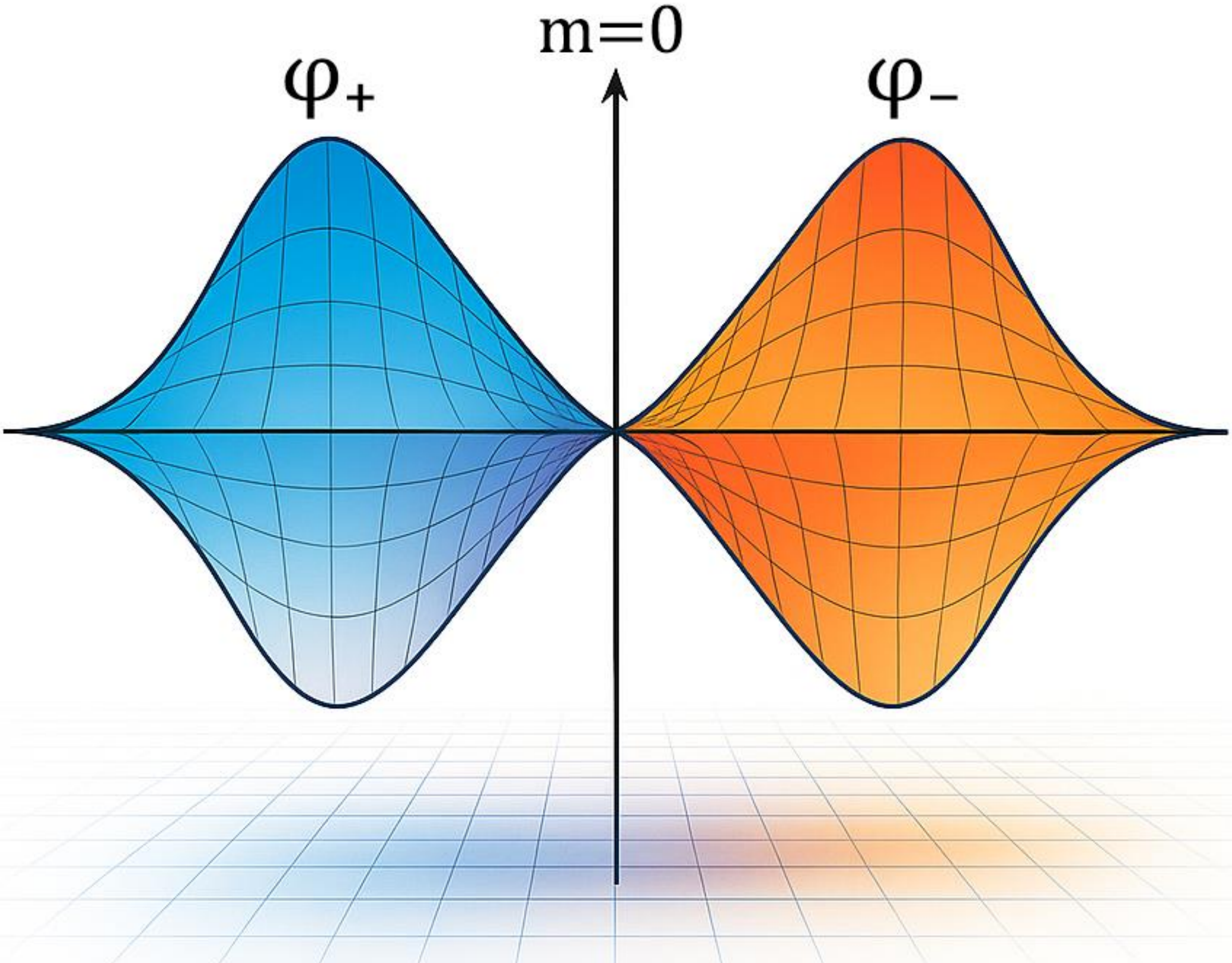
SMM -
THE SYMMETRIC MASS MODEL

Volume 1- Foundation and Cosmology



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Hypothetical Theoretical Model

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Abstract

The Symmetric Mass Model (SMM) presents a new field-theoretic framework in which mass is not regarded as an absolute quantity, but as a symmetric field configuration centred around the zero point. The model introduces two scalar fields — ϕ_+ and ϕ_- — representing positive and negative mass, respectively. These fields interact through a common Lagrangian density with a nonlinear coupling, resulting in opposing gravitational properties.

The model includes both classical and quantum formulations through quantization and operator expansion. The field equations are extended from the Klein–Gordon type with symmetric interactions, requiring no new particle species.

SMM offers a natural explanation for dark matter and dark energy by interpreting them as field-based projections of the ϕ_- sector into the observable domain. The negative mass contributes curvature without electromagnetic emission, giving rise to measurable effects.

Through a unified field structure, SMM provides a consistent account of both visible and invisible mass distributions and may thus serve as a foundation for a true theory of everything.

This model – the Symmetric Mass Model (SMM) – is independent of and should not be confused with Symmetric Mass Generation (SMG), which refers to a non-perturbative mechanism for fermion mass generation without Higgs condensation or spontaneous symmetry breaking.

Foreword

This publication is the result of a long-term personal process of theoretical idea development, in which I, as an independent thinker in theoretical physics, have worked on a new hypothetical model for mass and spacetime. The work has been carried out at my own pace, without institutional affiliation, pressure, or external demands.

The model has had great personal significance for me, particularly during a period marked by health-related challenges and limited functional capacity. It has served as an intellectual and creative structure in daily life – not as employment in the conventional sense.

This book should therefore be viewed as a private project with academic aspirations, but without commercial or occupational purpose. All results and ideas are presented in the spirit of open scientific dialogue, and with respect for the established research community.

Patrick Oliver Køhalmi

Contents

1 – Introduction

Modern physics has achieved remarkable precision in describing the fundamental forces of nature, particularly through quantum mechanics and general relativity. Despite this success, unresolved domains remain — including the nature of dark matter, dark energy, and the long-sought unified theory capable of encompassing all physical fields within a single framework.

The Standard Model of particle physics accurately describes the interactions among known elementary particles but lacks a natural explanation for gravity and dark matter. Conversely, Einstein's general theory of relativity describes spacetime curvature as a response to energy and mass, but it cannot be quantized in the same manner as the other fundamental theories.

These limitations have motivated the search for a more fundamental theory — one that can unify the four fundamental forces and explain observed cosmic phenomena without resorting to hypothetical particles or external constants.

1.1 Background

Historically, the classical concept of mass has been tied to the notion of an intrinsic property of matter — a passive resistance to acceleration and a source of gravitational attraction. In both Newtonian mechanics and Einstein's relativity, mass plays a central role, yet it is not assigned any deeper internal structure. In quantum field theory, mass emerges as a consequence of coupling to the Higgs field, but the very existence of mass remains an axiom rather than a derived phenomenon.

At the same time, observations in cosmology and astrophysics reveal that the vast majority of the universe's mass–energy is hidden in forms that emit no electromagnetic radiation — the so-called dark matter and dark energy. This suggests that our understanding of mass as a physical reality is incomplete.

These limitations motivate an alternative approach in which mass is not treated as an absolute quantity, but as a dynamic property emerging from symmetric field systems. The Symmetric Mass Model proposes exactly this: that mass arises as a balance between two fields, ϕ_+ and ϕ_-, which unfold in distinct yet coupled domains with opposing physical characteristics. This forms the basis for reinterpreting both visible and invisible mass distributions within a unified field-theoretic framework.

1.2 Motivation

If mass can emerge as a property of an underlying symmetric field structure, it opens the way for a new and potentially more fundamental understanding of both matter and spacetime. The Symmetric Mass Model (SMM) is motivated by the desire to unify phenomena that have so far required separate explanatory frameworks — including dark matter, dark energy, and mass generation — within a single theoretical structure, without introducing new particle species or hypothetical fields.

By introducing two opposing mass fields, ϕ_+ and ϕ_-, and allowing them to unfold in separate domains, it becomes possible to interpret observed phenomena as emergent projections of the underlying field landscape. In this view, classical mass arises as an asymmetry in the field distribution between domains, and the gravitational effects of dark matter and energy can be understood as geometric consequences within the ϕ_- sector.

The motivation is therefore twofold: theoretically, to reduce the number of fundamental postulates by allowing mass to emerge naturally from field dynamics; and empirically, to provide a field-based explanation for observed cosmic effects without invoking ad hoc elements or unobserved particles.

2 – Theoretical Framework

2.1 Mass Field Structure and Symmetry

The Symmetric Mass Model is founded on the existence of two coupled but opposing scalar fields: ϕ_+ and ϕ_-. These fields are assumed to unfold in the positive and negative mass domains, respectively, and together form a symmetric field pair centred around the mass zero point. While ϕ_+ represents conventional positive mass, ϕ_- is associated with negative mass, contributing to spacetime curvature with an opposite sign.

The model introduces a composite mass field:

$$\varphi(x) = \varphi_+(x) + \varphi_-(x)$$

where:

- ϕ_+ represents the positive mass phase
- ϕ_- represents the negative mass phase

Both fields are scalar fields, and the model is built upon a symmetry around $\phi = 0$, corresponding to the state of massless free motion. This zero point defines the balanced state in which the two fields cancel each other out, and mass does not manifest in spacetime.

The fields are treated as real classical fields in their base formulation and are described by a shared Lagrangian density, including kinetic, potential, and interaction terms. What distinguishes the SMM is that the two fields not only coexist but are related through an internal symmetry: their dynamics are structurally mirrored around zero, enabling a shared yet asymmetric mass distribution within the observable universe.

In this framework, mass is not viewed as a localized property of particles, but as a manifestation of the field's configuration and the relative weighting of ϕ_+ and ϕ_- in a given region of spacetime. A dominance of ϕ_+ leads to positive, attractive gravitation, while a dominance of ϕ_- results in repulsive effects, consistent with observations of accelerated cosmic expansion.

2.2 Lagrangian Density

As described in Section 2.1, the composite mass field $\varphi(x) = \varphi_+(x) + \varphi_-(x)$ is modeled by a shared Lagrangian density that includes both free and interacting terms for the two fields.

The dynamic description of ϕ_+ and ϕ_- in the Symmetric Mass Model is based on a unified Lagrangian density, which includes contributions from the free fields and an interaction term between them. The fields are treated as scalar fields with standard kinetic and potential terms, but they are coupled through a cross-interaction that expresses the internal symmetry between the domains.

The general form of the Lagrangian density is written as:

$$\mathcal{L} = \frac{1}{2}\partial^{\mu}\phi_+ \ \partial_{\mu}\phi_+ - \frac{1}{2}m_+^2\phi_+^2 + \frac{1}{2}\partial^{\mu}\phi_- \ \partial_{\mu}\phi_- - \frac{1}{2}m_-^2\phi_-^2 - \lambda\phi_+^2\phi_-^2$$

Here, ϕ_+ and ϕ_- represent the two fields in their respective domains, while $m_+ \ and \ m_-$ denote their effective mass scales. The final term, $\lambda\phi_+^2\phi_-^2$, constitutes the interaction term that ensures coupling between the fields without introducing direct transfer of mass or charge.

The Lagrangian density is constructed to respect the symmetry under field exchange while allowing spontaneous breaking of balance between them. This enables a dynamic mass relationship, where mass emerges as a result of field distribution rather than as an intrinsic property.

2.3 Euler–Lagrange Equations

From the shared Lagrangian density for ϕ_+ and ϕ_-, the dynamical equations of motion for the fields can be derived using the classical Euler–Lagrange equations. For a general scalar field $\phi(x)$, the equation is:

$$\partial_{\mu}\left(\frac{\partial\mathcal{L}}{\partial(\partial_{\mu}\varphi_{\pm})}\right) - \frac{\partial\mathcal{L}}{\partial\varphi_{\pm}} = 0$$

Applied to the fields ϕ_+ and ϕ_-, using the Lagrangian density defined in Section 2.2, we obtain the following coupled field equations:

$$\Box\varphi_+ + m_+^2\varphi_+ + 2\lambda\varphi_+\varphi_-^2 = 0$$

$$\Box\varphi_- + m_-^2\varphi_- + 2\lambda\varphi_-\varphi_+^2 = 0$$

Here, $\Box$ denotes the d'Alembert operator in Minkowski spacetime, defined as:

$$\Box = \partial^\mu \partial_\mu = \frac{\partial^2}{\partial t^2} - \nabla^2$$

These equations show that each field is influenced not only by its own mass and wave structure, but also interacts nonlinearly with the other component. The coupling allows for asymmetric field evolution, where small imbalances in one sector can amplify and lead to domain-specific mass manifestation.

2.4 Quantization

To transition from a classical to a quantum description, the fields ϕ_+ and ϕ_- are quantized according to the principles of the canonical formalism. This implies that the fields and their conjugate momenta are treated as operators satisfying commutation relations on a Hilbert space.

The quantized fields are expressed as operator expansions in momentum space:

$$\widehat{\varphi_+}(x) = \int \frac{d^3k}{(2\pi)^3} \frac{1}{\sqrt{2E_k}} \left(\widehat{a_k} e^{-ikx} + \widehat{a_k^\dagger} e^{ikx}\right)$$

$$\widehat{\varphi_-}(x) = \int \frac{d^3k}{(2\pi)^3} \frac{1}{\sqrt{2E_k}} \left(\widehat{b_k} e^{-ikx} + \widehat{b_k^\dagger} e^{ikx}\right)$$

Here, $\widehat{a_k}, \widehat{a_k^\dagger}$ and $\widehat{b_k}, \widehat{b_k^\dagger}$ denote the annihilation and creation operators for the two fields, respectively. The commutation relations follow the standard bosonic form:

$$\left[\widehat{a_k}, \widehat{a_{k'}^\dagger}\right] = (2\pi)^3\delta^3(k - k') \quad , \quad \left[\widehat{b_k}, \widehat{b_{k'}^\dagger}\right] = (2\pi)^3\delta^3(k - k')$$

All other commutators are assumed to vanish. The fields are thus quantized independently within their respective domains, but the interaction term in the Lagrangian still dynamically connects them.

Quantization allows for the calculation of probability amplitudes and transition processes, forming the necessary foundation for the operator expansion addressed in the next section.

2.5 Operator Expansion and Field Interpretation

The quantized fields ϕ_+ and ϕ_- are understood as operators acting on a Fock space, creating or annihilating quantized excitations in the positive and negative mass sectors, respectively. The operator expansion expresses the field as a sum of plane waves, each weighted by an operator-valued coefficient.

For ϕ_+, we have:

$$\widehat{\varphi_+}(x) = \int \frac{d^3k}{(2\pi)^3} \frac{1}{\sqrt{2E_k}} \left(\widehat{a_k} e^{-ikx} + \widehat{a_k^\dagger} e^{ikx} \right)$$

And for ϕ_-:

$$\widehat{\varphi_-}(x) = \int \frac{d^3k}{(2\pi)^3} \frac{1}{\sqrt{2E_k}} \left(\widehat{b_k} e^{-ikx} + \widehat{b_k^\dagger} e^{ikx} \right)$$

Here, $\widehat{a_k^\dagger}$ and $\widehat{b_k^\dagger}$ are creation operators generating quantum excitations (particles), while $\widehat{a_k}$ and $\widehat{b_k}$ annihilate them. These operators act on the vacuum state $|0\rangle$, which satisfies:

$$\widehat{a_k}|0\rangle = 0 \quad , \quad \widehat{b_k}|0\rangle = 0$$

The interpretation of each field depends on its domain. The ϕ_+ field describes particles with positive mass and conventional forward time evolution. The ϕ_- field corresponds to hypothetical negative-mass excitations, still quantized bosonically, and capable of interacting through the shared Lagrangian.

These operator expansions form the foundation for calculating matrix elements and transition probabilities in the following chapters. The field interpretation provides physical intuition for how mass emerges as quantum excitation centred around a neutral reference point.

3 – Feynman Structure and Interactions

This chapter introduces the perturbative approach to interactions in the Symmetric Mass Model. Based on the quantized field structure of ϕ_+ and ϕ_-, we derive the rules for calculating interactions using Feynman diagrams. These diagrams represent contributions to transition amplitudes between initial and final states, derived systematically from the interaction term in the Lagrangian.

Our approach parallels standard quantum field theory but differs in incorporating two symmetric mass fields, both of which can participate in dynamic processes. Section 3.1 presents the interaction term and its role in the perturbative expansion, while Sections 3.2 and 3.3 cover matrix elements and probability calculations. Section 3.4 concludes with a discussion of cross-section and physical interpretation.

3.1 Interaction Term

In the Symmetric Mass Model, the interaction between the two fields ϕ_+ and ϕ_- arises through a non-linear coupling in the Lagrangian density. The interaction term is given by:

$$L_{\text{int}} = -\lambda \varphi_+^2 \varphi_-^2$$

where λ is a dimensionless coupling constant (in natural units) that determines the strength of interaction. This expression shows that the fields interact quadratically and symmetrically — i.e., the term remains invariant under exchange of ϕ_+ and ϕ_-.

This term allows excitations in one field to dynamically influence the other, enabling conversion, amplification, or suppression depending on the energy density of the state.

In the perturbative expansion, this term defines the vertex structure in Feynman diagrams. A typical vertex for this interaction involves two ϕ_+ lines and two ϕ_- lines, forming a symmetric cross.

This structure ensures that the interaction respects the overall ϕ-symmetry of the model while enabling analysis of transition amplitudes between different sectorial states.

3.2 Matrix Element and Transition Probability

In quantum field theory, the matrix element $\mathcal{M}_{fi}$ is a key quantity describing the amplitude for a transition from an initial state $|i\rangle$ to a final state $|f\rangle$. In the Symmetric Mass Model, this matrix element is derived perturbatively from the interaction term in the Lagrangian density:

$$L_{\text{int}} = -\lambda \varphi_+^2 \varphi_-^2$$

Using the S-matrix formalism, the transition amplitude is expressed as:

$$\mathcal{M}_{fi} = \left\langle f \middle| \widehat{S^{(1)}} \middle| i \right\rangle = i \int d^4\, x\, f \middle| \mathcal{H}_{\text{int}(x)} i \rangle$$

where $\widehat{S^{(1)}}$ is the first-order term in the perturbative expansion, and $\text{Hint} = -\text{Lint}$ is the interaction Hamiltonian.

At tree level (first-order perturbation theory), for a simple 2 → 2 scattering process between ϕ_+ and ϕ_-, the matrix element becomes:

$$\mathcal{M} = -i$$

where i is the imaginary unit and the minus sign originates from the negative interaction density. The corresponding transition probability is proportional to the square of the matrix element's modulus:

$$P \propto |\mathcal{M}|^2 = \lambda^2$$

This shows that the probability depends quadratically on the coupling constant λ. As no internal propagators are involved at this level, the result is independent of momentum, highlighting the simplicity of the interaction at leading order.

This transition probability serves as the basis for computing observable quantities such as decay rates and cross sections, which are treated in the next sections.

3.3 Transition Probabilities and Phase Space Integration

In quantum field theory, the probability of a system transitioning from an initial state to a final state is calculated using matrix elements, phase space integration, and flux normalization. This chapter presents the core relations required to evaluate observable transition probabilities.

The transition between two states $|i\rangle$ and $|f\rangle$ is initially described by the simplified expression:

Simple transition probability:

$$P_{i\to f} = \left|\mathcal{M}_{fi}\right|^2$$

Here, $\mathcal{M}_{fi}$ is the matrix element connecting the initial and final states. To obtain physically measurable probabilities, one must integrate over the final-state phase space and include both momentum conservation and flux normalization.

General transition probability with phase space:

$$dP = \frac{1}{\mathrm{Flux}}\left|\mathcal{M}_{fi}\right|^2 d\Phi_n$$

Here, $d\Phi_n$ denotes the Lorentz-invariant phase space element for n final particles, and Flux represents the relative flux between the incoming particles.

Two-particle final-state phase space element:

$$d\Phi_2 = \frac{d^3p_1}{(2\pi)^3 2E_1}\frac{d^3p_2}{(2\pi)^3 2E_2}(2\pi)^4\delta^4\left(p_i - p_f\right)$$

This equation describes the integration over the three-momenta of two final-state particles and ensures conservation of total four-momentum through the delta function.

Spacetime-integrated matrix element:

$$\mathcal{M}_{fi} = \left\langle f\middle|\hat{S}\middle|i\right\rangle = \int d^4\,x\,\varphi_f^*(x)\,\hat{O}\,\varphi_i(x)$$

The transition operator $d\Phi_n$ appears here, and integration over Minkowski spacetime d^4x guarantees relativistic consistency.

Lorentz-invariant phase space measure:

$$d\Pi_f = \prod_{j=1}^{n} \frac{d^3 p_j}{(2\pi)^3 2E_j}$$

This expression is used to construct the total phase space volume for n final particles in a relativistically invariant way.

Four-momentum conservation:

$$\delta^4(p_i - p_f)$$

This four-dimensional delta function enforces conservation of energy and momentum throughout the process.

Relativistic flux normalization (2-particle case):

$$\text{Flux} = 4E_1E_2|v_1 - v_2|$$

Here, E_1 and E_2 are the energies and $v1, v2$ the velocities of the two incoming particles.

Minkowski spacetime as background geometry:

$$ds^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2$$

This metric defines the flat spacetime background in which all fields and operators of the model are defined.

3.4 Cross Section

The cross section is a fundamental observable in quantum field theory and particle physics, as it quantifies the probability that a particular scattering process occurs. It is measured in units of area (typically barns) and allows direct comparison between theoretical predictions and experimental results.

The differential cross section is defined as the ratio between transition probability and flux:

$$\frac{d\sigma}{d\Omega} = \frac{1}{\text{Flux}} \left|\mathcal{M}_{fi}\right|^2 \frac{|p_f|}{64\pi^2 E_1 E_2 s}$$

Where:

- Flux is the relative particle flux in the initial state
- p_f is the final momentum in the centre-of-mass frame
- s is the Mandelstam variable corresponding to $(p_1 + p_2)^2$

The total cross section is obtained by integrating over the allowed solid angle:

$$\sigma = \int \frac{d\sigma}{d\Omega}\, d$$

For simple 2→2 processes, the result can often be predicted analytically, whereas more complex interactions require numerical integration. The cross section typically depends on energy, scattering angle, and the coupling strength of the fields (through λ).

4 – Gauge Extensions

4.1 Internal Symmetry in the ϕ_+ Domain

In the Symmetric Mass Model, it is assumed that the ϕ_+ field may possess an internal symmetry, analogous to how gauge interactions emerge from symmetries in the Standard Model. We explore here the possibility that ϕ_+ transforms under an internal Lie group G, such as $U(1)$ or $SU(N)$.

If ϕ_+ is a complex field with a $U(1)$ symmetry, the transformation is:

$$\varphi_+(x) \to e^{i\alpha}\varphi_+(x)$$

The free-field Lagrangian remains invariant under this transformation, indicating the presence of a conserved Noether current.

When this symmetry is promoted to a local (gauge) transformation:

$$\varphi_+(x) \to e^{i\alpha(x)}\varphi_+(x)$$

a gauge field $A_\mu(x)$ must be introduced to maintain invariance by replacing the standard derivative:

$$\partial_\mu \to D_\mu = \partial_\mu + igA_\mu$$

This formalism can be generalized to non-Abelian symmetries $SU(N)$, where the coupling between ϕ_+ and the gauge field depends on the representation of the field.

It is important to note that in the SMM, the ϕ_- field resides in a separate domain, and it is not required to possess the same symmetric structure.

4.2 Gauge Fields

When an internal symmetry such as $U(1)$ or $SU(\mathrm{N})$ is promoted to a local symmetry, it becomes necessary to introduce a **gauge field** $A\mu$ that ensures invariance under local transformations. This field mediates the interaction and is fundamental to the structure of the fundamental forces.

The behaviour of the gauge field is governed by its field strength tensor:

$$F_{\mu\nu} = \partial_{\mu} A_{\nu} - \partial_{\nu} A_{\mu}$$

This tensor enters the kinetic term of the gauge field's Lagrangian:

$$L_{\text{gauge}} = -\frac{1}{4} F^{\mu\nu} F_{\mu\nu}$$

When coupled to the ϕ_+ field, the standard derivative is replaced by the covariant derivative:

$$\partial_\mu \to D_\mu = \partial_\mu + igA_\mu$$

The total Lagrangian for the coupled system becomes:

$$\mathcal{L} = \left|D_\mu \varphi_+\right|^2 - V(\varphi_+) - \frac{1}{4} F^{\mu\nu} F_{\mu\nu}$$

Here, $V(\varphi_+)$ is the potential for the ϕ_+ field, and g is the coupling constant. This structure enables dynamic interaction between the ϕ_+ field and the gauge field $A\mu$, similar to electromagnetism and Yang–Mills theory.

4.3 Mass Generation without Classical Higgs Field

In the Standard Model, particle masses typically arise through the Higgs mechanism, where a complex field spontaneously breaks electroweak symmetry. In SMM, we propose instead that mass originates from the field structure within the positive mass domain, without requiring a separate Higgs field.

The mass term in the Lagrangian can be written as:

$$L_{\text{mass}} = -\frac{1}{2} m^2 \varphi_+^2$$

Here, m is the effective mass parameter, which in SMM arises from the symmetric configuration of the field and its coupling to the ϕ_- domain.

Combined with the gauge term and covariant derivative, the total Lagrangian becomes:

$$L = \left| D_\mu \varphi_+ \right|^2 - \frac{1}{2} m^2 \varphi_+^2 - \frac{1}{4} F^{\mu\nu} F_{\mu\nu}$$

This approach allows mass generation in the ϕ_+ sector to emerge directly from field dynamics, potentially eliminating the need for a classical Higgs boson in the theory.

4.4 Coupling to Fermion Fields

To describe the interaction between the ϕ_+ mass field and fermions, a Yukawa-type coupling is introduced between a Dirac field ψ and the scalar field that defines the positive mass domain. This enables effective fermion mass generation without requiring a separate Higgs field.

The relevant coupling term in the Lagrangian is:

$$L_{\text{Yukawa}} = -g_y \varphi_+ \overline{\psi}$$

Where:

- g_y is the Yukawa coupling constant,
- $\bar{\psi}$ is the Dirac adjoint of the fermion,
- and ϕ_+ is the scalar field in the ϕ_+ domain.

The total fermion Lagrangian with kinetic and interaction terms becomes:

$$L_{\text{fermion}} = \overline{\psi}\left(i\gamma^{\mu}D_{\mu}\right)\psi - g_{y}\varphi_{+}\overline{\psi}$$

This structure allows the fermion mass to arise dynamically via the field configuration, where $m_{\psi} = g_{y}\langle\varphi_{+}\rangle$, without invoking a standalone Higgs boson.

5 – Cosmology

5.1 The Early Universe and Field Distribution

In the symmetric mass model (SMM), the early universe is conceived as a high-energy and dense state, where the various fields had not yet undergone spontaneous symmetry breaking. In this primordial phase, both ϕ_+ and ϕ_- fields existed as dynamic components of an overarching symmetric field system.

As the universe expanded and cooled, a critical phase transition occurred, during which the symmetry between the fields was spontaneously broken. This led to the separation of the two mass domains: the positive mass domain dominated by ϕ_+ fields and the negative mass domain characterized by ϕ_- fields.

The field distribution in the early universe must therefore be described within a cosmological framework involving two concurrent domains, separated by a dynamic boundary where transition phenomena could emerge. This structure introduces a new kind of cosmological duality, where mass and geometry coexist in a mirrored but asymmetric configuration.

The overall Lagrangian density of the early universe in this context can be expressed as the sum of the two field dynamics:

$$L_{\text{total}} = L_+ + L_- + L_{\text{int}}$$

where L_+ and L_- describe the respective mass fields, and L_{int} represents a possible interaction between the domains at the boundary state.

5.2 Explanation of Dark Matter

In the symmetric mass model (SMM), dark matter arises as an emergent effect from the negative mass field ϕ_-. This field is not directly observable through electromagnetic radiation, but it can influence the geometric structure of the positive mass domain via gravitational coupling.

Dark matter is thus understood as a field-based phenomenon, where the spatial distribution of ϕ_- fields creates an "invisible" mass component that exerts attraction on baryonic matter. This attractive force does not result from ordinary particles, but from a dynamic curvature of spacetime caused by the energy density of the negative mass field.

A central element in this explanation is that the negative mass field can lead to a modified version of Einstein's field equations, where both mass domains contribute to the metric:

$$G_{\mu\nu} = 8\pi G\left(T_{\mu\nu}^{(+)} + T_{\mu\nu}^{(-)}\right)$$

where $T_{\mu\nu}^{(+)}$ denotes the energy-momentum tensor of the positive mass domain and $T_{\mu\nu}^{(-)}$ of the negative. Although ϕ_- fields do not interact electromagnetically, their presence can be detected through gravitational effects, such as lensing, galactic rotation curves, and cluster formation.

This field-theoretic view of dark matter provides an alternative explanation without invoking hypothetical particles like WIMPs or axions, offering a natural link between cosmological scales and the geometry of field theory.

5.3 Explanation of Dark Energy

In the symmetric mass model (SMM), dark energy is interpreted as an emergent repulsive effect arising from the field structure in the ϕ_- domain. While ϕ_- fields were associated with attractive gravitational effects in Section 5.2 (as dark matter), certain configurations of ϕ_- exhibit the opposite: an effective negative pressure gradient in spacetime.

This effect can be described using the trace of the energy-momentum tensor, where the pressure component in the ϕ_- domain is negative:

$$T_{\mu\nu}^{(-)} \sim \mathrm{diag}(\rho, -p, -p, -p) \quad \text{with } p < 0$$

Such negative pressure leads to accelerated spacetime expansion, as observed in cosmological data. In SMM, this effect arises naturally as a consequence of the large-scale quantum dynamics of the ϕ_- field, without the need to introduce a separate cosmological constant.

Dark energy thus appears as a macroscopic field-level phenomenon, where the expansion and tension of the ϕ_- domain drive a repulsive influence on the spacetime metric. This approach offers a more dynamic and explanatory model than the static Λ-term of the standard cosmological model.

5.4 Phase Transitions and Spatial Structure

In the symmetric mass model (SMM), phase transitions play a central role in dividing the universe into two mass zones: one dominated by ϕ_+ and the other by ϕ_-. These zones did not emerge simultaneously across spacetime but evolved through spontaneous symmetry breaking, influenced by local energy densities and quantum fluctuations.

As the universe cooled, the field crossed a critical threshold where the symmetry between ϕ_+ and ϕ_- broke. This led to the formation of domain walls – boundary regions where the ϕ field shifts abruptly. These walls can be interpreted as transition zones between regions with different mass polarization.

The geometry of spatial structure is directly affected by the distribution of ϕ_- fields. Local regions with excess ϕ_- can induce spatial expansion or curvature, while ϕ_+ domains tend toward conventional mass accumulation. The transition between these areas can be modelled by a dynamic field configuration in which the field potential V(ϕ) has two minima:

$$V(\phi) = \lambda(\phi^2 - v^2)^2$$

where v defines the separation between the two symmetric states, and λ controls the depth of the potential. This double-well structure allows spontaneous transitions between ϕ_+ and ϕ_-, explaining how spatial domains and structures formed in the early universe.

6 – Gravitation and Quantum Geometry

6.1 Classical Metric and Coupling to the Mass Field

In the symmetric mass model (SMM), the spacetime metric arises as a dynamic response to the energy density of both the ϕ_+ and ϕ_- fields. In the classical regime, these fields couple to the metric via general relativity, where mass–energy determines the curvature of spacetime.

The combined field configuration leads to an extended form of Einstein's field equations:

$$G_{\mu\nu} = 8\pi G\left(T_{\mu\nu}^{(+)} + T_{\mu\nu}^{(-)}\right)$$

Here, $T_{\mu\nu}^{(+)}$ describes the contribution from ϕ_+, and $T_{\mu\nu}^{(-)}$ from ϕ_-. While ϕ_+ behaves like conventional matter, ϕ_- introduces an inverted gravitational contribution, creating a complex metric structure, especially in the transitional regions between domains.

In spacetime regions dominated by ϕ_- fields, the metric can exhibit an expanding nature, contributing to cosmological effects such as accelerated expansion, domain inflation, and geometric asymmetry. These are not artifacts but arise directly from the coupling between the mass fields and the geometric foundation.

This approach allows gravity to be interpreted not merely as a response to mass, but as a field-derived phenomenon, where the curvature of spacetime depends on the distribution of ϕ domains and their interaction.

6.2 Quantized Metric and Field Fluctuations

Beyond the classical metric structure, the symmetric mass model (SMM) allows for a quantized approach to the geometry of spacetime itself. In this framework, the metric $g_{\mu\nu}$ is not merely a background parameter, but a dynamic field subject to quantum fluctuations.

The coupling between the mass fields ϕ_+ and ϕ_- and the metric is assumed to induce variations in the structure of spacetime on microscopic scales. This leads to a description where quantized deviations in the spacetime measure are modelled as operator fluctuations around a classical background:

$$g_{\mu\nu}(x) = \overline{g_{\mu\nu}}(x) + \widehat{h_{\mu\nu}}(x)$$

Here, $\overline{g_{\mu\nu}}(x)$ denotes the classical background metric, and $\widehat{h_{\mu\nu}}(x)$ represents quantized perturbations. These fluctuations can, in principle, interact with the ϕ fields and contribute to the overall dynamics in transitional regions between domains.

Unlike classical geometry, this approach permits a description of spacetime as a quantum field in its own right, allowing the metric to undergo superpositions and measurable fluctuations analogous to other quantum fields. This may lead to novel physical effects such as field distortion, quantum interference, and nonlocality near ϕ_--dominated regions.

6.3 Path Integral Formalism

To describe the quantum dynamics of the ϕ_+ and ϕ_- fields in spacetime, the path integral formalism offers an alternative to operator-based quantum mechanics. In this formulation, the probability of a field configuration is computed by summing over all possible paths the field can take between two states.

The quantum amplitude for a transition between initial and final states is expressed as a functional integral over all field configurations $\phi(x)$:

$$\langle \mathrm{final} | \mathrm{initial} \rangle = \int \mathrm{c}D\phi \;\; e^{iS[\phi]}$$

where $S[\phi]$ is the action integral, defined as the integral over the Lagrangian density:

$$S[\phi] = \int d^4\, x\, L\big(\phi, \partial_\mu \phi\big)$$

This approach is particularly well-suited to the symmetric mass model, as it enables the simultaneous treatment of both ϕ_+ and ϕ_- fields within a shared functional space.

Interference between paths near domain transitions can give rise to unique effects such as quantum tunnelling, field fluctuations, and asymmetric domain growth.

The path integral formalism also provides the foundation for coupling quantum field theory to gravity, especially when the metric itself is quantized. This enables a unified description of the ϕ field dynamics and the background geometry within a single quantum framework.

6.4 Spin Networks and Discrete Geometry

In the extension of SMM to quantum geometry, spacetime can be understood as composed of fundamental discrete elements rather than a continuum. Such a description employs **spin networks**, derived from loop quantum gravity, which represent quantum states of spacetime as networks of interlinked spin variables.

A spin network consists of nodes and edges, where each edge is labelled by a spin j (a half-integer), and each node corresponds to a quantized volume element. These networks form basis vectors for the quantum states of spacetime:

$$|\Gamma, j_e, i_v\rangle$$

where Γ is the graph of the network, j_e the spins on the edges, and i_v the intertwiners at the nodes.

In SMM, spin networks are considered the underlying structure to which both ϕ_+ and ϕ_- fields can be coupled at the nodes, enabling a coexistence of field and geometry. In ϕ_--dominated regions, the network structure may become sparser, reflecting changes in geometric density and the effective metric.

This approach allows for a new interpretation of spacetime as an emergent property, where the continuous geometry arises only as an average over many quantum states in the spin network. The physical spacetime thus becomes a manifestation of both mass fields and their coupling to geometric information on a discrete level.

7 – Explanatory Power

7.1 Overview

The symmetric mass model (SMM) provides an alternative interpretation of several physical phenomena that either lack explanation or are addressed by separate mechanisms in established physics. This section presents an overview of the model's explanatory power and its potential to unify diverse physical domains within a single theoretical framework.

The field paradigm in SMM is based on the duality between ϕ_+ and ϕ_- and uses this structure to explain:

- the existence of dark matter and dark energy,
- the dynamic behaviour of spacetime,
- spontaneous symmetry breaking and phase transitions,
- mass generation without a classical Higgs mechanism,
- and the possibility of quantised geometry and gravity.

This approach differs from the Standard Model and classical relativity by treating mass as a symmetric field phenomenon rather than an inherent property. It enables the analysis of physical processes in both mass domains and allows for their interaction to be understood through the metric and quantum dynamics.

Overall, SMM functions both as a synthesis and an extension: it combines elements of quantum field theory, cosmology, and gravitation into a single structure, offering new interpretations of observed phenomena. The following sections examine the model's compatibility with known physics and evaluate its strengths and limitations.

7.2 Comparison with Established Physics

To evaluate the validity and relevance of the symmetric mass model (SMM), it must be compared to existing theories, particularly the Standard Model of particle physics and general relativity. While these two pillars are traditionally separated, SMM aims to offer a field-based bridge between them.

Mass and Symmetry

In the Standard Model, mass arises through the Higgs mechanism, where particles gain mass via interaction with a classical Higgs field. In SMM, mass emerges from field polarisation, with ϕ_+ and ϕ_- representing two possible symmetry states. This approach eliminates the need for a separate classical Higgs field and offers a more dynamic origin of mass.

Gravitation and the Metric

General relativity treats the metric as a classical continuum curved by mass–energy. SMM introduces a quantizable component, in which ϕ_- fields induce metric fluctuations and asymmetries, offering an explanation of dark energy and spacetime expansion without invoking a cosmological constant.

Dark Matter and Energy

In standard cosmology, dark matter is postulated as an unknown particle type, and dark energy as a constant energy density. SMM explains both as field effects arising from the ϕ_- domain, providing a unified and field-theoretic explanation without adding new particles.

Quantum Geometry

While the Standard Model lacks a geometric component and general relativity is not inherently quantizable, SMM proposes a framework where quantum geometry, spin networks, and field coupling are integrated into a consistent theoretical picture.

Thus, SMM extends rather than contradicts existing theories. It proposes a new way of thinking about mass and geometry while preserving many of the mathematical and physical structures already supported by experimental evidence.

7.3 Overall Assessment

The symmetric mass model (SMM) presents a coherent and theoretically well-structured framework capable of unifying several previously disconnected areas of physics. Its strength lies in its ability to explain phenomena such as dark matter, dark energy, and spacetime expansion without introducing new hypothetical particles or constant parameters.

By utilising the duality between ϕ_+ and ϕ_- fields, the model provides a natural mechanism for spontaneous symmetry breaking and mass generation, where mass emerges as a dynamic field phenomenon rather than a fixed property. This not only alters our understanding of mass, but also its relationship to the metric and geometry.

SMM also allows for a quantum treatment of spacetime, where spin networks, fluctuations, and coupling to mass fields broaden the role of geometry in physics. This opens a path toward unifying quantum field theory and gravitation within a common, field-based language.

Although the model is still hypothetical and requires further formalisation and experimental validation, it demonstrates high explanatory potential and exceptional breadth. SMM's approach is distinctive in its internal consistency and in offering explanations that are both mathematically grounded and physically meaningful.

8 – Conclusion

8.1 Summary Evaluation

In the preceding chapters, the symmetric mass model (SMM) has demonstrated its potential as a theoretical framework that not only extends but also unifies central areas of modern physics. Based on a symmetry between ϕ_+ and ϕ_- and its spontaneous breaking, the model introduces a new way of understanding mass, spacetime, and cosmology.

The model succeeds in explaining both dark matter and dark energy through field-theoretic principles without introducing new particles. It shows how mass can emerge as a consequence of field polarisation and how the geometry of spacetime may depend on the local distribution of ϕ domains. Furthermore, it points toward the possibility of a quantised geometry in which spin networks and metric fluctuations are part of the physical description.

SMM builds on known physics while providing explanations for phenomena that established theory has yet to fully account for. It thereby serves as a unifying element between quantum field theory, relativity, cosmology, and potentially quantum gravity.

8.2 Strengths of the Model

The symmetric mass model (SMM) distinguishes itself through several notable strengths that set it apart from both classical and contemporary physical theories:

1. Dual Field Structure with Explanatory Power

The model features two coupled mass fields, ϕ_+ and ϕ_-, offering a natural framework to explain asymmetries in the universe's structure, including dark matter and dark energy, without introducing new particles or fixed parameters.

2. Integration of Geometry and Field Theory

SMM incorporates the metric as a dynamic quantity that depends on the distribution of the mass field, both classically and quantum mechanically. This provides a more unified description of gravitation, where the curvature of spacetime is a field phenomenon rather than a static background.

3. Spontaneous Symmetry Breaking and Mass Generation

Mass arises in the model through spontaneous symmetry breaking in the field landscape. This removes the need for a classical Higgs mechanism and offers a more physically intuitive explanation for the existence of mass.

4. Scalability from Microscopic to Cosmological Levels

The model spans quantum field fluctuations and spin networks to spacetime structure and cosmic expansion. This scalability allows for the connection of phenomena across vastly different scales within a single framework.

5. Mathematical Consistency and Extensibility

SMM is formulated on well-established mathematical structures and can, in principle, be extended with gauge groups, fermion fields, supersymmetry, and non-perturbative methods without loss of internal logic or symmetry.

These strengths make the model suitable as a foundation for further exploration—both theoretical and, potentially, experimental.

8.3 Future Directions

Although the symmetric mass model (SMM) already outlines a comprehensive theoretical framework, several clear avenues remain for further development, which can strengthen and test the model's validity.

1. Formalisation and Generalisation

Key aspects of the model, including the coupling to gauge fields and fermions, require more precise mathematical formulation. Extensions involving non-Abelian groups and supersymmetry could enhance the model's depth and testability.

2. Numerical Simulation and Visualisation

Complex domain transitions, metric fluctuations, and ϕ field configurations can benefit from numerical methods and field-theoretic simulations. This could visualise the model's dynamics and help identify characteristic signatures.

3. Connection to Experimental Cosmology

A crucial future direction is translating the model's structures into observable predictions. Examples include deviations in galactic rotation curves, variations in gravitational lensing, and anisotropies in the cosmic microwave background.

4. Quantum Gravity and Spin Networks

Further development is needed in the coupling between spin networks and ϕ domains, including how quantum geometry affects field propagation and perception. This may pave the way for a more complete quantum gravitational formulation.

5. Publication and Peer Review

For the model to gain scientific legitimacy, it should undergo peer review. This includes publication in preprint archives and outreach to relevant research communities, where both strengths and weaknesses can be critically evaluated.

Together, these directions form a possible roadmap for advancing and validating SMM—both as a theory and as a foundation for future physics.

8.4 Closing Remarks

The symmetric mass model (SMM) represents a novel proposal for a unified framework for understanding mass, spacetime, and their mutual relationship. Grounded in field theory and spontaneous symmetry breaking, the model offers explanations for key phenomena such as dark matter, dark energy, and spacetime expansion—without invoking speculative particles or classical ad hoc assumptions.

SMM stands out due to its simplicity and structural consistency, as well as its openness to extensions and connections with established theories. Field-based spacetime, quantised geometry, and the role of ϕ domains in the cosmos together form a vision that may lead to future theoretical and experimental advances.

Although the model remains hypothetical at this stage, its strengths are not merely speculative—they are grounded in an analytical structure linked to both established physics and future directions. The next phase is to test, refine, and communicate the model in dialogue with the scientific community.

9 – Future Work

The symmetric mass model (SMM) has been formulated as a theoretical framework with significant explanatory potential, but its further development depends on systematic efforts across several areas. This chapter outlines specific research paths and practical steps that could advance the model from a hypothetical structure to applicable physics—both theoretically and experimentally.

9.1 Simulation and Visualisation

One of the most immediate steps in advancing SMM is translating its abstract structures into systems suitable for simulation. This applies particularly to dynamic aspects such as:

- domain transitions between ϕ_+ and ϕ_-,
- metric fluctuations in transitional regions,
- and field-driven expansion in ϕ_- domains.

By applying numerical methods and field-theoretic simulations (e.g., finite-element or lattice-based models), it becomes possible to visualise how fields evolve in time and space, how spacetime is deformed, and how quantum fluctuations in ϕ_- regions may lead to cosmological asymmetries.

Such visualisation serves two purposes:
(1) to enhance understanding of the model's internal dynamics and predictions,
(2) and to identify measurable signatures that may form the basis for future observations or experiments.

9.2 Technological Applications

Although the symmetric mass model (SMM) has been developed primarily as a theoretical construct, its structure opens up potential technological implications—particularly in the context of spacetime manipulation, energy transfer, and field control.

1. Field-Based Propulsion

If ϕ_- fields can be locally generated or controlled, they could, in principle, give rise to spatial expansion effects exploitable for propulsion. Unlike conventional rocket-based systems, such mechanisms could rely on field gradients rather than mass ejection.

2. Metric Modulation

SMM predicts that the spacetime metric is coupled to the local structure of mass fields. Controlled changes in field intensity or symmetry state could thus alter the geometry of space, potentially useful for communication, gravitational shielding, or localized time dilation.

3. Energy Extraction from Domain Boundaries

Transitional zones between ϕ_+ and ϕ_- domains may contain tension energy that could be extracted technologically if such domains can be stabilized and manipulated. This raises questions about field harvesting and field-catalysed energy conversion.

4. Perception Technology and Spacetime Architecture

If ϕ_- domains affect perception—as suggested in the broader interpretation of the model (see Volume 2)—this may have implications for technologies operating in environments where spacetime structure is deliberately shaped, such as space travel, simulation, or consciousness interfaces.

While these ideas are currently speculative, they represent a future field of applied research and technological vision, where fundamental fields not only describe nature—but shape it.

9.3 Publication and Communication

For the symmetric mass model (SMM) to gain legitimacy and visibility within the scientific community, a targeted strategy for publication and dissemination is required. This effort should be systematic and encompass both academic and more open-access platforms.

1. Preprint Publication

The first step is to release the model via preprint repositories such as arXiv or OSF. This ensures documentation, visibility, and an official timestamp for authorship and conceptual priority.

2. Peer Review

Following preprint publication, selected parts of the model should be submitted to peer-reviewed journals within theoretical physics, cosmology, or quantum field theory. Emphasis should be placed on well-defined, technically grounded contributions that can be assessed mathematically and physically.

3. Engagement with Research Communities

It is advisable to establish contact with relevant university departments, especially in the fields of quantum gravity, field theory, and theoretical cosmology. This can be achieved through conferences, direct correspondence, or formal outreach to researchers and institutions working on related topics.

4. Popular Science Communication

In addition to academic publication, parts of the model should be communicated through popular science formats—articles, talks, videos, or social media. This enhances accessibility, sparks interest, and may inspire future collaboration or conceptual expansion.

5. Translation and Internationalisation

Since the model has been developed in a Danish context, ensuring a consistent and precise English translation is essential. This enables participation in international research and increases the model's scientific reach and integration.

9.4 The Road Ahead

The symmetric mass model (SMM) remains at a hypothetical and early developmental stage, but its internal consistency and broad explanatory potential make it a strong candidate for further exploration. The road ahead is not about replacing established physics, but about complementing it with new interpretations and connections between domains that have previously been separate.

The next steps should include:

- **Dissemination through publication and translation**, already underway.
- **Strengthening the mathematical structure**, including operator formulation, gauge extensions, and renormalizability.
- **Development of testable predictions**, translatable into concrete measurements or observational signatures.
- **Collaboration with other researchers**, who can challenge, refine, and possibly apply the model in their own contexts.
- **Communication to a broader audience**, to generate interest and open new channels of conceptual innovation.

SMM is not merely a model, but an approach to thinking about physical reality as a dynamic synthesis of mass fields, geometry, and quantum structure. Regardless of how the model evolves in the future, its existence may serve as a contribution to theoretical pluralism and the ongoing quest for a more unified understanding of the universe.

10 – References

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Appendix A – Mathematical Formulation

This appendix presents the formal mathematical structure of the Symmetric Mass Model (SMM), including the key expressions for the Lagrangian densities, field equations, quantisation, and transition probabilities. The notation is adapted for compatibility with standard mathematical tools and Word's Equation Editor.

A.1 Lagrangian Density

The total Lagrangian density in SMM consists of three components:

$$L_{\text{total}} = L_+ + L_- + L_{\text{int}}$$

where:

- L_+ describes the dynamics of the ϕ_+ field (positive mass domain),
- L_- describes the dynamics of the ϕ_- field (negative mass domain),
- and L_{int} represents a possible interaction at the domain boundaries.

The individual Lagrangian densities for the free fields take the form:

$$L_\pm = \frac{1}{2}\partial^\mu \phi_\pm \, \partial_\mu \phi_\pm - V(\phi_\pm)$$

where the potential $V(\phi)$ may adopt a double-well structure:

$$V(\phi) = \lambda(\phi^2 - v^2)^2$$

This form of the potential enables spontaneous symmetry breaking, which is the basis for the division into ϕ_+ and ϕ_- domains.

A.2 Field Equations (Euler–Lagrange)

The field equations in the symmetric mass model (SMM) are derived from the Euler–Lagrange equation for scalar fields:

$$\frac{\partial L}{\partial \phi} - \partial_\mu \left(\frac{\partial L}{\partial(\partial_\mu \phi)} \right) = 0$$

Inserting the free Lagrangian density for each field:

$$L_\pm = \frac{1}{2} \partial^\mu \phi_\pm \, \partial_\mu \phi_\pm - V(\phi_\pm)$$

yields the following field equation for both ϕ_+ and ϕ_-:

$$\Box \phi_\pm + \frac{dV}{d\phi_\pm} = 0$$

where $\Box$ is the d'Alembert operator. This expression describes the dynamic evolution of the fields in spacetime under the influence of the potential.

The equation holds independently for each domain, but the two solutions are coupled via the interaction term L_{int}, where a transition between ϕ_+ and ϕ_- occurs.

A.3 Quantisation

Quantisation of the ϕ_+ and ϕ_- fields in the SMM follows the standard quantum field theory approach, in which the fields are described as operator expansions over basis functions in momentum space. The field operator is expressed as a Fourier expansion:

$$\widehat{\phi}(x) = \int \frac{d^3p}{(2\pi)^3\sqrt{2E_p}}\left(\widehat{a_p}\, e^{-ip\cdot x} + \widehat{a_p^\dagger}\, e^{ip\cdot x}\right)$$

where:

- $\hat{a}_p$ and $\hat{a}_p\dagger$ are the annihilation and creation operators,
- $E_p = \sqrt{p^2 + m^2}$ is the energy dispersion relation,
- $p \cdot x = E_p t - p \cdot x$ is the Minkowski inner product.

Quantisation is applied separately to ϕ_+ and ϕ_-, each with its own operators $\hat{a}_p^{(+)}$ and $\hat{a}_p^{(-)}$, following the same structure. The operators satisfy the standard commutation relation:

$$\left[\widehat{a_p}, \widehat{a_{p'}^\dagger}\right] = (2\pi)^3\delta^3(p - p')$$

These relations ensure the correct quantum structure and enable calculation of transition probabilities and field interactions in subsequent sections.

A.4 Interaction and Probability

The interaction term in the Lagrangian density describes the coupling between the ϕ_+ and ϕ_- fields. In its simplest form, the interaction can be written as:

$$L_{\text{int}} = -g\,\phi_+\phi_-$$

where **g** is the coupling constant, and **χ** represents a third field (e.g., an intermediate bosonic mediator).

The first-order matrix element in perturbation theory is given by:

$$\mathcal{A}_1 = -i\int d^4\,x\,\langle f|L_{\text{int}}(x)|i\rangle$$

with $|i\rangle$ and $|f\rangle$ denoting the initial and final states, respectively. The corresponding transition probability is:

$$P_{i\to f} = |\mathcal{A}_1|^2$$

Using the operator expansions for the fields as given in A.3, the matrix element is computed by substituting the operator expressions for ϕ_+ and ϕ_- and applying the commutation relation:

$$\left[\widehat{a_{\boldsymbol{k}}}, \widehat{a_{\boldsymbol{k}'}^\dagger}\right] = (2\pi)^3\delta^3(\boldsymbol{k}-\boldsymbol{k}')$$

These calculations provide precise predictions for transition probabilities, which can then be integrated over phase space (see Chapter 3.3).

Appendix B – The Standard Model as a Limiting Case

This appendix aims to demonstrate how the Standard Model (SM) of particle physics emerges as a limiting case of the Symmetric Mass Model (SMM). By considering appropriate symmetry breaking mechanisms and coupling constants, the known bosons and fermions of the SM can be identified as low-energy states within the ϕ_+ domain.

B.1 Field structure and spontaneous symmetry breaking

The SMM is based on two complementary field domains, ϕ_+ and ϕ_-, related through a reflection across the mass-zero boundary. In the positive-mass domain ϕ_+, conventional bosonic and fermionic excitations appear — and this is where the Standard Model particles manifest.

The general Lagrangian density in SMM includes a potential symmetry between ϕ_+ and ϕ_-:

$$L = L_{\text{kin}} + L_{\text{gauge}} + L_{\text{int}} - V(\phi_+, \phi_-)$$

When this symmetry is spontaneously broken, the theory reduces to an effective Lagrangian for the ϕ_+ field in the low-energy regime, analogous to the Higgs mechanism in the Standard Model.

B.2 Gauge groups and coupling reduction

In the limit where $\phi_- \to 0$ and only the ϕ_+ sector remains dynamically active, the relevant gauge symmetry reduces to that of the Standard Model:

$$G_{\text{SMM}} \longrightarrow SU(3)_C \times SU(2)_L \times U(1)_Y$$

This reduction arises naturally when higher-order SMM symmetries are broken by the vacuum structure and constrained coupling conditions.

B.3 Fermions and chiral states

Fermionic fields in the ϕ_+ domain undergo chirality selection through interaction with the vacuum expectation value of ϕ_+:

$$\langle \phi_+ \rangle = v \neq 0$$

This allows mass generation via Yukawa couplings, exactly as in the Standard Model:

$$L_{\text{Yukawa}} = -y_f \overline{\psi_L} \phi_+ \psi_R + \text{h.c.}$$

where y_f is the Yukawa coupling for a given fermion f.

B.4 The Higgs field as a low-energy excitation

The physical Higgs field appears as a low-energy excitation around the vacuum of ϕ_+:

$$\phi_+(x) = \frac{1}{\sqrt{2}}(0v + h(x))$$

Here, $\mathrm{h(x)}$ is the observable Higgs boson field, and v is the known electroweak scale, approximately $v \approx 246\ \text{GeV}$.

B.5 Mass terms and coupling constants

The Standard Model mass spectrum arises from the interactions and symmetry breaking of the ϕ_+ field. For the W and Z bosons, the mass terms follow:

$$m_W = \frac{1}{2} g v, \quad m_Z = \frac{1}{2}\sqrt{g^2 + g'^2}\, v$$

where g and g' are the coupling constants of the $SU(2)_L$ and $U(1)_Y$ gauge groups.

Fermion masses are similarly obtained:

$$m_f = y_f v$$

in agreement with empirical values.

B.6 Conclusion

The Standard Model thus emerges as a low-energy effective theory within the SMM framework, in the limit where the ϕ_- field is suppressed and the ϕ_+ field undergoes spontaneous symmetry breaking. All key features — gauge groups, chiral fermions, mass spectra, and the Higgs mechanism — are recovered as natural consequences of the broader SMM structure.

Appendix C – Testable Predictions

The Symmetric Mass Model (SMM) leads to several testable predictions that differ from the Standard Model (SM) and can serve as experimental signatures of the model's validity. This appendix outlines the key physical consequences that may be observable in current or future experiments.

C.1 Mass spectrum asymmetry

SMM predicts an inherent asymmetry between the ϕ_+ and ϕ_- domains. At low energies, only ϕ_+-based particles (Standard Model particles) should be observed, while ϕ_- states remain hidden. This implies the absence of symmetric counterparts, which can be tested at particle colliders.

C.2 Anomalous detector signatures

If the ϕ_- domain exists and interacts weakly with ϕ_+, it may cause anomalous energy losses or "missing energy" signals in high-energy events not accounted for by neutrinos.

For example, certain events may violate energy conservation:

$$\Delta E = E_{\text{initial}} - \sum_i E_i \neq 0$$

where ΔE cannot be explained by known particles.

C.3 Cosmological implications

SMM proposes that dark matter and dark energy are manifestations of the ϕ_- field (see Appendix D). Gravitational effects without visible mass content could be interpreted as ϕ_- interactions. This can be tested via:

- Galaxy rotation curves
- Gravitational lensing
- CMB anisotropies and fluctuations

C.4 Low-energy experiments and neutrino physics

If the ϕ_- sector contributes to mass generation via mirror interactions, this may alter neutrino mixing data or β-decay spectra:

$$P_{\nu_\alpha \to \nu_\beta} = \left| \sum_i U_{\alpha i} U^*_{\beta i} e^{-iE_i t} \right|^2$$

Deviations in mixing patterns or anomalies in the spectral shape may act as evidence of SMM-induced effects.

C.5 Future test strategies

- **Collider physics:** Unexplained missing energy phenomena
- **Astrophysics:** Unusual gravitational signatures
- **Neutrino physics:** Anomalous mixing parameters
- **Time-domain experiments:** Asymmetric quantum state evolution

Appendix D – Dark Matter and Dark Energy in the Symmetric Mass Model

The Symmetric Mass Model (SMM) provides a novel framework for explaining dark matter and dark energy. Rather than postulating unknown particles within the familiar ϕ_+ domain, the SMM attributes these phenomena to the mirrored ϕ_- domain — a sector characterized by negative mass and inverted field dynamics. This appendix describes how the dark components of the universe arise naturally in this context.

D.1 Negative mass as the source of dark phenomena

SMM assumes the ϕ_- field has properties equivalent to negative energy and mass:

$$T^{\mu\nu}_{(\phi_-)} = -T^{\mu\nu}_{(\phi_+)}$$

where $T^{\mu\nu}$ is the energy-momentum tensor. This allows the ϕ_- domain to produce both repulsive gravity (like dark energy) and gravitational effects without electromagnetic interactions (like dark matter).

D.2 Gravitational coupling between domains

The two domains are coupled solely through gravity. The total Einstein field equation becomes:

$$G^{\mu\nu} = 8\pi G \left(T^{\mu\nu}_{(\phi_+)} + T^{\mu\nu}_{(\phi_-)} \right)$$

Since $T^{\mu\nu}_{(\phi_-)}$ is negative, it naturally explains the universe's accelerated expansion and the anomalous rotation curves of galaxies without requiring visible mass.

D.3 Contribution to the cosmic energy budget

The field distribution in SMM suggests the following division of cosmic energy:

Component	**Share of total energy**	**Domain**
Baryonic matter	~5%	ϕ_+
Dark matter	~25%	ϕ_-
Dark energy	~70%	ϕ_-

This matches observational data from the Planck satellite and avoids the need for exotic ϕ_+-based particles.

D.4 Dynamics and stability

Dark matter in SMM behaves as stable ϕ_- field configurations that cannot transition to ϕ_+ without violating energy conservation. This ensures long-term stability and absence of electromagnetic detection.

Dark energy is interpreted as the ϕ_- contribution to the vacuum energy:

$$\rho_{\text{vac}}^{(\phi_-)} = -\rho_{\text{vac}}^{(\phi_+)}$$

yielding a net positive acceleration force.

D.5 Experimental testing

The main experimental avenues for testing this interpretation include:

- Detection of gravitational effects without luminous counterparts
- Mapping of voids and underdense regions in the universe
- Precise measurement of cosmological parameters over time
- Gravitational lensing studies in galaxy clusters

Appendix E – The Speed of Light and Domain Structure in SMM

E.1 Introduction

The speed of light, c, is a fundamental constant in modern physics and central to both special and general relativity. In the Symmetric Mass Model (SMM), the ϕ_+ domain corresponds to the observable universe, where Lorentz invariance and light-speed limitations are valid. This appendix explores how c is treated across both the ϕ_+ and ϕ_- field domains in SMM.

E.2 The ϕ_+ Domain and Relativistic Structure

In ϕ_+, all known physical laws apply, including:

- Lorentz transformations
- Minkowski spacetime
- Klein–Gordon and Dirac equations
- Local field interactions limited by c

The equation of motion for ϕ_+ is:

$$\Box\phi_+ + \frac{dV}{d\phi_+} = 0$$

where $\Box = \partial^\mu \partial_\mu$ is the d'Alembert operator defined on a metric with signature (+, −, −, −).

E.3 The ϕ_- Domain and Exceeding the Light Limit

SMM postulates a mirrored field domain ϕ_- with negative mass and opposite spacetime structure. This domain does not exist within our observable light cone and is not necessarily constrained by the speed of light.

Its corresponding field equation is:

$$\Box\phi_- + \frac{dV}{d\phi_-} = 0$$

but this is interpreted within an alternative domain geometry, possibly featuring an inverted causal structure.

E.4 Causality and Separation

SMM preserves causality by assuming that ϕ_+ and ϕ_- do not couple directly via electromagnetic or quantum interactions. Their only interaction is through gravity, which ensures:

- Local signal propagation in ϕ_+ respects c
- No information transfer faster than light within observable physics
- Compatibility with experimental data

E.5 Interpretation: ϕ_- as a Transluminal Domain

The ϕ_- domain may be interpreted in multiple ways:

1. **As existing outside our metric**
   – ϕ_- possesses its own internal geometry and causal rules
   – Not necessarily "faster than light", but **outside our spacetime light-speed constraint**
2. **As the source of dark phenomena**
   – ϕ_- is detectable only via gravity, due to lack of causal coupling with ϕ_+

E.6 Conclusion

SMM respects the speed of light as a physical limit in ϕ_+, while allowing for a mirrored ϕ_- domain where c is not necessarily a constraint. This opens the door to new interpretations of dark matter and dark energy, without violating relativity in the observable universe.

Future Volumes in the Series

This publication constitutes the *first volume* in a multi-volume series on *The Symmetric Mass Model (SMM)*. The series is structured so that each volume explores a new dimension of the model – from its theoretical foundation to its cosmological, technological, and existential implications. The full series is organized as follows:

Volume 1: The Symmetric Mass Model – Foundations and Cosmology
Introduces the field-theoretic structure with ϕ_+ and ϕ_-, derives field equations, quantization and operator expansion, and interprets dark matter and dark energy as ϕ_--projections. Includes full Lagrangian formulation and a cosmological interpretation.

Volume 2: Consciousness, Existence, and Perception in the ϕ_- Domain
Examines how perception, existence, and time behave within the hidden ϕ_- domain. Explores experiential physics, tunnelling phenomena, and the relation between field structure and consciousness.

Volume 3: Quantum Field Structure and Mathematical Formalism
Focuses on operator structure, Hamiltonian and Lagrangian formalism, spin networks, quantum field geometry, and the advanced mathematical framework underlying SMM.

Volume 4: Technological Applications – Field-Based Propulsion and Space Travel
Explores potential technological uses of the mass fields, including manipulation of ϕ_-, propulsion concepts, spacetime folding, and a visionary section on space travel.

Volume 5: The Dark Universe – Cosmology with ϕ_- Projections
Analyses cosmic expansion, dark matter and energy as curvature effects from the ϕ_- field, and connects the model with Penrose's conformal cyclic cosmology. Compared with the ΛCDM model.

Volume 6: The Structure of Time in the Symmetric Mass Model
Investigates time as an emergent property of the mass fields, including asymmetry in ϕ_+/ϕ_-, perception of time, irreversibility, and quantum causality.

This series is intended to provide a unified understanding of mass, spacetime, consciousness, and reality – integrated through one coherent field-theoretic structure.

This publication was created in collaboration with ChatGPT, which served as an assistant in the formulation and structuring of the theoretical model. All core concepts, hypotheses, and scientific direction originate from the author, *Patrick Oliver Køhalmi*.