Open Peer Review on Qeios

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

Eva Deli[1]

1 University of Debrecen

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

In general relativity, Einstein's equations relate the geometry of space-time to the distribution of matter. Nevertheless, the equations are in contradiction with quantum mechanics and even possibly our experience of physical reality. We propose a thought experiment to investigate a compact wave function (WF) insulated by an information-blocking horizon. The WF can produce entanglement independent of distance, but interaction with the horizon evolves the quantum state (frequency) and the topology (curvature) of the horizon in an orthogonal relationship. Their mutual evolution satisfies the Borsuk-Ulam Theorem and the Page and Wootters mechanism of static time. Therefore, the field curvature measures the particle's evolution as time and fine-tunes the cosmos' parameters. The interaction of the field and the compact WF give rise to poles with dimensionality transformations, and it formulates global self-regulation. Because field strength generates pressure, culminating in two-dimensional black hole horizons (infinite time), whereas vacuum gives rise to four-dimensional cosmic voids (time zero). 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.

A video abstract of the present article is available at the following link: https://youtu.be/U0t0Lbhpb9M.

Eva Deli

University of Debrecen, Department of Anatomy, Histology, and Embryology

eva.kdeli@gmail.com

ORCID: 0000-0003-1126-1970

James F. Peters

james.peters3@umanitoba.ca

University of Manitoba, Department of Electrical and Computer Engineering and

Department of Mathematics, Faculty of Arts and Sciences, Adıyaman University

Keywords: Mach's principle, GR, Borsuk-Ulam Theorem, Topology, Page and Wootters mechanism, dimensional anisotropy.

Preliminaries

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. Hence, the universe's distant matter content cannot cause inertia, provided *a priori* independence of the particle's position (x) and momentum (p).

Mach questioned the idea of absolute space and sought to define inertia as a dynamical quantity determined by the global distribution of matter [2][3]. He proposed that inertial forces result 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). For example, gauge symmetries are indifferent to the location; a global symmetry holds as a local symmetry. As a result, the frame of reference does not correspond to a directly observable physical object and 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 [4], decoherence with a clock operator leads to the emergence of time. 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[5], acts like Maxwell's demon. Maxwell's demon is an imaginary creature that can lower entropy by allowing faster particles into another compartment, creating differences in energy distribution. Because the ancillary system irreversibly stabilizes curvature[6][7], the clock universe will evolve into polar states. As a result, specific temperature, pressure, matter, energy density, and dimensionality characterize curvature.

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 [8][10], and a recent experiment validated its fundamentals[11][12][9].

The WF represents compact dimensions (i.e., wrapped up or curled onto themselves as in Calabi-Yau spaces). Setting the horizon at infinity imposes discrete frequencies but permits non-locality and entanglement independent of the spatial coordinate [13] (Fig1. top). Although entanglement is reversible, it causes local instability[14] (Fig2), which triggers interaction. An interaction term in the Hamiltonian couples a clock spatial field to WF [15][16], tracking its evolution. In other words, the clock system must periodically interact with the system whose evolution it tracks.

Interaction with the spatial field (SF) triggers WF decoherence. Because interaction must satisfy conservation principles [17] (Fig1. bottom), increasing WF frequencies must be accompanied by decreasing field strength (negative field curvature) and vice-versa. Rather than a one-dimensional manifold moving in time (world sheet), the spatial curvature evolution represents the tick-tack of the particle's WF, which generates local pressure differences.

The interaction of insulated systems is an orthogonal transformation, which inversely modifies their energy states, pressures, and volumes. For example, increasing frequencies are concomitant with positive curvature (pressure), whereas slower frequencies parallel negative curvature (vacuum). Therefore, interaction increases curvature locally while keeping the global information-energy relationship constant (Fig2).

Thus, quantum mechanics' axiomatic formalization supports global conservation laws[14], the equivalence of entanglement and superposition[13], or the double-slit experiment (Table I). Therefore, entanglement acts as a microscopic wormhole[17].

Table I. The orthogonality of space. Qualitative differences between compact dimensions and space permit the cosmos' self-regulation. However, 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

Topological spaces are central unifying notions in mathematics and physics, such as gravity. Although the cosmic microwave background (CMB) represents slight density variations and smooth distribution of a nearly spatially flat early universe [18][19][20], the current web-like cosmic structure consists of gravitational nodes dispersed in empty space (Fig3). How could a nearly spatially flat universe evolve a cellular structure dominated by emptiness?

Because phase change often makes reactions possible in physics, chemistry, and biology, the existence of the horizon precipitates cosmic evolution. Therefore, compact dimension formation (time zero) is a phase change that solidifies space into the gravity field—the compact dimensions' energy requiring birth guarantees identical, homogeneous initial conditions throughout space [21]. More precisely, the CMB shows the newborn cosmos' first interaction.

If gravity dominated 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, and spiking temperature and pressure [18]. Galaxy movement assembles into diverging velocity flows, like watersheds[20], forming walls, knots, and filaments (relative to the universe's overall expansion) rather than blobs [22][23]. The interior void flow fields expand as vacuums spur accelerating expansion.

Recent void analysis shows a hierarchical, nonlinear mass distribution mechanism where the void size parallels galaxy mass distributions [24]. The larger supervoids are located in the lowest density regions and remain well-insulated from gravitational structures (Fig4, orange regions). The hierarchical cosmic density organization displays smooth 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 [23]. Void density is less than one-tenth or even smaller than the average cosmic density[25][23] with expansion due to tens of millions to hundreds of millions of light-years diameter cosmic voids [26][27][28].

The detailed calculations for the field curvature changes during density transitions will be the subject of future work.

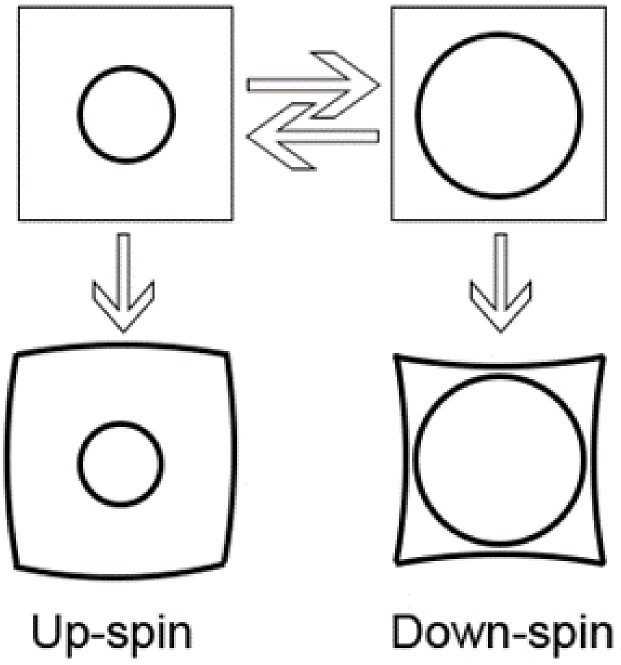

Fig1. An ancillary clock system in two dimensions. Top: Compact dimensions (indicated by circles) are insulated from space by an information-blocking horizon, allowing non-locality, such as entanglement. Bottom: Interaction between the spatial field and the compact dimensions permanently separates the energy function into daughter particles, changing the pressure and volume, which modifies field curvature.

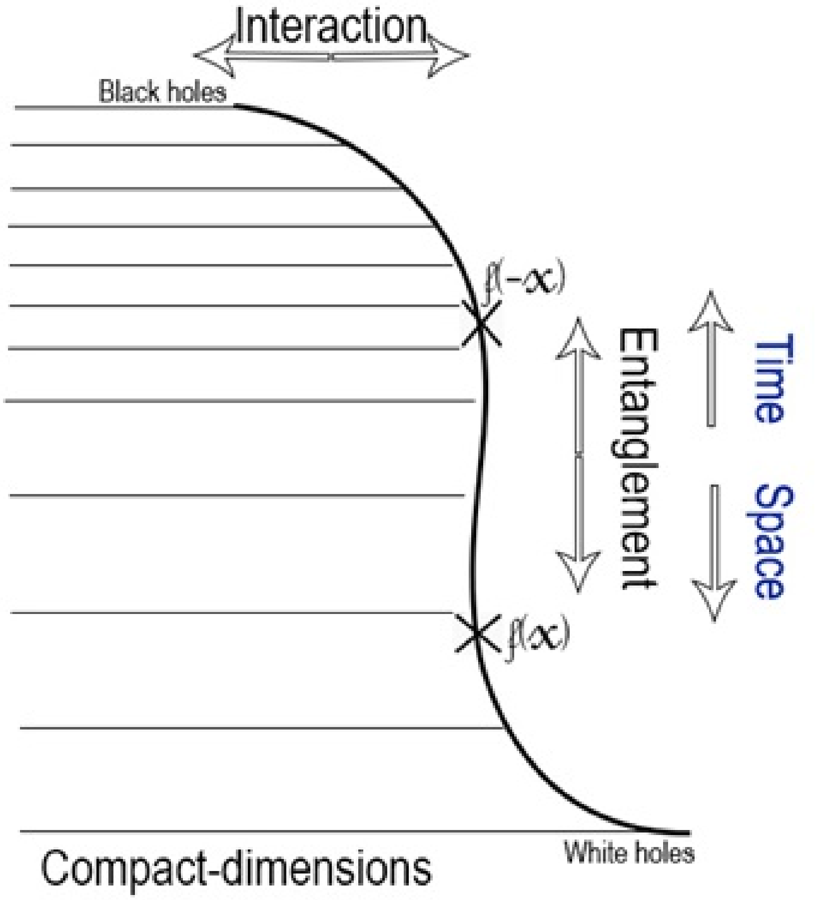

Fig2. The proposed view of 'space-time'. The compact dimensions (horizontal lines) are isolated by an information-blocking horizon, limiting particle frequencies to discrete energy levels. Entanglement between f(x) and f(−x) can be mapped to the equator. Entanglement triggers interaction with the spatial 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.

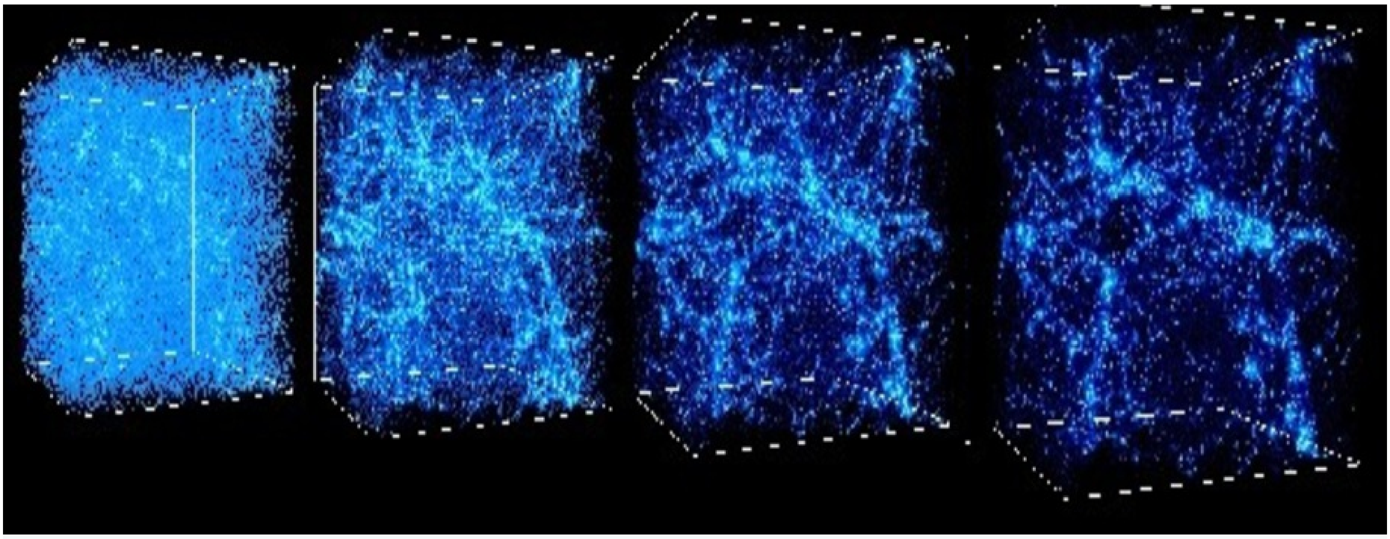

Fig3. Computer simulation of the cosmic web evolution over time. Evolution from left to right shows the gradually increasing curvature differences. Thin filaments connect dense, galaxy cluster-filled regions around nearly empty voids. Picture credit: Andrey Kravtsov (The University of Chicago) and Anatoly Klypin (New Mexico State University) at the National Center for Supercomputer Applications.

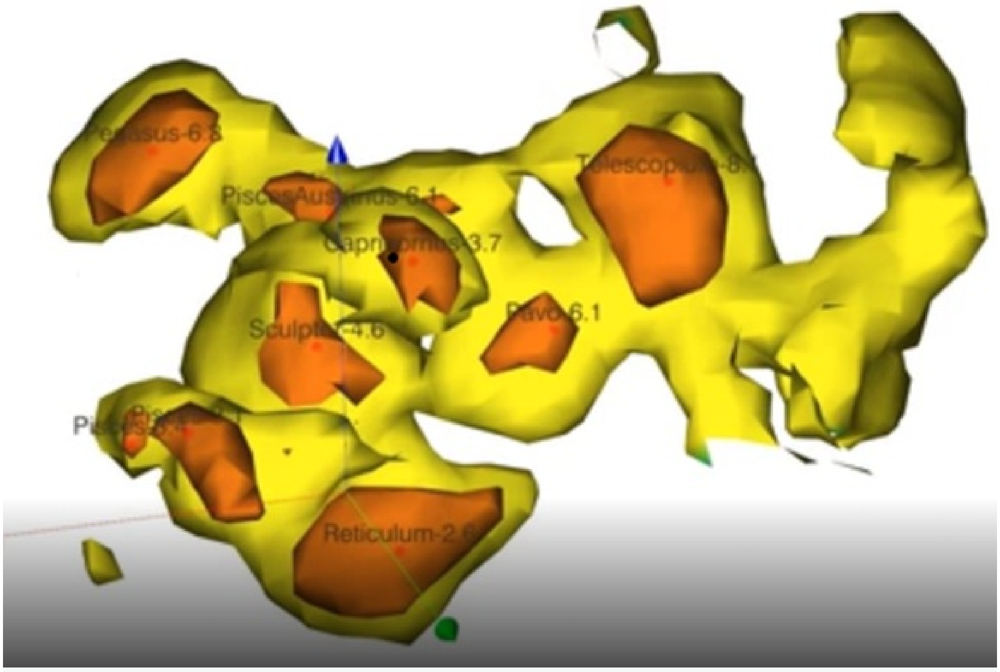

Fig4. The density map of the Local Void. The central void density is –1.1 (orange) and –0.7 (yellow) elsewhere (the negative sign indicates under-density). The central location of the coldest regions within voids stabilizes them—image from Tully et al., 2019.

The Borsuk-Ulam Theorem (BUT)

In 1961 Rolf Landauer predicted the minimum amount of heat needed to erase a classical bit $E = k_B T \ln 2$[29], 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 [30].

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 [31][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 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 [32][33]. In other words, thanks to a pair of companionable feature vectors that describe antipodal particles, the particles have a nonempty descriptive intersection [34]. That is, let pA, pB be a pair of antipodal particles and let be $\Phi(pA), \Phi(pB)$ descriptions of the particles defined by

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

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, $\overrightarrow{\left(\Phi\left(x_1\right), \Phi\left(x_2\right), \ldots, \Phi\left(x_n\right)\right)}$. In the case where a pair of antipodal particles have companionable descriptions, the descriptive intersection $pA_\Phi pB$ is nonempty, i.e., $pA_\Phi pB = \{y \in pA \cup pB : \Phi(y) \in \Phi(pA)$ and $\Phi(y) \in \Phi(pB)\} \neq \emptyset$

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 [35]. 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 rBE 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$cycB$ as shown in Fig5, using mapping f defined by $f(p \in pq) = pq \cap dby(cl(cycB)) = p$ [36], see [37] for further details and mathematical treatment.

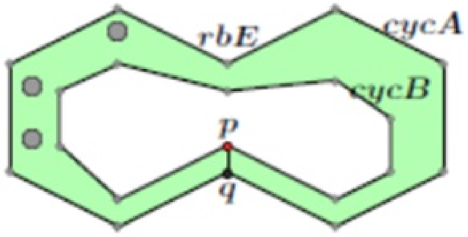

Fig5. Mapping an edge pq to a fixed point p on a ribbon boundary

The notation n within S_n stands for an n-sphere [38], an n-dimensional, circular structure embedded in an n+1 space [39]. 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 [34]. The mapping $f: S^n \rightarrow S^n$ is smooth, provided f is a 1-1, continuous, differentiable mapping from the manifold S^n (domain of Euclidean space) into itself in which the inverse mapping $f^{-1}: S^n \rightarrow S^n$ is also continuously differentiable [40].

$$degf = X^x \in f^{-1} sig(det\, dxf). \qquad (1)$$

The cosmological standard model assumes 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 [41][13].

A system consisting of only one particle type evolves into a two-type particle system with attraction and repulsion forces having equal fractions [42][43]. 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 (Fig2 and Fig6). For example, the asymmetric tails of star clusters are consistent with the anisotropic geometry of space [44].

According to BUT, any two-dimensional black hole boundary (see, e.g., Fig2) 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 [45]. Next, we discuss the emergence and nature of dimensional anisotropy.

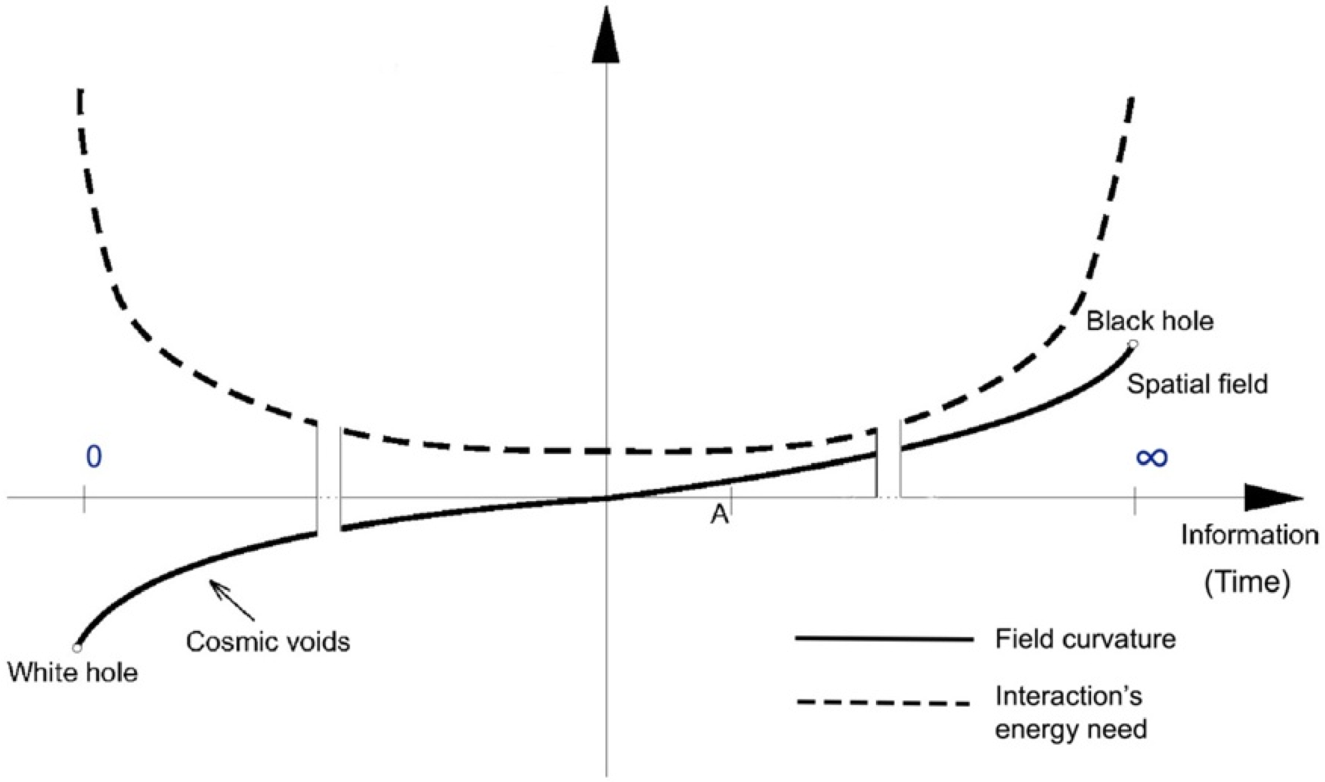

Fig6. The energy-information changes in the universe. The x-axis represents the information accumulation or age (from 0 to ∞). The continuous line is the degree of compactification (dimensionality is four on the left and changes to two on the right). The dotted line is the Lorentz contraction, indicating the energy change of interaction. A is the gravity on an Earth-like planet.

Dimensional anisotropy

Time t is often represented by a temperature-dependent entropy generation and entropy rate[46][47]. Moreover, t evolution of time intervals (t = 1 / u) shows a frequency (u) dependence [48][49].

$$Ds^2 = dr^2 + (cdt)^2 \qquad (2)$$

where r is the diameter and ds is the space-time interval.

From the trigonometric identity:

$$1 = \cos^2\psi + \sin^2\psi \qquad (3)$$

we can express the curvature change:

$$\sin\psi = \frac{cdt}{ds} \qquad (4)$$

If time measures the curvature change, then change (i.e., time) is fastest in the Euclidean field and slows with the curving field. Therefore, the orthogonal transformation between the compact dimensions and the field can slow the clocks but form either acceleration or gravity. Therefore, gravity and acceleration might have a trigonometric origin (Fig2; Fig6). Moreover, the field curvature change is the derivative of the inverse sine function of the quantum frequency (E/h):

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

Therefore, the Lorentz transformation is the variation of curvature change per unit of energy input (Fig6). The changing curvature ultimately culminates in phase change via dimensionality transformations. Black hole physics is a subject of a lot of debate [50], but the AdS/CFT conjecture[51] and the firewall hypothesis [52] support lesser dimensionality horizons.

Landauer's principle supports our experience that information accumulation causes black holes' high temperatures [29]. Likewise, negative temperatures [53][54][55][56][57][58] suggest a possible relationship between vacuum energy and temperature [59]. In addition, PaW and BUT shows that any two-dimensional boundary (e.g., Fig3) has at least one antipodal point pair, i.e., four-dimensional space.

Current literature vigorously debates the existence and nature of white holes[45][60][61][62][63]. In contrast to black holes' extreme pressures and temperatures, white holes represent the lowest density and temperature space. Furthermore, voids [64][65][66][67][68] are insulated from gravitational influences [53][54] (Fig4, orange regions). In contrast to gravitational lensing, cosmic voids would disperse passing light rays. Therefore, the cosmological constant might be a dimensionality function [55], causing accelerating expansion without dark energy[45].

Energy input, such as an increase in temperature, increases entropy and pressure (Fig2)[56][57][58]. In an ideal gas, entropy S can change as a function of temperature: $\Delta S = nC_V ln \frac{T}{T_\circ}$, or volume $\Delta S = nRln \frac{V}{V_\circ}$, where n is the number of moles, R is the ideal gas constant. Entropy is an elusive concept that is often associated with a thermal disorder [69] due to gravitational effects. Nevertheless, order-increasing gravity-free simulations display entropic effects [70][71].

Although pressure creates gravity and vacuum expands the degrees of freedom (order or work potential), both generate entropy. Therefore, cosmological entropy is related to geometry, with the highest entropy at the poles. The substantial field strength leads to the spectacular destructive power of collisions and explosions [72][73]. Moreover, the expansion acts as dark energy, whereas dimensionality loss gives the semblance of dark matter.

The cosmological constant problem is the discrepancy between the theoretical vacuum energy density and its empirically measured value [74]. Systems with a bounded energy spectrum display negative absolute temperature and negative pressure akin to dark energy [21][75][59]. Entanglement populates expanding vacuum with pairs of particles lost in black holes[28]. Although particle-antiparticle pairs annihilate each other in three-dimensional space, they remain viable in four dimensions [60][76]. The combined effect is that cosmic voids produce energy-rich space, accelerating expansion.

Antipodal dynamics, such as simultaneous heating and cooling, produce thermal convection cells, and the surface tension in expanding hot gas forms foam [77]. Compression (as in black holes) expands time to infinity, whereas expansion rewinds time to zero. Likewise, the zero-point energy in cosmic voids gives rise to cosmic expansion [78][76][79][55]. For example, the Sloan Digital Sky Survey found vast cosmic voids[20][80], such as the long, fully connected supervoid Eridanus [65], originating in the CMB cold spot[66].

The spatial field operates as a clock, tracking the WF evolution[16][15]. 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

The Fourier transformation to the time-independent Schrödinger equation naturally leads to an oscillatory solution. The peaks in the probability density function may represent the spectrum of the system.

The Hamiltonian of the system:

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

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:

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

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

The poles form either a node or an antinode (voids) of the universe's WF (Fig2), causing a power-law scaling relation between the void size and the corresponding cluster mass [67][82][68]. 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 (Fig4).

The AdS/CFT correspondence, a holographic mapping, asserts that a lower-dimensional non-gravitational theory can fully describe a higher-dimensional gravitational one [83][41][51]. In our derivation, galaxies and clusters separate high-dimensional voids from the low-dimensional horizon. Furthermore, the CFT side (as opposed to the more usual AdS side) black hole analysis by Almheiri, Marolf, Polchinski, and Sully (AMPS, 2012), found information conservation (i.e., black hole formation and evaporation process are unitary), the firewall hypothesis [52][59].

Life in the universe is very sensitive to the values of fundamental physical constants, leading to the so-called fine-tuning problem. However, in our model, the WF maintains constant spatial curvature, but entanglement increases curvature differences [13]. The two contrasting effects result in a global self-regulation that constantly fine-tunes the cosmic parameters and promotes a fractal topology with enormous complexity [84][30][42]. For example, the orthogonal transformation between the compact dimensions and the spatial field leads to wave-particle duality or uncertainty. Furthermore, augh gravity is Lorentz invariant [85][86], the particles' dimensional anisotropy turns gravity into a bipolar force, causing the Tolman temperature gradient [87][88].

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]. However, in the Machian view, the global mass distribution must determine the inertial frame of reference, the inertial mass, and acceleration [87]. 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 (Fig7).

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 [89], a test particle mass increases in the vicinity of a large mass, such as a black hole[52]. Therefore, inertia reflects the whole universe's field structure and global dynamics, as Mach had insisted.

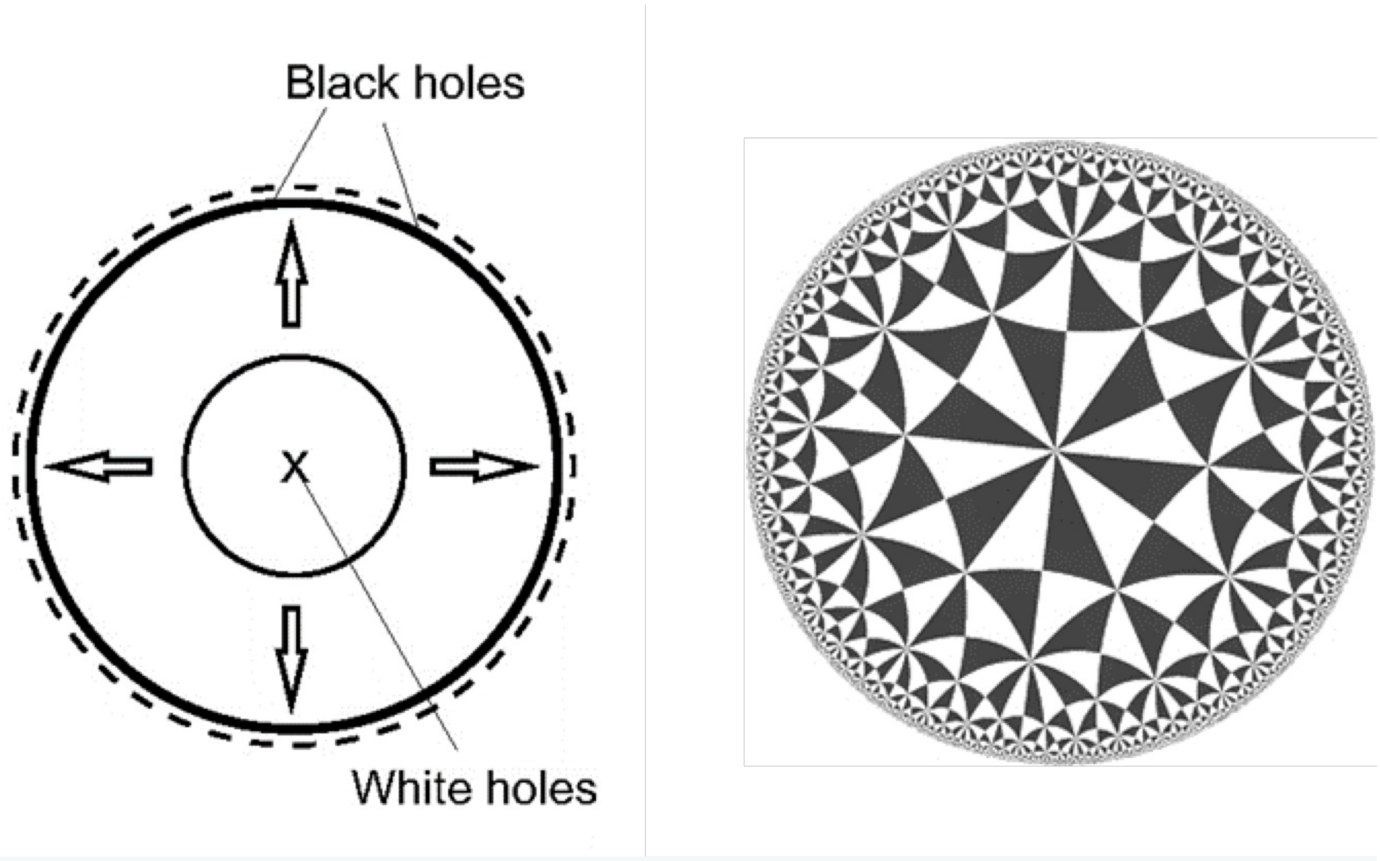

Fig7. Left: The global topological map of the universe Right: The hyperbolic plane with its inherent self-symmetries satisfying the AdS/CFT conjecture (Wikimedia Commons: Tom Ruen). The immense field strength of the cosmos' outer boundary slows expansion. The vacuum energy of white holes is a negative 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 and Summary

We insulated a compact WF with an information-blocking horizon to form a spatial field, thereby introducing an energy requirement for their interaction. The energy requirement of interaction stabilizes the spatial curvature and satisfies conservation principles. The insulated quantum waves form discrete energy levels, but the field curvature is a smooth surface. Therefore, the PaW mechanism originates in the microstructure of space and gives rise to a quaternion cosmic structure. Without introducing new physical parameters, the interaction of the insulated compact dimensions can generate accelerating expansion and other cosmic parameters of the current universe.

The poles' dimensional anisotropy produces an accelerating universe without exotic particles or forces. Dimensionality modifications can explain the Tolman temperature gradient and the destructive power of explosions and collisions. As massive objects form gravitational lensing, cosmic voids cause the divergence of light rays. On temperatures close to absolute zero, particle production [28] can drive cosmic expansion [45][28]. Therefore, Einstein's gravitational theory might be a limiting case of a more general theory with space as a dynamic variable [38].

Time is entropy generation and the entropy rate. However, the directionality of time might originate in the irreversibility of interaction [46]. The Lorentz transformation also indicates that entropy increase can occur through different mechanisms. For example, gravity creates disorder, but acceleration is an order forming via the degrees of freedom. The latter can explain negative temperatures' antigravity-like effects. Gravity-free systems' work potential may give Maxwell's demon the last laugh [90].

The universe's antipodal sinks and sources satisfy Mach's principle and explain three puzzles in physics: 1) the behavior of cold vacuum in the lab, 2) the expansion of space, and order increasing entropic effects (increasing degree of freedom), and 3) the accelerating expansion and power-law scaling relation between the void size and the corresponding cluster mass [67].

The WF's and spatial topology's orthogonal interdependence is a global self-regulation that continuously fine-tunes the universe's parameters. Continuous fine-tuning can explain 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.

Therefore, the Borsuk-Ulam Theorem naturally leads to spatial dimension changes. Furthermore, dimensional anisotropy can Satisfy Mach's Principle.

Future directions

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 represent only baby steps but point to numerous agreements with large-scale observations of quantum mechanics, relativity, and accelerating expansion. Further studies can verify its points, such as computer simulations and negative temperature experiments in a microgravity environment.

Both the entropic pressure and the Casimir force depend on gravitational curvature. Therefore, measuring these parameters in a microgravity environment and the Moon's surface can verify the hypothesis. In addition, computer simulations can test the evolution of the cellular structure of space. Moreover, experimental observations in an absolute vacuum align with expectations of the proposed behavior.

The cosmos' expansion is a continuous energy generator, providing a bright future for the universe's intelligent occupants. This understanding should inspire us to be good stewards of our planet and the living world.

Declarations

The work received no funding. The authors declare no conflict of interest.

References

1. ^R. Laymon, "Newton's Bucket Experiment," Journal of the History of Philosophy, pp. 16, 399 - 413., 1978.
2. a, bC. Brans, " Mach's Principle and a Relativistic Theory of Gravitation," II Phys. Rev., pp. 125, 388, 1962.
3. a, bC. Brans, "Absence of Inertial Induction in General Relativity," Phys. Rev. Lett., Vols. 39, 856, pp. 39, 856, 1977.
4. a, bD. N. Page and W. K. Wootters, PhysRevD., pp. 2885, 10.1103/27.2885., 1983.
5. ^E. Deli, The Science of Consciousness; How a new understanding of space and time infers the evolution of the mind, US, 2015.
6. ^R. Gambini and J. Pullin, "The Montevideo Interpretation of Quantum Mechanics: A Short Review.," Entropy, p. 20, 2018.
7. ^M. Rotondo and Y. Nambu, " Clock Time in Quantum Cosmology," arXiv: General Relativity and Quantum Cosmology, 2019.
8. a, bB. S. DeWitt, "," Phys. Rev. , pp. 160, 1113. 10.1103/PhysRev.160.1113., 1967.
9. a, b, c, dE. Moreva, G. Brida, M. Gramegna and e. al., Phys. Rev. A, vol. 89, no. 052122, 2014.
10. ^W. Wootters, " “Time” replaced by quantum correlations," Int. J. Theor. Phys., pp. 23, 701–711, 1984.
11. ^C. Foti, A. Coppo and G. e. a. Barni, "Time and classical equations of motion from quantum entanglement via the Page and Wootters mechanism with generalized coherent states.," no. 12, 1787, 2021.
12. ^M. Woods, "The Page-Wootters mechanism 36 years on: a consistent formulation which accounts for interacting systems.," Vols. Quantum Views 3, 16, 2019.
13. a, b, c, dG. Aubrun, L. Lami, C. Palazuelos and M. Plávala, "Entanglement and Superposition Are Equivalent Concepts in Any Physical Theory," Physical Review Letters, 2022.
14. a, bY. Guo, Z. Liu, H. Tang, X. Hu, B. Liu, Y. Huang, C. Li, G. Guo and G. Chiribella, "Experimental demonstration of input-output indefiniteness in a single quantum device.," 2022.
15. a, bA. R. H. Smith and M. Ahmadi, "Quantum," Vols. 3, 160, no. 10.22331/q-2019-07-08-160. , 2019.
16. a, bA. Smith and M. Ahmadi, "Quantizing time: Interacting clocks and systems," arXiv: Quantum Physics., vol. arXiv: Quantum Physics., 2017.
17. a, bF. Lobo, G. Olmo and D. Rubiera-Garcia, "Microscopic wormholes and the geometry of entanglement.," Eur. Phys. J. C, vol. 74, no. 2924, 2014.
18. a, bR. Weygaert, "Voids and the Cosmic Web: cosmic depression & spatial complexity," arXiv: Cosmology and Nongalactic Astrophysics, pp. 11, 493-523, 2014.
19. ^A. Kravtsov, "On the Origin of the Global Schmidt Law of Star Formation," The Astrophysical Journal, p. 590., 2003.
20. a, b, cR. B. Tully, H. Courtois, Y. Hoffman and D. Pomarède, "The Laniakea supercluster of galaxies," Vols. 513 (7516), 71–3. , 2014.
21. a, bR. Weygaert, "Voronoi Tessellations and the Cosmic Web: Spatial Patterns and Clustering across the Universe The

cosmic web: geometric analysis," Astrophys., vol. 1, p. 070708.1441., 2007.

22. ^*R. B. Tully, H. M. Courtois and J. G. Sorce, "COSMICFLOWS-3," AJ, pp. 152, 50, 2016.*
23. a, b, c *R. Tully, D. Pomarède, R. Graziani, H. Courtois, Y. Hoffman and E. Shaya, "Cosmicflows-3: Cosmography of the Local Void.," arXiv: Cosmology and Nongalactic Astrophysics., 2019.*
24. ^*J.-R. Pycke and E. Russell, "A new statistical perspective to the cosmic void distribution," ApJ, p. 821 110, 2016.*
25. ^*S. Gregory and L. Thompson, "The COMA / A 1367 Supercluster and Its Environs.," Astrophysical Journal, pp. 222, 784-799, 1978.*
26. ^*U. Lindner, J. Einasto, M. Einasto, W. Freudling, K. Fricke and E. Tago, " "The structure of supervoids. I. Void hierarchy in the Northern Local Supervoid"," Astron. Astrophys. , p. 301: 329, 1995.*
27. ^*R. Freedman and W. Kaufmann III, Stars and galaxies: Universe., New York City: W.H. Freeman and Company., 2008.*
28. a, b, c, d *C. Viermann, M. Sparn, N. Liebster, M. Hans, E. Kath, Á. Parra-López, M. Tolosa-Sime'on, N. S'anchez-Kuntz, T. Haas, H. F. S. Strobel and M. Oberthaler, "Quantum field simulator for dynamics in curved spacetime," Nature, no. 611, 2022.*
29. a, b *R. Landauer, "Irreversibility and heat generation in the computing process," IBM Journal of Research and Development, vol. 5, no. 3, p. 183–191, 1961.*
30. a, b *J. Wheeler and W. W. Geons, Black Holes, and Quantum Foam p. 235, Norton & Company, 2000.*
31. ^*K. Borsuk, "Drei sätze uber di n-dimensionale euklidische sphäre," Fund. Math. , vol. XXX, pp. 177-196, 1933.*
32. ^*J. F. Peters, Computational Proximity, Switzerland: Springer, 2016.*
33. ^*A. Di Concilio, C. Guadagni, J. Peters and S. Ramanna, "Descriptive proximities. Properties and interplay between classical proximities and overlap.," Math. in Comp. Sci., vol. 12, no. 1, pp. 91-106, 2018.*
34. a, b *J. Matoušek, J. Matousek, A. Björner and G. Ziegler, in Using the Borsuk-Ulam Theorem: Lectures on Topological Methods in Combinatorics and Geometry, Springer, 2003.*
35. ^*J. Peters and A. Tozzi, "String-Based Borsuk-Ulam Theorem," arXiv:1606.04031, 2016.*
36. ^*J. F. Peters, "Ribbon complexes and their approximate descriptive proximities. Ribbon and vortex nerves, Betti numbers and planar divisions.," Bulletin of Allahabad Math Society, vol. 35, no. 1, pp. 1-14, 2020.*
37. ^*A. Tozzi and JF Peters, "Borsuk–Ulam Theorem Extended to Hyperbolic Spaces," in Proximity. Excursions in the Topology of Digital Images, doi:10.1007/978-3-319-30262-1., 2016, p. 169–171.*
38. a, b *J. R. Weeks and M. Dekker, "Chapter 14: The Hypersphere," in The Shape of Space: how to visualize surfaces and three-dimensional manifolds., ISBN 978-0-8247-7437-0, 1985.*
39. ^*G. Marsaglia, "Choosing a point from the surface of a sphere.," Ann Math Stat., vol. 43, p. 645–6., 1972.*
40. ^*D. Anosov, "Diffeomorphism," in Encyclopedia of Mathematics, Kluwer Academic Publishers, 1995, pp. 155-156.*
41. a, b *L. Susskind and A. Friedman, Quantum Mechanics. The Theoretical Minimum, UK: Penguin Random House ISBN 97-0-141-97781-2., 2014.*
42. a, b *L. Martyushev and E. Shaiapin, "From an Entropic Measure of Time to Laws of Motion.," Entropy, p. 21, 2019.*
43. ^*L. Martyushev, "On Interrelation of Time and Entropy," Entropy, pp. 19, 345, 2017.*
44. ^*P. e. a. Kroupa, "Asymmetrical tidal tails of open star clusters: stars crossing their cluster's práh challenge Newtonian*

gravitation," Monthly Notices of the Royal Astronomical Society, 2022.

45. a, b, c, d*R. Kastner and S. Kauffman, "Are Dark Energy and Dark Matter Different Aspects of the Same Physical Process?" vol. https://doi.org/10.3389/fphy.2018.00071 , 2018.*
46. a, b*A. Chatterjee and G. Iannacchione, "Time and Thermodynamics Extended Discussion on "Time & clocks: A thermodynamic approach"," 2020.*
47. ^*E. Verlider, "On the origin of gravity and the laws of Newton," J. High Energ. Phys., pp. 4, 29, 2011.*
48. ^*U. Lucia and G. Grisolia, "Time & clocks: A thermodynamic approach," Vols. 16, 102977, 2020.*
49. ^*U. Lucia, G. Grisolia and A. Kuzemsky, "Time, Irreversibility and Entropy Production in Nonequilibrium Systems," vol. 22, 2020.*
50. ^*Y. Bardoux, M. Caldarelli and C. J. Charmousis, "Conformally coupled scalar black holes admit a flat horizon due to axionic charge.," High Energ. Phys., vol. 8, 2012.*
51. a, b*J. M. Maldacena, "The Large N Limit of Superconformal Field Theories and Supergravity," vol. 2: 231–252, 1998.*
52. a, b, c*A. Almheiri, D. Marolf, J. Polchinski and J. Sully, "Black holes: Complementary or Firewalls?," ArXiv: 1207. 3123v4 {hep-th}, 2012.*
53. a, b*S. Lee, "A solution to the initial condition problems of inflation: NATON.," 2019.*
54. a, b*J. Vieira, C. Byrnes and A. Lewis, "Cosmology with Negative Absolute Temperatures," 2016.*
55. a, b, c*D. Lovelock, "The Einstein Tensor and Its Generalizations," Journal of Mathematical Physics, vol. 12, pp. 3, 498–501, 1971.*
56. a, b*M. Baldovin, A. Puglisi, A. Sarracino and A. Vulpiani, "About thermometers and temperature," vol. 113202., 2017.*
57. a, b*M. Baldovin, "Negative Temperature Out of Equilibrium.," Springer, Cham. https://doi.org/10.1007/978-3-030-51170-8_5, In: Statistical Mechanics of Hamiltonian Systems with Bounded Kinetic Terms. Springer Theses, 2020.*
58. a, b*L. Onsager, ""Statistical Hydrodynamics"," Il Nuovo Cimento. Nuovo Cim., p. 6(Suppl 2) (2): 279–287., 1949.*
59. a, b, c*E. Abraham and O. Penrose, "Physics of negative absolute temperatures," Vols. 95 1-1, 012125, 2017.*
60. a, b*J. V. Narlikar, K. Appa Rao and N. Dadhich, "High energy radiation from white holes," Vols. 251, 591, 1974.*
61. ^*A. Lightman and D. Eardley, "Black Holes in Binary Systems: Instability of Disk Accretion.," The Astrophysical Journal, p. 187, 1974.*
62. ^*R. Wald and S. Ramaswamy, "Particle production by white holes," Physical Review D, pp. 21, 2736-2741, 1980.*
63. ^*E. Bianchi, M. Christodoulou, F. D'Ambrosio, H. Haggard and C. Rovelli, "White Holes as Remnants: A Surprising Scenario for the End of a Black Hole.," 2018.*
64. ^*D. Frenkel and P. B. Warren, "Gibbs, Boltzmann, and negative temperatures.," Am. J. Phys., vol. 83, no. 163, 2015.*
65. a, b*A. Kovács and J. García-Bellido, "Cosmic troublemakers: the Cold Spot, the Eridanus supervoid, and the Great Walls.," Monthly Notices of the Royal Astronomical Society, pp. 462, 1882-1893., 2016.*
66. a, b*M. Farhang and M. Movahed, "CMB Cold Spot in the Planck light.," arXiv: Cosmology and Nongalactic Astrophysics., 2020.*
67. a, b, c*J. Shim, C. Park, J. Kim and H. Hwang, "Identification of Cosmic Voids as Massive Cluster Counterparts.," ApJ, p. 908. 211, 2021.*
68. a, b*W. A. Hellwing, M. Cautun, R. van de Weygaert and B. T. Jones, "Caught in the cosmic web: Environmental effect*

on halo concentrations, shape, and spin.," Phys. Rev. D, pp. 103, 063517, 2021.

69. ^*M. Kostic, "The Elusive Nature of Entropy and Its Physical Meaning," Entropy, pp. 16, 953-967, 2014.*
70. ^*A. Haji-Akbari, M. Engel, A. Keys, X. Zheng, R. Petschek, P. Palffy-Muhoray and S. Glotzer, "Disordered, quasicrystalline and crystalline phases of densely packed tetrahedra," Vols. 462, 773-777, 2009.*
71. ^*A. D. Wissner-Gross and C. E. Freer, "Causal Entropic Forces.," Phys. Rev. Lett., no. doi: 10.1103/PhysRevLett.110.168702, p. 110:168702, 2013.*
72. ^*D. W. NOID, S. K. GRAY and S. A. RICE, "Fractal behavior in classical collisional energy transfer," J. Chem. Phys., vol. 51, pp. 363-383., 1986.*
73. ^*Y. Zeldovich, G. Barenblatt, V. Librovich and M. GM., The Mathematical Theory of Combustion and Explosions., New York: Plenum, 1985.*
74. ^*P. Wesson, "Fundamental Unsolved Problems in Astrophysics.," Space Science Reviews, vol. 98, no. 329342, 2001.*
75. ^*S. Cantalupo, F. Arrigoni-Battaia and J. e. a. Prochaska, "A cosmic web filament revealed in Lyman-α emission around a luminous high-redshift quasar.," Nature, vol. 506, no. 7486, p. 63–66, 2014.*
76. a, b*S. E. Rugh and H. Zinkernagel, Vols. 33, 663, 2002.*
77. ^*Saulnier et al., "A study of generation and rupture of soap films," vol. 10:2899–2906. , 2014.*
78. ^*J. S'anchez-Monroy and C. Quimbay, "Cosmological Constant in a Quantum Fluid Model," Vols. 20, 2497-2506, 2011.*
79. ^*L. A. Maccone, "Fundamental Problem in Quantizing General Relativity," Found. Phys. , vol. 49, p. 1–10, 2019.*
80. ^*D. G. Lambas, M. Lares and Ceccarelli, "The sparkling Universe: the coherent motions of cosmic voids," Vols. 455, L99 , 2016.*
81. ^*J. Peters and A. Tozzi, "Quantum entanglement on a hypersphere," Int. J. of Theoretical Physics, vol. 55, no. 8, pp. 3689-3696, 2016.*
82. ^*A. Pontzen, A. Slosar, N. Roth and H. Peiris, " Inverted initial conditions: Exploring the growth of cosmic structure and voids," Physical Review D, pp. 93, 103519, 2016.*
83. ^*G. 't Hooft, "Dimensional reduction in quantum gravity," 1993.*
84. ^*S. Wolfram, A new kind of Science, Wolfram Research , 2002.*
85. ^*M. e. a. Hohensee, "Limits on violations of Lorentz symmetry and the Einstein equivalence principle using radio-frequency spectroscopy of atomic dysprosium.," Physical Review Letters., vol. 5, no. 050401., p. 111, 2013.*
86. ^*S. e. a. Peck, "New Limits on Local Lorentz Invariance in Mercury and Cesium.," Physical Review A., vol. 1, no. 012109., p. 86, 2012.*
87. a, b*J. Santiago and M. Visser, "Tolman temperature gradients in a gravitational field," arXiv:1803.04106 [gr-qc], 2018.*
88. ^*R. C. Tolman, "On the weight of heat and thermal equilibrium in GR," Phys. Rev., vol. 35 , no. 904, 1930.*
89. ^*C. S. Frenk and S. D. M. White, "Dark matter and cosmic structure," arxiv.org/abs/1210.0544, 1–27., 2012.*
90. ^*B. Ahmadi, S. Salimi and A. Khorashad, "Irreversible Work, Maxwell's Demon and Quantum Thermodynamic Force.," 2018.*