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*Article*

# 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: *Score* (a collapsed entropy core from mass), $S_{EM}$ (a structured electromagnetic entropy field from charge), and *Sthermal* (a diffuse entropy component from ambient interactions). We show that spin emerges as a rotating $S_{EM}$ shell around Score, 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 (UECP); quantum structure; entropy geometry; memory fields; quantum information; information theory; recursive amplification of S-fields (RAS); recursive compression of S-fields; entropy fields; measurement problem; electron collapse

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## Statement of Significance

The 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 entropy field dynamics. 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.

## 1. Introduction—The Electron Beyond the Particle

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: mass, charge, and spin. These quantities are not derived from internal structure or dynamic processes but instead introduced axiomatically into the formalism. The wave–particle duality, while elegant, remains

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interpretive: it allows electrons to behave as delocalized waves or localized particles depending on the measurement, yet it provides no mechanistic account of how localization occurs, nor why electrons possess the exact properties they do. Thus, while quantum theory accurately predicts outcomes of experiments, it does not reveal what an electron truly is. What, then, is an electron in the absence of observation — left alone in vacuum, governed only by the quantum vacuum field? It still manifests mass, radiates an electric field, interacts magnetically, and exhibits spin. These observable phenomena suggest a deeper field structure or internal entropy dynamic. In this work, we present a thermodynamic reformulation of the electron grounded in *S-Theory* — a unified framework in which physical properties emerge from recursive interactions between entropy fields.

### *1.1. Generalized Definition of Entropy in S-Theory*

S-Theory begins with a primordial entropic background, $S_\infty$: 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 $S_\infty$, these quanta fluctuate freely without correlation or geometry, representing maximal entropy. Physical structure arises when subsets of 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 $\mathbf{r}$ 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,

$$S(\mathbf{r}) = k_B \, \Delta A^{-1} \, \ln \Omega_S(\mathbf{r}) \quad \left[\mathrm{J\,K^{-1}\,fm^{-2}}\right] \tag{2}$$

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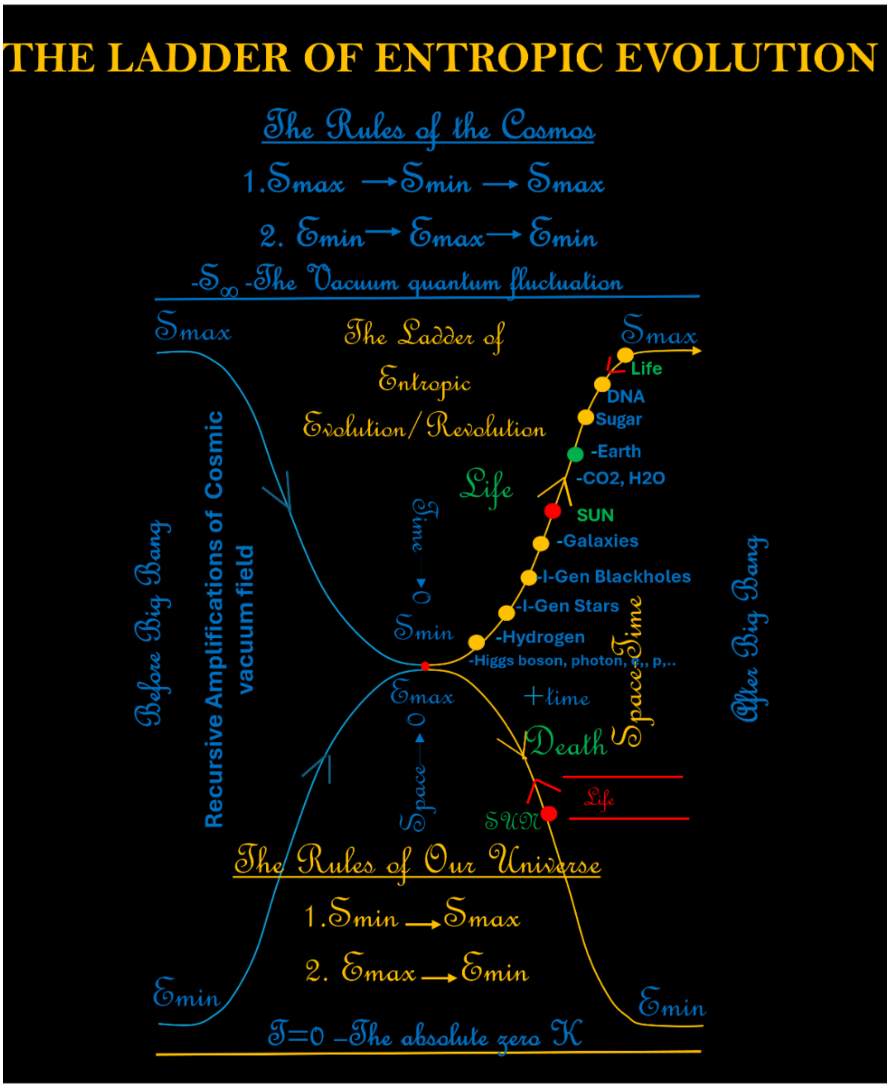


**Figure 1.** Ladder of Entropic Evolution/Collapse.

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

$$\Omega_S(\mathbf{r}) = \Omega_{\text{th}}(\mathbf{r}) + \Omega_{\text{sEM}}(\mathbf{r}) + \Omega_{\text{Score}}(\mathbf{r}) \quad (2.1)$$

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

- $\mathbf{\Omega_{th}}$counts micro configurations of entropic quanta that produce macroscopic thermal energy through random, minimally correlated arrangements.
- $\mathbf{\Omega_{sEM}}$counts field-structured micro configurations of entropic quanta arising from correlations linked to electric charges and magnetic field organization.
- $\mathbf{\Omega_{Score}}$ counts mass-forming micro configurations of entropic quanta, representing maximally correlated clusters that behave as stable cores.

At each location $r$, 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 *Score*) 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.

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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. In S-Theory, however, 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, 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.

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

$$s(\mathbf{r}) \equiv S(\mathbf{r})/S_0 \in [0,1]$$

where $S_0$ is a fixed ground-state reference (peak of the total entropy density). Intuitively, the fraction of non-dimensional entropic density $s$ ≈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 (e.g., rings for s-like and dipoles for p-like structure). The state update is the local, pointwise map given by the recursive fractal equation,

$$s_{n+1}(\mathbf{r}) = s_n(\mathbf{r})^2 + s_c(\mathbf{r}) \quad (3)$$

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* ∈ [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 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. *Sthermal* 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 *Sthermal* components recursively (through a process we call *Recursive Amplification of Sfield*, or RAS), the system saturates. The $S_{EM}$ field compresses and aligns with the *Score* core, yielding a collapse that produces definite quantities — charge, spin, 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, *iv)* and *entanglement* may arise via field correlations between overlapping *Score* fields across space. This work builds on our companion paper on hydrogen orbital formation 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 — and offers 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

### *2.1. 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, 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*, yes—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) Score* — frozen, memory-like entropy bound in particles or matter; a conserved structural core, *iii) Sthermal* — 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. 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 $S_\infty$, 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 $S_\infty$.

These two forward paths of Entropy *S* and Energy *E* are bounded by $S_\infty$ (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 [1] 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 [1–3]. 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 $S_\infty$ through order, and it* unifies quantum events, biological replication, and gravitational collapse under one thermodynamic cycle [4].

## 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 *Score(r)* and represents the internal collapsed identity of the electron arising from its rest mass.

### 3.1. Mathematical Formulation of Score from Electron Mass

*(i) The Score Field – Entropy Core of the Electron*

We define the core entropy field of the electron, denoted as *Score(r),* to represent the structured entropy arising from the electron's rest mass.

$$S_{\text{core}}(r) = A_m \cdot e^{-r^2/(2\sigma_m^2)} \quad (2)$$

Where: $A_m$ is the normalization constant for entropy density (not mass), $\sigma_m$ is the characteristic width of the *Score* field.

*(ii) From Mass to Entropy: Core Logic*

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

$E = m_e c^2$ *and* $S = E/T \Rightarrow \quad S = m_e c^2/T$ (3)

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 *Score* 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 $\sigma_m$ is not arbitrary. It is chosen based on the *Compton wavelength* $\lambda_C$ of the electron:

$\sigma_m = \lambda_C = \hbar/m_e c \approx 3.86\times10^{-13}$ *m* (4)

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.

*(iii) Normalization of Score Field*

We now normalize *Score* such that its total integrated entropy corresponds to $S_e = k_B \ln 2$, representing *one bit* of fundamental entropy — the minimal quantum configurational entropy associated with a spin-½ particle (Ω = 2 microstates). That is,

$$\int S_{\text{core}}(r)\, dA = S_e \approx k_B \ln 2 \quad (5)$$

In polar coordinates:

$$\int_0^\infty 2\pi r \cdot A_m e^{-r^2/(2\sigma_m^2)}\, dr = S_e \quad (6)$$

This evaluates to:

$$A_m = \frac{S_e}{2\pi\sigma_m^2} \quad (7)$$

Using:

$k_B \ln 2 \approx 9.57\times10^{-24}$ *J/K*

$\sigma_m = \lambda_C = 3.86\times10^{-13}$ *m*

We obtain:

$Am \approx 9.57\times10^{-24}/2\pi\ (3.86\times10^{-13})^2 \approx 1.02\times10^2\ J/K$ (8)

*(iv) Physical Interpretation and justification*

This construction yields the *Score(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: *i)* Mass becomes a localized entropy configuration, not a constant, *ii)* The field is sharply confined ($\sim 10^{-13}$ *m*), representing the collapsed identity of the electron, *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 Score that* is clearly defined as an entropy field, not a mass density. $\sigma_m$ is set by *Compton wavelength*, not arbitrary. The normalization yields a physical entropy unit (e.g., 1 bit, or $k_B\ln 2$). This *Score* represents a normalized Gaussian entropy density, centered at the origin, which defines the electron's collapsed mass configuration. The field integrates to $k_B \ln 2$ and is localized at the Compton scale ($\sim 10^{-13}$ m), establishing mass as a structured entropy phenomenon in the S-Theory framework.

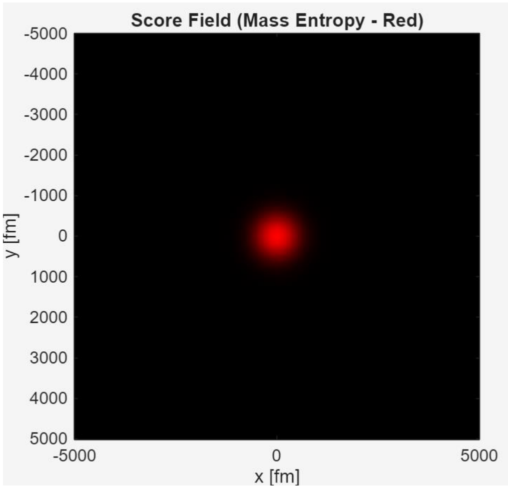


**Figure 2.** *Score* Field Distribution: Entropic Core of the Electron derived using equation (2).

*(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 $\Omega = 2$ states:

$S = k_B \ln \Omega = k_B \ln 2 = 0.693\ k_B$ (9)

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 *Score* field encodes the electron's "*1 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 *Score* 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:

$$\int S_{\text{core}}(r)\, dA = \ln 2 \approx 0.693 \approx \boxed{1\ \text{bit}} \quad (9)$$

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Thus, the electron's mass is reinterpreted as a field that contains exactly 1 bit of structured entropy — distributed in space such that its *Score* field integrates to *ln2*. In practice, some literature (especially in quantum information theory) approximates 1 bit entropy as "2" when expressed as Ω (number of microstates), which gives: S = lnΩ = ln2 ⇒ Ω=2. So, we are not integrating to a value of "2" directly, but rather: to $k_B\ln2$ in SI units, or 1 bit in information units, or 0.693 in pure math units. We present the mass of the electron as an entropy field (*Score*), peaked at the center, whose total integral is $k_B ln2$— representing one bit of structured entropy associated with the collapsed electron identity.

### *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 *Score* 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:

$$S_{\mathrm{EM}}(r) = A_q \cdot e^{-r^2/(2\sigma_q^2)} \quad (10)$$

Where: $A_q$ is the normalization constant linked to electromagnetic entropy density, $\sigma_q$ 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:

$$E = S \cdot T \quad \Rightarrow \quad S = \frac{E}{T} \quad (11)$$

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 *Score* field (Section 1), we define the total entropy in the $S_{EM}$ field as:

$$\int S_{\mathrm{EM}}(r)\, dA = S_{\mathrm{EM}}^{\mathrm{total}} = \gamma \cdot S_{\mathrm{core}} = \gamma \cdot k_B \ln 2 \quad (12)$$

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

*(ii) Choice of Spread Width $\sigma_q$*

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:

$$\sigma_q = \eta \cdot \lambda_C \quad (13)$$

where

$$\lambda_C = \frac{\hbar}{m_e c} \approx 3.86 \times 10^{-13}\ \mathrm{m} \quad (14)$$

$\lambda_C$ is the Compton wavelength, and $\eta$ is a scaling factor. Choosing $\eta$=4, we obtain:

$\sigma_q = 4 \cdot \lambda_C \approx 1.54\times10^{-12}$ m

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

*(iii) Normalization Constant*

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

$$A_q = \frac{\gamma \cdot k_B \ln 2}{2\pi\sigma_q^2} \quad (15)$$

For example, with $\gamma$=3 and the above value of $\sigma_q$, we obtain:

$$A_q \approx \frac{3 \cdot k_B \ln 2}{2\pi(1.54 \times 10^{-12})^2} \approx 1.4 \times 10^1 \text{ J/K} \quad (16)$$

This yields a broad entropy field that smoothly decays with distance and contributes significantly to the total entropy structure of the electron.

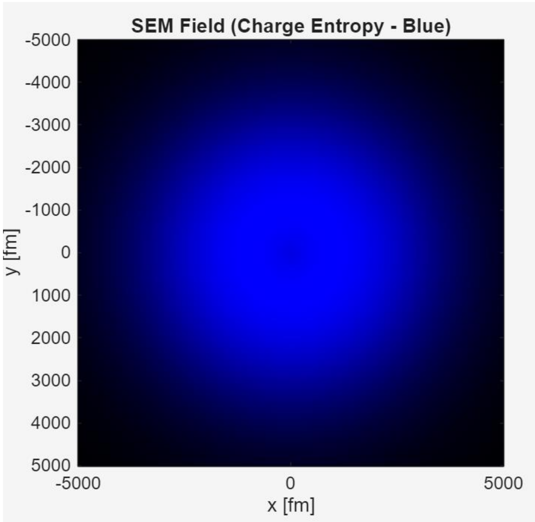


**Figure 3.** $S_{EM}$ Entropic EM field distribution of Electron.

*(iv) Estimation of microstates of $S_{EM}$: Comparison to Score*

In the previous section 2.2, we derived

Score = $k_B ln\Omega = k_B ln2 \approx 0.693\ k_B$ (17)

This corresponds to 1 bit and reflects collapsed identity (a binary quantum choice: spin-up/down, particle/antiparticle, etc.). Now: What Should $S_{EM}$ Represent? The $S_{EM}$ field is: *i)* spread out, not collapsed *ii)* derived from electromagnetic field energy *iii)* not a binary state, but a continuum of influence, so it shouldn't be just "1 bit" like Score. It should encode more entropy — a distributed informational cloud, not a defined choice.

When we set γ=3, we Are Saying:

$$S_{\text{EM}}^{\text{total}} = \gamma \cdot S_{\text{core}} = 3 \cdot k_B \ln 2 \approx 3 \cdot 0.693\, k_B \approx 2.079\, k_B \quad (18)$$

This is not 3 bits, but:

$$\Omega_{\text{EM}} = e^{S_{\text{EM}}/k_B} = e^{3 \ln 2} = 2^3 = 8 \quad (19)$$

*Interpretation*: If the *Score* field represents an electron's collapsed identity — 1 bit (Ω = 2), then the $S_{EM}$ field represents a more delocalized, entangled field — encoding Ω = 8 possible microstates (i.e., 3 bits of information). What does this tell us? The entropy content of $S_{EM}$ is higher not because it's more "informative" in a collapse sense, but because it's spread across more degrees of freedom. While *Score* = collapsed, bounded, $S_{EM}$ = expanded, radiative, and contains multiple field configurations or "degrees of potential interaction". So, we might interpret: *Score* as existence entropy (a single quantum identity), $S_{EM}$ as interaction entropy (the field's available entangled micro-configurations with space).

*(v) What if Gamma Were 5 Instead?*

$$S_{\text{EM}} = 5 \cdot k_B \ln 2 = k_B \ln 32 \quad \Rightarrow \quad \Omega = 32 \text{ configurations}$$

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

$$\boxed{\Omega_{\text{EM}} = 2^\gamma} \quad (20)$$

It gives us a semantic handle on field complexity.

*Final Summary:*

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

So, with γ=3, SEM carries 8x more microstate potential than Score.

*(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:

$$S_{\mathrm{EM}} = \int \frac{E_{\mathrm{Coulomb}}(r)}{T(r)}\, dV \quad (21)$$

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

$$\gamma \propto \left(\frac{\sigma_q}{\sigma_m}\right)^2 \quad (22)$$

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 *Score*-type). *ii)* the system selects one of the $\Omega$ microstates from the $S_{EM}$ field *ii)* So the measured charge corresponds to 1-bit output (Yes: charge detected; No: not detected). So, after the collapse:

$$S_{\mathrm{EM}}^{\mathrm{measured}} \approx k_B \ln 2 \quad \text{(same as Score)} \quad (23)$$

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

*(vii) Justification of γ = 3* (vs. *10)*

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

$\sigma_q = 4 \cdot \lambda_C$ (24)

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 γ ≈ 3–4 is reasonable based on spatial scaling. If we had chosen: $\sigma_q = 10\sigma_m$ → γ ≈ log(2x100) = 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: $\gamma$ is not fixed by charge, but by field geometry and available spatial entropy before collapse. So, $\gamma$ 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 1 bit remains — the rest is dissipated or encoded elsewhere. So $\gamma$ captures the pre-collapse entropy potential of the electron's EM field.

### *3.4. The Sthermal 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 (*Score*) and charge ($S_{EM}$) alone. These fields represent intrinsic, localized (*Score*) 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 *Sthermal*, short for *Structured Thermal Entropy*.

*(i) Origin and Necessity of Sthermal*

Whereas *Score* is derived from the concentrated entropy due to rest mass and $S_{EM}$ from the spread associated with the electromagnetic field, *Sthermal* 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 *Sthermal* the key dynamic

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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 Sthermal Field*

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

$$S_{\text{thermal}}(x,y) = A \cdot \text{smooth\_rand}(x,y) \cdot \exp\left(-\frac{x^2+y^2}{2\sigma_{\text{th}}^2}\right) \quad (25)$$

Where: *smooth_rand (x, y)* is a low-pass filtered 2D random noise (e.g., convolution with a Gaussian kernel), $\sigma_{th}$ is the thermal spread radius, much wider than $S_{EM}$ or *Score*, *A* is a small amplitude scaling factor, ensuring *Sthermal* 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 1 before visualization or summation into the RGB field.

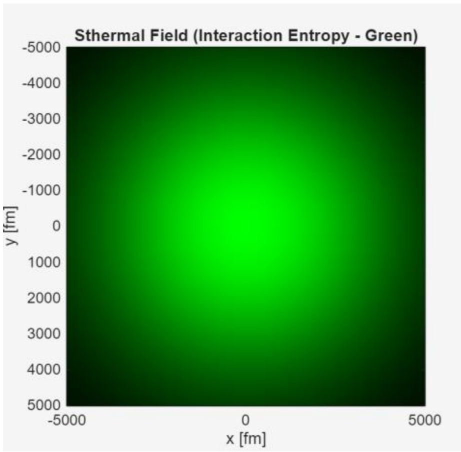


**Figure 4.** *Sthermal* field distribution of Electron.

*(iii) Physical Interpretation: The Missing Link in QM*

The *Sthermal* field (Figure 4) plays several vital roles that are ignored or marginalized in standard QM: *i)* entropy exchange: It captures the entropic flow to/from the environment, which is central to the measurement process *ii)* collapse sensitivity: the moment a high-energy photon enters the *Sthermal* field, recursive amplification of Sfield (RAS) with $S_{EM}$ can drive the system toward collapse, *iii) entropic equilibration: It defines the thermal envelope in which Score and* $S_{EM}$ *are modulated — without it, any energy-based picture misses the stochastic interactions needed for life, measurement, or evolution*, *iv)* time-evolution context: As shown in later sections, *Sthermal* governs local entropic time, as used in EPS (Entropy Positioning System [5]), defining the effective "aging" or dynamic change of field structure over time. Thus, in S-Theory, *Sthermal* 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.*

### 3.5. Combined Entropic Field of an Electron

Figures 5*a–c* present a summary of these three entropic subfields individually in color-coded visual form: *Score* in red, *SEM* in blue, and *Sthermal* in green, each emerging from the same radial coordinate space but expressing different spatial scales and intensity gradients. Figure 5*d* 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 (26).

$$S_{\text{total}}(\mathbf{r}) = S_{\text{core}}(\mathbf{r}) + S_{\text{EM}}(\mathbf{r}) + S_{\text{thermal}}(\mathbf{r}) \quad (26)$$

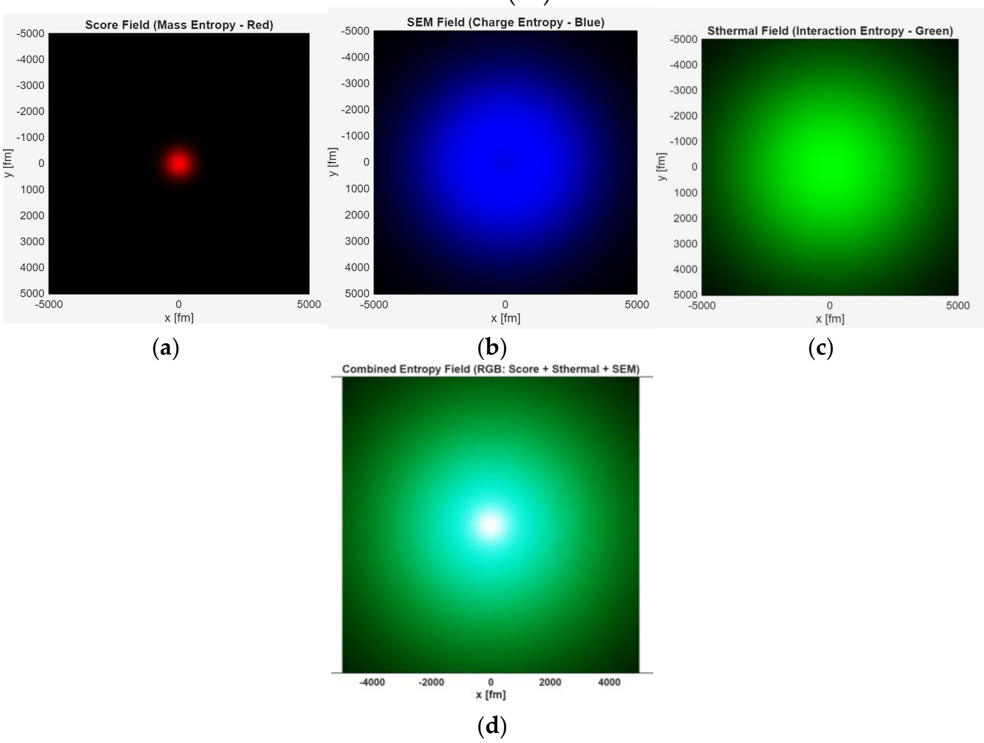


**Figure 5.** Combined *Stotal (r)* (total entropy field) of the Electron (RGB Composition).

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 Sthermal field appears as the green component, forming a diffuse glow enveloping the sharper Score (red-turned white in the combined image*)* and *SEM* (blue) fields. Its presence transforms the otherwise symmetrical Score–SEM model into a realistic, fluctuating, field-interactive system, opening the *door to a thermodynamic explanation of uncertainty, wavefunction collapse, and decoherence.*

*(i) Estimation of microstates of $S_{thermal}$: Comparison to Score and SEM*

Based on prior modeling, the *SEM* field is linked to the *Score* field by a scaling factor $\gamma$=3, leading to *SEM=3* x *Score* and an associated increase in microstates from $\Omega_{core}=2$ to $\Omega_{EM}=2^3=8$. For the *Sthermal* 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 *Sthermal=$\alpha \cdot$Score*. This yields a microstate range of $\Omega_{thermal} = 2\alpha = 32$ to 256. Thus, the *Sthermal* component carries the dominant share of entropy and microstates in the complete *Sfield* structure. Conceptually, the collapse process compresses this *Sthermal* cloud and the *SEM* field toward the *Score* 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*

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*dimension* neglected by traditional quantum mechanics and provides a more complete framework for understanding measurement, decoherence, 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:

$$\vec{v}_s(x,y) = A \cdot S(r) \cdot \begin{bmatrix} -\frac{y}{r} \\ \frac{x}{r} \end{bmatrix} \quad (27)$$

This creates a counterclockwise (CCW) circular rotation around the origin, representing spin-up, *x*/*r*, *y*/*r*, are unit tangent directions at radius *r*, ais the normalization constant, whose value is chosen so that the total angular momentum of the field equals ℏ/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:

$$L_z = \int \rho_s(r) \cdot v_\theta(r) \cdot r\, dA \quad (28)$$

Where:

$\rho_s(r) = S(r)$: entropy-based "mass" density analog.

$v_\theta(r) = A \cdot S(r)$: tangential velocity magnitude.

$r$: radius from the core.

$dA = 2\pi r\, dr$: area element in polar coordinates.

This gives

$$L_z = A \int_0^\infty S(r)^2 \cdot r^2 \cdot 2\pi\, dr \quad (29)$$

Substituting

$$S(r) = S_0\, e^{-r^2/(2\sigma^2)} \quad (30)$$

We get

$$L_z = 2\pi A S_0^2 \int_0^\infty r^2 e^{-r^2/\sigma^2} dr \quad (31)$$

This evaluates to

$$L_z = 2\pi A S_0^2 \cdot \frac{\sqrt{\pi}}{4} \sigma^3 \quad (32)$$

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

$$A = \frac{\hbar}{2\pi S_0^2 \cdot \frac{\sqrt{\pi}}{2} \cdot \sigma^3} = \frac{\hbar}{\pi^{3/2} S_0^2 \sigma^3} \quad (33)$$

In the simulation, we choose

- $\hbar = 1.055\times10^{-34}\, J\, s$
- $S_0 = 1$(dimensionless, normalized)
- $\sigma = 10\, fm = 10\times10^{-15}$ m

Resulting in:

$A \approx 4.79\times10^6$ (SI units) (34)

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*This ensures that the total angular momentum stored in the entropy-rotating field equals the electron's spin: Lz =ℏ/2*

*4.2. Spin-Up and Spin-Down Representation*

The sign of the spin vector field determines the spin direction:

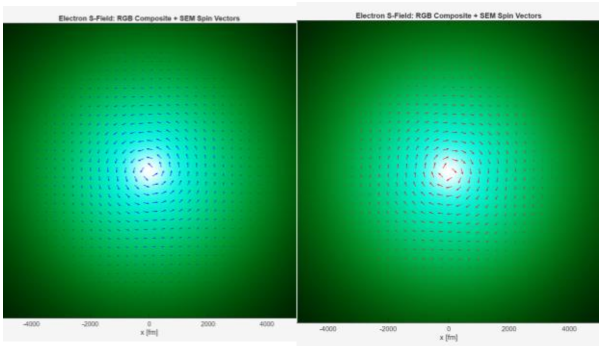
For **spin-up** ( $+\hbar/2$ ), we use:

$$\vec{v}_s = A \cdot S(r) \cdot \left(-\frac{y}{r}, \frac{x}{r}\right)$$

For **spin-down** ( $-\hbar/2$ ), we reverse the circulation:

$$\vec{v}_s = A \cdot S(r) \cdot \left(\frac{y}{r}, -\frac{x}{r}\right) \quad (35)$$

Figure 6 shows the Electron *SEM* field we generated in the previous section (Figure 5*d*) with overlaid spin vector fields derived from section 4.1. Figure 6*a* (Left): Spin-Up (counterclockwise vector circulation). Figure 6*b* (Right): 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 (*SEM*) surrounding the electron's core (*Score*). When a tangential vector field is applied to the *SEM* — creating a circulating entropy density around the *Score* — a coherent rotational structure forms. This rotating field, once normalized to yield angular momentum ℏ/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 ℏ/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 (*Score*), the electromagnetic entropy cloud (*SEM*), the ambient entropy fog (*Sthermal*), 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 7*a* as Sn (RAS0), where the electron's full *Sfield* 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* — the recursive amplification of the Sfield (RAS) mechanism of S-Theory.

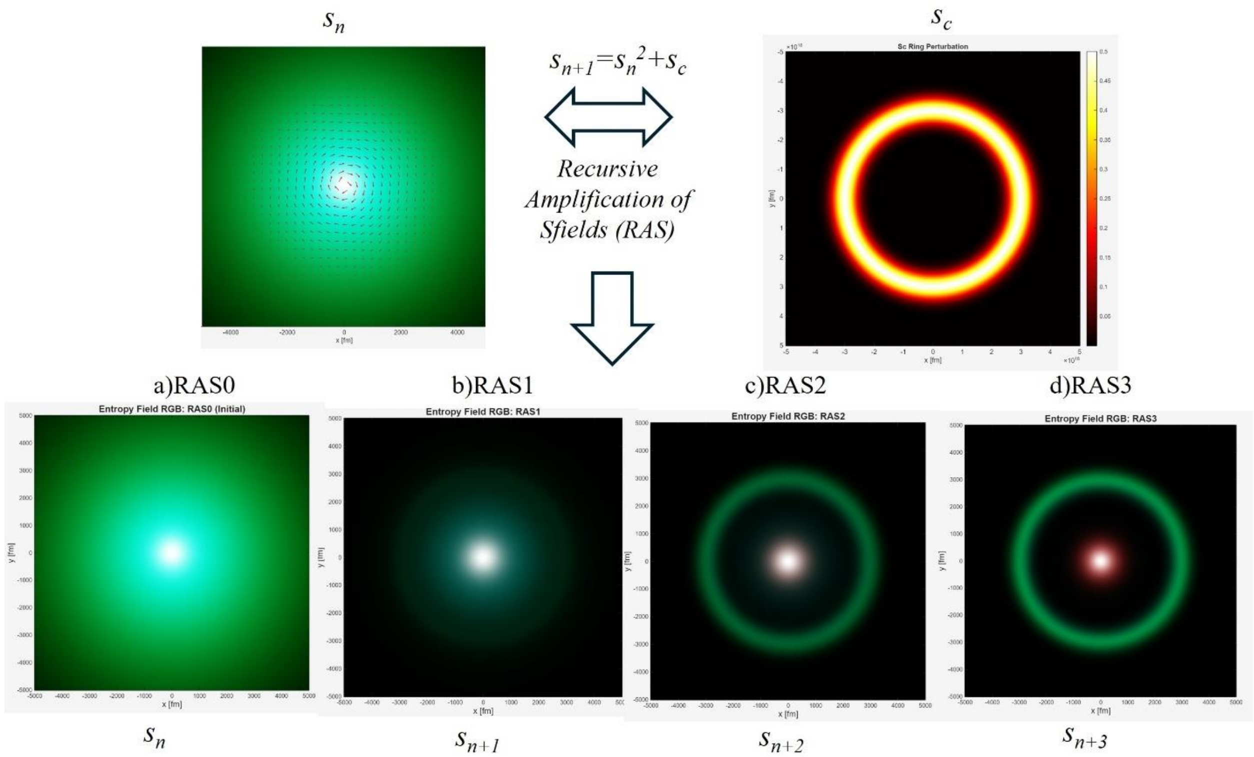



**Figure 7.** Recursive Entropy Field Dynamics of the Electron: Computed Pre-Collapse Configuration RAS0 ($s_n$) and Perturbation Ring ($s_c$) and RAS1 ($s_{n+1}$), RAS2 ($s_{n+2}$), and RAS3 ($s_{n+3}$).

### *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: $s_{n+1}=s_n^2+s_c$ *(2). 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 (*Score*) provides a localized anchor, while the incoming field perturbs its surrounding $S_{EM}$ and *Sthermal* layers. To model this, we inject a structured entropy field $s_c$ — a circular entropy ring as shown in Figure 7*b* — 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 — 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)* $s_{thermal}$: representing ambient entropy noise or vacuum fluctuations, *ii)* $s_{EM}$: 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 $s_{core}$ + $s_{EM}$ + $s_{thermal}$, 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 — 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 $s_n(x, y) = S_n(x, y)/S_0$, $sc(x, y) = Sc(x, y)/S_0$. The update is applied pointwise on a uniform 2-D grid as the non-dimensional map given in equation 2 with no per-step re-normalization. (Equivalently, in dimensional variables $Sn{+}1{=}Sn^2/S_0{+}Sc$, 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 **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.

### 6.1. Simulation of Sfield from RAS0 to RAS3 (Field Images)

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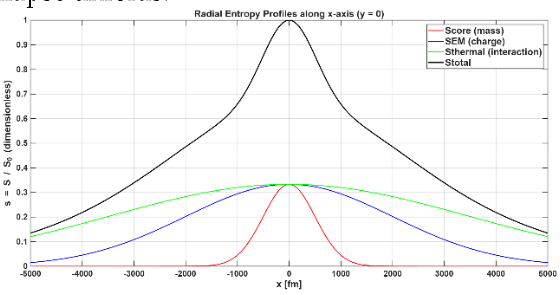
Figure *7a-d* illustrates the full-field evolution of the electron's entropy structure during recursive amplification (RAS) collapse. Figure. 7*a* shows the initial entropy field (RAS0), where the core ($s_{core}$), charge field ($s_{EM}$), and thermal field ($s_{thermal}$) form a smoothly blended, diffuse $s_{max}$ 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*.

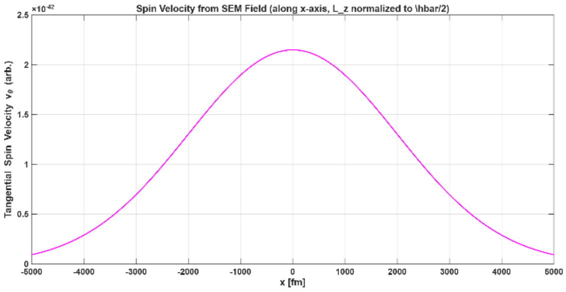
*6.2. Simulation of Sfield from RAS0 to RAS3 (Sfield Density Profiles)*

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*: Score, 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* (Eq. 4). ii) *Blue*: $s_{EM}$, the entropy from charge-based electromagnetic interaction. It is broader than the $s_{core}$, derived from Eq. 10, with width $\sigma_q=4\ \lambda_C$, and reflects the more spread-out field influence. iii) *Green:* $s_{thermal}$, 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

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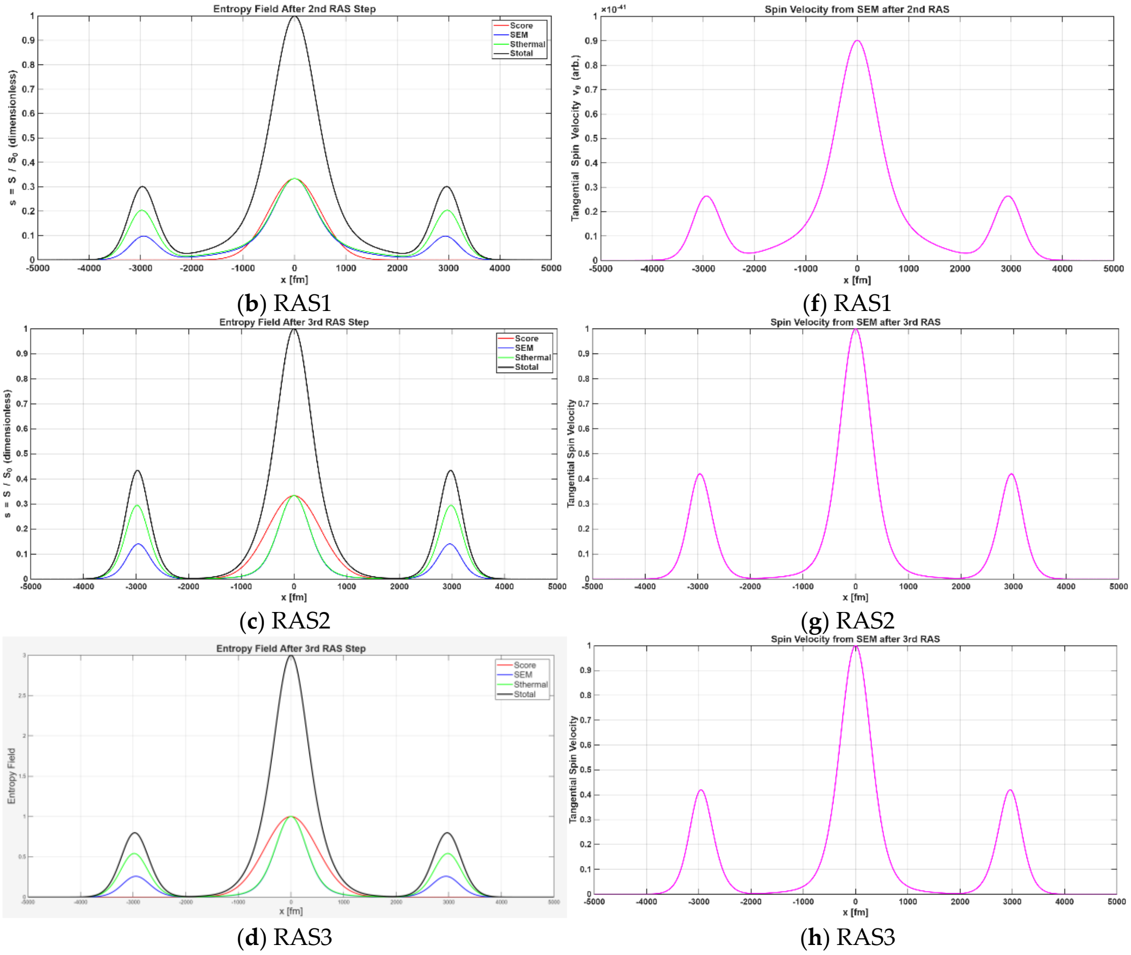



**Figure 8.** Recursive Entropic Collapse of the Electron: RAS Evolution of Entropy Field Magnitude and Spin Velocity. Subfigures *a–d* shows the evolution of $s_{core}$, $s_{EM}$, $s_{thermal}$, and $s_{total}$ entropy fields, along with the corresponding tangential *e-h)* spin velocities, across three recursive amplification steps.

*ii) Figure 8e: Tangential Spin Velocity Profile from* $s_{EM}$*:* The corresponding spin field (Figure 8*e*) 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: *i)* A wide, smooth bell-shaped profile indicating that spin is not sharply localized, *ii)* 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, Figures 8*a* and 8*e* provide a clear baseline: *i)* the electron is not a point, but an extended entropy structure, ii) its mass (score) is tightly bound and carries high local entropy density, *iii)* its charge field ($s_{EM}$) is broader and rotating — the source of spin.

*iv) RAS Step 1 — Beginning of Collapse: Compression and New Structure Formation:* In Figure 8*b*, we present the result of the first recursive amplification step (RAS1) applied to the electron's non-dimensional entropy field using the update rule: $s_{n+1}=s_n^2+s_c$ *(2)*. 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 8*a*). 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 — secondary peaks symmetrically located away from the core.

These likely represent redistributed and amplified *Sthermal* 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 x = 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 8*f*) confirms the same trend from a rotational perspective: *i)* The rotational entropy flow, previously broad (Figure 8*e*), 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.

*v) 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, *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.

*v) 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 8*c*): Key observations: *i)* 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.

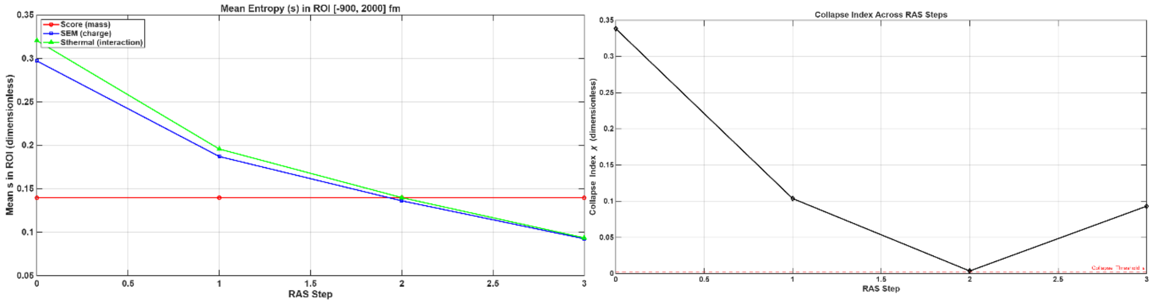
### *6.3. Local Mean of Entropy Field s, and the Collapse Criterion*

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

$$\bar{s}_n^A = \frac{1}{|A|}\int_A s_n \, dA \qquad (36)$$

This quantity is dimensionless and grid-independent, and we compute it analogously for each component ($s_{core}$, $s_{EM}$, *sthermal*). In the 1-D 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≈3000 *fm*; results are robust to symmetric alternatives such as [−1500, 1500] *fm* or to circular ROIs r≤2500 *fm*.

Figure 9*a* shows the evolution of local mean *s* for each of the three primary entropy fields — $s_{core}$ (red), $s_{EM}$ (blue), and *sthermal* (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 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, has focused its structure onto a central entropic state — a necessary condition for quantum measurement or collapse. Figure 9*b* provides a more explicit metric: the *Collapse Index*, denoted as $\chi$, 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:

$$\chi_n^A = \left|\bar{s}^A_{\mathrm{SEM},n} - \bar{s}^A_{\mathrm{Score},n}\right| + \left|\bar{s}^A_{\mathrm{Sth},n} - \bar{s}^A_{\mathrm{Score},n}\right| \tag{37}$$

By construction, $\chi$ is dimensionless. We declare "collapse" when $\chi$ falls below a small tolerance (we use $\varepsilon=2\times10^{-3}$ 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 $\chi_{min}$, beneath which the fields are considered thermodynamically indistinguishable. We observe: *i)* A steep decline in $\chi$ from RAS 0 to RAS 2. *ii)*At RAS = 2, $\chi$ 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, $\chi$ slightly increases — reflecting an over-collapse or post-collapse redistribution. Together, Figures 9*a* and 9*b* provide a robust thermodynamic collapse condition. *Collapse does not require abstract wavefunction postulates — 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.

## 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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**Data Availability Statement:** All numerical and simulation data are presented within the figures and text of this paper. The underlying MATLAB code for entropy field generation, recursive amplification, and collapse simulation is available from the corresponding author upon request for editorial or peer review.

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