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The Entropy Field Structure and the Recursive Collapse of the Electron: A Thermodynamic Foundation for Quantum Behavior

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Abstract

Conventional quantum mechanics treats the electron as a point-like particle endowed with intrinsic properties—mass, charge, and spin—that are inserted as axioms rather than derived from first principles. Here, we propose a thermodynamic reformulation of the electron grounded in entropy field dynamics, based on S-Theory. In this framework, the electron is composed of three distinct entropic components: S_{core} (a collapsed entropy core from configurational mass), S_{EM} (a structured electromagnetic entropy field from charge), and $S_{thermal}$ (a diffuse entropy component from ambient interactions). We show that spin emerges as a rotating S_{EM} shell around S_{core}, and that electron collapse—as in quantum measurement—can be modeled as a *Recursive Amplification of Sfield* (RAS) process driven by entropic feedback. Through mathematical formulation and high-resolution simulations, we demonstrate how the S-field components evolve under entropic excitation, culminating in a collapse threshold defined by local entropy density matching. This model not only explains the emergence of quantum properties but also offers a thermodynamic mechanism for electron–photon interaction, wavefunction collapse, and spin generation, revealing the inner structure and dynamics of one of nature's most fundamental particles.

Keywords: S-Theory; unified entropy collapse principle; quantum structure; entropy geometry; quantum information; recursive amplification of S-fields; recursive collapse of entropy fields; measurement problem; entropy field dynamics

1. Introduction: The Electron Beyond the Particle

1.1. Statement of Significance

An electron is one of the cornerstones of modern physics, yet its internal structure remains undefined in both classical and quantum theories. Existing frameworks assign mass, charge, and spin as axiomatic properties without offering a unifying explanation. This work presents a new thermodynamic and entropic model of the electron, proposing that these properties emerge from recursive dynamics of an entropy field. By simulating the evolution and collapse of entropy fields, we derive the electron's spatial profile, explain the origin of spin as a rotating entropy shell, and define a measurable collapse threshold. This perspective bridges statistical physics and quantum measurement, offering a unified and physically intuitive model of the electron. It represents a major step toward reconciling field theory, thermodynamics, and quantum behavior under a common entropic principle.

In modern quantum mechanics, the electron is described as a point-like particle: a fundamental entity with no spatial extent, yet endowed with intrinsic properties such as mass, electric charge, and spin. These properties are not derived from internal structure or dynamical processes but are instead introduced axiomatically into formalism [1]. While

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this approach has been extraordinarily successful in predicting experimental outcomes, it leaves open fundamental interpretive questions concerning the physical nature of the electron itself. Within nonrelativistic quantum mechanics, the electron is represented by a complex wavefunction whose modulus squared yields a probability density [2]. This description captures wave–particle duality and interference phenomena with remarkable accuracy, yet the wavefunction is not generally regarded as a physical field in real space. The process by which a delocalized wavefunction yields a localized detection event—the so-called wavefunction collapse—is introduced as a postulate rather than derived from underlying dynamics [3]. Relativistic quantum field theory further refines the description by treating the electron as an excitation of a Dirac field, from which spin and magnetic moment emerge algebraically [4]. Nevertheless, even within this framework, the electron remains point-like, with absent internal structure, and the divergences associated with self-interaction are handled through renormalization rather than physical modeling [5].

Motivated by these conceptual gaps, various alternative approaches have explored extended or structured descriptions of the electron, including zitterbewegung-based interpretations [6], soliton-like field models, and pilot-wave formulations [7]. These efforts aim to provide greater physical intuition for intrinsic properties such as spin and localization, yet they generally remain disconnected from thermodynamic or entropy-based considerations. Despite these diverse formulations, a common feature persists: the electron is assigned fixed observable properties without an explicit account of how such properties arise from internal organization or interaction with the surrounding vacuum. This raises a natural question: what is an electron in the absence of observation—left alone in a vacuum—governed only by its interaction with the electromagnetic and quantum vacuum fields? Even in such conditions, the electron manifests mass, radiates an electric field, interacts magnetically, and exhibits spin. These persistent, spatially distributed effects suggest the presence of an underlying field structure or internal entropy dynamics rather than a structureless point entity.

In this work, we propose a thermodynamic and real-space reinterpretation of the electron grounded in S-Theory [8,9], a unified framework in which physical properties emerge from the organization and evolution of entropy fields. The electron is modeled not as a point particle but as a localized, structured entropy field composed of three interacting components: a collapsed core entropy (S_{core}) associated with rest mass, (configurational), a structured electromagnetic entropy field (S_{EM}) associated with charge and spin, and a diffuse thermal entropy component ($S_{thermal}$). Through recursive amplification of these entropy fields and their interaction with external perturbations, observable electron properties—including spin generation and measurement-induced localization—arise dynamically. The goal of this work is not to modify the formal equations of quantum mechanics, but to provide a complementary thermodynamic interpretation that connects electron structure, electromagnetic behavior, and measurement phenomena within a single entropy-based framework.

1.2. Generalized Definition of Entropy in S-Theory

S-Theory begins with a primordial entropic background, S_∞: an unbounded, unstructured field composed of an infinite number of entropic quanta, the fundamental microscopic elements of the theory, as indicated in Figure 1. For mathematical convenience, individual entropic quanta are treated as elements of a complex potential field, whose real and imaginary components capture correlated and uncorrelated contributions. This allows wave-like interference and geometry to emerge from recursion, without postulating a separate quantum wavefunction. In S_∞, these quanta fluctuate freely without correlation or geometry, representing maximal entropy. Physical structure arises when subsets of

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these quanta become correlated, giving rise to three distinct correlation classes: (i) $S_{thermal}$, minimally correlated entropic quanta that generate thermal and background fluctuations; (ii) S_{EM}, highly correlated entropic quanta that organize into electromagnetic-like field structures; and (iii) S_{core}, maximally correlated entropic quanta that form stable, localized cores associated with mass. Energy and mass are not primitive; they emerge from these different correlation states. S_{EM} corresponds to organized field energy, S_{core} to localized mass structures, while $S_{thermal}$ represents background heat and noise. We define the local entropy at position **r** by counting the number of possible microscopic arrangements of entropic quanta within a finite local cell, subject to their correlation structure and boundary geometry. For 2D approximation,

$$S\,(\boldsymbol{r}) = k_B \Delta A^{-1} ln \Omega_s(\boldsymbol{r}) [\mathrm{JK}^{-1} fm^{-2}] \quad (1)$$

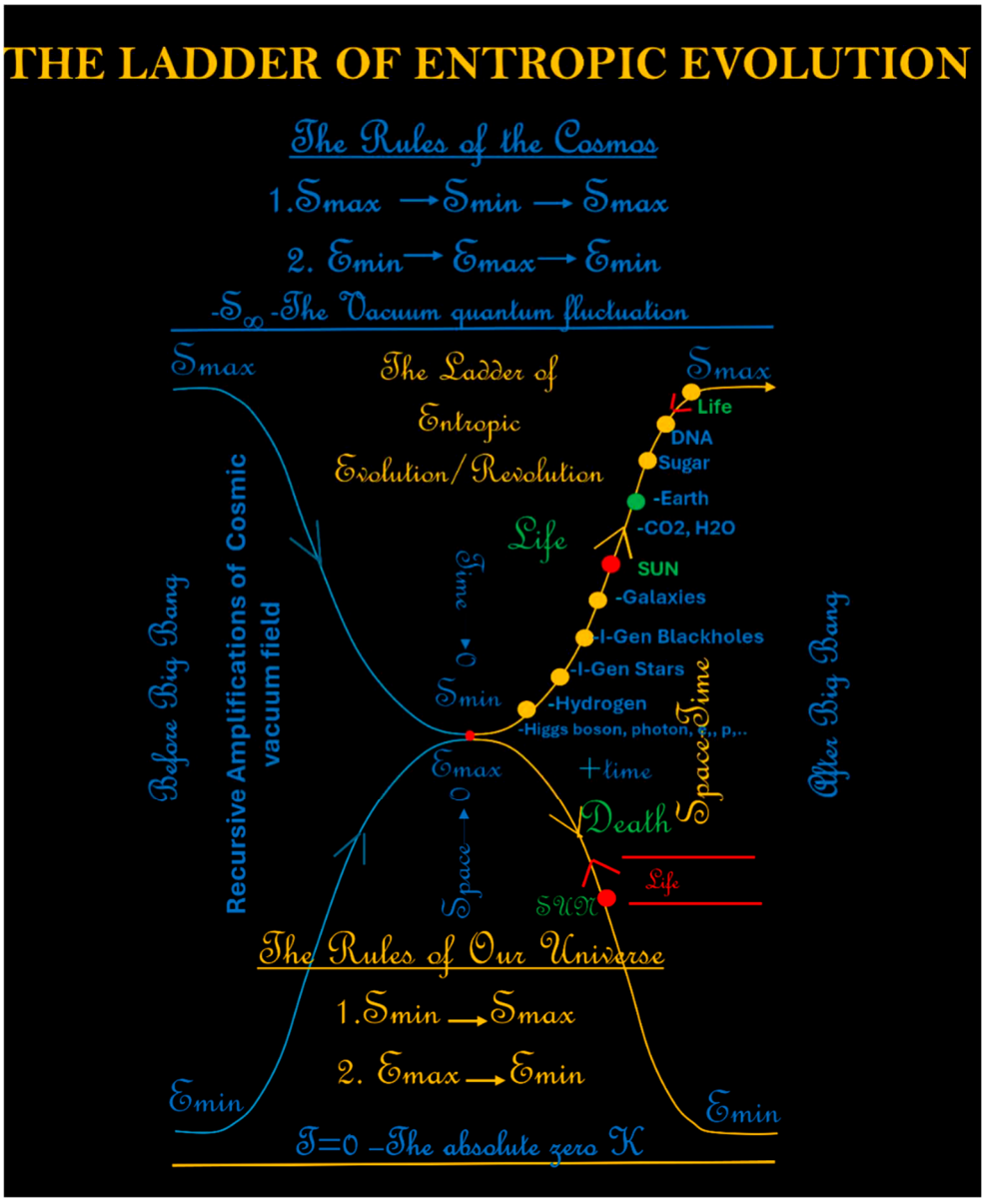


Figure 1. Conceptual schematic illustrating the hierarchical organization of entropy fields in S-Theory, from cosmological-scale vacuum entropy to localized particle-scale entropy structures. The ladder of entropic evolution/collapse.

Here, $\Omega_S(\boldsymbol{r})$ is the total number of distinguishable micro configurations of entropic quanta, decomposed into three contributions given by

$$\Omega_S(\boldsymbol{r}) = \Omega_{thermal}(\boldsymbol{r}) + \Omega_{S_{EM}}(\boldsymbol{r}) + \Omega_{Score}(\boldsymbol{r}) \quad (2)$$

corresponding to $S_{thermal}$, S_{EM}, and S_{core}, respectively.

- $\boldsymbol{\Omega}_{thermal}(\boldsymbol{r})$ counts micro configurations of entropic quanta that produce macroscopic thermal energy through random, minimally correlated arrangements.
- $\boldsymbol{\Omega}_{S_{EM}}(\boldsymbol{r})$ counts field-structured micro configurations of entropic quanta arising from correlations linked to electric charges and magnetic field organization.
- $\boldsymbol{\Omega}_{Score}(\boldsymbol{r})$ counts mass-forming micro configurations of entropic quanta, representing maximally correlated clusters that behave as stable cores.

At each location $\boldsymbol{r}$, the total S-field arises from counts of correlated and uncorrelated entropic quanta. The resulting field structure—composed of S_{core}, S_{EM}, and $S_{thermal}$—is the macroscopic manifestation of these local correlations. In regions dominated by $S_{thermal}$, the definition reduces to the classical Boltzmann form. In structured regions, correlated quanta (S_{EM} and S_{core}) reduce the number of accessible micro configurations, giving rise to organized energy fields and mass. This generalized entropy definition serves as the foundational expression for all subsequent derivations in S-Theory, unifying thermal entropy, electromagnetic field structure, and mass within a single entropic counting framework that encompasses both structured and unstructured components of physical reality.

This generalized definition does more than extend Boltzmann's counting: it introduces geometry as an intrinsic outcome of entropy correlations. In classical statistical mechanics, entropy quantifies the number of microstates consistent with a given macroscopic energy, but it carries no information about spatial form. However, in S-Theory, the correlated entropic quanta (S_{EM} and S_{core}) not only reduce accessible micro configurations but also organize them in space, producing stable geometric patterns. These correlated fields act as sculptors of structure: S_{core} defines localized cores, while S_{EM} defines coherent surrounding fields, together giving rise to shapes such as atomic orbitals [9], molecular structures, and eventually large-scale cosmic forms. In this way, geometry itself is an entropic construct, emerging directly from the distribution and correlation of entropic quanta, not imposed by external equations. This shift—from entropy as a scalar descriptor to entropy as a shaper of structure—is the central conceptual advance of S-Theory. In the present work, "entropic quanta" do not represent physical particles or elementary excitations analogous to quanta of a fundamental field. Rather, they serve as conceptual units used to quantify local configurational freedom and correlation, similar to microstate counting in statistical mechanics or information-theoretic entropy.

1.3. Scope and Interpretation of the Entropy Field

The entropy field introduced in this work is not intended to constitute a new fundamental quantum field theory with independent quanta, symmetry groups, or a governing Lagrangian. Rather, it represents a phenomenological, coarse-grained description of correlated and uncorrelated entropy components within the electron, motivated by principles of nonequilibrium thermodynamics and information theory [10,11]. In this sense, the entropy field plays a role analogous to effective fields used in statistical physics, hydrodynamic formulations of quantum mechanics [12], and information-theoretic approaches to physical systems [11]. The decomposition into collapsed entropy (S_{core}), structured electromagnetic entropy (S_{EM}), and diffuse entropy ($S_{thermal}$) is introduced as a minimal modeling framework to capture localization, spin, and interaction phenomena that are otherwise treated axiomatically in conventional quantum descriptions. The present work

does not aim to replace quantum electrodynamics or quantum field theory, which remain empirically successful at describing particle interactions. Instead, it seeks to provide a thermodynamic and configurational interpretation of electron properties and collapse dynamics that complement existing formalisms and clarify their physical underpinnings.

Because the entropy field is introduced as a phenomenological descriptor rather than a fundamental dynamical field, it is not associated with an independent Lagrangian density, gauge symmetry, or Lorentz-covariant field equation. All relativistic and quantum consistency is inherited from the underlying physical fields whose configurational structure the entropy field represents.

To generate orbital fields in 2D, we work with the dimensionless capacity field:

$$s\left(\boldsymbol{r}\right) = S\left(\boldsymbol{r}\right)/S_0 \quad \in [0,\ 1]$$

where S_0 is a fixed ground-state reference (peak of the total entropy density). Intuitively, the fraction of non-dimensional entropic density $s \approx 1$ marks locations with many compatible micro-configurations available under the same mesoscopic constraints (high local accessibility), while $s \approx 0$ marks nodes (strong constraints). Environmental influence is encoded by a driver $s_c(\boldsymbol{r})$ that specifies *where* capacity can be unlocked. The state update is the local, pointwise map given by the recursive fractal equation,

$$s_{n+1}\left(\boldsymbol{r}\right) = s_n\left(\boldsymbol{r}\right)^2 + s_c\left(\boldsymbol{r}\right) \tag{3}$$

interpreted as a constrained maximum-entropy relaxation toward the next S-max pattern. Here, $s_n = S/S_0$ is the non-dimensional entropy density field $s \in$ [0,1] at iteration n (initialized, e.g., with a *1s*-like ground-state profile), s_c is a non-dimensional source term representing entropy input from the surrounding fields (constructed from the *Sthermal* and/or S_{EM} components), and s_{n+1} is the updated field; under iteration, the map approaches a high-entropy configuration s_{max}. The superlinear self-term s^2 captures cooperative, contrast-enhancing growth—peaks tend to sustain, nodes persist—so that, together with a rim-localized s_c, the evolution is edge-driven (consistent with the annular area scaling $A \propto R^2$) rather than a global smear. Thus, the recursive Equation (3) is essentially a phenomenological constrained-entropy ascent toward the next S_{max} macrostate.

Here, *Score* derives from the electron's mass (configurational) and acts as a gravitational anchor. S_{EM} forms a dynamic, spatially distributed shell—a Gaussian-like field whose amplitude and extent correspond to the observed electric charge. $S_{thermal}$ surrounds and perturbs this system, carrying uncorrelated entropy from the quantum environment. Critically, we propose that measurement is a physical collapse—not a mystical boundary, but a thermodynamic threshold. When an external energy input (e.g., a photon) amplifies the S_{EM} and $S_{thermal}$ components recursively (through a process we call Recursive Amplification of S-field, or RAS), the system saturates. The S_{EM} field compresses and aligns with the S_{core} core, yielding a collapse that produces definite quantities: charge, spin, and position. In this view, quantum measurement is not arbitrary, but a structural transformation governed by entropy field thresholds.

This model offers several breakthroughs: (i) charge emerges from the saturated integral of the S_{EM} field; (ii) spin arises from the rotational geometry of the compressing S_{EM} shell; (iii) collapse becomes a predictable entropy field transition, not an undefined probabilistic jump; and (iv) entanglement may arise via field correlations between overlapping S_{core} fields across space. This work builds on our companion paper on hydrogen orbital formation [9] and extends it by simulating the collapse process of a single free electron through successive RAS steps. The resulting predictions align with known physical constants and give physical meaning to abstract quantum attributes. We argue that quantum

properties are not fundamental mysteries, but emergent thermodynamic consequences of entropy field dynamics. By grounding the electron in entropic structure, this work bridges statistical physics, thermodynamics, and quantum field behavior, offering a new path toward a unified physical understanding.

To understand the electron not as a mysterious point particle but as a structured thermodynamic entity, we must first reframe our foundational assumptions. Instead of treating properties like charge and spin as primitive constants, we propose that they emerge from the underlying structure and dynamics of entropy fields. This requires a new framework—one that places entropy, not energy, at the root of physical reality. In the following section, we summarize the core tenets of S-Theory, the entropic field model that underpins this work and sets the stage for constructing a realistic, collapse-capable electron.

2. S-Theory as a Physical Expansion of Quantum Mechanics

A Brief Overview of S-Theory and Recursive Entropic Evolution

The development of S-Theory arose from a profound reflection on the limitations and open questions that still haunt modern physics. Quantum mechanics, despite its predictive success, leaves us with unsolved paradoxes—wavefunction collapse, quantum entanglement, and the emergence of classical reality from probabilistic fields. General relativity, though geometrically elegant, fails to incorporate thermodynamics or explain biological structure, information flow, or the arrow of time. The search for a unified theory has often resorted to increasingly abstract mathematical frameworks—such as string theory, loop quantum gravity, and multiverse models—without resolving how complexity, replication, and consciousness emerge in a real, evolving universe. We propose that the missing piece is not a new dimension or force but a reversal of the foundational assumption itself.

Instead of taking energy as the primary quantity, S-Theory begins with entropy: the tendency toward disorder, but also the hidden architecture behind structure, evolution, and intelligence. Our observable universe is energetic, but underlying entropy fields guide every transformation, every structure, and every collapse. In this view, energy is structured entropy, space is the geometry of entropy correlation, and time is recursive entropic feedback (S_{max}-S_{min}-S_{max} cycle). S-Theory introduces three primary components: (i) S_{EM} (structured entropy of electromagnetic fields); (ii) S_{core} (frozen, memory-like entropy bound in particles or matter; a conserved structural core); and (iii) $S_{thermal}$ (residual, unstructured entropy that manifests as heat, noise, or decoherence; the chaotic background). Together, these form the entropic trinity of physical reality. The recursive evolution of these entropy fields is governed by a simple, elegant, fractal-like equation (Equation (3)).

This simple yet powerful formulation models the emergence of structure, replication, and collapse across scales [9]. This entropic evolution logic is visually captured in the core recursive framework of S-Theory: the S-Ladder—a dynamic trajectory of entropy field evolution across all scales, as shown in Figure 1. It begins from S_∞, the infinite, unmeasured, uncorrelated entropy quanta of the quantum vacuum, where energy and structure do not yet exist. A localized recursive collapse initiates a descent to (S_{max}/E_{min})—a saturated quantum coherence state with minimal correlation—followed by an expansion into (S_{min}/E_{max}) with maximum correlation, which in turn undergoes spontaneous symmetry breaking and recursive partitioning back to (S_{max}/E_{min}), as represented in Figure 1. Life, replication, complexity, and consciousness of OUR universe all emerge from this return journey: an entropic climb from (S_{min}/E_{max}) back toward (S_{max}/E_{min}) and eventually merging again into the cosmic reservoir S_∞.

These two forward paths of Entropy S and Energy E are bounded by S_∞ (the entropy field of the vacuum) and $T = 0$ (absolute zero, the energetic floor of the universe). In this diagram (Figure 1), the left descent shows the universe's thermodynamic fall, from cosmic entropy collapse to the 'Big Bang' that leads to the formation of matter and stars. The right ascent reflects the emergence of organized complexity: stars, Earth, molecules, and eventually life. In the solar system, crucially, the Sun (represented as a red dot in Figure 1) plays a pivotal role: by injecting energy (E_{sun}) into Earth, it reverses the E_{min}-path back toward E_{max}, triggering a corresponding inevitable reversal in the S-path (red arrow in the figure). This reversal from S_{max} towards S_{min} within living systems is what Erwin Schrödinger [13] referred to as "negative entropy"—a local entropy contraction against the cosmic flow, enabled by solar input and recursive feedback mechanisms. This is not accidental, but an inevitable thermodynamic symmetry of a universal entropic cycle [14,15]. In this view, life is not a statistical anomaly but a *required resolution in the larger recursive equation*: a pathway from disorder back to structure via memory fields, $S_{thermal}$ fluctuations, and S_{max} convergence. This is the *Ladder of Entropic Evolution—not climbing out of chaos but recursively spiraling back toward* S_∞ *through order*—and it unifies quantum events, biological replication, and gravitational collapse under one thermodynamic cycle [8].

S-Theory refers to a phenomenological entropy-based framework used to model correlated and uncorrelated configurational degrees of freedom within an electron. It is not proposed as a new fundamental theory with independent dynamical laws, but as an interpretive layer that complements established quantum and relativistic formalisms [16,17] by introducing thermodynamic and information-theoretic structure [18–20]. Also, unless otherwise stated, the equations introduced in this work represent phenomenological modeling relations rather than first-principles derivations. Where established results from statistical mechanics, information theory, or quantum mechanics are used, appropriate references are provided. From a nonequilibrium thermodynamics perspective, the existence of entropy production and exchange flows necessitates spatial extent; the entropy-field representation adopted here provides a natural way to apply these principles at the particle level [21–23]. In this work, the entropy-field components are defined in a quasi-equilibrium sense as steady-state distributions corresponding to a dynamically balanced electron–EM-vacuum system; explicit entropy-production and flow equations are deferred to future work.

3. Generating the Entropy Field Model of an Electron

In S-Theory, the electron's mass is not treated as a scalar quantity or a point object, but rather as a structured entropy field—a localized distribution of entropy density, centered at the origin and falling off radially. This core field is denoted $S_{core}(r)$ and represents the internal collapsed identity of the electron arising from the configuration of its rest mass. By "structured entropy," we refer specifically to configurational (information) entropy under constraints, i.e., entropy associated with correlated degrees of freedom whose accessible microstates are restricted by localization, symmetry, or interaction. In this sense, correlation reduces the total number of accessible microstates while simultaneously enabling a stable structure. For an electron, the minimal quantum configurational entropy associated with a spin-½ particle is $\Omega = 2$ macrostates corresponding to spin degeneracy.

3.1. Mathematical Formulation of S_{core} from Electron Mass

(i) The S_{core} Field: Entropy Core of the Electron

We define the core entropy field of the electron, denoted as $S_{core}(r)$, to represent the structured entropy arising from the configuration of the electron's rest mass.

$$S_{core}(\boldsymbol{r}) = A_{m.}e^{-r^2/(2\sigma_m{}^2)} \tag{4}$$

where A_m is the normalization constant for entropy density (not mass), σ_m is the characteristic width of the S_{core} field.

(ii) From configurational Mass to Entropy: Core Logic

According to S-Theory, mass is structured entropy. Following Einstein,

$$E = m_e c^2 \text{ and } S = E/T \Rightarrow S = m_e c^2/T \tag{5}$$

where T is an effective entropic temperature—a measure of entropy freedom (low for stable mass). This structured entropy is not spread across all space but localized into a dense core: the S_{core} field, which stores the "collapsed identity" of the electron. This entropy is highly localized, meaning the field must peak sharply and decay rapidly, consistent with a Gaussian profile. The spatial width σ_m is not arbitrary. It is chosen based on the *Compton wavelength* λ_C of the electron:

$$\sigma_m = \lambda_C = \hbar/m_e c \approx 3.86 \times 10^{-13} \text{ m} \tag{6}$$

This defines the natural localization radius of the electron's core entropy. This corresponds to the natural quantum length scale over which the electron's wavefunction—or here, entropy field—is confined. The Gaussian form introduced in Equation (4) represents the spatial distribution of the electron's collapsed configurational entropy. The total entropy content of the S_{core} field is fixed independently by the electron's rest mass and is discussed in Equation (7). Accordingly, the Gaussian profile does not generate electron mass through spatial integration but rather distributes a predefined entropy budget in space. The spatial form of the entropy-density fields is chosen using the maximum-entropy principle. For a localized system with fixed total entropy and finite second moment, the entropy-maximizing distribution is Gaussian. Accordingly, the S_{core}, S_{EM}, and $S_{thermal}$ fields are represented using Gaussian envelopes, which reflect the most unbiased spatial localization of correlated entropy consistent with the imposed constraints. This choice is not unique but provides a natural and analytically transparent baseline.

(iii) Normalization of S_{core} Field

We now normalize S_{core} such that its total integrated entropy corresponds to $Se = k_B \, ln \, 2$, representing *one bit* of fundamental entropy—the minimal quantum configurational entropy associated with a spin-½ particle ($\Omega = 2$ macrostates corresponding to spin degeneracy). That is,

$$\int S_{core}(r) dA = S_e \sim k_B ln 2 \tag{7}$$

Here, $\Omega = 2$ refers to the experimentally observed spin degeneracy of the electron (spin-up and spin-down) and represents a minimum identity entropy (macroscopic). It does not imply that the internal entropy field possesses only two microscopic configurations, which may be numerous or continuous. The distinction between microscopic configurational entropy and observable degeneracy (macroscopic) is essential: the former characterizes the internal entropy field structure, while the latter anchors particle identity and measurement outcomes.

In polar coordinates,

$$\int_0^\infty 2\pi r. \; A_m e^{-r^2/(2\sigma_m^2)} \, dr = S_e \tag{8}$$

This evaluates to

$$A_m = \frac{S_e}{2\pi\sigma_m^2} \tag{9}$$

Using

$$k_B ln2 \approx 9.57 \times 10^{-24}\,\mathrm{J/K}$$

$$\sigma_m = \lambda_C = 3.86 \times 10^{-13}\ \mathrm{m}$$

we obtain

$$A_m \approx 9.57 \times 10^{-24}/2\pi\,(3.86 \times 10^{-13})^2 \approx 1.02 \times 10^{2}\,\mathrm{J/K} \quad (10)$$

(iv) Physical Interpretation and justification

This construction yields the $S_{core}(r)$ field as a sharply peaked entropy density centered at the origin and localized at the Compton scale. Its integral gives one bit of structured entropy, meaning that (i) mass becomes a localized entropy configuration, not a constant, (ii) the field is sharply confined (~10^{-13} m), representing the collapsed identity of the electron, and (iii) entropy is quantized in discrete bits, even for elementary particles.

This approach reinterprets mass as frozen, structured entropy, embedded in space via a measurable field distribution. This field represents the irreducible structured identity of the electron—the entropy signature associated with its mass. As shown in Figure 2 (red color field), this field sharply peaks at the center and decays radially. Now we have *a* S_{core} that is clearly defined as an entropy field, not a mass density. σ_m is set by Compton wavelength, not arbitrary. Normalization yields a physical entropy unit (e.g., one bit, or $k_B$ln2). This S_{core} represents a normalized Gaussian entropy density, centered at the origin, which defines the electron's collapsed mass configuration. The field integrates to $k_B ln2$ and is localized at the Compton scale (~10^{-13} m), establishing mass as a structured entropy phenomenon in the S-Theory framework.

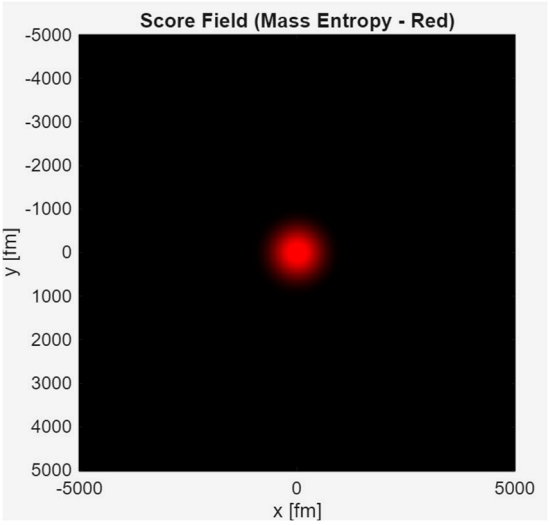


Figure 2. Score Field distribution: entropic core of the electron derived using Equation (4).

(v) Why ln 2? The Identity Bit of the Electron

In S-Theory, every stable quantum system must possess a minimal entropy signature anchoring its individuality. For the electron, with spin-½ and Ω = 2 macrostates corresponding to spin degeneracy states,

$$S = k_B\ ln\ \Omega = k_B\ ln\ 2 = 0.693\ k_B \quad (11)$$

This is not thermal entropy but ontological entropy—a measure of how many *internal* configurations a collapsed system can realize. This idea, consistent with quantum information theory, provides a deep bridge between thermodynamics and identity: the S_{core} field encodes the electron's "*one bit of being*." This assignment does not imply thermal

entropy in the conventional sense, but instead defines a minimum ontological entropy associated with the electron's existence as a distinct, indivisible fermion. In the context of S-Theory, this unit entropy anchors the S_{core} field, allowing us to treat the electron's mass as a localized, structured entropy field normalized to a fundamental quantum of identity. This normalization not only aligns with Boltzmann entropy and quantum spin logic but also provides a consistent base for comparing and interpreting the electron's associated fields, including the spread entropy of charge (Section 3.2) and the dynamic thermal field during interaction (Section 3.3). In dimensionless units (e.g., setting $k_B = 1$ in natural units), this is

$$\int S_{core}(r)dA = ln2 = 0.693 \sim 1\ bit \tag{12}$$

Thus, the electron's mass is reinterpreted as a field that contains exactly one bit of structured entropy—distributed in space such that its S_{core} field integrates to $ln2$. In practice, some literature (especially in quantum information theory) approximates one bit entropy as "2" when expressed as Ω (number of microstates), which gives $S = \ln\Omega = \ln 2 \Rightarrow \Omega = 2$. So, we are not integrating to a value of "2" directly, but rather to $k_B \ln 2$ in SI units, or one bit in information units, or 0.693 in pure math units. We present the mass of the electron as an entropy field (S_{core}), peaked at the center, whose total integral is $k_B ln2$, representing one bit of structured entropy associated with the collapsed electron identity. It should be emphasized that the entropy-field formalism developed here does not rely on a direct enumeration of spin microstates; the reference to two spin macrostates reflects observable degeneracy and does not alter the construction of the S_{core}, S_{EM}, or $S_{thermal}$ fields.

3.2. Mathematical Formulation of S_{EM} from Charge

The S_{EM} field represents the distributed electromagnetic entropy associated with the electron's electric charge. Unlike the S_{core} field, which is sharply localized due to mass, the S_{EM} field is spatially broader and reflects the outward entropy radiation of charge. We model it using a radially symmetric Gaussian:

$$S_{EM}(\boldsymbol{r}) = A_q . e^{-r^2/(2\sigma_q{}^2)} \tag{13}$$

where A_q is the normalization constant linked to electromagnetic entropy density, σ_q is the characteristic spread of the field (typically $\sigma_q > \sigma_m$).

(i) From Charge to Entropy: The S-Theory Logic

In classical electrodynamics, an electric charge creates a radial Coulomb field that stores *energy*. In S-Theory, energy is interpreted as structured entropy:

$$E = S.T \rightarrow S = \frac{E}{T} \tag{14}$$

Thus, the Coulomb field around the electron gives rise to a corresponding spread entropy field, S_{EM}, which encodes the spatial distribution of electromagnetic potential in thermodynamic terms. Rather than normalizing this field to the charge magnitude $|q_e|$, we normalize it to a meaningful entropy quantity. To ensure consistency with the S_{core} field (Section 1), we define the total entropy in the S_{EM} field as

$$\int S_{EM}(r)dA = S_{EM}^{total} = \gamma . k_B ln2 \tag{15}$$

Here, γ is a dimensionless scaling factor reflecting the broader spatial influence of charge compared to mass. Typically, $\gamma > 1$.

(ii) Choice of Spread Width σ_q

The spatial spread of the S_{EM} field is selected to reflect the more diffuse nature of electromagnetic fields. Rather than using the classical electron radius, we define

$$\sigma_q = \eta . \lambda_c \tag{16}$$

where

$$\lambda_c = \frac{h}{m_e c} \sim 3.86 \times 10^{-13}\text{m} \tag{17}$$

λ_C is the Compton wavelength, and η is a scaling factor. Choosing η = 4, we obtain

$$\sigma_q = 4 \cdot \lambda_C \approx 1.54 \times 10^{-12}\ \text{m}$$

This ensures that the S_{EM} field is smoother and more extended than the S_{core} field, in accordance with observed electromagnetic behavior.

(iii) Normalization Constant

Given the Gaussian form of the S_{EM} field, the entropy normalization gives

$$A_q = \frac{\gamma . k_B ln2}{2\pi\sigma_q^2} \tag{18}$$

For example, with γ = 3 and the above value of σ_q, we obtain

$$A_q = \frac{3\ .\ k_B ln2}{2\pi(1.54 \times 10^{-12})^2} = 1.4 \times 10^1\ J/K \tag{19}$$

This yields a broad entropy field that smoothly decays with distance and contributes significantly to the total entropy structure of the electron, as shown in Figure 3.

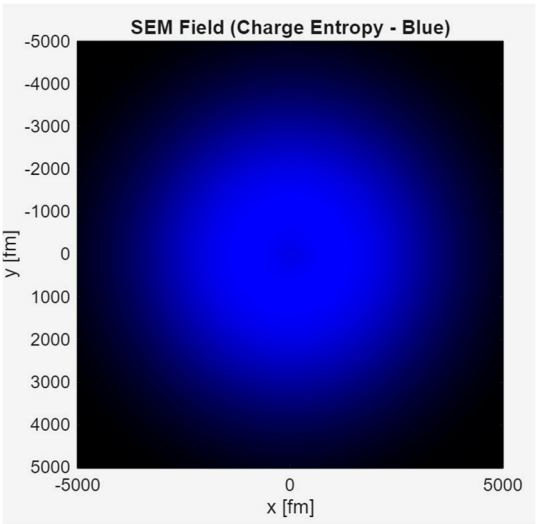


Figure 3. S_{EM} Entropic EM field distribution of the electron.

(iv) Estimation of Microstates of S_{EM}: Comparison to S_{core}

In the previous Section 3.2, we derived

$$S_{core} = k_B\ ln\Omega = k_B ln2 \approx 0.693\, k_B \tag{20}$$

This corresponds to one bit and reflects collapsed identity (a binary quantum choice: spin-up/down, particle/antiparticle, etc.). What should S_{EM} represent? The S_{EM} field is (i) spread out, not collapsed; (ii) it is derived from electromagnetic field energy; (iii) the

field is not a binary state, but a continuum of influence, so it shouldn't be just "one bit" like S_{core}. It should encode more entropy—a distributed informational cloud, not a defined choice.

When we set $\gamma = 3$, we are saying

$$S_{EM}^{total} = \gamma . S_{core} = 3.\, k_B ln2 = 2.079\, k_B \tag{21}$$

This is not three bits, but

$$\Omega_{\mathrm{EM}} = e^{S_{\mathrm{EM}}/k_B} = e^{3\ln 2} = 2^3 = 8 \tag{22}$$

Interpretation: If the S_{core} field represents an electron's collapsed identity—one bit ($\Omega = 2$)—then the S_{EM} field represents a more delocalized, entangled field encoding $\Omega = 8$ possible microstates (i.e., three bits of information). What does this tell us? The entropy content of S_{EM} is higher not because it is more "informative" in a collapse sense, but because it is spread across more degrees of freedom. While S_{core} = collapsed, bounded, S_{EM} = expanded, radiative, and contains multiple field configurations or "degrees of potential interaction". So, we might interpret S_{core} as existence entropy (a single quantum identity) and S_{EM} as interaction entropy (the field's available entangled micro-configurations with space).

(v) What if Gamma Were 5 Instead?

$$S_{EM} = 5.k_B ln2 = k_B ln32 \;\Rightarrow \Omega = 32 \text{ configurations}$$

So, γ is directly scaling the microstate count of the SEM:

$$\Omega_{EM} = \; 2^{\gamma} \tag{23}$$

It gives us a semantic handle on field complexity.

Final Summary:

Field	Total Entropy S	Bits	Microstates Ω	Meaning
S_{core}	$k_B \ln 2$	1	2	Binary identity (collapse)
S_{EM}	$\gamma \cdot k_B \ln 2$	γ	2^{γ}	Distributed EM interaction entropy

So, with $\gamma = 3$, S_{EM} carries $8\times$ more microstate potential than S_{core}.

(vi) Physical Basis of γ: Linked to Spatial Entropy Volume

Entropy depends not only on the amount of energy (charge field), but also on how spread out it is. We define

$$S_{EM} = \int \frac{E_{Coulomb\ (r)}}{T(r)} dV \tag{24}$$

So, a larger spatial spread (larger σ_q) means more possible configurations for the field $\rightarrow$ higher Ω_{EM}, higher γ. A tightly confined field (small σ_q) means fewer options $\rightarrow$ smaller γ. So, γ is directly tied to the spatial entropy volume:

$$\gamma \propto \left(\frac{\sigma_q}{\sigma_m}\right)^2 \tag{25}$$

We can think of it as a "configurational volume ratio." What happens to S_{EM} after the collapse? When a measurement occurs (e.g., detecting charge or interaction), (i) the spread entropy collapses to a localized structure (like a S_{core}-type), and (ii) the system selects one of the Ω microstates from the

S_{EM} field. So, the measured charge corresponds to a one-bit output (Yes: charge detected; No: not detected). So, after the collapse,

$$S_{EM}^{measured} \approx k_B ln2 \ (same\ as\ S_{core}) \tag{26}$$

The rest of S_{EM}'s entropy radiates outward or decoheres, just like a wavefunction collapse in QM.

(vii) Justification of $\gamma = 3$ (vs. 10)

Our choice of $\gamma = 3$ is not a guess, but a provisional assignment based on a physical scale:

$$\sigma_q = 4 \cdot \lambda_C \tag{27}$$

Since $\sigma_q/\sigma_m = 4$ and entropy scales with area,

$$\left(\frac{\sigma_q}{\sigma_m}\right)^2 = 16 \Rightarrow \gamma \approx log_2 16 = 4$$

So, $\gamma \approx 3$–4 is reasonable based on spatial scaling. If we had chosen $\sigma_q = 10\sigma_m \rightarrow \gamma \approx \log(2 \times 100) = 6.6$, this would imply 6–7 bits of field complexity, valid only if the electron is embedded in a very high-energy or noisy EM environment. So, γ is not fixed by charge, but by field geometry and available spatial entropy before collapse. So, γ is not arbitrary but tied to the spread radius of the entropy field; charge is constant, but entropy associated with that charge depends on space and configuration freedom. After measurement, only one bit remains; the rest is dissipated or encoded elsewhere. So, γ captures the pre-collapse entropy potential of the electron's EM field.

3.3. The $S_{thermal}$ Field: Entropic Interaction Between Structure and Environment

In the S-Theory framework, the entropy field of a fundamental particle, such as the electron, is not fully described by mass (S_{core}) and charge (S_{EM}) alone. These fields represent intrinsic, localized (S_{core}) and spatially extended (S_{EM}) components of structured entropy. However, the third and often overlooked dimension is interaction entropy—the distributed and fluctuating entropic field arising from the electron's coupling to the surrounding environment and vacuum fluctuations. We call this field $S_{thermal}$, short for structured thermal entropy.

(i) Origin and Necessity of $S_{thermal}$

Whereas S_{core} is derived from the concentrated entropy due to configurational rest mass and S_{EM} from the spread associated with the electromagnetic field, $S_{thermal}$ arises from external interactions, including temperature-dependent noise, quantum vacuum fluctuations, and photon scattering. It captures the entropy flow into and out of the electron's system boundary. This makes $S_{thermal}$ the key dynamic component that determines whether the electron collapses (measurement), radiates (scattering), or remains in a superposed, thermodynamically stable state. Traditionally, quantum mechanics assumes idealized closed systems and primarily models probabilities via the wavefunction. In contrast, S-Theory explicitly recognizes the system's coupling to its entropic surroundings, leading to a more complete and physically grounded model of the electron as a dynamic structure embedded in a sea of entropy. This aligns closely with open quantum systems and thermofield dynamics, yet goes further by defining a scalar field that measures the residual entropy potential surrounding a quantum object.

(ii) Mathematical Formulation of the $S_{thermal}$ Field

The $S_{thermal}$ field shown in Figure 4 is constructed as a low-amplitude, wide-spread Gaussian random field added to the entropy profile. Unlike S_{core} and S_{EM}, which are symmetric and physically defined by core parameters (mass and charge), $S_{thermal}$ is non-symmetric and randomly modulated, representing microscopic stochasticity and interaction history. We define the $S_{thermal}$ field over a 2D domain using a low-frequency filtered random noise modulated by a Gaussian envelope:

$$S_{thermal}(x,y) = A.\ smooth_rand(x,y).\ exp\left(-\frac{x^2+y^2}{2\sigma_{th}^2}\right) \tag{28}$$

where *smooth_rand (x, y)* is a low-pass filtered 2D random noise (e.g., convolution with a Gaussian kernel), σ_{th} is the thermal spread radius, much wider than S_{EM} or S_{core}, A is a small amplitude scaling factor, ensuring $S_{thermal}$ does not dominate in isolation but strongly modulates during collapse events, the units are normalized entropy density per unit area. This field is then normalized to a maximum of one before visualization or summation into the RGB field.

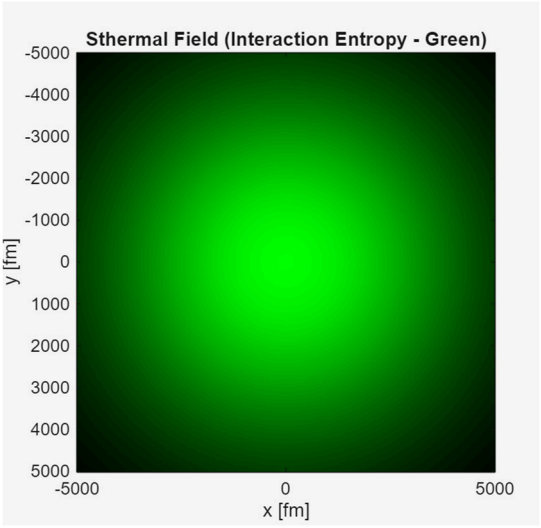


Figure 4. $S_{thermal}$ field distribution of the electron.

(iii) Physical Interpretation: The Missing Link in QM

The $S_{thermal}$ field (Figure 4) plays several vital roles that are ignored or marginalized in standard QM: (i) entropy exchange, as it captures the entropic flow to/from the environment, which is central to the measurement process; (ii) collapse sensitivity, as the moment a high-energy photon enters the $S_{thermal}$ field, recursive amplification of S-field (RAS) with S_{EM} can drive the system toward collapse; (iii) entropic equilibration, which defines the thermal envelope in which S_{core} and S_{EM} are modulated—without it, any energy-based picture misses the stochastic interactions needed for life, measurement, or evolution; and (iv) time-evolution context, as $S_{thermal}$ governs local entropic time, defining the effective "aging" or dynamic change in field structure over time, as shown in later sections. Thus, in S-Theory, $S_{thermal}$ is not optional. It is the thermodynamic gradient and stochastic scaffold without which no real system (including electrons, molecules, or brains) can evolve or respond to measurement.

3.4. Combined Entropic Field of an Electron

Figure 5a–c presents a summary of these three entropic subfields individually in color-coded visual form: S_{core} in red, S_{EM} in blue, and $S_{thermal}$ in green, each emerging from the same radial coordinate space but expressing different spatial scales and intensity gradients. Figure 5d is the combined entropy field of the electron (RGB Composition). This RGB fusion *total* image synthesizes the three entropic components into a single composite field given by Equation (29).

$$S_{total}(\boldsymbol{r}) = S_{core}(\boldsymbol{r}) + S_{EM}(\boldsymbol{r}) + S_{thermal}(\boldsymbol{r}) \quad (29)$$

The red (mass), green (thermal), and blue (charge) channels are superimposed, forming a complete entropy structure of the electron. The bright white center signifies the peak of recursive entropic amplification, where all three fields converge—a region of maximum coherence and minimum uncertainty. This unified representation provides a visual and thermodynamic map of the electron as a structured entropy field, central to the S-Theory reinterpretation of quantum mechanics. In Figure 5d, the $S_{thermal}$ field appears as the green component, forming a diffuse glow enveloping the sharper S_{core} (red, appearing white in the combined image) and S_{EM} (blue) fields. Its presence transforms the otherwise symmetrical S_{core}–S_{EM} model into a realistic, fluctuating, field-interactive system, opening the door to a thermodynamic explanation of uncertainty, wavefunction collapse, and decoherence.

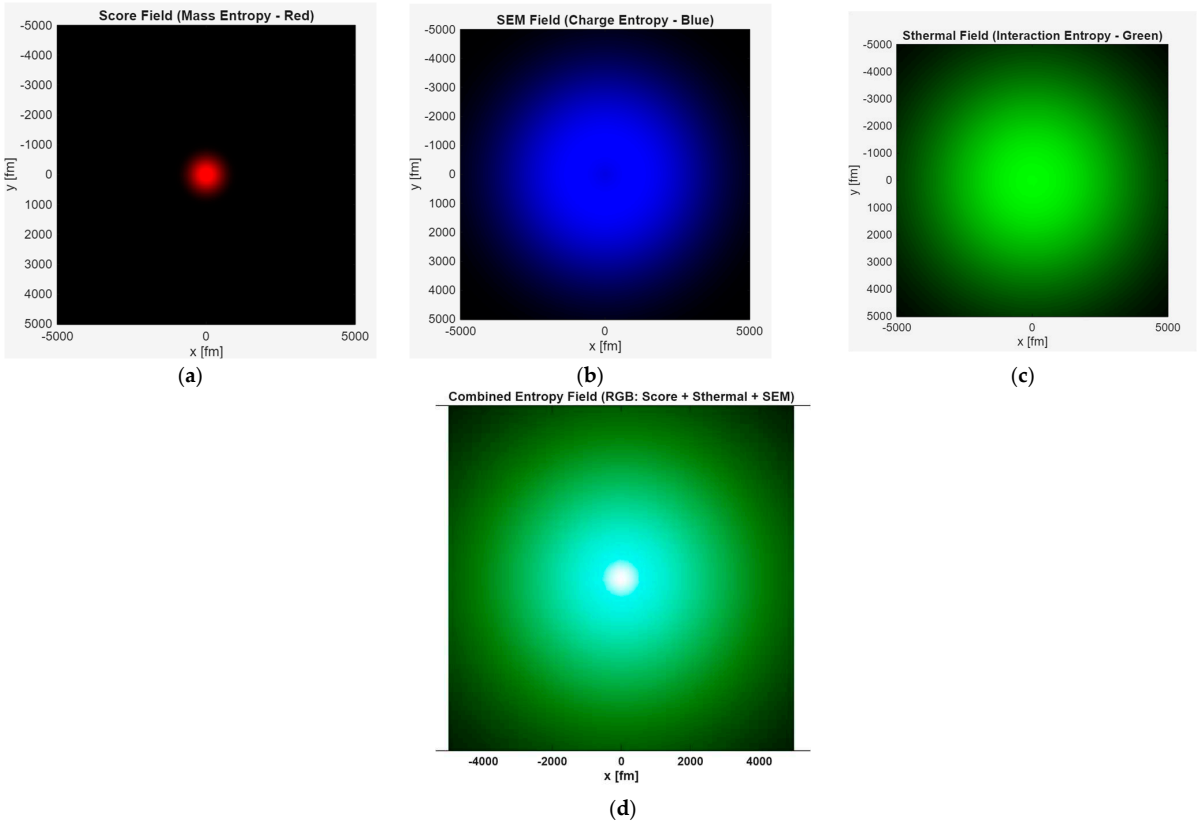


Figure 5. Combined *Stotal* (*r*) (total entropy field) of the electron (RGB composition).

(i) Estimation of Microstates of $S_{thermal}$: Comparison to S_{core} and S_{EM}

Based on prior modeling, the S_{EM} field is linked to the S_{core} field by a scaling factor $\gamma = 3$, leading to $S_{EM} = 3 \times S_{core}$ and an associated increase in microstates from $\Omega_{\text{core}} = 2$ to $\Omega_{\text{EM}} = 2^3 = 8$. For the $S_{thermal}$ field, which has the most significant spatial extent and represents the thermodynamic residue of interaction, we estimate a higher scaling factor $\alpha \approx 5$–8 resulting in $S_{thermal} = \alpha \cdot S_{core}$. This yields a microstate range of $\Omega_{\text{thermal}} = 2^{\alpha} = 32$ to 256. Thus, the $S_{thermal}$ component carries the dominant share of entropy and microstates in the complete *S-field* structure. Conceptually, the collapse process compresses this $S_{thermal}$ cloud and the S_{EM} field toward the S_{core} core, and leaves behind a coherent, spinning entropy structure, giving rise to measurable properties like charge and spin. This expanded entropy perspective, uniquely enabled by S-Theory, restores the missing thermodynamic dimension neglected by traditional quantum mechanics and provides a more complete framework for understanding measurement, decoherence, entanglement, and particle identity.

4. S_{EM} Field Structure with Spin

4.1. Rotational Spin Field: Mathematical Formulation

To embed spin into the S_{EM} field we discussed in Section 3, we define a tangential vector field (i.e., field lines circulating the core) with magnitude proportional to the entropy field. The vector field $\vec{v}s$ is constructed as

$$\vec{v}s(x,y) = A.S(r).\begin{bmatrix} -\frac{y}{r} \\ \frac{x}{r} \end{bmatrix} \tag{30}$$

This creates a counterclockwise (CCW) circular rotation around the origin, representing spin-up, x/r, y/r, are unit tangent directions at radius r, and A is the normalization constant, whose value is chosen so that the total angular momentum of the field equals $\hbar/2$. It captures the localized rotational motion of the entropy field that gives rise to quantum spin.

(i) Total Integrated Spin and Normalization Constant

We calculate the total angular momentum of the entropy-based spin field as

$$L_z = \int \rho_s(r).v_\theta(r).rdA \tag{31}$$

where

$\rho_s(r) = S(r)$ is an entropy-based "mass" density analog
$v_\theta(r) = A.S(r)$ is the tangential velocity magnitude
r = radius from core
$dA = 2\pi rdr$ is an area element in polar coordinates

This gives

$$L_z = A\int_0^\infty S(r)^2.r^2.2\pi dr \tag{32}$$

Substituting

$$S(\boldsymbol{r}) = S_{0.}e^{-r^2/(2\sigma^2)} \tag{33}$$

we obtain

$$L_z = 2\pi AS_0^2\int_0^\infty r^2.e^{-r^2/\sigma^2\,dr} \tag{34}$$

This evaluates to

$$L_z = 2\pi AS_0^2.\frac{\sqrt{\pi}}{4}\sigma^3 \tag{35}$$

Setting $L_z = \hbar/2$, we solve for A

$$A = \frac{\hbar}{2\pi.S_0^2.\frac{\sqrt{\pi}}{2}.\sigma^3} = \frac{\hbar}{\pi^{3/2}S_0^2\sigma^3} \tag{36}$$

In the simulation, we choose

- $\hbar = 1.055 \times 10^{-34} J\,s$
- $S_0 = 1$ (dimensionless, normalized)
- $\sigma = 10 fm = 10 \times 10^{-15}$ m

Resulting in

$$A \approx 4.79 \times 10^6 \text{ (SI units)}$$

This ensures that the total angular momentum stored in the entropy-rotating field equals the electron's spin: Lz = $\hbar/2$.

4.2. Spin-Up and Spin-Down Representation

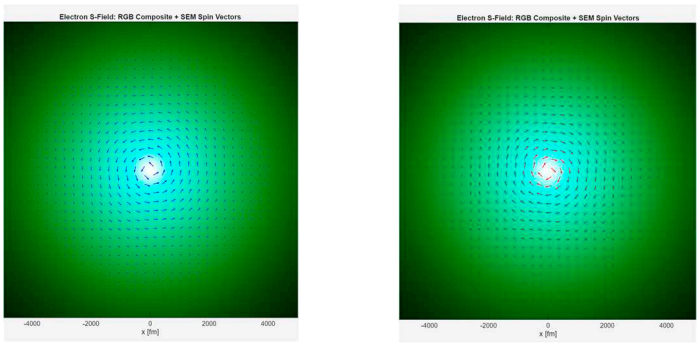
The sign of the spin vector field determines the spin direction:
For spin-up ($+\hbar/2$), we use

$$\vec{v}s(x,y) = A.S(r).\left(-\frac{y}{r},\frac{x}{r}\right) \tag{37}$$

For spin-down ($-\hbar/2$), we use

$$\vec{v}s(x,y) = A.S(r).\left(\frac{y}{r},=\frac{x}{r}\right) \tag{38}$$

Figure 6 shows the Electron S_{EM} field we generated in the previous section (Figure 5d) with overlaid spin vector fields derived from Section 4.1. Figure 6a (Left) is spin-up (counterclockwise vector circulation). Figure 6b (Right) depicts spin-down (clockwise circulation). In summary, in standard quantum mechanics, spin is treated as an intrinsic property—a fundamental quantum number assigned without origin. In contrast, S-Theory proposes that spin arises naturally from the rotation of the structured entropy field (S_{EM}) surrounding the electron's core (*Score*). When a tangential vector field is applied to the S_{EM}—creating a circulating entropy density around the S_{core}—a coherent rotational structure forms. This rotating field, once normalized to yield angular momentum $\hbar/2$, generates the emergent phenomenon we observe as spin-½. During collapse, this rotational entropy localizes into a sharply defined peak, yielding a measurable spin state and conserving angular momentum, which is discussed in Section 5.



(**a**) spin-up (+ħ/2) (**b**) spin-up (−ħ/2)

Figure 6. Entropy field structure of the electron with spin orientation: (**a**) spin-up electron (+ħ/2); (**b**) spin-down electron (−ħ/2).

We have shown that the spin of the electron in S-Theory is not an abstract quantum number, but a direct result of distributed entropy field rotation, modulated by the local field structure. The total spin emerges from integration of the rotational entropy field, and the exact quantum value $\hbar/2$ is recovered through normalization. This marks a significant shift in how quantum properties can be physically visualized and simulated, bringing us one step closer to a unified entropic theory of particles, structure, and dynamics.

5. Entropy-Based Collapse of the Electron: A Recursive Amplification Structure (RAS)

Having constructed the total entropy field of the electron—composed of the core entropy (S_{core}), the electromagnetic entropy cloud (S_{EM}), the ambient entropy fog ($S_{thermal}$), and the rotational spin vector field—we are now positioned to investigate the critical question: what happens when this entropy field is perturbed or measured? The complete initial state is shown in Figure 7a as Sn (RAS0), where the electron's full *S-field* is visualized as an RGB composite with embedded spin vectors. At the heart of this section lies a bold hypothesis: electron collapse is not a mystical event, but a recursive thermodynamic phenomenon, governed by the same law that drives emergence [9]—the recursive amplification of the S-field (RAS) mechanism of S-Theory.

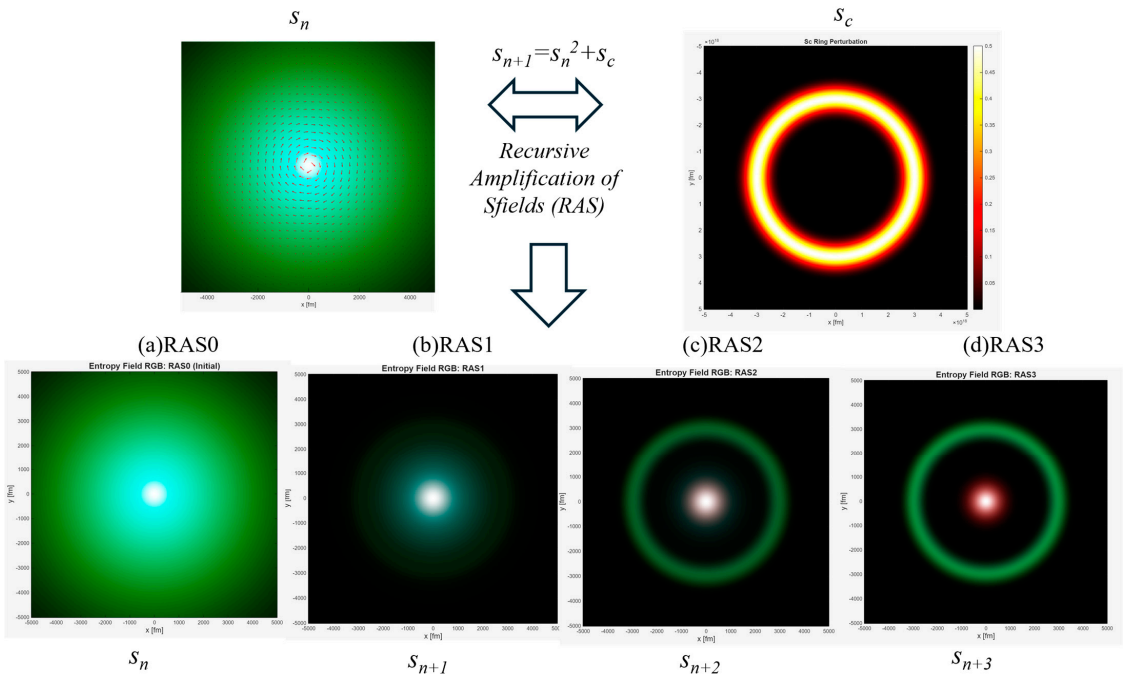


Figure 7. Recursive entropy field dynamics of the electron: computed pre-collapse configuration (**a**) RAS0 (s_n) and perturbation ring (s_c), as well as (**b**) RAS1 (s_{n+1}), (**c**) RAS2 (s_{n+2}), and (**d**) RAS3 (s_{n+3}).

5.1. Why RAS? A Thermodynamic Recasting of Collapse

In standard quantum mechanics, wavefunction collapse is an axiomatic process: a particle's probabilistic wave abruptly localizes upon observation. Yet this notion lacks a physical mechanism; why or how collapse happens is left unanswered. The measurement problem remains one of the most elusive paradoxes of physics. S-Theory replaces this postulate with a process: recursive entropy amplification. Instead of an abstract projection, collapse is modeled as a real-space interaction between an electron's entropy field and an external perturbation—an s_c field—producing dynamic feedback that amplifies some entropy structures and dissipates others. Mathematically, this is expressed by the core evolution equation: $s_{n+1} = s_n{}^2 + s_c$ (3). This is not a metaphor, but a nonlinear recursive interaction rule that defines the electron's response to high-energy input.

5.2. What Triggers Collapse?

In real measurements—whether in scattering, detection, or excitation—collapse is typically initiated by a high-energy photon or interaction field. This event is extremely short-lived but locally intense. The spatial size of a photon wave packet often exceeds that of an electron by several orders of magnitude. Yet the interaction zone is confined: the core entropy of the electron (S_{core}) provides a localized anchor, while the incoming field perturbs its surrounding S_{EM} and $S_{thermal}$ layers. To model this, we inject a structured entropy field s_c—a circular entropy ring as shown in Figure 7b—surrounding the electron core. This field simulates the entropy profile of an incident high-frequency photon or external EM perturbation.

5.3. Why a Ring? Spatial Logic of Measurement

A key insight is that collapse is not merely energy absorption, but spatial reconfiguration of entropy density. A photon interacting with an electron does not strike a point; rather, it perturbs the surrounding EM field. Thus, the s_c field is modeled as an annular entropy ring, representing the entropy input distributed around the electron at a radius of maximum interaction, consistent with the observed size scales of photon–electron interactions. This structure ensures that the RAS process acts not at the center (s_{core}), but in the outer entropy field ($s_{EM} + s_{thermal}$), triggering a recursive redistribution that feeds back inward.

5.4. What Is s_c? A Perturbation of Entropic Origin

The s_c field is constructed as a Gaussian ring of entropy density, incorporating both thermal and EM contributions: (i) $s_{thermal}$ represents ambient entropy noise or vacuum fluctuations; (ii) s_{EM} is a focused external field such as a photon pulse. s_c is therefore not a specific particle, but a generalized entropic perturbation. It reflects the entropy structure of the interaction source—whether light, field, or force—and becomes the seed for amplification.

5.5. Collapse as Recursive Amplification

The RAS mechanism is now engaged: the initial electron entropy field (s_n), composed of $s_{core} + s_{EM} + s_{therma}l$, interacts with s_c. The nonlinear recursion begins: (i) where s_n and s_c are in-phase or aligned, their entropies amplify; (ii) where they interfere destructively, entropy dissipates; (iii) the total field reorganizes into a new configuration s_{n+1}. This process continues recursively, converging when the field saturates—specifically, when the entropy density at the s_{core} region equals or exceeds a collapse threshold. At this point, we define collapse: a focusing of distributed entropy into the core, with expulsion or dissipation of the residual field (e.g., $s_{thermal}$).

6. Collapse of Electron: A Recursive Entropic Interpretation from Field Profiles

6.1. Non-Dimensional Formulation and Numerical Setup

Let $S\,(x, y)$ denote an entropy-density field with units $J{\cdot}K^{-1}{\cdot}fm^{-2}$. We fix a single reference scale from the baseline state (RAS0), $S_0 = max\,(x, y)\,S_{tot,0}(x, y)$ and work with non-dimensional fields $s_n\,(x, y) = S_n\,(x, y)/S_0$, $s_c\,(x, y) = Sc\,(x, y)/S_0$. The update is applied pointwise on a uniform 2D grid as the non-dimensional map given in Equation (3) with no per-step re-normalization (Equivalently, in dimensional variables $S_{n+1} = Sn^2/S_0 + S_c$, which makes the role of S_0 explicit). *Domain and discretization*.

We use $(x, y) \in [-L, L]^2$(fm) on a uniform grid of size $N \times N$ times with $\Delta x = \Delta y$ and area element $dA = \Delta x \Delta y$. (Values used in the figures: L = 5000 *fm*, N = 400). *Source term*. The ring-like perturbation is introduced as a dimensionless field s_c (x, y) = $c_{frac}\, s^c$ (x, y), where s^c is a unit-peak shape (e.g., Gaussian ring), and *cfrac* $\in$ (0,1) controls its strength. *Recovery of physical units for observables*. When reporting integrated or moment-type quantities, we first restore units via $S = s\, S0$ and integrate with the same dA. The spin-like moment is then normalized so that $Lz = \hbar/2$. The charge-like integral is reported in Coulombs after a single calibration at the stated RAS step. This keeps the recursion dimensionless while ensuring all reported observables carry correct physical units. *Visualization and units*. Spatial axes are in *fm*. Field magnitudes are plotted as $s = S/S_0$ (dimensionless, common scale, additive view). ROI summaries are reported as mean s over the interval (dimensionless). Spin Lz is in $J{\cdot}s$; charge-like integrals are in $\boldsymbol{C}$. *Note.* The field s is "probability-like" (non-negative and dimensionless) but is *not* a probability density unless explicitly normalized by its area integral—sanity *checks*. We verify (i) additivity $s_{tot} = s_{core} + s_{EM} + s_{thermal}$ pointwise and (ii) consistency of the area element dA across all integrals. These checks ensure dimensional consistency throughout.

6.2. Simulation of S-Field from RAS0 to RAS3 (Field Images)

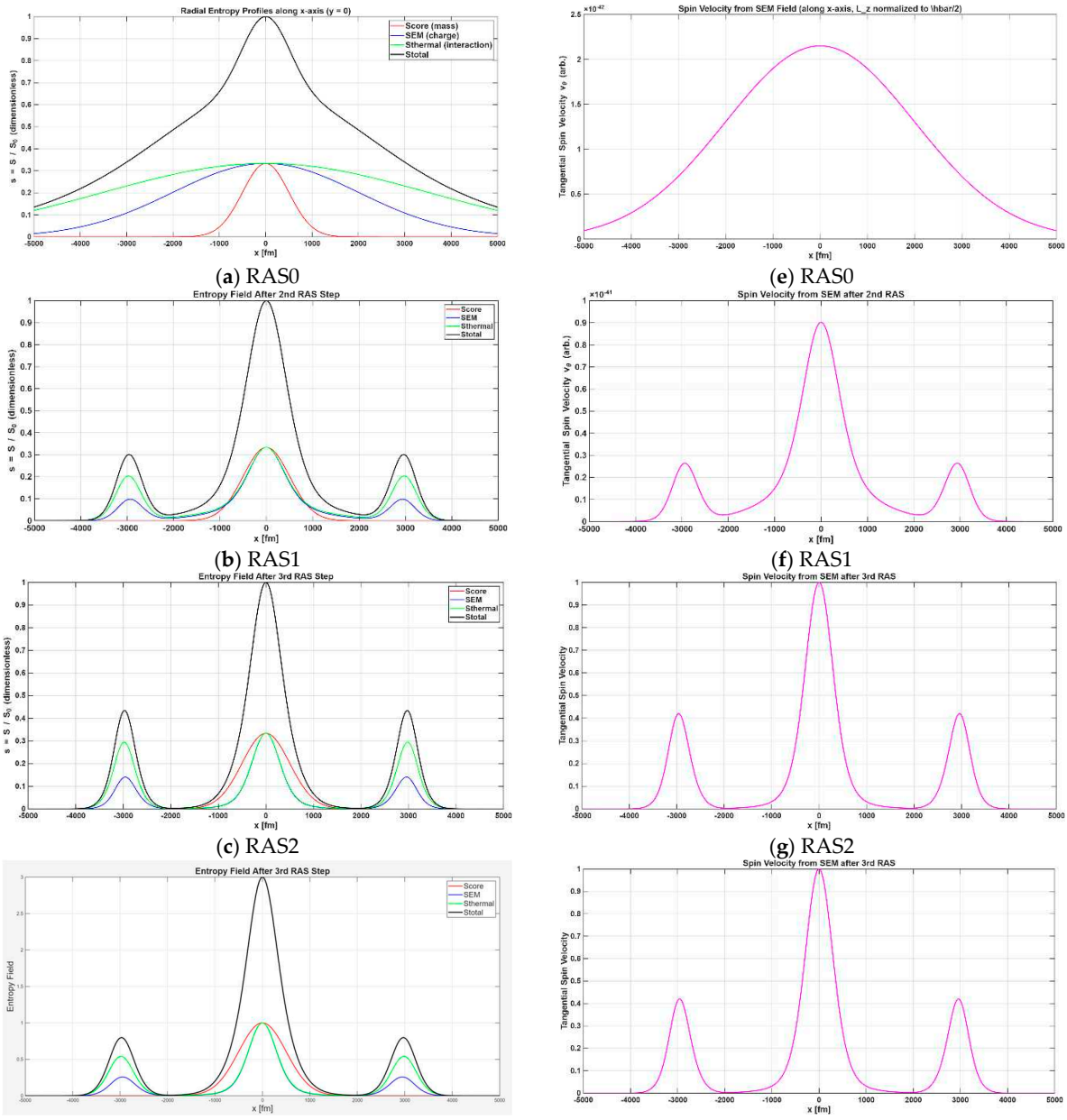
Figure 7a–d illustrates the full-field evolution of the electron's entropy structure during recursive amplification (RAS) collapse. Figure 7a shows the initial entropy field (RAS0), where the core (s_{core}), charge field (s_{EM}), and thermal field ($s_{thermal}$) form a smoothly blended, diffuse s_{max} structure. As RAS progresses in panels (b) through (d), entropy density compresses inward while outer structures sharpen, forming coherent radial shells. In RAS1, the central s_{core} begins to dominate visually, and by RAS2, the entire field exhibits clear bifurcation between a dense entropic core and a high-gradient ring. RAS3 reveals the signature of collapse—a highly saturated central entropy density surrounded by structured field lobes—confirming that the electron's measurable attributes emerge from recursive entropy focusing.

Notably, the luminous green ring visible in RAS2 and RAS3 represents a sharply structured $s_{thermal}$ field, encircling the compressed s_{core} and s_{EM}. This outward-diffusing $s_{thermal}$ carries entropic energy from the core and acts as the thermodynamic interface with the measurement environment. It is this ring—rich in entropy but weak in structural anchoring—that first reaches the detector or measurement system, triggering the collapse of the inner fields into observable quantities like charge, mass, or spin. In this view, measurement is not a collapse of the wavefunction but a natural entropic diffusion from structured order ($s_{core} + s_{EM}$) into thermal interaction ($s_{thermal}$), followed by irreversible entanglement with the observing system. The field evolution here provides the most precise visual and thermodynamic map of what measurement truly means in physical reality.

6.3. Simulation of S-Field from RAS0 to RAS3 (S-Field Density Profiles)

We work with the non-dimensional field $s = S/S_0$ for all updates and plots; physical units are restored only when reporting observables via $S = sS_0$ with a single area element dA.

(i) Figure 8a: *Baseline Entropy Profile ($y = 0$ Line Cut).* Figure 8a shows the radial entropy field profile of the electron, taken along the x-axis at y = 0. This is the reference state before any perturbation or measurement. The black curve represents the total entropy field $s_{total} = s_{core} + s_{EM} + s_{thermal}$. This is the total information field defining the electron's identity, interaction, and ambient coupling. Each colored curve corresponds to one component: (i) *Red* corresponds to S_{core}, the entropy field associated with mass, sharply localized around the origin (x = 0). This narrow peak reflects the dense, bounded entropy of the electron's "collapsed" existence—the s_{core} field derived from *Compton-width Gaussian* (Equation (6)). (ii) *Blue* corresponds to s_{EM}, the entropy from charge-based electromagnetic interaction. It is broader than the s_{core}, derived from Equation (13), with width $\sigma_q = 4\ \lambda_C$, and reflects the more spread-out field influence. (iii) *Green* corresponds to $s_{thermal}$, the broadest field, capturing ambient entropy interactions (background photons, stochastic field noise), modeled with a Gaussian of even larger spread. While less dense, it plays a crucial role in the collapse. This trinity of fields (s_{core}, s_{EM}, and $s_{thermal}$) forms the entropic structure of the electron. Although s_{EM} and $s_{thermal}$ are spatially broad, their entropy density is lower compared to s_{core}. This distinction is critical: it is not just the spatial extent, but the local entropy density that determines how collapse unfolds.



(**a**) RAS0 (**e**) RAS0

(**b**) RAS1 (**f**) RAS1

(**c**) RAS2 (**g**) RAS2

(**d**) RAS3 (**h**) RAS3

Figure 8. Recursive entropic collapse of the electron: RAS evolution of entropy field magnitude and spin velocity. Subfigures (**a**–**d**) show the evolution of s_{core}, s_{EM}, $s_{thermal}$, and s_{total} entropy fields, along with the corresponding tangential (**e**–**h**) spin velocities across three recursive amplification steps.

(ii) Figure 8e: *Tangential Spin Velocity Profile from* $s_{EM.}$ The corresponding spin field (Figure 8e) plots the tangential velocity profile derived from the rotation of the s_{EM} field, projected along the same axis. Unlike s_{core}, which is static and non-rotating, s_{EM} carries a directional entropy flow—the root of electron spin in S-Theory. Here we observe the following. (a) A wide, smooth bell-shaped profile indicating that spin is not sharply localized. (b) The maximum spin velocity is around the mid-region, confirming that spin is a field effect, not a core identity. This redefines spin not as an abstract quantum number, but as a distributed rotational flow of entropic interaction, physically visualized and dependent on s_{EM} structure. Together, Figure 8a,e provide a clear baseline: (a) the electron is not a point, but an extended entropy structure, (b) its mass (s_{core}) is tightly bound and carries high local entropy density, and (c) its charge field (s_{EM}) is broader and rotating—the source of spin.

(iii) *RAS Step 1—Beginning of Collapse: Compression and New Structure Formation.* In Figure 8b, we present the result of the first recursive amplification step (RAS1) applied to the electron's non-dimensional entropy field using the update rule: $s_{n+1} = s_n{}^2 + s_c$ *(3).* This process simulates the effect of an external entropy perturbation s_c—such as a measurement photon—interacting with the native entropy field of the electron.

The effects are striking: (i) Central Compression of Entropy: The total entropy curve (black) shows a marked narrowing toward the origin compared to the baseline (Figure 8a). This signals the onset of collapse, where entropy is being drawn inward, amplifying its central density through recursive feedback. (ii) Merging of s_{EM} and $s_{thermal}$: The blue and green curves, previously distinct (representing charge and thermal entropy fields), now collapse into a single, nearly overlapping profile. This reflects a loss of their separate field identity—a key signature of collapse—while still remaining broader than the red s_{core}. (iii) Emergence of side lobes: A significant new phenomenon appears: side lobes, or secondary peaks, symmetrically located away from the core. These likely represent redistributed and amplified $S_{thermal}$ entropy, pushed outward as central compression proceeds.

This may correspond to potential interaction zones or field residues post-collapse. (iv) Formation of a core–wall structure: The overall profile now begins to resemble a two-zone system: a compressed core region near $\times = 0$, surrounded by a high-entropy "wall", marking the first formation of structured spatial boundaries in the entropy field. This suggests the field is beginning to reconfigure, preparing for discrete measurable outcomes. The spin velocity profile (Figure 8f) confirms the same trend from a rotational perspective:

(i) The rotational entropy flow, previously broad (Figure 8e), now becomes narrower and steeper, showing that the rotational field is collapsing toward the core.

(ii) Like the entropy profile, side peaks begin to emerge in the spin field. These may represent angular momentum residues or quantized spin channels, possibly linked to the appearance of discrete spin outcomes upon measurement.

(iii) *Interpretation of RAS1*: The first RAS step shows that electron collapse is not instantaneous but begins with a recursive inward pull that (*i*) amplifies entropy density at the center, (ii) blurs the boundary between charge and thermal fields, (iii) initiates structure bifurcation via side lobes, and (iv) begins reorganizing the spin field into quantized modes. This is the initial quantization pulse—a process not postulated but physically modeled from entropy field logic.

(iv) *RAS2—Threshold Convergence and Collapse Criteria Emerges*: At the second recursive amplification step (RAS2), the behavior of the entropy field undergoes a dramatic transformation. All three core entropy components—s_{core} (mass), s_{EM} (charge), and $s_{thermal}$ (interaction)—now appear almost fully collapsed and overlapping, forming a single dense central peak (Figure 8c): Key observations: *(a)* Trinity Field Convergence. For the first time, the red (s_{core}), blue (s_{EM}), and green ($s_{thermal}$) curves are no longer distinguishable in the core region. This convergence implies that their local mean entropies in the local area are equilibrated. The total entropy (black) thus becomes a sharply peaked structure, suggesting near-complete field unification.

6.4. Local Mean of Entropy Fields, and the Collapse Criterion

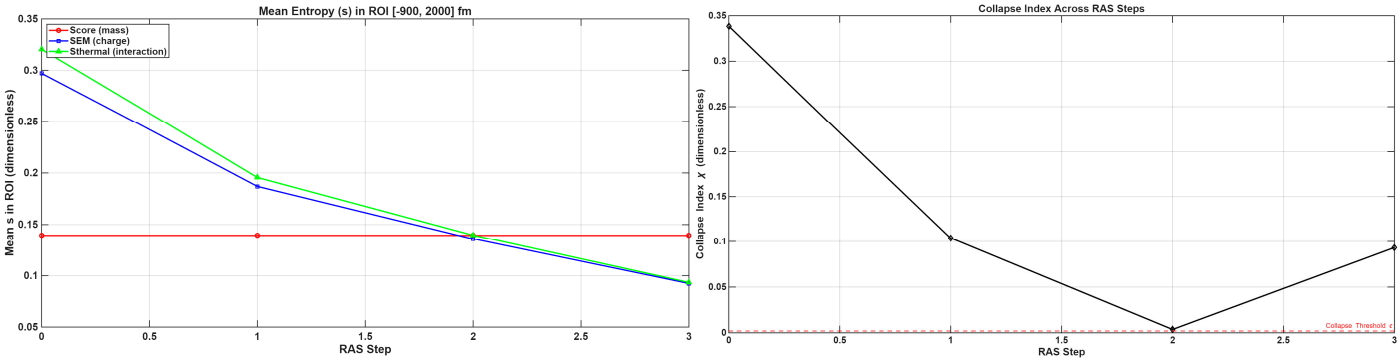
When we report a single number that characterizes the field in a neighborhood, we use the mean of s over a chosen region A:

$$\bar{s}^A = \frac{1}{|A|}\int s_n dA \tag{39}$$

This quantity is dimensionless and grid-independent, and we compute it analogously for each component (s_{core}, s_{EM}, $s_{thermal}$). In the 1D profiles shown in Section 6, we use an interval ROI along y = 0, specifically $[-900, 2000]$ fm. This window captures the core of the field while intentionally excluding the external ring source at r $\approx$ 3000 *fm*; results are robust to symmetric alternatives such as $[-1500, 1500]$ *fm* or to circular ROIs r $\leq$ 2500 *fm*.

Figure 9a shows the evolution of local mean s for each of the three primary entropy fields—s_{core} (red), s_{EM} (blue), and $s_{thermal}$ (green)—within a fixed region of interest (ROI: −900 to + 2000 *fm*) across successive RAS iterations (RAS 0 to 3). This plot provides critical insight into how the entropy field components compress during recursive amplification. Notably, (i) s_{core} remains constant throughout,

as expected from a mass-anchored entropy source, and (ii) s_{EM} and $s_{thermal}$ both decline in density with each RAS step, rapidly converging toward the s_{core} baseline. (iii) At RAS = 2, both s_{EM} and $s_{thermal}$ densities intersect the s_{core} line—a key moment indicating entropic equilibration in the core region. This convergence suggests that at RAS step 2, the distributed field components (charge and thermal interaction) become sufficiently compressed to match the core mean entropy s over the local area. The field, once delocalized, focused its structure onto a central entropic state—a necessary condition for quantum measurement or collapse. Figure 9b provides a more explicit metric: the *Collapse Index*, denoted as χ, which quantifies the difference in local entropy density between the s_{EM}/$s_{thermal}$ and s_{core} fields.



(**a**) Mean of s over a region A (**b**) Field convergence and collapse index

Figure 9. Collapse criteria based on entropic density and field convergence.

Collapse Index

To quantify the approach of the charge-like (s_{EM}) and interaction-like ($s_{thermal}$) components toward the core (s_{core}), we define a collapse index from the ROI means:

$$\chi_n^A = \left|\bar{s}_{SEM,n}^A\right| - \left|\bar{s}_{Score,n}^A\right| + \left|\bar{s}_{thermal,n}^A\right| - \left|\bar{s}_{Score,n}^A\right| \quad (40)$$

By construction, χ is dimensionless. We declare "collapse" when χ falls below a small tolerance (we use $\varepsilon = 2 \times 10^{-3}$ or when it decreases monotonically with n). In the chosen ROI, where the source is negligible, the map reduces effectively to $s_{n+1} \approx {s_n}^2$ away from the center, so the s_{EM} and $s_{thermal}$ mean decay with each RAS step while the mass-like s_{core} (held fixed by design) stays flat—precisely as observed in the trends of Section 6. A collapse threshold (dashed red line) is defined based on a minimal tolerance χ_{min}, beneath which the fields are considered thermodynamically indistinguishable. We observe (i) a steep decline in χ from RAS 0 to RAS 2. (ii) At RAS = 2, χ dips below the collapse threshold, signaling that all three fields (s_{core}, s_{EM}, and $s_{thermal}$) have become indistinguishable in entropy density within the ROI. (iii) Beyond RAS2, χ slightly increases, reflecting an over-collapse or post-collapse redistribution. Together, Figure 9a,b provide a robust thermodynamic collapse condition. Collapse does not require abstract wavefunction postulates; rather, it emerges naturally from recursive entropy convergence. The S-Theory model shows that when local entropy densities of all fields align within a defined region, collapse is inevitable. This provides a physically grounded, quantifiable mechanism for quantum measurement, potentially resolving one of the deepest mysteries in foundational physics.

The simulations presented in this section are intended as phenomenological illustrations of entropy-field dynamics and internal configurational evolution within the proposed framework. They do not represent direct simulations of experimentally measurable observables, nor do they imply that the modeled quantities are currently accessible using existing quantum measurement techniques. Their purpose is to explore qualitative behavior, internal consistency, and potential implications of the entropy-based model. Future experimental relevance of the proposed entropy-field framework remains an open question; the present work focuses on theoretical interpretation rather than immediate experimental validation.

Also, in the present formulation, the entropy-field components S_{EM} and $S_{thermal}$ are defined phenomenologically as local measures of correlated electromagnetic structure and minimally correlated

thermal disorder, respectively. While these components implicitly assume an ambient electromagnetic environment, the explicit contribution of electromagnetic vacuum polarization and vacuum-induced entropy flows is not modeled here. Recent work has highlighted the role of Casimir polarization of the electromagnetic vacuum in sustaining stationary nonequilibrium microscopic systems [24]. Incorporating explicit vacuum entropy and energy-density effects into the entropy-field framework represents an important direction for future development of S-theory.

Within standard quantum mechanics, wave-function collapse is commonly treated as a methodological feature of the operator formalism rather than as a modification of underlying dynamics. The entropy-field framework proposed here does not challenge this view. Instead, it offers a complementary physical interpretation in which localization during measurement is associated with real-space configurational reorganization and entropy redistribution. This perspective is consistent with phenomenological approaches that extract finite particle structure from relativistic wave equations, such as recent analyses of the Dirac equation [24]. The present work thus aims to enrich the physical interpretation of quantum measurement without altering the predictive apparatus of quantum mechanics.

7. Summary and Reflections

In this work, we redefined the electron not as a point particle but as a structured entropy field composed of three fundamental components: the core entropy field (S_{core}) arising from mass, the electromagnetic entropy cloud (S_{EM}) from charge, and the ambient thermal field ($S_{thermal}$). Through recursive amplification of *S-fields* (RAS), we modeled how these fields evolve under measurement-like excitation, leading to collapse—a process long treated as mysterious in quantum theory. We demonstrated that electron collapse is not an abstract postulate, but a physically computable convergence of entropy density, where s_{EM} and $s_{thermal}$ compress toward s_{core} until their local densities match. At this threshold, structural collapse and field alignment occur naturally, explaining the act of measurement, localization, and spin entanglement as entropic outcomes. Our RAS formulation—$s_{n+1} \leftrightarrow {s_n}^2 + s_c$—reveals that quantum behavior is a natural consequence of recursive thermodynamic interactions, not an exception to physical law. This entropy-first approach offers a unified thermodynamic origin for spin, charge, localization, and collapse, clarifying the foundations of quantum mechanics from a field-based perspective. The predictive power of the model invites further applications, including the double-slit interference, entanglement, and matter genesis. If classical physics gave us force, and quantum mechanics gave us probability, S-Theory gives us structure through entropy—a bridge from the infinite potential of the vacuum to the precise reality of a single electron.

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