Deterministic Structures in Gravitational Fields: A Unified Model Bridging Black Hole Singularities and Quantum Topology

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Abstract

This paper presents a deterministic model that unifies gravitational, strong, weak, and electromagnetic interactions by examining the intersection of gravitational fields. These fields, which expand and contract periodically, create a shared nucleus of subfields characterized by complementary topological transformations. Within this framework, singularities are reinterpreted as abrupt curvature discontinuities, linking phenomena across quantum and cosmic scales. The model offers insights into energy and density transfer and information preservation. It explores connections to dark matter, reflection positivity, the mass gap problem, and Hodge cycles, providing a pathway to understand the breakdown of General Relativity in both atomic and black hole structures.

1 Introduction

In 2020, Roger Penrose was awarded the Nobel Prize in Physics for his work demonstrating the existence of black hole singularities—points of extreme curvature where density and gravity become infinite—within the framework of Einstein's General Relativity.

Although it remains a theoretical model, Penrose mathematically demonstrated that the gravitational collapse of massive stars leads to a process of extreme compression, culminating in the formation of a curvature singularity where density and the gravitational field reach infinity, resulting in the creation of a black hole. Other researchers, such as Kip Thorne, have modeled black hole formation by studying binary black hole mergers and the resulting gravitational waves.

Mathematically, singularities are characterized as points where a curve abruptly changes direction or sign, forming a sharp cusp where a tangent cannot be defined. Such a singular point is described as a point-like region of undefined or infinite curvature.

Within the framework of General Relativity, which models gravity as a consequence of spacetime curvature, such a curvature singularity represents a point where gravitational forces become infinitely strong. This leads to a breakdown of the laws of General Relativity, highlighting the need for a more comprehensive theory to fully describe the behavior of spacetime in the presence of curvature singularities, which are considered extreme conditions.

The static universe model, prevalent at the beginning of the 20th century, was a foundational assumption in Einstein's original General Relativity theory. To maintain a static gravitational field, Einstein introduced a cosmological constant — an outward-pushing force — to compensate for the inward gravitational pull caused by spacetime curvature.

However, in 1922, Alexander Friedmann developed

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solutions to Einstein's General Relativity equations that demonstrated that the universe, as a curved spacetime manifold, could be dynamically changing — either expanding or contracting — instead of being static. Friedmann's solutions showed that, depending on the universe's density and the cosmological constant, different evolutionary scenarios involving contraction and expansion were possible, laying the groundwork for modern cyclic cosmology.

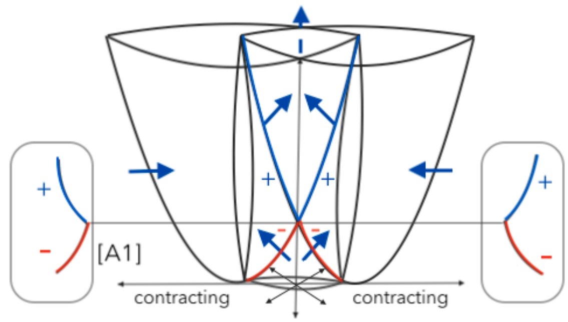

Figure 1: *Singularities in the symmetric system when both intersecting fields contract.*

2 Model Description

In this paper, we propose a novel model in which black holes emerge from the intersection of two merging gravitational fields whose curvature periodically varies in or out of phase. This intersection forms a nucleus composed of two vertical and two transverse gravitational subfields, which are characterized as black holes with an inner singularity point where gravitational forces remain finite.

Additionally, the model posits that similar singularities exist in the curvature of subatomic field particles, being integrated into the nucleus proposed by a deterministic dual atomic model formed by two intersecting gravitational fields varying in or out of phase.

Under this framework, black holes and subatomic particles share identical topological structures, wherein curvature singularities involve abrupt changes in sign or direction. These singularities contrast with the gradually changing, smooth curvature predicted by General Relativity, possibly resulting in the failure of Einstein's equations.

Conceptually, our model shares a link with Gerard 't Hooft's work, particularly in exploring connections between black holes and subatomic particles through a deterministic framework, although it differs in both approach and results.

The intersecting gravitational fields produce two vertical and two transverse subfields. The vertical subfields resemble inverted cones of light meeting at their apex, while the transverse subfields resemble mirrored regions connected at a cusp singularity. This apex marks the intersection of the gravitational fields, creating regions of positive, negative, or mixed curvature.

In string theory, curvature singularities emerge as Calabi-Yau conifold cusps, with various mechanisms proposed to resolve the resulting infinities by introducing extended fundamental objects and extra dimensions to smooth spacetime curvature, aiming to unify quantum mechanics and General Relativity.

We relate the transverse subfields and their singularities to topological features such as conifold singularities and Calabi-Yau transverse regions, akin to those in string theory, though our approach to compactifying additional dimensions is distinct. This framework maintains finite gravitational forces at singularity points, offering a unified view of spacetime geometry.

Our model conceptualizes the transverse subfields, their singularities, and elliptic orbits as curved, "trapped" folds within a dual system, providing a relativistic interpretation of their hyperdimensionality. Additional spatial coordinates are necessary to describe the transverse subfields because their Y-axis would be considered from the perspective of their host gravitational fields as a diagonal, introducing dilation or contraction in the resultant measures of space and time. Additionally, a second time dimension is needed to describe the differences in phase between the nuclear subfields and their respective hosts, or the different phases between the mirror subfields when antisymmetry is introduced.

With opposite phases, the upper vertical subfield will move right or left toward the side of the host field that contracts. Moving leftwards, that subfield will act as an electron. The pushing force generated by the outer positive side of its left curvature when moving left is interpreted as an electric charge. On the right side of the system, that vertical subfield will exist as a virtual particle; that is, it will not currently exist but will later appear as a positron subfield moving rightwards when the left field expands and the right contracts.

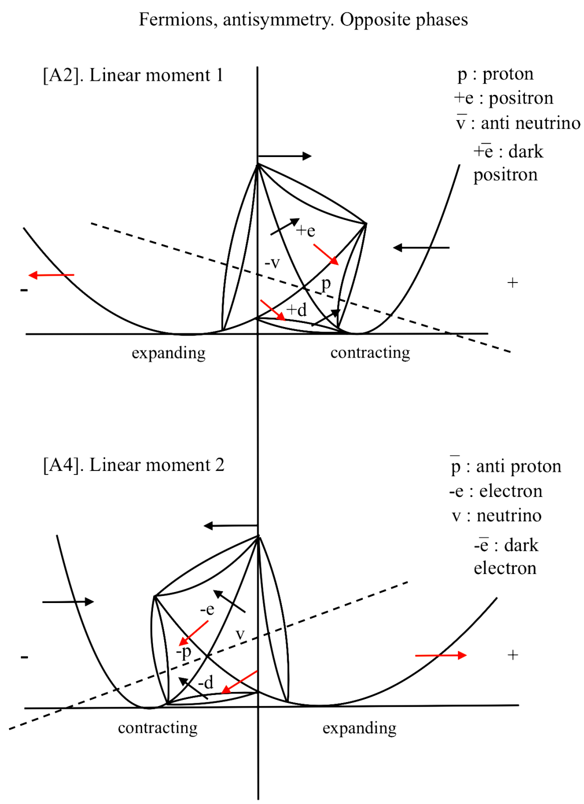

Figure 2: *Atmic model: Antisymmetric system.*

The pendular displacements of this subfield allow us to describe it as a Majorana antiparticle, a particle that is its own antiparticle at different times.

The inner curvature of this vertical subfield is formed by two negative curvatures united by a cusp point; it also can be considered as a single negative curvature that abruptly changes direction at its central singularity point.

Simplifying its curvature in a 2D model, we can say that acting as a positron, when the right field expands and the left one expands, the subfield's right side curvature is formed by the negative curvature inside the right-handed half part of the left expanding field, and the subfield's left curvature is formed by the negative side of the curvature inside the left half part of the right contracting field.

At that same stage, when the right field contracts and the left one expands, the right transverse subfield receives a double pushing force that contracts it: one caused by the positive outer side of the right-handed half part of the left expanding field, and another caused by the inner negative curvature of the left half part of the right contracting field. At that moment, the left transverse subfield does not exhibit symmetry because it will be experiencing a double decompression: Its upper positive curvature will move rightwards because it is formed by the outer side of the half part of the right contracting field; and its bottom negative curvature will also move right because it is formed by the negative side of the right half part of the left expansive field.

The subfield that contracts increases its inner kinetic orbital energy and its mass density, creating a stronger bond that unites the system. The subfield that expands decreases its inner kinetic energy and its mass density, representing a weaker bond in the interactions that allow the nucleus and the whole system to remain united.

When the left field contracts and the right one expands, the left transverse subfield will contract, reaching mirror symmetry with the previous stage of the right transverse contracting subfield, which now will be expanding.

The left expanding transverse subfield at moment 1 will be the mirror antiparticle of the right expanding transverse subfield at moment 2; and the left contracting transverse subfield at moment 2 will be the antiparticle of the right contracting subfield at moment 1. These would be Dirac antiparticles.

These topological transformations represent an oscillatory flux of transfer density and energy between the left and right sides of the system.

In this antisymmetric system, the singularity point will move left or right of the center of the system, toward the side of the fields that contract.

In the context of this dual atomic model, the right transverse contracting subfield is predicted to be a contracting proton that decays into a neutrino when expanding; the right expanding transverse subfield is proposed to be an antineutrino that becomes an antiproton when contracting. Neutrons are characterized in this model as the neutral stage where the negative and positive sides of the system annihilate their charges because the vertical subfields pass through the vertical axis that determines the center of the system, and the transverse subfields exhibit the same shape and density during the short moment when the left and right fields have the same curvature while contracting and expanding (or expanding and contracting).

Antisymmetry is introduced in the system because of a delay in the phase of one of the intersecting fields. This implies the necessity of an additional time dimension represented by a coordinate that moves—in a type of Wick rotation—from the imaginary coordinate Y to a purely imaginary coordinate represented by a diagonal axis.

As the vertical subfield cannot simultaneously be at the left and right sides, and the transverse subfields cannot be simultaneously expanding or simultaneously contracting, they can be considered governed by an exclusion principle. Considering Pauli's principle in the context of mirror symmetry or antisymmetric field-particles, we could state that the four subfields in this antisymmetric system would be fermions.

When the phases of the intersecting fields synchronize, the upper central subfield will move upwards while contracting, receiving a double inward force caused by the negative side of the left half part of the right field's curvature, and by the negative side of the right half part of the left field's curvature. The singularity point will move upwards through the central Y axis. The double force of compression would cause an upward pushing force that can be interpreted as Hawking radiation in the context of cosmological black holes, a pulsation that emits a photon in an atomic realm.

When a moment later both intersecting fields ex-

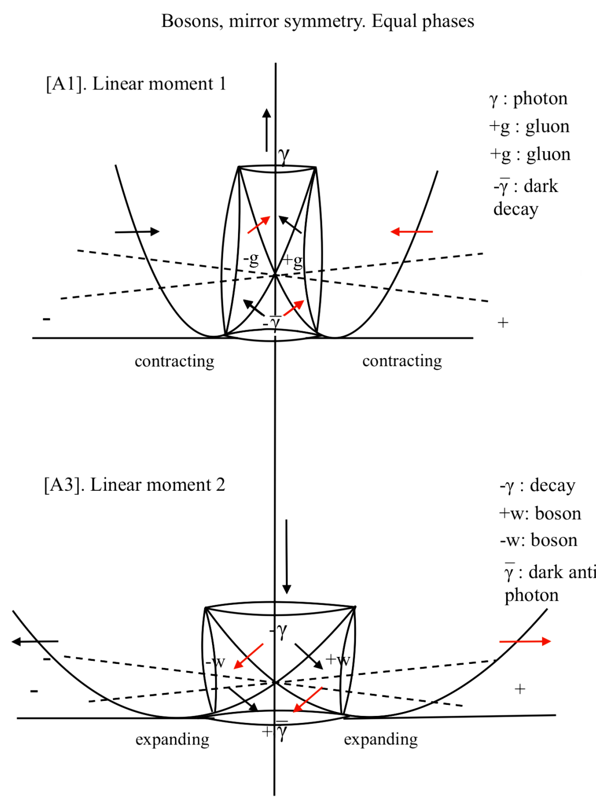

Figure 3: *Symmetric system: subatomic particles.*

pand, the vertical subfield will expand moving downwards, losing its inner density and slowing its inner kinetic orbital energy. This decay that occurs in the concave side of the system does not imply a loss of information because an equivalent inverted force will emerge at the convex side of the system, where an inverted cone of light with a double positive curvature connected by the singularity point receives the compression caused by the positive side of the right half part of the left expanding field, and by the positive side of the left half part of the right expanding field. This inverted pulsation would cause an antiphoton. Photon and antiphoton would follow the Exclusion principle.

However, in the symmetric system, the transverse subfields have chiral symmetry; they simultaneously contract or expand, being interchangeable under rotation. As the left and right transverse subfields simultaneously contract or simultaneously expand, their states of being contracting or expanding would not be ruled by the Pauli Exclusion Principle, being characterized as bosons.

Individually considered, each intersecting field has a smooth curvature with no singularity; if they were separately considered black holes, they would fit with Kerr's statements about the non-mandatory existence of singularities in black holes.

However, considered as a system, it can be said that although singularity points exist inside the "trapped" transverse subfields and in the vertical subfields, a singularity point does exist on the outer side of the black hole systems, below Penrose's event horizon, representing a counterexample to Penrose's censorship conjecture.

The inner singularity of the subfield placed at the convex side of the system will be seen naked by an observer at a distance looking at the convex side of the black hole system. Its inner kinetic energy and material density will be considered dark by an observer placed in the concave side of the system.

Initially, it can be thought that the dynamics of the system can be described by two separate functions: a complex differential function that describes the evolution of the symmetric system, and a complex conjugate differential function which describes the evolution of the antisymmetric system. Even

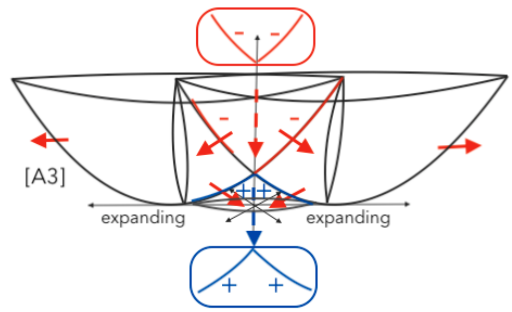

Figure 4: *Singularities in the symmetric system when both intersecting fields expand.*

if they synchronize and desynchronize periodically, those smooth and continuous transformations would respond to the traditional continuity of classical wave mechanics. Then, where does the quantum behaviour originate from?

By representing the pushing forces caused by the inner or outer curvatures of the expanding or contracting fields with eigenvectors of value 1 or -1, and representing those eigenvectors as the elements of a set of 2x2 complex rotational matrices, the evolution of the vectors indicates an interpolation between the symmetric complex and the antisymmetric complex conjugate moments of a rotational system:

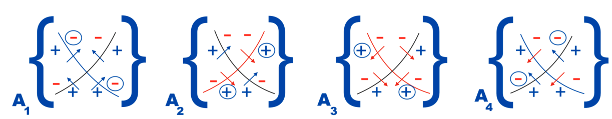

Figure 5: *Rotational system: eigenvectors evolution interpolates the symmetric and the antisymmetric systems.*

A first symmetric stage where both intersecting fields contract. A second antisymmetric stage where the right field contracts and the left expands. A third symmetric stage where both intersecting fields expand. A fourth antisymmetric stage where the left intersecting field contracts and the right expands. The nuclear transformations in curvature through these stages imply a total of 4x4=16 singularities, which relates this composite model with a Kummer-type surface and thus with algebraic geometry.

Along with the abrupt changes in the smoothness of the curvature of the nuclear subfields, the discontinuity derived from that unexpected interpolation may be interpreted as a quantum jump in the continuous development of a classical wave function.

A larger mathematical background has been added to the model in a previous paper Bueno [2023a], characterizing the curvature singularities with Gorenstein theory, illustrating with the curvature singularity the mass gap problem and reflection positivity, and describing the interpolation of the symmetric and antisymmetric transformations of the nuclear subfields as Hodge cycles related to Tomita-Takesaki theory.

3 Other Diagrams

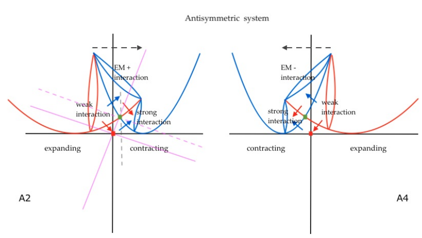

Figure 6: *Singularities in the antisymmetric system: Reflection positivity.*

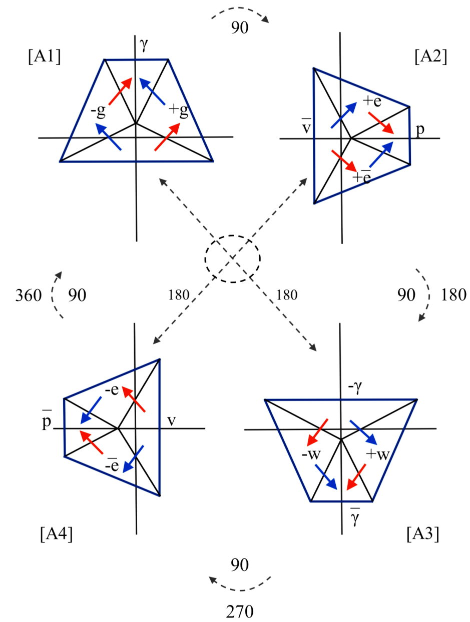

Figure 7: *Rotational system: interpolation between the symmetric and antisymmetric systems.*

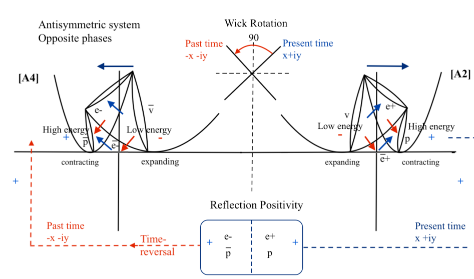

Figure 8: *Singularities in the antisymmetric system: Mass gap.*

Keywords: black holes, singularities, Cosmic Censorship Conjecture, intersecting gravitational fields, information paradox, mirror symmetry, strong and weak interactions, electromagnetic interactions, naked singularities, quantum field theory, General relativity, Gorenstein singularities, Hodge cycles, Kummer surfaces, T-duality, reflection positivity, SYZ conjecture, mass gap problem.

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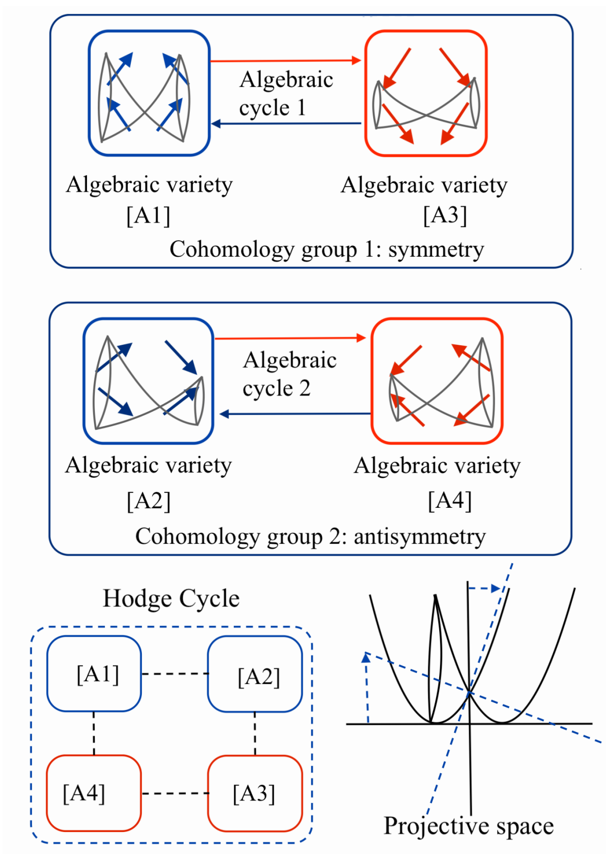

Figure 9: *Hodge cycles.*

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