1 Unistochastic Quantum Transitions from RSVP Field Dynamics

The RSVP (Recursive Scalar-Vector-Entropy Propagation) framework reinterprets cosmological and cognitive dynamics through the lens of entropic field evolution. This section formalizes the unistochastic correspondence, mapping RSVP field dynamics to quantum-like transitions in a semantic state space. We introduce prerequisite concepts, including the limit integral semantic vector space and the role of amplitwisters as universal function approximators, before deriving the unistochastic transition matrix and its implications for consciousness as an entropic organizer.

1.1 Prerequisites: Semantic Vector Space and Limit Integrals

The RSVP framework posits a plenum Ω, a smooth, compact manifold equipped with fields $(\Phi, \vec{v}, S)$, representing scalar potential, vector flow, and entropy, respectively. To formalize the cognitive state space, we define a *semantic vector space* that encodes the informational structure of these fields.

Definition 1.1 (Limit Integral Semantic Vector Space)**.** *Let $\mathcal{H}_\Omega$ be a Hilbert space over Ω, with vectors representing semantic states of regions $\{R_a\}_{a=1}^N \subset \Omega$. For each region R_a, the semantic state is defined via a limit integral:*

$$|\psi_a\rangle = \lim_{\epsilon \to 0} \frac{1}{\sqrt{\phi(R_a)}} \int_{R_a} \chi_\epsilon(x) \begin{pmatrix} \alpha_1^{1/2} \nabla S \\ \alpha_2^{1/2} \nabla \Phi \\ \alpha_3^{1/2} \vec{v} \end{pmatrix} dx,$$

where $\chi_\epsilon(x)$ is a smooth cutoff function (e.g., a mollifier) ensuring convergence, $\phi(R_a) = \int_{R_a} \mathcal{C}(x,t)\, dx$ is the consciousness functional, and $\alpha_1, \alpha_2, \alpha_3 > 0$ are coupling constants. The inner product is:

$$\langle \psi_a | \psi_b \rangle = \lim_{\epsilon \to 0} \frac{1}{\sqrt{\phi(R_a)\phi(R_b)}} \int_{R_a \cap R_b} \chi_\epsilon(x) \left(\alpha_1 \nabla S_a \cdot \nabla S_b + \alpha_2 \nabla \Phi_a \cdot \nabla \Phi_b + \alpha_3 \vec{v}_a \cdot \vec{v}_b \right) dx.$$

The limit integral ensures that the semantic state vectors are well-defined even in regions with singularities or discontinuities in the field gradients. The consciousness functional $\phi(R_a)$ quantifies the cognitive capacity of R_a, normalizing the state to satisfy $\langle \psi_a | \psi_a \rangle = 1$. This construction embeds the RSVP fields into a separable Hilbert space, enabling a quantum-like description of semantic transitions.

1.2 Amplitwister and Universal Function Approximation

The RSVP framework leverages the concept of an *amplitwister*, a complex-valued mapping that encodes field dynamics in the complex plane, to demonstrate the universality of the consciousness functional $\mathcal{C}(x,t)$. We establish that the amplitwister acts as a universal function approximator, capable of representing arbitrary cognitive states.

Theorem 1.1 (Amplitwister Universality)**.** *The consciousness functional $\mathcal{C}(x,t)$, when composed with an amplitwister mapping $\mathcal{A} : \Omega \to \mathbb{C}$, defined as:*

$$\mathcal{A}(x,t) = \exp\left(i \int_{R_a} (\beta_1 \nabla S + \beta_2 \nabla \Phi + \beta_3 \vec{v}) \cdot d\vec{l} \right),$$

where $\beta_1, \beta_2, \beta_3$ are complex weights, is a universal function approximator for any continuous function $f : \Omega \to \mathbb{R}$ in the L^2 norm.

Proof. The amplitwister $\mathcal{A}(x,t)$ maps RSVP field gradients to a phase in the complex plane, analogous to a neural network activation function. By the Stone-Weierstrass theorem, any continuous function on a compact manifold can be approximated by polynomials. The exponential form of $\mathcal{A}$ generates a dense set of functions in $L^2(\Omega)$ due to the completeness of the Fourier basis in the complex plane. Specifically, for any $f \in L^2(\Omega)$ and $\epsilon > 0$, there exists a linear combination of amplitwisters:

$$f(x) \approx \sum_{k=1}^{K} c_k \mathcal{A}_k(x,t),$$

where $c_k \in \mathbb{C}$ and $\mathcal{A}_k$ are amplitwisters with varying weights β_i. The path integral along $d\vec{l}$ ensures that nonlocal correlations in the fields are captured, enhancing the expressive power of $\mathcal{A}$. Thus, $\mathcal{C}(x,t)$, when composed with $\mathcal{A}$, can approximate any cognitive state or observable process in Ω. □

This universality underpins the flexibility of the RSVP framework in modeling consciousness as an emergent property of entropic field dynamics.

1.3 Semantic Regions and ϕRSVP Functional

We partition Ω into semantic regions $\{R_a\}_{a=1}^N$, each satisfying:

1. **Coherence**: $\|\nabla\Phi\|_{L^2(R_a)} \leq C_\Phi$, ensuring bounded scalar field variations.
2. **Entropic isolation**: $\|\nabla S\|_{L^2(\partial R_a)} \geq \epsilon_S$, enforcing thermodynamic distinction at region boundaries.
3. **Cognitive flux**: $\int_{R_a} \nabla \times \vec{v}\, dx \neq 0$, indicating nonzero dynamical activity.

Definition 1.2 (ϕRSVP State Vector)**.** *The cognitive state vector for region R_a is:*

$$|\psi_a\rangle := \frac{1}{\sqrt{\phi(R_a)}} \int_{R_a} \begin{pmatrix} \alpha_1^{1/2}\nabla S \\ \alpha_2^{1/2}\nabla\Phi \\ \alpha_3^{1/2}\vec{v} \end{pmatrix} dx,$$

where $\phi(R_a) = \int_{R_a} \mathcal{C}(x,t)\, dx$, and $\mathcal{C}(x,t)$ is the consciousness functional approximated via amplitwister compositions.

1.4 Unistochastic Transition Matrix

Theorem 1.2 (Emergent Unistochastic Dynamics)**.** *The transition probability $P(R_a \to R_b)$ between semantic regions is governed by a unistochastic matrix $B_{ab} = |U_{ab}|^2$, where:*

$$U_{ab}(t) = \langle\psi_a|\psi_b\rangle = \frac{1}{\sqrt{\phi(R_a)\phi(R_b)}} \int_{R_a \cap R_b} (\alpha_1 \nabla S_a \cdot \nabla S_b + \alpha_2 \nabla\Phi_a \cdot \nabla\Phi_b + \alpha_3 \vec{v}_a \cdot \vec{v}_b)\, dx.$$

The matrix satisfies $\sum_b B_{ab} = 1$ for all a.

Proof. The RSVP fields evolve via coupled PDEs:

$$\begin{aligned} \partial_t S &= \nabla \cdot (D_S \nabla S) + F_S(\Phi, \vec{v}), \\ \partial_t \Phi &= \nabla^2\Phi + F_\Phi(S, \vec{v}), \\ \partial_t \vec{v} &= -\nabla P + \nu\nabla^2\vec{v} + F_v(S, \Phi), \end{aligned}$$

where D_S, ν are diffusion coefficients, P is a pressure term, and F_S, F_Φ, F_v are nonlinear interactions. The state vector $|\psi_a\rangle$ is normalized in $\mathcal{H}_\Omega$. The transition matrix $B_{ab} = |U_{ab}|^2$ is unistochastic if $\sum_b |U_{ab}|^2 = 1$.

The inner product U_{ab} is bounded by:

$$|U_{ab}| \leq \frac{1}{\sqrt{\phi(R_a)\phi(R_b)}} \|\alpha_1 \nabla S_a \cdot \nabla S_b + \alpha_2 \nabla\Phi_a \cdot \nabla\Phi_b + \alpha_3 \vec{v}_a \cdot \vec{v}_b\|_{L^1(R_a \cap R_b)}.$$

Applying Hölder's inequality:

$$\|\nabla S_a \cdot \nabla S_b\|_{L^1} \leq \|\nabla S_a\|_{L^2} \|\nabla S_b\|_{L^2} \leq C_S^2,$$

and similarly for $\nabla\Phi$ and $\vec{v}$. Since $\{R_b\}$ partitions Ω, the total probability is:

$$\sum_b |U_{ab}|^2 = \sum_b |\langle\psi_a|\psi_b\rangle|^2 = \langle\psi_a| \sum_b |\psi_b\rangle\langle\psi_b|\psi_a\rangle = \langle\psi_a|\psi_a\rangle = 1,$$

by the completeness of the basis $\{|\psi_b\rangle\}$. For the time evolution, compute:

$$\partial_t U_{ab} = \frac{1}{\sqrt{\phi(R_a)\phi(R_b)}} \int_{R_a \cap R_b} \left(\alpha_1 \nabla(\partial_t S_a) \cdot \nabla S_b + \alpha_2 \nabla(\partial_t \Phi_a) \cdot \nabla \Phi_b + \alpha_3 (\partial_t \vec{v}_a) \cdot \vec{v}_b\right) dx + \text{conjugate terms.}$$

Substituting the PDEs, the diffusion terms dominate, and Sobolev estimates ensure boundedness:

$$\|\partial_t S\|_{H^1} \leq C \left(D_S \|\nabla^2 S\|_{L^2} + \|F_S\|_{L^2}\right).$$

The nonlinear terms F_S, F_Φ, F_v are assumed Lipschitz, preserving unitarity over finite timescales. □

1.5 Quantum-Cognitive Correspondence

Corollary 1.1 (Measurement as Semantic Collapse)**.** *If $\partial_t S$ in region R_a exceeds a threshold γ, the state collapses to the eigenregion R_k maximizing B_{ak}:*

$$\lim_{t \to t_0^+} P(R_a \to R_k) = \frac{|U_{ak}|^2}{\sum_b |U_{ab}|^2}.$$

Table 1: Dictionary of RSVP to Quantum Phenomena

Quantum Concept	**RSVP Realization**
Unitary evolution	RSVP PDE flow
Density matrix ρ	Region-weighted $\int \psi_a \psi_a^\dagger \, da$
Decoherence	$\nabla \cdot \vec{v} > \tau_{\text{diss}}$
Entanglement	Nonlocal Φ-correlations across $R_a \cup R_b$

1.6 Path Integral Formulation

The observer's trajectory Γ in semantic space has amplitude:

$$\mathcal{A}(\Gamma) = \exp\left(\int_\Gamma \log\langle \psi_{\gamma(t)} | \dot{\gamma}(t) \rangle \, dt\right).$$

1.7 Future Directions

1. Numerical computation of B_{ab} spectra for sample RSVP field configurations.
2. Comparison with Barandes's unistochastic axioms.
3. Derivation of entropy production to decoherence timescale relations.