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Can Dimensional Anisotropy Satisfy Mach's Principle? A Topological Approach to Variable Dimensions of Space using the Borsuk-Ulam Theorem

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Abstract

We create a model universe by insulating a compact Wave Function (WF) with an information-blocking horizon. The WF can produce entanglement independent of distance but interaction with the horizon evolves the quantum state (frequency) of the WF and the topology (curvature) of the horizon, satisfying the Borsuk-Ulam Theorem and the Page and Wootters mechanism of static time. Therefore, in an orthogonal relationship, the field curvature measures the particle's evolution over time. Because increasing field strength accumulates pressure, whereas negative curvature creates a vacuum, their opposing dynamics give rise to poles with dimensionality transformations; pressure culminates in two-dimensional black hole horizons (infinite time), whereas vacuum gives rise to four-dimensional cosmic voids (time zero). The orthogonality of the field and the compact WF is global self-regulation that evolves and fine-tunes the cosmos' parameters. The four-dimensional cosmic voids can produce accelerating expansion without dark energy on the one hand and pressure gives the impression of dark matter on the other. The verifiable and elegant hypothesis satisfies Mach's principle. Above alternative answer regarding the spreading of light also makes absolutely necessary to perform the above missing experiment, as a direct way that convinces anybody how light is spreading. The present article will empower big labs to perform this crucial experiment.

Keywords: Mach's principle; GR; Borsuk-Ulam Theorem; Topolog; Page and Wootters mechanism; Dimensional anisotropy

Introduction

There is a difference in Newton's bucket's water surface when the water is at rest and when the bucket rotates along a curved surface relative to the stars [1]. Nevertheless, in Newtonian physics, the intrinsic state of a particle, i.e., its mass has no immediate connection with its extrinsic state in space and time, i.e., its locus and velocity. The universe's distant matter content cannot cause

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inertia, provided a priori independence of position (x) and momentum (p) of the particle. The idea of absolute space was questioned by Mach, who sought to define inertia as a dynamical quantity determined by the global distribution of matter [2, 3]. He proposed that inertial forces resulting from a body's motion relative to the bulk of matter in the universe. Mach's profound insight into Newtonian mechanics' shortcomings inspired Einstein to develop general relativity (GR). Gauge symmetries are indifferent to the location; a global symmetry holds as a local symmetry. The frame of reference does not correspond to a directly observable physical object, and it can be moved around without changing the physical situation. Nevertheless, Einstein had to postulate "boundary conditions" at infinity.

A path integral of the gravitational action can be used to derive the Wheeler–DeWitt equation which defines the WF, containing information about the geometry and matter content. Although the physical states do not evolve in time, decoherence with a clock operator leads to the reemergence of time [4]. Therefore, attaching a spatial field to the WF with which it interacts creates an evolving clock universe, tracking the discrete frequency evolution of the WF. The resulting system, which satisfies the Wheeler–DeWitt equation acts like Maxwell's demon, an imaginary creature that can lower entropy by allowing faster particles into another compartment [5]. After a while, the compartment would have slower, cold particles, whereas the other would grow hot. Similarly, the clock universe will evolve into polar states, with contrasting parameters of temperature, pressure, matter and energy density, and even dimensionality. Therefore, the ancillary system creates irreversibility, stabilizing curvature [6, 7].

In the present work, we will investigate the evolution of spatial topology in a model WF connected to a clock system. The Borsuk-Ulam Theorem (BUT) can explain how entanglement generates spatial anisotropy, with implications for entropy, inertia, and Mach's principle. We close with a discussion and summary.

The Wave function

The Page and Wootters mechanism (PaW) presents a static universe without time evolution (i.e., the Hamiltonian of the theory does not generate time translations of the physical states for an external time) [8, 4, 9]. The PaW intuitively satisfies energy conservation and a recent experimental proof validated its fundamentals [8-12].

The WF represents compact dimensions (i.e., wrapped up or curled up onto themselves as in Calabi-Yau spaces). The horizon imposes discrete frequencies, but it permits non-locality, the formation of entanglement independent of the spatial coordinate **(FIG 1 top)**. Entanglement is reversible, but it causes local instability, **(FIG. 2)**, which triggers interaction. An interaction term in the Hamiltonian couples a clock spatial field to WF, tracking its evolution. In other words, the clock system periodically must interact with the system whose evolution it is tracking [13, 14].

Interaction with the Spatial Field (SF) causes decoherence of the WF, satisfying conservation principles [15] **(FIG. 1 bottom)**. Decoherence changes the WF's frequencies **(FIG. 1)**, forming the Lagrangian and stabilizing the curvature. Rather than a one-dimensional manifold moving in time (world sheet), the spatial curvature evolution represents the tick-tack of the particle's WF, i.e., time. Interaction generates local pressure differences while leaving the global state unchanged. The above setup supports quantum mechanics' axiomatic formalization: entangled sister particles satisfy conservation laws during quantum phenomena, such as entanglement or the double-slit experiment **(TABLE 1)**.

Table 1. The orthogonality of space qualitative differences between compact dimensions and space, permit the cosmos' self-regulation. Global self-regulation, which fine-tunes the cosmos' parameters, requires the orthogonality of space and compact dimensions

Compact dimensions	**Clock system (gravity field)**
Discrete WF	Topological manifold
Non-locality, insulated from gravity	locality (forms pressure and curvature)
Entanglement is reversible	Interaction is irreversible (stable topology)
Constant frequencies increase entropy	Tolman density gradient
Evolution via the Schrödinger equation	The Schrödinger equation describes the global evolution
Measurement causes decoherence, changing the WF frequency	Measurement updates the field curvature
Discrete energy level	Dimensional anisotropy

Topological Considerations

The interaction of insulated systems inversely modifies their energy states, pressures, and volumes, in an orthogonal transformation. Therefore, increasing frequencies are concomitant with positive curvature (pressure), whereas slower frequencies parallel negative curvature (vacuum). Because the WF determines the field strength (curvature or metric), interaction formulates the cosmos' global topology **(FIG. 2)**.

Topological spaces are central unifying notions in mathematics and physics, such as gravity. The cosmic microwave background (CMB) represents slight density variations and smooth distribution of a nearly spatially flat early universe, but empty space dominates throughout the current web-like cosmic structure **(FIG. 3)** [16-18]. How could a nearly spatially flat universe evolve into one dominated by emptiness?

If the global structure of the cosmos (as suggested by GR) were dominated by gravity, then empty space would occupy corners between globular galactic accumulations. In reality, the opposite happens; voids squeeze galactic structures, in a nearly spherically symmetric galaxy outflow, pushing against massive objects, spiking temperature and pressure [16]. Galaxy movement is channeled into diverging velocity flows, like watersheds forming walls, knots, and filaments, (relative to the universe's overall expansion) [18-20]. The interior void flow fields expand, as vacuums spur accelerating expansion.

Recent void analysis shows hierarchical structures, indicating a nonlinear mass distribution mechanism, where the void size parallels galaxy mass distributions [21]. The larger supervoids are located in the lowest density regions and remain well-insulated from gravitational structures (**FIG. 4**, orange regions). The hierarchical cosmic density organization displays smooth density transitions ranging from vacuum -2.3, −1.1, −0.7, 0.2 and progressing through increasingly dense 1.00, 1.25, 1.50, 1.75, 2.00, and 2.25 [20]. Void density is less than one-tenth or even smaller than the average cosmic density [22, 20]. This way, tens of millions to hundreds of millions of light-years diameter cosmic voids expand the cosmos, giving rise to a quaternion universe. The detailed calculations for the field curvature changes during density transitions will be the subject of future work [23, 24].

Current literature vigorously debates the existence and nature of white holes, which show an analogy to cosmic voids [25-29]. As black holes require extreme pressures and temperatures, white holes represent the lowest density and temperature central portions of voids, protected from gravitational influences (**FIG. 4**, orange regions) [30-36]. Because light paths converge by massive objects, light rays experience divergence when passing through cosmic voids. Therefore, the cosmological constant might be a dimensionality function, causing accelerating expansion without dark energy and dark matter [37, 25].

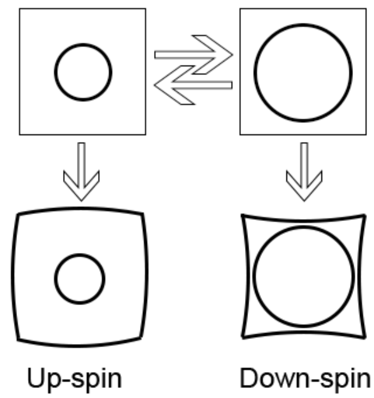

FIG. 1 **An ancillary clock system in two dimensions Top: Compact dimensions (indicated by circles) are insulated from space by an information blocking horizon, allowing non-locality, such as entanglement. Bottom: Interaction between the spatial field and the compact dimensions permanently separates the energy function into daughter particles, changing the pressure and volume, which modifies field curvature.**

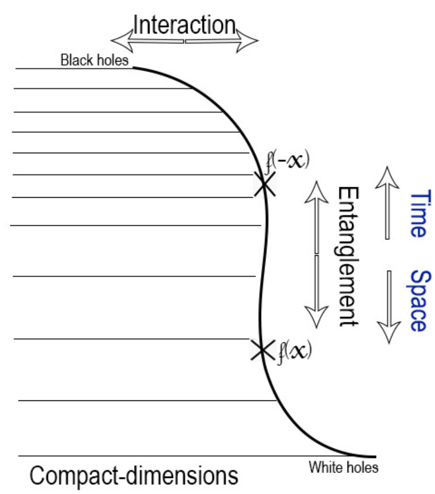

FIG. 2 **The proposed view of 'space-time' The compact dimensions (horizontal lines) are isolated by an information-blocking horizon, limiting particle frequencies to discrete energy levels. Entanglement between f(x) and f(−x) can be mapped to the equator. Entanglement triggers interaction with the spatial field (right curved line), forming a clock system that tracks the evolution of discrete compact frequencies via smooth topology between black holes (top) and cosmic voids (bottom). The field strength increases toward the top. In black holes, time=∞, space=0; in cosmic voids, space=∞, time=0.**

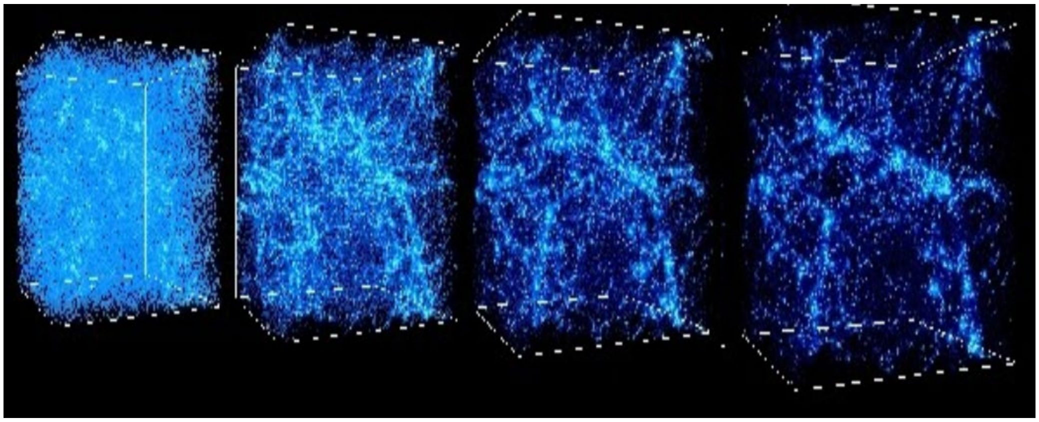

FIG. 3 **Computer simulation of the cosmic web evolution over time Evolution from left to right shows the gradually increasing curvature differences. Thin filaments connect dense, galaxy cluster-filled regions around nearly empty.Voids. Picture credit: Andrey Kravtsov (The University of Chicago) and Anatoly Klypin (New Mexico State University) at the National Center for Supercomputer Applications.**

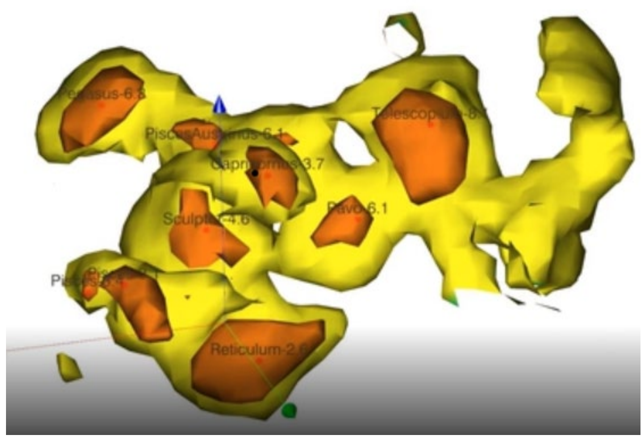

FIG. 4 **The density map of the Local Void The central void density is −1.1 (orange) and −0.7 (yellow) elsewhere (the negative sign indicates under-density). The central location of the coldest regions within voids stabilizes them-image from Tully *et al.*, 2019.**

The Borsuk-Ulam Theorem (BUT)

In 1961 Rolf Landauer predicted the minimum amount of heat needed to erase a classical bit $E = k_B\ T\ ln\ 2$ [38], where k_B is the Boltzmann constant and T is the temperature of a "reservoir" with which the bit exchanges heat. Because E/T is constant (on a constant temperature), interaction modifies the local volume (pressure), which evolves the large-scale structure. Entanglement updates the particles' energy state [9]. The antipodal volume transformations of sister particles update the field curvature [39].

The Borsuk-Ulam Theorem (BUT) states that if an *n*-sphere is mapped continuously into an n-dimensional Euclidean space R^n, there is at least one pair of antipodal points on S^n which map onto the same point of R^n [40, 9]. Correspondence can be found between a pair of antipodal points, and they can be represented in terms of one point. The analog of this mapping process is the drawing together of separate antipodal free particles whose entangled states are correlated in a quantum mechanics view of BUT.

This correlation of entangled states can be explained mathematically in terms of the descriptive proximity of a pair of antipodal particles [41, 42]. In other words, thanks to a pair of companionable feature vectors that describe antipodal particles, the particles have a nonempty descriptive intersection [43]. That is, let pA, pB be a pair of antipodal particles and let be $\Phi\left(pA\right), \Phi\left(pB\right)$ descriptions of the particles, defined by

$$\Phi(pA) = \{x \varepsilon pA : \Phi(x), \text{a description of x in pA}\}$$

$$\Phi(pB) = \{x' \varepsilon pB : \Phi(x'), \text{a description of x' in pB}\}.$$

For example, $\Phi(pA)$ is a set of descriptions of the parts of *pA*, represented by a feature vector that describes *pA* with its *n* parts, namely, $\overrightarrow{(\Phi(x_1), \Phi(x_2), ..., \Phi(x_n))}$. In the case where a pair of antipodal particles have companionable descriptions, the descriptive intersection $pA \underset{\Phi}{\cap} pB$ is nonempty, i.e, $pA \underset{\Phi}{\cap} pB = \{\mathrm{y} \in \mathrm{pA} \cup \mathrm{pB} : \Phi(\mathrm{y}) \in \Phi(\mathrm{pA}) \text{ and } \Phi(\mathrm{y}) \in \Phi(\mathrm{pB})\} \neq \varnothing$. That is, there is at least one component y in the union pA, pB that has a description $\Phi(y)$ that is common to the descriptions of $\Phi(pA)$ and $\Phi(pB)$, i.e., $\Phi(y) \in \Phi(pA)$ and $\Phi(y) \in \Phi(pB)$. In effect, particles whose states have companionable descriptions can be mapped to a higher state in terms of their descriptive intersection.

From a compactified dimensions perspective, a higher dimension feature vector that describes a physical structure can be shrunk to a lower-dimensional structure by convolving (rolling together) the features in a description into a more concise feature vector [44]. According to BUT, the pressure of positive curvature correlates with a negative curvature vacuum. This convolution can be represented topologically by a collection of contraction maps from surface points (each with its own feature vector) to a fixed point, such as a surface centroid with a single feature vector with a reduced number of features. For example, the points on an edge attached between the boundaries of a ribbon rb*E* can be mapped to a fixed point *p* in the intersection of *p* with the ribbon boundary body of the closure cl of ribbon cycle cyc*B* as shown in **FIG. 5**, using mapping f defined by $f(p \in \overline{pq}) = \overline{pq} \cap bdy(cl(cycB)) = p$, see for further details and mathematical treatment [45,46].

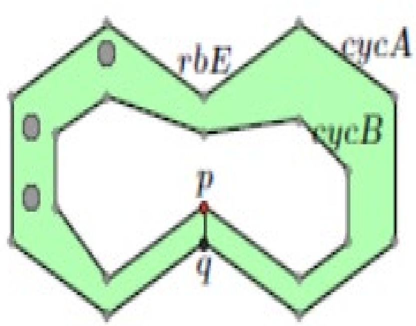

FIG. 5 **Mapping an edge $\overline{pq}$ to a fixed point p on a ribbon boundary**

The notation n within S_n stands for an n-sphere, an n-dimensional, circular structure embedded in an n+1 space [47, 48]. For example, a 2-sphere (S_2) is the 2-dimensional surface of a 3-dimensional space. Antipodal points are, e.g., the poles of a sphere [43]. The mapping $f : S^n \rightarrow S^n$ is smooth, provided is a 1-1, continuous, differentiable mapping from the manifold (domain of Euclidean space) into itself in which the inverse mapping $f^{-1} : S^n \rightarrow S^n$ is also continuously differentiable [49].

$$\deg f = X^x \in f^{-1} sig(\det dxf). \tag{1}$$

The cosmological standard model rests on the assumption that the universe is isotropic around all observers. However, applying conservation principles with BUT show that antipodal changes, separated in space or time, map into one. This spatial and temporal separation results in dimensional anisotropy. Antipodal changes might originate in entanglement and the quantization of particles in quantum mechanics [50].

A system consisting of only one type of particle evolves into a two-type particle system with attraction and repulsion forces having equal fractions [51, 52]. Antipodal transformations, the emergence of attraction and repulsion forces can map into Euclidean space; the lack of volume within positive curvature is compensated for excess volume within negative curvature regions (**FIG. 2** and **FIG. 6**). According to BUT, any two-dimensional black hole boundary (see, e.g., **FIG. 2**) must have at least one antipodal, i.e., a four-dimensional point corresponding to it. Rather than treating the causes of the two regimes independently (dark energy and dark matter), PaW offers a unique cause arising from the same fundamental physical process [25].

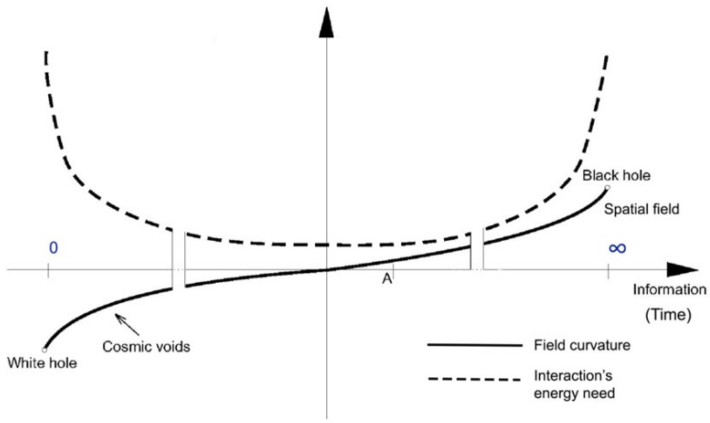

FIG. 6 **The energy-information changes in the universe. The x-axis represents the information accumulation or age (from 0 to ∞). The continuous line is the degree of compactification (dimensionality reduction from 4 on the left to 2 on the right). The dotted line is the Lorentz contraction, indicating the energy change of interaction. A is the gravity on an Earth-like planet.**

Dimensional Anisotropy

Both acceleration and gravity cause the slowing of clocks. Time is often represented by a temperature-dependent entropy generation and entropy rate [53, 54]. The evolution of time intervals (t = 1 / υ) shows a frequency (υ) dependence [55, 56].

$$Ds^2 = dr^2 + (cdt)^2 \tag{2}$$

From the trigonometric identity:

$$1 = cos^2\psi + sin^2\psi \tag{3}$$

$$\sin\psi = \frac{cdt}{ds} \tag{4}$$

Time emerges from an orthogonal transformation between the compact dimensions and the spatial field, where antipodal thermodynamics are slowing the clocks in a seemingly identical manner; therefore, gravity and acceleration might have a trigonometric origin (**FIG. 2**; **FIG. 6**). Moreover, the field curvature change is the derivative of the inverse sine function of quantum frequency:

$$\frac{d}{d\psi}\sin^{-1}\psi = \frac{1}{\left(1-\psi^2\right)} \tag{5}$$

Therefore, the Lorentz transformation can be interpreted as the curvature change per unit of energy input (**FIG. 6**). The changing curvature ultimately culminates in phase change via dimensionality transformations. Black hole physics is a subject of a lot of debate [57], but the AdS/CFT conjecture and the firewall hypothesis support lesser dimensionality horizons [57-59]. Landauer's principle supports our experience that information accumulation causes black holes' high temperatures [38]. Likewise, the existences of negative temperatures [60-65], suggests a possible relationship between vacuum energy and temperature [66]. In addition, PaW and BUT shows that any two-dimensional boundary (e.g., **FIG. 3**) has at least one antipodal point pair, i.e., four-dimensional space.

Energy input, such as an increase in temperature, increases entropy and pressure (**FIG. 2**) [67-69]. In an ideal gas, entropy S can change as a function of temperature: $\Delta S = nC_v In\frac{T}{T_0}$, or volume $\Delta S = nR\ln\frac{V}{V_0}$ where n is the number of moles, R is the ideal gas constant. Entropy, an elusive concept, is often associated with a thermal disorder caused by gravitational effects [70]. Nevertheless, gravity-free simulations can produce order-increasing entropic effects enhancing the ability to work [71, 72].

Therefore, pressure creates entropy via gravity and a vacuum creates entropy by expanding the degrees of freedom (order or work potential). Cosmological entropy is related to geometry; it increases with temperature and pressure (toward black holes) or with volume (toward white holes) with the poles representing the highest entropy. Systems with a bounded energy spectrum display negative absolute temperature, and negative pressure akin to dark energy [73, 74, 66]. The expansionary potential of space acts as dark energy, whereas the loss of dimensionality gives the semblance of dark matter.

The cosmological constant problem is the discrepancy between the theoretical vacuum energy density and its empirically measured value [75]. However, if vacuum energy is the function of field strength, then spatial expansion is the function of field strength with cosmic expansion originating in the zero-point energy of the cosmic voids [26, 37, 77-78]. The Sloan Digital Sky Survey found vast cosmic voids, such as the long, fully connected supervoid, Eridanus, which originates in the CMB cold spot [18, 31, 32, 79].

Antipodal dynamics, such as simultaneous heating and cooling, produce thermal convection cells, and the surface tension in expanding hot gas forms foam [80]. Compression (as in black holes), expands time to infinity, whereas expansion rewinds time to zero. The spatial field operates as a clock, tracking the WF evolution [14, 13]. Time progression from time zero in the white holes to time infinity in the black holes correlates with gravity as black hole horizons' immense field strength slow expansion [81]. The cosmos dimensionality alternation between two and four dimensions acts as a harmonic oscillator.

The Cosmos as a Harmonic Oscillator

Applying the Fourier transform to the time-independent Schrödinger equation naturally leads to an oscillatory type solution. The peaks in the probability density function can be interpreted as the spectrum of the system.

The Hamiltonian of the system:

$$\hat{H} = -\frac{\hbar^2}{2m}\frac{\partial 2}{\partial x2} + V_{(x)} \tag{6}$$

where m is the particle mass, the first term is the kinetic energy operator and V(x) is the potential energy.

The time-independent Schrödinger equation:

$$\frac{-\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x) \tag{7}$$

where ħ is Planck's constant divided by 2π, and ψ is called the WF of the system.

The WF of the universe forms either a node or an antinode (voids) at its poles (**FIG. 2**), causing a power-law scaling relation between the void size and the corresponding cluster mass [33, 82, 34]. The scatter in the scaling relation is more significant at low redshifts and small voids, indicating that larger voids are more insulated from environmental influences (**FIG. 4**).

The AdS/CFT correspondence, a holographic mapping, asserts that a lower-dimensional non-gravitational theory can fully describe a higher-dimensional gravitational one [83, 50, 58]. In our derivation, we find that gravitational regions separate high dimensional voids from the low dimensional horizon. When using the CFT side (as opposed to the more usual AdS side) to analyze black holes as a starting point, Almheiri, Marolf, Polchinski, and Sully (AMPS, 2012) found information conservation (i.e., black hole formation and evaporation process are unitary), the firewall hypothesis [59, 66].

Although the poles keep three-dimensional space stable, local disturbances by collisions and explosions have spectacular destructive power [84, 85]. The WF and spatial field form global self-regulation that fine-tunes the cosmic parameters and can promote fractal topology with enormous complexity [86, 39, 51]. The orthogonal transformation between the compact dimensions and the spatial field leads to many well-known consequences of quantum mechanics. Although gravity is Lorentz invariant [87, 88], the particles' dimensional anisotropy turns gravity into a bipolar force, causing the Tolman temperature gradient [89, 90].

Inertia

Brans showed that if one adopts the modern geometric interpretation of GR, then the inertial mass of a free test particle cannot change in a gravitational field [2, 3]. In the Machian view, the global mass distribution must determine the inertial frame of reference, the inertial mass, and acceleration [89]. Although particles appear constant, their vibrations are related to the field strength (curvature or metric). Therefore, an object's position corresponds to a freely hanging plumb (**FIG. 7**).

Deviations in the angle of that plumb (location of the object) change the equilibrium of the whole universe and lead to inertia. Inertia is proportional to the object's mass and the field strength (i.e., topological distance from the black hole) represented by the metric $g(v, w)$. Congruent with the intuitive expectation that the inertial mass is related to the global topology a test particle mass increases in the vicinity of a large mass, such as black holes [91, 59]. Therefore, inertia reflects the whole universe's field structure and global dynamics, as Mach had insisted.

In physics, chemistry, and biology, compound or phase change formation often precipitate reactions. Because interaction requires compact dimensions, their formation is time zero, a phase-change that solidified space into the gravity field. The compact dimensions' energy requiring birth guarantees identical, homogeneous initial conditions throughout space [73], which is supported by the CMB.

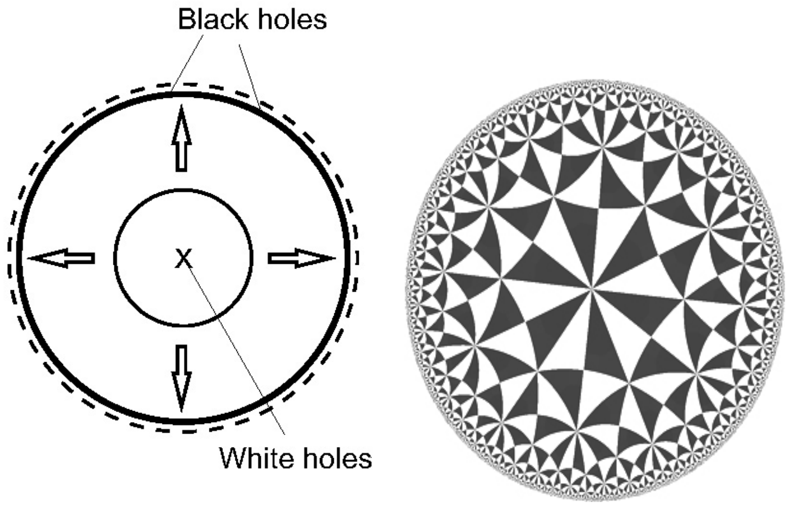

FIG. 7 **Left: The global topological map of the universe Right: The hyperbolic plane with its inherent self-symmetries satisfying the AdS/CFT conjecture (Wikimedia Commons: Tom Ruen) The immense field strength of the cosmos' outer boundary slows expansion. The vacuum energy of white holes is a negative pressure that expands space into the fourth dimension (hyperbolic geometry). The poles' opposing dynamics (2 and 4 dimensions) enforce constant interactions on the dynamic and unstable three-dimensional regions (marked by white arrows), causing complexity and biological evolution.**

Discussion

We formed a spatial field by insulating a compact WF with an information-blocking horizon. Their energy-requiring interaction stabilizes the spatial curvature and satisfies the axiomatic formalization of the two leading theories in modern physics, quantum mechanics and GR. This way, the field curvature represents the clock-like evolution of the universe, fulfilling fundamental conservation principles, according to the PaW mechanism. Therefore PaW originates in the microstructure of space, a quaternion cosmic structure with four-dimensional white and two-dimensional black poles.

The global dimensional anisotropy can reproduce the relativity of motion and an accelerating universe without exotic particles or forces. It explains the Tolman temperature gradient and the destructive power of explosions and collisions due to sudden dimensionality modifications. As massive objects form gravitational lensing, cosmic voids cause divergence of light rays. The cosmological constant, a dimensionality function, can cause accelerating expansion [37, 25]. Therefore, Einstein's gravitational theory might be a limiting case of a more general theory with space as a dynamic variable [47].

Time is defined by entropy generation and the entropy rate. The irreversibility of interaction might lead to the directionality of time, the age of its coordinate. A relationship between time and frequency, $t=1/\upsilon$ supports gravity's connection to entanglement [53, 55].

Although increasing and eliminating gravitational effects increase entropy, the first creates disorder, whereas eliminating gravity permits order and increases the degrees of freedom. The relationship may explain negative temperatures' antigravity-like effects. Gravity-free systems' heightened work potential may give Maxwell's demon the last laugh Law [92].

The universe's antipodal sinks and sources satisfy Mach's principle and explain three unexplained puzzles in physics: the so far unexplained behavior of (1) cold vacuum in the lab, (2) the expansion of space, and order increasing entropic effects (increasing degree of freedom), (3) the accelerating expansion and a tight power-law scaling relation between the void size and the corresponding cluster mass [33].

The orthogonal interdependence of the WF and spatial topology is global self-regulation that continuously fine-tunes the universe's parameters. It can provide new considerations for understanding the cosmological constant and the coincidence problem (matter density depends on dimensionality). The three-dimensional Euclidean space represents a dynamic birthplace for the formation of stars, planets, and biological evolution.

Physics' solid foundation should not be changed at a whim. Nevertheless, the persistent questions at the core of relativity (dark matter and dark energy), cosmology (the horizon problem and inflation), and quantum mechanics urge us to reconsider fundamental questions at the heart of physics. The above considerations show a close fit with large-scale observations of our physical world (quantum mechanics, relativity, and accelerating expansion). Computer simulations and negative temperature experiments in a microgravity environment can verify its points.

Declarations

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