ e & \backslash & n & / & < e > & \backslash & n & / & e \end{array}$$

$\mathrm{Li}_2 structure formula$

Roton and Resonance-Trajectory Representations.

Molecular Geometry.

Residual Molecular Exposure.

13.3 Aggregate States and Intermolecular Resonance Transitions

> **Solidification involves a mode transition within the molecular resonance structure itself.** A predominantly axial intermolecular coupling mode is replaced by a multidirectional trajectory mode capable of forming persistent spatial resonance networks.

Linear Intermolecular Closure in Liquids. Once a molecule has formed a stable internal identity, its realized electron trajectory determines which orbital-span (*o*-span) relations remain externally available. The first level of persistent intermolecular organization is proposed to arise through predominantly axial *o*-span channels. Molecules can thereby form short, continuously changing linear resonance sequences without becoming locked into one extended spatial structure.

A liquid may therefore be understood as an interwoven collection of temporary linear molecular trails. Individual molecules repeatedly enter and leave such sequences as their positions and orientations change. This gives the liquid its collective character: the molecules remain locally related and resist complete separation, while the short linear closures can rearrange easily enough to permit flow. The liquid is thus neither an unstructured collection of independent molecules nor an incomplete crystal. It realizes a distinct predominantly one-directional intermolecular resonance mode.

Three-Dimensional Closure in Solids. A solid state becomes available when compatible *o*-span relations can be realized persistently in several spatial directions, allowing each molecule to participate simultaneously in a stable network of neighbouring closures. For molecules whose ordinary resonance structure exposes predominantly axial channels, this may require a transition into a three-dimensional electron-trajectory mode with a different external channel topology. Other molecules may already possess multidirectional *o*-span latitude in their molecular ground state; in such cases, solidification primarily consists in the collective realization, orientation, and distance locking of channels that were previously only intermittently used.

Solidification is therefore not described merely as molecules moving more slowly, approaching more closely, or accumulating a greater number of unchanged liquid-state relations. It involves a transition from temporary and predominantly linear intermolecular closure to persistent multidirectional resonance organization. Depending on the molecular structure, this transition may require an internal trajectory reconfiguration, the activation of already available directional channels, or a combination of both. The resulting network permits crystal-like distance, phase, and orientation locking that cannot be sustained within the continuously rearranging liquid state.

Aggregate-State Transitions and Latent Energy. The residual *o*-span characteristics of a molecule may already contribute to the transition from gas to liquid. As molecular motion decreases, compatible intermolecular relations become more frequently realizable and prevent the molecules from separating freely. These relations remain temporary and continuously reorganized,

however. Liquid molecules may therefore remain closely packed without becoming fixed into persistent distance-, phase-, and orientation-locked positions.

During freezing, this flexible local coupling is replaced by a persistent multidirectional resonance network. Depending on the molecular structure, the transition may involve a reconfiguration of the internal electron trajectory, the sustained realization of already available directional *o*-span channels, or both. The resulting collective closure reduces unresolved resonance accommodation within the participating structures. As the new network closes, the displaced accommodation is transferred into neighbouring molecular motion and appears as released heat, which must be removed for solidification to continue.

Melting reverses the collective locking. Energy is required to open the persistent multidirectional *o*-span network and restore the positional, rotational, and resonance realization latitude characteristic of the liquid state. This need not always return the molecule to a purely axial internal trajectory; multidirectional channels may remain present but cease to be persistently aligned and realized toward fixed neighbours. During the transition, the supplied energy is therefore absorbed primarily by the opening and reorganization of collective resonance closures rather than by an immediate rise in temperature.

Aggregate Geometry and Density. The multidirectional closure of a solid does not necessarily produce denser packing. A persistent three-dimensional resonance network must preserve the distances, orientations, and channel directions required by its collective geometry. The more flexible linear relations of a liquid can continuously rearrange and allow molecules to occupy gaps that remain inaccessible within the fixed solid network.

Water provides a characteristic example. Its oxygen-centred molecular trajectory may support a three-dimensional *o*-span mode with several preferred directions, while the hydrogen arrangement supplies further angular coupling latitude. In ice, these relations become locked into a persistent spatial network and impose an open crystal geometry. In liquid water, the predominantly linear and continuously changing intermolecular trails can overlap, bend, and reorganize more compactly. The larger volume of ice is therefore attributed to the geometrical requirements of its multidirectional resonance mode rather than to weaker intermolecular coupling.

Molecular Channel Geometry. Different substances undergo aggregate-state transitions under different conditions because their molecular resonance modes expose different channel geometries. A molecule with a strong axial *o*-span mode may readily form liquid-like linear trails while requiring a substantial trajectory reconfiguration before a compatible three-dimensional network becomes available. Molecules already possessing pronounced multidirectional internal trajectories may transition more naturally into spatially locked structures.

Within this interpretation, melting points, boiling points, crystal geometries, and density changes depend not only on the strength of intermolecular coupling, but also on whether the participating molecules can switch between compatible one-dimensional and three-dimensional resonance modes. Aggregate-state transitions are therefore treated as collective changes in molecular resonance topology.

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The author is an independent researcher with a long-standing interest in foundational aspects of quantum theory, field dynamics and emergent phenomena in complex systems.

Companion Website and Further Material

A non-technical introduction, extended explanations, graphical illustrations and ongoing discussions of the Roton Quantum Model are available on the project website:

- Roton Quantum Model – intuitive overview and guided tour: https://ledoigt.ch
- Technical notes, simulations and updates: https://ledoigt.ch/ledoigt/notes
- Discussion and feedback channel: https://ledoigt.ch/ledoigt/discuss

These resources are intended as a more accessible companion to the present article, offering step-by-step motivation, visualizations, and evolving refinements of the model.

Data and Code Availability

Simulation scripts, illustrative numerical experiments and example configurations of Rotons used to explore the qualitative behavior reported in this work are (or will be) made available at:

- Code repository (numerical experiments): https://github.com/ledoigt
- Supplementary animations and figures: https://ledoigt.ch/ledoigt/collections/

Interested readers are invited to reproduce, extend and critically test the presented ideas.

Author's Note

This work is intended as an open invitation to the theoretical physics and complex-systems communities to examine, challenge and refine the Roton Quantum Model. The author explicitly welcomes critical assessments, alternative formulations and concrete proposals for experimental or numerical tests, which may help to clarify the model's scope, limits and possible connections to established frameworks.