The Probabilistic Field Hypothesis: From Pre-Spacetime States to Emergent Physics

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Abstract

We propose a hypothesis that physical spacetime and interactions emerge from a deeper probabilistic field existing at zero entropy level. In this state there is no space or time, only amplitudes and probability fields representing potential configurations of all possible energies and interactions. We outline the basic postulates, present preliminary mathematical formulations, and sketch a research program aimed at connecting this framework with known physical laws and constants.

1 Postulate 1: Zero-Entropy State

We posit the existence of a fundamental level with no time and no space, characterized by vanishing entropy:

$$S \to 0.$$

In this regime, the universe is described by a pure probabilistic field of amplitudes:

$$\Psi = \sum_i a_i |i\rangle,$$

where $\{|i\rangle\}$ are potential configurations (spaces, energies, interactions) and $a_i \in \mathbb{C}$ are their amplitudes.

2 Postulate 2: Energy as Pure Potential

Energy exists in this zero-entropy regime only as potential, not as realized dynamics.

$$E = \frac{1}{2} k |u|^2,$$

with u being a displacement in the probabilistic field and k a universal stiffness coefficient.

Quantized form:

$$E_n = \hbar\omega \left(n + \tfrac{1}{2}\right),$$

where ω arises from the structure of the probability field rather than from classical geometry.

3 Postulate 3: Emergence of Spacetime

The appearance of time and space is modeled as a decoherence process:

$$\Psi \xrightarrow{\text{decoherence}} \rho(x,t) = |\Psi(x,t)|^2.$$

Thus, spacetime coordinates (x,t) are emergent from the underlying amplitude structure.

4 Postulate 4: Compact and Extended Modes

Not all modes unfold into macroscopic spacetime. Energy is distributed over dimensions as

$$E = \sum_{D=0}^{\infty} \sum_{n_D} \hbar\omega_D \left(n_D + \epsilon_D\right),$$

with ω_D denoting eigenfrequencies of D-dimensional modes and ϵ_D the zero-point shifts. Modes with large ω_D remain compactified (e.g. Calabi–Yau), while modes with small ω_D extend into the observable macroscopic dimensions.

5 Postulate 5: Entropy and Dimensional Dynamics

The growth of entropy corresponds to the unfolding of dimensions:

- At $S = 0$ all dimensions exist only as potential modes.
- For $S > 0$ a subset of modes decoheres into extended spacetime.

6 Research Program

Stage 1. Mathematical Formalization

- Build explicit models of Ψ as a non-coordinate probability field.
- Introduce spectrum $\{\omega_D\}$ as universal modes.
- Relate ω_D to fundamental constants $\hbar, c, G, k_B$.

Stage 2. Reduction to Known Laws

- Demonstrate that projection to $3+1$ dimensions reproduces $E = mc^2$, Schrödinger equation, and Einstein equations.
- Renormalize coefficients k, ω_D to Planck units.

Stage 3. Numerical Experiments

- Simulate simple probabilistic fields (two or three superposed modes).
- Track which modes unfold into "space" with increasing entropy.
- Compare to known compactification patterns of Calabi–Yau manifolds.

Stage 4. Standard Model Connection

- Attempt to express interaction constants (electroweak, strong, gravity) in terms of ω_D.
- Explore approximations of their observed magnitudes after renormalization.

Stage 5. Empirical Signatures

- Search for imprints of compactified modes in the CMB spectrum or dark energy distribution.
- Hypothesis: fluctuations from compactified dimensions may appear as noise or anomalies in the observed spectrum.

7 Conclusion

We have outlined a framework where the universe originates from a probabilistic field at zero entropy, with spacetime, energy, and interactions emerging via decoherence and unfolding of modes. This proposal suggests a new path: not from space to wave, but from wave to space. Future research will focus on renormalizing the framework to reproduce known physics and exploring potential experimental signatures.