Applied Physics Research; Vol. 8, No. 4; 2016
ISSN 1916-9639 E-ISSN 1916-9647
Published by Canadian Center of Science and Education

Quantum Gravity as Higher Dimensional Perspective

Rob Langley[1]

[1] Norwich, UK

Correspondence: Rob Langley, Norwich, UK. E-mail: rhlangley@hotmail.co.uk

Received: July 11, 2016 Accepted: July 19, 2016 Online Published: July 29, 2016

doi:10.5539/apr.v8n4p38 URL: http://dx.doi.org/10.5539/apr.v8n4p38

Abstract

Although highly predictive in their respective macroscopic and microscopic domains of applicability, General Relativity and quantum mechanics are mathematically incompatible, perhaps most markedly in assumptions in their formalisms concerning the nature of space and time. In *perspective* we already have a conceptual structure that links the local, macroscopic frame and the remote, apparently microscopic frame. A mathematical principle is invoked as a natural limit on $\mathrm{D}(n)$, so that effects which are clearly perspectival at $\mathrm{D} = 3$ become 'more real' (*effectively* observer-independent) with each $\mathrm{D}(n)$ increment. For instance, the apparently microscopic becomes the effectively microscopic and *scale extremes are juxtaposed*, so that black holes are local, macroscopic vanishing-points, in a similar way to that in which in projective geometry the point at infinity is incorporated into the foreground. (In other words, *a black hole is a blown-up 'Planck-scale' singularity*.) Characteristics of the earthbound frame are applied to $\mathrm{D} > 3$, suggesting a physical basis for entanglement, and perspectival interpretations of quantum gravity, dimensional reduction and the information paradox. We claim that the familiar processes whereby multiple physical states become describable by a single state in which composition information appears to be lost (e.g., 'falling into a black hole', the state of quantum linearity, and the state of freefall) are all examples of effective convergence of a space or *n*-surface to a single point of perspective.

Keywords: black holes, cosmological coincidence problem, dimensional reduction, firewalls, information paradox, measurement paradox, observers, quantum gravity, time.

1. Introduction

1.1 Background

Whilst General Relativity (GR) and quantum mechanics (QM) are rigorously proven and highly predictive, their mathematical formalisms and respective macroscopic and microscopic domains of applicability have remained conceptually disparate. GR is typified by Einstein's field equation (shown with the cosmological parameter),

$$R_{ab} - \frac{1}{2} R g_{ab} + \lambda\, g_{\mathrm{ab}} = \frac{8\pi G}{c^4} T_{ab}\,, \tag{1}$$

which equates geometry and matter-energy degrees of freedom. Time is a covariantly transforming coordinate of a dynamic, arbitrarily differentiable, semi-Riemannian (asymptotically Minkowskian) spacetime manifold, and observers are incidental. The field equations are highly nonlinear, and unconstrained geodesic convergence leads to the formation of a black hole, with a central singularity at which GR breaks down. The information and firewall paradoxes also point to profound conceptual issues in our understanding of black holes.

In QM, states $|\psi\rangle$ are vectors in Hilbert space $(\mathcal{H})$ and unitary state development is typically described by the Schrödinger equation,

$$i\hbar \frac{\partial}{\partial t}(|\psi\rangle \boldsymbol{r}, t) = \widehat{H}(|\psi\rangle \boldsymbol{r}, t). \tag{2}$$

The linearity of $\mathcal{H}$ is such that any linear combination $\psi(\boldsymbol{r}, t) = a_1\psi_1(\boldsymbol{r}, t) + a_2\psi_2(\boldsymbol{r}, t)$ of $n \geq 2$ solutions, where $a_1\psi_1(\boldsymbol{r}, t)$ and $a_2\psi_2(\boldsymbol{r}, t)$ are complex weighted, linearly superposed alternatives, is also a solution. The Copenhagen Interpretation (CIQM) comprises two, conceptually conflicting dynamics; (i) the **U**-process, which describes the linear, unitary, continuous, deterministic, and reversible development of complex-weighted, superposed alternatives, and (ii) the **R**-process, which describes the nonlinear, nonunitary, discontinuous, nondeterministic and irreversible projection (in von Neumann's scheme) of $|\psi\rangle$ onto an eigenbasis of mutually orthogonal eigenvectors. Classical probabilities p_C are derived via the Born rule $p_C = |a|^2$ in $|\psi\rangle$-collapse to a single definite outcome, but there is no axiomatic prescription for when to invoke this second postulate. CIQM is irreducibly probabilistic, inspiring the Einstein-Bohr debates concerning EPR entangled states such as $1/\sqrt{2}\left(|0\rangle_A \otimes |1\rangle_B - |1\rangle_A \otimes |0\rangle_B\right)$, the measurement outcomes of which demonstrate statistical correlations that violate the Clauser, Horne, Shimony and Holt inequality, $\rho(a,b) + \rho(a,b') + \rho(a',b) - \rho(a',b') \leq 2$, indicating that the predictions of QM cannot be reproduced by any local hidden variables theory. In QM, time is an external, Newtonian parameter, and observers are implicated to the extent that their intervention appears to disturb deterministic state development.

1.2 Historical Background

Newton thought of gravitation as a universal force (Newton, 1687) but did not attempt to explain it. Einstein's GR (Einstein, 1915) therefore represented a significant scientific development in describing it as local curvature of the spacetime manifold. However, the subsequent, highly successful unification of the strong, weak and electromagnetic interactions as the gauge symmetries (e.g., Glashow, 1961, Weinberg, 1967, Salam, 1968) that together comprise the Standard Model (SM) of particles and interactions has motivated attempts to incorporate gravitation in terms of the exchange of gravitons, the hypothetical gauge boson of the gravity field. Since 'gravity gravitates' it is nonrenormalisable at high energies and is therefore in need of UV completion. Most approaches therefore advocate a minimum length; $\ell \sim \ell_P = \sqrt{\hbar G/c^3} = 1.62 \times 10^{-35}\mathrm{m}$. For instance, string theory invokes a one-dimensional cut-off on a flat spacetime background, and loop quantum gravity proposes an intrinsically relativistic, granular spacetime structure. Amongst many other approaches are AdS/CFT (Maldacena, 1998), canonical quantum gravity, causal dynamical triangulation and twistor theory (see Kiefer, 2014, for a general review).

1.3 Perspective approach

The method adopted in the approach outlined in this paper is simply to examine the main characteristics of the familiar perspectival relationship between the earthbound observer and the horizon, and to note those that demonstrate conceptual similarities with mathematical issues in quantum gravity. Whilst we appear to inhabit a Universe with three spatial dimensions and one time dimension, it is noted that it also allows the freedoms to accelerate, to nonuniformly accelerate, and so on. These temporal derivatives are taken seriously as indications of higher dimensionality, so characteristics are extrapolated to $\mathrm{D} > 3$ in order to assess conceptual fitness.

1.4 Observations

The notion of physical 'composition' (i.e., that larger things are made of smaller things) is reconsidered. In particular, it is noted;

(i) that when matter enters a *black hole*, composition information is effectively *missing*, being replaced by a black hole state defined by just electric charge (Q), mass (M) and angular momentum (J),

(ii) that since matter is subject to the universality of *freefall*, its composition information is effectively *missing*, being replaced by a single geodesic equation, $(\mathrm{d}^2x^i/\mathrm{d}\lambda^2) + \sum_{j,k} {\Gamma^i}_{jk}\,(\mathrm{d}x^j/\mathrm{d}\lambda)(\mathrm{d}x^k/\mathrm{d}\lambda) = 0$ (in which λ is the affine parameter and ${\Gamma^i}_{jk}$ are the connection coefficients), and

(iii) that when a quantum system enters a state of *linear superposition* or *entanglement*, information about the composition or configuration of the experimental set-up (e.g., which-path data) is effectively *missing*, being replaced by a single state $(|\psi\rangle)$ that seems able to describe system, measurement apparatus *and* environment.

In each case, a '**MANY**' system with multiple variables and interdependencies 'falls' into a simple '**ONE**' state defined by one or very few parameters, and possibly without composition at all.

1.5 Notation

The case in which a $\mathrm{D}(n)$ surface is spherically closed and embedded in $\mathbb{R}^{\mathrm{D}(n+1)}$ is denoted typically as $\mathrm{D}(n)|\mathrm{D}(n+1)$; for instance, the earthbound scenario is denoted $\mathrm{D2}|\mathrm{D3}$.

1.6 Structure

The paper is structured as follows. In Section 2, the main characteristics of perspective and the $\mathrm{D2}|\mathrm{D3}$ frame are explored and applied to $\mathrm{D} > 3$, with a direct equivalence claimed at $\mathrm{D4}|\mathrm{D5}$ between relativity and quantisation. In answer to the question of whether or not application to $\mathrm{D} > 3$ is infinitely extendable, a simple mathematical principle is invoked in Section 3 as a natural limit on $\mathrm{D}(n)$, and the possible implications of this are discussed. In Section 4, a correspondence between perspective and gauge symmetry is proposed, including a perspectival interpretation of the Standard Model of particles and interactions and the QED sector. A definition of gravitation in terms of universal expansion is outlined in Section 5, and the notion of macroscopic charge is introduced. In Section 6 we propose perspectival interpretations of black holes, entropy and the information paradox. Time is considered as a perspectival effect in Section 7, and Section 8 looks briefly at observer degrees of freedom and includes a short summary of the perspective model.

2. Perspective and curvature

2.1 Main Characteristics

Whereas perspective in $\mathbb{R}^3$ is that illusory effect whereby the apparent height of a receding object appears to contract to a point at spatial infinity, perspective from a point of view above a surface that is closed with constant positive curvature means that a receding object will disappear over a horizon before the object's apparent height goes to zero. Using metres as units, we first consider the earthbound observer Alice, who stands with 3-height $h_3 = 2$ above the 2-surface, which is closed with constant radius of curvature, $r_2 = 6.371 \times 10^6$ (Figure 1b).

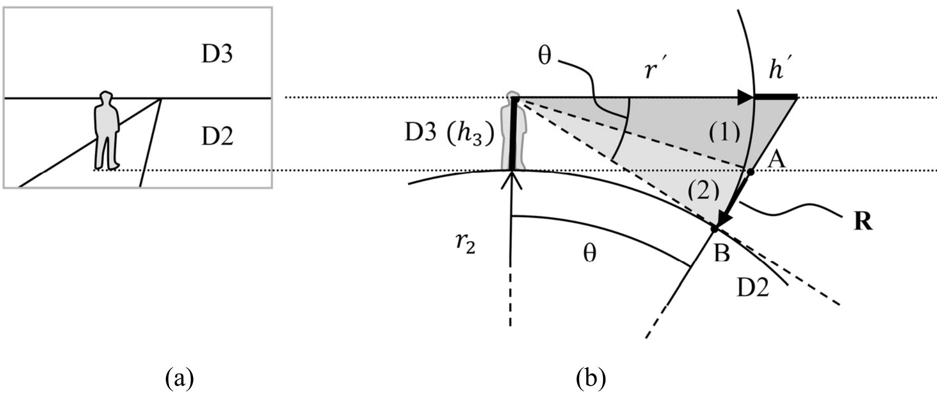


Figure 1. The familiar geometry of the earthbound $(\mathrm{D2|D3})$ scenario.

The following are the basic properties of the relationship between the earthbound observer and the horizon.

1) Assuming $h_3 \lll r_2$, the 2-surface looks flat to good approximation (Figure 1a).
2) With increasing distance from Alice, there is an increasing divergence between apparent flatness of the 2-surface and actual global closure (Figure 1b).
3) Parallel lines on the 2-surface (e.g., railway lines) appear to converge to an apparent D0 point or *singularity* on the S^1 horizon (at a distance $\ell \approx 5.05 \times 10^3$).
4) With increasing distance from Alice, objects appear to ***contract*** and *space appears to* ***expand***, and Alice reasons that these rates must be exactly equivalent; $\mathbf{CON} \equiv \mathbf{EXP}$.
5) There is a $\mathrm{D}(n-3)$ **dimensional reduction** from Alice's 3-height to an apparent D0 point on S^1.
6) There are two such points; A, where Alice (naively) believes she is looking, and B, where she is actually looking. In 3-space, these are clearly the same point; i.e., A and B are identified (A ≡ B).
7) If Alice gains sufficient 3-height, she will see the D0 *point* singularity transform or *open up* to become a D1 *line* singularity (i.e., there is now a non-zero separation, $\ell > 0$, between railway lines as they disappear over the horizon). This ***forced transition***, A → B, acts as a *gate* that reveals the embedding of $\mathcal{M}^2$ in $\mathbb{R}^3$ (i.e., the $\mathrm{D2|D3}$ case).
8) The difference between apparent flatness and actual global closure is just Alice's local 3-height (h_3), ***projected*** (and rotated through $\theta = 0.045°$) to the remote, S^1 horizon. (Alice's apparent 3-height, as projected to the remote frame and seen from the local frame, is less than the thickness of the average human hair; $h_{3(LOC)} \rightarrow (h_{3(REM)} \approx 6.3 \times 10^{-5})$.)
9) The angle $\theta = 0.045°$ subtended at Alice's eye between the *true* horizontal line of sight (i.e., tangential at a radius of $r_2 + h_3$) and a line of sight to the actual horizon is equal to that subtended at the centre of the Earth between radial lines to the locations of Alice and the horizon, so *the relationship (and transition) between points A and B is proportional to and associated with those between the local observer and the remote horizon*.
10) The transition $\mathbf{R} = (\mathrm{A} \rightarrow \mathrm{B})$ is also that from triangle (1) with $a^2 = b^2 + c^2 + 2\cos\theta$, to triangle (2), with $a^2 = b^2 + c^2$, so the transition A → B is associated with the loss of the $2\cos\theta$ term.

11) **Observer-dependency of the S^1 horizon can be expressed as the fact that 2-distance to the S^1 horizon is *a constant in every frame*.**
12) The h_3 of an object that disappears over S^1 does not cease to exist but is 'conserved in 3-space'.

2.2 Scenarios

2.2.1 The D2|D3 Scenario

Alice and Bob are standing on Earth. As Bob stands close to Alice, his 3-height (h_3) is at its maximum value, but as Bob recedes from Alice, his apparent height in Alice's frame is $h_{3(B)app.} \to \sigma_3$, where $\sigma_3 > 0$ is an effective minimum (as they stand at each other's curvature limit) before Bob disappears over the S^1 horizon in Alice's frame. As noted above, the rate at which Bob appears to *contract* with increasing distance from Alice's location must be exactly the same as that with which space appears to *expand*; $\mathbf{CON} \equiv \mathbf{EXP}$. We also note that at D2|D3, observer-dependency of the S^1 planetary horizon is just the fact that 2-distance to the S^1 horizon is a constant in every frame.

2.2.2 The D3|D4 Scenario

We assume that the 3-dimensional hypersurface $\mathcal{M}^3$ is spherically closed (Einstein, 1923), and that 4-height (h_4) is *velocity* $(\mathrm{d}s/\mathrm{d}t)$, rather than the Minkowski spacetime interval, $\Delta s^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - (c\Delta t)^2$. Also assuming $h_4 \lll r_3$, the 3-manifold $\mathcal{M}^3$ appears to be flat, but as Bob recedes from Alice, his apparent velocity in her frame is $h_{4(B)app.} \to \sigma_4$, where $\sigma_4 > 0$ is some irreducible constant (since $\sigma_4 = 0$ would represent a preferred rest frame). The respective local and remote curvature limits are taken to be a maximum velocity, $v_{max} = c = 3 \times 10^6 \mathrm{ms}^{-1}$ and a minimum *energy*, $E_{min} = hv, h/2\pi = 1.055 \times 10^{-34} \mathrm{m}^2\,\mathrm{kg/s}$; i.e., the characteristic constants of GR and QM. At D3|D4, apparent expansion of space with increasing 3-distance is interpreted as ***universal expansion with constant velocity*** (Lemaître, 1927), (Hubble, 1929), and observer-dependency of the S^2 cosmological horizon is just the fact that 3-distance to the S^2 horizon is a constant in every frame.

2.2.3 The D4|D5 Scenario

Again, we take the 4-manifold $\mathcal{M}^4$ to possess constant positive curvature, and 5-height (h_5) to be *acceleration* $(\mathrm{d}^2 s/\mathrm{d}t^2)$. Assuming $h_5 \lll r_4$, the 4-surface *feels flat*; in other words, Alice does not detect higher curvature (i.e., she never experiences her own mass). As Bob recedes from Alice, freefalling towards the curvature limit (the S^3 black hole event horizon), his apparent acceleration $(h_{5(B)app.})$ decreases until he appears to hover at $r = 2GM$, as the photons comprising his image redshift to infinity. However, $\sigma_5 = 0$ would represent a preferred *velocity* frame, which is precluded in GR since it is impossible to say that a body is not being gravitationally accelerated. Therefore, $h_{5(B)app.} \to (\sigma_5 > 0)$, providing an IR cut-off. The respective local and remote curvature limits are taken to be a *maximum* acceleration, $a_{max} = \alpha$ (where $\omega_\alpha \approx \ell_P$), and a *minimum* acceleration, $a_{min} = \lambda$ (where $\lambda = 1 \times 10^{-52} \mathrm{m}^{-2}$ is the *cosmological constant*) (Note 1.). At D4|D5, apparent expansion with increasing 4-distance from Alice is interpreted as ***accelerating universal expansion*** (Reiss et al,1998), (Perlmutter et al, 1999). We also note that at D4|D5, ***observer-dependency of the S^3 black hole event horizon is just the fact that 4-distance (i.e., $v = c$) to S^3 is a constant in every frame***. In other words, we have derived Lorentz invariance, in which frames differ by the factor, $\gamma = 1/\sqrt{1 - (v^2/c^2)}$. At the microscopic scale, *constant 4-distance to the S^3 horizon is interpreted as the quantum*; the irreducible unit that prevents the electron spiralling into the atomic nucleus. Therefore *relativity at the macroscopic level is equivalent to quantisation at the microscopic level*, so we get;

$$\mathbf{RELATIVITY} = \mathbf{QUANTISATION}. \qquad (3)$$

We next explore whether this sequence is infinitely extendable.

3. Limit Principle

We first specify two references, s_1 and s_2. At step 1, we specify a new reference representing the *difference* between them, $s_1 - s_2$, and at step 2, using the new reference, we then specify a further reference representing the difference, $s_1 - (s_1 - s_2)$. At the third iteration, the difference becomes *detached* from the original references; $(s_1 - (s_1 - s_2)) - (s_1 - s_2)$; i.e., s_1 only appears in brackets after this level (Figure 2).

	s_1 s_2	
0	▮ ▮	s_1, s_2
1	▯ ▮ ▯	$s_1 - s_2$
2	▯ ▮ ▯ ▯	$s_1 - (s_1 - s_2)$
3	▯ ▯ ▮ ▯ ▯	$(s_1 - (s_1 - s_2)) - (s_1 - s_2)$
4	▯ ▯ ▯ ▮ ▯ ▯	$((s_1 - (s_1 - s_2)) - (s_1 - s_2)) - (s_1 - s_2)$
5	▯ ▯ ▯ ▯▮▯ ▯	$(((s_1 - (s_1 - s_2)) - (s_1 - s_2)) - (s_1 - s_2)) - (s_1 - s_2)$

Figure 2. At step 3, the new reference is detached from the original references

We now interpret references s_1 and s_2 as *locations*, so that the difference $s_1 - s_2$ is then a *change* of location, or *velocity* $(\mathrm{d}s/\mathrm{d}t)$, the difference $s_1 - (s_1 - s_2)$ represents a *change* of velocity, or *acceleration* $(\mathrm{d}^2t/\mathrm{d}t^2)$, and the difference $(s_1 - (s_1 - s_2)) - (s_1 - s_2)$ corresponds to a *change* of acceleration, or nonuniform acceleration $(\mathrm{d}^3t/\mathrm{d}t^3)$. Of critical noteworthiness is the fact that from this level onwards, there is no further reference to the original locations; i.e., *there is no longer a physical reference or datum against which to distinguish higher derivatives* (Figure 3).

	s_1 s_2	
0	▮ ▮	3-space positions (s_1, s_2)
1	▯ ▮ ▯	velocity $(\mathrm{d}s/\mathrm{d}t)$
2	▯ ▮ ▯ ▯	uniform acceleration $(\mathrm{d}^2s/\mathrm{d}t^2)$
3	▯ ▯ ▮ ▯ ▯	nonuniform acceleration $(\mathrm{d}^3s/\mathrm{d}t^3)$
4	▯ ▯ ▯ ▮ ▯ ▯	change of nonuniform acceleration $(\mathrm{d}^4s/\mathrm{d}t^4)$
5	▯ ▯ ▯ ▯▮▯ ▯	nonuniform change of $(\mathrm{d}^4s/\mathrm{d}t^4)$; $(\mathrm{d}^5s/\mathrm{d}t^5)$

Figure 3. Beyond step 3, detachment from original references implies indistinguishability of derivatives

3.1 Diminishing Freedoms

The limit principle implies the existence of a maximum physical reality, and therefore that effects which are clearly perspectival at D3 become ‘more real’ (effectively observer-independent) with each $\mathrm{D}(n)$ increment. Alice therefore possesses diminishing freedoms with respect to ‘effective physical reality’. For this reason we define dimensionality in terms of freedoms. Euclidean 3-space $(\mathbb{R}^3)$ may be defined in terms of Alice’s freedom to orientate according to the set of axes $\{x, y, z\}$. In $\mathbb{M}^{3,1}$ Alice’s freedom is curtailed; whilst she can orientate in $\{x, y, z, t\}$ to the extent that relativistic velocity can be thought of as rotation in spacetime (Penrose, 1959), (Terrell, 1959), she is now subject to time. A five-dimensional continuum $(\mathbb{M}^{3,1,1})$ may be defined in term of Alice’s freedom to *accelerate*, but when she does she elicits an inertial reaction and is subject to gravitation. A similar diminishing of observer freedom can be seen from a brief study of horizon characteristics. At D2|D3, the S^1 planetary horizon is completely observer-dependent, moving with Alice’s change of location. At D3|D4, the S^2 cosmological horizon is semi-observer-dependent, moving with Alice’s change of velocity, but implying loss of causal contact, and therefore being semi-permeable. At D4|D5, the S^3 black hole event horizon appears to Alice in Minkowski coordinates to be a completely observer-independent, strictly one-way membrane. To further illustrate this general process, we note that the separation of points A and B (which is clearly illusory in $\mathbb{R}^3$) becomes increasingly (effectively) ‘physically real’ with each $\mathrm{D}(n)$ increment, until at the highest level, the identification $\mathrm{A} \equiv \mathrm{B}$ may be interpreted as the physical underpinning of entanglement.

3.2 Observations and Claims

Based on our consideration of the limit principle, we make the following observations and claims regarding gravitation, mass and time.

(i) Given a massive central body and gravitationally bound satellite on various orbits, gravitation *cancels* the pseudoforces $(\vec{\boldsymbol{F}}_{pseudo}^{(\mathrm{d}^n s/\mathrm{d}t^n)})$ that would otherwise be experienced by that satellite if it was forced to follow identical trajectories in free (sourceless) space, with no known or expected limit to $\mathrm{d}^n s/\mathrm{d}t^n$ as

$n \to \infty$. For instance, a body forced to trace a circular path would experience constant centrifugal acceleration $(\mathrm{d}^2s/\mathrm{d}t^2)$, a body forced to trace an elliptical path would experience nonuniform acceleration $(\mathrm{d}^3s/\mathrm{d}t^3)$, a body forced to trace an elliptical path with perihelion advance would experience a change of nonuniform acceleration $(\mathrm{d}^4s/\mathrm{d}t^4)$, and so on.

(i) It follows that Newton's second law, $\vec{\boldsymbol{F}} = m\boldsymbol{a}$, generalised as $\vec{\boldsymbol{F}}(\mathrm{d}^ns/\mathrm{d}t^n) = m(\mathrm{d}^ns/\mathrm{d}t^n)$, also has no known or expected limit as $n \to \infty$. In accordance with his third law (the action-reaction principle), the reaction force must be equal to any derivative of force applied; $\vec{\boldsymbol{F}}(\mathrm{d}^ns/\mathrm{d}t^n)_{ACT.} \equiv \vec{\boldsymbol{F}}(\mathrm{d}^ns/\mathrm{d}t^n)_{REACT.}$

(ii) Derivatives of 3-space position become indistinguishable at defined thresholds, as demonstrated by the following simple, testable thought-experiments. Firstly, a passenger in a very powerful car is prevented from detecting motion except by the experience of pseudoforces felt against the back of the seat. S/he will be able to distinguish between constant velocity $(\mathrm{d}s/\mathrm{d}t)$ and constant acceleration $(\mathrm{d}^2s/\mathrm{d}t^2)$ (i.e., increased but constant effective mass, or m_E), and between constant acceleration $(\mathrm{d}^2s/\mathrm{d}t^2)$ and nonuniform acceleration $(\mathrm{d}^3s/\mathrm{d}t^3)$ (i.e., between increased but constant m_E and uniformly increasing m_E, or $(\mathrm{d}/\mathrm{d}t)m_E$), but will *not* be not able to distinguish between nonuniform acceleration $(\mathrm{d}^3s/\mathrm{d}t^3)$ and a change of nonuniform acceleration $(\mathrm{d}^4s/\mathrm{d}t^4)$ (i.e., between $(\mathrm{d}/\mathrm{d}t)m_E$ and $(\mathrm{d}^2s/\mathrm{d}t^2)\, m_E$). (Defining dimensionality in terms of freedoms, the boundary D6|D7 is therefore undetectable.) Secondly, we note that on a graph plotting time $(x = t)$ against velocity $(y = v)$ (Figure 4), $(\mathrm{d}s/\mathrm{d}t)$ is a horizontal line at $y > 0$, $(\mathrm{d}^2s/\mathrm{d}t^2)$ is diagonal, and $(\mathrm{d}^3s/\mathrm{d}t^3)$ is a parabola, the gradient of which is of course nowhere vertical. No higher derivative of motion can therefore be represented on this graph; since a parabola is an infinitely extended ellipse, which is an extended circle, any tighter curve is effectively a spiral. A computer with input readings of pressure (necessarily compared to functions held in memory) would be able to detect the difference between nonuniform acceleration $(\mathrm{d}^3t/\mathrm{d}t^3)$ and a change of nonuniform acceleration $(\mathrm{d}^4t/\mathrm{d}t^4)$ (i.e., between a circle and spiral, or equivalently between D6 and D7), but *not* between $(\mathrm{d}^4t/\mathrm{d}t^4)$ and $(\mathrm{d}^5t/\mathrm{d}t^5)$, since all tighter curves are just varying classes of spiral. In other words, ***detection of the $\boldsymbol{D7|D8}$ boundary is noncomputable***.

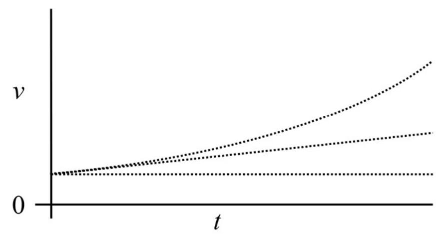


Figure 4.

3.3 Implications of the Limit Principle

The conclusions that may be drawn from the limit principle are;

(i) that effects that are clearly perspectival at D3 become 'more real' (*effectively* observer-independent) with each $\mathrm{D}(n)$ increment,
(ii) that *the Universe only differentiates twice with respect to time*,
(iii) that therefore there exists a *maximum physical reality* at D6,
(iv) that the Universe runs out of physical references with which to distinguish derivatives; i.e., it does not distinguish beyond this level, and so *the notion of physicality is therefore not valid at* $\mathrm{D}(n > 6)$,
(v) that D7 is *non-physical*, and corresponds to the *mathematical* realm, and
(vi) that D8 is associated with *observer degrees of freedom* (i.e., the D7|D8 boundary is noncomputable).

4. Perspective-Gauge Equivalence

4.1 Perspective as Gauge

We imagine astronauts Alice and Bob, who have no prior understanding of space or perspective, moving apart in free 3-space. They disagree on who is contracting, and theorise the existence of an embedding 3-space $\mathbb{R}^3$ to account for this. Now on the Earth's surface, the difference between apparent flatness and actual global closure in

Alice's frame is just her 3-height (h_3) projected (and rotated through θ) to the remote S^1 horizon, where it is the collapse vector **R** (Figure 1b), and if Alice and Bob stand at each other's curvature limit (horizons) they will now disagree on contraction *and* phase. Taking the 2-surface as the base space $\mathcal{M}^2$, then the 3-height h_3 is the fibre, $\mathcal{V}$, representing an internal space at each point on $\mathcal{M}^2$, generating a fibre bundle, $\mathcal{B}$, with $\mathcal{B} = \mathcal{M} \times \mathcal{V}$. The *perspective* field comprises gauge connections that correspond to the group $\mathcal{G}$ of continuous symmetries of $\mathcal{B}$, and in that there is a canonical projection, submersion or surjective map, $\pi: \mathcal{B} \to \mathcal{M}$, then the phase (θ) is a continuous image of $\mathcal{M}$ in $\mathcal{B}$. Alice and Bob then theorise the existence of $\mathbb{R}^3$ plus curvature of $\mathcal{M}^2$, in which case, the collapse vector **R** is the *gauge boson* or *field quantum* of the theory; i.e., the coupling constant or interaction strength (curvature) that translates between frames and restores *local* gauge invariance.

4.2 Gauge as Perspective: the Standard Model

The Standard Model (SM) of particle fields and interactions is described mathematically as the non-Abelian gauge group $\mathrm{SU}(3) \times \mathrm{SU}(2) \times \mathrm{U}(1)/\mathrm{Z}_6$, and physically as a sequence of early-epoch phase transitions in which the fundamental interactions split off from a primordial, unified force following a hot Big Bang at $t = 0$, some 13.82 billion years ago. In the perspective approach, this structure is thought of as a series of global, spherical closures, each generating a characteristic fermion; e.g., closure of D0 generates closed 0-forns (1-dimensional strings) that live on D1, closure of D2 generates closed 1-forms (2-dimensional quarks) that live on D2, etc. This forms a set of concentric, nested n-spheres, or 'onion' layers, in which a nucleus is composed of hadrons, which are composed of quarks, etc (Figure 5). In this approach, each composite form is therefore a '**MANY**' system, in which 'larger' n-forms are thought of as being composed of 'smaller' n-forms.

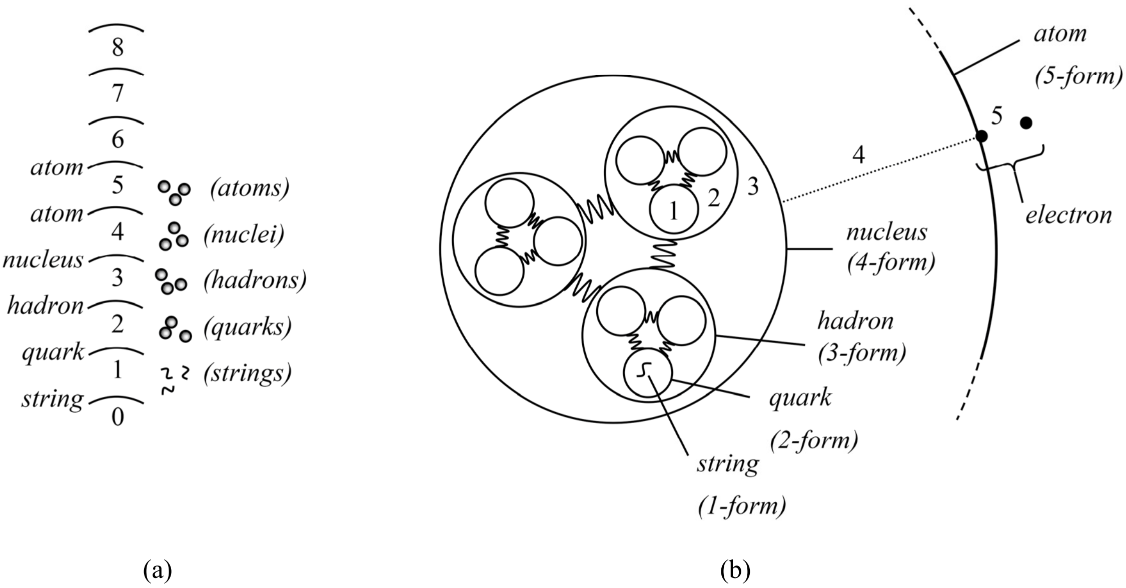


Figure 5. Onion-skin interpretation of composite particles' lower internal spaces

The structure can also be seen as two sets of $\mathrm{D}(n-3)$ reductions; (i) $\mathrm{D}(4 \le n \le 8) \xrightarrow{D(n-3)} \mathrm{D}(1 \le n \le 5)$, from each n-height to a Planck-dimension limit point of $\mathrm{D}(n-3)$ perspectival convergence (or fermion), and (ii) $\mathrm{D5} \xrightarrow{D(n-3)} \mathrm{D2}$, which juxtaposes leptons with quarks. The n-height, projected into the remote frame, corresponds to the coupling constant (the curvature of the gauge connection). This is the associated boson, which in the perspective model is just the collapse vector $\mathbf{R}_{\mathrm{D}(n)}$ (see Figure 1b), as depicted in Figure 6. In this approach, larger n-forms are ***not composite***, but are instead, single '**ONE**' states (i.e., ℓ_P^n perspectival convergence limits).

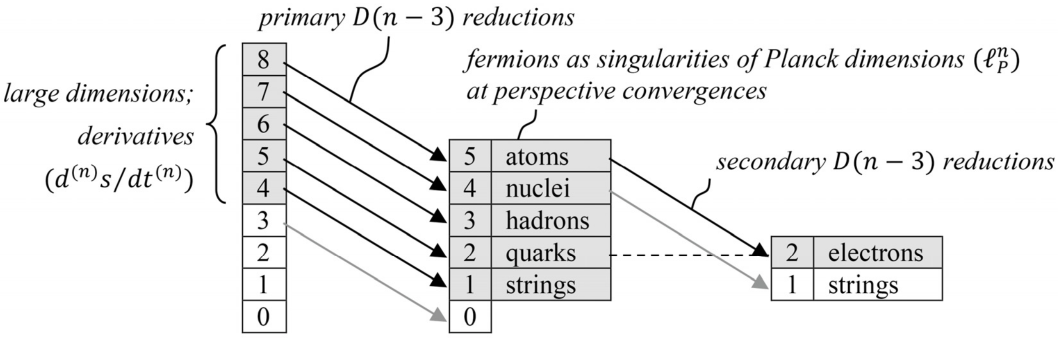


Figure 6. Two groups of $\mathrm{D}(n-3)$ reductions form particles as perspectival convergence limit points, juxtaposing quarks and leptons (dashed line)

4.2.1 Quarkworld

Each particle splits the $\mathrm{D}(0 \leq n \leq 8)$ spectrum into lower and higher internal spaces. For instance, a quark is a closed 1-form (i.e., a 2-form) that lives on $\mathbb{R}^2$, the spectrum being $[0)1)\mathbf{2}(3(4(5(6(7(8]$, where brackets denote spherical closures. We may then define quark orientation on $\mathbb{R}^2$ as a superposition of generators labelled $\{R, G\}$. Although the quark possesses 3-height (h_3) above the closed 2-surface, since $h_3 \lll r_2$, the 2-surface 'looks flat' (i.e., appears to be $\mathbb{R}^2$) and labelling is therefore arbitrary (*globally* gauge invariant) in the quark's frame. However, since D2 is spherically closed, the third generator $\{B\}$ corresponds to the *absolute* $\mathbb{R}^3$ reference frame; i.e., the $\mathrm{SU}(3)$-colour embedding space. The gauge field or Ehresmann connection is mediated by eight gluons, the basis states of the Lie algebra that transform in the adjoint representation of $\mathrm{SU}(3)$, which is 8-dimensional, thereby excluding the outlawed colour singlet state, $(r\bar{r}+g\bar{g}+b\bar{b})/\sqrt{3}$. The exchange of a gluon represents the *absolute* $\{R, G, B\}$ orientation or rotation of quarks with respect to $\mathbb{R}^3$, restoring symmetry via *local* gauge invariance.

The 2-surface that quarks inhabit is the interior of a hadron, the closed 2-form (i.e., 3-form) that splits the spectrum as $[0)1)2)\mathbf{3}(4(5(6(7(8]$. There is a $\mathrm{D}(n-3)$ projection from the quark's 3-height to an apparent D0 point on the S^1 boundary of 'Quarkworld' (in effect, point A in Figure 1b). A cyclic oscillation between points A and B (D0 and D1) corresponds to an 'inside-out hadron', which we interpret as a Quarkworld 'black hole'. As quarks fall towards it, the $\mathrm{SU}(3)$-colour charge they carry (corresponding to 3-height, h_3) appears to decrease as $r \to max$ at S^1 and finally disappears. Thus $\mathrm{SU}(3)$-colour bleaches out of Quarkworld with the formation of colour-neutral hadrons.

4.2.2 Mixing-space

Assuming $h_5 \lll r_4$, the 4-surface is defined by four directions or generators that appear to be gauge-equivalent (i.e., labelling is arbitrary). However, since $h_5 > 0$, the 4-surface is spherically closed and orientation is no longer gauge-invariant. In the SM this is the spontaneous electroweak symmetry breaking (EWSB) mechanism from $\mathrm{SU}(2) \times \mathrm{U}(1)_Y$ to $\mathrm{U}(1)_{em}$, whereby the $W^{\pm}$ and Z^0 IVBs acquire mass. As part of the same process, charge associated with $\mathrm{U}(1) = \{e^{i\theta}\}$ is given by the Gell-Mann-Nishijima formula, $Q = Y/2 + I_3$ (where Y is weak hypercharge relating baryon number and strangeness, and I_3 is the third component of weak isospin, in which $\mathrm{SU}(2)$ is defined by the Pauli matrices, σ_j). In the perspective model, each (non-identical) generator then produces its own copy or *family* of 3-space, the directions of which correspond to *generations*. The superposition of directions (generators) at higher $\mathrm{D}(n)$ are rotations that transform lower $\mathrm{D}(n)$ particles (see Figure 7). In terms of the SM, this is to say that the Cabibbo-Kobayashi-Maskawa (CKM) matrix describes expectation-values for transitions between families and generations of quarks (with the Cabibbo angle corresponding to probabilities of decay modes), and the Pontecorvo-Maki-Nakagawa-Sakata (PMNS) matrix summarises weightings for lepton-mixing.

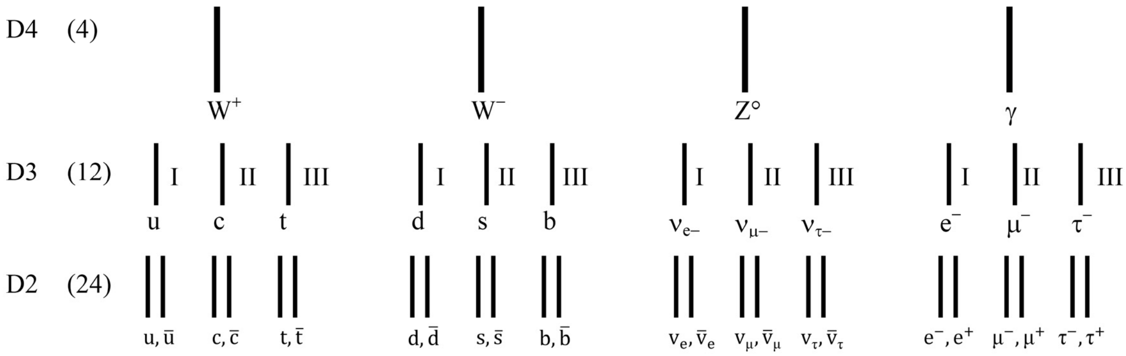


Figure 7. $\mathrm{D}(n)$ directions are *particles* at $\mathrm{D} > n$, and IVBs at $\mathrm{D} > n$ are *fermionic* generations at $\mathrm{D} < n$. In this progression, *space* at $\mathrm{D}(n)$ is a lower internal space of a *fermion* at $\mathrm{D}(n+1)$

4.3 QED

In the perspective model, the atomic nucleus is a closed 3-form (a 4-form) on $\mathcal{M}^4$ that possesses 5-height (h_5) above the 4-surface. From h_5 there is a $\mathrm{D}(n-3)$ projection to an apparent D2 (*area*) singularity (ℓ_P^2) on the S^3 boundary separating D4|D5. This is point A in Figure 1b, and the *oscillation* between points A and B corresponds in the perspective model to the coupling between the unprimed and primed Dirac spinors of the Penrose zigzag electron, $|\psi\rangle_{e^-} = (\alpha_A, \beta_{A'})$ (Penrose, 2004). In this picture, each component acts as a source for the other, with the 'coupling constant' $2^{-1/2}M$ representing the interaction strength between the spinors, $\nabla^A_{B'}\alpha_A = 2^{-1/2}M\beta_{B'}$, $\nabla^{B'}_A\beta_{B'} = 2^{-1/2}M\alpha_{A'}$, in which $\nabla^A_{B'}$ and $\nabla^{B'}_A$ are 2-spinor translations of the gradient operator ∇. Each component has $m = 0$ and $v = c$, but the electron as a whole has $m > 0$ and a drift velocity, $v < c$. In the perspective model, the oscillation between spinors is just the continual cycle of divergence of apparent flatness from actual global closure and subsequent collapse.

Maximum infilling of electron shells is defined by the Aufbau Principle, with $N_{(\mathrm{e}^-)} = 2, 8, 18, 32, 50 \ldots 2n^2$, repeating the periodicity of blocks 2, 6, 10, 14. However, no known element has more than 32 electrons in any one shell, and there is no stable element beyond period E_7 in the Periodic Table. In the perspective model this is due to the limit principle, in which, by the third iteration, the new reference becomes detached from the original physical references, introducing partial indistinguishability beyond this level. Spectral lines (energy levels) become completely indistinguishable at the ionisation level (calculation of orbitals reaches a threshold of prohibitive computational complexity), beyond which lies the continuum, as $n_E \to \infty$. We thus have a picture of the atom as nucleus surrounded by multiple S^3 horizons, which, due to $h_5 \lll r_4$, is a quantum superposition, $|\psi\rangle_{atom} = c_1\psi_1 + c_2\psi_2 + c_3\psi_3 + \ldots + c_n\psi_n$, in which $\psi_1, \psi_2, \psi_3, \ldots \psi_n$ are the eigenstates of an observable (e.g., the principle quantum number, n) corresponding to eigenvalues $a_1, a_2, a_3, \ldots a_n$. The positive charge of the nucleus is perfectly balanced by the collective negative charges of electrons; $N_{(\mathrm{p}^+)} = N_{(\mathrm{e}^-)}$.

The earliest visualisation of the atom was Ernest Rutherford's model of a central nucleus surrounded by electrons on planet-like orbits. However, being based on classical electrodynamics and the equipartition theorem (the assumption that the energy of a standing wave is continuous), it elicited the UV catastrophe, in which the expectation that a black body should radiate equally across all available frequency modes caused the blackbody spectrum to blow up at short wavelengths. One consequence of this was that an electron would be accelerated and therefore radiate, spiralling rapidly into the atomic nucleus. The crisis in theory was averted by application of Planck's constant and the quantisation of energy, $E = h\nu$, meaning that energy could only be emitted or absorbed in quantised values that exactly matched atomic energy level spacings. The Rutherford-Bohr model was the first to incorporate Planck's radiation law into a model of energy levels as stationary harmonic states, with electrons still on circular orbits; i.e., at constant 3-distances from the central nucleus.

In the modern picture, electrons populate *s*, *p*, *d*, and *f* orbitals, or standing probability waves, the densities of which define the classical probability $|\psi(x)|^2$ of finding an electron at any given position, in accordance with Heisenberg's relation, $\Delta x \cdot \Delta p \geq \hbar$. In the perspective model, the nucleus is bounded by S^2 and possesses 5-height (h_5), with electron shells being multiple S^3 horizons. Therefore, observer-dependency of the S^3 horizon in the nucleus frame is just the fact that 4-distance $(E = h\nu)$ is a constant in every frame. Whilst *s*-orbitals are concentric (i.e., are defined by fixed 3-distances from the nucleus), since 4-distance is the conserved quantity (rather than 3-distance), an electron probability wave (e.g., the lobe-shaped *p*-orbitals) can pass straight through the atomic nucleus, since the probability of finding the electron at the nucleus is the theoretical minimum.

At $\mathrm{D2|D3}$, to gain extra 3-height is to see the apparent D0 (point) at perspectival convergence transform or 'open up' to become an actual D1 (line) that reveals the embedding, $\mathrm{D2|D3}$. This is the *forced transition* $\mathrm{D0} \rightarrow \mathrm{D1}$ (i.e., revealing the identification $\mathrm{A} \equiv \mathrm{B}$ in Figure 1b). Likewise, at $\mathrm{D4|D5}$, to gain extra 5-height is to *non-gravitationally accelerate*, and to see the apparent D2 (area) singularity open up to become an actual D3 (volume) singularity, revealing the embedding, $\mathrm{D4|D5}$. This is to force the transition $\mathrm{D2} \rightarrow \mathrm{D3}$. The unit of $\mathrm{D4|D5}$ (i.e., of the $\mathbb{R}^5$ absolute embedding space) is interpreted as a photon, which is absorbed (emitted) by a decelerated (accelerated) electron. (Whilst in the conventional view it would be reasonable to say that the forced transition $\mathrm{D2} \rightarrow \mathrm{D3}$ is associated with the emission of a photon, in the perspective model the picture is that of *projection* of the local to the remote frame. The boson is then a 'unit of projection', in which case, strictly speaking, ***photons do not travel***.)

5. Gravitation

5.1 Macroscopic Charge

We next ask if there is a precedent for a notion of 'charge' at the macroscopic scale. In this regard, we note that matter tends towards horizons; either *expanding* as part of the Hubble flow towards the S^2 cosmological horizon, or *contracting* towards S^3 black hole event horizons. We interpret these tendencies, $\mathbf{EXP}$ and $\mathbf{CON}$, as *charge* at the macroscopic level (see Figure 8).

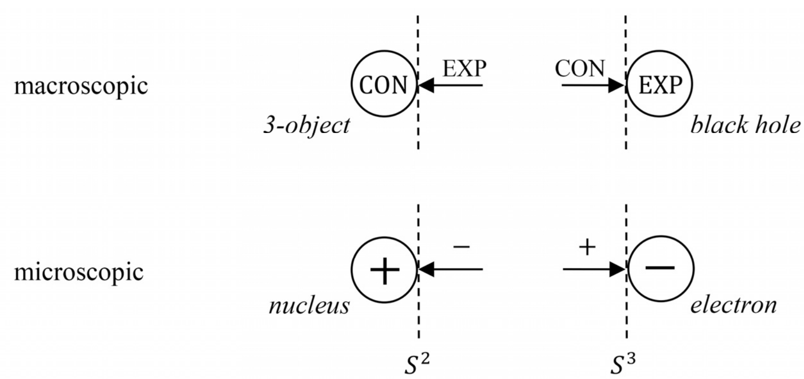


Figure 8. Macroscopic charge. Labelling of $\mathbf{EXP}$ and $\mathbf{CON}$ is of course arbitrary, demonstrating our inability to define macroscopic charge in any absolute sense

This allows us to consider the action of the Weyl (conformal) tensor C_{abcd} in terms of $\mathbf{EXP}$ and $\mathbf{CON}$ components, so that static tidal influence (falling off as the inverse cube of the separation distance) would be thought of as a standing wave, and the traceless component of the Riemann tensor as (transverse) gravitational waves (Figure 9) that correspond to the *transport* of curvature; i.e., bodies warped by gravity-waves react (with *varying* tidal forces) as though the massive source of the waves was in the vicinity.

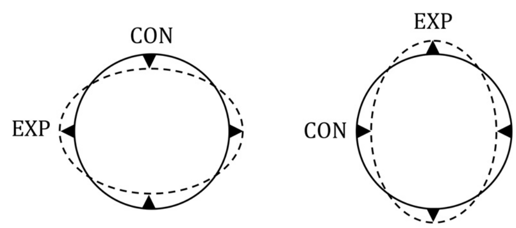


Figure 9. Plus-polarised (transverse) gravitational waves depicted as an oscillation of $\mathbf{EXP}$ and $\mathbf{CON}$ components

5.2 Gravity As Perspective

Whilst at D2|D3, expansion of space with increasing 2-distance from the observer is a purely apparent effect, at D4|D5 it is an 'effectively actual' accelerating universal expansion. Gravity is a perspectival effect in the following sense. The cosmological models of Copernicus and Brahe with circular orbits were generalised by Kepler's elliptical orbits. In Kepler's second law, a radial line linking the central body at one focus of the ellipse to the orbiting body sweeps out equal areas in equal times, which is redolent of perspective. In the frame of an observer with 3-height (h_3) above the Earth's 2-surface, equal calibrations of the 2-surface appear to become more dense as $r \rightarrow max$ at S^1. A receding object moving at constant velocity therefore appears to slow down (decelerate), whilst continuing to cross equal calibrations at equal times in its own frame, just as in Kepler's model, a body actually accelerates (Note 2) and decelerates as calibration spacing varies.

At D4|D5 (i.e., in a Universe with accelerating expansion), while the spacing of calibrations of the 4-surface from the viewpoint of the 'stationary' local observer with 5-height (h_5) decreases exponentially as $r \rightarrow max$ at S^3 (i.e., a receding body's apparent acceleration appears to decrease), the spacing of calibrations relative to the local observer increases exponentially. The receding body still sweeps out calibrations in equal times in its own frame (i.e., in GR, proper time, τ, is maximised). The 'point at infinity' of projective geometry is incorporated *everywhere* in the finite foreground. In the perspective model this is due to the fact that the local frame is 'effectively actually' projected into the remote frame, and thus a linear, perspectival effect at $\mathrm{D}(n)$ is incorporated into a closed, 'gravitationally bound' foreground at $\mathrm{D}(n+1)$. Gravity is therefore the 'effectively actual' accelerated expansion of space towards the remote frame; i.e., gravity is 'accelerated expansion (**EXP**) towards points (**CON**)'. In terms of the SM, gravity is the bleaching of **EXP/CON** charge from the D4 Universe.

5.3 Quantum Gravitational Description of Freefall

At the microscopic level, the perspective model picture is of a positively-charged nucleus, a closed 3-form (i.e., a 4-form) with 5-height (h_5) projecting $\mathrm{D}(n-3)$ to (and perfectly balanced by) negatively-charged electrons (actually to ℓ_P^2 or a 'zag' spinor) populating the electron shells (multiple S^3 horizons) that surround it. Likewise, the notion of macroscopic charge suggests the picture of a massive 4-object (i.e., possessing an h_5 potential) surrounded by multiple 'derivative shells' $(\mathrm{d}^n s/\mathrm{d}t^n)$ populated (in an appropriate sense, to be defined below) by black holes (or more correctly, to an ℓ_P^2 singularity on S^3), as depicted in Figure 10.

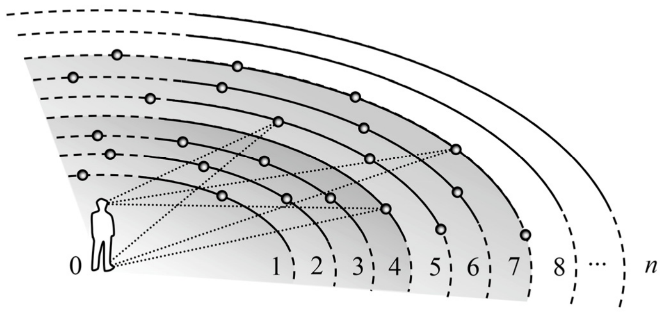


Figure 10. The generalised model for perspective at $\mathrm{D} > 3$. The $\mathrm{D}(n)$-height (depicted here as observer height) generates a spectrum of multiple horizons (H) with an effective limit of $N_H = 7$. Perspectival reduction $\mathrm{D}(n-3)$ is to apparent singularities on horizons

Just as there is a quantum description of the atom as a superposition of 'nucleus-plus-electron shells', so it would be plausible to describe freefall as a 'quantum-gravitational' superposition of 'massive-4-object-plus-derivative-shells'. In the same way that the limit principle imposes a threshold (at E_7) beyond which energy levels are no longer distinguishable, so in this approach to QG, derivative shells are no longer distinguishable beyond D7. (In this context, it is reasonable to interpret the spectrum of derivatives as a temporal quantisation.)

6. Black holes

6.1 Black Holes as Slits

Likewise, since electrons demonstrate wave-like behaviour, we would expect the same from black holes. According to the Correspondence Principle (CP), classical dynamics (typified by Newton's $\vec{\boldsymbol{F}} = m\boldsymbol{a}$) is recovered in the statistical limit and for well-defined wavepackets from quantum dynamics (typified by the

Schrödinger equation, $i\hbar(\partial/\partial t)(|\psi\rangle \boldsymbol{r}, t) = \hat{H}(|\psi\rangle \boldsymbol{r}, t))$, and so the CP must therefore also relate the respective GR and QM 'charges', **mass** and **information**, and the associated dynamics (**acceleration** and **measurement**) by which each is registered. This therefore validates a comparison between black holes and the slits in the Young double-slit experiment. Assuming no which-path detection, then in the frame of an emitted particle, *the slits themselves must become superposed or wavelike*. Therefore, if interference fringes are to appear, then just as the particle cannot 'know' by which slit it is entering the set-up, so *Bob cannot know towards which black hole he is falling*. Bob is therefore *falling into N black holes* and the tidal forces (fluctuations and oscillations) he experiences are in effect a 'Weyl interference field' that corresponds to a quantum gravitational linear superposition of an eigenbasis of distinct (mutually orthogonal) black hole spacetime geometries; $|\psi\rangle = \sum_{p=1}^{n} p = p_1 g_{\mu\nu}^{(1)} + p_2 g_{\mu\nu}^{(2)} + p_3 g_{\mu\nu}^{(3)} \ldots + p_n g_{\mu\nu}^{(n)}, n \leq 8$.

In QED, the location of a bound electron is subject to a minimum amount of uncertainty. In the perspective model, position and velocity variables $(\Delta x \cdot \Delta v \geq \hbar)$ do not commute (and therefore produce probabilistic outcomes) because they are dimensionally distinct; $\Delta x \Rightarrow \mathbb{R}^3\colon\{x, y, z\}$ and $\Delta v \Rightarrow \mathbb{R}^{1,3}\colon\{x, y, z, t\}$. Whilst the Bohr model implies a fixed 3-distance separating nucleus and electron shells, in the perspective model we define a fixed 4-distance $(E = hv)$ to the S^3 horizon that is a constant in every frame. This means that the 'trajectory' of an electron (described by orbital configurations) is probabilistic, thereby allowing *p*-orbital lobes to cross the nucleus. Likewise in QG, falling 'into' a black hole is also probabilistic, and it seems reasonable to suggest that ***black hole entropy*** $(S_{BH} = k_B A/4\ell_P^2 = c^3 A/4G\hbar)$ ***measures the probability of finding a black hole at any given spacetime location***. Thus, $N(\ell_P^2)_{BH}$ measures the black hole's 'connectedness' with the rest of the Universe, in the sense that m_{BH} is dispersed (*via* $E = mc^2$) by $N(\gamma_{HR})$, where HR is Hawking radiation (i.e., *projection-units*).

6.2 Falling towards a Black Hole

We will now explore these ideas using Alice and Bob, who are in orbit around a black hole. They synchronise clocks before Bob begins a freefall descent towards the black hole. As Bob approaches what is $r = 2GM$ in Alice's frame, she sees him begin to decelerate. This is to say that his apparent acceleration (in Alice's frame) decreases to some irreducible minimum $(\sigma_5 > 0)$ as he approaches the S^3 horizon, providing an IR cut-off for the apparently arbitrary redshift of the photons that comprise his rapidly fading image in her frame. However, since $h_5 \lll r_4$, the 4-surface *feels* flat (i.e., Bob never experiences his own mass) and the ℓ_P^2 limit of effective perspectival convergence towards which he is heading in his frame *never leaves the* S^3 *horizon*. Therefore, Bob sees an illusory event horizon recede in front of him (Hamilton, 2012); what Alice thinks of as $r = 2GM$ does not exist in his frame. As Alice sees Bob decelerate asymptotically to $r = 2GM$, she reasons that he must be burned up by what is in effect a *firewall* (Almheiri et al, 2013), which is a requirement of the Equivalence Principle (EP) when applied to Hawking radiation. In the perspective model, as Bob approaches what is $r = 2GM$ in Alice's frame, she and Bob are located at each other's curvature limits. That is to say that Bob has a relative recessional acceleration with respect to Alice (due to the accelerating expansion of space) that goes to some maximum, which we interpret as that threshold in free space at which the frequency of Unruh radiation becomes transplanckian ; $a_{max} \Rightarrow (\omega_{HR} < \ell_P)$, where ω is wavelength.

Depending on the size of the black hole, at some value of r, Bob begins to experience increasingly extreme tidal deformations. (In Alice's frame, if these begin outside $r = 2GM$, they will be *exactly* obscured by the redshift generated by the huge Lorentz and gravitational shifts.) These tidal fluctuations are interpreted as the Weyl interference field corresponding to superposition of distinct black hole spacetime geometries. Bob's body is subject to an effectively real higher perspective convergence and is therefore spaghettified. The (D2) quarks and leptons that comprise the remains of his body reach (in finite time) what in the conventional picture is $r = 0$, where they merge with the illusory horizon. Had Bob's clock been intact, it would have recorded *exactly* the time at which Alice, allowing for dilation caused by the Lorentz and gravitational shifts, calculated that Bob would have crossed $r = 2GM$. Therefore, a black hole, defined by the Schwarzchild radius (r_{Sch}) is in effect the difference in spacetime path lengths as measured in the frames of asymptotic Alice and infalling Bob. What are $r = 0$ and $r = 2GM$ in the conventional picture are the entangled (identified) points A and B in Figure 1b.

6.3 Bootstrap Space

Bob's infall is really his projection, $\mathrm{D5} \xrightarrow{\mathrm{D}(n-3)} \mathrm{D2}$, from the local, macroscopic frame to the remote, effectively microscopic frame. Like Alice's fall into a rabbit-hole (Carroll, 1865), Bob (had he remained intact) would see what is microscopic in the conventional picture (e.g., the ℓ_P^2 point of effective perspectival convergence) as *macroscopic*. In the perspective model, therefore, black holes are not merely *dual* to electrons, but, somewhat preposterously, *black holes **are** electrons*. This means that the macroscopic and microscopic scales are juxtaposed and thoroughly mixed. The conventional '3-ness of space' is thus replaced by the notion of the $\mathrm{D}(n-3)$ *absence* of 3-dimensionality between a given *n*-height (h_n) and the apparent $\mathrm{D}(n-3)$ limit of effective perspective convergence. As seen from the highest level at $\mathrm{D7|D8}$, Bob is *effectively* actually projected from the local, macroscopic frame to the (previously *apparently*, but now, *effectively*) microscopic frame, where it then appears to him to be macroscopic. In the perspective model this is what we would call '**bootstrap space**'.

6.4 Dark Energy, Dark Matter

Black hole-electron correspondence also suggests that, just as polarisation of the QED vacuum is the dressing of the bare electron charge by a slight displacement of virtual $\mathrm{e}^- + \mathrm{e}^+$ pairs (respectively, away from and towards the charge), so polarisation of the GR vacuum would correspond to the dressing of the bare black hole '$\mathbf{EXP}$' charge by a displacement of 'virtual' $\mathbf{EXP}$ (dark energy) and $\mathbf{CON}$ (dark matter) charges (respectively, away from and towards the charge); i.e., by a halo of dark matter. (Baryonic matter would then be the residue resulting from the mutual cancellation of displacement, or lattice distortion between the two virtual states.)

6.5 The Graviton Frame

In Alice's asymptotic frame, the black hole emits Hawking photons, but as Bob's remains hit the so-called curvature singularity at $r = 0$ (point A in Figure 1b) they encounter a *graviton*; i.e., they enter the *graviton* frame. Since points A and B are entangled (identified), Bob's remains are transported instantaneously (in Alice's frame) to $r = 2GM$, where, in Alice's frame, Bob is burned up by a firewall. (In quantum gravitational terms, this is the *teleportation* of curvature.) Bob's spacetime path length to the so-called $r = 0$ is clearly greater than that measured in Alice's frame to the so-called $r = 2GM$, but there is no backwards-in-time violation of causality since a graviton is by definition a minimum unit of spacetime uncertainty; $\Delta t \cdot \Delta E \geq \gamma_G$. In QG models involving a minimum length-scale, there are no gravitational radiation modes at scales $\ell < \ell_P$ because spacetime ceases to exist at that scale. Since projection effectively blows up the Planck scale to the macroscopic level, the graviton frame – in the conventional picture, the 'black hole interior' – is gravity-free. That is to say that the tidal force is gauged away in perspective coordinates. This transformation from photon (rank 1) to graviton (rank 2) frame is interpreted in the perspective model as the maximal extension of the Schwarzchild solution. Covered by Kruskal-Szekeres coordinates, the solution describes a non-traversible Einstein-Rosen (ER) bridge linking spacelike-separated black hole throats in two (asymptotically flat) exterior regions.

6.6 The Information Paradox

In the conventional picture, if Hawking radiation is completely thermal (Hawking, 1971), the black hole scattering matrix is nonunitary, clearly violating QM. Complementarity, based on the holographic paradigm, allows information to exist both in the exterior and interior regions as long as observers cannot communicate (Susskind et al, 1993), (Stephens et al, 1994), but Almheiri, Marolf, Polchinski and Sully (AMPS) (Almheiri et al, 2013) demonstrated inconsistencies in the theory's postulates (i.e., that evaporation is unitary, that QFT adequately describes $r > 2GM$, that the black hole exhibits a discrete spectrum and that there is no drama at $r = 2GM$). They reasoned (i) that if evaporation is unitary and maximal entanglement is monogamous, early radiation (C) and late radiation (B) must be entangled, generating highly energetic quanta (i.e., a firewall) at $r = 2GM$ where entanglement between B and interior modes (A) is broken, or, if (ii) the EP is to be preserved, then B must be only entangled with A, resulting in nonunitarity. The ER = EPR conjecture of Maldacena and Susskind (Maldacena & Susskind, 2013), in which ER bridges are dual to Einstein-Podolsky-Rosen (EPR) entanglement (with non-traversibility and non-signalling therefore also being necessarily dual), allows entanglement of A and B (ensuring no drama), and entanglement of B and C via ER bridges (ensuring unitarity). Given certain assumptions about computational complexity (Susskind, 2014), the asymptotic observer Alice may measure Hawking radiation and thereby generate a Schenker shockwave in the ER bridge (Stanford & Susskind, 2014) and thus send a firewall to the entangled black hole throat.

In the perspective model, the maximal extension of the Schwarzchild solution is invoked when infalling mass-energy reaches the conventional $r = 0$. Therefore, the information content of infalling mass-energy, characterised in terms of *photons* or qubits that define inter-electron spacings, when it reaches $r = 0$, then becomes characterised in terms of *gravitons* that define inter-black hole spacings. In other words, the photonic 'essence' of infalling mass-energy is replicated as gravitonic essence on the cosmic scale. Bob's remains fall into $N_{(BH)}$, where $N_{(BH)} \propto N_{(e^-)}$ of the infalling matter. The information paradox is therefore a perspectival effect; the information content of infalling matter defined as inter-electron connectivity at $\mathrm{D4|D5}$ is conserved 'on the other side of the vanishing-point' as inter-black hole connectivity at $\mathrm{D7|D8}$. The catch is that it is now in-principle inaccessible since it exists in the 'non-computable realm'. In terms of the SM, this process appears in the h_5 frame as *the bleaching of information from the D4 universe*.

Just as at the microscopic level, an atom is a quantum superposition of nucleus-plus-multiple-energy-levels-populated-by-electrons, so at the macroscopic level, a 'cosmic atom' is a quantum gravitational superposition of massive-4-object-plus-derivative-shells-populated-by-black-holes. In QED, the UV crisis (in which an electron would radiate and spiral into the nucleus) was averted because an atom can only absorb or emit energy as photons with frequencies that match inter-electron spacing. Likewise, in QG, the 'gravitational crisis' (the notion that 'mass-energy can fall into a black hole') is averted because a 'cosmic atom' can only absorb or emit energy as gravitons with frequencies that match inter-black hole spacing. The rate of state development is defined as the number of distinct (mutually orthogonal) states it transitions in a given time (Note 3). In QED these are electrons at energy levels and in QG they are black holes on derivative shells. The strong suggestion is therefore that 'cosmic atoms' and microscopic atoms *are the same thing*, just seen from two scale extremes.

6.7 Antimatter

According to the CPT theorem, the present overwhelming preponderance of matter over antimatter is associated with a violation of CP-symmetry (a combined charge-parity transformation) that has been experimentally observed in weak decay of neutral kaons (Christenson et al, 1964), and which was presumably also present in the early Universe. The theorem also states that CP-violation implies T-violation (direction reversal). A complex phase is observed in the PMNS matrix, but not in the CKM matrix, and the strong CP problem suggests that the apparent invariance of QCD under combined CP transformations is due to fine-tuning. However, such phases are not enough anyway to account for the matter-antimatter imbalance. Antimatter occurs inside mesons, in beta-decay and other particle interactions, and as virtual particle-antiparticle pairs in vacuum polarisation and vacuum fluctuations (e.g., as implicated in the heuristic model of black hole evaporation).

In the perspective model, local $\mathrm{D}(n)$ height $(h_{\mathrm{D}(n)})$ is effectively projected to the remote horizon where it represents the difference (much reduced, when seen from the local frame) between apparent flatness and actual global closure. Where $h_{D(n+1)} \lll r_{D(n)}$, the $\mathrm{D}(n)$ surface appears to be flat to very good approximation. The limit point of effective perspectival convergence is the 'bare charge' that is 'dressed' by virtual displacements of the charge associated with that *n*-surface. In other words, vacuum polarisation or the generation of virtual particle-antiparticle pairs (and more generally, matter-antimatter imbalance) is thought of as *entanglement* between point A (associated with divergence of apparent flatness of any given *n*-surface from actual global closure) and point B (associated with subsequent collapse to actual global closure), as shown in Figure 1b. The collapse vector **R** then corresponds to the (near) mutual annihilation of displaced charges, leaving a residue proportional to $h_{D(n+1)}/r_{D(n)}$, where $h_{D(n+1)} \lll r_{D(n)}$. In the $\mathrm{D4|D5}$ frame, points A and B correspond respectively to the zag (primed Dirac spinor) and zig (unprimed Dirac spinor) components that together comprise a fermion, At $\mathrm{D7|D8}$, points A and B correspond respectively to an on- or off-shell antiparticle $(\bar{p})$ and particle (p) pair. This is to say that $\bar{p}p$ pairs are linked by ER bridges (Jensen et al, 2014). In that case, the weakness of Hawking radiation must be proportional to the smallness of the amplitude for the scattering matrix of a lepton-nucleon interaction to enable a $W^{\pm}$ or Z^{0} boson to, in effect, reach back into the quark-gluon epoch to rotate a quark between flavours (e.g., in beta-decay), where 'small' means 'fine-tuned'.

Matter-antimatter symmetry imbalance (allowed by $\Delta t \cdot \Delta E \geq \hbar$) at $r = 2GM$ is generally depicted as outgoing (positive frequency) and infalling (negative frequency) modes, denoted as **←(→**, where the left-pointing arrow indicates the mode that escapes to infinity, the bracket is the horizon and the right-pointing arrow is the infalling mode. However, the Feynman-Stueckelburg time-reversal interpretation implies ←(**←**. In the perspective model, as infalling Bob reaches the so-called $r = 0$ he enters the graviton frame that transports him instantaneously to the so-called $r = 2GM$ in Alice's frame. In the perspective model, temporal asymmetry is just the gradient of $\mathrm{D}(n) \rightarrow \mathrm{D}(n-3)$, so the reversal corresponds to the fact that the graviton is the minimum unit of spacetime uncertainty $(\Delta t \cdot \Delta E \geq \gamma_G)$, the gauge boson that restores *local* invariance under T-transformations.

6.8 Experimentally Testable Claim

Just as there is a microwave background resulting from the surface of last scattering (recombination) at $\mathrm{D4|D5}$, so we argue that there should be a *mathematical* background at $\mathrm{D7|D8}$, corresponding to a distribution of *primes*. In other words, variation in homogeneity that in conventional terms seeded galaxy formation (and by inference, determines the distribution of black holes) is due to eigenvalue asymptotics (Berry, 1986), (Berry & Keating, 1999). Therefore, given also that the act of quantum measurement is *not* a process of amplification, but is rather the perspectival projection from the local frame to the remote (or *effectively* microscopic) frame, then *the pattern of impacts on the second screen is a quantum distribution reflecting the cosmic distribution of black holes*. This is to say that black holes can be thought of as *paths*, and that individual impacts on the second screen are faithfully replicating (modulo the wavelike distortion of the interference fringes) the distribution of black holes in the direction that the experiment is oriented, as depicted in Figure 11. In other words, each impact will indicate the direction of the next nearest and most massive black hole as the superposed state transitions through distinguishable states. In effect, the double-slit experiment is a form of *camera* (Note 4). Therefore, the pattern of impacts on the second screen (together with the implied particle trajectories) is *deterministic but noncomputable* (i.e., *effectively* or *sufficiently* random).

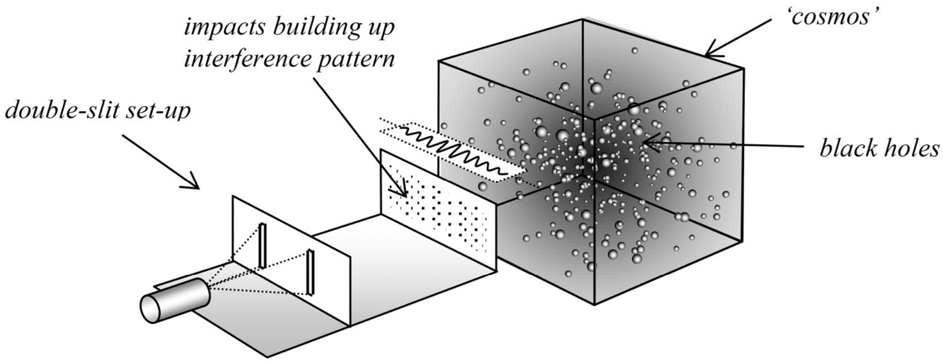


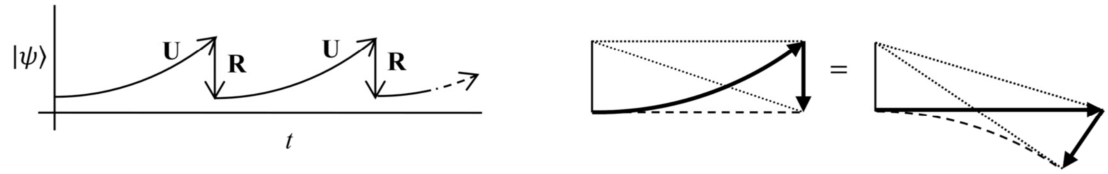
Figure 11. (Not to scale.) The Young double-slit set-up should replicate the distribution of black holes in the direction in which the experiment is orientated, subject to the waveform due to the interference pattern. Particle impact positions should reflect black hole proximity and mass, so the first impact would correspond to the nearest and most massive black hole, and so on

7. Time

7.1 Cosmological Time

In GR, time is just another covariantly transforming coordinate of an arbitrarily differentiable, dynamic spacetime manifold, and in QM it is an external (absolute), Newtonian parameter. In the canonical approach to QG, the Hamiltonian that generates state development is a constraint, leading to the Wheeler-de Witt equation, $\hat{H}(x)|\psi\rangle_U = 0$, which implies that time is frozen. Time is also implicit in the SM, in which the physical Universe is conceived of in terms of early-epoch phase transitions associated with the collective gauge group $\mathrm{SU}(3) \times \mathrm{SU}(2) \times \mathrm{U}(1)/\mathrm{Z}_6$. However, the cosmological coincidence problem (and variations of it) ask why we appear to find ourselves at a certain 'distance' in time (1.382×10^9yr from the initial singularity, $t = 0$) at which the evolving densities of dark energy (e.g., the cosmological constant) and matter are comparable. In (Avelino & Kirshner, 2016) the question is posed in terms of the dimensionless age of the Universe, $H_0 t_0$. As the authors explain, the claim that $H_0 t_0 = 1$ is in effect the assertion that the age of the Universe is exactly equal to the *Hubble time*, implying a *constant* rate of expansion since $t = 0$; i.e., as required in the perspective model.

In asking if QG has a bearing on the issue, we could note that in the perspective model, just as in QED the photon mediates between $+$ and $-$ charges and restores local gauge invariance (i.e., compensates for perspectivality at the microscopic D4|D5 level), so in QG, the graviton mediates between **CON** and **EXP** charges and restores local gauge invariance (i.e., compensates for perspectivality at the macroscopic D4|D5 level). It is interesting to note that in the Conformal Cyclic Cosmology (CCC) conjecture of Penrose (Penrose, 2006), (Penrose, 2008), there is a conformally smooth transition between the state of maximum universal ***expansion*** of the previous phase and the maximally ***contracted*** state of the present phase. In the perspective model, the geometry of CCC is seen as being analogous to the cycle of **U**- and **R**-processes of QM (Penrose, 1989), with a single graviton mediating between the **EXP** and **CON** phases (Figure 12). In this approach, black holes are local 'points at infinity' that act as perspectival, 'macro-micro flip-over' points.



(a) (b)

Figure 12. The cycle of **U**- and **R**-processes of QM (a) are interpreted as divergence of the apparently flat surface from actual global (spherical) closure and subsequent collapse (b). In the perspective model, the collapse vector **R** is the gauge boson that restores local ('pre-perspectival') symmetry. The same geometry may be applied to the transition between the maximal universal expansion $(\mathcal{J}^{+})$ and maximal contraction $(t = 0)$ phases in the Conformal Cyclic Cosmology conjecture of Penrose (i.e., 'the collapse of the universal wavefunction')

7.2 Gravitons and Time

In the perspective model, the projection $\mathrm{D5} \xrightarrow{\mathrm{D}(n-3)} \mathrm{D2}$ maps the local, macroscopic (black hole) frame in the present era to the primordial photon epoch of the SM after nucleosynthesis but prior to electron acquisition by ions, when the densities of relativistic radiation (photons) and non-relativistic matter (atomic nuclei) were equal. (The subsequent decoupling of matter and radiation and the generation of charge-neutral atoms corresponds in the perspective model to the global closure of D4.) At recombination, or the surface of last scattering, the photon mean path length became effectively infinite, and the Universe thus became transparent to electromagnetic radiation. At the present, macroscopic scale, the coincidence (or 'why now?') problem questions why the energy densities of dark energy (i.e., the cosmological constant, λ) and matter should be comparable. The implication in is that there is a perspective map $f(P)\colon (\rho_\lambda \approx \rho_M) \rightarrow (\rho_\gamma \approx \rho_M)$, from the coincidence problem at the present, macroscopic era (scale) to the pre-decoupling radiation-matter densities of the SM photon epoch. Therefore we claim that *gravitons at the macroscopic scale are photons at the microscopic scale*, in which case, the experimental absence of gravitons would indicate that ***the Universe is not 'yet' transparent to gravitons***. In other words, black holes exchange gravitons in a higher or *future* space.

7.3 Bootstrap Time

The perspective model therefore links events that in the conventional picture are separated by billions of years. The thermodynamic specialness of the Big Bang that most strongly characterises time-symmetry violation (i.e., the basis of the second law) is defined by Penrose in terms of the accuracy with which the Creator would have had to specify the initial singularity $(t = 0)$, given as one part in $10^{10^{123}}$ (Penrose, 1989), (Penrose, 2004). In the perspective model, the transition phases of the SM comprise a coherent superposition or spectrum of S^6 horizons in the D7|D8 frame, and the specialness of the initial singularity is just the projection of that coherence from h_8 to the effectively temporally remote frame at $t = 0$. In this sense, the present era h_8 (observer) frame is 'effectively actually' projected into the effectively primordial epoch, and so we would expect, for instance, that quark masses would be ranged *perspectivally*; i.e., with the 'biggest' (top and bottom) quarks being 'closest' to 'the observer at $t = 0$'. Therefore, in the 'current era', we see a perspectival projection of local, 'human-scale' time to the temporally remote frame, where it is seen from the local frame as highly contracted, and juxtaposed with expanded, 'cosmic scale' time. The initial singularity, $t = 0$, is therefore (however *effectively* real) still a perspectival illusion, and so time in the perspective model is in effect '**bootstrap** time'.

7.4 Inversion from Microscopic to Macroscopic Scales

To illustrate further, we imagine a 2-sphere in 3-space, orbited at a fixed distance by an object with a trajectory such that, *in time*, the object will map the entire surface of the 2-sphere. Ignoring physical constraints, we arbitrarily increase the orbital velocity of the object until, in the frame of the 2-sphere, the 2-sphere is surrounded by a 'blurred' S^2 horizon. At some higher, critical (infinite) velocity, an abrupt inversion will occur, such that the object will become suddenly stationary (and massive), and surrounded at the fixed 3-distance by the *inverted* 2-sphere surface; i.e., the entire 2-surface is now visible to the object *all at the same time*. This is of course suggestive of an atomic nucleus on spherically closed D4 spacetime with an electron (a Dirac spinor pair) orbiting at a fixed 4-distance $(v = c)$ on the S^3 horizon. In the nucleus frame, the electron appears as an S^3 surface, smeared-out due to $\Delta x \cdot \Delta p \geq \hbar$. The critical inversion velocity is $v = c$, which in the Penrose zigzag picture of the electron is the fundamental velocity of each Dirac spinor. At the point of inversion, the orbiting object is suddenly stationary and massive, and is orbited by the 2-sphere. In this analogy, the point of inversion represents a transition from the microscopic level (nucleus orbited by electron) to the macroscopic level (massive object orbiting a black hole). In effect, the inversion from the 'nucleus-orbited-by-electron' picture to the 'massive-object-orbiting-a-black-hole' picture means that we are seeing a 'freeze-frame' image of the SM epoch; i.e., we surmise but do not *observe* galactic rotation, etc.

8. Discussion and Summary

8.1 Quantum Mechanics and Observers

Observer degrees of freedom are necessarily associated with the highest frame, D7|D8, and (from the limit principle, D8 being 'beyond the mathematical realm'), are therefore to be associated with *noncomputability*. We take the view that this has a direct bearing on QM, as follows. In order to ensure peaceful coexistence of relativity and EPR-entanglement, all that is needed is conservation of no-signalling. Outcomes of measurements performed on entangled qubits by spacelike separated observers Alice and Bob are irreducibly probabilistic, or *stochastic*. However, since 'true randomness' can by definition never be proven, all that is required to conserve no-signalling is 'sufficient randomness', which we interpret as *noncomputability*.

Now, since the CP relates the 'charges' **mass** and **information**, it must also relate the dynamics by which those charges are registered, namely **acceleration** and **measurement**, respectively. In the perspective model, information and mass are related by a $\mathrm{D}(n-3)$ projection. At D4|D5, assuming $h_5 \lll r_4$ (i.e., minimum 5-height) we have a superposition comprising an h_5 **mass** potential plus eigenbasis of multiple (orthonormal) S^3 horizons, and at D7|D8 assuming $h_8 \lll r_7$ (i.e., minimum 8-height) we have a superposition comprising an h_8 **information** potential plus eigenbasis of multiple (orthonormal) S^6 horizons. (In the perspective model, the ontological status of the wavefunction $|\psi\rangle$ is therefore that of a '**ONE**' state; i.e., an ℓ_P^5 perspectival convergence limit). Just as at D4|D5, to gain extra 5-height is to ***accelerate***, so at D7|D8, to gain extra 8-height is to ***measure***. Therefore the projection $\mathrm{D8} \xrightarrow{\mathrm{D}(n-3)} \mathrm{D5}$ applies noncomputability to measurement outcomes at D4|D5; probability enters the process with von Neumann projection of the state vector onto the eigenbasis. To the extent that observer choice is independent, the same independence is therefore applied to quantum systems. In other words, particles must demonstrate as much freedom as experimenters (Conway and Kochen, 2008).

8.2 What does it Mean to Quantise Gravity?

In the perspective model, gravitons are exchanged in a higher, 'future' space (D7|D8) between black holes. The preparation of a pure state at D7|D8 (an h_8 information potential) and the interpretation of a quantum measurement outcome requires *understanding*, which Penrose believes is essentially non-mathematical and therefore the observer's highest faculty (Penrose, 1989), (Penrose, 1994). In the perspective model, the mathematical limit on $\mathrm{D}(n)$ implies the existence of a 'maximum physical reality', and that effects which are clearly perspectival at D3 become 'more real' (effectively observer-independent) with each $\mathrm{D}(n)$ increment, as the observer loses degrees of freedom with respect to 'physical reality' (i.e., becomes subject to external forces). From the highest frame (D7|D8), I observe 'maximum physical reality'. I am therefore both maximally objective (of 'physical reality') and maximally subject (to physical phenomena), represented by the following equivalence of statements that apply to D4|D5;

(1a)		(1b)	
'I am inside the Universe'		**'The Universe is inside me'.**	(4)
('Physical reality is [necessarily] maximally convincing'.)	=	('I can report internal representations of physical reality'; i.e., sensory perceptions.)	

There then follows from this a further equivalence of statements that apply to D7|D8;

(2a)		(2b)	
'I am inside my sensory perceptions'		**'My sensory perceptions are inside me'.**	
('My sensory perceptions are maximally convincing'; i.e., qualia.)	=	('I can report internal representations of my sensory perceptions'; i.e., consciousness.)	(5)

In terms of fibre bundles, a particle's (nested) internal spaces are isometric to its (nested) embedding spaces; e.g., quark interactions that appear to quarks to be free actually indicate their higher (*future*) confinement inside hadrons. In the same way, it should be possible to define a *fibre bundle* (or extended SM gauge) structure of consciousness, in which brain states represent higher or future embedding spaces. Although a detailed consideration is beyond the scope of this paper, the basic idea would be that $N_{BH} \approx N_{NEU.}$ (where NEU denotes neurons). Thus an observer corresponds to a *centre* or point of perspective with 8-height (h_8) at D7|D8 (in effect, the celestial sphere) from which frame the observer sees a linear quantum gravitational superposition of multiple S^6 horizons populated by black hole (ERB) and quantum EPR (or BCS) pairs. In other words, this is the way in which it appears to us that we are 'in the Universe'; i.e., in our present era, to quantise gravity (to switch off tidal forces) is to *measure* or *think*.

8.3 Summary

We have considered macroscopic and microscopic versions of two $\mathrm{D}(n-3)$ reductions; (i) the $\mathrm{D5} \rightarrow \mathrm{D2}$ reduction, which describes gravitational collapse and represents the ***splitting*** of mass and information (i.e., in which *properties become indefinite*), and (ii) the $\mathrm{D8} \rightarrow \mathrm{D5}$ reduction, which describes wavefunction collapse and represents the ***joining*** of mass and information (i.e., in which *properties become definite*). The $\mathrm{D8} \rightarrow \mathrm{D5}$ and $\mathrm{D5} \rightarrow \mathrm{D2}$ reductions are themselves linked by a $\mathrm{D}(n-3)$ reduction, and therefore one horizon **splits** or **joins** these two process;

'SOMETHING ENTERS A BLACK HOLE' ≡ 'SOMETHING HAPPENS'. (6)

In other words, the processes 'falling into a black hole' $(\mathrm{D5} \xrightarrow{\mathrm{D}(n-3)} \mathrm{D2})$ and '$|\psi\rangle$-collapse' $(\mathrm{D8} \xrightarrow{\mathrm{D}(n-3)} \mathrm{D5})$ both generate 'macroscopic properties'.

In the D4|D5 frame, 4-distance was interpreted at the macroscopic level as $v = c$ and at the microscopic level as $E = h\nu$. Since observer-dependency of the S^3 horizon is just the fact that 4-distance to the S^3 horizon is a constant in every frame, this therefore suggested a direct equivalence, RELATIVITY = QUANTISATION. The information paradox was interpreted as a perspectival effect in which information is not lost, but does become noncomputable. The approach is falsifiable on the basis of experiments proposed.

From the D4|D5 frame at the macroscopic level, massive 4-objects are orbited by black holes (entangled $r = 0$ plus $r = 2GM$ pairs) on S^3 horizons, and from the D4|D5 frame at the microscopic level, atomic nuclei (4-forms) are orbited by electrons (Dirac spinor pairs) on S^3 horizons. From the D7|D8 frame at the macroscopic level, information potentials are orbited by ERBs (black hole pairs) on S^6 horizons, and at the microscopic level, information potentials are orbited by EPR-entangled particle pairs (e.g., $\bar{p}p$ or BCS pairs) on S^6 horizons. The microscopic and macroscopic versions of the two principle reductions therefore generate four sectors, as summarised in Figure 13.

	$\mathrm{D8} \rightarrow \mathrm{D5}$	$\mathrm{D5} \rightarrow \mathrm{D2}$
macro	QG	GR
micro	BCS	QED

Figure 13. The macroscopic and microscopic versions of the $\mathrm{D}(n-3)$ perspective reductions, $\mathrm{D8} \rightarrow \mathrm{D5}$ and $\mathrm{D5} \rightarrow \mathrm{D2}$

References

Almheiri, A., Marolf, D., Polchinski, J., & Sully, J (2013). Black Holes: Complementarity or Firewalls? *Journal of High Energy Physics, 2*. http://dx.doi.org/10.1007/JHEP02(2013)062

Avelino, A., & Kirshner, R.P. (2016). *The Dimensionless Age of the Universe: a Riddle for Our Time*. arXiv:1607.00002v1 [astro-ph.CO]

Berry, M. V. (1986). Riemann's zeta function: a model for quantum chaos?. In *Quantum chaos and statistical nuclear physics* (pp. 1-17). Springer Berlin Heidelberg. http://dx.doi.org/10.1007/3-540-17171-1_1

Berry, M. V., & Keating, J. P. (1999). The Riemann zeros and eigenvalue asymptotics. *SIAM review*, *41*(2), 236-266. http://dx.doi.org/10.1137/S0036144598347497

Carroll, L. (1865). *Alice's Adventures in Wonderland*.

Christenson, J. H., Cronin, J. W., Fitch, V. L., & Turlay, R. (1964). Evidence for the 2π Decay of the K_2^0 Meson System. *Physical Review Letters, 13*, 138. http://dx.doi.org/10.1103/PhysRevLett.13.138

Conway, J., & Kochen, S. (2008). *The Strong Free Will Theorem*. http://dx.doi.org/10.1017/CBO9780511976971.014

Einstein, A. (1913). Entwurf einer verallgemeinerten Relativitätstheorie und eine Theorie der Gravitation. I. Physikalischer Teil von A. Einstein II. Mathematischer Teil von M. Grossmann (Outline of a Generalized Theory of Relativity and of a Theory of Gravitation. I. Physical Part by A. Einstein II. Mathematical Part by M. Grossmann). *Zeitschrift für Mathematik und Physik, 62*, 225–244, 245–261.

Einstein, A. (1915). *Erklärung der Perihelbewegung des Merkur aus der allgemeinen Relativitätstheorie* (Explanation of the Perihelion Motion of Mercury from the General Theory of Relativity). Preussische Akademie der Wissenschaften, Sitzungsberichte, 1915 (part 2), 831–839.

Einstein, A. (1915). *Feldgleichungen der Gravitation* (The Field Equations of Gravitation). Preussische Akademie der Wissenschaften, Sitzungsberichte, (part 2, pp. 844–847).

Einstein, A. (1923). *The Meaning of Relativity: Including the Relativistic Theory of the Non-Symmetric Field*. Fifth Edition. Princeton University Press. http://dx.doi.org/10.1007/978-94-011-6022-3

Einstein, A., Podolsky, B., & Rosen, N. (1935). Can quantum-mechanical description of physical reality be considered complete? *Phys. Rev., 47,* 777. http://dx.doi.org/10.1103/PhysRev.47.777

Gingerich, O., & Kenneth Lang, K. (1979). *A Source Book in Astronomy and Astrophysics*, 1900–1975. Harvard University Press. http://dx.doi.org/10.4159/harvard.9780674366688.c114

Glashow, S. L. (1961). Partial Symmetries of Weak Interactions. *Nuclear Physics, 22*(4), 579-588. http://dx.doi.org/10.1016/0029-5582(61)90469-2

Hamilton, A. J. (2014). Illusory horizons, thermodynamics, and holography inside black holes. In *Relativity and Gravitation* (pp. 99-110). Springer International Publishing. ttp://dx.doi.org/10.1007/978-3-31906761-2_13

Hawking, S. W. (1971). *Gravitational radiation from colliding black holes*. *Phys. Rev. Lett., 26*, 1344-1346. http://dx.doi.org/10.1103/PhysRevLett.26.1344

Hubble, E. (1929). A relation between distance and radial velocity among extra-galactic nebulae. *Proceedings of the National Academy of Sciences, 15*(3), 168–73. http://dx.doi.org/10.1073/pnas.15.3.168

Jensen, K., Karch, A., & Robinson, B. (2014). The holographic dual of a Hawking pair has a wormhole. *Physical Review D, 90*. http://dx.doi.org/10.1103/PhysRevD.90.064019

Kiefer, C. (2014). *Conceptual Problems in Quantum Gravity and Quantum Cosmology*. http://dx.doi.org/10.1155/2013/509316

Lemaître, G. (1927). *Un Univers homogène de masse constante et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extra-galactiques*. Annales de la Société Scientifique de Bruxelles (in French) 47: 49.

Maldacena, J. (1998). The Large N Limit of Superconformal field theories and supergravity. *Advances in Theoretical and Mathematical Physics, 2*, 231-252. http://dx.doi.org/10.4310/ATMP.1998.v2.n2.a1

Maldacena, J., & Susskind, L. (2013). Cool horizons for entangled black holes. *Fortschritte der Physik, 61*, 781. http://dx.doi.org/10.1002/prop.201300020

Newton, I. (1687). *Philosophiæ Naturalis Principia Mathematica*.

Penrose, R. (1959). The Apparent Shape of a Relativistically Moving Sphere. *Proceedings of the Cambridge Philosophical Society, 55*(01), 137–139. http://dx.doi.org/10.1017/S0305004100033776

Penrose, R. (1989). *The Emperor's New Mind: Concerning Computers, Minds and the Laws of Physics*. Oxford University Press.

Penrose, R. (1994). *Shadows of the Mind: A Search for the Missing Science of Consciousness*. Oxford University Press.

Penrose, R. (2004). *The Road to Reality: A Complete Guide to the Laws of the Universe*. Jonathan Cape, London.

Penrose, R. (2006). *Before the big bang: An outrageous new perspective and its implications for particle physics* (pp. 2759–2767). Edinburgh, Scotland: Proceedings of EPAC 2006.

Penrose, R. (2008). Causality, quantum theory and cosmology. In S. Majid (Ed), *On Space and Time* (pp141-195. p184). Cambridge University Press. http://dx.doi.org/10.1017/CBO9781139644259.004 and http://dx.doi.org/10.1017/CBO9781139197069.004

Perlmutter, S. et al. (The Supernova Cosmology Project). (1999). *Measurements of Omega and Lambda from 42 high redshift supernovae*. *Astrophysical J., 517*, 565-86.

Reiss, A. G. et al. (Supernova Search Team). (1998). *Observational evidence from supernovae for an accelerating universe and a cosmological constant*. *Astrophysical J., 116*, 1009-38. http://dx.doi.org/10.1086/300499

Salam, A. (1968). Elementary Particle Physics: Relativistic Groups and Analyticity. In N. Svartholm (Ed.), *Eighth Nobel Symposium*. Almquvist and Wicksell, Stockholm: p367.

Stanford, D. & Susskind, L. (2014). Complexity and Shock Wave Geometries. *Physical Review D.. 90*. http://dx.doi.org/10.1103/PhysRevD.90.126007

Stephens, C.R., 't Hooft, G., & Whiting, B. F. (1994). Black hole evaporation without information loss. *Class. Quant. Grav., 11*, 621. http://dx.doi.org/10.1088/0264-9381/11/3/014

Susskind, L. (2014). *Computational Complexity and Black Hole Horizons*. http://dx.doi.org/10.1002/prop.201500092

Susskind, L., Thorlacius, L., & Uglum, J. (1993). *The Stretched Horizon and Black Hole Complementarity*. *Phys. Rev. D, 48*, 3743. http://dx.doi.org/10.1103/PhysRevD.48.3743

Terrell, J. (1959). Invisibility of the Lorentz Contraction. *Physical Review, 116*(4), 1041–1045, http://dx.doi.org/10.1103/PhysRev.116.1041

Weinberg, S. (1967). *A Model of Leptons*. *Physical review Letters, 19*(21), 1264-1266. http://dx.doi.org/10.1103/PhysRevLett.19.1264

Notes

Note 1. Indeed, it is expected in the perspective model that all apparently fine-tuned values may be determined, and hierarchical problems resolved, in terms of the effective projection of values associated with the local, macroscopic frame into the remote or effectively microscopic frame.

Note 2. In a general relativistic setting, of course, there is strictly no such thing as gravitational acceleration.

Note 3. In QM this is absolute, Newtonian time, but in a metric treatment of QM it would be (quantum) proper time.

Note 4. This departure from CIQM would be lab-testable.