Resolving Spin and Entanglement with Testable Local Hidden Variables

The Liquid Gravity Atomic Model and a Proposed Stern–Gerlach Experiment Challenging Standard Probabilistic Predictions

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This paper is the foundational companion to Hodges (2026b), "A Mechanistic Model for Sequential and Entangled Spin Correlations: The LGAM Proximal Correlation Model," which develops and computationally verifies the mechanism proposed here. The present paper focuses on the physical picture and its philosophical motivation; the companion paper focuses on the mechanism's precise mathematical structure and numerical validation. Cross-references to the relevant sections of that paper are given throughout below.

Abstract

We present the Liquid Gravity Atomic (LGA) framework: an alternative, causal model in which electron spin and related quantum phenomena emerge from structured nuclear dynamics rather than being intrinsic properties of electrons. In LGA, nucleons form linked multichain arrangements whose internal figure-8 standing-wave motions generate oscillating fields that propagate along proton–neutron chains. The terminal neutron in each chain transmits a driven, oscillatory field into the orbital region; electrons tethered to these orbitals inherit a two-turn (720°) rotational signature and the observed up/down spin behavior. Superposition appears as an alternating spin pattern set by the neutron pulse position (West/East hemispheres), and entanglement is maintained by phase-locked pulse pairs whose angular positions are coordinated at the particles' shared point of origin.

LGA characterizes measurement probabilities in terms of a magnetic-angle dependence (0° → no flip; 90° → 50/50 flip/no-flip) arising from torque on the pulse — a threshold we show here follows from a specific geometric structure (the polar/equatorial angular distinction, Section 8.1) rather than being an independently assumed rule, a result established rigorously and verified computationally in the companion paper (Hodges 2026b, Section 1.3).

We further refine the account of entanglement given here by identifying, in the companion paper, a minimal and precisely-located shared-value step — a single shared variable generated from a single measurement setting, prior to particle separation — which we term a Proximal Correlation Model, and which we distinguish there from superdeterminism, Bohmian mechanics, and retrocausal accounts (Hodges 2026b, Section 6).

The paper outlines the physical mechanisms, symbol conventions for diagrams, and experimental signatures that distinguish LGA from quantum expectations, and proposes concrete Stern–Gerlach tests to validate or falsify the model.

A Note on Methodology

As with its companion paper (Hodges 2026b), this revision of the present paper was developed through iterative dialogue with Claude, an AI system developed by Anthropic, used throughout as a research and drafting partner rather than as an autonomous author. Physical ideas, section restructuring, and the cross-references to the companion paper's results introduced in this revision were proposed, discussed, and revised collaboratively; the underlying physical claims and conclusions remain the author's own. This note is included for consistency with the fuller methodological disclosure given in Hodges (2026b, Section 3), which describes the iterative computational testing process used to develop the mechanistic model itself.

1. Introduction

The concept of spin occupies a foundational yet paradoxical role in quantum mechanics. Unlike classical angular momentum, spin is treated as an intrinsic property of elementary particles, [2] lacking a clear mechanical origin. This abstraction has contributed to longstanding interpretational difficulties, including the measurement problem and apparent violations of classical causality.

Despite the predictive success of quantum formalism, the absence of a physically intuitive mechanism for spin remains a motivation for alternative approaches. The present work investigates whether electron spin may arise as an emergent phenomenon rooted in atomic and nuclear structure, rather than being a fundamental quantum postulate.

2. Experimental and Historical Context

2.1 Stern–Gerlach Experiment

The Stern–Gerlach experiment [3] yielded a significant and unexpected result from an investigation initially designed for different purposes. It demonstrated that neutral silver atoms, when passed through a non-uniform magnetic field, separate into two discrete spatial trajectories. This outcome revealed quantized angular momentum states, which were later interpreted as the spin orientations of electrons: spin-up and spin-down.

It is important to note that the electron is considered to be in a superposition of all possible spin states until a measurement is made, at which point the quantum state collapses into a definite spin orientation. Additionally, it is noteworthy that free electrons cannot be measured using this technique; only valence electrons in atoms, such as silver, can be tested in this manner. The Stern–Gerlach experiment laid the groundwork for critical concepts in quantum physics, including particle collapse, probability, and superposition.

2.2 The EPR paper

The discovery of the double-slit experiment sparked a debate about the workings of the quantum realm, focusing on concepts such as wave-particle duality, wave function collapse, and entanglement. The discussion featured prominent figures like Niels Bohr, who argued that the quantum world is fundamentally unknowable and that we must accept its inherent strangeness, given the remarkable accuracy of quantum probabilities. In contrast, Albert Einstein maintained that the quantum realm should ultimately adhere to classical principles.

Together with Boris Podolsky and Nathan Rosen, Einstein co-authored a paper in 1935 known as the EPR paper, which contended that quantum probability undermines the causal nature of reality. They argued that “spooky action at a distance” — the instantaneous connection between entangled particles — cannot be real, suggesting that quantum theory is incomplete. They posited that there must be hidden variables that govern the synchronized behavior of entangled particles, regardless of the distance separating them.

2.3 John Bell's theorem

In 1964, physicist John Bell developed a method for testing local hidden variable theories [4] against the probabilistic, non-local predictions of quantum mechanics [5]. He designed an experiment based on the Stern-Gerlach setup, where two entangled electrons measure their spins at different angles. Bell's findings demonstrated a measurable difference between the outcomes predicted by hidden variable theories and those predicted by quantum mechanics. Although his theorem was largely overlooked at the time, its significance has come to light in recent years, leading to several Nobel Prizes awarded for tests of Bell's theorem.

2.4 Many Interpretations of Quantum Mechanics

The challenge of quantum mechanics lies in its ability to provide a highly precise mathematical framework for calculating quantum probabilities, yet it offers no concrete explanation for how these results manifest physically. This situation often appears to contravene classical principles of locality and causality. Consequently, numerous interpretations have been proposed to elucidate the underlying nature of this perplexing quantum realm.

Many-Worlds Interpretation: This interpretation posits that rather than collapsing into a single state upon measurement, all possible states of a quantum system coexist, resulting in a branching of reality with each collapse event.

Superdeterminism: This interpretation suggests that all particles are predetermined from the beginning of time, implying that entangled particles possess prior knowledge of their respective outcomes, and thus display local pre-knowledge.

Time-Travel Interpretation: This interpretation proposes that particles can communicate with their past selves, allowing them to remain correlated into the future.

Despite these interpretations, none provide testable or falsifiable methods to validate their claims, leaving the scientific community in a state of ongoing debate regarding the true nature of phenomena in the quantum world.

2.5 What Can We Learn from History?

The narrative of quantum physics has shifted away from seeking explanations based on real-world, local causality, leaning instead toward ideas that resemble science fiction or mythological magic. Throughout the history of quantum physics, significant details have often been overlooked, and new assumptions have taken center stage. Claims such as Bell's theorem disproving Einstein, the notion that rethinking quantum mechanics leads to clarity, and the assertion that locality and causality cannot coexist contribute to a frenzy of unconventional interpretations that dominate scientific discourse today.

I contend that Einstein was correct in asserting the incompleteness of quantum theory and that a locally causal, hidden-variable explanation remains worth examining. Critics argue that Bell's theorem rules out local hidden variables, but it rules out only certain classes of models — specifically those that assign a single predetermined outcome to each measurement setting (which I will call single-valued hidden variables).

Quantum probability outcomes suggest that each hidden variable must accommodate two possible results for a given measurement angle, with associated probabilities; these form a class of multi-valued hidden variables. Producing multiple outcomes locally requires at least two parameters — for example, the orientation of a magnetic field and the particle's own angular position. Combining these locally defined parameters can yield probabilistic outcome statistics consistent with quantum predictions.

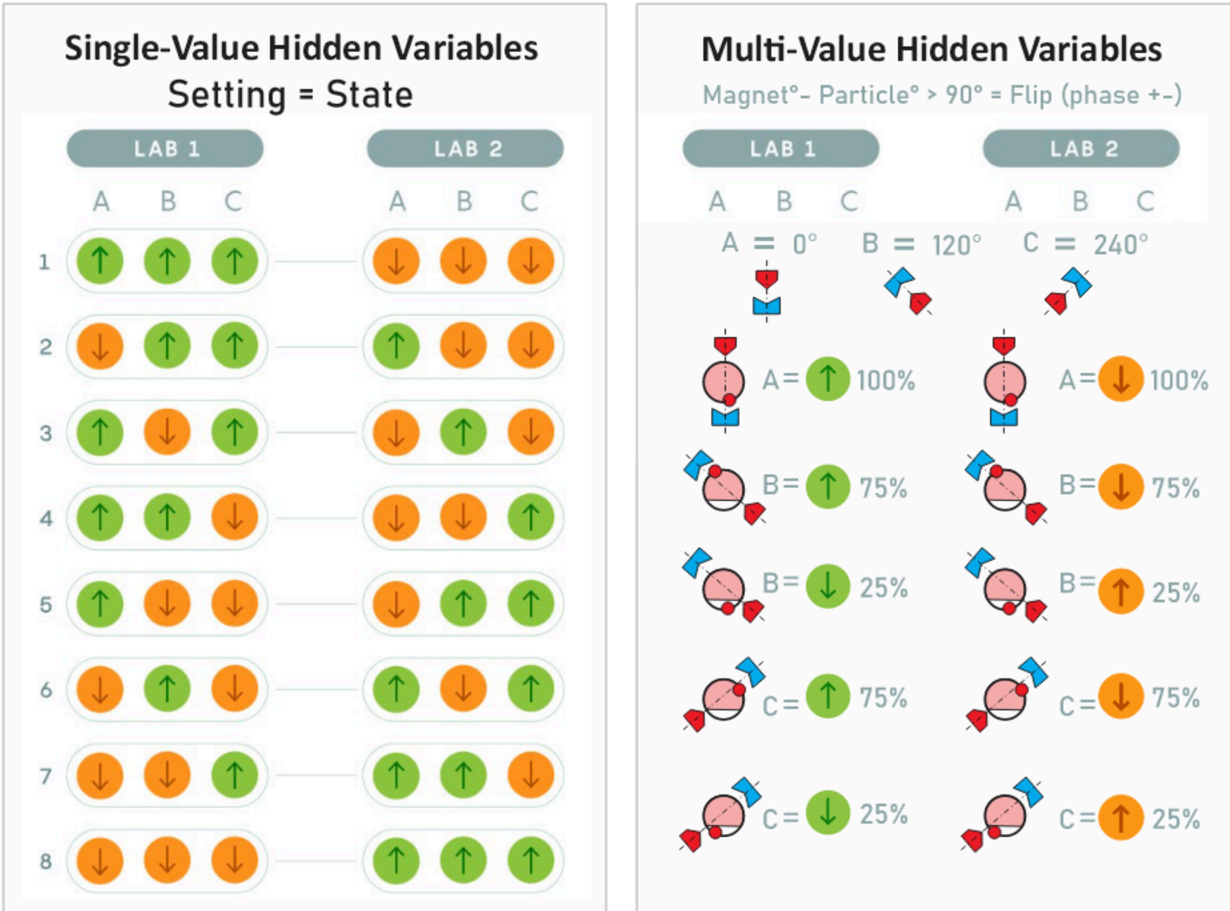


Figure 1. A schematic that compares single-value hidden variables with multi-value hidden variables.

3. Hypothesis

This paper proposes that electron spin is not an intrinsic quantum property but an emergent classical behavior produced by nuclear dynamics. We hypothesize that quantum phenomena are ultimately classical and that their apparent mystery can be resolved through a causal, mechanistic account of the underlying physics. A clearer picture of atomic structure can help answer three central questions in quantum mechanics: What is spin? What causes wavefunction collapse? Is entanglement explained by a variable shared at the particles' common origin, or by some other mechanism?

The core idea is that the mechanical structure and dynamics of the atomic nucleus drive the behavior observed in electrons. Important structural and dynamical details of the nucleus have been neglected in mainstream accounts; incorporating these pieces yields a coherent, causal account that explains spin, collapse, and entanglement in mechanistic terms.

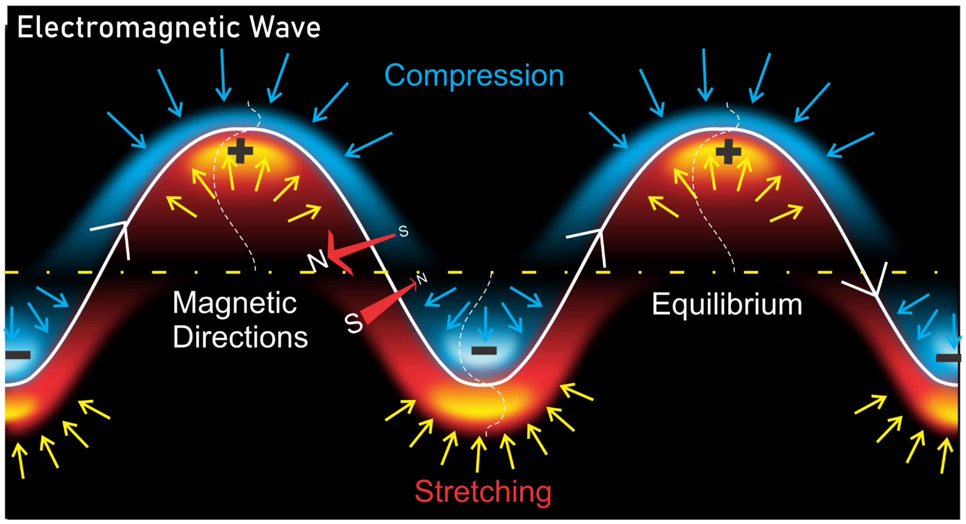
4. The Liquid Gravity Atomic (LGA) Framework

This section outlines the Liquid Gravity Atomic (LGA) framework, which offers an alternative account of electron spin as an emergent property of nuclear structure rather than an intrinsic attribute of the electron.

Context and motivation. Mainstream physics treats half-integer spin as an intrinsic quantum property of electrons; this description explains experimental results but does not provide a classical causal mechanism for how spin arises or how measurement collapses an outcome. The LGA framework instead traces spin back to the nucleus and the dynamical fields it generates.

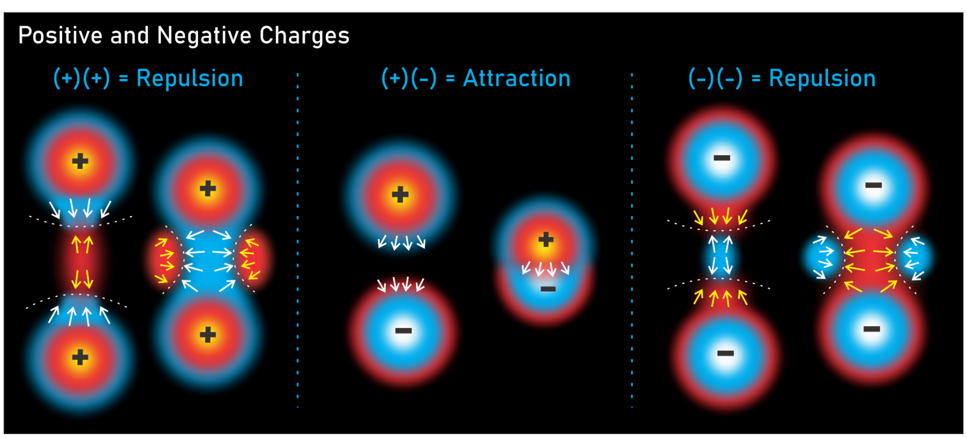
Core ideas

- Fundamental medium: LGA proposes that all particles, fields, and forces emerge from a single, ubiquitous medium with both fluid and elastic properties. Interactions are carried by positive and negative pressure gradients in this medium, enabling charges, waves, standing waves, and gravity to operate across macroscopic and quantum scales.
- Emergent particles: In LGA, subatomic particles arise from patterns of energy propagation within the fundamental medium.
- Electromagnetic waves: Electromagnetic waves exploit the medium's elasticity; the medium's restoring resistance provides the periodic exchange between stretching and compression that sustains wave propagation.



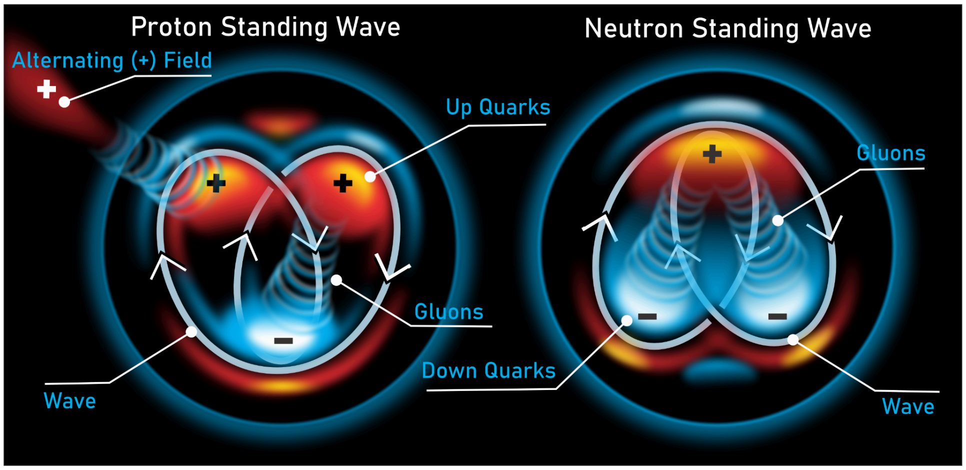
Electromagnetic wave in the medium (unlabeled diagram, as in the original).

- Charges and electrostatic interaction: Charges manifest as localized stretches or compressions of the medium. Limited stretching or compression between like regions produces repulsion, while complementary deformations produce attraction, giving rise to electrostatic behavior.



Positive and negative charges in the medium (unlabeled diagram, as in the original).

- Nucleons and strong interactions: Nucleons are modeled as high-energy pulses confined within a condensed superfluid region of the medium. They adopt figure-eight (∞) standing-wave patterns that produce alternating positive and negative eddies and drive vortex-tube structures. These complementary vortex interactions produce the binding behavior identified experimentally as quarks and gluons and explain nucleon-level (hydrodynamic-like) behavior in a single-medium picture.



Proton and neutron standing waves (unlabeled diagram, as in the original).

- Spin Emergence from the nucleus: LGA proposes that electron spin emerges from structured motions within the nucleus, transmitted outward to the orbitals that bind electrons. Electrons themselves do not carry intrinsic spin in this picture; rather, they inherit rotational characteristics from nuclear dynamics.
- Nuclear structure: Whereas the Liquid Drop Model (LDM) describes the nucleus as a relatively loose, dynamic collection of nucleons, LGA posits a highly structured arrangement in which nucleons form linked multichain configurations. These chained structures mediate the transmission of fields from protons into the orbital region.
- Role of neutrons: In LGA, neutrons play an active role in distributing the positive field of the atomic shells. While neutrons are electrically neutral, they receive and relay positive field effects along proton–neutron chains; the terminal neutron in each chain couples that field into the orbital region.
- Shared nucleon dynamics: Both protons and neutrons are modeled as having internal standing-wave motion following a figure-8 path that alternates through regions of effective positive and negative phase within their roughly spherical structure.

Transmission to orbitals: The dynamic rotation and oscillation of the terminal neutron's field impose a driven motion on the orbital fields. Electrons, being tethered to these orbitals, acquire the observed 720° (two-turn) rotational signature attributed to electron spin through this coupling.

Summary of the mechanism: Protons initiate a circulating positive field. Neutrons propagate and structure that field via coupled wave motion through nucleon chains. The terminal neutron in each chain transmits an oscillating field into the orbital region. Electrons inherit the resulting rotational properties from the orbital field, producing the effective spin behavior (including the characteristic 720° property) observed in experiments.

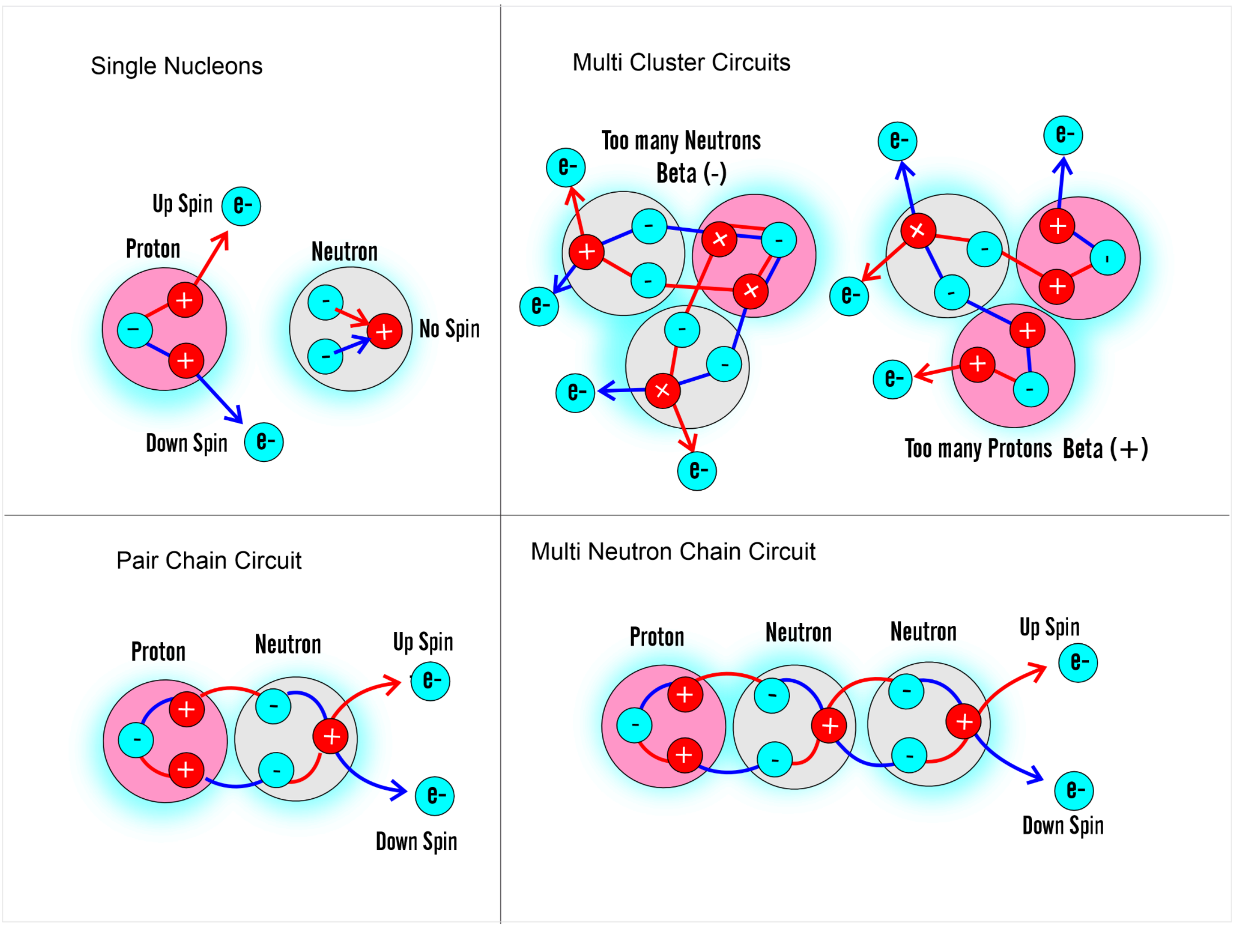


Figure 2. Schematic of proton–neutron chain coupling and transmission of orbital field.

5. Nucleon Dynamics and Orbital Formation

5.1 Balanced Helix Path State (Superposition)

In the absence of external magnetic influence, the neutron propagates a pulse along a closed, double-loop figure-eight trajectory. This energy pulse completes a 720° dual-wave cycle, passing through two negative zones and one positive zone twice per cycle. The resulting alternating positive field radiates outward to form the sss-orbital. The valence electron is confined within this alternating field and follows the same 360° rotational motion on each side, oscillating between opposing sides of the orbital. In this balanced state, no fixed spin orientation exists.

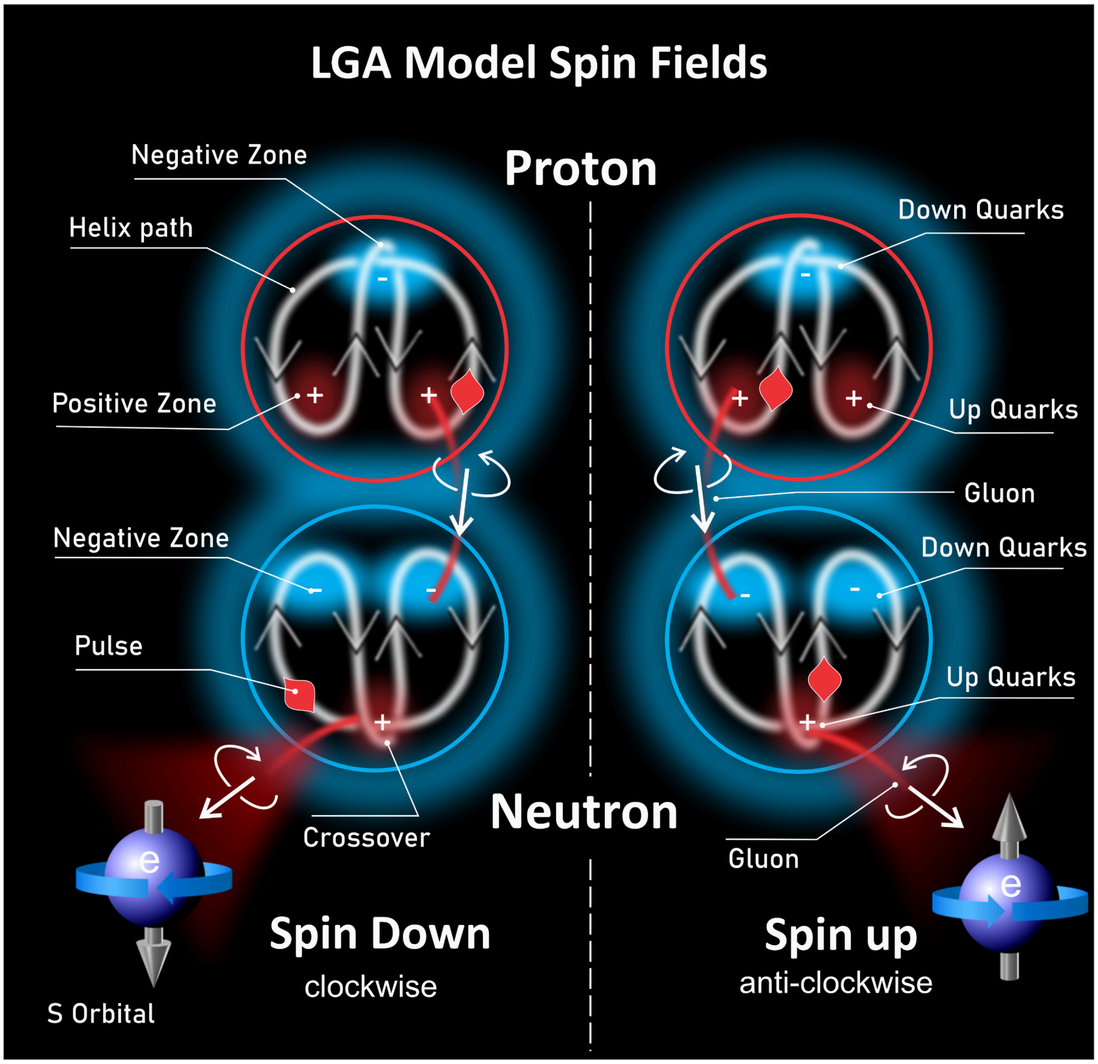


Figure 3. Helix pulse trajectory showing negative zones, positive zone, and crossover point.

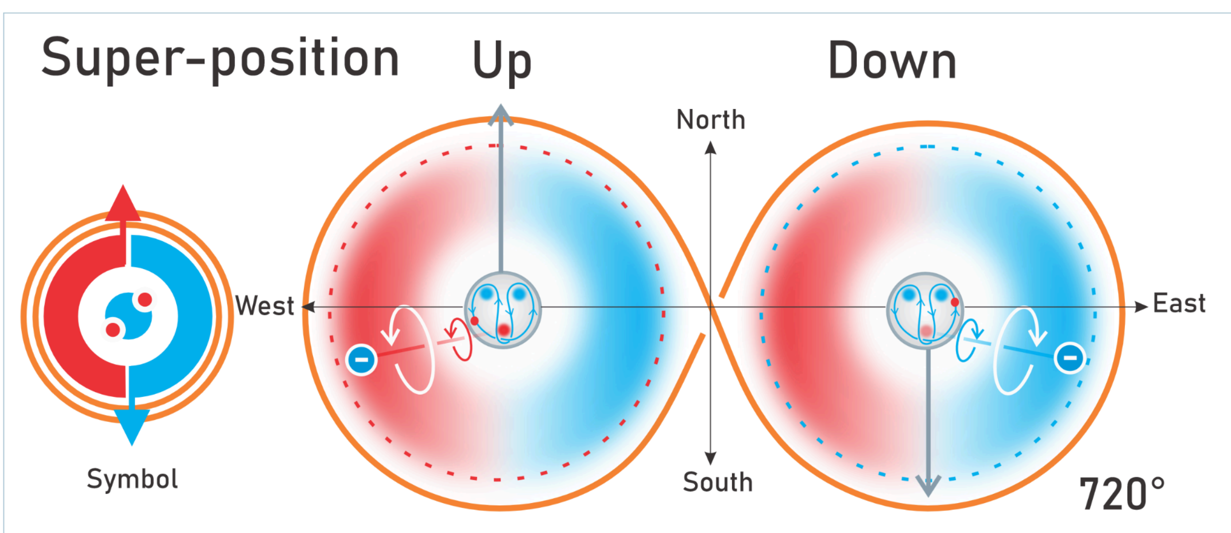


Figure 4. Simplified atom (single nucleon shown): the nucleon's figure-8 trajectory and the separated West and East hemispheres.

6. Magnetic-Field-Induced Eigenstate

6.1 Wave collapse into an Eigenstate

The collapse of the wavefunction — commonly called the measurement problem — refers to the unresolved question of what physically causes a quantum state to reduce to a single eigenstate. Here, we identify a sequence of steps and conditions that, in this model, produce the collapse of an atom's electron state.

- Driven spin. In this framework, the electron's spin is not taken as an isolated intrinsic property but as a response to the neutron's propagation of the positive field; the electron's motion tracks that field.
- Field competition. When the atom enters a strong external magnetic field, the electron becomes subject to both the local positive field and the external magnetic field. The competing fields deform the electron's trajectory, concentrating (collimating) the electron's spatial distribution.
- Geometric consolidation and dynamical change. This spatial consolidation increases the effective centrifugal influence on the neutron pulse and drives a dynamical transition of the pulse trajectory from a balanced helical/figure‑eight path into a locked single‑loop rotation.
- Stabilization. Although the external magnetic perturbation is transient, the new geometric configuration produces increased centrifugal stability that maintains the single‑loop rotation. The result is a persistent, well‑defined rotational (spin) orientation — i.e., a collapsed eigenstate — that can survive after the atom leaves the magnetic region.

This four-step sequence has since been implemented and directly verified computationally (Hodges 2026b, Sections 4.1–4.2 and 5.1), including reproduction of the classical three-stage measurement-disturbance effect predicted by quantum mechanics.

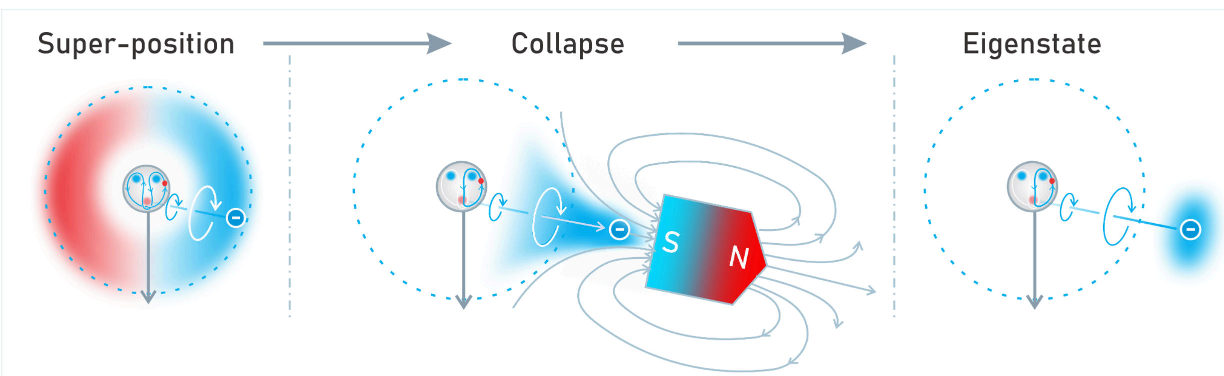


Figure 5. Transition from superposition to collapse to a persistent eigenstate of spin down.

7. Measurement without Observer Dependence

In the Stern–Gerlach experiment, atomic beam splitting arises from deterministic interaction between the atomic magnetic structure and the external field. The magnetic field constrains the system into a single rotational state, which remains stable upon subsequent measurements using identically aligned detectors.

In this model, measurement outcomes are determined by physical interaction rather than observer-induced wavefunction collapse. [9]

8. Spin State Reversal

Reorientation of the external magnetic field can unlock the single-loop state depending on the progression of the neutron pulse. Torque increases as the pulse approaches the crossover point of the original figure-eight trajectory.

- Torque is minimal at the apex of negative zones
- Torque is maximal at the crossover point

Spin reversal occurs when magnetic torque exceeds pulse-generated torque.

8.1 Two Angular Degrees of Freedom: Polar and Equatorial Structure

The pulse's position on its figure-eight trajectory is more precisely understood as two distinct angular coordinates, in the ordinary physical sense of polar and equatorial (azimuthal) angles on a sphere, each governed by a different rule:

- The equatorial angle, φ, is the pulse's own orientation, set once at the moment the atom enters a measurement region and not itself recalculated between successive measurements — it persists as a fixed value carried forward.
- The polar angle, θ, is the angle actually used in the torque comparison of Section 9: it is measured relative to whichever magnet is currently doing the measuring, so the magnet's own direction serves as the polar axis.

This distinction has a direct geometric consequence: for the torque relationship of Section 9 to hold — magnetic torque and pulse-generated torque crossing at exactly the reversal threshold — the crossover point of the original figure-eight trajectory must sit precisely diametrically opposite the magnet's own direction on this polar axis. This is exactly what is implemented by the 180° reorientation of the pulse's polar angle upon a flip event (Section 9.1). A single, unmoving equatorial value can therefore still yield genuinely different polar readings — and hence different measurement outcomes — at successive stages, purely because each stage measures against a different magnet.

This polar/equatorial structure is stated here at the physical/geometric level; its full computational implementation and role in reproducing the measurement-disturbance effect are given in Hodges (2026b), Sections 4.1.2 and 4.2.

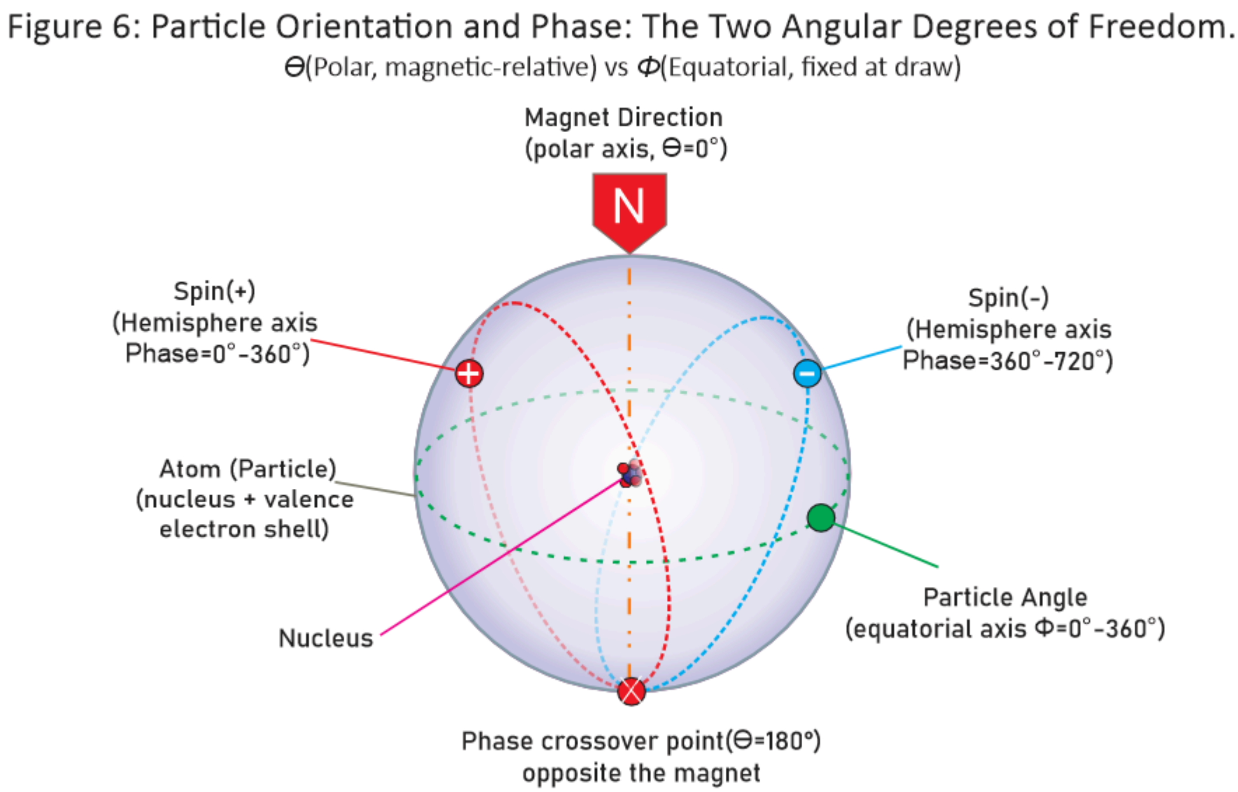


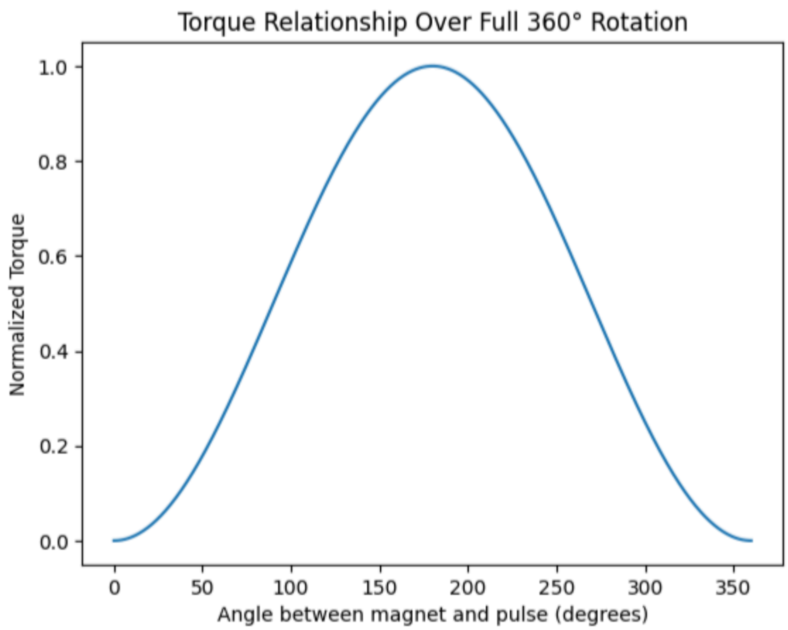
Figure 6. Particle Orientation and Phase: The Two Angular Degrees of Freedom. The atom — nucleus plus valence electron shell — sits at the sphere's centre. Spin(+) and Spin(−) correspond to the two halves of the electron's inherited 720° phase cycle (Section 1.2), occupying different planes in three dimensions; they meet at a single true crossing point at θ=180°, diametrically opposite the magnet. The equatorial angle φ (green) is fixed at the moment of generation. (Adapted from Hodges 2026b, Figure B4.)

9. Torque–Angle Relationship

The torque acting on the neutron pulse as a function of angular separation between the magnetic field and pulse orientation is modeled as:

$$\tau(\theta) = \tau_{\square ax} \cdot \sin^2(\theta/2)$$

$$(1 - \cos\theta)/2 = \sin^2(\theta/2)$$



$$\tau(\theta) = \tau_{\max} \sin^2\left(\frac{\theta}{2}\right)$$

$$\frac{1-\cos\theta}{2} = \sin^2\left(\frac{\theta}{2}\right)$$

Figure 7. Torque relationship over a full 360° rotation.

9.1 Deriving the Flip Threshold

The relationship above gives the magnetic torque acting on the pulse, with reversal occurring when this magnetic torque exceeds a competing, pulse-generated torque. Treating the pulse-generated torque as the mirror complement of the magnetic torque, evaluated over the same relative angle —

$$\tau_{pulse}(\theta) = \tau_{max} \cdot \cos^2(\theta/2)$$

— the reversal condition $\tau_{magnetic} > \tau_{pulse}$ becomes $\sin^2(\theta/2) > \cos^2(\theta/2)$. Using the identity $\sin^2(x) - \cos^2(x) = -\cos(2x)$ with $x = \theta/2$, this simplifies to $\cos(\theta) < 0$, which holds if and only if $\theta > 90°$. The competing-torque relationship therefore derives, rather than merely motivating, the $|\theta| > 90°$ flip threshold used throughout the rest of this paper: the two torque curves cross exactly at the point where the reversal condition changes sign.

This derivation has been verified both algebraically and numerically (Hodges 2026b, Section 1.3): a two-stage sequential simulation implementing the explicit torque comparison, rather than the $|\theta| > 90°$ threshold directly, reproduces the same established results exactly, including 100.0% same-setting invariance at every angle tested.

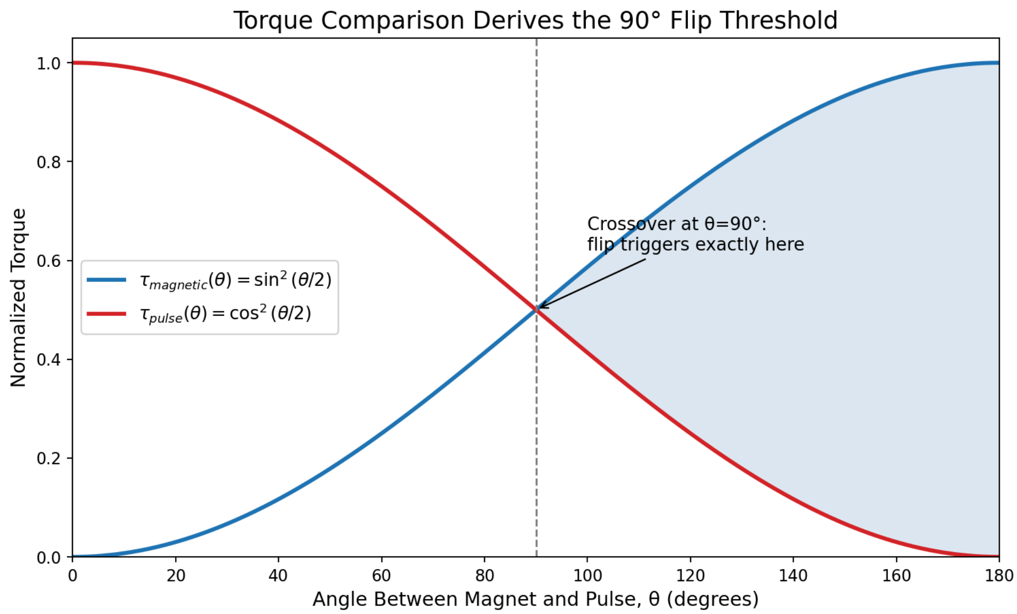


Figure 8. The magnetic torque (blue, $\sin^2(\theta/2)$) and the mirrored pulse-generated torque (red, $\cos^2(\theta/2)$) cross exactly at θ=90°, deriving the discrete flip threshold directly from the torque relationship above. (From Hodges 2026b, Figure B2.)

Magnetic angle: The magnetic angle is the orientation of a measurement axis relative to the defined up/down spin directions of entangled electrons. Magnetic torque on an electron increases as the measurement axis deviates from the spin direction. Each electron remains tethered to its nucleus, and entangled partners can be separated arbitrarily while preserving their correlation. In this framework, the magnetic angle determines the probability of a spin flip: at 0° the flip probability is 0% (certainty of no‑flip), and at 90° the flip and no‑flip outcomes are equally likely (50/50).

Pulse position: The pulse position denotes the rotating energy wave that circulates in opposing loops and remains phase‑locked with its entangled counterpart. Torque on the pulse rises as it approaches its crossover point. The pulse carries local variables that coordinate the relative states of paired atoms — analogous to synchronized atomic clocks on distant satellites. Measuring one particle reveals the partner's spin via this coordinated pulse information, interpreted here as coordinated (hidden) variables, with the specific dependency made precise in Section 10 below. Phase itself only records the resulting sign (spin + or −) after each flip; it does not determine whether a flip occurs.

Spin Flip Threshold: Spin-flip zones are defined by the ratios of competing torques between the external magnetic field and the cross-over loop. These thresholds match the percentage values of quantum probability calculations. The critical factor is the particle's angular position relative to the flip threshold. If that position lies within the flip zone, the electron spin will invert to its opposite state. Conversely, if it is within the "No-Flip" zone, it will maintain its current orientation.

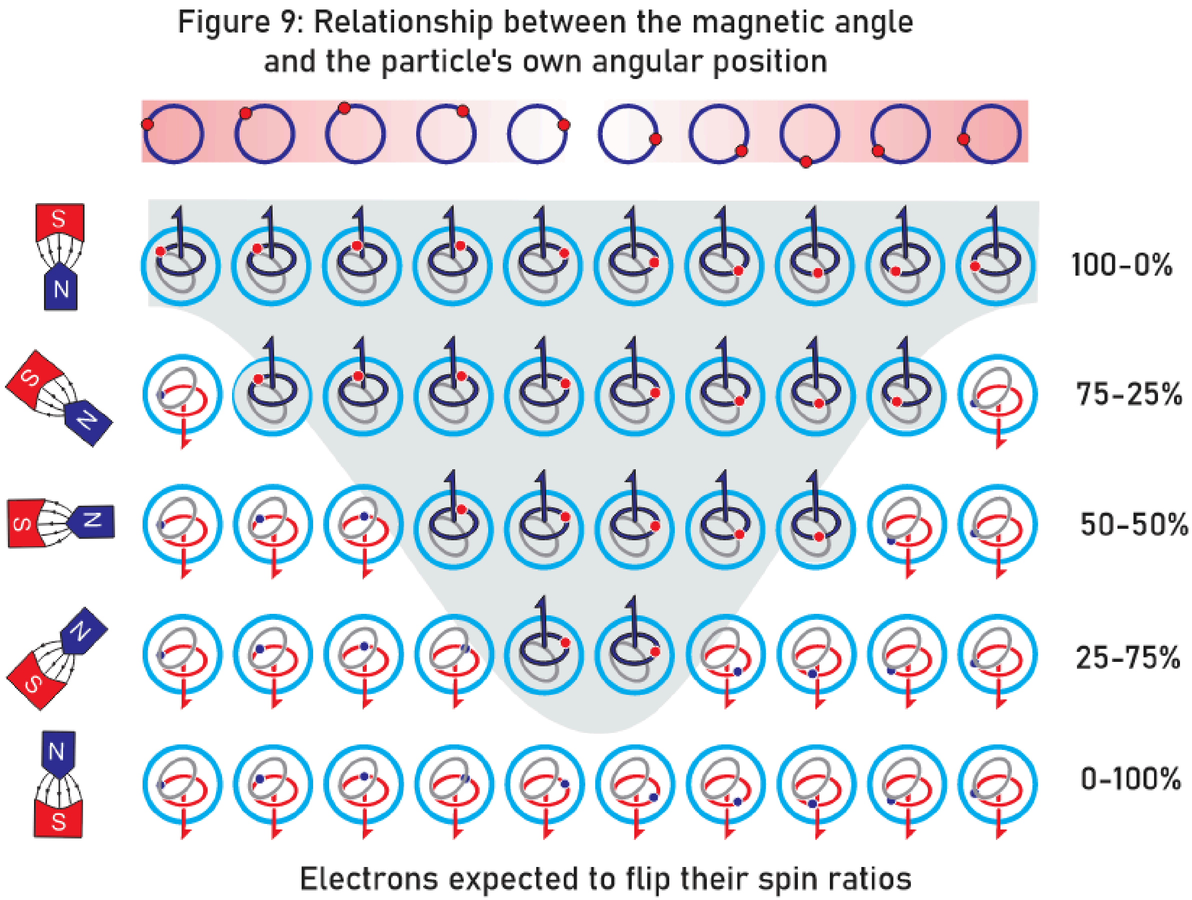


Figure 9. The relationship between the external magnetic angle and the particle's own angular position relative to the flip threshold.

10. Bell's Theorem Test

Testing Bell's theorem requires a comparison of theoretical predictions with empirical results. To date, the primary contenders in this realm have been predictions derived from quantum probability and the hidden variable theories proposed by Einstein and his collaborators. Classical hidden variable theories suggest a statistical likelihood of differing outcomes ranging from 55.6% to 100%. In contrast, quantum probability calculates that differing results will occur 50% of the time. Empirical testing involving a limited number of iterations often fails to yield conclusive results, as probability accuracy increases with the quantity of tests conducted.

With a high number of test iterations, these two frameworks have consistently shown that quantum probability predictions align more closely with experimental outcomes, particularly those approaching the 50% threshold. Figure 10 below presents an example from IBM's Qiskit, which employs qubits to measure real-world probabilities using a quantum computer, yielding a result of 0.4997333333333333, closely approximating the expected quantum probability. The accuracy of probability testing increases with the number of trials conducted, and advancements in quantum testing recently earned the Nobel Prize in 2022 for enhancing the outcomes of entangled state measurements. [12] Utilizing supercomputers to generate millions of test events significantly improves the statistical reliability of these outcomes. [13]

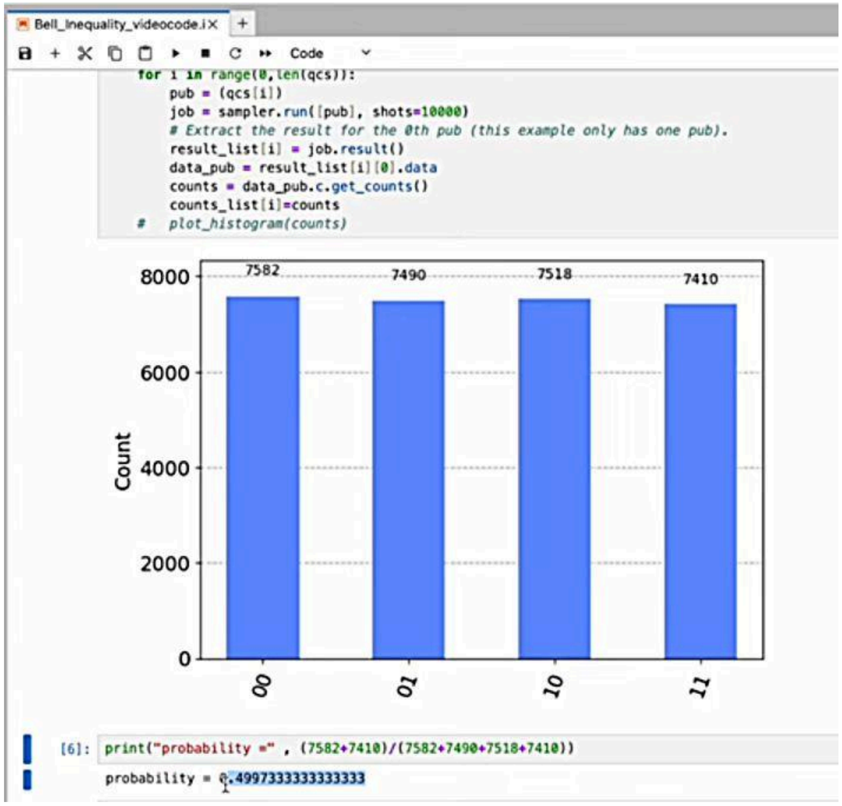


Figure 10. A screen grab of the Qiskit application running over 7000 entangled measurement tests to determine the probability results.

10.1 The Proximal Correlation Model: Locating the Shared-Value Step

Earlier drafts of this work illustrated, via a hand-worked ten-trial test, that phase-locked, synchronized pulse pairs can reproduce quantum-like correlation statistics that exceed the 55.6%–66% bound available to traditional (single-valued) hidden variable models. That illustration, however, left open exactly where, and in what minimal form, a shared dependency between the two particles is required.

This question is answered directly in the companion paper (Hodges 2026b, Section 6), through systematic computational testing of the full sequential-and-entangled mechanism described in Sections 8–9 above. The key finding is that the shared-value dependency required by the entangled case is not diffuse — it does not require either particle's process to reference the other's magnet setting in general — but locates to a single, minimal point: the generation of one shared pulse-orientation value, drawn from a distribution centered on the setting of exactly one of the two magnets. The other magnet's setting is never referenced during this generative step; it enters the calculation only afterward, in a threshold comparison of the kind described in Section 9, using only its own setting.

Concretely: of the two entangled particles, the one carrying the “opposite” spin label orients directly to its own magnet, using only its own setting. The second particle does not independently orient to any magnet — it inherits, or mirrors, the already-completed orientation of the first. Each magnet then reads this shared value using only its own setting. This is the specific, minimal event responsible for the correlation between distant measurement outcomes, and we term the resulting model a Proximal Correlation Model.

Two properties of this dependency are worth stating explicitly, both established numerically in the companion paper:

- It is not a matter of degree. Introducing even a small (as little as 2%) independent influence from the second magnet into the generative step measurably degrades the same-setting invariance the model otherwise satisfies exactly. The second magnet's setting must play no generative role whatsoever, not merely a small one.

- It requires no signal to travel between separated locations, at any speed, provided both measurement settings are established before the particles physically separate — the information required (the angle of the one generative magnet) is co-located with the particle pair at a single point in spacetime. This causal-consistency condition, and its scope, is discussed fully in Hodges (2026b), Section 6.2.

On this basis, the Proximal Correlation Model can be distinguished from three established categories in the hidden-variable literature (Hodges 2026b, Section 6.5): it requires no cosmological pre-correlation of the kind proposed by superdeterminism; no continuously-updating guiding field of the kind required by Bohmian mechanics; and, under the fixed-prior-to-separation assumption above, no backward-in-time influence of the kind proposed by retrocausal accounts. It is, instead, a single, identifiable physical event — the generation of one shared value from one magnet's setting, prior to separation — that we regard as this paper's central refinement of the "phase-locked pulse pair" account of entanglement introduced in Section 9.

The full derivation, the numerical verification of this step (including tests that rule out alternative, more diffuse forms of shared dependency), and the resulting CHSH statistic are given in Hodges (2026b), Sections 5.2–6.1.

10.2 Statistical Consistency with Bell-Type Tests

When evaluated under Bell-style statistical constraints, the LGAM mechanism described above reproduces probability distributions consistent with experimental observations. Computationally, the sequential single-particle mechanism reproduces the quantum mechanical transition probability $\cos^2(\theta/2)$ to within approximately 1.6 percentage points across the full 0°–180° separation range, and the entangled-pair extension reproduces the same correlation curve to within 2 percentage points, while satisfying same-setting invariance exactly (100.000% across all tested angles) and rotational consistency independent of absolute reference angle (Hodges 2026b, Sections 5.1–5.2).

Most significantly, the four correlation terms required for the CHSH combination (Clauser, Horne, Shimony, & Holt, 1969), computed at the conventional optimal test angles, yield $S \approx 2.817$, exceeding the classical bound of $|S| \leq 2.000$ — the maximum reachable by any model in which each particle's outcome depends only on its own local setting — and closing to within 0.4% of the quantum mechanical maximum of $2\sqrt{2} \approx 2.828$ (Hodges 2026b, Section 5.2). We emphasize, following the companion paper's Section 5.3, that curve-fit accuracy alone does not establish this dependency; the CHSH value, sensitive to the cross-dependency structure between independently-chosen settings, is the determining test, and it is the S value — not the curve fit — that establishes the entangled mechanism's status as a Proximal Correlation Model rather than a process in which each side's outcome depends only on its own setting.

The model, therefore, satisfies empirical limits while attributing observed randomness to the particle's angular position relative to the magnet at each measurement, rather than to intrinsic indeterminacy, and does so via the specific, minimal, and previously undescribed shared-value step identified in Section 10.1.

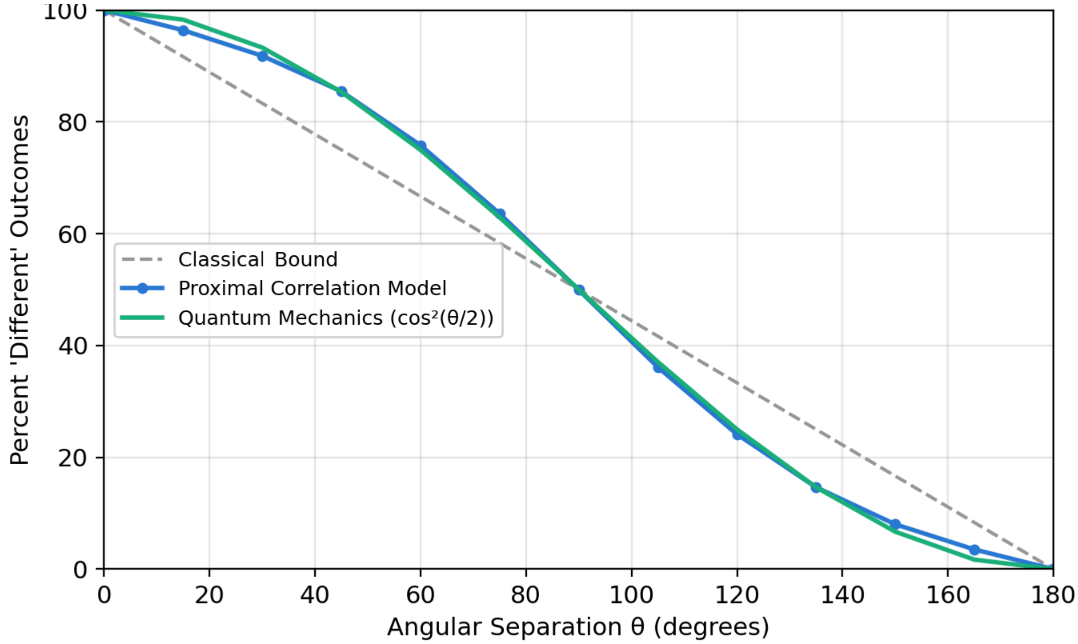


Figure 11. Model output (blue) closely tracks the quantum mechanical prediction (green) and diverges substantially from the classical linear bound (grey dashed) that any model with fully independent, per-particle inputs is restricted to. (From Hodges 2026b, Figure 1.)

11. Discussion

This framework supplants traditional intrinsic spin postulates with a mechanically grounded, field-mediated mechanism. Spin quantization is shown to arise from stable rotational path locking, while the resulting probabilistic outcomes are influenced by sensitivity to the particle's angular position relative to the magnet at the moment of interaction — a claim now derived, rather than assumed, via the torque relationship of Section 9.1.

The comparisons of entangled states reveal that synchronized hidden variables can yield results commensurate with those predicted by quantum probability. Furthermore, this approach supports the validity of Einstein's EPR paradox, suggesting that such hidden variables provide a plausible explanation for entanglement phenomena while preserving the deterministic nature of the underlying physical processes. The companion paper's identification of a single, minimal, and precisely located shared-value step (Section 10.1) sharpens this claim considerably: rather than a general appeal to "coordinated variables," the present framework now specifies exactly which variable is shared, when it is generated, and from which single measurement setting it draws — a level of precision we regard as a substantive advance over the qualitative account given in earlier drafts of this paper. This claim carries a stated boundary, however: it holds for measurement settings fixed before the particles separate. Whether this account survives when settings are chosen only afterward — the condition genuine delayed-choice experiments are designed to enforce — is addressed directly in the companion paper (Hodges 2026b, Section 6.2), and remains open for the photon-polarization systems such experiments actually use, a physically distinct case this paper does not address. Whether this shared-value step is best described as "local" or "non-local" is itself a matter on which the literature does not agree; we take no position on that terminology here and refer readers to the companion paper's direct discussion of both readings (Hodges 2026b, Section 6.6).

12. Conclusion

A nuclear-origin, torque-mediated mechanism for electron spin has been presented within the Liquid Gravity Atomic framework. The model offers a deterministic, observer-independent reinterpretation of the Stern–Gerlach experiment and provides a classical foundation compatible with observed quantum statistics. The torque relationship governing spin-state reversal, previously proposed on physical grounds alone, is shown in Section 9.1 to derive the discrete 90° flip threshold used throughout this work, rather than merely motivating it. The account of entanglement given here — coordinated, phase-locked pulse pairs — is refined in the companion paper (Hodges 2026b) into a Proximal Correlation Model: a specific, minimal, and previously undescribed shared-value step, distinguished from superdeterminism, Bohmian mechanics, and retrocausal accounts, and matching the CHSH inequality's magnitude to within 0.4% of the quantum mechanical maximum. Further experimental investigation — beginning with the tethered-versus-free-electron test proposed in Section 13 below — is invited to distinguish this model from standard quantum interpretations.

13. Testable Predictions Distinguishing the LGA Spin Model from Standard Quantum Mechanics and Other Hidden Variable Models

A defining requirement of any alternative physical model is the ability to generate experimentally testable predictions that differ from established theory. The Liquid Gravity Atomic (LGA) spin mechanism makes predictions that, if observed, would distinguish it from conventional quantum-mechanical interpretations.

13.1 Investigating Spin Transition Probabilities in Tethered vs. Free Electrons using Stern-Gerlach Apparatus

Objective: To investigate the spin transition probabilities of tethered electrons compared to free electrons, assessing how these probabilities are influenced by torque exchange with an external magnetic field. Previous attempts to conduct this experiment faced challenges due to the Lorentz force acting on charged particles in electromagnetic fields; advancements in modern techniques may allow for the cancellation of these effects.

LGA Prediction: Tethered electrons exhibit probabilistic results due to torque exchange, while free electrons solely respond to the external magnetic field without flipping spins, resulting in classical behavior.

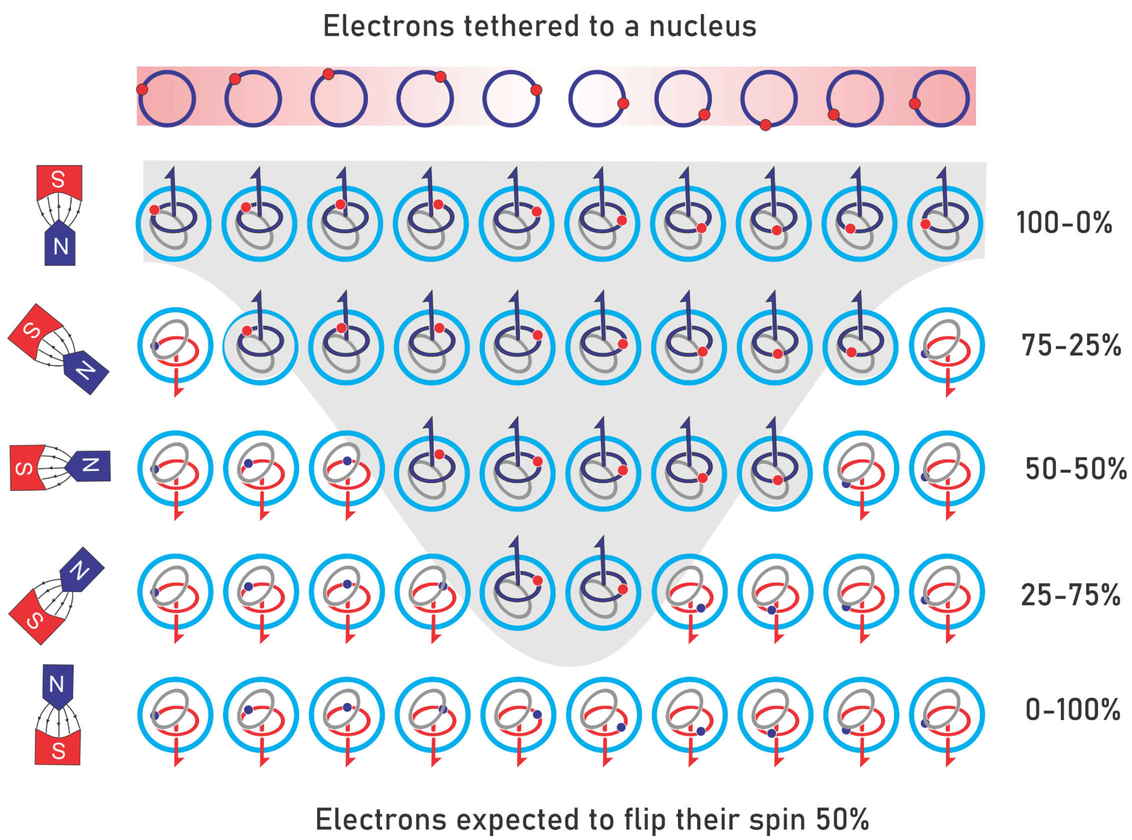


Figure 12. Expected LGA results of electrons tethered to a nucleus using the Stern-Gerlach Apparatus.

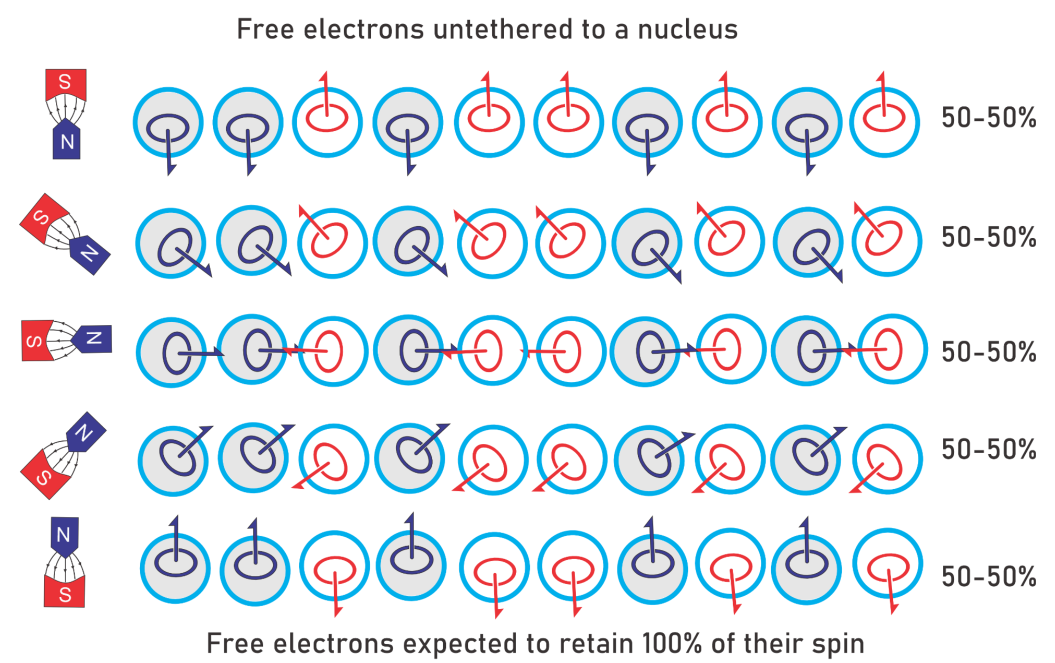


Figure 13. Expected LGA results of free electrons untethered to a nucleus using the Stern-Gerlach Apparatus.

QM Expectation: Both tethered and free electrons are predicted to yield uniform probabilistic results when subjected to the Stern-Gerlach apparatus, resulting in no observable difference in outcomes.

Experimental design: (1) prepare controlled tethered (e.g. silver, Ag47) and free (thermionic emission) electron sources; (2) configure a multi-stage Stern-Gerlach apparatus with adjustable magnetic field orientations, accounting for Lorentz-force effects; (3) implement a protocol to systematically rotate the magnetic field between measurement stages; (4) measure resultant spin states at each stage; (5) analyze transition-probability data for variation between tethered and free electrons; (6) repeat across many trials for statistical validation.

Conclusion: This study seeks to reconcile theoretical predictions with observable phenomena in quantum mechanics. The observation of any effect that transcends established quantum corrections could challenge the prevailing notion that spin is an intrinsic, observer-independent quantum property.

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Figure references

Figures 1–5, 7, 9, 12–13 and the three unlabeled diagrams in Section 4: Michael Hodges, Liquid Gravity Atomic Model, https://liquidgravity.nz/LGAM/

Figures 6, 8, 11: adapted from Hodges (2026b), Figures B4, B2, and 1 respectively.

Figure 10: Qiskit video, https://youtu.be/pS69lqCMdy8