

# **How the McGucken Principle of a Fourth Expanding Dimension Generates and Unifies the Dual A-B Channel Structure of Physics**

*(A: Hamiltonian Operator Formulation & B: Lagrangian Path Integral),*

*(A: Noether Conservation Laws & B: Second Law of Thermodynamics),*

*(A: Heisenberg Picture & B: Schrödinger Picture),*

*(A: Particle Aspect & B: Wave Aspect),*

*(A: Local Microcausality & B: Nonlocal Bell Correlations),*

*(A: Rest Mass & B: Energy of Spatial Motion),*

*and (A: Time & B: Space)*

*via  $dx_4/dt = ic$*

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*Light Time Dimension Theory*

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*“The supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience.”*

— Albert Einstein, Herbert Spencer Lecture, Oxford, 1934

*“More intellectual curiosity, versatility and yen for physics than Elliot McGucken’s I have never seen in any senior or graduate student... I am absolutely delighted that this semester McGucken is doing a project with the cyclotron group on time reversal asymmetry.”*

— Dr. John Archibald Wheeler, Joseph Henry Professor of Physics, Princeton University

*“Behind it all is surely an idea so simple, so beautiful, that when we grasp it — in a decade, a century, or a millennium — we will all say to each other, how could it have been otherwise?”*

— John Archibald Wheeler

*“And yet it moves.” The fourth dimension moves.*

— Galileo Galilei · McGucken

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## Abstract

The McGucken Principle, which states that the fourth dimension is expanding in a spherically-symmetric manner at the velocity of light  $dx_4/dt = ic$ , generates and thus unifies a vast array of physical phenomena spanning the quantum, classical, relativistic, and thermodynamic realms, which, for the first time in the history of physics, are united under a single physical principle. Via its physical reality, the McGucken Principle gives us two channels of foundational sets of mathematical tools: Channel A (the algebraic-symmetry content): algebraic-symmetry itself, temporal uniformity, spatial homogeneity, spherical isotropy, Lorentz covariance, and the perpendicularity marker  $i$  for  $x_4$ ; and, on Channel B (the geometric-propagation content): Huygens' wavefront propagation, the forward light cone, and the monotonic arrow of time. Einstein stated in his 1934 Herbert Spencer Lecture at Oxford: *"The supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience."* The McGucken Principle  $dx_4/dt = ic$  meets Einstein's criterion with exactness and completeness. Throughout this paper,  $dx_4/dt = ic$  is formally demonstrated to generate, as parallel and independent theorems through two logically distinct channels of McGucken's single geometric principle, all of the following diverse physical phenomena: **(i)** the Hamiltonian operator formulation (Channel A) and the Lagrangian path integral (Channel B) of quantum mechanics; **(ii)** the time-symmetric Noether conservation laws (Channel A) and the time-asymmetric Second Law of Thermodynamics with its five arrows of time (Channel B); **(iii)** the Heisenberg picture (Channel A) and the Schrödinger picture (Channel B); **(iv)** the particle aspect (Channel A) and the wave aspect (Channel B) of quantum objects; **(v)** the local operator algebra of axiomatic quantum field theory (Channel A) and the nonlocal Bell correlations (Channel B) confirmed by Aspect (1982), Zeilinger (1998), and Hensen (loophole-free, 2015); **(vi)** the mass/energy duality  $E^2 = (pc)^2 + (mc^2)^2$  joining rest mass (Channel A, four-velocity budget in  $x_4$ ) with kinetic energy (Channel B, budget in three-space), with  $E = mc^2$  the Channel A limit at spatial rest; and **(vii)** the space/time duality of the Minkowski interval  $ds^2 = dx^2 - c^2dt^2$  joining time (Channel A, symmetry parameter) with space (Channel B, propagation domain of  $x_4$ ). None of these seven dualities derives from any of the others; all seven descend from  $dx_4/dt = ic$  as sibling consequences of the same dual-channel structure. Channel A is the algebraic-symmetry content of  $dx_4/dt = ic$ : temporal uniformity, spatial homogeneity, spherical isotropy as static symmetry, Lorentz covariance,  $U(1)$  phase invariance, Clifford-algebraic extensions to  $SU(2)$  and  $SU(3)$ , and diffeomorphism covariance. Channel B is the geometric-propagation content: spherical expansion at rate  $c$  from every point, Huygens' secondary wavelets, and monotonic one-way advance. The *McGucken Equivalence* identifies quantum non-locality as the three-dimensional shadow of four-dimensional  $x_4$ -coincidence on the light cone: photons at  $|v| = c$  satisfy  $dx_4/d\tau = 0$ , so two photons co-emitted at

a common event share the  $x_4$ -coordinate forever regardless of spatial separation, making Bell correlations  $E(a, b) = -\cos \theta_{ab}$  a geometric consequence rather than “spooky action.” Wave/particle duality, which the physics community has accepted since Bohr’s 1927 Como lecture as the standard form of dual-structure reading in physics, serves as the rhetorical precedent that licenses the same logical move at the other six levels. At the thermodynamic level the dual-channel structure dissolves the Loschmidt reversibility objection of 1876 and the Penrose Past Hypothesis as theorems rather than boundary conditions. A Compton-frequency coupling predicts a species-independent temperature-persistent diffusion  $D^{(McG)}_x = \varepsilon^2 c^2 \Omega / (2\gamma^2)$  as a laboratory-testable signature.

Level	Channel A output	Channel B output
1. Foundational QM	Hamiltonian operator formulation	Lagrangian path integral
2. Mechan- ics/Thermodynamics	Noether conservation laws	Second Law + arrows of time
3. Dynamical QM	Heisenberg picture	Schrödinger picture
4. Ontological QM	Particle aspect	Wave aspect
5. Causal/correlational QM	Local microcausality	Nonlocal Bell correlations
6. Mass/energy	Rest mass $m$ ( $u^\mu u_\mu$ budget in $x_4$ )	Energy of spatial motion (budget in $x$ )
7. Space/time	Time $t$ (symmetry parameter)	Space $x$ (propagation domain of $x_4$ )

The present paper is the master synthesis of a corpus of companion papers each developing a specific level in technical detail: Level 3 (foundational QM, Hamiltonian/Lagrangian through two disjoint routes to  $[\hat{q}, \hat{p}] = i\hbar$ ) is developed at full length in [MG-TwoRoutes]; the four-sector Lagrangian  $\mathcal{L}_{McG} = \mathcal{L}_{kin} + \mathcal{L}_{Dirac} + \mathcal{L}_{YM} + \mathcal{L}_{EH}$  uniquely forced by  $dx_4/dt = ic$  is developed in [MG-Lagrangian]; Level 6 (locality/nonlocality with the six senses of geometric nonlocality of the McGucken Sphere and the Two Laws of Nonlocality) is developed in [MG-Nonlocality] and in §V.8 of [MG-TwoRoutes]; the Level 7 thermodynamic extension with the Loschmidt resolution and Past Hypothesis dissolution is developed in [MG-ConservationSecondLaw]; the Feynman-diagram apparatus of quantum field theory is derived as theorems of  $dx_4/dt = ic$  in [MG-FeynmanDiagrams]. The present paper situates all seven dualities as parallel sibling consequences of the same geometric principle  $dx_4/dt = ic$ .

**Keywords:** McGucken Principle;  $dx_4/dt = ic$ ; dual-channel structure; mass/energy duality; Minkowski interval; Hamiltonian/Lagrangian formulations; Heisenberg/Schrödinger pictures; wave/particle duality; locality and nonlocality; McGucken Equivalence; Two McGucken Laws of Nonlocality; Noether conservation laws; Second Law of Thermodynamics; arrows of time; Loschmidt objection; Past Hypothesis; Compton-coupling diffusion; priority record; Princeton origin.

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## **I. Introduction**

### **I.1 The Structural Precedent: Wave/Particle Duality**

Since Bohr's 1927 Como lecture [1] quantum mechanics has operated on a structural foundation that admits two logically distinct readings of a single physical object. A photon propagating through a double-slit apparatus exhibits wave-like interference when the apparatus is configured to detect the pattern on the screen, and exhibits particle-like localization when the apparatus is configured to record which slit the photon traversed. The physical photon is one thing; the two descriptions are two readings of it, selected by experimental context. No contradiction arises because the readings are not competing descriptions of a single measurement outcome but simultaneous structural features of the object that can be independently queried.

This structural move — single physical object, dual structural reading, experimental context selects which reading is foregrounded — has been standard physics for ninety-nine years. Copenhagen accepts it. Many-worlds accepts it. Bohmian mechanics accepts it. QBism accepts it. The interpretations disagree about what the readings ontologically mean but agree that the dual structure is there. Referees of quantum mechanics papers do not reject submissions on the grounds that a single equation admitting two structurally different readings constitutes a logical contradiction; if they did, the field would have stalled in 1927.

The present paper takes wave/particle duality as the precedent that licenses a broader claim: the dual-reading structure is not confined to the ontological level of quantum objects but is a general feature of physics, generated by the geometric structure of the underlying principle from which physics descends. That principle is  $dx_4/dt = ic$ , the McGucken Principle [2, 3]: the fourth dimension advances at the velocity of light, spherically symmetrically from every spacetime point.

### **I.2 The Dual-Channel Content of $dx_4/dt = ic$**

The principle  $dx_4/dt = ic$  carries two logically distinct informational contents in a single geometric statement:

**$dx_4/dt = ic$**  → *Channel A (algebraic-symmetry):* uniform rate, invariant under

spacetime isometries; and *Channel B (geometric-propagation)*: spherical expansion at rate  $c$  from every point.

The two channels unpack two distinct aspects of the same statement. Channel A extracts the uniformity and invariance features — the rate  $ic$  is independent of time, position, direction, and choice of inertial frame, and has no preferred phase origin on the complex coordinate  $x_4 = ict$ . These features generate the spacetime symmetry groups (Poincaré, gauge, diffeomorphism) whose Noether currents are the conservation laws of physics. Channel B extracts the propagation features —  $x_4$  advances in a spherically symmetric wavefront from every spacetime point, the resulting McGucken Sphere grows monotonically, and the advance is one-way at  $+ic$  rather than  $-ic$ . These features generate Huygens’ secondary-wavelet structure, the path-integral sum over paths, the isotropic spatial random walk producing Brownian motion, and the monotonic entropy increase of the Second Law.

### I.3 Seven Levels of Dual-Channel Duality

The dual-channel structure generates structurally parallel dualities at **seven** levels of physical description.

Level	Channel A output	Channel B output
1. Foundational QM	Hamiltonian operator formulation	Lagrangian path integral
2. Mechan- ics/Thermodynamics	Noether conservation laws	Second Law + arrows of time
3. Dynamical QM	Heisenberg picture	Schrödinger picture
4. Ontological QM	Particle aspect	Wave aspect
5. Causal/correlational QM	Local microcausality	Nonlocal Bell correlations
6. Mass/energy	Rest mass $m$ ( $u^\mu u_\mu$ budget in $x_4$ )	Energy of spatial motion (budget in $x$ )
7. Space/time	Time $t$ (symmetry parameter)	Space $x$ (propagation domain of $x_4$ )

**Table 1.** *The dual-channel structure of  $dx_4/dt = ic$  across seven levels of physics. None of these dualities derives from any of the others; all descend from the Principle as parallel sibling consequences.*

The ordering leads with Level 1 (Hamiltonian/Lagrangian formulations of quantum mechanics) and Level 2 (Noether conservation laws and the Second Law of

Thermodynamics) because these are the levels at which the dual-channel unification is most structurally consequential: Level 1 unifies the two ninety-eight-year-coexisting formulations of quantum mechanics through disjoint derivational chains to the common identity  $[\hat{q}, \hat{p}] = i\hbar$ , and Level 2 pairs a time-symmetric feature (conservation laws) with a time-asymmetric feature (Second Law), dissolving the 150-year-old Loschmidt reversibility objection. Levels 3 through 5 develop three further within-QM dualities: the Heisenberg/Schrödinger picture at the dynamical level (Level 3), the wave/particle aspects at the ontological level (Level 4 — the structural precedent the physics community has accepted since Bohr’s 1927 Como lecture), and the local operator algebra / nonlocal Bell correlations at the causal/correlational level (Level 5, the feature Einstein identified in 1935 and Bell sharpened in 1964). Levels 6 and 7 are the kinematic dualities (mass/energy and space/time) — the two dualities that Einstein’s 1905 *Annus Mirabilis* first identified as distinct objects joined by a single geometric identity, both of which appear here as parallel sibling consequences of the same dual-channel structure that generates Levels 1 through 5.

The *physical* reach of McGucken’s Principle becomes clearest under the counterfactual test: strip the universe of the physical reality of  $x_4$ ’s expansion and treat  $x_4 = ict$  as a mere coordinate convention in the manner of Minkowski 1908 and Pauli 1921, and ask what remains. The answer is that Channel B evaporates entirely. The forward light cone, which the present paper identifies as the three-dimensional cross-section of  $x_4$ ’s physical expansion (Proposition 11), is not a coordinate-free object that can be recovered from the metric sign convention alone; it *is* the surface traced out as  $x_4$  advances at rate  $c$  from a source event. The McGucken Sphere, Huygens’ secondary wavelet, the forward light cone, and the support of the retarded Green’s function of the wave equation are one geometric object under four names, and that object is the physical content of  $dx_4/dt = ic$ . Take the physical reading away and there is no geometric object of propagation — no wavefront, no light cone, no Huygens principle in its geometric form, no random walk from  $x_4$ ’s expansion, no photon stationarity, no shared  $x_4$ -coordinate for co-emitted photons, no McGucken Equivalence, no Two Laws of Nonlocality, and no strict  $dS/dt > 0$  result. Channel B is wholly constituted by the physical expansion of  $x_4$ ; it has no coordinate-only substitute. Channel A loses its derivational chains as well. The Minkowski-signature action — whose isometries are the Poincaré group whose Noether currents are the ten kinematic conservation laws, and whose invariances generate the Stone-theorem translation groups whose self-adjoint generators are the four-momentum operators — is itself the integrated form of  $dx_4/dt = ic$  with  $x_4 = ict$ . The minus sign on  $c^2dt^2$  in  $ds^2 = dx^2 - c^2dt^2$  is the algebraic shadow of  $i^2 = -1$ , and  $i^2 = -1$  is the perpendicularity marker of  $x_4$  (Proposition 6). Without the physical expansion of  $x_4$ , there is no  $x_4 = ict$  as a dynamical statement, no  $i$  as a perpendicularity marker, and no principled reason for the action to carry the Minkowski signature at all. The Poincaré group,

the Stone-theorem unitary representation, the canonical commutation relation  $[\hat{q}, \hat{p}] = i\hbar$ , the microcausality condition on spacelike-separated field operators, the  $U(1)$  gauge structure on the  $x_4$ -phase, the Clifford-algebraic extension to  $SU(2)$  and  $SU(3)$ , and the diffeomorphism covariance of the smooth four-manifold all inherit their geometric grounding from  $dx_4/dt = ic$ . Channel A's outputs survive as *calculational results* in textbook field theory, which writes down the Minkowski action as a postulate and works forward from there; but their *derivational origin in the physical expansion of  $x_4$*  is lost entirely, and with it the explanation of why the action has the signature it has, why the  $i$  in  $\exp(-ia\hat{p}/\hbar)$  is the imaginary unit rather than an arbitrary constant, and why Noether's theorem yields exactly the conservation laws it does and no others. The full loss is therefore symmetric across the two channels: Channel B evaporates as a geometric object; Channel A evaporates as a derivational chain; both evaporate as contents of the dual-channel structure this paper develops. The physical interpretation of  $dx_4/dt = ic$  is therefore not decorative metaphysics layered over a coordinate convention; it is the load-bearing content from which the geometry of propagation, the causal structure of space-time, the thermodynamic arrow, the nonlocal correlations of entangled systems, and the framework's one falsifiable empirical prediction all descend. To recognize  $dx_4/dt = ic$  as a statement about the physical behavior of the fourth dimension is to recognize that the light cone, the wavefront, the Bell correlation, the arrow of time, the Second Law, and the Compton-coupling diffusion are seven faces of a single geometric fact. To treat it as a mere mathematical trick is to lose that fact, and with it the unified physical picture this paper develops across all seven levels. If the goal of physical theory is to describe the physical world — the world of photons on expanding wavefronts, of entangled pairs whose polarizations remain coupled across kilometers, of entropy that always increases, of the second hand that moves in one direction only — then the physical reading of  $dx_4/dt = ic$  is not an interpretive preference but the necessary condition for the description to exist at all. Strip the physical expansion of  $x_4$  and ask what remains in the above table: not one of the seven Channel A outputs or the seven Channel B outputs survives as a *derived* feature of physics. The fourteen cells of Table 1 are fourteen consequences of one physical fact, and the fact is that the fourth dimension is expanding at the velocity of light in a spherically symmetric manner. So it is that the physical reading of  $dx_4/dt = ic$  is not an interpretive preference but the necessary condition for the description to exist at all. Ergo, via the empirical evidence of all observational physical phenomena — the wavefronts of the double-slit experiment, the null worldlines of photons in relativity, the monotonic increase of entropy in every closed system ever measured, the Bell-inequality violations confirmed by Aspect (1982), Zeilinger (1998), and Hensen (2015), the conservation of energy and momentum and angular momentum and charge across every experimental test ever conducted, and the seven dualities of physics this paper derives — we present the undeniable physical principle: *the fourth dimension is expanding at the velocity*

of light in a spherically symmetric manner. Einstein wrote:

“All knowledge of reality starts from experience and ends in it. Propositions arrived at by purely logical means are completely empty as regards reality. Because Galileo saw this, and particularly because he drummed it into the scientific world, he is the father of modern physics — indeed, of modern science altogether.”

— *Albert Einstein (1879–1955), in Einstein’s Essays in Science, translated by Alan Harris (1934)*

The McGucken Principle began in physical reality by studying and contemplating light in quantum mechanics, relativity, and thermodynamics, and it ends by providing an equation shown to naturally lead to all that which we physically experience.

## **I.4 Structure of the Paper**

§II develops Level 1 (Hamiltonian/Lagrangian formulations of quantum mechanics) with two disjoint chains to  $[\hat{q}, \hat{p}] = i\hbar$ . §III develops Level 2 (the thermodynamic extension: Noether conservation laws and Second Law of Thermodynamics) including the Loschmidt resolution and Past Hypothesis dissolution. §IV develops Level 3 (Heisenberg/Schrödinger pictures). §V develops Level 4 (wave/particle duality) — the structural precedent accepted since Bohr’s 1927 Como lecture. §VI develops Level 5 (locality/nonlocality) including the McGucken Equivalence and the Two McGucken Laws of Nonlocality. §VII develops Levels 6 and 7 (the kinematic dualities of mass/energy and space/time). §VIII develops the Compton-coupling diffusion prediction. §IX states the novelty against prior art at each level and summarizes the novelty of the synthesis. §X inventories the physics gained by recognizing the physical reading of  $dx_4/dt = ic$  and connects the framework to Einstein’s 1934 criterion for what a physical theory should achieve. §XI concludes.

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## **II. The Foundational Duality: Hamiltonian and Lagrangian Formulations (Level 1)**

Both formulations descend as independent theorems through disjoint intermediate chains. The Hamiltonian route uses Channel A; the Lagrangian route uses Channel B. Full development in [MG-TwoRoutes]; here we summarize.

### **II.1 The Hamiltonian route (Channel A, five propositions)**

**Proposition 6 (Minkowski metric).** *The integrated form  $x_4 = ict$  evaluated in  $d\ell^2 = dx_1^2 + dx_2^2 + dx_3^2 + dx_4^2$  with  $dx_4 = ic dt$  produces  $ds^2 = dx_1^2 + dx_2^2 + dx_3^2 - c^2dt^2$ . The minus sign is the shadow of  $i^2 = -1$ , the perpendicularity marker of*

$x_4$ . See [MG-Proof, Theorem 1].

**Proposition 7 (Momentum operator as translation generator).** Spatial translations are represented by  $U(a) = \exp(-ia\hat{p}/\hbar)$  by Stone's theorem. The  $i$  inherits from Proposition 6's perpendicularity marker; the  $\hbar$  inherits from the action per  $x_4$ -cycle at the Planck frequency [MG-Commut, §IV]; [MG-Constants, §V].

**Proposition 8 (Momentum operator in configuration representation).** In Schrödinger representation with  $(U(a)\psi)(q) = \psi(q - a)$ , differentiating at  $a = 0$  yields  $\hat{p} = -i\hbar \partial/\partial q$ .

**Proposition 9 (Canonical commutation relation).**  $*[\hat{q}, \hat{p}] f = q(-i\hbar \partial_q f) - (-i\hbar \partial_q)(qf) = i\hbar f$ . Therefore  $[\hat{q}, \hat{p}] = i\hbar \mathbb{1}$ .

**Proposition 10 (Stone-von Neumann uniqueness).** Proposition 9 with irreducibility forces the Schrödinger representation to be essentially unique up to unitary equivalence. Hamiltonian route closes.

## II.2 The Lagrangian route (Channel B, six propositions)

**Proposition 11 (Huygens' principle from  $x_4$ -spherical expansion).** The three-dimensional cross-section at observer time  $t$  from emission  $p_0$  is the McGucken Sphere  $\Sigma_+(p_0)$  of radius  $c(t - t_0)$ . This is geometrically the forward light cone and structurally Huygens' secondary wavelet [MG-HLA, Theorem 1].

**Proposition 12 (Iterated Huygens generates all paths).** Dividing  $[t_i, t_f]$  into  $N$  intervals and applying Huygens at each step, the  $N \rightarrow \infty$  limit yields all continuous paths from  $q_i$  to  $q_f$ . The Feynman sum over paths is geometrically the sum over chains of McGucken Spheres [MG-PathInt, §III].

**Proposition 13 (Accumulated  $x_4$ -phase gives the Feynman weight).** The  $x_4$ -oscillation at the Compton frequency  $\omega_C = mc^2/\hbar$  produces an accumulated phase per interval  $\varepsilon$  of  $\exp(i mc^2 \gamma^{(-1)} \varepsilon/\hbar)$ . Non-relativistically  $mc^2 \gamma^{(-1)} \approx mc^2 - \frac{1}{2}mv^2$ . The first term absorbs as global phase; the second is  $-T$ . With potential  $V$ , the short-interval phase is  $\exp((i\varepsilon/\hbar)(T - V)) = \exp((i\varepsilon/\hbar) L_{\text{classical}})$ . Integrated:  $\text{phase}(\text{path}) = \exp(iS[\text{path}]/\hbar)$ .

**Proposition 14 (Feynman path integral).** Composing Propositions 12 and 13 and taking  $N \rightarrow \infty$ :  $K(q_f, t_f; q_i, t_i) = \int \mathcal{D}x(t) \exp(iS[x(t)]/\hbar)$ . The Feynman path integral is a theorem of  $dx_4/dt = ic$ .

**Proposition 15 (Schrödinger equation from short-time kernel).** Gaussian integration of  $K_\varepsilon$  against  $\psi(q', t)$  to first order in  $\varepsilon$  yields  $i\hbar \partial\psi/\partial t = -(\hbar^2/2m) \partial^2\psi/\partial q^2 + V(q) \psi$ .

**Proposition 16 (CCR via Schrödinger kinetic term).** Identifying  $-(\hbar^2/2m) \partial^2/\partial q^2$  with  $\hat{p}^2/(2m)$  forces  $\hat{p} = -i\hbar \partial/\partial q$ . Direct computation yields  $[\hat{q}, \hat{p}] = i\hbar$ . The Lagrangian route closes at the same identity through disjoint intermediate

structures.

### II.3 Structural comparison of the two routes

The two routes share  $dx_4/dt = ic$  and  $[\hat{q}, \hat{p}] = i\hbar$ . Every intermediate structure is disjoint: Minkowski metric versus Huygens; Stone versus iterated spherical expansion; direct commutator versus Gaussian integration; Stone-von Neumann versus Schrödinger extraction. The factor  $i$  traces on both routes to  $x_4$ 's perpendicularity marker;  $\hbar$  to the action per  $x_4$ -cycle at the Planck frequency. Two disjoint proofs of the same theorem: the structural signature of a correct foundation. Full fifteen-framework completeness argument in [MG-TwoRoutes, §§IV-VI].

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## III. The Thermodynamic Extension: Conservation Laws and the Second Law (Level 2)

Level 2 is the first level at which the dual-channel structure extends outside quantum mechanics. It pairs a time-symmetric feature (Noether conservation laws) with a time-asymmetric feature (Second Law and five arrows of time), and in doing so resolves the 150-year-old Loschmidt reversibility objection. Full development in [MG-ConservationSecondLaw].

### III.1 Channel A: the Noether catalog

**Proposition 21 (The ten Poincaré charges).** *Temporal uniformity implies time-translation invariance, implying  $dE/dt = 0$ . Spatial homogeneity implies  $dP/dt = 0$ . Spherical isotropy implies  $dJ_{ij}/dt = 0$ . Lorentz covariance implies  $dK_i/dt = 0$  on shell.*

**Proposition 22 (The internal symmetries).** *\*Absence of a preferred phase origin on  $x_4 = ict$  is global  $U(1)$  phase invariance, gauged to local  $U(1)$ , generating Maxwell's equations and  $dQ_{EM}/dt = 0$ . The Clifford structure of  $Cl(1, 3)$  extends to  $SU(2)_L$  and  $SU(3)_c$ , with conserved weak isospin and color charges.\**

**Proposition 23 (Diffeomorphism invariance).** *\*Coordinate-independence of  $x_4$ 's advance implies diffeomorphism invariance of the action, implying  $\nabla_\mu T^{\mu\nu} = 0$  by Noether's second theorem.\**

Full twelve-fold Noether catalog in [MG-Noether]. Each conservation law is time-symmetric.

### III.2 Channel B: the Second Law

**Proposition 24 (Spherical isotropic random walk).** *The spherical symmetry of  $x_4$ 's expansion contains no preferred spatial direction. The spatial projection of each particle's  $x_4$ -driven displacement is a vector of magnitude  $r = c\Delta t/\gamma$  in a*

direction uniformly distributed over  $S^2$ . Iterated  $N$  times:  $\langle |x_N - x_0|^2 \rangle = Nr^2 = Dt$  with  $D = c^2\Delta t/\gamma^2$ .

**Proposition 25 (Boltzmann-Gibbs entropy growth).** *The central limit theorem yields a Gaussian of variance  $Dt$  per dimension. The Boltzmann-Gibbs entropy is  $S(t) = (3/2) k_B \ln(4\pi eDt) + \text{const}$ , with  $dS/dt = 3k_B/(2t) > 0$  strictly for all  $t > 0$ . Not on average, not statistically — absolutely. Entropy cannot decrease because  $x_4$  cannot retreat.*

**Proposition 26 (Shannon entropy on the McGucken Sphere).** *For a photon emitted isotropically from  $p_0$ , the photon rides the McGucken Sphere of radius  $R = c(t - t_0)$  with uniform distribution. Shannon entropy  $S(t) = k_B \ln(4\pi(ct)^2) + \text{const}$ , with  $dS/dt = 2k_B/t > 0$ . The entropy grows because the sphere grows; the sphere grows because  $x_4$  advances at rate  $c$ .*

### III.3 The five arrows of time

All five classical arrows trace to the single geometric fact that  $x_4$  advances monotonically at rate  $c$ :

1. **Thermodynamic arrow:** direction of  $dS/dt > 0$  (Propositions 25, 26).
2. **Radiative arrow:** direction of outgoing retarded Green's function; advanced solutions are not physically realized because they would require  $x_4$  retreat.
3. **Causal arrow:** direction of propagation into the forward light cone, which is the expanding McGucken Sphere.
4. **Cosmological arrow:** direction of cosmological expansion, macroscopic expression of every particle's forced advance through  $x_4$  at rate  $c$ .
5. **Psychological arrow:** memory encodes events in the past light cone; the causal arrow instantiated in neural systems.

Reichenbach (1956) unified the thermodynamic and causal arrows; Penrose (1989) grounded the thermodynamic arrow in cosmological boundary conditions but not in a dynamical principle; the McGucken Principle unifies all five as consequences of a single equation.

### III.4 Resolution of the Loschmidt objection

Loschmidt (1876) observed that if microscopic dynamics are time-reversal symmetric, the strict H-theorem cannot follow rigorously — any entropy-increasing trajectory is matched by a time-reversed entropy-decreasing trajectory of equal statistical weight. Boltzmann's 1877 response resolves the tension statistically but not absolutely, and requires the Past Hypothesis as auxiliary input.

The tension presupposes that the time-symmetric conservation laws and the time-asymmetric Second Law have a common origin that must itself be either time-symmetric or time-asymmetric. Under the McGucken framework, they have a common origin —  $dx_4/dt = ic$  — but they descend through two logically

distinct channels. Channel A reads the principle through its algebraic-symmetry content, which is time-symmetric (the Poincaré group includes T), producing time-symmetric conservation laws. Channel B reads the same principle through its geometric-propagation content, which is time-asymmetric ( $x_4$  advances at +ic monotonically), producing the time-asymmetric Second Law.

This is the same structural move wave/particle duality makes. The photon through the double-slit is not “really” a wave or “really” a particle; it has both simultaneously. The dynamics of the universe is not “really” time-symmetric or “really” time-asymmetric; it has both Channel A (symmetric) and Channel B (asymmetric) content simultaneously. A referee who accepts wave/particle duality without objection cannot consistently reject the conservation-law/Second-Law duality on “which reading is privileged” grounds: the structural logic is identical.

### **III.5 Dissolution of the Past Hypothesis**

For a system whose entropy increases through Channel B, the lowest-entropy moment is by construction the moment when  $x_4$ 's expansion begins from the initial configuration. For the universe as a whole, this moment is identified with the hot Big Bang. The universe began in a low-entropy state not as a fine-tuned boundary condition but as the geometric starting point of  $x_4$ 's expansion.

Penrose's 1989 figure of  $10^{(-10^{123})}$  for the improbability of the initial state assumes a uniform prior over microstates consistent with the macroscopic initial conditions. Under the McGucken framework the prior is not uniform — the geometric structure of  $x_4$ 's expansion selects the lowest-entropy moment as its starting point. The Past Hypothesis is not disproved; it is derived.

## **IV. The Dynamical Duality: Heisenberg and Schrödinger Pictures (Level 3)**

The Heisenberg picture places evolution on operators:  $\hat{A}(t) = U^\dagger(t) \hat{A}(0) U(t)$  with  $U(t) = \exp(-i\hat{H}t/\hbar)$ . The Schrödinger picture places evolution on states:  $|\psi(t)\rangle = U(t)|\psi(0)\rangle$ . Under the dual-channel reading, the Heisenberg picture is the Channel A reading of  $x_4$ 's advance (operator-algebraic, symmetry-generator content), and the Schrödinger picture is the Channel B reading (state-propagation, wavefront-evolution content). The Hamiltonian  $\hat{H}$  inherits its factor  $i/\hbar$  from the perpendicularity marker of  $x_4$  through the same chain as  $\hat{p}$ . Full formal proof (Theorem V.7.3) that the two pictures are two readings of the same physical  $x_4$ -advance in [MG-TwoRoutes, §V.7].

## **V. Wave/Particle Duality as the Structural Precedent (Level 4)**

We develop Level 4 first because it is the level the physics community has accepted for ninety-nine years. Establishing wave/particle duality as a Channel-A/Channel-B reading licenses the framework at every other level.

### **V.1 Channel B generates the wave aspect**

The spherical symmetry of  $x_4$ 's expansion from every spacetime point is Huygens' principle. Every event  $p_0$  is the center of a McGucken Sphere  $\Sigma_+(p_0)$  of radius  $c(t - t_0)$ . The retarded Green's function of the wave equation is  $G_+(x - x', t - t') = \delta(t - t' - |x - x'|/c) / (4\pi|x - x'|)$ . Iterated Huygens expansion generates wavefront propagation. The double-slit interference pattern is the constructive and destructive superposition of McGucken Spheres from the two slits. The de Broglie wavelength  $\lambda_{dB} = h/p$  is the  $x_4$ -phase accumulation rate per unit of spatial motion, derived as a theorem of  $dx_4/dt = ic$  through the Compton-frequency coupling [MG-deBroglie, Theorem 1].

The wave aspect of quantum objects is the Channel B reading of  $dx_4/dt = ic$ .

### **V.2 Channel A generates the particle aspect**

The invariance of  $x_4$ 's advance under spacetime translations generates, by Stone's theorem, a strongly continuous unitary group  $U(a) = \exp(-ia\hat{p}/\hbar)$  with self-adjoint four-momentum generators  $\hat{p}^\mu$ . Localized detection events are eigenvalue events of the position observable  $\hat{q}$ . Quantized energy and momentum exchanges in photoelectric emission (Einstein 1905), Compton scattering (Compton 1923), and every "particle-like" process are eigenvalue exchanges of Channel A's algebraic observables [MG-Compton].

The particle aspect of quantum objects is the Channel A reading of  $dx_4/dt = ic$ .

### **V.3 Both readings are simultaneous, both are real**

A photon traversing a double-slit apparatus has both readings simultaneously. Channel B gives the spherical Huygens wavelets producing the interference pattern. Channel A gives the localized detection event at a specific screen pixel producing the discrete particle click. Which-path measurement foregrounds Channel A and suppresses the Channel B interference; open-slit interference observation foregrounds Channel B. No contradiction arises because the readings are not competing descriptions but structural features that can be independently queried. This is the structural precedent accepted since 1927. The dual-channel framework extends it to six other levels.

## VI. The Causal/Correlational Duality: Locality and Nonlocality (Level 5)

The sixth level is the coexistence of local microcausality and nonlocal Bell correlations — Einstein’s “spooky action at a distance” (1935) [5] sharpened by Bell (1964) [6] into the experimentally decisive inequality, confirmed by Aspect (1982) [7], Zeilinger (1998) [8], Hensen (loophole-free, 2015) [9], and the 2022 Nobel-recognized program of Clauser–Aspect–Zeilinger.

Under the dual-channel framework these two facts are not in tension: they are Channel A and Channel B readings of the same geometric fact, just as the wave and particle aspects of Level 4 are not in tension. Full treatment including the six senses of geometric nonlocality of the McGucken Sphere (foliation leaf, level set of a distance function, Huygens caustic, Legendrian submanifold, conformal pencil member, null-hypersurface cross-section), the double-slit/delayed-choice/quantum-eraser resolutions, and the New-York–Los-Angeles falsification challenge in [MG-Nonlocality]; Copenhagen-resolution supplement with explicit singlet-correlation derivation in [MG-NonlocCopen]; four-level within-QM context in [MG-TwoRoutes, §V.8].

### VI.1 Channel A: local microcausality

**Proposition 17 (Local operator algebra).** *Lorentz covariance of the rate, the Minkowski metric (Proposition 6), and spatial-translation invariance (Proposition 7) generate the local operator structure of relativistic QFT. Field operators  $\hat{\phi}(x)$  are Lorentz-covariant; causal influence propagates only within the forward light cone; therefore microcausality  $[\hat{\phi}(x), \hat{\phi}(y)] = 0$  for spacelike-separated  $x, y$ . Local gauge invariance, from the absence of a preferred phase origin on  $x_4 = ict$  (Proposition 22), forces Yang–Mills structure with local commutation relations on gauge connections.*

This is the content of axiomatic QFT (Wightman axioms, Haag–Kastler algebras). Channel A is the local reading of  $dx_4/dt = ic$ .

### VI.2 Channel B: nonlocal correlations via the McGucken Equivalence

**Proposition 18 (Photon  $x_4$ -stationarity).** *A photon at  $|v| = c$  satisfies  $u^\mu u_\mu = -c^2$  with the entire budget carried by spatial motion. Therefore  $dx_4/d\tau = 0$  for a photon. A photon does not advance in  $x_4$ . It rides the McGucken Sphere of radius  $R = ct$  expanding from its emission event at  $x_4 = ict_0$ , and its  $x_4$ -coordinate remains fixed at  $ict_0$  throughout its worldline.*

**Proposition 19 ( $x_4$ -coincidence of co-emitted photons).** *Two photons A and B created at common  $p_0 = (x_0, t_0)$  satisfy  $x_4^\wedge(A)(\tau) = x_4^\wedge(B)(\tau) = ict_0$  for all  $\tau$ , regardless of three-dimensional separation. The four-dimensional interval  $ds^2_{AB}$*

$= (\Delta x)^2 - c^2(\Delta t)^2 + (\Delta x_4)^2 = 0$  because  $\Delta x_4 = 0$  and the spatial-temporal terms cancel along the light cone.

**Proposition 20 (The McGucken Equivalence).** *Quantum nonlocality, as measured by  $E(a, b) = -\cos \theta_{ab}$  for entangled photon pairs, is the three-dimensional shadow of four-dimensional  $x_4$ -coincidence on the light cone. The “spooky action at a distance” is not action at a distance at all; it is coincidence in a dimension the three-dimensional observer does not see [MG-Equiv].*

This is the *McGucken Equivalence*. It resolves the tension Einstein identified in 1935: no superluminal signal, no hidden-variable violation, no retrocausal influence. The two photons are, in four-dimensional geometry, at the same  $x_4$ -coordinate throughout their existence.

### VI.3 Dual-channel coexistence, not competition

Channel A (microcausality) and Channel B (nonlocal correlations) do not compete. They are simultaneous readings of  $dx_4/dt = ic$  through its algebraic-symmetry and geometric-propagation contents. The Bell experiments confirm the Channel B reading; standard QFT confirms the Channel A reading. No contradiction arises because the two readings query different structural aspects of the same geometric fact.

Feynman diagrams provide an additional structural view: each propagator rides a McGucken Sphere (Channel B), each vertex is a Sphere intersection (Channel B, geometrically parallel to entanglement swapping), and the overall diagrammatic structure respects microcausality (Channel A) through the  $ic$  prescription and the light-cone support of the propagator. Full development as chains of intersecting McGucken Spheres in [MG-FeynmanDiagrams, §VI].

### VI.4 The Two McGucken Laws of Nonlocality

**Theorem 3 (First McGucken Law of Nonlocality:  $x_4$ -coincidence persistence).** *Let  $A$  and  $B$  be two worldlines originating at common  $p_0 = (x_0, t_0)$  and propagating at  $|v| = c$ . Then for all  $\tau > 0$ ,  $x_4^{\wedge}(A)(\tau) = x_4^{\wedge}(B)(\tau) = ict_0$ , independent of three-dimensional separation. The four-dimensional interval  $ds^2_{AB} = 0$  throughout: three-dimensional spatial separation does not produce  $x_4$ -separation for objects traveling at  $c$ .*

**Proof.** By Proposition 18,  $dx_4/d\tau = 0$  along every worldline at  $|v| = c$ . Integrating from common  $p_0$  yields  $x_4(\tau) = ict_0$  for both. The spatial-temporal cancellation holds along the light cone. ■

**Theorem 4 (Second McGucken Law of Nonlocality: Bell correlations as  $x_4$ -shadow).** *The measurable three-dimensional correlations between observables on two worldlines satisfying the First Law are the three-dimensional projections of their four-dimensional  $x_4$ -coincidence. For entangled photon pairs:  $E(a, b) =$*

$-\cos \theta_{ab}$ , saturating Tsirelson's  $2\sqrt{2}$  CHSH bound and exceeding Bell's  $|S| \leq 2$ . Confirmed by Aspect (1982), Zeilinger (1998), Hensen loophole-free (2015). The correlation is not reducible to any local-hidden-variable model because the two observables are, in four dimensions, at the same  $x_4$ -coordinate — a geometric identity rather than a causal link.

**Corollary 2 (No superluminal signal).**  $x_4$ -coincidence is a geometric identity, not a causal influence. Marginal distributions at A are independent of measurement choices at B. The McGucken Equivalence is consistent with relativistic causality while violating Bell's local-hidden-variable bound.

## VI.5 Structural placement of the Laws

The Two Laws stand alongside the other derived structures of the dual-channel framework:  $[\hat{q}, \hat{p}] = i\hbar$  at Level 1 (Propositions 9 and 16, two routes); wave/particle at Level 4 (§III); First and Second Laws of Nonlocality at Level 5 (Theorems 3 and 4);  $dS/dt > 0$  strict and the Noether catalog at Level 2 (Propositions 21–26). Each is a derived theorem of  $dx_4/dt = ic$ .

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## VII. The Kinematic Dualities: Mass/Energy and Space/Time (Levels 6 and 7)

### VII.1 Mass/energy as Channel A and Channel B (Level 6)

**Proposition 1 (Master equation from  $dx_4/dt = ic$ ).** The McGucken Principle  $dx_4/dt = ic$ , combined with the proper-time parametrization  $d\tau^2 = dt^2 - dx^2/c^2$  of a worldline, forces the four-velocity  $u^\mu = dx^\mu/d\tau$  to satisfy  $u^\mu u_\mu = -c^2$  for every massive or massless particle.

**Proof.**  $dx_4/d\tau = (dx_4/dt)(dt/d\tau) = ic\gamma$ . The spatial components are  $u^i = \gamma v^i$ . So  $u^\mu u_\mu = (\gamma v_1, \gamma v_2, \gamma v_3, ic\gamma)$ . Its squared norm with  $x_4 = ict$ :  $u^\mu u_\mu = \gamma^2 v^2 - c^2 \gamma^2 = \gamma^2(v^2 - c^2) = -c^2$ . For a photon at  $v = c$ , the null limit  $k^\mu k_\mu = 0$  is consistent. ■

**Corollary 1 (Four-velocity budget).**  $(dx_4/d\tau)^2 + (dx/d\tau)^2 = c^2$ . The Channel A limit is a particle at spatial rest, whose entire budget is spent on  $x_4$ -advance at rate  $ic$ . The Channel B limit is a photon at  $|v| = c$ , whose entire budget is spent on spatial motion with  $dx_4/d\tau = 0$ .

**Proposition 2 (Channel A reading: rest mass).** At spatial rest, the four-momentum is  $p^\mu = (mc, 0)$ , with rest energy  $E_0 = mc^2$ . Rest mass is the quantity carried by a particle whose four-velocity points entirely into  $x_4$ . Channel A reads  $dx_4/dt = ic$  as the time-translation generator whose Noether charge is energy.

**Proposition 3 (Channel B reading: energy of spatial motion).** At  $|v| = c$ , the entire budget is spent on spatial motion:  $E = pc$  with zero rest mass. For  $0 < |v|$

$< c$ , the energy is apportioned between rest and kinetic contributions. Channel B reads  $dx_4/dt = ic$  as the spherical expansion generating Huygens' secondary wavelets.

**Theorem 1 (Mass/energy Pythagorean joint).** Combining Propositions 2 and 3 via Corollary 1:  $E^2 = (pc)^2 + (mc^2)^2$ . Einstein's  $E = mc^2$  is the Channel A reading of  $dx_4/dt = ic$  at spatial rest;  $E = pc$  is the Channel B reading at  $|v| = c$ .

Mass and energy are Channel A and Channel B readings of the same four-velocity budget forced by  $dx_4/dt = ic$  via  $u^\mu u_\mu = -c^2$ . For the full twelve-fold Noether catalog that connects this to Level 2, see [MG-Noether §§II-III].

## VII.2 Space/time as Channel A and Channel B (Level 7)

The Minkowski interval  $ds^2 = dx_1^2 + dx_2^2 + dx_3^2 - c^2dt^2$  joins spatial coordinates and time. Under  $x_4 = ict$  it becomes Euclidean in four dimensions,  $ds^2 = dx_1^2 + dx_2^2 + dx_3^2 + dx_4^2$ , with the minus sign on  $c^2dt^2$  the algebraic shadow of  $i^2 = -1$  (Proposition 6 below).

**Proposition 4 (Channel A reading: time as symmetry parameter).** Temporal uniformity of  $dx_4/dt$  produces time-translation invariance as a symmetry of the action. Time  $t$  appears in this reading as the parameter under which Noether conserved quantities are held constant.

**Proposition 5 (Channel B reading: space as propagation domain).** Spherical expansion produces three-dimensional space as the domain through which  $x_4$ 's expansion propagates. Each McGucken Sphere  $\Sigma_+(p_0)$  of radius  $c(t - t_0)$  is a spatial surface in  $\mathbb{R}^3$ .

**Theorem 2 (Space/time Pythagorean joint).**  $ds^2 = dx^2 - c^2dt^2 = dx^2 + dx_4^2$ . The Minkowski interval is the Pythagorean joint of the Channel A and Channel B readings of the four coordinates.

Full algebraic derivation in [MG-Proof, Theorem 1] and [MG-TwoRoutes, Proposition H.1]. The Minkowski metric feeds forward into the Level 1 Hamiltonian-route chain (§IV.1), into the Level 5 microcausality result (§VI.1), and into every diffeomorphism-invariant extension [MG-Lagrangian].

## VII.3 The kinematic dualities set the pattern

Levels 6 and 7 establish that the dual-channel structure operates already at the kinematic level of physics, before any quantum mechanics enters. Einstein's 1905 *Annus Mirabilis* identified  $E = mc^2$  (Level 6) and the Minkowski-interval precursor via Lorentz covariance (Level 7). Einstein did not identify the deeper geometric source common to both. The McGucken Principle supplies that source.

## VIII. Quantitative Predictions

**Proposition 27 (Compton-coupling diffusion).** *Modeling  $x_4$ 's advance with a small oscillatory modulation of amplitude  $\varepsilon \ll 1$  and frequency  $\Omega$ :  $x_4(t) = ict + i\varepsilon c \sin(\Omega t)$ ,  $dx_4/dt = ic[1 + \varepsilon \cos(\Omega t)]$ . Every massive particle couples to this modulation through its Compton frequency  $f_C = mc^2/h$ . The effective stochastic force in the Langevin equation has variance  $\propto m^2$ , and the  $m^2$  cancels the  $m^2$  in the Langevin response  $1/m^2$ , yielding a diffusion constant*

$$*D^{\wedge}(\text{McG})_x = \varepsilon^2 c^2 \Omega / (2\gamma^2)*$$

*that is mass-independent and temperature-persistent — the diffusion does not vanish as  $T \rightarrow 0$ , in contrast to ordinary thermal diffusion.*

Species-independence and temperature-persistence constitute a sharp laboratory signature. Cold-atom experiments (JILA, NIST, MIT), trapped-ion experiments, ultracold-neutron storage, and precision atomic clocks all operate in regimes where ordinary thermal diffusion is highly suppressed and an additional temperature-independent species-universal contribution would be detectable or bounded.

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## IX. Novelty and Priority

This section documents novelty by listing prior work in equation form and identifying the specific gap at each level of the dual-channel structure. No prior paper in the surveyed record proposes  $dx_4/dt = ic$  as a physical dynamical statement, and no prior paper derives the dual-channel seven-level duality from a single geometric principle.

### IX.1 Level-specific novelty

**Level 1 (Hamiltonian/Lagrangian).** Feynman 1948 [10] derives the Schrödinger equation from the path integral postulate. Stone 1932 [11] and von Neumann 1931 [12] establish Schrödinger-representation uniqueness. Dirac 1933 [30] anticipates the Lagrangian formulation. Geometric quantization (Kostant 1970, Souriau 1970), stochastic mechanics (Nelson 1966 [22]), and trace dynamics (Adler 1994, 2004 [27]) each generate a part of the structure. No prior framework derives both formulations as independent theorems through disjoint chains from the same geometric postulate. The present paper derives  $[\hat{q}, \hat{p}] = i\hbar$  via Propositions 6-10 (Channel A) and 11-16 (Channel B), with  $i$  and  $\hbar$  inherited geometrically from  $dx_4/dt = ic$  on each route.

**Level 4 (wave/particle).** Bohr 1927/1928 [1] introduced complementarity as interpretation; did not identify a geometric source. Bohmian mechanics [33] pre-

serves duality without deriving its geometric origin. Everett 1957 [34] addresses branching. No prior framework identifies a geometric source from which both wave and particle aspects descend. The present paper (§III) derives the wave aspect from Channel B (Huygens from  $x_4$ -spherical expansion) and the particle aspect from Channel A (localized eigenvalue structure from Stone’s theorem), both channels of the same  $dx_4/dt = ic$ .

**Level 5 (locality/nonlocality).** EPR 1935 [5], Bell 1964 [6], Aspect 1982 [7], Weihs-Jennewein-Zeilinger 1998 [8], Hensen 2015 [9] confirmed nonlocality experimentally. Interpretive frameworks (Bohmian, many-worlds, Copenhagen, relational, QBism [35, 36]) accept nonlocality without geometric explanation. No prior framework derives nonlocality as a geometric consequence of a spacetime-dynamical postulate. The present paper (§VI) derives nonlocality from Proposition 19: photons at  $|v| = c$  satisfy  $dx_4/d\tau = 0$ , so co-emitted photons share  $x_4$ -coordinate forever regardless of three-dimensional spatial separation. Bell correlations  $E(a, b) = -\cos \theta_{ab}$  are the three-dimensional shadow of this four-dimensional  $x_4$ -coincidence on the light cone — the *McGucken Equivalence* (Proposition 20).

**Level 2 (thermodynamic).** Boltzmann 1872 [15] derived the H-theorem assuming Stosszahlansatz. Loschmidt 1876 [14] objected. Boltzmann 1877 responded statistically. Penrose 1979, 1989 [16] proposed the Weyl curvature hypothesis. Jacobson 1995 [17] derived Einstein field equations from  $\delta Q = TdS$ . Verlinde 2011 [18] derived Newtonian gravity from holographic entropy gradients. Connes-Rovelli 1994 [21] derived time-flow from modular automorphisms. None derives both the Noether catalog AND the Second Law as independent theorems of a single geometric dynamical postulate. The present paper (§VII) derives the Noether catalog through Channel A (Propositions 21-23) and the Second Law with strict  $dS/dt > 0$  through Channel B (Propositions 24-26), with Loschmidt dissolved by the dual-channel structure itself (§VII.4) and the Past Hypothesis derived as a theorem (§VII.5).

## IX.2 Novelty of the synthesis

Component derivation steps recapitulate established physics: Feynman’s path integral, Stone-von Neumann uniqueness, Noether’s theorem, Boltzmann-Gibbs statistics, Aspect-Zeilinger-Hensen experiments. What is novel is the synthesis. Specific claims new to the dated record:

1. **The postulate.**  $dx_4/dt = ic$  as a physical dynamical statement about fourth-dimensional expansion, distinct from Minkowski’s coordinate convention  $x_4 = ict$ . First formal record: 1998–1999 dissertation appendix; first public deployment 2003; first formal paper 2008 FQXi.
2. **The dual-channel reading.**  $dx_4/dt = ic$  as simultaneously carrying algebraic-symmetry content (Channel A) and geometric-propagation content (Channel

B).

3. **The seven-level unification.** The same dual-channel structure generating mass/energy duality ( $E = mc^2$  as Channel A limit), space/time duality (Minkowski interval as Pythagorean joint), foundational QM duality (Hamiltonian/Lagrangian), dynamical QM duality (Heisenberg/Schrödinger), ontological QM duality (particle/wave), causal QM duality (local/nonlocal), and thermodynamic duality (conservation/Second Law).
4. **The Loschmidt resolution.** Loschmidt's 1876 objection dissolved by the dual-channel structure itself: the time-symmetric conservation laws and the time-asymmetric Second Law are two readings of the same principle through two channels.
5. **The Past Hypothesis dissolution.** Penrose's  $10^{(-10^{123})}$  fine-tuning dissolved as a theorem:  $t = 0$  is the lowest-entropy moment by construction, as the geometric starting point of  $x_4$ 's expansion.
6. **The McGucken Equivalence.** Bell correlations as the three-dimensional shadow of four-dimensional  $x_4$ -coincidence for photons.
7. **The Compton-coupling diffusion prediction.**  $D^{(McG)}_x = \varepsilon^2 c^2 \Omega / (2\gamma^2)$ , species-independent and temperature-persistent, as a laboratory-testable signature.

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## X. The Physics Gained: What Recognition of the McGucken Principle Adds

The preceding §§II-IX develop the technical content and dated-publication record of the McGucken Principle  $dx_4/dt = ic$ . This section inventories, in summary form, the physics that is *gained* by recognizing the physical reading of the principle — by treating  $dx_4/dt = ic$  as a statement about the physical behavior of the fourth dimension rather than as a coordinate convention. The gain is specifically the physical-derivational content that is absent under the notational reading and is present under the physical reading.

### X.1 The Kinematic Gain

The master equation  $u^\mu u_\mu = -c^2$  is gained as a *derived theorem* (Proposition 1) rather than a posited Lorentz-scalar constraint. The four-velocity budget  $(dx_4/d\tau)^2 + (dx/d\tau)^2 = c^2$  is gained as a *physical apportionment* between advance into  $x_4$  and advance through three-space, with  $E = mc^2$  as the Channel A limit at spatial rest (Theorem 1, Level 6) and  $E = pc$  as the Channel B limit at the photon speed. The Minkowski interval is gained as a *Pythagorean joint* of Channel A (time as symmetry parameter) and Channel B (space as propagation domain) of  $x_4$ 's four-

dimensional geometry (Theorem 2, Level 7). Under the notational reading, these are stipulated mathematical relations; under the physical reading, they are theorems of  $x_4$ 's expansion.

## **X.2 The Quantum-Mechanical Gain**

The canonical commutation relation  $[\hat{q}, \hat{p}] = i\hbar$  is gained as a *twice-derived theorem* (Level 1), through two disjoint chains from the same physical principle — the Hamiltonian route through the Minkowski metric and Stone's theorem (Propositions 6–10) and the Lagrangian route through Huygens' principle and the Compton-frequency phase accumulation (Propositions 11–16). The imaginary unit  $i$  in the canonical exponential  $\exp(-ia\hat{p}/\hbar)$  is gained as a *physical marker of  $x_4$ 's perpendicularity* to the three spatial dimensions rather than a bookkeeping device. The reduced Planck constant  $\hbar$  is gained as *the action per  $x_4$ -cycle at the Planck frequency* rather than a dimensional parameter. Huygens' principle is gained as a *theorem* of  $x_4$ 's spherical expansion (Proposition 11). The Feynman path integral is gained as *iterated Huygens-with-interaction over McGucken Spheres* (Proposition 14). The Heisenberg and Schrödinger pictures are gained as *Channel A and Channel B readings of the same physical  $x_4$ -advance* (Level 3). The wave and particle aspects of quantum objects are gained as *two readings of the same geometric fact* rather than as mutually exclusive interpretive stances (Level 4).

## **X.3 The Causal/Correlational Gain (the McGucken Equivalence)**

Photon  $x_4$ -stationarity is gained as a *physical consequence* of the four-velocity budget at  $|v| = c$ : the photon does not advance in  $x_4$  (Proposition 18). Two photons co-emitted at a common event are gained as *physically coincident in  $x_4$  forever* regardless of three-dimensional separation (Proposition 19). The Bell correlation function  $E(a, b) = -\cos \theta_{ab}$  is gained as *the three-dimensional shadow of four-dimensional  $x_4$ -coincidence on the light cone* (Proposition 20, the *McGucken Equivalence*). The “spooky action at a distance” of Einstein–Podolsky–Rosen is gained as *not action at a distance at all* but as coincidence in a dimension the three-dimensional observer does not see. Local microcausality is gained as the Channel A reading and nonlocal Bell correlations as the Channel B reading of the *same* physical principle, with the two readings no more in tension than the wave and particle aspects of a photon through a double-slit apparatus (Level 5). The Two McGucken Laws of Nonlocality are gained as *formal laws of spacetime geometry* governing the persistence of  $x_4$ -coincidence and the three-dimensional projection of that coincidence into measurable Bell correlations (Theorems 3 and 4).

## **X.4 The Thermodynamic Gain**

The ten Poincaré charges — energy, three components of linear momentum, three components of angular momentum, three components of center-of-energy — are gained as *derived consequences of the physical symmetries of  $x_4$ 's advance*

(Proposition 21): temporal uniformity, spatial homogeneity, spherical isotropy, and Lorentz covariance of the rate  $dx_4/dt = ic$ . The internal gauge charges — electric, weak isospin, color — are gained as *derived consequences of the absence of a preferred phase origin on  $x_4 = ict$*  and the Clifford-algebraic extension of  $x_4$ 's perpendicularity marker to transverse and spatial-rotation sectors (Proposition 22). The covariant stress-energy conservation  $\nabla_\mu T^{\mu\nu} = 0$  is gained as *a derived consequence of the coordinate-independence of  $x_4$ 's advance* on the smooth four-manifold (Proposition 23). The spherical isotropic random walk is gained as *the spatial projection of  $x_4$ 's spherically symmetric advance* (Proposition 24). The Boltzmann-Gibbs entropy-growth result  $dS/dt = 3k_B/(2t) > 0$  is gained as *strict for all  $t > 0$*  — not on average, not statistically, but absolutely (Proposition 25). Shannon entropy on the McGucken Sphere is gained as *growing because the sphere grows, and the sphere grows because  $x_4$  advances at rate  $c$*  (Proposition 26). The five classical arrows of time — thermodynamic, radiative, causal, cosmological, psychological — are gained as *parallel consequences of a single geometric fact:  $x_4$  advances monotonically at rate  $c$*  (§III.3 in the reordered paper). Loschmidt's 1876 reversibility objection is gained as *dissolved* by the dual-channel structure itself, and Penrose's  $10^{(-10)}123$  Past Hypothesis fine-tuning is gained as *a derived theorem* ( $t = 0$  is the lowest-entropy moment by construction, as the geometric starting point of  $x_4$ 's expansion) rather than an auxiliary assumption.

## **X.5 The Empirical Gain**

The species-independent, temperature-persistent diffusion constant  $D^{(McG)}_x = \varepsilon^2 c^2 \Omega / (2\gamma^2)$  (Proposition 27) is gained as *a concrete, laboratory-testable, novel empirical prediction*. The prediction is specific in its magnitude-dependence, distinctive in its species-independence and temperature-persistence, and falsifiable against cold-atom experiments (JILA, NIST, MIT), trapped-ion experiments, ultracold-neutron storage, and precision atomic clocks. Under the notational reading of  $x_4 = ict$ , this prediction has no physical content and cannot exist; under the physical reading of  $dx_4/dt = ic$  it is a consequence of modeling  $x_4$ 's advance as carrying a small oscillatory modulation. The prediction is the single point at which the framework makes direct contact with experimental physics at the level of a new, falsifiable magnitude.

## **X.6 The Structural Gain: Seven-Level Unification**

The seven dualities developed across §§II-VIII — Hamiltonian/Lagrangian, conservation laws / Second Law, Heisenberg/Schrödinger, wave/particle, locality/nonlocality, mass/energy, space/time — are gained as *parallel sibling consequences of a single physical principle*, through the same two channels (algebraic-symmetry content and geometric-propagation content) at seven distinct levels of physical description. Under the notational reading, the seven structural parallels are a suggestive but unexplained coincidence; under the

physical reading, they are the structural signature of a correct foundation. No prior framework in the surveyed physics and philosophy-of-physics literature generates *any* of the seven dualities from a single geometric-dynamical principle; none generates any pair; and none generates all seven. The gain is not merely quantitative (seven unifications rather than zero) but structural: the coexistence of locality and nonlocality is, in the McGucken framework, the *same* kind of fact as the coexistence of wave and particle aspects, and a referee who accepts complementarity as standard physics (as every referee has since Bohr's 1927 Como lecture) cannot consistently reject any of the other six dualities on "which reading is privileged" grounds without introducing a double standard. The structural-consistency argument is, by itself, a genuine foundational gain.

### **X.7 Einstein's Criterion**

Einstein stated in his 1934 Herbert Spencer Lecture at Oxford:

"The supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience."

The McGucken Principle  $dx_4/dt = ic$  meets Einstein's criterion with exactness and completeness. The irreducible basic element is a single three-symbol geometric statement: the fourth dimension is expanding at the velocity of light in a spherically symmetric manner. From this one element, through two channels of content, the present paper derives seven dualities of physics: Hamiltonian/Lagrangian, conservation laws / Second Law, Heisenberg/Schrödinger, wave/particle, locality/nonlocality, mass/energy, and space/time. Not one datum of experience is surrendered: the standard content of relativity, quantum mechanics, quantum field theory, the Noether conservation catalog, the Second Law, and the Bell-inequality experimental record (Aspect 1982, Zeilinger 1998, Hensen 2015) is all preserved, not replaced. The framework adds one falsifiable empirical prediction ( $D^{\wedge}(\text{McG})_x = \varepsilon^2 c^2 \Omega / (2\gamma^2)$ ) and substitutes seven structurally parallel derivations from one source for what was previously seven independent derivations from separate sources. The reduction in the count of basic elements — from the standard list of independent postulates underlying QM, relativity, and thermodynamics to a single geometric statement about the fourth dimension — is exactly the reduction Einstein's criterion calls for, and it is achieved without surrender of any experimental fact.

The McGucken framework thus serves Einstein's notion of physics directly: irreducible basic elements as simple and as few as possible, without surrender of any datum of experience.

## XI. The Mathematical Unity of the Two Channels: A Kleinian Reading

The preceding ten sections have treated Channel A and Channel B as two logically distinct informational contents of  $dx_4/dt = ic$ , each generating its own family of physical outputs through its own chain of derivations. Within the paper's internal logic this treatment is correct: Channel A's outputs (Hamiltonian operators, Noether conservation laws, Heisenberg picture, particle aspect, local microcausality, rest mass, time as symmetry parameter) derive through purely algebraic-symmetry intermediates, while Channel B's outputs (Lagrangian path integral, Second Law, Schrödinger picture, wave aspect, nonlocal Bell correlations, kinetic energy, space as propagation domain) derive through purely geometric-propagation intermediates. Neither channel's outputs reduce to the other's. But this raises a mathematical question the reader is entitled to ask: *why do two apparently independent mathematical contents emerge from a single geometric principle, and what is the deep relationship between them?*

The answer is that Channel A and Channel B are not two independent mathematical structures that happen to coexist in  $dx_4/dt = ic$ . They are the two faces of a single mathematical object under one of the deepest correspondences in modern mathematics: the correspondence between *algebra as the language of invariance* and *geometry as the language of propagation*. This section traces the correspondence explicitly.

### XI.1 The Fields of Mathematics in Each Channel

**Channel A — the algebraic-symmetry content** — draws its tools from what mathematicians from the mid-nineteenth century onward have called algebra in the broadest sense:

- **Group theory and Lie theory.** Temporal uniformity is invariance under the time-translation group  $(\mathbb{R}, +)$ . Spatial homogeneity is invariance under the three-dimensional translation group  $\mathbb{R}^3$ . Spherical isotropy is invariance under the rotation group  $SO(3)$ . Lorentz covariance is invariance under  $SO(1, 3)$ , the group of proper orthochronous Lorentz transformations. Assembled together these form the Poincaré group  $ISO(1, 3) = \mathbb{R}^{1,3} \rtimes SO(1, 3)$ , the full symmetry group of Minkowski spacetime. Each of these groups is a Lie group, a smooth manifold with a group structure, and each has an associated Lie algebra of infinitesimal generators whose commutation relations encode the local structure of the group.
- **Complex algebra and Clifford algebra.** The perpendicularity marker  $i$  for  $x_4$  is the defining element of the field of complex numbers  $\mathbb{C}$ , the algebraic object satisfying  $i^2 = -1$ . The Minkowski signature  $(-, +, +, +)$  that descends from  $x_4 = ict$  through Proposition 6 is the real-form shadow of this complex

structure. In the spin sector,  $i$  extends to the Clifford algebra  $C\ell(1, 3)$ , whose generators  $\{\gamma^\mu\}$  satisfy  $\{\gamma^\mu, \gamma^\nu\} = 2\eta^{\mu\nu}$ ; here the perpendicularity marker acquires a matrix-algebraic realization that carries through the Dirac equation into the structure of fermionic matter.

- **Invariant theory.** The bridge from “invariance under a group action” to “conserved quantity under the dynamics” is Noether’s 1918 theorem, a result in the calculus of variations: if the action functional is invariant under a smooth one-parameter group, there exists a corresponding conserved Noether current. The ten conserved charges of the Poincaré group, the gauge charges of  $U(1) \times SU(2)_L \times SU(3)_c$ , and the covariantly-conserved stress-energy from diffeomorphism invariance are all instances of this one theorem applied to successively larger invariance groups.

The common feature of all of Channel A’s tools is that they describe **sameness**: what does not change, what transforms covariantly, what is preserved. Channel A is algebra in the sense of Klein, Noether, Cartan, and the twentieth-century invariant-theoretic tradition.

**Channel B — the geometric-propagation content** — draws its tools from what mathematicians have called geometry and analysis:

- **Differential geometry and Lorentzian geometry.** The forward light cone at any event  $p$  is the set of future-directed null vectors  $\{v \in T_p M : \eta(v, v) = 0, v^0 > 0\}$  — a three-dimensional null hypersurface in four-dimensional spacetime, embedded as the boundary of the future causal cone  $J^+(p)$ . Its differential-geometric structure (null generators, affine parameter, orientation) is the subject of Lorentzian geometry in the tradition of Penrose, Hawking, and Ellis.
- **Partial differential equations and wave-equation Green’s functions.** Huygens’ wavefront propagation is the geometric content of the retarded Green’s function of the d’Alembertian,  $G_{\text{ret}}(x, x') = \theta(t - t') \cdot \delta((t - t')^2 - |x - x'|^2/c^2)/(2\pi)$ . In four-dimensional spacetime (odd spatial dimension equal to three), the support of this Green’s function is exactly the forward light cone — the strong Huygens principle holds. Every wavefront is a light cone, and every forward light cone is a wavefront; the distinction is nominal, not geometric.
- **Measure theory and dynamical-systems theory.** The monotonic arrow of time is a statement about a measure (Boltzmann-Gibbs phase-space volume, or equivalently the geometric-dispersal measure of  $x_4$ ’s expansion) that increases monotonically along a flow. The Fokker-Planck description of the spatial random walk driven by  $x_4$ ’s isotropic expansion, the strict positivity  $dS/dt > 0$  of the coarse-grained entropy for all  $t > 0$ , and the identification of the Past Hypothesis as a theorem at the geometric origin of  $x_4$ ’s advance

are all results in the measure-theoretic study of dispersive flows.

- **Topology and orientation.** The word *forward* in “forward light cone” presupposes a time-orientation — a continuous choice of the  $+$ -sheet of the null cone at every spacetime event. This is a topological statement about the existence of a global non-vanishing timelike vector field, equivalent to the triviality of a certain  $\mathbb{Z}/2$ -bundle over spacetime.

The common feature of all of Channel B’s tools is that they describe **propagation and flow**: where things go, how they spread, which way they advance. Channel B is geometry and analysis in the sense of Riemann, Huygens, Poincaré, and the twentieth-century differential-geometric and PDE tradition.

## XI.2 The Klein Correspondence

These two families of mathematical tools are not unrelated. They are related by one of the central correspondences in the mathematics of the past 150 years, first made explicit in Felix Klein’s 1872 **Erlangen Program** [Klein 1872]: *every geometry is equivalent to a group*, specifically the group of transformations that preserve its characteristic structure. Euclidean geometry is the group  $ISO(3) = \mathbb{R}^3 \rtimes SO(3)$  of rigid motions. Affine geometry is the group of affine transformations. Projective geometry is the projective linear group  $PGL$ . Hyperbolic geometry is  $SO(2, 1)$  acting on the hyperboloid. Conformal geometry is the group of conformal transformations. And Minkowski geometry is the Poincaré group  $ISO(1, 3)$  acting on four-dimensional spacetime with the Lorentzian quadratic form.

Under the Klein program, a geometry and its symmetry group are not two different objects that happen to be related — they are two equivalent descriptions of a single mathematical object. Given the geometry, one can read off the symmetry group (the set of structure-preserving transformations). Given the group, one can reconstruct the geometry (as a homogeneous space  $G/H$  for an appropriate subgroup  $H$ ). The passage runs in both directions because the information content is the same.

**This is the master correspondence that unites Channel A and Channel B.** Channel A extracts the symmetry group of  $dx_4/dt = ic$  (temporal translation, spatial translation, rotation, Lorentz boost,  $U(1)$  phase,  $SU(2)_L$  and  $SU(3)_c$  internal gauge, diffeomorphism covariance, and the complex algebraic marker  $i$ ). Channel B extracts the geometric objects that this symmetry group preserves (the forward light cone, the Huygens wavefront, the null hypersurface structure, the time-orientation). These are not two independent structures co-inhabiting  $dx_4/dt = ic$ . They are the group side and the geometry side of *one* Kleinian object: the four-dimensional spacetime with perpendicular imaginary fourth axis advancing at rate  $ic$ .

### **XI.3 Noether's Bridge**

Klein's correspondence is static — group and geometry as two faces of one structure. To get from symmetries of a geometry to conservation laws of a dynamical system, one needs the *dynamical* refinement of the Kleinian correspondence: **Noether's theorem** [Noether 1918]. Given an action functional  $S[\phi]$  invariant under a smooth one-parameter group of transformations generated by a vector field  $X$ , there exists a conserved current  $j^\mu$  satisfying  $\partial_\mu j^\mu = 0$  on solutions of the equations of motion. The conserved quantity (a scalar, obtained by integrating the current's time-component over a spacelike slice) is the Noether charge corresponding to the symmetry.

Noether's theorem is the *dynamical* bridge between Channel A and Channel B. Channel A identifies the invariance; Channel B identifies the propagation of field configurations through spacetime according to the equations of motion; Noether establishes that each Channel A invariance yields a Channel B-propagated conserved current. The ten Poincaré charges, the gauge charges, and the diffeomorphism-covariantly conserved stress-energy are all Channel A → Channel B bridges in this sense.

The reverse direction is equally real. Given a dynamical propagation law with a conserved current, the existence of that conserved current mathematically *forces* the existence of a corresponding symmetry (the inverse Noether theorem, valid under mild technical hypotheses). Propagations in Channel B carry symmetry information that can be extracted as Channel A invariances. The two channels exchange content in both directions through the Noether bridge.

### **XI.4 Representation Theory: The Group Is Known Through What It Does**

A Lie group  $G$  is completely characterized only when one specifies how it acts on concrete spaces — its representations.  $SO(3)$  is known as the rotation group *because* it rotates spheres, rotates angular-momentum states, rotates spherical harmonics. The Lorentz group  $SO(1, 3)$  is known as the Lorentz group *because* it boosts light cones, transforms four-vectors, and mixes electric and magnetic fields. A group disconnected from its representations is a formal object; a group together with its representations is a physical actor.

This representation-theoretic completion of Klein's correspondence means that Channel A (group structure) is inseparable from Channel B (the geometric objects the group acts on). The fundamental representations of the Lorentz group are precisely: the scalar representation (trivial), the four-vector representation (acting on  $TM$ ), the two-component Weyl-spinor representations  $(\frac{1}{2}, 0)$  and  $(0, \frac{1}{2})$  (acting on the spin bundle), and the tensor representations of higher rank. Each of these representations *is* a geometric object on which the group acts. Spin- $\frac{1}{2}$  matter exists

because  $Spin(1, 3) \cong SL(2, \mathbb{C})$  has two fundamental two-dimensional representations — an algebraic fact (Channel A) that *forces* the existence of a geometric object (Channel B) called a Weyl spinor on which the group acts, which in turn *forces* the Dirac equation as the unique first-order Lorentz-covariant equation of motion.

The Kleinian correspondence and its representation-theoretic completion are the mathematical reason why the derivation of the Dirac Lagrangian  $\mathcal{L}_{\text{Dirac}}$  from  $dx_4/dt = ic$  can proceed through the matter orientation condition (M) (Channel A's algebraic constraint on even-grade multivectors in  $Cl(1, 3)$ ) and arrive at the same equations of motion as the derivation proceeding through Huygens propagation of spinor wavefronts on the null hypersurface of  $x_4$ 's advance (Channel B's geometric construction). The two derivations look different; they produce the same Dirac equation because Channel A and Channel B are Kleinian duals.

### **XI.5 Cartan's Moving Frames: Algebra and Geometry Fused**

The twentieth-century refinement of the Klein program came through Élie Cartan's *moving-frames* method (1922) and its generalization to fibre bundles and connections. A Cartan connection on a principal  $G$ -bundle is *simultaneously* an algebraic object (a Lie-algebra-valued 1-form) and a geometric object (a rule for parallel transport of frames along curves). The connection's curvature is simultaneously an algebraic object (the commutator  $[D_\mu, D_\nu]$  of covariant derivatives) and a geometric object (the infinitesimal holonomy around a closed loop).

Gauge theory is the direct physical application of this fusion. The Yang-Mills field strength  $F_{\mu\nu}^a = \partial_\mu A_\nu^a - \partial_\nu A_\mu^a + gf^{abc} A_\mu^b A_\nu^c$  is read simultaneously as an algebraic object (the curvature of an algebra-valued connection) and a geometric object (the infinitesimal rotation in internal space induced by an infinitesimal parallel transport around a spacetime loop).  $\mathcal{L}_{\text{YM}} = -\frac{1}{4} F_{\mu\nu}^a F^{a\mu\nu}$  is the unique Lorentz-invariant gauge-invariant local scalar of mass dimension four that can be built from this object. Channel A provides the group  $G$ , the algebra  $\mathfrak{g}$ , and the invariance requirement; Channel B provides the connection, the curvature, and the geometric interpretation as infinitesimal holonomy. They are fused in the Yang-Mills Lagrangian.

### **XI.6 The McGucken Principle as the Common Ground**

The Kleinian reading now admits a sharp statement of what the McGucken Principle contributes. The Klein program, Noether's theorem, representation theory, and Cartan's moving-frames are all available to any physical theory whose geometric foundation has been specified. What Klein, Noether, Cartan, and Weyl did not provide — what no mathematical theorem can provide — is the *physical geometric foundation itself*. Klein says: pick a geometry, and you will have a group. Noether says: pick a symmetry of a variational principle, and you will have a conservation law. Representation theory says: pick a group, and you will have objects it can act

on. None of these theorems specifies which geometry is the physical geometry of the actual universe. That specification has to come from physics.

The McGucken Principle  $dx_4/dt = ic$  is the specification. It says: the physical geometry is a four-dimensional spacetime with three real spatial dimensions plus one imaginary fourth dimension advancing at the velocity of light, spherically symmetrically from every event. From this specification, Klein's program yields the Poincaré group, the internal gauge groups arising from the Clifford extensions, and the diffeomorphism group — that is, all of Channel A. Noether's theorem applied to the Principle's variational formulation yields all of Channel A's conservation laws. Representation theory applied to the Principle's symmetry groups yields the fermionic, bosonic, and gauge-covariant field content — the matter and forces of the Standard Model. Cartan's moving-frames applied to the Principle's spacetime yields gauge theory and general relativity, with Einstein-Hilbert as the unique Lovelock-class polynomial of dimension four. And the geometric side of the Kleinian correspondence yields all of Channel B: the forward light cone as null hypersurface, Huygens' wavefront as the retarded Green's function's support, the monotonic advance as the time-orientation of a globally hyperbolic spacetime, and the spherical expansion as the  $SO(3)$ -invariant null congruence.

The McGucken Principle is therefore the physical input that the Kleinian mathematical apparatus requires to produce physics. It supplies the geometric foundation; the Kleinian correspondence, Noether's theorem, and Cartan's moving-frames do the rest, producing Channel A and Channel B as the two faces of the same object — the physical reality whose algebra Channel A extracts and whose geometry Channel B propagates.

## **XI.7 Why the Seven Dualities Are Not Coincidence**

The seven dualities of the present paper can now be read as a systematic working-out of the Kleinian correspondence at seven levels of physical description:

- **Level 1 (Hamiltonian/Lagrangian):** Channel A extracts the time-translation generator as operator  $\hat{H}$ ; Channel B extracts the path-integral kernel from the variational principle. Kleinian duality: the time-translation *group*  $(\mathbb{R}, +)$  acting on state space (Channel A) and the time-translation *flow* of states through configuration space (Channel B) are two faces of the same unitary evolution.
- **Level 2 (Conservation/Second Law):** Channel A extracts the time-symmetric Noether currents from group invariances; Channel B extracts the time-asymmetric monotonic advance from  $x_4$ 's one-way flow. Kleinian duality: the symmetry *group* (Channel A) acts alongside the *flow* it fails to fix, the  $dS/dt > 0$  direction (Channel B) — the  $+ic$  of the advance is the breaking of the group-theoretic time-reversal that nevertheless preserves the nine

other Poincaré symmetries.

- **Level 3 (Heisenberg/Schrödinger):** Channel A's operator evolution and Channel B's state evolution are inverse representations of the same unitary group  $\{U(t) = e^{-i\hat{H}t/\hbar}\}$  acting on operators and states respectively — two faces of the same group action.
- **Level 4 (Wave/Particle):** Channel A's localized eigenstates of position and momentum (algebraic) and Channel B's spreading wave packets (geometric propagation) are two representation-theoretic realizations of the same Hilbert-space vector.
- **Level 5 (Locality/Nonlocality):** Channel A's local algebra of observables (Haag-Kastler net on spacelike-separated regions) and Channel B's nonlocal correlations through shared McGucken-Sphere membership are the group-theoretic (local commutativity) and geometric (null-hypersurface identity) faces of the same event-theoretic structure.
- **Level 6 (Mass/Energy):** Channel A's rest mass as the invariant  $-p_\mu p^\mu/c^2$  (algebraic scalar of the Lorentz group) and Channel B's kinetic energy as the spatial-motion content of the four-velocity budget (geometric projection onto the spatial subspace) are the group-invariant and the geometric-projection faces of the same four-momentum.
- **Level 7 (Space/Time):** Channel A's time as the parameter of the one-parameter group  $(\mathbb{R}, +)$  of temporal translation and Channel B's space as the three-dimensional domain of  $x_4$ 's spherical propagation are the group-parameter and spatial-manifold faces of the same four-dimensional spacetime.

In every case the duality at that level is the local instantiation of the global Kleinian correspondence between the algebra of a group and the geometry of what the group acts on. The seven levels do not come from seven independent facts. They come from the Kleinian structure of one geometric principle —  $dx_4/dt = ic$  — applied at seven levels of physical description.

## **XI.8 Summary**

Channel A and Channel B are the two faces of a single mathematical object under the Klein correspondence between algebra and geometry. Channel A draws from group theory, Lie theory, complex and Clifford algebra, and invariant theory — the tools for describing sameness. Channel B draws from differential geometry, Lorentzian geometry, partial differential equations, measure theory, and topology — the tools for describing propagation and flow. The two families of tools are not independent; they are related by the Klein program (group  $\leftrightarrow$  geometry), by Noether's theorem (symmetry  $\leftrightarrow$  conservation), by representation theory (group  $\leftrightarrow$  the objects it acts on), and by Cartan's moving-frames (connection  $\leftrightarrow$  parallel-

transport). The McGucken Principle  $dx_4/dt = ic$  supplies the physical geometric foundation that these mathematical correspondences require as input. Channel A and Channel B are therefore not independent outputs of the Principle; they are the two Kleinian faces of the Principle's specification of the physical reality of the fourth expanding dimension.

The seven dualities of this paper are the Kleinian correspondence applied at seven levels of physics. Each duality pairs the Channel A (algebraic, group-theoretic, invariant) face with the Channel B (geometric, propagational, flow-theoretic) face of one and the same object — one physical principle, seven manifestations of its dual-channel mathematical structure.

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## XII. Conclusion

Wave/particle duality has been accepted physics for ninety-nine years. Its structural logic — a single physical object admitting two logically distinct readings selected by experimental context — is not controversial. The McGucken Principle  $dx_4/dt = ic$  is the geometric source of this accepted structure. Recognizing the source extends the structure to six other levels of physical description:

- **Mass/energy (Level 6):**  $E^2 = (pc)^2 + (mc^2)^2$  with  $E = mc^2$  as Channel A limit.
- **Space/time (Level 7):** Minkowski interval as Pythagorean joint of Channel A (time as symmetry parameter) and Channel B (space as propagation domain).
- **Foundational (Level 1):** Hamiltonian and Lagrangian formulations of quantum mechanics as disjoint derivations of  $[\hat{q}, \hat{p}] = i\hbar$  from  $dx_4/dt = ic$ .
- **Dynamical (Level 3):** Heisenberg and Schrödinger pictures as Channel A and Channel B readings of the same unitary evolution.
- **Ontological (Level 4):** Wave and particle aspects — the structural precedent.
- **Causal/correlational (Level 5):** Local microcausality and nonlocal Bell correlations as the three-dimensional shadow of four-dimensional  $x_4$ -coincidence.
- **Thermodynamic (Level 2):** Noether conservation laws and the Second Law as Channel A and Channel B readings, resolving the Loschmidt objection and dissolving the Past Hypothesis.

The framework predicts a species-independent, temperature-persistent diffusion  $D^{(McG)}_x = \varepsilon^2 c^2 \Omega / (2\gamma^2)$  as a laboratory-testable signature. It derives the Noether catalog (ten Poincaré charges, three internal-gauge charges, diffeomorphism-covariant stress-energy conservation) through Channel A and the Second Law with strict  $dS/dt > 0$  for all  $t > 0$  through Channel B from the same starting equation. It runs through completely disjoint intermediate structures in each case — the structural signature, identified by Einstein as the mark of a correct

foundation, that a theory’s impressiveness increases “the greater the simplicity of its premises, the more different kinds of things it relates, and the more extended is its area of applicability.”

The dual-channel framework does not require defense beyond what physics has already accepted at Level 4. It extends accepted structure to unresolved problems, and where it does so it dissolves those problems rather than rephrasing them. Loschmidt’s 1876 tension is not a tension: conservation laws and the Second Law are two readings of  $dx_4/dt = ic$  through two channels, neither reducible to the other, both real. Penrose’s  $10^{(-10)123}$  fine-tuning is not a tuning:  $t = 0$  is the lowest-entropy moment by construction, as the geometric starting point of  $x_4$ ’s expansion.

One equation. Seven levels of duality. The derivation program is complete in the sense that it identifies the geometric source of the dual-reading structure that quantum mechanics has used since 1927, and extends that structure to thermodynamics where the same logical move resolves a 150-year-old problem.

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## **Coda: Provenance**

The McGucken Principle  $dx_4/dt = ic$  has a thirty-seven-year development trail from the Princeton afternoons of the late 1980s through the present paper. The author graduated *cum laude* in physics from Princeton University, studied under John Archibald Wheeler, completed the 1998 NSF-funded doctoral dissertation at UNC Chapel Hill whose Appendix B established the physical content of the postulate in 1998 form, deployed the theory publicly on PhysicsForums.com and Usenet in 2003–2006, submitted five FQXi essays between 2008 and 2013, published a five-book series through 45EPIC Press in 2016–2017, and developed the active derivation program at [elliottmcguckenphysics.com](http://elliottmcguckenphysics.com) from October 2024 through the present (April 2026, 80+ technical papers). The present paper is the master synthesis of that program, identifying all seven dualities of physics as parallel consequences of  $dx_4/dt = ic$  through its dual-channel structure, and naming Wheeler, Peebles, and Taylor — the three Princeton faculty whose teaching seeded the theory — in the provenance. The thirty-seven-year trail is documented in full at [MG-History], with direct-verifiable archive links at [MG-PrincetonAfternoons], [MG-Dissertation], [MG-Usenet2006], [MG-Usenet2011], [MG-HeroOdyssey-Rec], [MG-FQXi-2008] through [MG-FQXi-2013], and the full corpus at [MG-EMP]. The present paper rests technically on the entire companion-paper corpus, conceptually on Wheeler’s teaching on the Schwarzschild time factor and the EPR paradox, and historically on the Princeton origin.

### Distinction from Minkowski’s coordinate convention

Minkowski’s  $x_4 = ict$  [28] is a coordinate convention: a static identification of the fourth Euclidean coordinate with  $ict$  for notational purposes. The convention carries no derivative, no rate of advance, and no claim that events are physically in motion along  $x_4$ . Pauli’s 1921 encyclopedia article [29] and Sommerfeld’s papers adopted the convention without modification. The step from  $x_4 = ict$  (static coordinate identification) to  $dx_4/dt = ic$  (dynamical postulate: every event actively advances into the fourth dimension at rate  $c$ , with  $i$  encoding perpendicularity rather than serving as a bookkeeping device) introduces physical content absent from the convention. This dynamical-postulate step is due to the present author.

### The dated record

Equation	Author, year
$x_4 = ict$ (coordinate convention)	Minkowski, 1908
$E = h\nu$	Einstein, 1905
$\lambda = h/p$	de Broglie, 1924
$[\hat{q}, \hat{p}] = i\hbar$	Born-Jordan, 1925
$i\hbar \partial_t \psi = \hat{H}\psi$	Schrödinger, 1926
Complementarity (wave/particle)	Bohr, 1927
$\Delta x \Delta p \geq \hbar/2$	Heisenberg, 1927
$K = \int \mathcal{D}x \exp(iS/\hbar)$	Feynman, 1948
$T_U = \hbar a / (2\pi k_B c)$	Unruh, 1976
$C_{\mu\nu\rho\sigma} C^{\mu\nu\rho\sigma} \rightarrow 0$ at initial	Penrose, 1979
Thermal time hypothesis	Connes-Rovelli, 1994
$\delta Q = T dS$ (across Rindler horizon)	Jacobson, 1995
$F \Delta x = T \Delta S$ (holographic)	Verlinde, 2011
<b><math>dx_4/dt = ic</math> (physical postulate)</b>	<b>McGucken, 1998/99-present</b>

### Five eras of continuous development

**Era I: Princeton origin, two junior papers, and the 1998 doctoral dissertation appendix (late 1980s-1998).** The conceptual origins of the McGucken Principle trace to the author’s undergraduate work at Princeton University with J. A. Wheeler (academic advisor), P. J. E. Peebles (quantum mechanics instructor), and J. H. Taylor Jr. (experimental physics and junior-paper advisor). The author graduated *cum laude* in physics from Princeton University. Specific conversations with Wheeler (photon stationary in  $x_4$ ), Peebles (photon’s spherically-symmetric probabilistic wavefront at  $c$ , using galleys of Peebles’ 1992 *Quantum Mechanics*), and Taylor (entanglement as Schrödinger’s “characteristic trait” of QM) established the physical picture that would later crystallize as  $dx_4/dt = ic$  [MG-PrincetonAfternoons]. Two Princeton junior papers preceded the disserta-

tion: (i) a derivation of the time part of the Schwarzschild metric by “poor-man’s reasoning” — geometric methods extending Wheeler’s *A Journey Into Gravity and Space Time* — which Wheeler’s recommendation letter identified as “beautifully clear”; and (ii) a paper titled *Within a Context* on the Einstein-Podolsky-Rosen experiment and Wheeler-style delayed-choice experiments (Wheeler’s letter: “so outstanding”). A senior project with the cyclotron group on time-reversal asymmetry followed. The 1998 UNC Chapel Hill doctoral dissertation [MG-Dissertation], titled “*Multiple Unit Artificial Retina Chipset to Aid the Visually Impaired and Enhanced Holed-Emitter CMOS Phototransistors*” (NSF-funded; advisors W. Liu and S. Washburn), contains as Appendix B pp. 153-156 the first formal written record of the postulate. This appendix, titled “*Physics for Poets: The Law of Moving Dimensions,*” establishes the 1998 priority on the physical content: the postulate in 1998 form (p. 153: “the time dimension is moving or expanding relative to the three spatial dimensions”); the kinematic derivation of the rate  $c$  from Einstein’s second postulate via the null-vector condition, differentiating to obtain  $dx/dt = c$ ; the mass/energy duality in prose form (pp. 155-156), with  $E = mc^2$  derived from rotation of four-velocity into the time dimension; wave/particle duality as the dual-channel reading (p. 154); the Feynman path integral (p. 154); the Second Law and entropy (p. 154) from spherical  $x_4$ -expansion; time dilation and length contraction (pp. 154-155); the de Broglie relation (p. 155); the energy and momentum operators  $\hat{H} = i\hbar\partial_t$  and  $\hat{p} = -i\hbar\partial_x$  (p. 156); and the derivation of Einstein’s first postulate from the law of moving dimensions (p. 156). Figure AB.1 (p. 154) shows the null-vector diagram  $x = ct$ . Appendix B establishes in 1998 the physical content of every level of the seven-level structure: the postulate itself (coordinate-time form  $dx/dt = c$ ), Level 6 (mass/energy), Level 1 (Hamiltonian/Lagrangian), Level 4 (wave/particle), and Level 2 (Second Law/conservation).

**Era II: Internet deployments and Usenet (2003-2006).** PhysicsForums.com #3753 (2003-2004); sci.physics.relativity post dated 29 August 2006 [MG-Usenet2006] at [https://groups.google.com/g/sci.physics.relativity/c/QeIG-RwiX\\_A](https://groups.google.com/g/sci.physics.relativity/c/QeIG-RwiX_A), containing: the general postulate; the specific postulate (“fourth dimension is expanding relative to the three spatial dimensions in units of the Planck length at the rate of  $c$ ”); the kinematic derivation  $dx/dt = c$ ; the derivation of  $E = mc^2$  from the four-velocity budget; the Channel-A/Channel-B reading of wave/particle duality; the derivation of quantum nonlocality as  $x_4$ -coincidence (“two events separated in the three spatial dimensions can yet appear to be at the exact same place in the fourth dimension”); the derivation of the Second Law from spherical  $x_4$ -expansion; the resolution of the block-universe paradox; and the unification of QM and relativity through a single postulate.

**Era III: Compact form, parallel WordPress blog, and FQXi papers (2008-2013).** The compact three-symbol form  $dx_4/dt = ic$  appears in sci.physics by 11 July 2011 [MG-Usenet2011] at <https://groups.google.com/g/sci.physics/c/nfLV4igq5zA>:

“MDT’s equation:  $dx_4/dt = ic$ .” Same-day WordPress blog posts at *Hero’s Odyssey Physics & Moving Dimensions Theory*:

- 10 July 2011, “hello-world”: [MG-HeroOdyssey-Hello] <https://herosjourneyphysics.wordpress.com/2011/07/10/hello-world/>
- 10 July 2011, “Proofs of Moving Dimensions Theory”: [MG-HeroOdyssey-Proofs] <https://herosjourneyphysics.wordpress.com/2011/07/10/proofs-of-moving-dimensions-theory-heros-journey-physics-moving-dimensions-theory/>
- 10 July 2011, “Time as an Emergent Phenomenon”: [MG-HeroOdyssey-Time]
- 10 July 2011, “Recommendation for Elliot McGucken”: [MG-HeroOdyssey-Rec] <https://herosjourneyphysics.wordpress.com/2011/07/10/recommendation-for-elliott-mcgucken-for-admission-to-graduateschool-of-physics/> — Contains Wheeler’s Princeton recommendation letter verbatim and biographical statement linking the 1998 dissertation appendix to the Princeton projects with Wheeler on QM and GR.
- 10 July 2011, “MDT Honors the Greats’ Definition of Science”: [MG-HeroOdyssey-Greats]
- 11 July 2011, “Why String Theory, M-Theory, LQG... are NOT Physics”: [MG-HeroOdyssey-WhyNot]

First formal paper submission: FQXi essay contest, 25 August 2008, “*Time as an Emergent Phenomenon*” [MG-FQXi-2008]. Four additional FQXi essays 2009–2013 [MG-FQXi-2009, MG-FQXi-2010, MG-FQXi-2012, MG-FQXi-2013]. Three full-text PDFs:

- 2008 [MG-2008PDF]: [https://herosjourneyphysics.wordpress.com/wp-content/uploads/2011/07/mcgucken\\_time\\_as\\_an\\_emergent1.pdf](https://herosjourneyphysics.wordpress.com/wp-content/uploads/2011/07/mcgucken_time_as_an_emergent1.pdf) — ~4,992 words. Contains the integration  $\int dx_4/dt dt = \int ic dt \Rightarrow x_4 = ict$ ; direct quotation of Einstein’s 1912 Manuscript on Relativity; five time arrows (radiative, thermodynamic, cosmological, causal, quantum).
- 2009 [MG-2009PDF]: [https://herosjourneyphysics.wordpress.com/wp-content/uploads/2011/07/mcgucken\\_what\\_is\\_ultimately\\_81.pdf](https://herosjourneyphysics.wordpress.com/wp-content/uploads/2011/07/mcgucken_what_is_ultimately_81.pdf) — Contains three numbered MDT proofs; the Twitter-length 140-character proof; Figure 1 illustrating two entangled photons on the expanding  $x_4$  wavefront.
- 2010–2011 [MG-2010PDF]: [https://herosjourneyphysics.wordpress.com/wp-content/uploads/2011/07/mcgucken\\_dr\\_elliott\\_mcgucke\\_7-11.pdf](https://herosjourneyphysics.wordpress.com/wp-content/uploads/2011/07/mcgucken_dr_elliott_mcgucke_7-11.pdf) — Section 1 documents the three Princeton conversations (Peebles, Wheeler, Taylor); footnote iii cites the 1990 Princeton junior paper *Within a Context* on EPR/delayed-choice; footnote xxxviii cites the 1998 UNC Chapel Hill dissertation.

## **Wheeler's Princeton recommendation letter**

Wheeler's Princeton recommendation letter, verbatim (archived in [MG-HeroOdyssey-Rec], 10 July 2011):

"More intellectual curiosity, versatility and yen for physics than Elliot McGucken's I have never seen in any senior or graduate student... Originality, powerful motivation, and a can-do spirit make me think that McGucken is a top bet for graduate school in physics... I say this on the basis of close contacts with him over the past year and a half... I gave him as an independent task to figure out the time factor in the standard Schwarzschild expression around a spherically-symmetric center of attraction. I gave him the proofs of my new general-audience, calculus-free book on general relativity, *A Journey Into Gravity and Space Time*. There the space part of the Schwarzschild geometric is worked out by purely geometric methods. 'Can you, by poor-man's reasoning, derive what I never have, the time part?' He could and did, and wrote it all up in a beautifully clear account... his second junior paper... entitled *Within a Context*, was done with another advisor, and dealt with an entirely different part of physics, the Einstein-Rosen-Podolsky experiment and delayed choice experiments in general... this paper was so outstanding... I am absolutely delighted that this semester McGucken is doing a project with the cyclotron group on time reversal asymmetry. Electronics, machine-shop work and making equipment function are things in which he now revels. But he revels in Shakespeare, too. Acting the part of Prospero in the *Tempest*..." — *J. A. Wheeler, Princeton University*

The letter documents the two Princeton junior papers preceding the 1998 dissertation Appendix B: (i) derivation of the time part of the Schwarzschild metric by "poor-man's reasoning" (geometric methods extending Wheeler's *A Journey Into Gravity and Space Time*); and (ii) the *Within a Context* paper on EPR and Wheeler-style delayed-choice experiments. Together these trace the Princeton origin of both the dual-channel framework's GR content (Schwarzschild geometry) and its nonlocality/Bell content (EPR, delayed choice), which appear in the present paper as Level 6 through Level 5.

**Era IV: Books and consolidation (2016-2017).** Five-book series through 45EPIC Press: [McGucken 2016] *Light Time Dimension Theory: The Foundational Physics Unifying Einstein's Relativity and Quantum Mechanics*; [McGucken 2017a] *Einstein's Relativity Derived from LTD Theory's Principle: The Fourth Dimension is Expanding at  $c$ :  $dx_4/dt = ic$* ; [McGucken 2017b] *Relativity and Quantum Mechanics Unified in Pictures: Light Time Dimension Theory:  $dx_4/dt = ic$* ; [McGucken 2017c] *Quantum Entanglement and Einstein's "Spooky Action at a Distance" Explained via LTD Theory's Expanding Fourth Dimension  $dx_4/dt = ic$* ; [McGucken 2017d] *The Physics of Time: Time & Its Arrows in Quantum*

*Mechanics, Relativity, The Second Law of Thermodynamics, Entropy, The Twin Paradox, & Cosmology Explained via LTD Theory's Expanding Fourth Dimension*  
 $dx_4/dt = ic$ .

**Era V: Continuous development and active derivation program (2017-2026).**

- Facebook group *Elliot McGucken Physics* [MG-FB], 2017-present, >6000 followers: <https://www.facebook.com/elliottmcguckenphysics>
- Medium blog *Dr. Elliot McGucken Theoretical Physics* [MG-Medium], 2020-present: <https://goldennumberratio.medium.com/>
- Principal derivation program at *elliottmcguckenphysics.com* [MG-EMP], October 2024-present, 80+ technical papers: <https://elliottmcguckenphysics.com/>

Era V outputs establish as theorems of  $dx_4/dt = ic$ : Minkowski metric, four-momentum operator and canonical commutation relation, Schrödinger equation, Feynman path integral, Born rule, Dirac equation, Yang-Mills Lagrangians, Einstein field equations via the Schuller constructive-gravity closure, full Noether catalog of conservation laws, four-sector McGucken Lagrangian  $\mathcal{L}_{McG}$ , de Broglie relation, Heisenberg uncertainty principle, quantum nonlocality and Bell correlations via the McGucken Equivalence, Bekenstein-Hawking horizon entropy, cosmological constant, and Second Law and arrows of time.

**Summary of the dated trail**

Date	Source	Status
1998	UNC Chapel Hill dissertation, Appendix B pp. 153-156	Dated, university-archived
2003-2004	PhysicsForums.com (member #3753)	Public forum, author-verified
29 Aug 2006	sci.physics.relativity post	Direct Google Groups fetch-verified
2-5 Sep 2006	sci.physics.relativity follow-ups	Same thread, direct-verified
25 Aug 2008	FQXi essay contest	Institutionally indexed
2008-2011	Three full-text foundational PDFs	Direct PDF fetch-verified
2009-2013	Four additional FQXi essays	Institutionally indexed
10-11 Jul 2011	Hero's Odyssey Physics blog	Direct WordPress fetch-verified
11 Jul 2011	sci.physics (compact " $dx_4/dt=ic$ ")	Direct Google Groups fetch-verified
2016-2017	45EPIC Press book series (5 volumes)	ISBN-registered publications

Date	Source	Status
2017–present	Facebook group (>6000 followers)	Public, continuously archived
2020–present	Medium technical blog	Public, continuously archived
Oct 2024–2026	elliottmcguckenphysics.com (80+ papers)	Public, continuously archived

By the dated-publication-record standard physics uses — the same standard by which Newton’s priority on calculus rests on the 1687 *Principia* and Einstein’s on special relativity on the 1905 paper — priority on the physical content of  $dx_4/dt = ic$  rests with the present author, first recorded in the 1998 UNC Chapel Hill dissertation Appendix B (dated, university-archived) in coordinate-time form  $dx/dt = c$ , and in the compact imaginary-unit form in the 29 August 2006 *sci.physics.relativity* post (direct-verified). The earliest institutionally-indexed formal-paper record is the 25 August 2008 FQXi essay.

**Corpus context: companion papers**

The present paper is the master synthesis of a corpus of companion papers, each of which develops a specific level or set of levels at full technical length. Level 1 (Hamiltonian/Lagrangian through two disjoint routes to  $[\hat{q}, \hat{p}] = i\hbar$ ) is developed at full length in [MG-TwoRoutes], which also develops Level 3 (Heisenberg/Schrödinger pictures), Level 4 (wave/particle duality), and Level 5 (locality/nonlocality) as further dual-channel readings at the dynamical, ontological, and causal/correlational levels. The four-sector Lagrangian  $\mathcal{L}_{McG} = \mathcal{L}_{kin} + \mathcal{L}_{Dirac} + \mathcal{L}_{YM} + \mathcal{L}_{EH}$  around which every quantum-field-theoretic amplitude in the Standard Model and its diffeomorphism-invariant gravitational extension expands is uniquely forced by  $dx_4/dt = ic$  through a four-fold uniqueness theorem, developed at full length in [MG-Lagrangian]. The Yang–Mills sectors for  $SU(2) \times U(1)$  and  $SU(3)$  are forced by the Clifford-algebraic extension of  $x_4$ ’s perpendicularity marker developed in [MG-SM]; the Dirac sector by the first-order Lorentz-scalar uniqueness developed in [MG-Dirac]; the Einstein–Hilbert sector by Schuller’s constructive-gravity closure developed in [MG-SM, Theorem 12]. Level 5 (locality/nonlocality) with the six senses of geometric nonlocality of the expanding McGucken Sphere (foliation leaf, level set of a distance function, Huygens caustic, Legendrian submanifold in contact geometry, conformal pencil member, and null-hypersurface cross-section), the resolution within McGucken Spheres of the double-slit experiment, Wheeler’s delayed-choice experiment, and all quantum eraser experiments, and the Two McGucken Laws of Nonlocality is developed at full length in [MG-Nonlocality] and in §V.8 of [MG-TwoRoutes]. The Copenhagen-resolution supplement with the explicit singlet-correlation derivation from shared McGucken Sphere identity is developed in [MG-NonlocCopen]. The

McGucken Equivalence identifying quantum nonlocality as the three-dimensional shadow of four-dimensional  $x_4$ -coincidence on the light cone is developed in [MG-Equiv]. Level 2 (the thermodynamic extension) with the full twelve-fold Noether catalog, the Second-Law derivations with the strict  $dS/dt > 0$  result, the five arrows of time, the dissolution of the Loschmidt reversibility objection, and the derivation (not assumption) of the Past Hypothesis is developed at full length in [MG-ConservationSecondLaw]. Supporting entropy-increase derivations are in [MG-Entropy], [MG-Singular], [MG-KaluzaKlein], [MG-PhotonEntropy], and [MG-Eleven]. The master equation  $u^\mu u_\mu = -c^2$  and the kinematic mass/energy and space/time dualities are developed in [MG-Proof] and in [MG-Noether §§II-III]. Every element of the Feynman-diagram apparatus — propagator, ie prescription, vertex, external line, Dyson expansion, Wick’s theorem, loops, Wick rotation, Euclidean formulation, lattice QFT — is derived as a theorem of  $dx_4/dt = ic$  in [MG-FeynmanDiagrams], which also identifies Feynman diagrams geometrically as chains of intersecting McGucken Spheres (propagators ride individual Spheres; vertices are Sphere intersections; the Dyson expansion is a sum over topologically distinct chains of intersecting Spheres; loops are closed chains). Supporting derivations are in [MG-Commut], [MG-HLA], [MG-PathInt], [MG-Wick], [MG-Born], [MG-QED], [MG-Compton], [MG-deBroglie], [MG-Uncertainty], [MG-Constants], [MG-Twistor], [MG-Amplituhedron], [MG-Bekenstein], and [MG-Lambda]. The present paper synthesizes all seven levels into the single master statement: *all seven dualities descend from  $dx_4/dt = ic$  as parallel sibling consequences of the same dual-channel structure, through the same two channels, at seven distinct levels of physical description.*

The present paper is situated within Era V of this trajectory. Its specific claim — that the seven dualities of Hamiltonian/Lagrangian formulations, conservation laws and the Second Law, Heisenberg/Schrödinger pictures, wave/particle duality, local microcausality/nonlocal Bell correlations, mass/energy, and space/time all descend from  $dx_4/dt = ic$  as parallel sibling consequences of the same dual-channel structure — rests technically on the full Era V derivation program enumerated above, historically on the earlier development that established the Principle as a working foundation (Princeton origin, 1998 dissertation appendix, 2003–2006 Usenet deployments, 2008–2013 FQXi papers, 2016–2017 45EPIC Press books), and conceptually on the Princeton origin in Wheeler’s teaching on the Schwarzschild time factor and the EPR paradox.

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## **Afterword: One Lifetime’s Work on Light**

The three major bodies of work the author has pursued across a professional lifetime — the award-winning artificial retinal prosthesis developed during the 1998 NSF-funded doctoral dissertation at UNC Chapel Hill, which converts incident pho-

tons into neural signals to help blind patients see; quantum mechanics, which began with Planck's 1900 blackbody radiation law and Einstein's 1905 photoelectric effect paper and took its modern form around the behavior of the photon; and relativity, whose foundational postulate is the invariance of the speed of light for all inertial observers — share a single subject. That subject is light.

The McGucken Principle  $dx_4/dt = ic$ , which the present paper develops as the geometric foundation underlying the dual-channel structure of physics, places the speed of light at the center of spacetime itself: the fourth dimension advances at precisely the rate at which photons propagate, and the two facts are not independent but identical. Photons are matter riding the  $x_4$ -expansion; the  $x_4$ -expansion is the geometric substrate from which photon propagation emerges. The retinal prosthesis work is engineering that converts the same photons into the substrate of sight.

The reader is asked to keep this framing in mind through the technical development that follows. The paper derives both formulations of quantum mechanics, the conservation laws and the Second Law of Thermodynamics, both pictures of quantum dynamics, wave/particle duality, locality and nonlocality, mass/energy, and space/time as parallel consequences of a single geometric principle. The principle is a statement about light. The consequences are statements about everything light makes possible.

The thirty-seven-year theoretical program developed across the 1998 dissertation appendix, the 2008–2013 FQXi essays, the 2016–2017 45EPIC Press book series, and the ongoing derivation program at [elliottmcguckenphysics.com](http://elliottmcguckenphysics.com) is the same subject approached from the foundational direction. The retinal prosthesis and the physics program are not separate projects. They are one lifetime's work on light — what it is, what it does, and what we can do once we understand it.

Just as Ptolemy's observational data provided Kepler with the empirical evidence for his equations, physics across all domains has provided McGucken with the empirical evidence supporting his physical principle  $dx_4/dt = ic$ .

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## McGucken Corpus Cross-References

[MG-Dissertation] E. McGucken, *Multiple Unit Artificial Retina Chipset to Aid the Visually Impaired and Enhanced Holed-Emitter CMOS Phototransistors* (doctoral dissertation, University of North Carolina at Chapel Hill, 1998; advisors W. Liu and S. Washburn). Appendix B, "Physics for Poets: The Law of Moving Dimensions," pp. 153–156. Contains the first formal written record of the postulate (in coordinate-time form  $dx/dt = c$ ), the derivation of  $E = mc^2$  (eq. AB.1) from four-velocity rotation into the time dimension, wave/particle duality as the dual-channel

reading, Feynman-path-integral content, the Second Law and entropy from spherical  $x_4$ -expansion, the energy/momentum operator pair, time dilation, length contraction, and the derivation of Einstein's first postulate from the law of moving dimensions.

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