Can a Page and Wootters' mechanism (PaW) inspired particle model fulfill Mach's principle?

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Abstract

Page and Wootters' mechanism (PaW) predicts that quantum entanglement leaves the state of the universe static. We satisfy the above mechanism by dividing the cosmos into compact and non-compact dimensions, by insulating the wave function from space and gravity. In this scenario, entangled sister particles satisfy conservation principles independently of distance but modify local volume. Either pressure or vacuum generates an orthogonal transformation (interaction) to restore symmetry. Over time space contracts or expands to develop curvature. The universe degenerates into poles, two-dimensional black holes, and four-dimensional white holes, connected by a smooth topology. Dimensional anisotropy turns gravity into a bipolar force. The verifiable and elegant hypothesis supersedes general relativity by satisfying Mach's principle; it also offers a possible path for unification with quantum mechanics.

Discussion

Numerous pressing unsolved problems in physics and astrophysics, such as the accelerating expansion of the cosmos, and the unexplained velocities of stars in galaxies, might be related [1]. In the past, Mach's principle inspired Einstein to supersede Newton's gravity. Mach observed that there is a difference in the water surface when a water bucket is at rest and when the bucket rotates along a curved surface relative to the stars [2]. Once again, Mach's principle motivates us to question our underlying assumptions.

Einstein's imagination deciphered fundamental symmetries from falling objects, accelerating elevators, and blind beetles on curved surfaces. The symmetry of kinetic energies in action/reaction forms Newton's third law, which can give rise to a harmonic motion. Following Einstein's visual modeling, we analyze symmetries related to Newton's third law. Compact string vibrations and the external, non-compact space make up the total dimensions of space [3], which is the object of our investigation (Figure 1).

Contrary to our experience, the Page and Wootters' mechanism of static time (PaW), which is based on the Wheeler-De Witt equation of general relativity, proves that local changes leave the global state of cosmos unchanging [4, 5]. Insulating the wave function from space (gravity) by an information blocking horizon engenders non-locality; thus sister particles can satisfy conservation laws during quantum phenomena, such as entanglement or the double slit experiment (Table I).

Entanglement modifies pressure in non-compact dimensions (Figure 2) and triggers interaction: an orthogonal energy/information exchange between the wave function (Ψ) and its negative space (V) that satisfies Landauer's principle. Landauer's principle expresses the thermodynamic relationship between energy and information [6]. The irreversible changes in kinetic and potential energy form the local clock and lead to the *arrow of time.*

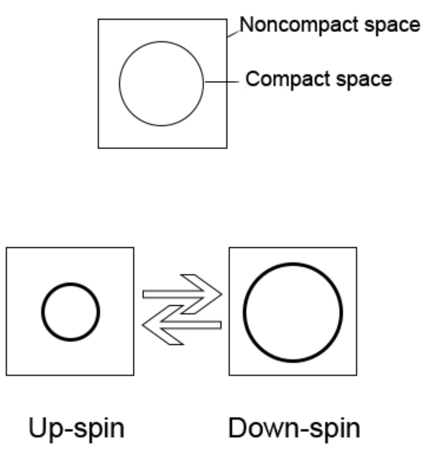

Figure 1. Volume changes due to entanglement Top: Particle and its negative space. Bottom: Entangled sister particles form local differences but share one wave function independent of distance.

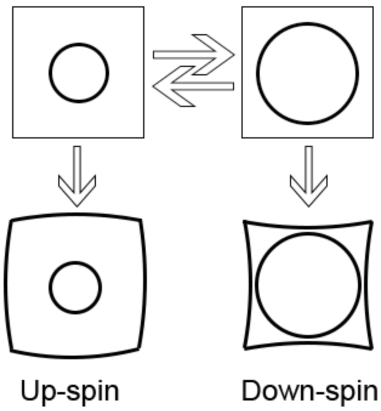

Figure 2. Decoherence Decoherence of the particle reformulates the wave function as the particle's next time moment. The average frequency of particle interaction (particularly of down-spin) forms the speed of a local clock.

The orthogonality of space

Compact dimensions	Non-compact-dimensions
Non-locality, independent of space or gravity	Local behavior, such as pressure
Quantum mechanics	Gravity - smooth field
Entanglement reversible	Interaction - irreversible
Discrete wave function keeps constant curvature and increases entropy	Minimal surface ⟶ density gradient

Self-regulation

Table I. The orthogonality of space Qualitative differences between compact and non-compact dimensions lead to the self-regulation of the cosmos.

The non-local wave function can cross several slits simultaneously and form interference. Measurement done behind one of the slits eliminates interference [7] because interaction brings about the next, discrete time-moment for the whole particle. The wave function and the spatial curvature thus evolve together (Figure 3.a; Figure 4).

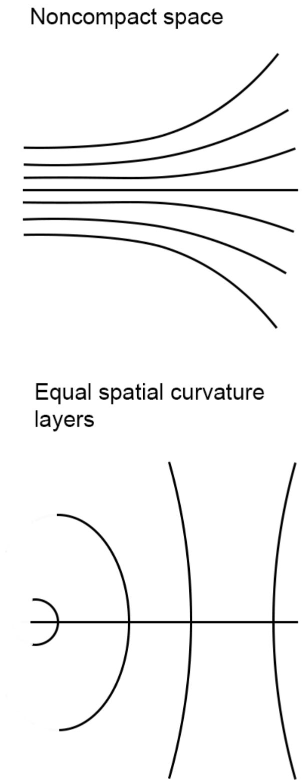

Figure 3.a

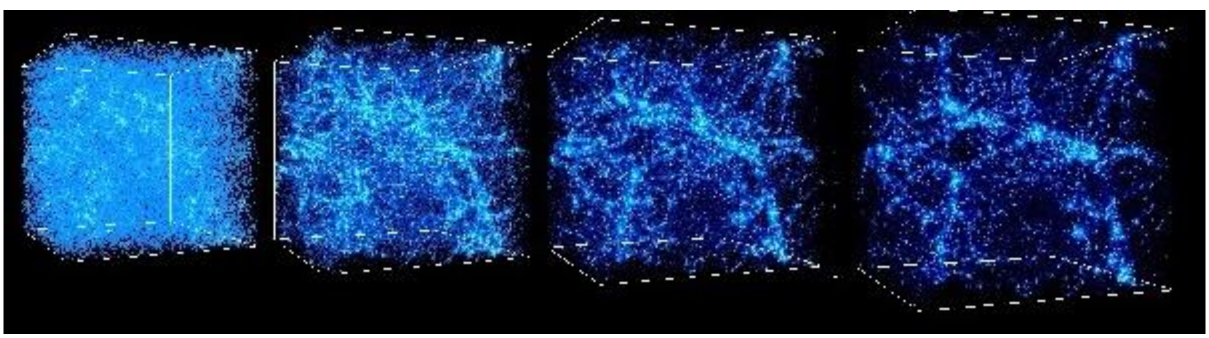

Figure 3.b

Figure 3.a,b, Anisotropy, the origin of spatial complexity 3.a, Over time, interaction contracts space (left) and expands it elsewhere (right). 3.b, The universe's evolution from left to right: the gradually increasing curvature differences culminate in the formation of poles, the white and black holes. Image credit: [24]

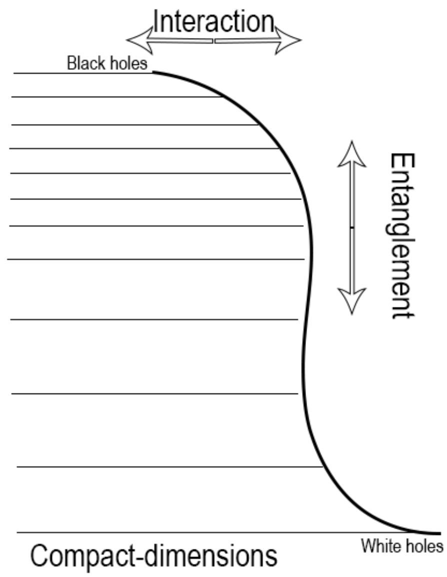

Figure 4. The proposed view of 'space-time' The compact dimensions (left) are isolated by an information blocking horizon, which limits particle frequencies into discrete energy levels. Entanglement increases field curvature differences and causes local pressure, which triggers interaction between the compact and non-compact dimensions. Space formulates a smooth topology between black holes (top) and white holes (bottom). The compact dimensions maintain constant external field curvature. The contrary effects of compact and non-compact dimensions lead to self-regulation which can fine-tune the parameters of the universe.

Entanglement increases spatial curvature differences and forms a global topology with a minimal surface, whereas an identical wave function keeps the field curvature constant and promotes fractal topology (Figure 4). Their different influences form self-regulation that can fine-tune the cosmic parameters and produce enormous complexity starting from a simple system [8] (Figure 3.b).

Orthogonality between compact and non-compact dimensions changes the sign (-) in the Lorentz metric and formulates the self-regulation of the cosmos as follows (Table I). Standing waves, within an equal-curvature field (Figure 4, horizontal lines; Figure 3.a, bottom) form a gradual, discrete change from the white to the black holes. Decreasing volume/dimensionality within positive curvature is compensated by increasing volume/dimensionality of negative curvature regions (Figure 3.a; Figure 4). Although dimensional anisotropy is Lorentz invariant [9, 10], it turns gravity into a bipolar force, which orients particles between spatial expansion and contraction. It leads to the immense destructive power of collisions and explosions, and the Tolman temperature gradient [11, 12].

Black hole temperatures correlate with great horizon information [13]. Black hole horizons are flat [14] with infinite curvature [15], requirements satisfied by dimensionality loss, a possibility presented by the AdS/CFT conjecture [16] and the firewall hypothesis [17].

The cosmic microwave background [18, 19] presents a nearly spatially flat early universe, which is in sharp contrast to the current web-like cosmic structure (Figure 6, 3).

Antipodal dynamics could very well explain the emerging Cellular Universe (Figure 1, 3, 6). For example, fluids under the influence of both heating and cooling produce thermal convection cells and the expansion of hot gas versus surface tension leads to the formation of soap bubbles [20]. The immense value of vacuum energy could spur the expansion dynamics suggested by PaW. Recent data from the Sloan Digital Sky Survey [13] also found that cold and vast cosmic voids expand, and merge like soap bubbles [21, 22]. PaW demands the existence of energy-rich and expanding antipodal regions of black holes, indicating that dark energy and dark matter are related [23].

The 60 to 123 orders of magnitude discrepancy between the theoretical vacuum energy density and the empirical vacuum energy density [24] is one of the great unsolved problems in physics. In the laboratory, systems with a bounded energy spectrum, display negative absolute temperature and negative pressure akin to dark energy [25, 26]. The experiment raises the possibility that vacuum energy is a function of temperature, allowing cosmic voids to expand space into the fourth dimension (Figure 3.a, right, Figure 4. bottom, Figure 5. center). Cosmic voids, which cannot be entered from the outside, display characteristics of white hole solutions of Einstein's field equations [27].

Space is a dynamic variable that changes between four-dimensions in the white holes, to two-dimensions in the black holes [28], indicating that the cosmological constant might be a dimensionality function [29].

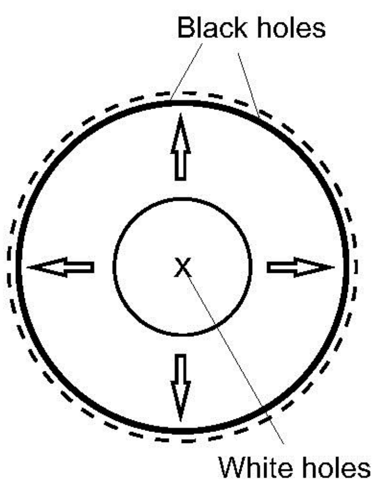

Figure 5. The global topological map of the universe Black holes form the two-dimensional outer boundaries of the cosmos. Their immense field strength slows expansion. The vacuum energy of white holes is a negative pressure that expands space into the fourth dimension. The opposing dynamics of the poles force constant interaction on the dynamic and unstable three-dimensional regions (marked by white arrows), which increases complexity and engenders evolution.

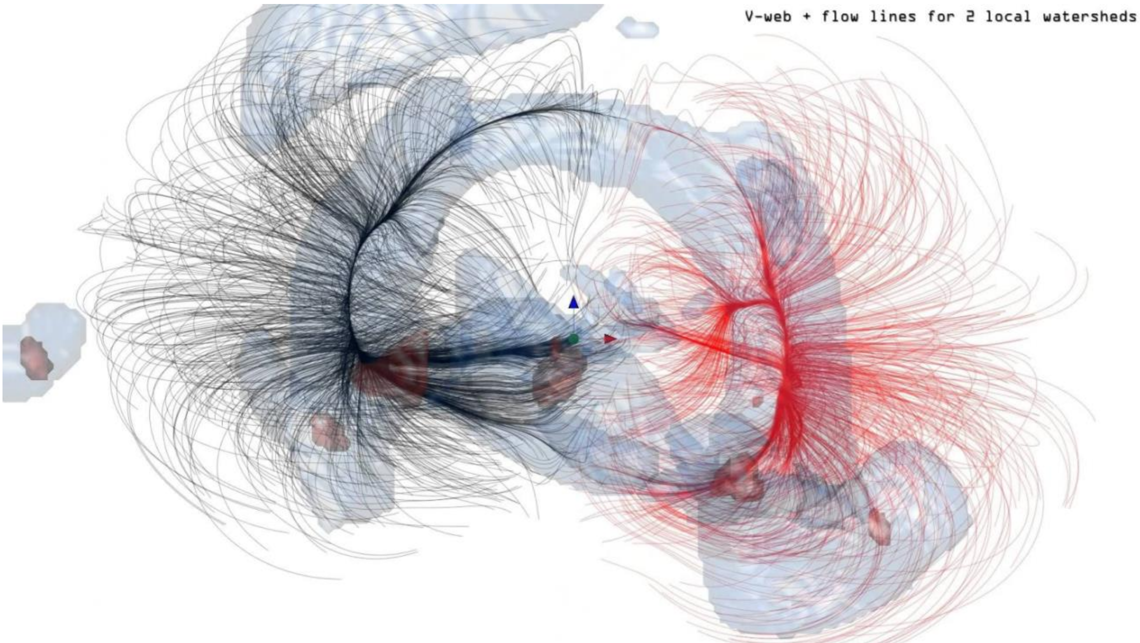

Figure 6, A representation of the structure and flows of mass within 6,000 km s−1 (~80 Mpc) Surfaces of red and blue represent outer contours of clusters and filaments determined from Wiener Filter analysis. Blue and red flow threads delineate spatial topology of diverging velocity flows and basins of attraction. Notice the topological similarity to Figure 5. Permission and Picture credit [21]

Conservation principles discovered for our three-dimensional environment can be applied for the anisotropic universe only in the global sense. Antipodal effects of the smooth global topology formulate a harmonic function, where the frequency corresponds to event (interaction) frequency, and the tension of the spring (x) is analogous to the field strength (Figure 3,a, Figure 5).

The Force (F) satisfies Hooke's law,

$$F = m\frac{d^2x}{dt^2} = -kx, \qquad (1)$$

where k is a constant. Harmonic motion remains constant as long as there is no energy loss or gain. In the universe, the formation of new space accelerates the expansion.

The constant energy vibrations of compact dimensions can be modeled as concentric, equal-curvature circles (Figure 3.a top, Figure 4, 5), which, like astrophysical discs, can be described by the Schrödinger equation [30].

The velocity (v) as a function of time:

$$v = -A\omega\sin(\omega t - \delta) \qquad (2)$$

where A is the amplitude of oscillations, ω is angular frequency, t is the time, x is the position, δ phase change and v is velocity. The Dirac equation combines the wave equation with the mass energy equivalence. In natural units $\hbar = c = 1$.

$$(i\delta - m)\Psi = 0 \qquad (3)$$

The relativistic Dirac equation universal applicability expresses many qualities of the matter structure. Interpretation of the four by four matrices by the present model shows the upper left quadrant (real particle) as movement forward in time toward black holes, whereas the lower right, antimatter quadrant corresponds to negative time, in the direction of the white holes. Modeling the topology of space by a wave equation could lead to a deeper understanding of gravity without evoking dark energy and dark matter.

In the Machian view, the global mass distribution must determine the inertial frame of reference, the inertial mass, and acceleration [31, 32]. Newtonian gravity and GR are successful in describing our three-dimensional experience within the solar system but cannot explain the galactic and global topology [33], which might be related to the inertial mass [31]. The hypothesis builds on the geometric ideas of Einstein that connect spatial curvature with gravity. By applying GR for four and two-dimensions, the intuitive and highly economic principles achieve relativity of motion and an accelerating universe without introducing exotic particles or forces.

An object's position corresponds to a freely hanging plumb. Deviations in the angle of that plumb (location of the object) thereby change the equilibrium of the whole universe and lead to inertia, a force that is proportional to both the mass of the object and the field strength (i.e., topological distance from the black hole). Inertia is most significant in the vicinity of the black holes; their horizons form an unapproachable boundary [17] (Figure 5). The proposed hypothesis solves the horizon problem by showing that the formation of compact dimensions is the start of interactions, the beginning of time, and the birth of the cosmos.

This new model builds on several recent theoretical findings and incorporates gravity with string theory and quantum mechanics. Quantum entanglement triggers interaction with the classical environment, a discrete, irreversible information record that is recognized as time. The visual, intuitive and straightforward framework shows a close fit with large-scale observations; therefore the proposed microscopic model might elucidate some unsolved problems in contemporary physics, such as the cosmological constant, the coincidence problem (matter density varies with dimensionality), dark matter, dark energy, the interpretation of quantum mechanics, and unification. The PaW, which explains the global topology of space, originates in the microstructure of space.

Conclusions

The model satisfies Mach's principle and eliminates much uncertainty around the Standard Model. Tests in quantum mechanics and interaction and deviations in the Casimir force measured in microgravity can verify its tenets. Field strength and vacuum energy form two forces of a harmonic oscillator that satisfies Newton's third law and drives cosmic expansion. The symmetry between the wave function and action might be the source of Landauer's principle and Maldacena duality [16]. We can answer the question in the title in the affirmative. Nature seems to favor a particle model based on PaW to satisfy Mach's principle.

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The Landauer's limit

$E=kT\ln 2$

Therefore, in black holes great energy is needed to erase information, whereas in white holes minimal energy is satisfactory to do the same. Therefore, black holes are information saturated, whereas white holes are information free.