M0 – Foundational Ontology and Structural Definitions of Scalar–Conformal NUVO Systems

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Notation and Conventions

- $\mathcal{M}$ denotes the spacetime manifold.
- η denotes the reference Lorentzian metric (typically Minkowski in a global chart).
- g denotes the physical metric.
- The scalar field $\Lambda : \mathcal{M} \to \mathbb{R}_{>0}$ is the NUVO modulation field.
- The physical metric is scalar–conformal:

$$g_{\mu\nu} = \Lambda^2 \, \eta_{\mu\nu}.$$

- $\Lambda_0 > 0$ denotes the baseline scalar availability level supported by the intrinsic delivery structure of the underlying field. In the absence of localized structural occupation the scalar field satisfies $\Lambda(x) = \Lambda_0$.
- The dimensionless scalar diagnostic is

$$\lambda(x) \coloneqq \frac{\Lambda(x)}{\Lambda_0}.$$

- The scalar field represents the *locally available structural capacity* of the underlying delivery field. Localized structures may reduce this availability through occupation or transport, but the intrinsic delivery baseline Λ_0 remains fixed.
- Greek indices $\mu, \nu, \ldots$ range over spacetime coordinates $0, 1, 2, 3$.
- We use the Einstein summation convention unless explicitly stated otherwise.

Remark 0.1. *Unless otherwise stated, the background signature is* $(-, +, +, +)$.

Abstract

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[*] Bibliography is provisional. Cross-references to companion NUVO-series papers (M-, SR-, Q-, QB-, QM, RQM-series) will be updated with Zenodo DOIs in subsequent versions.

This paper consolidates the foundational ontology and structural definitions underlying the scalar–conformal NUVO program. The mathematical framework developed across the M, SR, and Q series introduces a scalar capacity field whose conformal modulation of a reference Lorentzian metric generates the physical geometry in which transport, exchange, and structural closure occur. While the definitions and interpretive vocabulary of the framework appear throughout the series, they are distributed across multiple sectoral developments.

The present manuscript collects these elements into a single foundational reference. We define the primitive objects of the framework, clarify the ontological interpretation of the scalar capacity field and the underlying delivery substrate, and establish a taxonomy of structural configurations including closed loops, open loops, and dynamic radiative structures. The hierarchical relationship between delivery, capacity availability, scalar diagnostics, conformal geometry, and observable transport is made explicit.

We further record the sector structure of the NUVO program, identify which results are primitive assumptions, which are derived consequences, and which rely on empirical calibration. Finally, we provide a program-wide glossary of terms and an explicit ledger of assumptions and open problems. This paper therefore serves as the ontological and definitional foundation for interpreting the NUVO series.

1 Introduction

1.1 Purpose of the Present Paper

The scalar–conformal NUVO program develops a unified mathematical framework in which geometry, transport, and structural persistence arise from a single scalar modulation of a reference Lorentzian metric. Across the M-, SR-, and Q-series manuscripts, this framework has been used to construct a sequence of internally consistent sector developments including gravitational reduction, exchange transport, radiative propagation, relativistic kinematics, and bound-state closure phenomena.

In the course of these developments a consistent interpretive vocabulary has emerged describing the physical meaning of the scalar field, the nature of structural configurations that occupy the underlying substrate, and the transport processes that connect persistent structures. However, these definitions presently appear distributed across multiple sectoral papers. While this distributed presentation reflects the chronological development of the program, it can obscure the conceptual unity of the framework and make it difficult for readers to identify the primitive assumptions, derived structures, and interpretive terminology that recur throughout the series.

The purpose of the present paper is therefore consolidative rather than sectoral. We collect and formalize the ontological commitments, primitive definitions, and structural classifications that underlie the NUVO framework. The goal is to provide a single reference document that records the program-wide meaning of key quantities such as the scalar capacity field, the delivery substrate, and the loop structures that represent persistent configurations and exchange channels.

Importantly, the present manuscript introduces no new dynamical sector results. Its role is to clarify the interpretive structure already used throughout the NUVO series and to provide a stable definitional foundation upon which subsequent sector developments may be understood.

1.2 Overview of the NUVO Program

At its mathematical core, the NUVO framework begins with a spacetime manifold $\mathcal{M}$ equipped with a fixed reference Lorentzian metric η. Physical geometry is generated by a positive scalar field Λ through the conformal relation

$$g_{\mu\nu} = \Lambda^2 \, \eta_{\mu\nu}.$$

The scalar field is interpreted as a diagnostic of the locally available structural capacity of an underlying delivery substrate. Regions in which persistent structures occupy this capacity exhibit reduced availability relative to a reference baseline, producing spatial variation in the scalar field and therefore a conformal modulation of the physical metric.

Within this geometry a hierarchy of sector developments has been constructed. The foundational M-series [1] establishes the scalar geometry, the variational structure of the scalar field, and the transport mechanisms associated with exchange currents. Subsequent work identifies gravitational behavior as a reduction arising from gradients in the scalar capacity field and develops a transport sector describing exchange processes between anchored structures. Radiative transport and finite-core propagation are then treated as specialized dynamic configurations of this exchange structure.

The SR-series [2] shows that relativistic kinematics can be recovered as a structural consequence of the internal circulation of persistent configurations within the scalar-modulated geometry. In this interpretation, time dilation and related relativistic phenomena arise from modifications of the internal circulation period of a persistent structure rather than from purely kinematic postulates.

Finally, the Q-series [3] investigates the consequences of exchange-cycle closure for bound systems. In that context quantization arises from holonomic closure conditions on exchange transport cycles, and the discrete spectra of bound states are interpreted as structural closure states of the exchange sector. Subsequent analysis extends these ideas to moving closure configurations, providing a geometric interpretation of matter-wave phenomena in terms of coherence events along the worldline of a persistent structure.

Although these sector developments share a common mathematical and conceptual foundation, the definitions that support them are presented where they first become operational within each sector. The result is a coherent but distributed ontology that benefits from explicit consolidation.

1.3 Finite Capacity as a Physical Question

The development of physical theory has repeatedly revealed that assumptions about the background structure of nature—assumptions that once appeared self-evident—may ultimately require revision. In the Newtonian formulation of mechanics, space and time were treated as absolute and uniform structures: an immutable stage upon which physical processes unfolded. The geometry of space did not respond to matter, nor did the flow of time depend upon the physical systems occupying it.

The advent of relativity dramatically altered this perspective. Einstein's theory replaced the rigid Newtonian background with a dynamical spacetime geometry whose curvature is determined by the distribution of energy and momentum [4]. In this sense the geometric framework of physics itself became a responsive participant in the structure of physical law rather than a passive arena in which those laws operate.

Subsequent developments in theoretical physics have continued to challenge the intuition that physical background structures are unbounded or inexhaustible. In particular, several lines of research suggest that physical systems may admit only a finite number of independent states or a finite amount of information within bounded regions of spacetime.

One of the most influential examples is the Bekenstein bound [5], which proposes an upper limit on the entropy that can be contained within a finite region of space with finite energy. Closely related ideas appear in holographic formulations of gravitational physics [6,7], where the maximum entropy of a region scales with the area of a bounding surface rather than the volume of the region itself. These developments have led to the broader holographic principle [8], suggesting that the number of degrees of freedom available to a physical system may be more restricted than naive continuum reasoning would imply.

Other perspectives approach similar questions from the standpoint of information processing. Estimates of the total computational capacity of the observable universe [9] indicate that the number of operations that can have occurred since the Big Bang is finite and extraordinarily large but nonetheless bounded. Such analyses do not imply that the universe literally behaves as a computer, but they highlight the possibility that physical law may operate within limits on the information that physical systems can store, process, or transmit.

These observations do not by themselves establish that spacetime possesses a locally finite "capacity" in the sense explored in the present work. The entropy bounds and information-theoretic limits derived in other contexts arise from considerations of thermodynamics, quantum field theory, and gravitational horizons. They do not directly imply the existence of a scalar field governing the local availability of structural support for persistent configurations.

Nevertheless, taken together they illustrate an important conceptual point: the assumption that physical systems possess unlimited structural support has repeatedly been challenged as theoretical understanding has progressed. Limits on entropy, information, and state counting all suggest that the physical world may contain intrinsic constraints on how much structure can exist within a given domain.

The NUVO framework explores one possible realization of this idea. Rather than treating the geometric environment of physical systems as uniformly capable of supporting arbitrary structure, the framework introduces a scalar field that represents the locally available structural capacity of an underlying delivery substrate. Persistent configurations occupy this capacity, reducing the amount available in their vicinity and thereby modulating the geometry experienced by transport processes.

In this interpretation, geometry is not merely curved by the presence of matter, but is also influenced by the availability of structural support within the underlying substrate. The scalar field therefore acts as a diagnostic of how much capacity remains available to sustain additional structure at a given location.

It is important to emphasize that the present work does not claim that nature is known to possess such a finite-capacity substrate. Rather, the scalar–conformal framework investigates the consequences of taking this possibility seriously as a structural hypothesis. The central question motivating the program is therefore simple:

What would follow if the physical substrate supporting persistent structures possessed finite, redistributable capacity?

The remainder of the NUVO program develops the mathematical and structural implications of this question. Beginning from a minimal scalar–conformal geometry, the framework explores how capacity distribution, exchange transport, and structural closure might give rise to the gravitational, relativistic, and bound-state phenomena examined in the subsequent sector analyses.

In this sense the NUVO program should be viewed not as a replacement for existing physical theories, but as an investigation of an alternative structural principle whose consequences may illuminate new relationships among geometry, transport, and persistent structure.

1.4 Structure of the Present Manuscript

The remainder of this paper organizes the ontological and definitional structure of the NUVO program in a systematic manner.

Section 2 records the primitive mathematical setting of the framework, including the spacetime manifold, the reference geometry, the scalar capacity field, and the scalar–conformal construction of the physical metric.

Section 3 addresses the ontological interpretation of these mathematical objects. In particular, we clarify the role of the delivery substrate, the meaning of structural capacity, and the concepts of capacity availability, occupation, and depletion that arise when persistent configurations interact with the underlying field.

Section 4 introduces the diagnostic hierarchy relating the delivery substrate, capacity distribution, scalar diagnostic field, and the resulting conformal geometry. This hierarchy clarifies which quantities represent primitive substrate properties and which serve as observational diagnostics.

Section 5 develops the taxonomy of structural configurations used throughout the program, including closed loop structures associated with persistent matter, open loop structures associated with exchange transport, and dynamic radiative configurations.

Section 6 summarizes the sector organization of the NUVO program and records the relationship between the foundational M-series and the subsequent relativistic and quantization developments.

Section 7 discusses the role of empirical calibration within the framework, particularly the use of a single bound-state energy scale as an input for the hydrogen closure analysis.

Section 8 provides a ledger distinguishing primitive postulates, derived structural results, correspondence relations, and empirical inputs.

Section 9 addresses the structural phase introduced in the moving closure analysis and clarifies its present status within the program.

Section 10 records the weak-limit closure assumptions that separate the scalar capacity sector from exchange transport in the present stage of development.

Section 11 outlines several open problems and directions for further development of the framework.

Finally, Section 12 provides a glossary of terminology intended to serve as a program-wide reference for the NUVO series.

2 Primitive Mathematical Setting

The NUVO framework begins from a minimal geometric structure consisting of a spacetime manifold, a reference Lorentzian metric, and a positive scalar field whose conformal modulation generates the physical geometry. This section records the primitive mathematical objects of the framework and fixes the notation used throughout the remainder of the manuscript.

2.1 Spacetime Manifold and Reference Geometry

Let $\mathcal{M}$ denote a smooth four–dimensional spacetime manifold. The manifold is equipped with a fixed Lorentzian metric η which serves as the reference geometry of the framework. In a global inertial chart the reference metric may be written in the Minkowski form

$$\eta_{\mu\nu} = \mathrm{diag}(-1,\, 1,\, 1,\, 1).$$

The reference metric provides the causal structure and index structure used throughout the theory. In particular, tensor contractions and index raising or lowering operations are performed with respect to η unless otherwise specified.

At the level of the present foundational development the reference metric is treated as non–dynamical. Physical geometry arises through a scalar–conformal modulation of this reference structure.

2.2 Scalar Capacity Field

The central field of the NUVO framework is a smooth positive scalar field

$$\Lambda : \mathcal{M} \to \mathbb{R}_{>0}.$$

This scalar field represents the local diagnostic quantity governing the conformal deformation of the reference geometry. Spatial and temporal variation of Λ encodes the distribution of structural capacity availability within the underlying substrate.

The scalar field therefore determines the local geometric scaling between the reference metric and the physical metric experienced by transport processes.

2.3 Baseline Capacity and Normalized Scalar

We introduce a fixed positive reference value

$$\Lambda_0 > 0$$

representing the baseline scalar level corresponding to a uniform reference state of the underlying substrate.

From this quantity we define the dimensionless normalized scalar

$$\lambda(x) := \frac{\Lambda(x)}{\Lambda_0}.$$

The normalized scalar λ provides a convenient diagnostic for describing deviations from the reference state while preserving the positivity of the scalar field.

2.4 Scalar–Conformal Physical Metric

The physical geometry of the framework is defined through a conformal relation between the scalar field and the reference metric. The physical metric g is given by

$$g_{\mu\nu} = \Lambda^2 \, \eta_{\mu\nu}.$$

Equivalently, in terms of the normalized scalar one may write

$$g_{\mu\nu} = \Lambda_0^2 \, \lambda^2 \, \eta_{\mu\nu}.$$

All physical transport processes, geodesic motion, and structural closure phenomena are evaluated with respect to the physical metric g. The reference metric η remains a fixed background geometry used to define the conformal structure and tensor operations.

This scalar–conformal relation constitutes the fundamental geometric postulate of the NUVO framework. Subsequent developments of the program describe how variations in the scalar field arise from the presence of persistent structures and how transport processes within the resulting geometry give rise to the sector phenomena developed in later papers of the series.

3 Ontological Commitments

The mathematical structure introduced in the previous section contains a scalar field whose conformal modulation of a reference geometry generates the physical metric. In order to interpret the physical meaning of this scalar field and the structural phenomena described in later sector developments, the NUVO framework adopts a set of ontological commitments regarding the nature of the underlying substrate and the configurations that occupy it.

The purpose of the present section is to record these commitments explicitly and to establish the terminology used throughout the series when describing structural configurations and their interaction with the scalar capacity field.

3.1 The Delivery Field

Underlying the scalar field Λ we posit the existence of a continuous substrate referred to as the *delivery field*. The delivery field represents the medium through which structural support is provided to persistent configurations within the framework.

The delivery field is not itself identified with the scalar field. Rather, the scalar field acts as a diagnostic of the locally available structural capacity of this substrate. In this sense the scalar field measures the ability of the delivery field at a given location to sustain persistent configurations and support transport processes.

Within the present formulation the delivery field is treated as a primitive ontological element. Its detailed microscopic structure is not specified. Instead, the theory proceeds by describing how the availability of structural capacity within this substrate varies in response to the presence of persistent configurations.

3.2 Structural Capacity

The central physical quantity represented by the scalar field is *structural capacity*. Structural capacity refers to the ability of the delivery substrate to support persistent structural configurations and the transport processes associated with them.

At any point in spacetime the delivery field possesses an intrinsic capacity for supporting such configurations. However, the portion of this capacity that remains available depends on the degree to which the substrate is already occupied by existing structures.

The scalar field Λ therefore represents the locally available portion of this structural capacity relative to a reference baseline.

3.3 Capacity Availability and Occupation

The framework distinguishes between three related notions:

- **Intrinsic delivery capacity.** The total structural support provided by the delivery substrate in the absence of persistent configurations.
- **Available capacity.** The portion of this intrinsic capacity that remains unoccupied and is therefore available to support additional structure.
- **Occupied capacity.** The portion of structural capacity bound by existing persistent configurations.

The scalar field Λ functions as a diagnostic of the available capacity. Variations in the scalar field therefore encode the distribution of occupation within the underlying substrate.

3.4 Anchored Structures and Capacity Depletion

Persistent physical configurations are represented within the NUVO framework by *anchored structures*. An anchored structure is a configuration that occupies structural capacity of the delivery substrate in a stable or long-lived manner.

Examples of anchored structures include the persistent configurations that later appear as matter bundles within the structural taxonomy of the theory. Because anchored structures occupy capacity, their presence reduces the locally available capacity relative to the baseline reference level.

This reduction is referred to as *capacity depletion.* Regions of spacetime containing anchored structures therefore exhibit deviations of the scalar field from its baseline value. Through the scalar–conformal relation introduced in the previous section, these variations in the scalar field induce corresponding modifications of the physical metric.

In this way the distribution of persistent structures within the delivery substrate determines the geometry in which transport processes occur.

3.5 Interpretive Role of the Scalar Field

It is important to emphasize that the scalar field is not interpreted as the delivery substrate itself. Rather, it serves as a diagnostic quantity describing the state of capacity availability within that substrate.

The scalar field therefore occupies an intermediate position in the hierarchy of the theory: it reflects the distribution of structural occupation within the delivery field while simultaneously determining the conformal geometry that governs observable transport processes.

The next section formalizes this relationship by introducing the diagnostic hierarchy connecting delivery, capacity distribution, the scalar field, and the resulting physical geometry.

4 Diagnostic Hierarchy of Fields

The previous sections introduced both the mathematical structure of the scalar–conformal geometry and the ontological interpretation of the scalar field as a diagnostic of structural capacity availability within an underlying delivery substrate. In order to clarify the logical relationships between these elements, it is useful to record the hierarchy connecting the delivery field, the scalar diagnostic, and the resulting physical geometry.

The NUVO framework therefore distinguishes between the underlying substrate responsible for structural support and the observable fields that arise as diagnostics of its state. This distinction ensures that the scalar field is not interpreted as the fundamental medium itself, but rather as a quantity that reflects the local distribution of structural occupation.

4.1 Delivery and Capacity Distribution

At the base of the hierarchy lies the delivery field introduced in Section 3. The delivery field represents the substrate responsible for supplying structural capacity throughout spacetime.

Within this substrate the presence of anchored structures produces a distribution of structural occupation. Regions containing persistent configurations consume a portion of the available capacity, while regions free of such configurations retain the full baseline capacity. The resulting spatial and temporal variation of available capacity defines the *capacity distribution* of the substrate.

The capacity distribution itself is not directly represented by a tensorial field in the present formulation. Instead, it is inferred through the scalar diagnostic introduced below.

4.2 Scalar Diagnostic Field

The scalar field Λ introduced in Section 2 serves as a diagnostic of the locally available structural capacity within the delivery substrate.

Let Λ_0 denote the baseline scalar value corresponding to a reference configuration of the substrate in which structural capacity is uniformly available. Deviations of Λ from this reference level encode the degree to which structural capacity has been locally occupied by anchored configurations.

The normalized scalar

$$\lambda(x) = \frac{\Lambda(x)}{\Lambda_0}$$

therefore provides a dimensionless measure of capacity availability. Regions in which persistent structures occupy structural capacity exhibit deviations of λ from unity, reflecting the local state of the substrate.

4.3 Emergent Conformal Geometry

The scalar diagnostic field determines the physical geometry through the conformal relation

$$g_{\mu\nu} = \Lambda^2 \eta_{\mu\nu}.$$

Variations in the scalar field therefore generate a corresponding variation of the physical metric. In this way the distribution of structural occupation within the delivery substrate indirectly determines the geometry experienced by transport processes.

This relation establishes the scalar field as the intermediary between substrate-level capacity distribution and the observable geometry in which physical motion occurs.

4.4 Observable Transport in the Physical Metric

All transport processes considered in the NUVO framework are evaluated with respect to the physical metric g. Geodesic motion, exchange transport, and structural closure phenomena therefore occur within the geometry generated by the scalar–conformal relation.

Observable trajectories and circulation periods depend on the structure of g, while the scalar field that determines this geometry reflects the underlying capacity distribution of the delivery substrate.

The resulting hierarchy may therefore be summarized schematically as

$$\text{delivery substrate} \longrightarrow \text{capacity distribution} \longrightarrow \text{scalar diagnostic field} \longrightarrow \text{conformal physical geometry} \longrightarrow$$

This hierarchy clarifies the interpretive role of each element of the framework and provides a conceptual bridge between the ontological commitments of Section 3 and the structural taxonomy introduced in the following section.

5 Structural Taxonomy of NUVO Systems

Having established the ontological interpretation of the scalar capacity field and the diagnostic hierarchy relating the delivery substrate to observable geometry, we now introduce the structural configurations that occupy the substrate and give rise to the transport phenomena developed in subsequent sector analyses.

Within the NUVO framework persistent configurations of the delivery substrate are represented by loop structures. These loops represent stable or semi-stable patterns of structural occupation and transport within the capacity field. Different classes of loops correspond to different physical roles within the framework, including persistent matter configurations, interaction channels, and radiative transport structures.

The present section records the taxonomy of these loop structures and clarifies their conceptual roles within the program.

5.1 Closed Loop Structures

Closed loop structures represent persistent configurations that occupy structural capacity of the delivery substrate without producing net exchange with the surrounding environment. Such loops form self-contained circulation patterns within the scalar-modulated geometry.

Because closed loops do not terminate on external structures, the capacity they occupy remains locally bound within the loop configuration. This property allows closed loops to persist as stable structural entities.

Within later sector developments these closed loop configurations serve as the structural representation of persistent matter configurations. Their internal circulation properties determine characteristic quantities such as circulation period and structural stability, which in turn influence the transport behavior of the configuration within the physical metric.

5.2 Open Loop Structures

Open loop structures differ from closed loops in that they terminate on distinct anchored structures. Rather than forming a self-contained circulation pattern, an open loop represents a channel through which exchange transport may occur between two structural anchors.

These open loops therefore mediate interaction processes within the framework. Transport through an open loop corresponds to the flow of exchange quantities between anchored configurations.

In later sector developments the collective behavior of open loop transport gives rise to the exchange current structures that produce the weak-limit correspondence with familiar gauge-field dynamics.

5.3 Dynamic Radiative Loops

In addition to closed and open loop configurations, the framework admits dynamic loop structures that propagate through the scalar geometry without remaining anchored to persistent configurations.

These dynamic loops represent radiative transport structures within the delivery substrate. Their motion through the scalar-modulated geometry constitutes a propagating exchange configuration that transfers structural influence between distant regions of the substrate.

The radiative sector developed in later work analyzes the properties of such dynamic loop structures and their propagation through the physical metric.

5.4 Bundled Configurations and Persistent Matter

While individual loops provide the basic structural elements of the framework, persistent physical objects generally correspond to bundled configurations composed of multiple interacting loops.

A bundle represents a stable structural complex in which closed loops and associated exchange channels combine to form a persistent configuration occupying a finite region of the delivery substrate. The collective properties of the bundle determine the macroscopic behavior of the corresponding physical object.

Within the NUVO program, such bundled configurations provide the structural basis for persistent matter systems. Their internal circulation patterns and exchange couplings determine both their transport behavior and their interaction with surrounding structures.

The loop taxonomy introduced here therefore provides the structural foundation upon which the subsequent sector developments of the framework are constructed.

6 Sector Structure of the NUVO Program

The NUVO framework has been developed through a sequence of mathematical manuscripts organized into sectoral series. Each series treats a particular class of phenomena as a specialization or consequence of the scalar–conformal structure introduced in the foundational papers.

The purpose of the present section is to summarize the relationship between these sector developments and the underlying geometric framework described in the preceding sections. This overview is not intended to reproduce the detailed results of the individual papers, but rather to record the role that each sector plays within the overall program.

6.1 Scalar Capacity Sector

The foundational sector of the program establishes the scalar capacity framework and the conformal geometry that arises from it. This work is developed in the M-series papers.

The early papers of that series introduce the scalar capacity field, the conformal relation between the scalar field and the reference metric, and the variational structure governing the scalar field. These results establish the geometric environment within which all subsequent structural and transport phenomena are analyzed.

Later papers in the same series develop the transport properties of the scalar field and introduce the exchange structures that arise when persistent configurations occupy the delivery substrate.

6.2 Gravitational Reduction

Within the scalar capacity sector, gradients in the scalar field produce variations in the conformal geometry that governs transport. These geometric variations give rise to trajectories that correspond to gravitational behavior.

The gravitational sector therefore emerges as a reduction of the scalar capacity framework in regimes where persistent structures produce slowly varying capacity depletion fields. Motion in these fields follows geodesics of the conformally modulated physical metric.

The derivation of this gravitational reduction appears in the M-series analysis of scalar field dynamics.

6.3 Exchange Transport Sector

When anchored structures interact through open loop configurations, exchange transport channels arise within the scalar-modulated geometry. The exchange sector analyzes the transport processes that occur along these open loop structures.

Collective exchange transport leads to the emergence of exchange currents and associated conservation relations. In appropriate limits, the resulting transport equations exhibit correspondence with the structure of familiar gauge-field dynamics.

This exchange transport sector forms a central component of the M-series development.

6.4 Radiative Transport Sector

Dynamic loop configurations represent propagating exchange structures within the scalar geometry. These structures form the basis of the radiative transport sector.

Radiative configurations propagate through the scalar-modulated geometry while carrying exchange structure between spatially separated regions of the delivery substrate. The analysis of these radiative structures and their propagation properties is developed in later M-series work.

6.5 Relativistic Kinematics Sector

The SR-series of papers investigates the consequences of the scalar framework for the kinematics of persistent structures in motion.

Within this analysis relativistic time dilation and related phenomena are interpreted in terms of changes in the internal circulation properties of persistent structural configurations as they move through the scalar-modulated geometry.

This approach provides a structural interpretation of relativistic kinematics within the broader NUVO framework.

6.6 Quantization and Closure Sector

The Q-series papers examine the consequences of exchange transport for bound structural systems. In particular, they analyze the conditions under which exchange transport cycles close upon themselves in a holonomic manner.

These closure conditions lead to discrete structural states for bound systems. In this interpretation quantization arises from geometric closure constraints on exchange transport cycles rather than from intrinsic wave-mechanical assumptions.

Applications of this closure structure to atomic systems are explored in the hydrogen analysis developed in the Q-series.

6.7 Moving Coherence and Matter-Wave Sector

The later Q-series papers extend the closure analysis to persistent structures in motion. In this regime observable interaction events occur when the moving structural configuration returns to states of coherence with the exchange transport sector.

This interpretation provides a geometric explanation of matter-wave phenomena in terms of discrete coherence events along the worldline of a moving persistent structure.

Together, these sector developments illustrate how a variety of physical phenomena can be understood as structural consequences of the scalar–conformal framework established in the foundational papers of the NUVO program.

7 Empirical Calibration Structure

The scalar–conformal NUVO framework is developed as a structural theory in which geometry, transport processes, and closure phenomena arise from the distribution of structural capacity within the delivery substrate. While much of the resulting structure follows from the mathematical relations established in the foundational papers, certain sector analyses require the introduction of an empirical calibration scale.

The purpose of the present section is to clarify the role of such calibration within the NUVO program and to distinguish between quantities that are assumed as empirical inputs and those that arise as derived consequences of the structural framework.

7.1 Hydrogen Ground-State Calibration

In the bound-state analysis developed in the Q-series, the hydrogen atom provides a natural system for investigating the consequences of exchange-cycle closure. Within this analysis the ground-state binding energy of hydrogen,

$$E_1 = 13.6\,\mathrm{eV},$$

is used as a single empirical calibration scale.

The introduction of this calibration establishes the energy scale for the exchange closure sector. Once this scale is fixed, the closure relations governing exchange cycles determine the corresponding length scales and action scales that characterize the bound system.

In this sense the hydrogen ground-state energy functions as a reference datum anchoring the closure analysis to observed physical systems.

7.2 Derived Structural Quantities

Given the calibration described above, the closure relations derived in the Q-series lead to a sequence of structural quantities that characterize the hydrogen system. These include characteristic orbital length scales, exchange cycle parameters, and the action scales associated with closure transport.

Within the framework these quantities are not introduced as independent empirical constants. Rather, they arise as structural consequences of the closure relations once the overall energy scale has been fixed.

In particular, the relationships among characteristic atomic length scales, exchange cycle parameters, and action scales emerge from the holonomic closure conditions governing the exchange sector.

7.3 Status of Fundamental Constants

The present stage of the NUVO program therefore distinguishes between two classes of quantities.

The first class consists of calibration inputs that establish the absolute scale of the physical system under consideration. In the hydrogen analysis the ground-state binding energy plays this role.

The second class consists of quantities that arise from the structural relations of the framework once the calibration scale has been specified. These include the characteristic length scales and action relations associated with exchange-cycle closure.

In this way the framework explains how multiple physical quantities are structurally related within a given system, while recognizing that the absolute scale of those relations may be fixed by empirical input.

Further work within the program aims to investigate whether deeper structural constraints on the delivery substrate may ultimately determine these calibration scales from first principles. At present, however, the use of a minimal empirical calibration provides a practical bridge between the structural framework and observed physical systems.

8 Ledger of Assumptions and Derived Results

The NUVO program is developed as a sequence of mathematical constructions built upon a small set of primitive geometric and ontological assumptions. As the framework has expanded across multiple sector analyses, it has become useful to explicitly distinguish between those elements that are assumed at the foundational level and those that arise as derived consequences of the structural framework.

The present section records this distinction in a program-wide ledger. The goal is to provide conceptual transparency regarding the status of the various quantities and relations used throughout the series.

8.1 Primitive Postulates

The primitive postulates of the NUVO framework consist of the minimal geometric and ontological assumptions required to construct the theory.

- **Spacetime manifold.** Physical processes occur on a smooth four-dimensional spacetime manifold $\mathcal{M}$.
- **Reference Lorentzian metric.** A fixed Lorentzian metric η provides the reference causal structure used to define the scalar–conformal geometry.
- **Scalar capacity field.** A positive scalar field Λ represents the diagnostic of locally available structural capacity within the delivery substrate.
- **Scalar–conformal physical metric.** The physical geometry is defined through the conformal relation

$$g_{\mu\nu} = \Lambda^2 \eta_{\mu\nu}.$$

- **Delivery substrate.** An underlying substrate provides structural capacity whose local availability is diagnosed by the scalar field.
- **Structural loop configurations.** Persistent and transport structures within the substrate are represented by loop configurations occupying structural capacity.

These postulates define the minimal structural framework from which the subsequent sector developments proceed.

8.2 Derived Structural Results

Within the scalar–conformal framework a number of structural results follow from the mathematical relations governing the scalar field and the transport properties of loop configurations.

Among the principal derived results developed across the series are the following:

- **Gravitational reduction.** Gradients in the scalar capacity field produce geodesic motion within the conformally modulated physical metric.
- **Exchange transport structure.** Open loop configurations generate exchange currents and associated transport relations between anchored structures.
- **Radiative propagation.** Dynamic loop configurations propagate through the scalar geometry as radiative transport structures.
- **Relativistic circulation effects.** The internal circulation of persistent configurations produces structural modifications of observed time intervals consistent with relativistic kinematics.
- **Exchange-cycle closure states.** Holonomic closure conditions on exchange transport cycles lead to discrete structural states for bound systems.

These results arise as structural consequences of the scalar–conformal framework combined with the loop taxonomy introduced in the previous sections.

8.3 Correspondence Relations

Several sector developments of the NUVO program establish correspondence relations with familiar physical theories. These correspondence relations do not assert identity between the NUVO framework and those theories, but rather demonstrate that certain limiting behaviors reproduce structures known from established physics.

Examples include the following:

- Gravitational motion corresponding to geodesic trajectories in the scalar–conformal metric.
- Exchange transport relations exhibiting structural similarity to gauge-field conservation equations in appropriate limits.
- Structural circulation effects producing kinematic relations consistent with relativistic time dilation.
- Exchange-cycle closure relations producing discrete spectral structures in bound systems.

Such correspondences serve as consistency checks on the structural framework and provide a bridge between the NUVO program and existing physical descriptions.

8.4 Calibration Inputs

Certain sector analyses introduce empirical inputs in order to fix the absolute scale of the structural relations derived within the framework.

The principal example appears in the hydrogen closure analysis, where the ground-state binding energy is used as a calibration scale for the exchange closure sector. Once this scale is specified, the structural relations of the framework determine the corresponding hierarchy of length and action scales associated with the bound system.

The use of such calibration inputs does not alter the structural relations derived within the framework, but rather anchors those relations to experimentally observed physical systems.

Recording these inputs explicitly allows the program to maintain a clear distinction between structural derivation and empirical calibration.

9 Structural Phase and Moving Coherence

The closure analysis developed in the Q-series establishes that persistent bound configurations arise when exchange transport cycles satisfy holonomic closure conditions. In the simplest case of a stationary bound configuration, closure occurs when the exchange cycle returns to its initial structural state after a complete circulation.

When persistent structures move through the scalar-modulated geometry, however, the conditions required for exchange closure become more subtle. The structural configuration may evolve along its trajectory in such a way that the internal state of the loop system is not identical after a single circulation period. In order to maintain a consistent notion of closure for moving structures, the framework introduces an additional structural phase parameter associated with the internal evolution of the configuration.

The purpose of the present section is to clarify the role of this structural phase and to record its status within the current stage of the NUVO program.

9.1 Introduction of the Structural Phase

Let a persistent structural configuration evolve along a worldline parameterized by proper time τ. In addition to the geometric transport of the configuration through the scalar-modulated spacetime, the internal structure of the loop configuration may undergo a phase-like evolution during this motion.

To account for this evolution, the moving closure analysis introduces a structural phase function

$$\theta(\tau),$$

which records the internal phase of the structural configuration along its trajectory.

Closure of an exchange cycle for a moving configuration therefore requires not only geometric return of the exchange path but also consistency of the internal structural phase.

9.2 Role in Maintaining Closure Coherence

The structural phase plays a central role in maintaining coherence of exchange transport cycles for moving configurations. In particular, observable interaction events correspond to moments at which the exchange structure returns to a coherent state with the surrounding exchange transport sector.

Because the internal phase of the configuration evolves continuously along its trajectory, such coherence events occur only at discrete points along the worldline where the structural phase satisfies the closure condition required for exchange interaction.

This interpretation provides a geometric picture in which the motion of a persistent configuration is continuous, while observable interaction events occur at discrete coherence points along that trajectory.

Within the Q-series analysis this structure leads naturally to an interpretation of matter-wave phenomena in terms of the spacing between successive coherence events associated with the evolving structural phase.

9.3 Status within the Present Framework

At the present stage of the NUVO program the structural phase $\theta(\tau)$ is introduced as a structural parameter describing the internal evolution of moving loop configurations.

While the phase plays an important role in the moving closure analysis, its microscopic origin has not yet been derived directly from the underlying loop geometry. Instead, it is currently treated as an intrinsic structural degree of freedom associated with persistent configurations.

Future work within the program aims to investigate whether this structural phase can be derived from more detailed properties of the loop structures that constitute persistent bundles. In particular, it is expected that the internal circulation patterns of bundled loop configurations may provide a geometric origin for the phase evolution introduced here.

For the purposes of the present framework, however, the structural phase serves as a consistent parameter allowing the closure analysis to be extended from stationary configurations to moving persistent structures.

10 Weak-Limit Closure Assumptions

The sector developments summarized in the preceding sections are constructed under a set of simplifying assumptions that separate the scalar capacity dynamics from the exchange transport sector in the regime of weak structural coupling. These assumptions allow the individual sectors of the framework to be analyzed in a controlled manner while preserving the underlying scalar–conformal structure.

The purpose of the present section is to record these assumptions explicitly and to clarify the regime of validity within which they are applied.

10.1 Exchange Transport in the Weak Limit

Within the NUVO framework exchange transport occurs along open loop configurations connecting anchored structures. These exchange processes carry structural influence between persistent configurations and form the basis of the interaction sector of the theory.

In the weak-limit regime considered in the present program stage, exchange transport is treated as occurring within a background scalar geometry determined primarily by the capacity depletion associated with persistent anchored structures. The exchange transport itself is assumed not to produce a significant modification of the scalar capacity field.

This assumption allows the scalar capacity sector and the exchange transport sector to be analyzed sequentially: first determining the scalar-modulated geometry produced by anchored structures, and then studying the exchange transport processes that occur within that geometry.

10.2 Scalar Backreaction Considerations

The separation described above implies that the exchange transport sector does not act as a direct source for variations in the scalar capacity field within the weak-limit approximation. Instead, the dominant contribution to the scalar field is assumed to arise from the occupation of structural capacity by persistent anchored configurations.

In regimes where exchange transport remains small compared with the capacity occupation associated with anchored structures, this approximation provides a consistent description of the system.

It is important to emphasize, however, that this separation is not expected to represent the complete behavior of the theory in all regimes. In circumstances where exchange transport becomes sufficiently intense, the associated structural processes may be expected to produce measurable modifications of the scalar capacity field.

10.3 Regime of Validity

The weak-limit closure assumptions therefore define the regime of validity for the present sector developments of the NUVO program.

Within this regime the scalar capacity field is primarily determined by the distribution of anchored structures, while exchange transport and radiative processes occur within the resulting scalar-modulated geometry.

Beyond this regime a fully coupled treatment of scalar capacity dynamics and exchange transport may become necessary. The development of such a coupled description represents an important direction for future work within the framework.

Recording the weak-limit assumptions explicitly helps clarify which results of the current program follow directly from the foundational structure and which rely on controlled approximations appropriate to the regimes considered in the existing sector analyses.

11 Open Problems and Program Roadmap

The preceding sections have summarized the foundational structure of the scalar–conformal NUVO framework, including its geometric postulates, ontological interpretation, structural taxonomy, and the sector developments constructed upon this foundation. While these results establish a coherent structural program, several important questions remain open and define the next stages of development for the framework.

The purpose of the present section is to identify these open problems and to outline a conceptual roadmap for further work within the program.

11.1 Derivation of the Structural Phase

In the moving closure analysis of the Q-series, a structural phase parameter was introduced in order to maintain coherence of exchange transport cycles for persistent configurations in motion.

Although this phase provides a consistent description of moving closure states and leads naturally to the interpretation of matter-wave phenomena, its microscopic origin has not yet been derived directly from the underlying loop geometry.

A central open problem for the program is therefore the derivation of this structural phase from the internal dynamics of bundled loop configurations. It is expected that the circulation properties of such bundles may provide a geometric origin for the phase evolution introduced in the current framework.

11.2 Derivation of the Binding Scale

In the bound-state analysis of the hydrogen system, the ground-state binding energy is used as an empirical calibration scale for the exchange closure sector. Once this calibration is introduced, the closure relations determine a hierarchy of structural quantities associated with the bound system.

An important goal for future work is the derivation of this binding scale directly from deeper properties of the delivery substrate and the structural capacity dynamics. Such a derivation would eliminate the need for external calibration and would provide a more complete first-principles account of bound-state structure within the framework.

11.3 Exchange–Scalar Coupling Beyond the Weak Limit

The present sector analyses treat exchange transport and scalar capacity dynamics as effectively decoupled in the weak-limit regime. This approximation allows the individual sectors to be analyzed in a controlled manner, but it is not expected to remain valid in all physical regimes.

A further stage of development will therefore involve the analysis of fully coupled scalar and exchange dynamics. In such regimes the transport of exchange structures may contribute directly to the distribution of structural capacity and thus modify the scalar field itself.

Understanding this coupled behavior is expected to be particularly important in systems involving strong exchange transport or high structural density.

11.4 Multi-Structure Closure Systems

The bound-state analyses developed thus far focus primarily on systems involving a small number of interacting structural configurations. Extending the closure analysis to multi-structure systems represents another major direction for future work.

Such systems may involve networks of exchange transport channels and multiple interacting bundles, leading to more complex closure structures and potentially new classes of persistent configurations.

The development of a general theory of multi-structure closure would therefore provide an important extension of the current framework.

11.5 Extensions Toward Nuclear and Standard Model Domains

The structural framework developed in the NUVO program provides a basis for describing persistent configurations, exchange transport, and closure phenomena within the scalar–conformal geometry.

A long-term objective of the program is to explore whether these structural principles can be extended to describe additional physical domains, including systems involving strongly coupled bundles and more complex interaction networks.

Such extensions may provide a pathway toward structural descriptions of nuclear-scale phenomena and potentially offer new perspectives on the organization of particle interactions within the broader framework.

11.6 Summary of Program Development

The open problems identified above illustrate that the NUVO program should be understood as an evolving theoretical framework rather than a completed physical theory. The foundational geometry and sector structure developed thus far provide a consistent starting point, but several key questions remain to be addressed.

Future work will therefore focus on deriving presently assumed structural parameters from deeper properties of the loop configurations and on extending the coupled dynamics of the scalar capacity and exchange transport sectors.

These developments will determine the extent to which the structural framework established in the present series can provide a more complete description of physical systems.

12 Glossary of Program Terminology

The NUVO program introduces a number of technical terms used consistently throughout the M-, SR-, and Q-series manuscripts. The purpose of the present section is to record these terms and their intended meanings in a single reference location in order to support clarity and reproducibility across the series.

12.1 Delivery Field

The *delivery field* refers to the underlying substrate whose local structural availability is represented by the scalar field $\Lambda(x)$. The delivery field itself is not modeled directly in the present framework; instead its effective influence is encoded through the modulation of structural capacity by the scalar field.

The term is therefore interpretive and refers to the conceptual substrate whose availability governs the formation and persistence of structural configurations.

12.2 Structural Capacity

Structural capacity denotes the local ability of the delivery substrate to support persistent configurations. In the mathematical formalism this quantity is represented by the scalar modulation field $\Lambda(x)$.

Regions of reduced capacity correspond to locations where persistent structures occupy a portion of the available structural support.

12.3 Structural Availability

Structural availability refers to the normalized measure of capacity relative to a baseline reference value. In the program notation this quantity is expressed by the dimensionless diagnostic

$$\lambda(x) = \frac{\Lambda(x)}{\Lambda_0}.$$

This normalized field provides a convenient representation of relative structural depletion or abundance across the manifold.

12.4 Anchored Structure

An *anchored structure* is a persistent configuration that occupies structural capacity and therefore produces a localized modification of the scalar field.

Anchored structures represent the fundamental persistent entities of the framework and serve as the sources of scalar capacity depletion in the geometric sector of the theory.

12.5 Closed Loop Configuration

A *closed loop configuration* is a structural configuration whose transport cycle closes on itself without requiring external exchange channels.

Closed loops represent persistent structural bundles and form the basis for matter-like configurations within the NUVO ontology.

12.6 Open Loop Configuration

An *open loop configuration* is a transport structure that connects distinct anchored structures and allows exchange transport between them.

Open loops therefore provide the structural mechanism by which interaction processes occur in the exchange sector of the theory.

12.7 Dynamic Loop

A *dynamic loop* refers to a propagating transport structure that carries exchange influence through the scalar-modulated geometry without forming a persistent anchored configuration.

Dynamic loops represent the transport structures associated with radiative exchange processes.

12.8 Exchange Transport

Exchange transport denotes the propagation of structural influence along open or dynamic loop configurations connecting anchored structures.

The exchange sector of the NUVO program studies the properties of these transport processes and the circulation observables associated with them.

12.9 Closure State

A *closure state* is a configuration in which exchange transport cycles return to a coherent structural alignment after a complete circulation.

Closure conditions determine the existence of persistent bound configurations and play a central role in the quantization mechanisms developed in the Q-series.

12.10 Structural Phase

The *structural phase* is a parameter associated with the internal circulation of a persistent configuration.

In the moving closure analysis this phase evolves along the trajectory of the configuration and provides the mechanism by which coherent exchange conditions are maintained during motion.

12.11 Weak-Limit Regime

The *weak-limit regime* refers to the approximation in which the scalar capacity field is primarily determined by anchored structures while exchange transport produces negligible direct modification of the scalar field.

This regime provides the basis for the sector separation used in the current development of the NUVO program.

13 Summary

The NUVO program proposes a scalar–conformal framework in which the physical metric of spacetime is modulated by a single scalar field representing the locally available structural capacity of an underlying delivery substrate. From this primitive geometric assumption a sequence of sector developments has been constructed across the M-, SR-, and Q-series papers.

The present manuscript serves a distinct role within that program. Rather than introducing new sectoral results, it consolidates the conceptual and terminological foundations that underlie the existing series. The objective is to record, in a single location, the primitive mathematical setting, the interpretive ontology, the structural taxonomy of configurations, and the hierarchy of fields used throughout the framework.

Several key points of clarification arise from this consolidation.

First, the mathematical foundation of the program is intentionally minimal. The primitive structure consists of a spacetime manifold equipped with a fixed reference Lorentzian metric and a positive scalar modulation field whose square defines the physical metric through a conformal relation. This structure provides the geometric background for all subsequent sector developments.

Second, the ontology of the framework is expressed through a structural interpretation of this scalar modulation. Persistent configurations are modeled as anchored structures that occupy structural capacity, producing localized depletion of the scalar field. Interaction processes occur through exchange transport along open loop configurations connecting such structures, while dynamic loops represent propagating exchange transport.

Third, the framework organizes its results into a set of sectoral developments built upon the same geometric base. The M-series establishes the scalar–conformal geometry and its associated transport structures. The SR-series analyzes the kinematics of persistent configurations moving within the scalar-modulated geometry. The Q-series investigates the closure properties of exchange cycles and their role in producing discrete bound-state structures.

The glossary and assumption ledger included in this manuscript are intended to stabilize the vocabulary and logical structure of the program as it develops. By recording the primitive assumptions and derived results explicitly, the framework maintains clarity regarding which elements are foundational definitions, which are derived consequences, and which remain open questions.

Several open problems remain central to the continued development of the program. These include the derivation of structural phase dynamics from the internal geometry of loop bundles, the explanation of the empirical binding scale used in the hydrogen analysis, and the development of a fully coupled treatment of scalar capacity and exchange transport beyond the weak-limit approximation.

Taken together, the material presented here provides a unified reference for the conceptual and structural elements that appear throughout the NUVO series. Its purpose is to support consistency of notation, interpretation, and terminology as the program continues to develop its sector analyses and explore their extensions.

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