# The McGucken Principle $dx_4/dt = ic$ as the Common Foundation of the Conservation Laws and the Second Law of Thermodynamics: A Remarkable and Counter-Intuitive Unification

*How a Single Geometric Principle $dx_4/dt = ic$ Simultaneously Generates the Time-Symmetric Noether Currents of the Poincaré, $U(1)$, $SU(2)_L$, $SU(3)_c$, and Diffeomorphism Groups AND the Time-Asymmetric Second Law of Thermodynamics and the Five Arrows of Time, Resolving Loschmidt's 1876 Reversibility Objection as the Dual-Channel Content of a Single Principle Rather Than a Conflict Between Two Separate Foundations*


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*Light Time Dimension Theory*

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*"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

*"Something must be added to the geometrical conceptions comprised in Minkowski's world before it becomes a complete picture of the world as we know it."*
— Arthur Stanley Eddington, *The Nature of the Physical World* (1928)

*"And yet it moves."    The fourth dimension moves.*
— Galileo Galilei · McGucken

## Contents

## Abstract

For the first time in the history of physics, it is shown that the standard conservation laws (Noether *et al.*) and the Second Law of Thermodynamics both emerge as theorems of a single geometric principle — the McGucken Principle, which states that the fourth dimension is expanding in a spherically-symmetric manner: $dx_4/dt = ic$. This unification is both remarkable and counter-intuitive as it unites two categories that have occupied separate conceptual compartments for over 150 years, ever since Loschmidt's 1876 reversibility objection against Boltzmann. It is remarkable because the two categories have been held to originate from radically different kinds of foundations throughout the history of theoretical physics: conservation laws from time-symmetric symmetries of the action (Noether 1918), and the Second Law from time-asymmetric statistical behavior of macroscopic ensembles (Boltzmann 1872, Gibbs 1902). It is counter-intuitive because conservation laws are rigorous consequences of time-symmetric microscopic dynamics, while the Second Law is a statement of absolute time-asymmetry — $dS/dt > 0$ strictly, not on average, not statistically, but as an observed absolute prohibition. That both come from the *same* principle requires that the principle itself carry both time-symmetric and time-asymmetric content, and that it unpack these contents through two logically distinct channels that nevertheless agree at the foundational level of the underlying geometry.

This paper establishes this unification through three main steps. **First**, the conservation laws are derived as theorems of $dx_4/dt = ic$ via the complete Noether catalog developed in [MG-Noether]: the ten Poincaré charges (energy from temporal uniformity of $x_4$'s advance, three spatial momenta from spatial homogeneity, three angular momenta from spherical isotropy of $x_4$'s expansion, three boost charges from Lorentz covariance of $dx_4/dt = ic$), the internal U(1) electric charge from absence of a preferred phase origin on $x_4$, the non-Abelian $SU(2)_L$ weak isospin and $SU(3)_c$ color charges from Clifford-algebraic extensions of $x_4$-orientation to the transverse-and-spatial rotation sectors, and the diffeomorphism-invariance covariant energy-momentum conservation $\nabla_\mu T^{\mu\nu} = 0$. Each derivation follows the chain: Postulate 1 → geometric symmetry of $x_4$'s advance → symmetry of the action → Noether's theorem → conservation law. **Second**, the Second Law of Thermodynamics is derived as a theorem of $dx_4/dt = ic$ via the same principle read through a distinct structural channel: the spherically symmetric expansion of $x_4$ from every spacetime point at rate c forces the spatial projection of each particle's $x_4$-driven displacement to be isotropic at each moment. Iterated at successive time intervals, isotropic displacement is mathematically identical to Brownian motion [MG-Entropy]. The central limit theorem then yields a Gaussian spreading of any particle ensemble with monotonically increasing Boltzmann-Gibbs entropy $dS/dt = (3/2)k_B/t > 0$ strict for all $t > 0$ [MG-Singular, §V; MG-KaluzaKlein, §V.2]. For photons on the McGucken Sphere of radius $R = ct$, the Shannon entropy is $S(t) = k_B \ln(4\pi(ct)^2)$, also monotonic in t [MG-PhotonEntropy, §3]. Both entropies increase because the sphere grows; the sphere grows because $x_4$ advances at rate

c. **Third**, the structural unity of the two derivations is analyzed: both the conservation laws and the Second Law descend from the same principle through the *dual-channel structure* of its content — Channel A (algebraic-symmetry / temporal uniformity / spatial homogeneity / spherical isotropy as symmetry statements / Lorentz covariance of the rate) driving the Noether currents, and Channel B (geometric-propagation / spherical expansion from every point / isotropic wavefront emission) driving the Second Law. This is the same dual-channel structure identified at four other levels of physical description in [MG-TwoRoutes] and in the McGucken Equivalence [MG-Equiv; MG-Singular §VII]: at the foundational level it generates the Hamiltonian and Lagrangian formulations of quantum mechanics; at the dynamical level it generates the Heisenberg and Schrödinger pictures; at the ontological level it generates the wave and particle aspects of quantum objects; and at the causal/correlational level it generates the local microcausality of standard operator algebra and the nonlocal Bell correlations of entanglement (the McGucken Equivalence identifies quantum nonlocality as the three-dimensional shadow of four-dimensional $x_4$-coincidence on the light cone). The four preceding levels all sit *within* quantum mechanics and all pair two time-symmetric features; the thermodynamic level developed in the present paper is the *fifth* level at which the same dual-channel structure appears, and it is the level at which the dual-channel structure extends *beyond* quantum mechanics into thermodynamics, pairing a time-symmetric feature (conservation laws) with a time-asymmetric feature (Second Law + arrows of time).

The principal consequence is the dissolution of Loschmidt's 1876 reversibility objection. Loschmidt observed that if the microscopic dynamics (Newtonian in 1876, later extended to Hamiltonian, quantum, and gauge-field mechanics) are time-reversal symmetric, then the Boltzmann H-theorem cannot follow rigorously; any entropy-increasing trajectory must be accompanied by a time-reversed entropy-decreasing trajectory of equal statistical weight. Boltzmann's 1877 response — that entropy-decreasing trajectories are overwhelmingly improbable — resolves the tension statistically but not absolutely, and requires auxiliary low-entropy initial conditions (the Past Hypothesis; see Penrose 1989, 2004; Albert 2000) that are not derivable from the time-symmetric microscopic laws. Under the McGucken Principle, the tension is not a tension at all: the conservation laws and the Second Law are two readings of the same geometric fact through two distinct channels, and neither channel is reducible to the other. The time-symmetric content (Channel A) is what produces the conservation laws; the spherically-symmetric geometric-propagation content (Channel B) is what produces the Second Law. The two contents coexist in the single statement $dx_4/dt = ic$. Penrose's $10^{-10^{123}}$ fine-tuning problem for the low-entropy initial conditions of the universe dissolves as a theorem [MG-Eleven]: $x_4$'s origin is, geometrically necessarily, the lowest-entropy moment of any system participating in $x_4$'s expansion, so the "special initial state" is not tuned — it is the point from which $x_4$ has not yet expanded.

This paper is organized as follows. §I develops the 150-year-old problem. §II derives the conservation laws from $dx_4/dt = ic$ via the Noether catalog [MG-Noether]. §III derives the Second Law from $dx_4/dt = ic$ via spherical isotropic random walk and the Shannon-entropy growth on the McGucken Sphere. §IV derives the five arrows of time from the same principle. §V analyzes the structural unity: Channel A and Channel B of $dx_4/dt = ic$ as the two logical contents of a single principle, each generating one of the two categories. §VI develops the resolution of the Loschmidt reversibility problem and the dissolution of the Past Hypothesis. §VII shows how both the conservation laws and the Second Law are visible in the McGucken Lagrangian $\mathscr{L}$_McG developed in [MG-Lagrangian]. §VIII compares the McGucken framework to the 282-year Lagrangian tradition from Maupertuis (1744) through the Standard Model plus Einstein-Hilbert, showing that no prior Lagrangian in that tradition has encompassed the Second Law as a consequence; $\mathscr{L}$_McG does. §IX offers concluding remarks.

A further structural note: the unification developed in this paper situates the conservation-laws-plus-Second-Law result alongside a broader pattern in the McGucken corpus. The four papers of Einstein's 1905 *Annus Mirabilis* each introduced a foundational result — (i) the photoelectric effect with the light-quantum relation E = hf establishing the quantum of energy, (ii) the explanation of Brownian motion establishing the Einstein diffusion relation D = μk_BT and compelling the acceptance of atomic theory, (iii) the special theory of relativity with the constancy of the speed of light and the Lorentz transformations, and (iv) mass-energy equivalence $E = mc^2$ as a consequence of special relativity — and each is a theorem of $dx_4/dt = ic$ in the McGucken framework: E = hf from the oscillatory Planck-scale form of $x_4$'s advance [MG-Constants; MG-deBroglie, Theorem 1]; Brownian motion from the spatial projection of $x_4$'s spherically symmetric expansion, the derivation developed in §III of the present paper [MG-Entropy]; the constancy of c and the Lorentz transformations from the invariant rate of $x_4$'s expansion under Lorentz boosts [MG-Proof; MG-Noether, Proposition V.3]; and $E = mc^2$ from the master equation u^μu_μ = $-c^2$ with a spatially-resting particle carrying its entire four-momentum in the $x_4$ direction [MG-Noether, §II]. Einstein's 1905 *Annus Mirabilis* thus unifies, in the McGucken framework, into four simultaneous theorems of a single geometric principle — and the present paper adds a fifth unification (conservation laws plus the Second Law) descending from the same principle.

**Keywords:** McGucken Principle; $dx_4/dt = ic$; conservation laws; Second Law of Thermodynamics; Noether's theorem; Loschmidt reversibility objection; Past Hypothesis; arrows of time; Brownian motion; McGucken Sphere; dual-channel structure; geometric foundations of thermodynamics.

## Summary: The Two Categories at a Glance

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The structural unification developed in this paper may be summarized at a glance in the following table. The left column is Channel A, the algebraic-symmetry content of $dx_4/dt = ic$; the right column is Channel B, the geometric-propagation content. Both columns descend from the single starting principle and converge in the single Lagrangian $\mathscr{L}$_McG developed in [MG-Lagrangian]. The full propositions with proofs are developed in §§II–V; the Loschmidt resolution is developed in §VI; the visibility of both categories in $\mathscr{L}$_McG is developed in §VII; the comparison with the 282-year Lagrangian tradition is developed in §VIII.

| Structural element | Channel A: Conservation laws (§II) | Channel B: Second Law and arrows of time (§III–IV) |
|---|---|---|
| Starting principle | $dx_4/dt = ic$ | $dx_4/dt = ic$ |
| Content of principle used | Algebraic-symmetry content: temporal uniformity of $dx_4/dt$, spatial homogeneity of $x_4$'s expansion, spherical isotropy as symmetry statement, Lorentz covariance of the rate, absence of preferred phase origin on $x_4$ | Geometric-propagation content: spherical expansion from every spacetime point at rate c, Huygens' secondary wavelets, isotropic wavefront emission |
| First intermediate | Invariances of the free-particle action $S = -mc \int \lvert dx_4 \rvert$ under Poincaré and gauge transformations, established geometrically from temporal uniformity, spatial homogeneity, spherical isotropy, Lorentz covariance, and absence of a preferred $x_4$-phase origin | Huygens' principle: spherically-symmetric propagation from every point [MG-PathInt, Lemma 3.1]; spatial projection of $x_4$-driven displacement is isotropic at each moment [MG-Entropy; MG-Singular §V] |
| Second intermediate | Noether's theorem applied to each invariance yields the associated conserved current [MG-Noether, Sections IV–VII] | Iterated isotropic displacement produces Brownian motion via the central limit theorem [MG-Entropy]; Gaussian spreading of particle ensemble follows |

| Structural element | Channel A: Conservation laws (§II) | Channel B: Second Law and arrows of time (§III–IV) |
|---|---|---|
| Third intermediate | Full Noether catalog: Poincaré ten charges ($E$, $P^i$, $J^{ij}$, $K^i$), U(1) electric charge, $SU(2)_L$ weak isospin, $SU(3)_c$ color, diffeomorphism covariant conservation $\nabla_\mu T^{\mu\nu} = 0$ | Boltzmann-Gibbs entropy $S(t) = (3/2)k_B \ln(4\pi e D t)$ for massive particles [MG-Singular §V]; Shannon entropy $S(t) = k_B \ln(4\pi(ct)^2)$ for photons on McGucken Sphere [MG-PhotonEntropy §3] |
| Fourth intermediate | Each charge is a function of a symmetry of $dx_4/dt = ic$ and is derived, not assumed [MG-Noether] | Entropy rate: $dS/dt = (3/2)k_B/t > 0$ strict for all $t > 0$ [MG-KaluzaKlein, §V.2; MG-Singular, §V] |
| Fifth intermediate | The ten Poincaré charges are Noether currents of $x_4$'s spacetime isometries; the U(1), $SU(2)_L$, $SU(3)_c$ charges are Noether currents of $x_4$-phase/orientation symmetries; diffeomorphism conservation is the Noether current of $x_4$-manifold-covariance | Five arrows of time: thermodynamic, radiative, cosmological, causal, psychological — all from the single monotonic advance of $x_4$ at rate $c$ [MG-Singular, §VI; MG-KaluzaKlein, §V.3] |
| Time-symmetry character | **Time-symmetric.** The Poincaré group includes time-reversal T, the gauge groups are T-symmetric, and each Noether current is conserved under both forward and backward time evolution | **Time-asymmetric.** $dS/dt$ is strictly positive for all $t > 0$; entropy cannot decrease because $x_4$ cannot retreat; the arrows of time point forward absolutely |
| Final destination | Each conservation law: $dQ/dt = 0$ for $Q \in \{E, P^i, J^{ij}, K^i, Q_{EM}, Q_I, Q_c, T^{\mu\nu} \text{ flux}\}$ | $dS/dt > 0$ strict; the five arrows of time; Loschmidt resolution; Past Hypothesis dissolved (§VI) |

| Structural element | Channel A: Conservation laws (§II) | Channel B: Second Law and arrows of time (§III–IV) |
|---|---|---|
| Role in ℒ_McG | The Lagrangian ℒ_McG of [MG-Lagrangian] possesses all Poincaré + gauge + diffeomorphism invariances, and each invariance generates its Noether current under the standard procedure | ℒ_McG inherits $x_4$'s spherically symmetric expansion from Postulate 1; the entropy increase is a theorem of the Lagrangian's coupling to $x_4$ via the Compton-frequency coupling [MG-PhotonEntropy, §6] |
| Historical precedent | 200+ years: Lagrange 1788, Hamilton 1835, Noether 1918, Wigner 1939, Weyl 1918, Yang-Mills 1954, Glashow-Weinberg-Salam 1967-68 | No prior Lagrangian in the 282-year tradition from Maupertuis 1744 through the Standard Model has encompassed the Second Law as a theorem of its structure (§VIII) |
| Structural role | Symmetric: what is invariant under transformations | Asymmetric: what is monotonic under time evolution |

## I. Introduction: 150 Years of Separate Compartments

The conservation laws and the Second Law of Thermodynamics have stood as two foundational pillars of physics for over a century and a half, and they have stood in remarkably separate conceptual compartments. This separation is not accidental but structural: the two categories come from *different kinds of foundations*, operate on *different time-symmetry structures*, and have resisted unification despite repeated attempts.

### I.1 The Time-Symmetric Pillar: Conservation Laws from Noether's Theorem

On the one hand, the conservation laws of physics are the rigorous consequences of time-symmetric microscopic dynamics. Emmy Noether's 1918 theorem [Noether 1918] established that every continuous symmetry of the action corresponds to a conservation law: time-translation invariance yields energy conservation; spatial-translation invariance yields momentum conservation; rotational invariance yields angular-momentum conservation; Lorentz-boost invariance yields the boost charges; global phase invariance yields charge conservation; gauge invariance yields gauge-charge conservation; diffeomorphism invariance yields covariant energy-momentum conservation. The full catalog includes the ten Poincaré charges (energy, three momenta, three angular momenta, three boost charges), the internal U(1) electric charge, the non-Abelian $SU(2)_L$ weak isospin and $SU(3)_c$ color charges, and the diffeomorphism-invariant covariant conservation $\nabla_\mu T^{\mu\nu} = 0$.

Each of these conservation laws follows from a *time-symmetric* symmetry. The symmetry groups — Poincaré, U(1), $SU(2)_L$, $SU(3)_c$, diffeomorphism — are all invariant under time-reversal T (in the discrete sense; the continuous Lie group is structurally time-reversal-symmetric, with T serving as a discrete automorphism). The conservation laws they generate are statements about quantities that are *constant under time evolution in either direction*: energy is conserved whether you run time forward or backward; momentum is conserved whether you run time forward or backward; charge is conserved whether you run time forward or backward. This time-symmetry is not a feature of the specific Lagrangian being used; it is intrinsic to the structure of Noether's theorem: a continuous symmetry of the action produces a conserved current, and the conservation equation $\partial_\mu j^\mu = 0$ holds equally under $t \to -t$ as under $t \to t$. The conservation laws are the content of the Lagrangian's *time-symmetric structure*.

This time-symmetry is deep. It means that the microscopic laws of physics, as encoded in Lagrangians and derived from them via Noether's theorem, are *invariant under time reversal*. Energy does not spontaneously appear or disappear in either time direction; momentum does not spontaneously change in either time direction; charge does not spontaneously appear or disappear in either time direction. The microscopic laws are fundamentally *reversible*, and their associated conservation laws are fundamentally symmetric under time reversal.

### I.2 The Time-Asymmetric Pillar: The Second Law of Thermodynamics

On the other hand, the Second Law of Thermodynamics is a statement of *absolute time-asymmetry*. Entropy strictly increases: $dS/dt > 0$ — only in the forward time direction. Entropy does not decrease in isolated systems; thermal gradients equalize but do not spontaneously re-form; mixed fluids do not unmix; shattered cups do not spontaneously reassemble; warm coffee does not spontaneously refrigerate while warming the surrounding room. The Second Law is a statement about the absolute direction of physical evolution, and it asserts that this direction is the forward time direction and never the backward time direction.

This time-asymmetry is not a feature of some Lagrangians and not others; it appears to be a *universal* feature of every physical system in which enough degrees of freedom are present for thermodynamic behavior to emerge. The Second Law applies equally to mechanical, electromagnetic, gravitational, and quantum systems. It applies to galactic dynamics, to biological organisms, to stellar evolution, to chemical reactions, to black-hole thermodynamics. Wherever a macroscopic ensemble is present, the Second Law applies.

### I.3 The Separation Runs Through the Experimental Programs as Well

The separate-compartments status of the conservation laws and the Second Law is not confined to their theoretical foundations; it extends to the *empirical programs* by which each pillar has been assessed over the past 150 years. The two categories derive from different experiments, use different apparatus, and connect to different precision-measurement traditions. This parallel empirical separation is worth making explicit, because any unification at the foundational level must eventually contend with the fact that the unified principle must be consistent with two distinct bodies of experimental evidence collected under disjoint measurement programs.

**The conservation-law experimental program** consists of precision kinematic and balance measurements on isolated systems. Its modern form begins with Mayer (1842) and Joule (1843-1850), whose paddle-wheel, electrical-resistance, and calorimetric experiments established the mechanical equivalent of heat and thereby the conservation of energy across mechanical, thermal, and electrical forms. The program extends through Hertz's confirmation (1887-1889) of Maxwell's electromagnetic momentum as a conserved quantity, through the Compton scattering experiments (1923) verifying energy-momentum conservation at the quantum level for individual photon-electron collisions, through Millikan's oil-drop experiments (1909-1913) confirming the quantization and conservation of electric charge, and through the Reines-Cowan neutrino-detection experiments (1956) which completed the empirical confirmation of lepton-number conservation by direct detection of the missing particle required by energy-momentum balance in β-decay. The modern incarnation is at high-energy colliders: the LEP measurements at CERN (1989-2000) tested electroweak conservation laws to precision $\sim 10^{-4}$, the Tevatron (1987-2011) and now the LHC (2008-present) test four-momentum conservation in high-energy collisions event-by-event to the precision of particle-tracking systems. Parallel experimental programs test conservation of individual quantum numbers: proton-decay searches at Super-Kamiokande (1996-present) and Hyper-Kamiokande (under construction) constrain baryon-number non-conservation to $\tau > 10^{34}$ years; atomic-parity-violation experiments at JILA, Oxford, and elsewhere test parity-related selection rules to parts in $10^8$; searches for neutrinoless double-beta decay at GERDA, MAJORANA, and KamLAND-Zen constrain lepton-number violation at the meV scale of neutrino Majorana masses. The apparatus of this program is characteristically: particle detectors, magnetic spectrometers, calorimeters for individual-event energy reconstruction, and precision kinematic reconstruction of isolated collision or decay events.

**The Second-Law experimental program** uses entirely different apparatus and measures entirely different quantities. Its modern form begins with Carnot's 1824 analysis of heat-engine efficiency bounds and Clausius's 1850s-60s work relating entropy to heat flow, continues through Maxwell-Boltzmann velocity-distribution measurements (Loschmidt 1865, Maxwell 1860, and their successors) measuring molecular-speed distributions consistent with the equilibrium statistical-mechanics predictions, and reaches experimental maturity in Einstein's 1905 Brownian-motion paper and Perrin's 1908-1913 experimental confirmation of the Einstein-Smoluchowski diffusion relation via direct microscopic observation of colloidal particles. Modern Second-Law experiments include: diffusion measurements in ultracold-atom systems at JILA, NIST, and MIT (2000s-present) measuring mean-squared displacement and comparing to thermal-diffusion predictions; fluctuation-dissipation verifications in condensed-matter systems; measurements of entropy production in nonequilibrium steady states; precision calorimetry verifying the third law of thermodynamics as temperatures approach absolute zero; and, at cosmological scales, the CMB anisotropy power-spectrum measurements from COBE (1989-1993), WMAP (2001-2010), and Planck (2009-2013), which constrain the entropy of the early universe to part-per-billion precision in the 380,000-year-post-Big-Bang CMB radiation field, and the large-scale-structure surveys 2dFGRS (1995-2002), SDSS (2000-present), and DES (2013-2019), which measure the growth of cosmological entropy through the galaxy two-point correlation function and weak-lensing power spectrum. The apparatus of this program is characteristically: calorimeters for bulk heat measurement, microscopes and optical traps for Brownian-motion observation, satellite-borne radiometers for CMB measurement, and galaxy-survey telescopes for structure-formation statistics.

**These two experimental programs have essentially no overlap in apparatus, measurement procedure, or precision-measurement tradition.** A particle physicist measuring charge conservation at an LHC collision vertex uses no thermodynamic apparatus; a cosmologist fitting the Planck CMB power spectrum to ΛCDM uses no Noether current. The only historical point of genuine bridging is Joule's mid-nineteenth-century work, which measured the mechanical equivalent of heat and thereby connected the energy-conservation pillar (via the first law of thermodynamics) to the measurement tradition that would later produce the Second Law — but even Joule's work treats the two principles as separate statements about separate quantities (energy, which is conserved, and entropy, which increases), with their separation preserved in the statements of the first and second laws of thermodynamics.

The empirical-program separation reinforces the theoretical-compartment separation documented in §§I.1–I.2. Any claim to unify the conservation laws and the Second Law at the foundational level must therefore connect to *both* experimental programs simultaneously: the unifying principle must generate predictions consistent with the precision particle-physics conservation-law measurements AND with the cosmological and thermodynamic entropy-increase measurements, and the principle must accommodate the fact that these measurements have been historically disjoint. The McGucken Principle $dx_4/dt = ic$ accomplishes this dual connection: §II shows that the twelve Noether conservation laws are theorems of $dx_4/dt = ic$ (connecting to the conservation-law experimental program through the full Standard-Model-plus-GR empirical catalog); §§III-IV show that the Second Law, Brownian motion, the five arrows of time, and the CMB-era entropy evolution are theorems of the *same* principle through a distinct derivational channel (connecting to the Second-Law experimental program through the Boltzmann-Gibbs, Einstein-Smoluchowski, and cosmological-structure measurement traditions). The dual experimental connection through two structurally distinct channels of a single principle is the empirical analogue of the dual-channel theoretical structure developed in §V.

### I.4 The Loschmidt Reversibility Objection (1876)

The tension between these two pillars was first sharply articulated by Josef Loschmidt in 1876 [Loschmidt 1876], in a letter to Boltzmann raising what is now called the Loschmidt reversibility objection. Loschmidt observed that Boltzmann's 1872 H-theorem [Boltzmann 1872] — which argued that the Boltzmann H-function (negative of entropy) monotonically decreases under the assumption of Stosszahlansatz (molecular chaos) — cannot follow rigorously from time-symmetric microscopic dynamics. The microscopic laws are time-reversal symmetric; therefore, for any trajectory along which H decreases (entropy increases), there exists a time-reversed trajectory along which H increases (entropy decreases), of equal statistical weight under a time-symmetric distribution. Therefore the H-theorem cannot be a strict consequence of time-symmetric microscopic dynamics alone. Some auxiliary assumption must be at work, or the theorem must be weakened from "H monotonically decreases" to "H tends to decrease on average."

Loschmidt's objection was sharp and has never been fully answered in the terms of its statement. Boltzmann's 1877 response [Boltzmann 1877] argued that while entropy-decreasing trajectories exist in principle, they are overwhelmingly improbable compared to entropy-increasing ones; the number of microstates consistent with a high-entropy macrostate is astronomically larger than the number consistent with a low-entropy one, so a random trajectory will almost certainly be entropy-increasing. This statistical resolution has become the textbook answer for 150 years, and it has always been *unsatisfying* in three specific ways:

(i) **Probability is not necessity.** Boltzmann's argument gives a statistical tendency, not an absolute prohibition. The Second Law, as empirically observed, is *absolute*: entropy never decreases in isolated systems, not merely rarely. A statistical tendency that is not universal cannot, in principle, explain an absolute prohibition. As Penrose has emphasized [Penrose 1989, 2004], the problem is that the statistical argument treats the direction of time evolution symmetrically — the same argument that makes entropy-decrease improbable in the forward direction makes entropy-increase improbable in the backward direction, and the observed asymmetry is therefore not explained.

(ii) **The Past Hypothesis is required.** The statistical argument requires that the system *begin* in a low-entropy state. If it began in a high-entropy state, then the statistical argument would predict no further increase, and yet systems observed to be in high-entropy states continue to increase their entropy (or, more precisely, the universe as a whole continues to evolve toward higher entropy states). To explain this, cosmologists and philosophers of physics have introduced the *Past Hypothesis* — the claim that the universe began in a state of extraordinarily low entropy. Roger Penrose [Penrose 1989] quantified the improbability of this initial state as one part in $10^{(10}123)$ — a fine-tuning that is without precedent in physics, more extreme than any other fine-tuning problem including the cosmological constant's 10^(-120) problem. The Past Hypothesis is not derivable from the time-symmetric microscopic laws; it must be *added* as an auxiliary input to explain the observed direction of the Second Law.

(iii) **The microscopic laws remain time-symmetric.** No amount of statistical argument changes the fact that the microscopic laws themselves are time-symmetric. The Second Law's absolute time-asymmetry must therefore come from *somewhere*, and if not from the microscopic laws, then from initial conditions — which pushes the problem to cosmology. Cosmology then faces the Past Hypothesis problem in its full form: why did the universe begin in a state so special that Penrose's $10^{(-10}123)$ fine-tuning is required?

This is the 150-year-old state of the Loschmidt reversibility problem. Conservation laws come from time-symmetric microscopic dynamics; the Second Law's time-asymmetry comes from statistical behavior plus initial conditions; the two categories have operated in separate conceptual compartments, and no principle has been identified that would unify them as simultaneous theorems of a common foundation.

### I.5 Provenance of the McGucken Principle: Thirty-Seven Years of Development

The McGucken Principle $dx_4/dt = ic$ is not a recent proposal. It has been under continuous development for nearly four decades, beginning with the author's undergraduate work at Princeton University in the late 1980s and extending through the active derivation program of 2024-2026. A brief chronological record is included here to situate the present paper within that long arc [MG-History]. For the comprehensive documented chronology — including archived forum posts, Google Groups Usenet records, FQXi essay contest submissions, Blogspot timestamps, science forum records, and complete bibliography — the reader is referred to the standalone historical-provenance document at elliotmcguckenphysics.com [MG-History].

**Era I: The Princeton origin (late 1980s–1999).** The intellectual origins of the McGucken Principle trace to the author's undergraduate years at Princeton University, working directly with three giants of twentieth-century physics: John Archibald Wheeler — Joseph Henry Professor of Physics, student of Bohr, teacher of Feynman, close colleague of Einstein — who was the author's academic advisor; P.J.E. Peebles — Albert Einstein Professor Emeritus of Science, co-predictor of the cosmic microwave background radiation, later awarded the 2019 Nobel Prize in Physics for theoretical discoveries in physical cosmology — who was the author's professor for quantum mechanics, using the galleys of his then-forthcoming textbook *Quantum Mechanics*; and Joseph H. Taylor Jr. — James S. McDonnell Distinguished University Professor of Physics, 1993 Nobel Laureate for the discovery of the binary pulsar PSR B1913+16 — who was the author's professor for experimental physics and advisor for the junior paper on quantum entanglement. These Princeton afternoons, recounted in documented detail in [McGucken 2017c] and [MG-FB] E. McGucken, *Elliot McGucken Physics* (Facebook group), URL: https://www.facebook.com/elliotmcguckenphysics (2017–present). Public forum for the McGucken framework's ongoing development, maintained continuously from 2017 through 2026, with more than six thousand followers. Archive contains discussions of the equation $dx_4/dt = ic$, its derivational consequences, its relationship to the broader foundations-of-physics literature, and running commentary on contemporary physics developments.

[MG-Medium] E. McGucken, *Dr. Elliot McGucken Theoretical Physics* (Medium blog), URL: https://goldennumberratio.medium.com/ (2020–present). Public technical blog maintained continuously from 2020 through the present. Contains substantive technical papers including the original derivation of entropy's increase from $dx_4/dt = ic$, the McGucken Invariance paper revisiting Einstein's relativity of simultaneity, the Uncertainty Principle $\Delta x \Delta p \geq \hbar/2$ derivation from the Principle, derivations of the Principle of Least Action and Huygens' Principle from $dx_4/dt = ic$, comparative analyses of string theory and the McGucken Principle, and the McGucken Proof. Many of the papers later formalized in the 2024–2026 elliotmcguckenphysics.com technical series first appeared on this blog.

[MG-PrincetonAfternoons], produced the specific physical intuitions that later crystallized as the McGucken Principle $dx_4/dt = ic$.

The central conversation with Wheeler is a matter of record [MG-PrincetonAfternoons]. In Wheeler's third-floor Jadwin Hall office, the author asked: *"So a photon doesn't move in the fourth dimension? All of its motion is directed through the three spatial dimensions?"* Wheeler: *"Correct."* The author: *"So a photon remains stationary in the fourth dimension?"* Wheeler: *"Yes."* This exchange established the first half of the physical picture that would later ground the McGucken Principle: the photon, at $|\mathbf{v}| = c$, is stationary in $x_4$ while advancing through the spatial dimensions.

The complementary conversation with Peebles, the same afternoon, established the second half. In Peebles' office: *"When a photon is emitted from a source, it has an equal chance of being found anywhere upon a spherically-symmetric wavefront expanding at the rate of c?"* Peebles: *"Yes."* [MG-PrincetonAfternoons]. The photon's equal probability of being found anywhere on a spherically-symmetric expanding wavefront, combined with Wheeler's statement that the photon is stationary in $x_4$, yields the physical content of the McGucken Principle directly: the photon is the ideal tracer of $x_4$'s motion — because the photon is stationary relative to $x_4$ but spherically distributed on the expanding 3D wavefront, $x_4$ itself must be expanding spherically symmetrically at rate c. The argument is the *birth* of $dx_4/dt = ic$ in its physical form, though the equation itself was not yet written down.

The conversation with Taylor, in his office as junior-paper advisor, added the quantum-entanglement dimension of the project. Schrödinger had written in 1935 that entanglement is "the characteristic trait of quantum mechanics" — the feature that "enforces its entire departure from classical lines of thought." Taylor's remark to the author: *"Schrödinger said that entanglement is the characteristic trait of quantum mechanics. Figure out the source of entanglement, and you'll figure out the source of the quantum, as nobody really knows what, nor why, nor how ℏ is"* [MG-PrincetonAfternoons]. This charge — to identify the physical mechanism of entanglement as the gateway to understanding the quantum formalism — directly motivated the junior paper with Taylor on the Einstein-Podolsky-Rosen paradox and delayed-choice experiments, which later became the conceptual ancestor of the McGucken Equivalence identifying quantum nonlocality as a geometric consequence of $x_4$-coincidence on the light cone [MG-Equiv].

Wheeler assigned two junior-year research projects that became the conceptual seeds of the McGucken Principle. The first was the independent derivation of the time factor in the Schwarzschild metric using Wheeler's "poor man's reasoning" — the direct conceptual ancestor of the gravitational time-dilation argument later derived from $dx_4/dt = ic$ through invariant $x_4$ expansion meeting stretched spatial geometry near a mass. The second, with Taylor, was the project on the Einstein-Podolsky-Rosen paradox and delayed-choice experiments — the direct conceptual ancestor of the McGucken Equivalence. Wheeler's recommendation letter for graduate school, drafted after these projects, records Wheeler's assessment at the time: *"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 gave him as an independent task to figure out the time factor in the standard Schwarzschild expression around a spherically-symmetric center of attraction... He could and did, and wrote it all up in a beautifully clear account. His second junior paper, entitled 'Within a Context,' 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."* The time-reversal-asymmetry project referenced at the close of the letter is now visible as an early precursor of the Second-Law and arrows-of-time analysis developed in §§III–IV of the present paper — the conceptual thread from the Princeton cyclotron to the present paper's thesis runs through thirty-seven years of continuous development.

The birth of the specific equation $dx_4/dt = ic$ came several years after these Princeton conversations. On a windsurfing-trip lunch break, while reading Einstein's *1912 Manuscript on Relativity*, the insight crystallized that Minkowski's coordinate $x_4 = ict$ has physical meaning: differentiating gives $dx_4/dt = ic$, which encodes the physical expansion of the fourth dimension relative to the three spatial dimensions. This was the moment when the physical intuitions accumulated in Wheeler's and Peebles' offices — photons stationary in $x_4$, spherically symmetric expansion at rate c — became a single equation [MG-PrincetonAfternoons; McGucken 2017c]. The author then worked through the implications: that the expanding fourth dimension provides the foundational physical mechanism for relativity, time and its arrows, the Second Law of Thermodynamics, quantum nonlocality, and entanglement. The earliest written record of the equation and its consequences is an appendix to the author's 1998–1999 doctoral dissertation at the University of North Carolina at Chapel Hill [MG-Dissertation]. The dissertation's primary topic was the Multiple Unit Artificial Retina Chipset (MARC) to Aid the Visually Impaired — an NSF-funded biomedical engineering project that subsequently helped blind patients to see, received coverage in *Business Week* and *Popular Science*, and was supported by a Merrill Lynch Innovations Grant. The physics theory is in the appendix. Drawing on the two Wheeler collaborations, the Peebles quantum mechanics course, the Taylor entanglement project, and on Minkowski's coordinate $x_4 = ict$, the appendix proposes that time is not the fourth dimension itself but emerges as a measure of $x_4$'s physical expansion at rate c — the conceptual core of the framework that has now been under continuous development for thirty-seven years.

**Era II: Internet deployments and Usenet (2003–2006).** The theory first entered public discussion in 2003–2004 on PhysicsForums.com (member registration #3753) and on the Usenet newsgroups *sci.physics* and *sci.physics.relativity*, under the working names *Moving Dimensions Theory* (MDT) and later *Dynamic Dimensions Theory* (DDT). By 2005 the equation $dx_4/dt = ic$ was being posted systematically on Usenet as the mathematical core of the theory. These posts are archived in Google Groups' Usenet record.

**Era III: FQXi papers (2008–2013).** The theory received its first formal paper submission on August 25, 2008, to the Foundational Questions Institute (FQXi) essay contest: *"Time as an Emergent Phenomenon: Traveling Back to the Heroic Age of Physics (In Memory of John Archibald Wheeler)"* [MG-FQXi-2008]. Four additional FQXi papers followed between 2009 and 2013, developing the derivation of the Schrödinger equation's imaginary unit from $dx_4/dt = ic$, the discrete-$x_4$ Planck-scale quantum structure, the relationship to information-theoretic foundations, and a tribute to Wheeler's concept of "It from Bit." These five FQXi papers are the peer-visible, formally indexed record of the theory's pre-2016 development [MG-FQXi-2008; MG-FQXi-2009; MG-FQXi-2010; MG-FQXi-2012; MG-FQXi-2013].

**Era IV: Books and consolidation (2016–2017).** During 2016–2017 the theory was consolidated in a book series published through 45EPIC Press, including *Light Time Dimension Theory: The Foundational Physics Unifying Einstein's Relativity and Quantum Mechanics* [McGucken 2016], *Einstein's Relativity Derived from LTD Theory's Principle* [McGucken 2017a], *Relativity and Quantum Mechanics Unified in Pictures* [McGucken 2017b], *Quantum Entanglement and Einstein's "Spooky Action at a Distance" Explained via LTD Theory's Expanding Fourth Dimension* [McGucken 2017c], and *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* [McGucken 2017d]. The 2017 book on

*The Physics of Time* is particularly relevant to the present paper, because it already contained the argument that the Second Law of Thermodynamics, entropy, and the arrows of time follow from $dx_4/dt = ic$ — an argument whose formal technical development is the subject of §§III–IV here.

**Era V: Continuous public development and active derivation program (2017–2026).** The theory has been in continuous public development from the 2017 book series through to the present. Beginning in 2017, the author has maintained the Facebook group *Elliot McGucken Physics* [MG-FB] — currently with more than six thousand followers — as an open forum for the framework's ongoing development, with posts dating back to 2017 and continuing through 2026. Beginning in 2020, the author has maintained a public technical blog at *goldennumberratio.medium.com* [MG-Medium] titled *Dr. Elliot McGucken Theoretical Physics*, which has hosted substantive technical papers including the original derivation of entropy's increase [MG-Entropy, mirrored at Medium], the McGucken Invariance paper revisiting Einstein's relativity of simultaneity, the Uncertainty Principle derivation [MG-Uncertainty, mirrored at Medium], the Principle of Least Action and Huygens' Principle derivations, and comparative analyses of string theory and the McGucken Principle. The author has also maintained ongoing presence on Substack and other platforms. Beginning in October 2024 and continuing through April 2026, the derivational programme intensified into the production of approximately forty technical papers at elliotmcguckenphysics.com. These papers establish as theorems of $dx_4/dt = ic$: the Minkowski metric [MG-Proof], the four-momentum operator and the canonical commutation relation $[\hat{q}, \hat{p}] = i\hbar$ [MG-Commut], the Schrödinger equation [MG-HLA], the Feynman path integral [MG-PathInt], the Born rule [MG-Born], the Dirac equation with its Clifford structure and spin-½ [MG-Dirac], the general Yang-Mills Lagrangian [MG-QED; MG-SM], the Einstein field equations via Schuller's constructive-gravity closure [MG-SM, Theorem 12], the full Noether catalog of conservation laws summarized in §II of the present paper [MG-Noether], the full four-sector Lagrangian $\mathscr{L}$_McG [MG-Lagrangian], the de Broglie relation [MG-deBroglie], the Heisenberg uncertainty principle [MG-Uncertainty], quantum nonlocality and Bell correlations [MG-NonlocCopen], the Bekenstein-Hawking horizon entropy [MG-Bekenstein], the cosmological constant [MG-Lambda], and the Second Law and arrows of time developed in the present paper [MG-Entropy; MG-Singular; MG-KaluzaKlein; MG-PhotonEntropy; MG-Eleven]. The accompanying comparative analyses establish the framework's relationship to Jacobson's thermodynamics of spacetime, Verlinde's entropic gravity, Penrose's twistor theory, Witten's twistor string, Maldacena's AdS/CFT, Schuller's constructive gravity, Loop Quantum Gravity, string theory, Elitzur's cosmology, and other contemporary foundational-physics programmes.

The present paper is situated within Era V of this trajectory. Its specific claim — that the conservation laws and the Second Law of Thermodynamics both descend from $dx_4/dt = ic$ as theorems of a single geometric principle — rests technically on the Era V derivations just enumerated, historically on the earlier development that established the principle as a working foundation (dissertation appendix 1998–1999, FQXi papers 2008–2013, books 2016–2017), and conceptually on the Princeton origin in Wheeler's teaching on the Schwarzschild time factor and the EPR paradox. The thirty-seven-year development trail from the Princeton afternoons of the late 1980s to the present paper is documented in full at [MG-History], and the interested reader is encouraged to consult that record for the complete chronology.

### I.6 The Thesis of This Paper

The thesis of the present paper is that the McGucken Principle $dx_4/dt = ic$ provides exactly such a common foundation. From this single geometric principle:

**(A)** Every continuous symmetry of the action is derived as a geometric feature of $x_4$'s expansion [MG-Noether, Sections IV-VII]. Temporal uniformity of $x_4$'s advance is the time-translation invariance of the action. Spatial homogeneity of $x_4$'s expansion is translation invariance. Spherical isotropy of $x_4$'s expansion from every event is rotational invariance. Lorentz covariance of $dx_4/dt = ic$ is Lorentz invariance. Absence of a preferred phase origin on $x_4$ is global U(1) invariance. Clifford-algebraic extensions of $x_4$-orientation to transverse-and-spatial rotation sectors are the non-Abelian SU(2)_L and SU(3)_c gauge symmetries. Four-dimensional diffeomorphism invariance of the manifold on which $x_4$ expands is general covariance. The full Noether catalog — the ten Poincaré charges, the three gauge charges (U(1), SU(2)_L, SU(3)_c), and the covariant energy-momentum conservation ∇_μT^{μν} = 0 — follows as theorems of $dx_4/dt = ic$.

**(B)** The Second Law of Thermodynamics is derived as a geometric theorem of the same principle [MG-Entropy; MG-Singular §V; MG-KaluzaKlein §V.2; MG-PhotonEntropy §3]. Because $dx_4/dt = ic$ contains no preferred spatial direction (spherical symmetry), the spatial projection of each particle's $x_4$-driven displacement is isotropic at each moment. Iterated at successive time intervals, this isotropic displacement is mathematically Brownian motion; the central limit theorem yields Gaussian spreading of any particle ensemble with Boltzmann-Gibbs entropy S(t) = (3/2)k_B ln(4πeDt). The rate dS/dt = (3/2)k_B/t is strictly positive for all t > 0 — not probably positive, not on average, but absolutely: **entropy cannot decrease because $x_4$ cannot retreat**. For photons propagating on the McGucken Sphere of radius R = ct, the Shannon entropy is S(t) = k_B ln(4π(ct)²), which is also monotonically increasing because the sphere's radius grows monotonically with t. Both entropies increase because the sphere grows; the sphere grows because $x_4$ advances at rate c.

**(C)** The two derivations are structurally parallel: both descend from $dx_4/dt = ic$ through the dual-channel content of the principle. Channel A, the algebraic-symmetry content, is what produces the conservation laws. Channel B, the geometric-propagation content (spherical expansion from every point), is what produces the Second Law. Both channels are present in the single statement $dx_4/dt = ic$, and the two categories — conservation laws and Second Law — are two readings of the same geometric fact through the two channels. This is the same dual-channel structure identified in [MG-TwoRoutes] at three other levels of quantum-mechanical description — the foundational (Hamiltonian and Lagrangian formulations), the dynamical (Heisenberg and Schrödinger pictures), and the ontological (wave and particle aspects) — and in the McGucken Equivalence [MG-Equiv; MG-Singular §VII] at a fourth, causal/correlational level: locality and microcausality (Channel A) on one side, and quantum nonlocality and Bell correlations (Channel B) on the other, with the McGucken Equivalence identifying nonlocality as the three-dimensional shadow of four-dimensional $x_4$-coincidence on the light cone. The thermodynamic level developed in the present paper is the fifth level at which the same dual-channel structure appears, and it is the most structurally striking of the five because the four preceding levels all sit within quantum mechanics and all pair two time-symmetric features, whereas the thermodynamic level extends the dual-channel structure *beyond* quantum mechanics into thermodynamics, pairing a time-symmetric feature (conservation laws) with a time-asymmetric feature (Second Law). It unifies two historically-disparate categories — symmetric mechanics and irreversible thermodynamics — that Loschmidt's 1876 problem made appear irreconcilable.

The principal consequences follow. The Loschmidt reversibility objection is dissolved (§VI): the time-symmetric microscopic laws and the time-asymmetric Second Law are not in conflict but are two readings of a single principle through two distinct channels. The Past Hypothesis is dissolved (§VI): $x_4$'s origin is, geometrically necessarily, the lowest-entropy moment, so the "special initial state" is not tuned — it is the point from which $x_4$ has not yet expanded. The 282-year Lagrangian tradition from Maupertuis (1744) through the Standard Model plus Einstein-Hilbert is extended (§VIII): no prior Lagrangian in that tradition has encompassed the Second Law as a theorem of its structure; $\mathscr{L}$_McG of [MG-Lagrangian] does, because $\mathscr{L}$_McG descends from $dx_4/dt = ic$ and therefore inherits both the Channel A content (conservation laws) and the Channel B content (Second Law) as theorems.

That this unification is achieved by a single simple equation — $dx_4/dt = ic$ — whose right-hand side names only the perpendicularity marker i and the rate c is remarkable. That the equation should simultaneously encode both the time-symmetric content driving the conservation laws and the time-asymmetric content driving the Second Law is counter-intuitive. The structural analysis of §V makes the counter-intuitiveness precise: the principle has *three* distinct informational contents (uniformity, isotropy, directionality), and the pairing of any two of them generates a structural result that the prior literature has held in conceptual isolation from the other pairings. The conservation laws plus Second Law unification uses uniformity (Channel A) and isotropy (Channel B) as the pairing; the companion paper [MG-TwoRoutes] uses uniformity and isotropy for the Hamiltonian-Lagrangian unification. The same dual structure, applied to different levels of physical description, accomplishes each of these unifications.

## II. The Conservation Laws from $dx_4/dt = ic$

This section summarizes the derivation of the complete Noether catalog of conservation laws from the McGucken Principle, following [MG-Noether]. The full formal development with inline proofs occupies Sections IV–VII of that paper; here we summarize the derivational structure and state each result with citations to the corresponding propositions in [MG-Noether].

### II.1 The Noether Chain Under the McGucken Principle

The standard Noether-theorem derivation of a conservation law proceeds from an *assumed* symmetry of the action to a conserved current. Under the McGucken Principle, the symmetry itself is derived from the geometric content of $dx_4/dt = ic$. The full derivational chain is therefore:

*Postulate 1 ($dx_4/dt = ic$) → geometric symmetry of $x_4$'s advance → symmetry of the action (because the unique Lorentz-scalar reparametrization-invariant free-particle action is $S = -mc \int |dx_4|$, and every symmetry of $|dx_4|$ is automatically a symmetry of S) → Noether's theorem → conservation law.*

The Noetherian step is standard [Noether 1918]. The *geometric-antecedent step* — the derivation of the symmetry of the action from the geometric content of $dx_4/dt = ic$ — is the new content of [MG-Noether]. Each of the twelve conservation laws below is derived through a chain that differs from the standard only by the insertion of this geometric-antecedent step.

### II.2 The Poincaré Catalog: Ten Conservation Laws

The Poincaré group has ten generators: one time-translation, three spatial translations, three rotations, and three Lorentz boosts. Under the McGucken Principle, each is derived from a geometric feature of $x_4$'s expansion.

#### *II.2.1 Energy Conservation from Temporal Uniformity of $x_4$'s Advance*

**Proposition II.1** *(Energy conservation as a theorem of $dx_4/dt = ic$).*

*The rate $dx_4/dt = ic$ is independent of the coordinate time t — the advance of $x_4$ proceeds at the same rate ic at every moment. This temporal uniformity implies the time-translation invariance of the free-particle action $S = -mc \int |dx_4|$. By Noether's theorem, the conserved charge associated with time-translation invariance is the Hamiltonian H = p_i q̇^i − L, which is the energy. Therefore $dE/dt = 0$.*

**Reference.** [MG-Noether, §IV.2, Propositions IV.1 and IV.2] provides the full formal proof. The geometric-antecedent step — the derivation of time-translation invariance from temporal uniformity of $dx_4/dt = ic$ — is proven as an equivalence: (a) the free-particle action is invariant under $t \to t + \varepsilon$ for every $\varepsilon \in \mathbb{R}$ iff (b) the rate $dx_4/dt$ is independent of t.

### *II.2.2 Spatial Momentum Conservation from Spatial Homogeneity of $x_4$'s Expansion*

**Proposition II.2** *(Spatial momentum conservation as a theorem of $dx_4/dt = ic$).*

*$x_4$'s expansion proceeds identically at every spatial point $x \in \mathbb{R}^3$ — the rate $dx_4/dt = ic$ is independent of x. This spatial homogeneity implies the spatial-translation invariance of the free-particle action. By Noether's theorem, the conserved charges associated with spatial-translation invariance are the three spatial momenta P^i. Therefore dP^i/dt = 0 for i = 1, 2, 3.*

**Reference.** [MG-Noether, §IV.3, Propositions IV.3 and IV.4].

### *II.2.3 Angular Momentum Conservation from Spherical Isotropy of $x_4$'s Expansion*

**Proposition II.3** *(Angular momentum conservation as a theorem of $dx_4/dt = ic$).*

*$x_4$'s expansion from every spacetime point is spherically symmetric — no preferred spatial direction is selected by the Principle. Formally, this is the statement that the McGucken Sphere Σ_+(p_0) centered at every event p_0 is invariant under every orthogonal transformation R ∈ O(3) (Proposition II.8 of [MG-Noether]). This spherical isotropy implies the rotational invariance of the action about every spacetime point. By Noether's theorem, the conserved charges associated with rotational invariance are the three angular momenta J^{ij}. Therefore dJ^{ij}/dt = 0 for i, j = 1, 2, 3.*

**Reference.** [MG-Noether, §V.1, Propositions V.1 and V.2].

**Structural note.** The same spherical-isotropy content that produces angular-momentum conservation here is the Channel B content of $dx_4/dt = ic$ that produces the Second Law in §III. What Section V will make precise is that the *two roles of spherical isotropy* — as an algebraic symmetry generating a conservation law, and as a geometric-propagation feature generating an isotropic random walk — are the two aspects of a single content, readable in two distinct ways. This is the structural heart of the paper.

### *II.2.4 Boost Charges from Lorentz Covariance of $dx_4/dt = ic$*

**Proposition II.4** *(Poincaré boost charges as theorems of $dx_4/dt = ic$).*

*The rate $dx_4/dt = ic$ is Lorentz-covariant: in every inertial frame F′ obtained from F by a Lorentz boost, the magnitude $|dx_4'/dt'| = c$ is preserved, as is the four-vector structure of the worldline parametrization. This Lorentz covariance implies the Lorentz-boost invariance of the free-particle action. By Noether's theorem, the conserved charges associated with Lorentz-boost invariance are the three boost charges K^i = tP^i − x^i E. Therefore dK^i/dt = 0 for i = 1, 2, 3.*

**Reference.** [MG-Noether, §V.2, Propositions V.3 and V.4]. Note that the boost charges K^i are time-dependent quantities (they depend explicitly on t through tP^i − x^i E), but their total time derivative — including the explicit t-dependence — vanishes on shell, which is the sense in which they are conserved under Noether's theorem.

### *II.2.5 Summary: Ten Poincaré Charges*

The four subsections above together establish the complete Poincaré catalog: one energy E, three spatial momenta P^i, three angular momenta J^{ij}, and three boost charges K^i. All ten are conserved quantities of isolated systems. All ten are Noether currents of geometric symmetries of $x_4$'s expansion — temporal uniformity, spatial homogeneity, spherical isotropy, and Lorentz covariance.

**II.3 The Internal Symmetries: U(1), SU(2)_L, SU(3)_c**

The Standard Model's gauge symmetries — U(1)_EM for electromagnetism, SU(2)_L for weak isospin, and SU(3)_c for color — give rise to three additional conservation laws: electric charge, weak isospin, and color charge. Under the McGucken Principle, each is derived from a geometric feature of $x_4$'s orientation and phase structure.

### *II.3.1 Electric Charge Conservation from U(1) Phase Invariance of $x_4$*

**Proposition II.5** *(Electric charge conservation as a theorem of $dx_4/dt = ic$).*

*$x_4 = ict$ is a complex coordinate, and the physics is invariant under a global change of its phase origin: $x_4 \to e^{i\alpha} x_4$ for any real α produces no observable consequence. This absence of a preferred phase origin on $x_4$ is global U(1) phase invariance. Extended to a local transformation $x_4(p) \to e^{i\alpha(p)} x_4(p)$ — where the phase varies point-by-point — the invariance requires a connection, which is the gauge field A_μ on the $x_4$-orientation bundle. The curvature of this connection is F_{μν}, and Maxwell's equations follow as the Bianchi identity plus the Euler-Lagrange equations of the unique gauge-invariant kinetic term F_{μν}F^{μν}. By Noether's theorem, the conserved charge associated with global U(1) invariance is the electric charge Q_EM = $\int j^0 d^3x$, where j^μ is the electromagnetic current. Therefore dQ_EM/dt = 0.*

**Reference.** [MG-Noether, §VI, Propositions VI.1 through VI.5].

**II.3.2 Weak Isospin from SU(2)_L Structure of $x_4$-Transverse Clifford Algebra**

**Proposition II.6** *(Weak isospin conservation as a theorem of $dx_4/dt = ic$).*

*The Clifford algebra of four-dimensional Minkowski spacetime decomposes as Cl(1,3) ≅ $\mathscr{M}$_2(ℂ) × $\mathscr{M}$_2(ℂ) in the appropriate basis, and the rotations in the $x_4$-transverse plane (generated by the bivector $\gamma^0\gamma^1$ or its transformations under Lorentz rotations) generate an SU(2) subgroup acting on left-handed spinors. This is the SU(2)_L of the electroweak theory. The associated Noether current is the weak isospin current j^μ_I, and its conserved charge is Q_I. Therefore dQ_I/dt = 0.*

**Reference.** [MG-Noether, §VII.1, Proposition VII.1].

**II.3.3 Color Charge from SU(3)_c Structure of the Spatial Rotation Sector**

**Proposition II.7** *(Color charge conservation as a theorem of $dx_4/dt = ic$).*

*The spatial rotation sector of the Clifford algebra generates an SU(2)_R that, when combined with the spatial permutation symmetries of a three-fundamental structure (the three spatial dimensions x_1, x_2, x_3), extends to SU(3)_c acting on color-triplet quark wavefunctions. The associated Noether current is the color current j^μ_c, and its conserved charge is Q_c. Therefore dQ_c/dt = 0.*

**Reference.** [MG-Noether, §VII.2, Proposition VII.2]. Note that the derivation of SU(3)_c from $x_4$-geometry plus spatial permutation is less direct than the derivations of the Poincaré group and U(1), because SU(3)_c does not correspond to a single geometric symmetry of $x_4$'s expansion but rather to the combination of Clifford-algebraic structure and spatial permutation symmetry of the three-dimensional spatial manifold.

### II.4 Diffeomorphism Invariance: Covariant Energy-Momentum Conservation

**Proposition II.8** *(Covariant energy-momentum conservation as a theorem of $dx_4/dt = ic$).*

*The four-dimensional manifold on which $x_4$ expands is a smooth Lorentzian manifold M, and $x_4$'s advance is a diffeomorphism-invariant statement — the advance is independent of the coordinate chart used to describe the manifold. This diffeomorphism invariance implies the coordinate-independence of the action under arbitrary smooth transformations x^μ → f^μ(x). By Noether's second theorem (the general-coordinate case), the corresponding conservation law is the covariant energy-momentum conservation ∇_μ T^{μν} = 0, where T^{μν} is the stress-energy tensor of the matter fields.*

**Reference.** [MG-Noether, §VII.3, Propositions VII.3 and VII.4].

### II.5 Summary of §II: Twelve Conservation Laws as Theorems

Sections II.2 through II.4 have established twelve conservation laws as theorems of $dx_4/dt = ic$:

| Conservation law | Geometric origin | Reference |
|---|---|---|
| Energy E | Temporal uniformity of $dx_4/dt$ | [MG-Noether, §IV.2] |
| Three momenta P^i | Spatial homogeneity of $x_4$'s expansion | [MG-Noether, §IV.3] |
| Three angular momenta J^{ij} | Spherical isotropy of $x_4$'s expansion | [MG-Noether, §V.1] |
| Three boost charges K^i | Lorentz covariance of $dx_4/dt = ic$ | [MG-Noether, §V.2] |
| Electric charge Q_EM | Absence of preferred phase origin on $x_4$ | [MG-Noether, §VI] |
| Weak isospin Q_I | SU(2)_L structure of $x_4$-transverse Clifford algebra | [MG-Noether, §VII.1] |

| Conservation law | Geometric origin | Reference |
|---|---|---|
| Color charge Q_c | SU(3)_c structure of spatial rotation + permutation | [MG-Noether, §VII.2] |
| Covariant ∇_μ T^{μν} = 0 | Diffeomorphism invariance of the $x_4$-manifold | [MG-Noether, §VII.3] |

Each derivation follows the chain: Postulate 1 → geometric symmetry of $x_4$'s advance → symmetry of the action → Noether's theorem → conservation law. Each derivation shares only the starting Postulate 1 and the final Noetherian step with the others; each intermediate geometric symmetry is distinct. This is the structure of a *family* of twelve theorems descending from a single geometric principle, exactly as one would expect a correct foundational principle to generate its consequences.

The Noether catalog is time-symmetric throughout: each conservation law is a statement about a quantity that is constant under time evolution in either direction. This time-symmetry is inherited from the time-symmetric structure of Noether's theorem itself. **This is the characteristic signature of Channel A — the algebraic-symmetry content of $dx_4/dt = ic$.** Section III now turns to Channel B, and shows that the same principle generates the *time-asymmetric* Second Law of Thermodynamics through a structurally distinct chain.

## III. The Second Law of Thermodynamics from $dx_4/dt = ic$

This section derives the Second Law of Thermodynamics from the McGucken Principle. The derivation follows [MG-Entropy] (the original MSD simulation paper demonstrating spherical isotropic random walk from $x_4$'s spherical expansion), [MG-Singular, §V] (the formal derivation dS/dt = (3/2)k_B/t > 0 strict for all t > 0), [MG-KaluzaKlein, §V.2] (the analogous formal derivation in the context of the Kaluza-Klein comparison), and [MG-PhotonEntropy, §3] (the Shannon entropy derivation for photons on the McGucken Sphere). The structural claim is that the Second Law is *not* a statistical tendency but a *geometric necessity*: entropy cannot decrease because $x_4$ cannot retreat.

### III.1 The Mechanism: Spherical Isotropic Random Walk from $x_4$'s Expansion

The McGucken Principle states that $x_4$ advances at rate c in a spherically symmetric manner from every spacetime point. The spherical symmetry is not an auxiliary feature but an essential geometric content of the principle: $dx_4/dt = ic$ contains no preferred spatial direction, and the McGucken Sphere Σ_+(p_0) centered at every event p_0 is invariant under every R ∈ O(3) (Proposition II.8 of [MG-Noether]).

The consequence is that the spatial projection of each particle's $x_4$-driven displacement is *isotropic* at each moment. A particle at spacetime point $p_0$ at time $t_0$ is, one short time-interval Δt later, distributed over the McGucken Sphere of radius c·Δt centered on $p_0$, with probability density uniform over the sphere (because the expansion is spherically symmetric). In the massive-particle case, where the particle participates in $x_4$'s expansion through its Compton-frequency coupling [MG-Compton; MG-PhotonEntropy §6], the displacement projected onto the three spatial dimensions is a step of magnitude $r = c\cdot\Delta t/\gamma$, in a direction uniformly distributed over the sphere (where γ is the local Lorentz factor).

Iterated at successive time intervals of duration Δt, this gives exactly the structure of an isotropic random walk. [MG-Entropy] presents the elementary numerical simulation: twenty particles, initially arranged on a circle of radius r, evolve under the rule "each particle, at each second, moves a distance r in a random direction." The simulation is run five times; in every run, the mean-squared displacement (MSD) from the initial positions grows monotonically with time. The entropy calculated from the MSD grows in every step.

**Proposition III.1** *(Spherical isotropic random walk from $x_4$'s spherical expansion).*

*Under the McGucken Principle, the spatial projection of each particle's $x_4$-driven displacement over a short time interval Δt is a vector of magnitude $r = c\cdot\Delta t/\gamma$ in a direction uniformly distributed over the unit sphere $S^2 \subset \mathbb{R}^3$. Iterated over N time intervals, this generates an isotropic random walk on $\mathbb{R}^3$ with N steps of magnitude r in uniformly-distributed directions. The mean-squared displacement after N steps is $\langle|x_N - x_0|^2\rangle = N\cdot r^2 = (c^2\cdot\Delta t/\gamma^2)\cdot(N\cdot\Delta t) = D\cdot t$, where $D = c^2\cdot\Delta t/\gamma^2$ is the effective diffusion constant and $t = N\cdot\Delta t$ is the elapsed time.*

**Reference.** [MG-Entropy] presents the numerical demonstration; [MG-Singular, §V] presents the formal derivation. The central limit theorem then gives the distribution of $x_N$ for large N as Gaussian with variance D·t.

### III.2 Boltzmann-Gibbs Entropy Growth

The Boltzmann-Gibbs entropy of a Gaussian distribution in three dimensions with variance D·t in each dimension is

$$S(t) = -k_B \int P(x, t) \ln P(x, t)\, d^3x = (3/2)\, k_B \ln(4\pi\, e\, D\, t) + \text{const}.$$

**Proposition III.2** *(Boltzmann-Gibbs entropy of the isotropic random walk ensemble).*

*For an ensemble of particles undergoing spherical isotropic random walk under $dx_4/dt = ic$, the Boltzmann-Gibbs entropy at time $t > 0$ is*

$$S(t) = (3/2)\, k_B \ln(4\pi\, e\, D\, t) + \text{const},$$

*where D is the effective diffusion constant of Proposition III.1. The entropy rate is*

$$dS/dt = (3/2)\, k_B / t > 0$$

*strictly, for all $t > 0$.*

**Reference.** [MG-Singular, §V]; [MG-KaluzaKlein, §V.2]; [MG-Entropy, numerical verification].

**Structural note.** The strict positivity of dS/dt is the key mathematical content. It is *not* an averaged or statistical positivity; it is strict for every $t > 0$. The physical content is: **entropy cannot decrease because $x_4$ cannot retreat**. The monotonic advance of $x_4$ at rate c forces the MSD of any particle ensemble to grow monotonically, which forces the Boltzmann-Gibbs entropy to grow monotonically. There is no auxiliary assumption; the result follows from the geometric content of $dx_4/dt = ic$ through the central limit theorem applied to the iterated spherical isotropic random walk.

### III.3 The Shannon Entropy of Photons on the McGucken Sphere

For photons, the derivation is even more direct. A photon propagates at $|\mathbf{v}| = c$, so by the master equation $u^\mu u_\mu = -c^2$, its $x_4$-component satisfies $dx_4/dt = 0$: a photon does not advance along $x_4$ at all. Its entire four-speed budget is carried by spatial motion. The photon therefore "rides" the McGucken Sphere of radius $R = ct$ expanding from the emission event.

Quantum mechanics tells us that a photon emitted from an isotropic point source is distributed *uniformly* over the McGucken Sphere at any time t after emission. The positional Shannon entropy of this distribution is [MG-PhotonEntropy, §3]:

$S(t) = k_B \ln(4\pi(ct)^2) + const = 2\, k_B \ln(ct) + k_B \ln(4\pi) + const.$

**Proposition III.3** *(Shannon entropy on the McGucken Sphere).*

*The Shannon entropy of the positional distribution of a photon emitted from an isotropic point source at $t = 0$, at time $t > 0$ after emission, is*

$S(t) = k_B \ln(4\pi(ct)^2) + const.$

*This entropy grows monotonically with t:*

$dS/dt = 2\, k_B / t > 0$

*for all $t > 0$.*

**Reference.** [MG-PhotonEntropy, §3].

**Structural note.** The entropy grows because the sphere grows. The sphere grows because $x_4$ advances at rate c. This is the simplest, most direct, and most unambiguous connection between $x_4$'s advance and entropy increase in the entire McGucken corpus. It requires no diffusion equation, no Langevin equation, no central limit theorem — just the geometric growth of the McGucken Sphere and the Shannon entropy of a uniform distribution on a growing surface. Every photon emitted in the universe — from stars, from the CMB, from every quantum transition in every atom — rides a McGucken Sphere, and every McGucken Sphere carries increasing Shannon entropy outward as $x_4$ advances.

### III.4 The Compton-Coupling Diffusion: A Testable Mechanism

Beyond the elementary spherical isotropic random walk and photon Shannon entropy, the McGucken Principle predicts a specific diffusion term arising from the Compton-frequency coupling of massive particles to $x_4$'s oscillatory advance [MG-PhotonEntropy, §4-6]. The derivation is summarized here; the full stochastic analysis is in [MG-PhotonEntropy, §6].

Modeling $x_4$'s advance as carrying a small oscillatory modulation — amplitude $\varepsilon \ll 1$, frequency $\Omega$ — superimposed on its monotonic rate:

$x_4(t) = ict + i\varepsilon c \sin(\Omega t)$, so $dx_4/dt = ic [1 + \varepsilon \cos(\Omega t)]$.

Every massive particle couples to this modulation through its Compton frequency $f_C = mc^2/h$. In the Langevin equation for the particle's motion, the Compton coupling introduces an effective stochastic force whose variance scales as $m^2$ (linear with the Compton frequency). The resulting diffusion constant, after the $m^2$ in the noise variance cancels the $m^2$ in the Langevin response $1/m^2$, is

$D_x^{(McG)} = \varepsilon^2 c^2 \Omega / (2 \gamma^2)$.

Two features are striking: (i) this diffusion term is *temperature-independent* — it persists even at $T \to 0$, in contrast to ordinary thermal diffusion which vanishes at $T = 0$; (ii) the mass dependence *cancels* — $D_x^{(McG)}$ is universal across particle species after damping $\gamma$ is accounted for.

**Proposition III.4** *(Compton-coupling diffusion as a testable McGucken prediction).*

*Under the McGucken Principle with a Compton-frequency coupling of matter to $x_4$'s oscillatory advance, every massive particle experiences an additional diffusion term*

$D_x^{(McG)} = \varepsilon^2 c^2 \Omega/(2\gamma^2)$,

*independent of particle mass and persistent at $T \to 0$. This provides a sharp and specific experimental signature for cold-atom, trapped-ion, and precision-spectroscopy experiments.*

**Reference.** [MG-PhotonEntropy, §§4-6].

**Structural note.** The Compton-coupling diffusion is the quantitative, species-independent contribution to dS/dt from $x_4$'s expansion on top of the elementary Shannon-on-McGucken-Sphere result. The total entropy rate has the form $dS/dt = (3/2)k_B / t$ + contribution from $D_x^{(McG)}$; both terms are positive, and the second provides experimental falsifiability.

### III.5 Summary of §III: The Second Law as a Theorem

Sections III.1 through III.4 have established the Second Law as a theorem of $dx_4/dt = ic$:

- **Mechanism:** the spherical symmetry of $x_4$'s expansion forces isotropic spatial displacement at every moment.

- **Formal result:** iterated isotropic displacement is Brownian motion, with Gaussian spreading producing Boltzmann-Gibbs entropy $S(t) = (3/2)k_B \ln(4\pi eDt)$ growing at rate $dS/dt = (3/2)k_B/t > 0$ strict for all $t > 0$ [MG-Singular §V; MG-KaluzaKlein §V.2].
- **Photon result:** Shannon entropy on the McGucken Sphere $S(t) = k_B \ln(4\pi(ct)^2)$ grows monotonically [MG-PhotonEntropy §3].
- **Testable prediction:** the Compton-coupling diffusion $D_x^{(McG)} = \varepsilon^2c^2\Omega/(2\gamma^2)$ is species-independent and persists at $T \to 0$, providing a laboratory signature of the McGucken mechanism [MG-PhotonEntropy §6].

The Second Law is time-asymmetric: $dS/dt > 0$ strictly, not on average, not statistically, but absolutely. This time-asymmetry is inherited from the one-way advance of $x_4$ at rate c. **This is the characteristic signature of Channel B — the geometric-propagation content of $dx_4/dt = ic$.**

## IV. The Five Arrows of Time from $dx_4/dt = ic$

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Physics recognizes five temporal asymmetries — the thermodynamic arrow, the radiative arrow, the cosmological arrow, the causal arrow, and the psychological arrow. All five point in the same direction; none is explained by the time-symmetric fundamental laws of mechanics, electromagnetism, or quantum mechanics. The standard account appeals ultimately to the special initial conditions of the Big Bang — a cosmological boundary condition rather than a dynamical explanation (Penrose 1989, 2004).

Under the McGucken Principle, all five arrows of time derive from the single geometric fact that $x_4$ expands in one direction, irreversibly, at rate c [MG-Singular, §VI; MG-KaluzaKlein, §V.3]. The derivations are summarized here.

### IV.1 The Thermodynamic Arrow

The thermodynamic arrow is the direction in which entropy increases. Under the McGucken Principle, it is derived in §III: $dS/dt = (3/2)k_B/t > 0$ strict for all $t > 0$ for massive-particle ensembles undergoing spherical isotropic random walk, and $dS/dt = 2k_B/t > 0$ for photons on the McGucken Sphere. The direction of entropy increase is the direction of $x_4$'s advance.

### IV.2 The Radiative Arrow

The radiative arrow is the direction in which radiation propagates outward from sources rather than converging inward onto them. Formally, the retarded Green's function of the wave equation — which describes outward-expanding spherical wavefronts — is the physically realized solution, while the advanced Green's function (inward-converging spherical wavefronts) is mathematically valid but physically unrealized.

Under the McGucken Principle, the retarded solution corresponds to a McGucken Sphere of radius ct expanding outward at rate c, which is $x_4$'s expansion. The advanced solution would correspond to a contracting McGucken Sphere, which would require $x_4$ to retreat. Since $x_4$ does not retreat, the advanced solution is not physically realized. **The radiative arrow is enforced by the same geometric asymmetry as the thermodynamic arrow: $x_4$ advances at rate c in one direction only** [MG-Singular, §VI].

### IV.3 The Causal Arrow

The causal arrow is the direction in which causal influence propagates. The principle of causality requires that causes precede their effects: the causal influence of event A on event B requires that A lies in the past light cone of B. Formally, causal influence propagates into the forward light cone — the McGucken Sphere of radius ct expanding from any event.

Under the McGucken Principle, the forward light cone is the three-dimensional projection of $x_4$'s expansion from the event. Since $x_4$ does not retreat, the forward light cone does not contract, and causal influence cannot propagate backward. The causal structure of spacetime is the forward expansion of $x_4$ [MG-Singular, §VI; MG-KaluzaKlein, §V.3].

### IV.4 The Cosmological Arrow

The cosmological arrow is the direction of the universe's expansion. Observed galaxy redshifts confirm that the universe is expanding, with Hubble's law $v = H_0 D$ relating recession velocity to distance. Under the McGucken Principle, the cosmological expansion is the large-scale collective manifestation of every particle's forced advance through $x_4$ at rate c. Every particle in the universe contributes to the universal tendency toward expansion; the cosmological expansion is the macroscopic expression of the same geometric process that drives entropy and radiation. The Hubble parameter $H_0$ is set by the rate at which the spatial dimensions are stretched by $x_4$'s expansion [MG-Eleven, §III].

### IV.5 The Psychological Arrow

The psychological arrow is the direction in which we experience time: we remember the past and anticipate the future, not the reverse. This is not a primary physical arrow but a *derivative* of the causal arrow: memory is the physical record of events that have already influenced a system through the forward light cone. Brain states at time t encode information about events in the past light cone of t; they do not encode information about events in the future light cone. The psychological arrow is the causal arrow instantiated in neural systems [MG-Singular, §VI].

### IV.6 The Unity of the Five Arrows Under $dx_4/dt = ic$

All five arrows of time point forward because $x_4$ advances forward. All five have the same direction because they trace to the same geometric fact. All five are time-asymmetric because $x_4$'s advance is time-asymmetric. This is the first unified derivation of the five arrows of time from a single principle.

Reichenbach's 1956 account [Reichenbach 1956] unified the thermodynamic and causal arrows but left the cosmological arrow separate and the psychological arrow derivative. Penrose's Weyl-curvature hypothesis [Penrose 1989] attempts to explain the thermodynamic arrow through cosmological boundary conditions but does not derive the remaining arrows from the same source. The McGucken framework derives all five from a single equation — $dx_4/dt = ic$ — and the direction of all five is the same: the direction of $x_4$'s monotonic advance at rate c.

## V. The Structural Unity: Dual-Channel Content of $dx_4/dt = ic$

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This section analyzes the structural content of the principle $dx_4/dt = ic$ to make precise *why* a single principle generates both the time-symmetric conservation laws (§II) and the time-asymmetric Second Law (§III). The key observation is that $dx_4/dt = ic$ carries *two logically distinct informational contents* that can be read as two separate channels, and the two categories — conservation laws and Second Law — correspond to the two channels.

### V.1 Channel A: The Algebraic-Symmetry Content

The algebraic-symmetry content of $dx_4/dt = ic$ consists of the *uniformity* and *invariance* features of the principle:

- **Temporal uniformity:** the rate $dx_4/dt = ic$ is independent of t. This is the symmetry content that generates time-translation invariance.
- **Spatial homogeneity:** $x_4$'s expansion proceeds identically at every spatial point. This generates spatial-translation invariance.
- **Spherical isotropy (as symmetry):** $x_4$'s expansion from every point has no preferred spatial direction. This generates rotational invariance.
- **Lorentz covariance:** the rate $|dx_4/dt| = c$ is preserved under Lorentz boosts. This generates Lorentz-boost invariance.
- **Phase invariance:** the imaginary coordinate $x_4 = ict$ has no preferred phase origin. This generates U(1) gauge invariance.
- **Clifford-algebraic extensions:** the non-Abelian structure of Cl(1,3) extends $x_4$-orientation to transverse-and-spatial rotation sectors. These generate SU(2)_L and SU(3)_c gauge invariances.
- **Diffeomorphism invariance:** $x_4$'s advance is coordinate-independent on the smooth manifold M. This generates general covariance.

Each of these is a *symmetry statement* about $dx_4/dt = ic$. Each is *time-symmetric* in the sense that it holds equally under forward and backward time evolution. The conservation laws derived from each symmetry via Noether's theorem are correspondingly time-symmetric quantities.

**This is Channel A: the algebraic-symmetry content of the principle.** The conservation laws are its outputs.

### V.2 Channel B: The Geometric-Propagation Content

The geometric-propagation content of $dx_4/dt = ic$ consists of the *propagation* features of the principle:

- **Spherical expansion from every point at rate c:** $x_4$ advances spherically symmetrically from every spacetime event.
- **Huygens' secondary wavelets:** the McGucken Sphere Σ_+(p_0) from every event is the three-dimensional cross-section of $x_4$'s expansion, and is structurally identical to Huygens' secondary-wavelet construction.
- **Monotonic radial growth:** the radius R = ct of the McGucken Sphere grows monotonically with t.
- **Isotropic wavefront emission:** the spatial projection of $x_4$'s advance at every point is isotropic.
- **One-way advance:** $x_4$ advances at +ic, not −ic; the McGucken Sphere expands, it does not contract.

These are *propagation statements* about $dx_4/dt = ic$. Notice carefully: while (a) *spherical symmetry as a symmetry* appears in Channel A as a source of rotational invariance, (b) *spherical symmetry as a propagation feature* appears in Channel B as the mechanism generating Huygens' secondary-wavelet structure, isotropic random walks, and the monotonic growth of the McGucken Sphere. The same geometric feature — the fact that the principle contains no preferred spatial direction — plays two logically distinct roles in the two channels. In Channel A, it is a *static symmetry* (the McGucken Sphere at any fixed time is O(3)-invariant). In Channel B, it is a *dynamic propagation feature* (the McGucken Sphere at successive times is an expanding wavefront with isotropic emission at every point).

**This is Channel B: the geometric-propagation content of the principle.** The Second Law, Brownian motion, Huygens' principle, and the arrows of time are its outputs.

### V.3 The Two Channels as Independent Readings

The crucial structural observation is that Channel A and Channel B are *two logically distinct readings of the same principle*. They are not alternative principles; they are two aspects of the one principle $dx_4/dt = ic$. The proof that they are two readings of the same principle is that every consequence derived in each channel traces back to $dx_4/dt = ic$ and only to $dx_4/dt = ic$ — there is no auxiliary assumption, no additional input, no supplementary postulate. The principle's content is the conjunction of algebraic-symmetry statements and geometric-propagation statements; the two channels unpack the two kinds of content through two kinds of logical operations.

**Proposition V.1** *(Structural independence of Channel A and Channel B).*

*The algebraic-symmetry content of $dx_4/dt = ic$ (Channel A) and the geometric-propagation content of $dx_4/dt = ic$ (Channel B) are independent logical aspects of the same principle. Neither is derivable from the other; both are derivable from the prin-*

*ciple. The conservation laws (§II) are consequences of Channel A alone; the Second Law and arrows of time (§III, §IV) are consequences of Channel B alone.*

**Proof sketch.** Channel A extracts symmetries from the principle and applies Noether's theorem. The derivation makes no use of the propagation features of $x_4$'s expansion (spherical wavefront emission, monotonic radial growth, one-way advance); it only uses the invariance features (temporal uniformity, spatial homogeneity, spherical isotropy as static symmetry, Lorentz covariance, U(1) phase, Clifford extensions, diffeomorphism invariance). Channel B extracts propagation features from the principle and applies the central limit theorem and retarded Green's function analysis. The derivation makes no use of Noether's theorem or of any conservation law; it only uses the spherical expansion at rate c and the monotonic advance. The two chains are therefore logically independent in their derivational content; they share only the starting principle $dx_4/dt = ic$.

### V.4 The Structural Parallel with [MG-TwoRoutes]

The dual-channel structure developed here has an exact structural parallel with the dual-channel structure developed in the companion paper [MG-TwoRoutes], which establishes that the Hamiltonian and Lagrangian formulations of quantum mechanics both descend from $dx_4/dt = ic$ through Channel A and Channel B respectively. In [MG-TwoRoutes]:

- The **Hamiltonian route** proceeds through: Minkowski metric (from $x_4 = ict$, perpendicularity content) → Stone's theorem on translation invariance → momentum operator as generator of spatial translations → direct commutator computation → $[\hat{q}, \hat{p}] = i\hbar$ → Stone-von Neumann uniqueness. This is Channel A: algebraic-symmetry content.
- The **Lagrangian route** proceeds through: Huygens' principle (from $x_4$'s spherical expansion) → iterated spherical wavefronts generate all paths → accumulated $x_4$-phase $\exp(iS/\hbar)$ along each path → Feynman path integral → Schrödinger equation → kinetic-term momentum operator → $[\hat{q}, \hat{p}] = i\hbar$. This is Channel B: geometric-propagation content.

Moreover, [MG-TwoRoutes, §V] identifies *three* levels at which the same dual-channel structure appears:

- **Level 1 (Foundational):** Hamiltonian formulation (Channel A) and Lagrangian formulation (Channel B).
- **Level 2 (Dynamical):** Heisenberg picture (Channel A) and Schrödinger picture (Channel B).
- **Level 3 (Ontological):** Particle aspect (Channel A) and wave aspect (Channel B) of quantum objects.

The McGucken Equivalence [MG-Equiv; MG-Singular §VII] adds a fourth level within quantum mechanics:

- **Level 4 (Causal/correlational):** Local microcausality (Channel A) and quantum nonlocality / Bell correlations (Channel B) of quantum objects.

At this fourth level, Channel A gives the local structure of standard quantum field theory — operators at a point, local gauge invariance, microcausality in the form [O(x), O(y)] = 0 for spacelike-separated events. Channel B gives quantum nonlocality: because photons at v = c do not advance in $x_4$ ($dx_4/d\tau = 0$ along every photon worldline), two photons created at a common spacetime event share the same $x_4$-coordinate regardless of how far they travel spatially, and the four-dimensional interval between them remains null ($ds^2 = 0$) at all later times. The McGucken Equivalence is the structural identification of this $x_4$-coincidence as the geometric origin of the Bell correlations E(a,b) = −cos θ_{ab}: "nonlocality is the three-dimensional shadow of four-dimensional $x_4$-coincidence on the light cone" [MG-Singular §VII]. Local structure and nonlocal correlations coexist not as two competing accounts of the same physics but as two readings of $x_4$'s expansion through the two channels of the Principle.

The present paper adds a fifth level, which is the first level to extend the dual-channel structure *beyond* quantum mechanics into thermodynamics:

- **Level 5 (Thermodynamic):** Conservation laws (Channel A) and Second Law + arrows of time (Channel B).

This is the same dual-channel structure unpacking into different physics at each level. What makes Level 5 particularly striking is that it is the first level at which the structure extends beyond quantum mechanics. At Levels 1–4, the dualities all pair *two time-symmetric features* of quantum mechanics: Hamiltonian and Lagrangian formulations are both T-symmetric; Heisenberg and Schrödinger pictures are both T-symmetric; wave and particle aspects are both T-symmetric; microcausality and Bell correlations are both T-symmetric. At Level 5, the duality pairs *a time-symmetric feature (conservation laws) with a time-asymmetric feature (Second Law)*, and the two categories have occupied separate conceptual compartments for over 150 years since Loschmidt's 1876 objection. The dual-channel structure that has been unifying pairs of time-symmetric features within quantum mechanics at Levels 1–4 now extends outside quantum mechanics to unify a time-symmetric with a time-asymmetric feature at Level 5 — a structurally novel achievement with no precedent in the prior Lagrangian tradition.

### V.5 Why This Is Remarkable and Counter-Intuitive

**Remarkable**: the unification occurs at the level of a single geometric principle. Conservation laws and the Second Law are not unified by a higher-level statistical-mechanical construction, or by a cosmological boundary condition, or by an anthropic argument, or by any other auxiliary mechanism. They are unified by a single geometric fact: the fourth dimension is expanding in a spherically symmetric manner at rate c.

**Counter-intuitive**: the same geometric fact produces both a family of time-symmetric conservation laws (Channel A) and a family of time-asymmetric irreversibility laws (Channel B). The two families have radically different structural characters — one is about what is invariant under time evolution, the other is about what is monotonic under time evolution — yet they trace to the same principle. The counter-intuitiveness is precisely that *a single equation can carry both time-symmetric and time-asymmetric content simultaneously*, and can unpack each through a distinct logical channel to produce structural results of opposite time-symmetry character.

The remarkable-and-counter-intuitive character of the unification is, in fact, the structural signature of the principle's correctness. A foundational principle that generates only time-symmetric consequences (like a standard Hamiltonian) cannot produce the Second Law. A foundational principle that generates only time-asymmetric consequences (like a dissipative equation) cannot produce the conservation laws. Only a principle that carries both kinds of content — and carries them through logically distinct channels — can generate both categories as theorems. The McGucken Principle is such a principle. No prior principle in the history of theoretical physics has been demonstrated to carry both kinds of content simultaneously.

## VI. The Loschmidt Problem Resolved and the Past Hypothesis Dissolved

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This section develops the principal historical consequence of §§II–V: the Loschmidt reversibility objection of 1876 is resolved, and the Past Hypothesis required by the Boltzmann statistical account is dissolved. These are two distinct but related problems; each is addressed through the dual-channel structure of $dx_4/dt = ic$.

### VI.1 Loschmidt's Objection Restated

Loschmidt observed [Loschmidt 1876] that the time-reversal symmetry of microscopic dynamics is incompatible with the strict increase of entropy predicted by the H-theorem. If the microscopic laws are T-symmetric, then for every trajectory on which H decreases (entropy increases), there exists a time-reversed trajectory of equal statistical weight on which H increases (entropy decreases). The strict H-theorem therefore cannot follow from T-symmetric dynamics plus statistical-weight arguments alone.

This is the sharp form of Loschmidt's objection. It is not answered by saying that entropy-decreasing trajectories are improbable; probability is not necessity, and the Second Law as empirically observed is an absolute prohibition, not a statistical tendency.

### VI.2 The Resolution: Two Channels, Not One Dynamics

Under the McGucken framework, the resolution is structural rather than statistical. The time-symmetric microscopic laws and the time-asymmetric Second Law are *not two competing accounts of the same dynamics*. They are *two readings of a single prin-*

*ciple through two distinct channels*. The time-symmetric conservation laws come from Channel A (algebraic-symmetry content of $dx_4/dt = ic$); the time-asymmetric Second Law comes from Channel B (geometric-propagation content of $dx_4/dt = ic$). Neither channel is reducible to the other. Both are consequences of the single principle.

**The Loschmidt objection is therefore not an objection under the McGucken framework.** The objection presupposes that the microscopic laws and the Second Law have a *common origin* — that both must follow from the same foundational dynamics. Under the McGucken framework, they do have a common origin, but they follow through *two logically distinct channels*. The time-symmetry of the microscopic laws (Channel A output) is not violated by the time-asymmetry of the Second Law (Channel B output); the two do not contradict each other because they are readings of different channels. The Loschmidt tension is dissolved by recognizing that the principle has dual-channel content, not by strengthening statistical arguments or by postulating auxiliary initial conditions.

### VI.3 The Past Hypothesis and Its Dissolution

The statistical account of the Second Law (Boltzmann 1877) requires that the universe *began* in a state of low entropy — the Past Hypothesis. Penrose [Penrose 1989] quantified the improbability of this initial state as one part in $10^{(10}123)$, arguing that no known physical mechanism can produce such a fine-tuned initial state. The Past Hypothesis is therefore an auxiliary assumption imposed by hand to account for the observed direction of the Second Law.

Under the McGucken framework, the Past Hypothesis is dissolved as a theorem [MG-Eleven, §XIII]. The argument is: if the Second Law is a Channel-B consequence of $x_4$'s monotonic advance at rate c, then the lowest-entropy moment of any system participating in $x_4$'s expansion is, by construction, the moment when $x_4$ has not yet expanded. For a cosmological-scale system — the universe itself — the lowest-entropy moment is the origin of $x_4$'s expansion: the Big Bang. This is not a fine-tuned initial condition; it is the geometric starting point of the expansion that generates the Second Law.

**Proposition VI.1** *(The Past Hypothesis as a theorem of $dx_4/dt = ic$).*

*For a system whose entropy increases by the Channel-B mechanism (spherical isotropic expansion of $x_4$ at rate c from every point), the lowest-entropy moment of the system is the moment when $x_4$'s expansion begins from the initial configuration. For the universe as a whole, this moment is the origin of cosmological $x_4$-expansion — identified with the hot Big Bang. The universe therefore began in a low-entropy state as a theorem of the McGucken Principle, not as an auxiliary assumption.*

**Reference.** [MG-Eleven, §XIII], which develops the argument in the full cosmological context and shows that Penrose's $10^{(-10}123)$ fine-tuning problem is the wrong framing of the question: the lowest-entropy moment is not "tuned" to be improbable; it is *definitionally* the beginning, and every moment after it has higher entropy by the monotonic-advance theorem.

**Structural note.** The Past Hypothesis is not disproved or replaced under the McGucken framework; it is *derived*. What had been an auxiliary postulate in the Boltzmann account becomes a theorem in the McGucken account. The universe's low-entropy initial state is not a fine-tuning problem because it is not a tuning at all; it is the geometric starting point of $x_4$'s expansion, and the geometric starting point is, by definition, the lowest-entropy moment of the system. Penrose's $10^{(-10}$123) figure quantifies the improbability of the Past Hypothesis *under the assumption that the initial state is drawn from 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.

## VII. Both Categories Visible in the McGucken Lagrangian ℒ_McG

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The thesis of this paper — that both conservation laws and the Second Law descend from $dx_4/dt = ic$ — has a direct consequence at the level of the physics Lagrangian developed in [MG-Lagrangian]. Both categories are visible in ℒ_McG, the unique Lagrangian forced by the McGucken Principle.

### VII.1 The Structure of ℒ_McG

The Lagrangian ℒ_McG of [MG-Lagrangian] is a four-sector Lagrangian:

*ℒ_McG = ℒ_kin + ℒ_Dirac + ℒ_YM + ℒ_EH*

where ℒ_kin is the free-particle kinetic term (containing the $x_4$-advance content), ℒ_Dirac is the Dirac matter sector (fermions coupled to $x_4$-phase), ℒ_YM is the Yang-Mills gauge sector (U(1) × SU(2)_L × SU(3)_c connections on the $x_4$-orientation bundle), and ℒ_EH is the Einstein-Hilbert gravitational sector (curvature of the four-dimensional manifold on which $x_4$ expands). [MG-Lagrangian, Theorem VI.1] establishes that this four-sector structure is forced by $dx_4/dt = ic$ through a four-fold uniqueness argument.

### VII.2 The Conservation Laws Are Visible in ℒ_McG

By construction, ℒ_McG possesses all the continuous symmetries derived in §II — Poincaré (ten generators), U(1) phase (one), SU(2)_L (three), SU(3)_c (eight), and diffeomorphism invariance (infinite-dimensional). Each symmetry is manifest in the Lagrangian: the Poincaré invariances are manifest in the Lorentz-scalar construction of each sector; the gauge invariances are manifest in the minimal-coupling structure of the matter-gauge couplings; the diffeomorphism invariance is manifest in the covariant formulation of the full four-sector construction.

Applying the standard Noether procedure to ℒ_McG, each symmetry produces its conserved Noether current:

- Poincaré: ten currents (energy-momentum tensor T^{μν} plus the angular-momentum tensor M^{μνρ} and boost charges K^μ).
- Gauge: three currents (electromagnetic j^μ, weak isospin j^μ_I, color j^μ_c).
- Diffeomorphism: covariant conservation ∇_μ T^{μν} = 0 of the stress-energy tensor.

This is the direct visibility of the conservation laws in ℒ_McG: they appear as Noether currents of the Lagrangian's manifest symmetries. The chain **ℒ_McG → manifest symmetry → Noether current → conservation law** is the standard chain.

### VII.3 The Second Law Is Also Visible in ℒ_McG

The Second Law's visibility in ℒ_McG is less direct than the conservation laws', but it is present. The structure of the visibility is the following.

First, ℒ_McG is forced by $dx_4/dt = ic$ [MG-Lagrangian, Theorem VI.1]. Therefore ℒ_McG inherits the full content of $dx_4/dt = ic$ — both Channel A (algebraic-symmetry content manifest as the Lagrangian's invariances) and Channel B (geometric-propagation content manifest in the kinetic-term structure that couples matter to $x_4$'s advance).

Second, the kinetic-term ℒ_kin contains the coupling of matter fields to $x_4$'s advance through the Compton-frequency coupling [MG-PhotonEntropy, §6]. When this coupling is unpacked, it produces the Compton-coupling diffusion D_x^(McG) = $\varepsilon^2 c^2 \Omega/(2\gamma^2)$ of §III.4, which is the laboratory-testable Second-Law prediction of the McGucken framework.

Third, the Einstein-Hilbert sector ℒ_EH couples gravity to the four-dimensional manifold on which $x_4$ expands, and this coupling — through the Jacobson-Verlinde entropic-gravity structure discussed in [MG-Lagrangian, §VI] — makes entropy increase a theorem of the gravitational sector as well.

**Proposition VII.1** *(Second Law visibility in ℒ_McG).*

*The McGucken Lagrangian ℒ_McG = ℒ_kin + ℒ_Dirac + ℒ_YM + ℒ_EH is forced by $dx_4/dt = ic$ [MG-Lagrangian, Theorem VI.1]. The Second Law of Thermodynamics is a theorem of $dx_4/dt = ic$ (§III). Therefore the Second Law is a theorem of ℒ_McG. The chain from ℒ_McG to the Second Law proceeds through the kinetic-term's Compton-frequency coupling (for the massive-particle diffusion term D_x^(McG)), through the direct geometric expansion of the McGucken Sphere (for the photon Shannon entropy), and through the gravitational-entropic coupling of ℒ_EH (for the Jacobson-Verlinde entropic-gravity structure).*

**Reference.** [MG-Lagrangian, §VI, Theorem VI.1] (uniqueness of ℒ_McG); [MG-PhotonEntropy, §6] (Compton-coupling diffusion derived from kinetic-term structure); [MG-Jacobson; MG-Verlinde] (entropic-gravity structure in the gravitational sector).

### VII.4 Structural Significance

The visibility of both the conservation laws and the Second Law in ℒ_McG is the direct consequence of the dual-channel structure of §V. ℒ_McG inherits both channels from $dx_4/dt = ic$: Channel A (algebraic-symmetry content manifest as invariances) produces the Noether conservation laws; Channel B (geometric-propagation content manifest as $x_4$-coupling) produces the Second Law. The Lagrangian's dual content is therefore the Lagrangian-level manifestation of the dual-channel structure of the underlying principle.

This is the structural claim of §VII: **ℒ_McG is the unique Lagrangian in the history of theoretical physics that has both the conservation laws and the Second Law of Thermodynamics as theorems of its own structure.** The comparison with the 282-year Lagrangian tradition — which includes none of the prior Lagrangians that contain the Second Law as a theorem — is developed in the next section.

## VIII. Comparison with the 282-Year Lagrangian Tradition

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The Lagrangian tradition in theoretical physics spans from Maupertuis' 1744 Principle of Least Action to the Standard Model plus Einstein-Hilbert action of the present day. This section documents that no prior Lagrangian in the 282-year tradition has encompassed the Second Law of Thermodynamics as a theorem of its structure. The McGucken Lagrangian ℒ_McG is the first to do so.

### VIII.1 The 282-Year Sequence

The canonical sequence of Lagrangians in theoretical physics is:

- **Maupertuis (1744)** [Maupertuis 1744] and **Euler (1744)**: the Principle of Least Action for mechanical systems. Lagrangian of the form $L = T - V$.
- **Lagrange (1788)** [Lagrange 1788]: the systematic Lagrangian reformulation of Newtonian mechanics. *Mécanique Analytique* establishes the Lagrangian method in its modern form.
- **Hamilton (1833)** [Hamilton 1833, 1834]: Hamilton's principle, $\delta\int L\,dt = 0$, and the Hamiltonian reformulation. The Hamiltonian $H = \Sigma\, p_i \dot{q}^i - L$.
- **Maxwell (1865)** [Maxwell 1865]: the Lagrangian formulation of classical electromagnetism. $L = (1/2)(E^2 - B^2) - \rho\varphi + J\cdot A/c$ (in Gaussian units).
- **Einstein-Hilbert (1915)** [Hilbert 1915; Einstein 1915]: the Lagrangian for general relativity. $L_{EH} = R/(16\pi G)$, where R is the Ricci scalar.
- **Dirac (1928)** [Dirac 1928]: the Dirac Lagrangian for spin-½ fermions. $L_{Dirac} = \bar{\psi}(i\gamma^\mu D_\mu - m)\psi$.
- **Yang-Mills (1954)** [Yang-Mills 1954]: the non-Abelian gauge Lagrangian. $L_{YM} = -(1/4)\, F^a_{\mu\nu} F^{a\mu\nu}$.
- **Glashow-Weinberg-Salam (1961-1968)** [Glashow 1961; Weinberg 1967; Salam 1968]: the electroweak Lagrangian unifying electromagnetism and the weak interaction.

- **Quantum Chromodynamics (1973)** [Gross-Wilczek-Politzer 1973]: the SU(3)_c color Lagrangian.
- **Standard Model + Einstein-Hilbert (1975-present)** [Glashow-Weinberg-Salam plus GWS plus Higgs plus QCD plus Einstein-Hilbert]: the current complete Lagrangian of known physics, combining the Standard Model's electroweak and strong sectors with the Einstein-Hilbert gravitational action.

This 282-year sequence has systematically extended the Lagrangian framework to cover mechanics, electromagnetism, gravity, relativistic matter, gauge fields, and — in modern completion — all four known interactions. At each stage, the Lagrangian was extended to encompass new physical content.

### VIII.2 What Every Prior Lagrangian Lacks

None of the Lagrangians in the 282-year sequence encompasses the Second Law of Thermodynamics as a theorem of its structure. This is not an oversight; it is a *structural feature* of the Lagrangian tradition.

Every Lagrangian L in the sequence generates, via the Euler-Lagrange equations $\delta L/\delta q - (d/dt)(\delta L/\delta \dot{q}) = 0$, a set of *time-reversal symmetric* equations of motion. For mechanical, electromagnetic, gravitational, and gauge systems, the equations of motion are second-order in time and run equally well forward and backward: if q(t) is a solution, so is q(−t). This time-symmetry is a generic feature of Lagrangian systems, following from the reparametrization-invariant structure of the action.

The Second Law of Thermodynamics is a statement of *absolute time-asymmetry*. It cannot be encoded in a time-symmetric Lagrangian without auxiliary content. Thermodynamics has historically been treated as a *statistical-emergent* feature of microscopic Lagrangians, derivable from them only through coarse-graining procedures that introduce time-asymmetry through auxiliary assumptions (low-entropy initial conditions, Stosszahlansatz, molecular chaos, etc.). The Lagrangian itself does not contain the Second Law; the coarse-graining procedure adds it.

This is the 282-year state of the Lagrangian tradition: **no Lagrangian in the sequence has encompassed the Second Law as a theorem of its own structure without auxiliary coarse-graining assumptions.**

### VIII.3 What ℒ_McG Achieves

ℒ_McG of [MG-Lagrangian] breaks this pattern. The Second Law is a theorem of ℒ_McG's structure directly, without coarse-graining assumptions or auxiliary inputs. The mechanism is the dual-channel content of $dx_4/dt = ic$: ℒ_McG is forced by this principle, and the principle's Channel B content generates the Second Law as established in §III. The Second Law is therefore inherited by ℒ_McG from its geometric foundation, not added through coarse-graining.

**Proposition VIII.1** *(ℒ_McG is the first Lagrangian in the 282-year tradition with the Second Law as a direct theorem).*

*Every Lagrangian in the canonical sequence from Maupertuis (1744) through the Standard Model plus Einstein-Hilbert generates, via the Euler-Lagrange equations, time-reversal symmetric equations of motion and therefore cannot encompass the Second Law of Thermodynamics as a theorem of its own structure. The Second Law has historically been treated as emergent from these Lagrangians only through auxiliary coarse-graining assumptions. The McGucken Lagrangian $\mathscr{L}$_McG is the first Lagrangian in the tradition with the Second Law as a direct theorem of its structure, because $\mathscr{L}$_McG descends from the McGucken Principle $dx_4/dt = ic$ through the four-fold uniqueness argument of [MG-Lagrangian, Theorem VI.1], and the principle's Channel B content (§III of the present paper) forces the Second Law as a theorem.*

### VIII.4 The Three Phenomena Outside the 282-Year Lagrangian Tradition

There is a further structural observation. Three physical phenomena stand *outside* the 282-year Lagrangian tradition in the sense that no Lagrangian from Maupertuis through the Standard Model plus Einstein-Hilbert accounts for any of them:

1. **The Second Law of Thermodynamics** — the absolute time-asymmetry of entropy increase.
2. **Brownian motion** — the isotropic random-walk behavior of particles in thermal equilibrium.
3. **The five arrows of time** — the thermodynamic, radiative, cosmological, causal, and psychological arrows, all pointing forward.

All three are historically treated as emergent from the microscopic Lagrangian through auxiliary coarse-graining or statistical-mechanical procedures, not as theorems of the Lagrangian itself. Under the McGucken Principle, all three follow as theorems of the same geometric principle $dx_4/dt = ic$ that forces the four sectors of $\mathscr{L}$_McG: entropy increases because $x_4$ expands (§III.2); Brownian motion is isotropic because $x_4$'s expansion is spherically symmetric (§III.1); all five arrows of time point forward because $x_4$ advances in $+ic$ and never $-ic$ (§IV).

This is the structural claim of §VIII: **$\mathcal{L}$_McG is the first Lagrangian in the 282-year tradition to encompass all three of these phenomena as direct theorems of its structure, rather than as emergent features requiring auxiliary coarse-graining.** The unification of the conservation laws with the Second Law (and its two structural companions, Brownian motion and the arrows of time) is therefore a genuine structural extension of the Lagrangian tradition, not a reformulation of it.

## IX. Concluding Remarks

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The McGucken Principle $dx_4/dt = ic$ is the common foundation of both the conservation laws and the Second Law of Thermodynamics. This unification is remarkable because the two categories have stood in separate conceptual compartments for 150 years, ever since Loschmidt's 1876 reversibility objection made their reconciliation appear impossible within the framework of time-symmetric microscopic dynamics. It is counter-intuitive because the same geometric principle produces both time-symmetric structural results (the ten Poincaré charges, the three gauge charges, the covariant energy-momentum conservation of diffeomorphism invariance) and time-asymmetric structural results (the Second Law, Brownian motion, the five arrows of time) through two logically distinct channels of its content that nevertheless coexist in the single statement $dx_4/dt = ic$.

The resolution of the 150-year Loschmidt tension is not through strengthening the statistical arguments of the Boltzmann-Gibbs account, not through appealing to cosmological fine-tuning of initial conditions via the Past Hypothesis, not through invoking anthropic arguments, and not through replacing time-symmetric microscopic dynamics with time-asymmetric dissipative equations. The resolution is structural: the principle carries two kinds of content, and the two categories — symmetry-derived conservation and propagation-derived irreversibility — are the outputs of the two kinds of content read through two distinct channels. Neither output is reducible to the other; both are derivable from the principle.

The consequence at the level of the Lagrangian tradition is substantive. The McGucken Lagrangian $\mathscr{L}$_McG of [MG-Lagrangian] is the first Lagrangian in the 282-year tradition from Maupertuis (1744) through the Standard Model plus Einstein-Hilbert to encompass both the conservation laws (via the standard Noether procedure applied to $\mathscr{L}$_McG's manifest symmetries) and the Second Law of Thermodynamics (via the direct geometric inheritance of Channel B content from $dx_4/dt = ic$ through the Compton-frequency coupling of matter to $x_4$'s advance, through the direct geometric expansion of the McGucken Sphere, and through the Jacobson-Verlinde entropic-gravity structure of the gravitational sector). No prior Lagrangian in the tradition has had the Second Law as a direct theorem of its structure; $\mathscr{L}$_McG does, because $\mathscr{L}$_McG descends from a principle with dual-channel content.

The dual-channel structure identified in this paper is the *fifth* instance of the same structural pattern in the McGucken corpus. At the foundational level of quantum mechanics, Channel A generates the Hamiltonian formulation and Channel B generates the Lagrangian formulation [MG-TwoRoutes, §§II-III]. At the dynamical level, Channel A generates the Heisenberg picture and Channel B generates the Schrödinger picture [MG-TwoRoutes, §V.7]. At the ontological level, Channel A generates the particle aspect and Channel B generates the wave aspect of quantum objects [MG-TwoRoutes, §V.6]. At the causal/correlational level, Channel A generates the local microcausality of standard operator algebra and Channel B generates the nonlocal Bell correlations of entanglement, with the McGucken Equivalence [MG-Equiv; MG-Singular §VII] identifying quantum nonlocality as the three-dimensional shadow of four-dimensional $x_4$-coincidence on the light cone. At the thermodynamic level developed in the present paper, Channel A generates the conservation laws and Channel B generates the Second Law and arrows of time. Five independent structural appearances of the same dual-channel mechanism — four within quantum mechanics (foundational, dynamical, ontological, causal/correlational) and the fifth extending beyond quantum mechanics into thermodynamics — each producing a pair of historically-disparate categories as simultaneous theorems of the same principle, is strong structural evidence that the principle itself possesses the dual-channel character as a genuine feature of its content, not as an accidental coincidence.

The McGucken Principle is what the 150-year history of the Loschmidt problem has been seeking: a single simple physical principle that carries both the time-symmetric content required for conservation laws and the time-asymmetric content required for the Second Law, and that unpacks each through a distinct logical channel without requiring either to reduce to the other. The principle is not a refinement of the Boltzmann-Gibbs account of thermodynamics, and it is not a reformulation of Noether's theorem; it is the deeper geometric foundation from which both the Boltzmann-Gibbs account (at its validity) and Noether's theorem (as applied to the action of the McGucken Lagrangian) follow as consequences.

That such a unification is achievable at all — that a single simple equation can carry both the time-symmetric conservation content and the time-asymmetric irreversibility content — is the structural signature of the McGucken Principle as a correct foundational statement about physical reality. Dual-channel content appearing at five independent levels — four within quantum mechanics, the fifth extending beyond it into thermodynamics — producing pairs of categories held in conceptual separation for generations, each pair now unified as Channel-A and Channel-B readings of the same geometric fact, is the kind of result that Wheeler anticipated when he wrote: *"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?"*

One final structural note. The unification developed in this paper situates the conservation-laws-plus-Second-Law result in the broader pattern of the McGucken corpus, in which the founding results of modern physics all descend as theorems of $dx_4/dt = ic$. Einstein's four 1905 *Annus Mirabilis* papers — which together are widely acknowledged as the founding documents of twentieth-century physics — unify under the McGucken Principle as four simultaneous theorems of a single geometric foundation: (i) the photoelectric effect with $E = hf$ and the light quantum follow from the oscillatory Planck-scale form of $x_4$'s advance, with $\hbar$ as the quantum of action per oscillation cycle of $x_4$ at the Planck frequency [MG-Constants §V; MG-deBroglie Theorem 1]; (ii) Brownian motion follows from the spatial projection of $x_4$'s spherically symmetric expansion, which is precisely the derivation developed in §III of the present paper as Channel B of the dual-channel structure [MG-Entropy; MG-Singular §V]; (iii) the constancy of the speed of light and the Lorentz transformations of special relativity follow from the invariant rate of $x_4$'s expansion under Lorentz boosts, with the Minkowski metric arising by direct substitution of $x_4 = ict$ into the four-Euclidean line element [MG-Proof; MG-Noether Proposition V.3]; (iv) $E = mc^2$ follows from the master equation u^μu_μ = $-c^2$ applied to a spatially-resting particle whose entire four-momentum advances in the $x_4$ direction at rate c [MG-Noether §II]. Einstein's 1905 *Annus Mirabilis* was the announcement of four foundational results that appeared, in 1905, to require four independent conceptual starting points (light quanta, atomic theory, relativity, mass-energy equivalence). In the McGucken framework, the four results are four theorems of the single principle $dx_4/dt = ic$ — and the unification developed in the present paper (conservation laws plus Second Law) is the fifth theorem of the same principle. The photoelectric effect, Brownian motion, special relativity, mass-energy equivalence, the conservation laws, and the Second Law of Thermodynamics are six readings of a single geometric foundation: the fourth dimension is expanding at the velocity of light.

## Coda: Provenance

The McGucken Principle itself is not a recent proposal. It has been under continuous development for thirty+ years, beginning with the author's undergraduate work at Princeton University with John Archibald Wheeler, P.J.E. Peebles, and Joseph H. Taylor Jr. in the late 1980s, first written down in an appendix to the author's 1998–1999 doctoral dissertation at the University of North Carolina at Chapel Hill, developed through a sequence of five Foundational Questions Institute papers between 2008 and 2013, consolidated in a book series during 2016–2017, continued in active public development on Medium (*goldennumberratio.medium.com*, 2020–present) and Facebook (*Elliot McGucken Physics*, 2017–present, 6,000+ followers), and currently the subject of an active derivation programme of approximately forty technical papers at elliotmcguckenphysics.com (2024–2026) [MG-History; MG-Medium; MG-FB]. The present paper is situated within that long development trajectory: its specific claim — that the conservation laws and the Second Law of Thermodynamics both descend from $dx_4/dt = ic$ as theorems of a single geometric principle — rests technically on the twelve-fold Noether catalog developed in [MG-Noether] and on the Second-Law and arrows-of-time derivations developed in [MG-Entropy], [MG-Singular], [MG-KaluzaKlein], [MG-PhotonEntropy], and [MG-Eleven].

## References

### Primary Works of the McGucken Corpus

[MG-Principle] E. McGucken, "The McGucken Principle: The Fourth Dimension Is Expanding at the Velocity of Light C: $dx_4/dt=ic$ & The McGucken Proof of the Fourth Dimension's Expansion at the Rate of C: $dx_4/dt=ic$," elliotmcguckenphysics.com (October 25, 2024). URL: https://elliotmcguckenphysics.com/2024/10/25/the-mcgucken-principle-the-fourth-dimension-is-expanding-at-the-velocity-of-light-c-dx4-dtic-the-mcgucken-proof-of-the-fourth-dimensions-expansion-at-the-rate-of-c-dx4-dtic/ . The foundational statement of the McGucken Principle $dx_4/dt = ic$ together with the six-step McGucken Proof deriving the Principle from the physical postulates that (i) every object has four-speed c, and (ii) photons are spherically-symmetric expanding wavefronts at rate c.

[MG-PrincetonAfternoons] E. McGucken, "Princeton Afternoons with Noble and Nobel Physicists (the Birth of $dx_4/dt = ic$) & A Paper on Quantum Entanglement with John Archibald Wheeler and Joseph Taylor at Princeton University — Within a Context: A Discussion of Paradoxes in Quantum Theory between Curiosity and Perseverance," elliotmcguckenphysics.com (October 21, 2024). URL: https://elliotmcguckenphysics.com/2024/10/21/princeton-afternoons-with-noble-and-nobel-physicists-the-birth-of-dx4-dtic-a-paper-on-quantum-entanglement-with-john-archibald-wheeler-and-joseph-taylor-at-princeton-university/ . The documented first-person account of the Princeton afternoons in which the McGucken Principle was born: the author's conversations with John Archibald Wheeler (Joseph Henry Professor of Physics, advisor for the junior paper on the Schwarzschild time factor), P.J.E. Peebles (Albert Einstein Professor Emeritus, 2019 Nobel Laureate, professor for quantum mechanics), and Joseph H. Taylor Jr. (1993 Nobel Laureate for the discovery of PSR B1913+16, advisor for the junior paper on quantum entanglement and the EPR paradox). The paper reproduces the key dialogue — Wheeler confirming that photons remain stationary in $x_4$, Peebles confirming that photons have equal probability of being found anywhere on a spherically-symmetric expanding wavefront, Taylor's charge to figure out the source of entanglement — and traces these exchanges directly to the physical content of $dx_4/dt = ic$. Also documents the later moment on a windsurfing-trip lunch break, reading Einstein's 1912 Manuscript on Relativity, when the specific equation $dx_4/dt = ic$ crystallized. Originally published as the opening chapter of McGucken 2017c, *Quantum Entanglement and Einstein's "Spooky Action at a Distance" Explained via LTD Theory's Expanding Fourth Dimension*.

[MG-History] E. McGucken, "A Brief History of Dr. Elliot McGucken's Principle of the Fourth Expanding Dimension $dx_4/dt = ic$: Princeton and Beyond — Moving Dimensions Theory (MDT) → Dynamic Dimensions Theory (DDT) → Light Time Dimension Theory (LTD) → $dx_4/dt = ic$," elliotmcguckenphysics.com (April 2026). URL: https://elliotmcguckenphysics.com/2026/04/11/a-brief-history-of-dr-elliot-mcguckenstheory-of-the-fourth-expanding-dimension-princeton-and-beyond/ . The comprehensive chronological record of the McGucken Principle's development from undergraduate work with John Archibald Wheeler at Princeton University in the late 1980s through the UNC Chapel Hill doctoral dissertation (1998–1999), PhysicsForums and Usenet deployments (2003–2006), the five FQXi essay-contest papers (2008–2013), the 2016–2017 book series, and the active derivation programme of 2024–2026. Archived forum posts, Google Groups Usenet records, FQXi archives, Blogspot timestamps, and complete bibliography.

[MG-Dissertation] E. McGucken, *Multiple Unit Artificial Retina Chipset System to Aid the Visually Impaired and Enhanced CMOS Phototransistors*, Ph.D. Dissertation, Department of Physics and Astronomy, University of North Carolina at Chapel Hill

(1999). The primary dissertation topic is biomedical engineering (NSF-funded, Merrill Lynch Innovations Grant, *Business Week* and *Popular Science* coverage). The appendix contains the earliest written record of the McGucken Principle $dx_4/dt = ic$, developed from the author's undergraduate collaborations with John Archibald Wheeler on the Schwarzschild time factor and the Einstein-Podolsky-Rosen paradox.

[MG-FQXi-2008] E. McGucken, "Time as an Emergent Phenomenon: Traveling Back to the Heroic Age of Physics (In Memory of John Archibald Wheeler)," Foundational Questions Institute essay contest, August 25, 2008. URL: https://forums.fqxi.org/d/238 . The first peer-visible, formally documented, indexed statement of the theory. Establishes $dx_4/dt = ic$ as the "elementary foundation" from which time dilation, length contraction, mass-energy equivalence, quantum nonlocality, wave-particle duality, and entropy all arise. The title and dedication reflect the paper's direct lineage from Wheeler's heroic-age-of-physics conviction. Consolidated survey of all five FQXi papers (2008–2013) at https://elliotmcguckenphysics.com/2025/03/10/light-time-dimension-theory-dr-elliot-mcguckens-five-foundational-papers-2008-2013-exalting-the-principle-the-fourth-dimension-is-expanding-at-the-rate/ .

[MG-FQXi-2009] E. McGucken, "What is Ultimately Possible in Physics? Physics! A Hero's Journey with Galileo, Newton, Faraday, Maxwell, Planck, Einstein, Schrödinger, Bohr, and the Greats towards Moving Dimensions Theory. E pur si muove!," Foundational Questions Institute essay contest, September 16, 2009. URL: https://forums.fqxi.org/d/511 . The second FQXi paper; the first to use Moving Dimensions Theory as an explicit, formal name in a paper title.

[MG-FQXi-2010] E. McGucken, "On the Emergence of QM, Relativity, Entropy, Time, $i\hbar$, and ic," Foundational Questions Institute essay contest (2010). Extends the framework to derive the Schrödinger equation's imaginary unit from $dx_4/dt = ic$.

[MG-FQXi-2012] E. McGucken, "MDT's $dx_4/dt = ic$ Triumphs Over the Wrong Physical Assumption That Time Is a Dimension," Foundational Questions Institute essay contest (2012). URL: https://forums.fqxi.org/d/1429 . The most polemical of the FQXi papers; argues that the standard conflation of time with the fourth dimension has generated most of modern physics' paradoxes.

[MG-FQXi-2013] E. McGucken, "Where is the Wisdom We Have Lost in Information? Returning Wheeler's Honor and Philo-Sophy to Physics," Foundational Questions Institute essay contest (2013). A tribute to Wheeler, extending the framework to information-theoretic foundations.

[McGucken 2016] E. McGucken, *Light Time Dimension Theory: The Foundational Physics Unifying Einstein's Relativity and Quantum Mechanics: A Simple, Illustrated Introduction to the Physical Model of the Fourth Expanding Dimension* (45EPIC Hero's Odyssey Mythology Press, 2016). Amazon ASIN: B01KP8XGQ6. URL: https://www.amazon.com/dp/B01KP8XGQ6 . The first book-length treatment of the McGucken Principle.

[McGucken 2017a] E. McGucken, *Einstein's Relativity Derived from LTD Theory's Principle: The Fourth Dimension is Expanding at the Velocity of Light c* (45EPIC Press, 2017). Full derivation of special and general relativity from $dx_4/dt = ic$.

[McGucken 2017b] E. McGucken, *Relativity and Quantum Mechanics Unified in Pictures: A Simple, Intuitive, Illustrated Introduction to LTD Theory's Unification of Einstein's Relativity* (45EPIC Press, 2017).

[McGucken 2017c] E. McGucken, *Quantum Entanglement and Einstein's "Spooky Action at a Distance" Explained via LTD Theory's Expanding Fourth Dimension* (45EPIC Press, 2017). The book-length development of the McGucken Equivalence.

[McGucken 2017d] E. McGucken, *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* (45EPIC Hero's Odyssey Mythology Press, 2017). Amazon ASIN: B0F2PZCW6B. URL: https://www.amazon.com/dp/B0F2PZCW6B . Particularly relevant to the present paper: the 2017 book-length treatment of the argument that the Second Law of Thermodynamics, entropy, and the arrows of time all follow from $dx_4/dt = ic$. The formal technical development of this argument is the subject of §§III–IV of the present paper.

[MG-Lagrangian] E. McGucken, "The Unique McGucken Lagrangian: All Four Sectors — Free-Particle Kinetic, Dirac Matter, Yang-Mills Gauge, Einstein-Hilbert Gravitational — Forced by the McGucken Principle $dx_4/dt = ic$: A Derivation of the Least-Action Functional for Physics from the Single Geometric Principle $dx_4/dt = ic$, with a History of Lagrangian Methods from Maupertuis to Witten and a Formal Uniqueness Proof," elliotmcguckenphysics.com (April 23, 2026). URL: https://elliotmcguckenphysics.com/2026/04/23/the-unique-mcgucken-lagrangian-all-four-sectors-free-particle-kinetic-dirac-matter-yang-mills-gauge-einstein-hilbert-gravitational-forced-by-the-mcgucken-principle-dx%e2%82%84-2/ . The full four-sector Lagrangian $\mathscr{L}$_McG = $\mathscr{L}$_kin + $\mathscr{L}$_Dirac + $\mathscr{L}$_YM + $\mathscr{L}$_EH, forced by $dx_4/dt = ic$ through a four-fold uniqueness theorem (Theorem VI.1). The companion paper to the present work: [MG-Lagrangian] establishes the *uniqueness* of the Lagrangian forced by $dx_4/dt = ic$; the present paper establishes that this unique Lagrangian has both the conservation laws and the Second Law of Thermodynamics as theorems of its structure, a property no prior Lagrangian in the 282-year tradition possesses.

[MG-Noether] E. McGucken, "The McGucken Principle of a Fourth Expanding Dimension Exalts and Unifies The Conservation Laws: How the Symmetries of Noether's Theorem, the Conservation Laws of the Poincaré, U(1), SU(2), SU(3), Diffeomorphism Groups, and the Imaginary Structure of Quantum Theory and Complexification of Physics arise from $dx_4/dt = ic$," elliotmcguckenphysics.com (April 21, 2026). URL: https://elliotmcguckenphysics.com/2026/04/21/the-mcgucken-principle-of-a-fourth-expanding-dimension-exalts-and-unifies-the-conservation-laws-how-the-symmetries-of-noethers-theorem-the-conservation-laws-of-the-poincare-u1-su2-su3-di/ . The full Noether catalog derivation used throughout §II of the present paper: the ten Poincaré charges in §§IV-V, the U(1) electric charge in §VI, the non-Abelian SU(2)_L and SU(3)_c charges in §VII, and the diffeomorphism-invariance covariant energy-momentum conservation ∇_μT^{μν} = 0 in §VII. Each derivation follows the chain: Postulate 1 → geometric symmetry of $x_4$'s advance → symmetry of the action → Noether's theorem → conservation law.

[MG-TwoRoutes] E. McGucken, "The Deeper Foundations of Quantum Mechanics: How The McGucken Principle Uniquely Generates the Hamiltonian and Lagrangian Formulations of Quantum Mechanics, Wave/Particle Duality, the Schrödinger and Heisenberg Pictures, and Locality and Nonlocality all from $dx_4/dt = ic$," elliotmcguckenphysics.com (April 2026). URL: https://elliotmcguckenphysics.com . The companion paper developing the dual-channel structure at three levels of quantum-mechanical description (foundational, dynamical, ontological). The present paper adds two further levels — the causal/correlational level via the McGucken Equivalence [MG-Equiv] and the thermodynamic level developed in §§III–V — bringing the count of independent structural appearances of the dual-channel mechanism to five.

[MG-Entropy] E. McGucken, "The Derivation of Entropy's Increase and Time's Arrow from the McGucken Principle of a Fourth Expanding Dimension $dx_4/dt = ic$: A Deeper Connection Between Brownian Motion's Random Walk, Feynman's Many Paths, Increasing Entropy, and Huygens' Principle," elliotmcguckenphysics.com (August 25, 2025). URL: https://elliotmcguckenphysics.com/2025/08/25/the-derivation-of-entropys-increase-from-the-mcgucken-principle-of-a-fourth-expanding-dimension-dx4-dtic-a-deeper-connection-between-brownian-motions-random-walk-feynmans/ . The MSD simulation demonstrating entropy increase via spherical isotropic random walk, used in §III.1 of the present paper.

[MG-Singular] E. McGucken, "The Singular Missing Physical Mechanism — $dx_4/dt = ic$: How the Principle of the Expanding Fourth Dimension Gives Rise to the Constancy and Invariance of the Velocity of Light c; the Second Law of Thermodynamics; Time, Its Flow, Its Arrows and Asymmetries; Quantum Nonlocality, Entanglement, and the McGucken Equivalence; the Principle of Least Action; Huygens' Principle; the Schrödinger Equation; the McGucken Sphere and the Law of Nonlocality; Vacuum Energy, Dark Energy, and Dark Matter; and the Deeper Physical Reality from Which All of Special Relativity Naturally Arises," elliotmcguckenphysics.com (April 10, 2026). URL: https://elliotmcguckenphysics.com/2026/04/10/the-missing-physical-mechanism-how-the-principle-of-the-expanding-fourth-dimension-dx%e2%82%84-dt-ic-gives-rise-to-the-constancy-and-invariance-of-the-velocity-of-light-c-the-s/ . Section V develops the Second Law as geometric necessity with $dS/dt = (3/2)k_B/t > 0$ strict for all $t > 0$; §VI derives the five arrows of time; §VII develops the McGucken Equivalence of quantum nonlocality; §VIII develops McGucken's Law of Nonlocality. Used throughout §§III–IV of the present paper.

[MG-KaluzaKlein] E. McGucken, "The McGucken Principle as the Completion of Kaluza–Klein: How $dx_4/dt = ic$ Reveals the Dynamic Character of the Fifth Dimension and Unifies Gravity, Relativity, Quantum Mechanics, Thermodynamics, and the Arrow of Time," elliotmcguckenphysics.com (April 11, 2026). URL: https://elliotmcguckenphysics.com/2026/04/11/the-mcgucken-principle-as-the-completion-of-kaluza-klein-how-dx4-dt-ic-reveals-the-dynamic-character-of-the-fifth-dimension-and-unifies-gravity-relativity-quantum-mech/ . §V.2 provides the formal derivation dS/dt = (3/2)k_B/t > 0 strictly, used in §III.2 of the present paper; §V.3 catalogs the five arrows of time; §VI develops the crucial distinction between time t and the fourth coordinate $x_4$.

[MG-PhotonEntropy] E. McGucken, "How The McGucken Principle Exalts Relativity, Photon Entropy on the McGucken Sphere, and a Testable Mechanism for Thermodynamic Entropy," elliotmcguckenphysics.com (April 18, 2026). URL: https://elliotmcguckenphysics.com/2026/04/18/how-the-mcgucken-principle-exalts-relativity-photon-entropy-on-the-mcgucken-sphere-and-a-testable-mechanism-for-thermodynamic-entropy/ . Section 3 derives the Shannon entropy S(t) = k_B ln(4π(ct)$^2$) for photons on the McGucken Sphere, used in §III.3 of the present paper; §§4-6 develop the Compton-frequency coupling giving the diffusion term D_x^(McG) = ε$^2$c$^2$Ω/(2γ$^2$), used in §III.4 of the present paper; §6 provides the full stochastic/Langevin derivation of the Compton-coupling diffusion with mass cancellation.

[MG-Eleven] E. McGucken, "One Principle Solves Eleven Cosmological Mysteries: How the McGucken Principle of the Fourth Expanding Dimension $dx_4/dt$ = ic Resolves the Greatest Open Problems in Cosmology, Including the Low-Entropy Initial Conditions Problem," elliotmcguckenphysics.com (April 13, 2026). URL: https://elliotmcguckenphysics.com/2026/04/13/one-principle-solves-eleven-cosmological-mysteries-how-the-mcgucken-principle-of-the-fourth-expanding-dimension-dx%e2%82%84-dt-ic-resolves-the-greatest-open-problems-in-cosmology-inclu/ . §XIII dissolves the Past Hypothesis by showing that $x_4$'s origin is geometrically necessarily the lowest-entropy moment; Penrose's $10^{-10^{123}}$ fine-tuning framing is identified as the wrong framing. Used in §VI.3 of the present paper.

[MG-Proof] E. McGucken, "The McGucken Proof of the Fourth Dimension's Expansion at the Rate of c: $dx_4/dt$ = ic," elliotmcguckenphysics.com (October 25, 2024). URL: https://elliotmcguckenphysics.com/2024/10/25/the-mcgucken-principle-the-fourth-dimension-is-expanding-at-the-velocity-of-light-c-dx4-dtic-the-mcgucken-proof-of-the-fourth-dimensions-expansion-at-the-rate-of-c-dx4-dtic/ . See also the standalone expanded version at https://elliotmcguckenphysics.com/2024/10/30/einstein-minkowski-x4ict-and-the-mcgucken-proof-of-the-fourth-dimensions-expansion-at-the-velocity-of-light-c-dx4-dtic-2/ .

[MG-HLA] E. McGucken, "The McGucken Principle $dx_4/dt$ = ic as the Physical Mechanism Underlying Huygens' Principle, the Principle of Least Action, Noether's Theorem, and the Schrödinger Equation," elliotmcguckenphysics.com (April 11, 2026). URL: https://elliotmcguckenphysics.com/2026/04/11/the-mcgucken-principle-dx%e2%82%84-dt-ic-as-the-physical-mechanism-underlying-huygens-principle-the-principle-of-least-action-noethers-theorem-and-the-schrodinger-equation/ .

[MG-PathInt] E. McGucken, "A Derivation of Feynman's Path Integral from the McGucken Principle of the Fourth Expanding Dimension $dx_4/dt = ic$," elliotmcguckenphysics.com (April 15, 2026). URL: https://elliotmcguckenphysics.com/2026/04/15/a-derivation-of-feynmans-path-integral-from-the-mcgucken-principle-of-the-fourth-expanding-dimension-dx4-dt-ic/ .

[MG-Compton] E. McGucken, "A Compton Coupling Between Matter and the Expanding Fourth Dimension: A Proposed Matter Interaction for the McGucken Principle, with Consequences for Diffusion and Entropy," elliotmcguckenphysics.com (April 18, 2026). URL: https://elliotmcguckenphysics.com/2026/04/18/a-compton-coupling-between-matter-and-the-expanding-fourth-dimension-a-proposed-matter-interaction-for-the-mcgucken-principle-with-consequences-for-diffusion-and-entropy/ .

[MG-Constants] E. McGucken, "How the McGucken Principle of a Fourth Expanding Dimension $dx_4/dt = ic$ Sets the Constants c (the Velocity of Light) and h (Planck's Constant)," elliotmcguckenphysics.com (April 11, 2026). URL: https://elliotmcguckenphysics.com/2026/04/11/how-the-mcgucken-principle-of-a-fourth-expanding-dimension-dx4-dtic-sets-the-constants-c-the-velocity-of-light-and-h-plancks-constant/ .

[MG-Broken] E. McGucken, "How the McGucken Principle of the Fourth Expanding Dimension $dx_4/dt = ic$ Accounts for the Standard Model's Broken Symmetries, Time's Arrows and Asymmetries, and Much More," elliotmcguckenphysics.com (April 13, 2026). URL: https://elliotmcguckenphysics.com/2026/04/13/how-the-mcgucken-principle-of-the-fourth-expanding-dimension-dx%e2%82%84-dt-ic-accounts-for-the-standard-models-broken-symmetries-times-arrows-and-asymmetries-and-much-more/ .

[MG-Wick] E. McGucken, "The Wick Rotation as a Theorem of $dx_4/dt = ic$: How the McGucken Principle of the Fourth Expanding Dimension Provides the Physical Mechanism Underlying the Wick Rotation and All of Its Applications Throughout Physics," elliotmcguckenphysics.com (April 20, 2026). URL: https://elliotmcguckenphysics.com/2026/04/20/the-wick-rotation-as-a-theorem-of-dx%e2%82%84-dt-ic-how-the-mcgucken-principle-of-the-fourth-expanding-dimension-provides-the-physical-mechanism-underlying-the-wick-rotation-and-all-of-its-applicat/ .

[MG-Verlinde] E. McGucken, "The McGucken Principle $dx_4/dt = ic$ as the Physical Mechanism Underlying Verlinde's Entropic Gravity: A Unified Derivation of Gravity, Entropy, and the Holographic Principle from a Single Geometric Principle," elliotmcguckenphysics.com (April 11, 2026). URL: https://elliotmcguckenphysics.com/2026/04/11/the-mcgucken-principle-dx%e2%82%84-dt-ic-as-the-physical-mechanism-underlying-verlindes-entropic-gravity-a-unified-derivation-of-gravity-entropy-and-the-holographic-principle-from-a-single-ge/ .

[MG-Jacobson] E. McGucken, "The McGucken Principle of a Fourth Expanding Dimension (dx₄/dt = ic) as a Candidate Physical Mechanism for Jacobson's Thermodynamic Spacetime, Verlinde's Entropic Gravity, and Marolf's Nonlocality," elliotmcguckenphysics.com (April 12, 2026). URL: https://elliotmcguckenphysics.com/2026/04/12/the-mcgucken-principle-of-a-fourth-expanding-dimension-dx%e2%82%84-dt-ic-as-a-candidate-physical-mechanism-for-jacobsons-thermodynamic-spacetime-verlindes-entropic-gravity-and-marolfs-nonl/ .

[MG-Equiv] E. McGucken, "The McGucken Equivalence: Quantum Nonlocality and Relativity Both Emerge From the Expansion of the Fourth Dimension at the Velocity of Light," elliotmcguckenphysics.com (December 29, 2024). Also available at Medium: https://goldennumberratio.medium.com/the-mcgucken-equivalence-of-quantum-nonlocality-and-relativity-how-quantum-nonlocality-is-found-ce448d0b5722 . The structural identification of quantum nonlocality as the three-dimensional shadow of four-dimensional x₄-coincidence on the light cone.

[MG-Sphere] E. McGucken, "Quantum Nonlocality and Probability from the McGucken Principle of a Fourth Expanding Dimension — How dx₄/dt = ic Provides the Physical Mechanism Underlying the Copenhagen Interpretation as well as Relativity, Entropy, Cosmology, and the Constants of Nature," elliotmcguckenphysics.com (April 16, 2026). URL: https://elliotmcguckenphysics.com/2026/04/16/quantum-nonlocality-and-probability-from-the-mcgucken-principle-of-a-fourth-expanding-dimension-how-dx4-dt-ic-provides-the-physical-mechanism-underlying-the-copenhagen-interpr/ . The six-sense geometric locality of the McGucken Sphere (foliation leaf, distance-function level set, Huygens caustic, Legendrian submanifold, conformal-pencil member, null-hypersurface cross-section) as the mechanism that makes quantum nonlocal correlations a local-in-4D phenomenon.

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