PFUSRC-008: Probability Ontology ——Small Probability, Uncertainty, Fault-Tolerance Axiom, Valuation Axiom, and the Adaptive Risk-Avoidance of the β_1 Subject

Zhenmin Wang (Daoshen)

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Abstract

As a core ontological pillar of the PFUSRC framework, this paper introduces **Axiom 8 (Probability Stratification Axiom)** on the foundation of the existing seven axioms, establishing a complete mathematical-physical framework for probability ontology and formally closing the entire axiomatic system. This paper vertically anchors the full spectrum of PFUSRC achievements, serving as an extension of the axiomatic system in PFUSRC-00, an ontological foundation for the β_1 field theory in PFUSRC-001, an application of the 12/11 characteristic constant in probability dynamics grounded in PFUSRC-002, a philosophical underpinning for the quantitative predictions in PFUSRC-005/006, a probabilistic expression of the tangent space approximation of general relativity in PFUSRC-007, and a macroscopic thermodynamic manifestation of the non-integrable rotational residual in PFUSRC-13.

The core conclusions are quantified as follows:

1. **Probability Stratification Axiom**: Probability is not a statistical measure of human information deficiency but an intrinsic property of the hierarchical structure of the cosmos. Ontological units with higher regulatory weight converge in low-probability, weakly coupled, uncertain physical intervals. The small-probability domain carries core regulatory functions and cannot be artificially eliminated through valuation rules.

2. **Reach Cost Axiom**: The objective cost required to reach an event with probability P satisfies $C_{\text{reach}} = C_0 \cdot P^{-\alpha}$ ($\alpha > 0$), with dimensions of action $[E \cdot T]$. As probability approaches zero, the reach cost tends to infinity. Small probabilities naturally construct a physical safety barrier for the primordial subject, within which β_1 stably resides.

3. **New Interpretation of the Uncertainty Principle**: $\Delta x \cdot \Delta p \geq \frac{\hbar}{2} \cdot f(\beta_1)$, where $f(\beta_1) = e^{\kappa \Delta A}$ is the adaptive risk-avoidance response function of β_1, rigorously derived from the bicone convergence damping formula. In the normal state, $\Delta A = 0$ and $f(\beta_1) = 1$, reducing to the Heisenberg uncertainty principle. When a probe approaches the boundary of the β_1 subject, $\Delta A \to \Delta A_{\max}$ and $f(\beta_1) \to \infty$, with uncertainty diverging. The quantum measurement uncertainty effect is not an intrinsic randomness of microscopic particles but a dynamic escape representation of the primordial subject when encountering probing disturbances.

4. **Black Swan Theorem**: When the cumulative disturbance integral of the entire system exceeds the outer fault-tolerance critical threshold $D_{\text{tolerance}}$, the system undergoes structural collapse. This sudden change is a global rebalancing mechanism after β_1 is accidentally reached and the only observable empirical evidence of the hidden subject transitioning from implicit to explicit.

This paper establishes seven clear falsifiability criteria, satisfying the empirical standards of modern natural science. Proceeding from axioms, supported by multi-scale empirical evidence, and accompanied by clear falsifiability boundaries, this work completes the transformation of probability ontology from philosophical speculation into a quantitative physical theory.

Keywords: Probability Stratification Axiom; Reach Cost; β_1 Subject; Modified Uncertainty Principle; Black Swan Theorem; Fault-Tolerance Axiom; Valuation Axiom

1 Probability Axiom (Axiom 8)

1.1 Axiom Statement

Probability Stratification Axiom (Axiom 8, the eighth fundamental axiom of the PFUSRC system): Probability is not a statistical measure of human observational information deficiency but an intrinsic objective property derived from the topological stratification of the cosmic system. The more core the regulatory unit of the system, the more it converges in low-probability, weakly coupled, uncertain intervals.

1.2 Mathematical Formulation

Let the probability space of the cosmic system be $\mathcal{P}$. Its stratified structure satisfies:

$$\mathcal{P} = \mathcal{P}_{\text{high}} \cup \mathcal{P}_{\text{low}}, \quad \mathcal{P}_{\text{high}} \cap \mathcal{P}_{\text{low}} = \varnothing$$

where: - $\mathcal{P}_{\text{high}}$: high-probability interval, corresponding to the outer fault-tolerant structure (domain of classical physics) - $\mathcal{P}_{\text{low}}$: low-probability interval, corresponding to the β_1 exclusive ontological hidden probability domain (quantum uncertainty, weak interaction concentration interval)

1.3 Relation to the Valuation Axiom

The Valuation Axiom sets a truncation threshold P_{min} for engineering simplification:

$$\theta(P) = \begin{cases} 1, & P \geq P_{\text{min}} \\ 0, & P < P_{\text{min}} \end{cases}$$

The truncated probability space is $\mathcal{P}_{\text{valuation}} = \{P_i \mid P_i \geq P_{\text{min}}\}$.

Since $\mathcal{P}_{\text{low}} \subset \{P_i \mid P_i < P_{\text{min}}\}$, the Valuation Axiom operationally removes the probability space in which β_1 exists.

The information entropy loss due to truncation is:

$$\Delta S_{\text{truncation}} = -\sum_{P_i < P_{\text{min}}} P_i \ln P_i$$

This lost information entropy corresponds precisely to the ontological domain of β_1. The truncation entropy loss is homologous to the non-integrable rotational residual entropy increase in PFUSRC-13, reflecting the information cost of artificially removing the primordial domain through mathematical modeling.

1.4 Axiom Comparison Table

2 Four Categories of Empirical Evidence: Small Probability Supports the System Skeleton

2.1 Quantum Tunneling

Quantum tunneling probability $P_{\text{tunnel}} \ll 1$ sustains stellar fusion and the energy source of life. Without small-probability tunneling, the macroscopic energy chain of the cosmos would break.

Axiom	Content	Relation to Probability Axiom
Axiom 1	Global self-sustaining closure	Probability stratification holds within closed boundaries
Axiom 2	Shear-free deformation	Small-probability hiding does not destroy deformation sm
Axiom 3	Elimination of redundant dimensions	β_1 hides in low-probability domain, occupies no redundar
Axiom 4	Optimal self-organization of nodes	Node distribution determines probability stratification, ar
Axiom 5	Fixed projection rules	Projection of small-probability domain appears as uncert
Axiom 6	12/11 phase ratio invariance	Risk-avoidance motion ratio converges to 12/11
Axiom 7	Irreversible growth	Small-probability hiding serves overall growth
Axiom 8	**Probability stratification**	—

Table 1: Relationship between Axiom 8 and existing axioms

2.2 Genetic Mutation

Genetic mutation probability $P_{\text{mutate}} \ll 1$ is the sole driving force of biological evolution. All key transitions of living systems are anchored in small-probability intervals.

2.3 Wavefunction Collapse

Wavefunction collapse accompanies measurement uncertainty. The probabilistic discreteness of microscopic observations is not "intrinsic randomness" of particles but the passive avoidance of probing disturbances by the primordial subject (β_1).

2.4 Macroscopic Black Swan

Macroscopic black swan events have probability $P \to 0$ in conventional valuation models yet can shatter the top-level rules of mature systems. This proves that the small-probability region stores the highest-level constraints of the system, the non-eliminable underlying skeleton of the entire system architecture.

Conclusion of this section: Small probability is not "negligible noise" but the skeleton of the system. Removing the small-probability interval removes the core functions of the system.

3 Reach Cost and Safety Barrier

3.1 Reach Cost Axiom

Reach Cost Axiom: The cost required to reach an event with probability P satisfies the power-law form (primary recommended model):

$$C_{\text{reach}}(P) = C_0 \cdot P^{-\alpha}, \quad \alpha > 0$$

Dimension definition: The dimension of C_{reach} is action $[E \cdot T]$. C_0 is the cosmic reference action constant, unified with the global dimensional reference constant in PFUSRC-001.

Physical interpretation: C_{reach} is the minimum spacetime action that the observing system must pay to penetrate the low-probability shield, integrating quantum action, information entropy truncation, and bicone topological energy coupling.

The exponential form (alternative extended model) is:

$$C_{\text{reach}}(P) = C_0 \cdot e^{-\beta P}, \quad \beta > 0$$

Both functional forms satisfy the safety limit condition $C_{\text{reach}} \to \infty$ as $P \to 0$.

3.2 Safety Barrier

The small-probability space inhabited by the β_1 subject satisfies:

$$P_{\beta_1} < \epsilon, \quad \epsilon \ll 1$$

where ϵ is lower than the general valuation lower limit $P_{\min}$ in all domains. Thus, β_1 naturally falls under the double shielding of the valuation truncation region and the high-reach-cost region.

Consequently, the cost to reach β_1 tends to infinity:

$$C_{\text{reach}}(\beta_1) \to \infty$$

Safety Barrier Theorem: Small probability naturally forms an ontological safety barrier. β_1 is unreachable by conventional observation, valuation, or experimental cutting, not because it does not exist, but because the reach cost is infinite.

4 Uncertainty as the Risk-Avoidance Appearance of β_1

4.1 Rigorous Derivation of $f(\beta_1)$

Starting from the bicone convergence damping formula in PFUSRC-001:

$$\Phi = A_+ \cdot e^{-\kappa|A_+ - A_-|} \cdot \delta(S_{\max})$$

Define the probing disturbance difference $\Delta A = |A_+ - A_-|$. The risk-avoidance response intensity is inversely defined from the damping factor $e^{-\kappa \Delta A}$:

$$f(\beta_1) = e^{\kappa \Delta A}$$

where $\kappa = \pi_1 = 12/11$ (traceable to PFUSRC-002).

When the system is in the waist steady state, $\Delta A = 0$ and $f(\beta_1) = 1$, reducing to the Heisenberg uncertainty principle.

When a probe approaches the boundary of the β_1 subject, $\Delta A \to \Delta A_{\max}$ and $f(\beta_1) \to \infty$, with uncertainty diverging.

Conclusion: The modified uncertainty formula is a direct mathematical consequence of bicone topology and geometry, not an empirical hypothesis.

4.2 Reformulation of the Uncertainty Principle

The standard uncertainty principle is:

$$\Delta x \cdot \Delta p \geq \frac{\hbar}{2}$$

This paper modifies it to:

$$\Delta x \cdot \Delta p \geq \frac{\hbar}{2} \cdot e^{\kappa \Delta A}$$

Key distinction: The uncertainty principle is a lower bound on measurement precision and is not equivalent to "uncertainty." The latter is the observational appearance of β_1's risk-avoidance motion.

4.3 Relation Between Risk-Avoidance Motion and $\pi_1 = 12/11$

The risk-avoidance motion of β_1 follows the principle of least action, and its adjustment ratio converges to the PFUSRC intrinsic convergence constant:

$$\lim_{t\to\infty} \frac{\Delta\phi_{\text{avoid}}}{\Delta\phi_{\text{total}}} = \frac{12}{11}$$

This ratio is consistent with the entropy-phase relation in PFUSRC-13:

$$\Delta S = C \cdot \frac{12}{11} \cdot \Delta\phi + \Delta S_{\text{bg}}$$

4.4 Relation to the Tangent Space Approximation of GR

According to PFUSRC-007, general relativity holds only on the tangent plane at the waist of the bicone ($\Delta A = 0$). Once a probing disturbance deviates from the waist position, the tangent space approximation breaks down, $f(\beta_1) > 1$, and uncertainty deviates from the standard lower bound.

Uncertainty = the subject actively avoiding the detection boundary = projection of deviation from the waist.

The uncertainty principle is not equivalent to uncertainty. The former is a lower bound on measurement precision; the latter is the observational appearance of β_1's risk-avoidance motion.

You are not "discovering laws." You are "disturbing the subject."

5 Physical Substantive Definition of β_1

5.1 Ontological Positioning

The physical positioning of β_1 is as follows:

Level	Definition
Ontology	Dynamic intrinsic driving mode of the 11D bicone topological system
Physical essence	Dynamic shift source of vacuum zero-point energy
Low-dimensional projection (4D)	Quantum uncertainty, weak interaction, vacuum fluctuation
High-dimensional ontology ($\geq 11D$)	Topological subject manifold for self-stabilization, self-avoidance, and s

Table 2: Ontological positioning of β_1

5.2 Connection to Vacuum Physics

The low-probability domain P_{low} is reinterpreted as the **vacuum low-probability topological eigenregion**, the geometric source of vacuum zero-point fluctuations.

5.3 Connection to Dark Matter and Dark Energy

The observational characteristics of dark matter — not directly observable, highly influential, hidden existence, dominating structural evolution — correspond exactly to the topological hidden mass effect of β_1:

- **Dark matter** = β_1 topological hidden mass effect - **Dark energy** = β_1 risk-avoidance expansion phase effect

The vast majority of cosmic mass does not reside in the high-probability visible particle world (approximately 5%). Approximately 95% of cosmic ontological structure exists in the low-probability hidden topological domain. This proportion is highly consistent with mainstream cosmological observations.

6 Black Swan: The Only Explicit Evidence of Subject Breach

6.1 Breach Condition

Let the tolerance limit of the outer fault-tolerant system be $D_{\text{tolerance}}$ (fixed by the outer topology of the bicone). When the cumulative disturbance exceeds this threshold:

$$\text{Collapse} \iff \int_0^T \text{Disturbance}(t)\, dt > D_{\text{tolerance}}$$

At this point, the observation/system behavior unexpectedly cuts through the protective layer and reaches the hidden domain of β_1.

6.2 Relation to the Non-integrable Rotational Residual

According to PFUSRC-13, rotation is non-integrable:

$$\oint dF(\theta) = \varepsilon > 0$$

The residual ε is the microscopic source of entropy increase. When the residual accumulates over a long time and breaks through the critical value $\varepsilon_{\text{critical}}$:

$$\varepsilon \to \varepsilon_{\text{critical}} \Rightarrow \int \text{Disturbance}\, dt > D_{\text{tolerance}} \Rightarrow \text{Black Swan}$$

6.3 Black Swan Entropy Change

The entropy change of a black swan event consists of two parts:

$$\Delta S_{\text{BlackSwan}} = \Delta S_{\text{local}} + \Delta S_{\text{inner}} > 0$$

Here, ΔS_{inner} is precisely the macroscopic manifestation of the long-truncated and lost $\Delta S_{\text{residual}} = C \cdot \varepsilon$.

6.4 Black Swan Theorem

Black Swan Theorem: Black swan events are not random accidents but a local rebalancing mechanism after the β_1 subject is accidentally reached. They sacrifice local integrity to preserve the overall primordial structural safety.

The black swan is the only observable evidence of the small-probability ontology transitioning from implicit to explicit.

7 Quantifiable Predictions

7.1 Quantitative Prediction 1: Deviation of Uncertainty from the Heisenberg Limit

According to the relationship $f(\beta_1) = e^{\kappa \Delta A}$ increasing with detection intensity:

When the observed energy density reaches a certain critical value, the uncertainty product will systematically exceed $\hbar/2$:

$$\Delta x \cdot \Delta p = \frac{\hbar}{2} \cdot e^{\kappa \Delta A} > \frac{\hbar}{2}$$

The magnitude of deviation grows exponentially with detection intensity. This prediction provides a deviation curve trend that can be experimentally compared.

7.2 Quantitative Prediction 2: 12/11 Systematic Shift in Microscopic Transition Probabilities

Based on the PFUSRC-002 intrinsic constant 12/11:

In microscopic processes such as quantum transitions, tunneling, and decay, there will always be a fixed systematic shift between theoretical probability values and experimental measurements:

$$\frac{P_{\text{theoretical}}}{P_{\text{experimental}}} = \frac{12}{11} \quad \text{or} \quad P_{\text{experimental}} = \frac{11}{12} P_{\text{theoretical}}$$

This shift originates from the phase dissipation proportion of β_1's risk-avoidance motion and is a unique numerical prediction belonging entirely to the PFUSRC framework.

8 Addressing Ultimate Problems in Physics

8.1 Black Hole Information Paradox

PFUSRC explanation (unique final solution):

Information is never lost; it merely falls into the low-probability ontological domain P_{low}. Hawking radiation only releases high-probability surface information; deep ontological information is locked by the β_1 hidden barrier. The black hole information paradox is naturally resolved under the Probability Stratification Axiom.

8.2 Origin of Dark Matter and Dark Energy

PFUSRC explanation:

The vast majority of cosmic mass does not reside in the high-probability visible particle world (approximately 5%). Approximately 95% of cosmic ontological structure exists in the low-probability hidden topological domain.

- **Dark matter** = β_1 topological hidden mass effect - **Dark energy** = β_1 risk-avoidance expansion phase effect

These two major cosmological problems obtain a unified geometric origin within this framework.

9 Falsifiability Conditions

The core predictions of this theory are falsifiable. If any of the following conditions hold, the theory faces challenges:

1. **Deterministic reachability**: Future experiments can systematically predict and trigger small-probability events without triggering β_1's risk-avoidance response (collapse/increased uncertainty), i.e., stable and controllable reachability of target small-probability events without observed increase in uncertainty.

2. **Static capture of β_1**: β_1 can be deterministically captured without triggering collapse or black swan, i.e., β_1 can be statically measured and completely captured by formula valuation.

3. **Explanation of small probability without β_1**: A self-consistent and simpler mathematical framework exists that does not rely on a "subject" and can fully explain the four types

of phenomena (quantum tunneling, genetic mutation, wavefunction collapse, macroscopic black swans), and this framework is compatible with the axiomatic system of previous PFUSRC works.

4. **Failure of the π_1 ratio**: In multiple β_1 risk-avoidance events, the ratio $\Delta\phi_{\text{avoid}}/\Delta\phi_{\text{total}}$ systematically deviates from 12/11 and cannot be corrected after excluding calibration errors of the constant C.

5. **Non-accumulation of residual ε**: After a large number of repeated disturbances, the system never experiences black swan collapse, i.e., the residual ε never accumulates to the critical value $D_{\text{tolerance}}$.

6. **Absence of the 12/11 microscopic shift**: In microscopic processes such as quantum transitions, tunneling, and decay, the 12/11 systematic probability shift cannot be measured.

7. **Complete recovery of black hole information**: If black hole information is proven to be completely recoverable from Hawking radiation, leaving no β_1 hidden information residue.

10 Relation to Previous PFUSRC Works

Previous Work	Core Contribution	Connectio
PFUSRC-00	Axioms 1-6, 45° bicone, 55 points, 12/11	New Probab
PFUSRC-001	β_1 field, bicone convergence formula	$f(\beta_1) = e^{\kappa\Delta}$
PFUSRC-002	$\pi_1 = 12/11$, prime nodes	Risk-avoida
PFUSRC-005	Curvature radius hard anchor (380 million light-years)	Risk-avoida
PFUSRC-006	Four quantitative predictions	Black swan
PFUSRC-007	GR as tangent surface of bicone	$f(\beta_1) > 1$ w
PFUSRC-13	Kakeya problem and equivalent closure (non-integrable rotational residual)	Residual ε c

Table 3: Relationship with previous PFUSRC works

11 Conclusion

As a core ontological document of the PFUSRC system, this paper establishes **Axiom 8 (Probability Stratification Axiom)** on the foundation of the existing seven axioms, formally closing the entire theoretical axiomatic system. Through six sets of core mathematical formulas, the quantitative implementation of probability ontology is achieved, connecting all previous geometric, field-theoretic, constant, predictive, relativistic, and non-integrable residual studies across the entire series.

Summary of core formulas:

1. $\mathcal{P} = \mathcal{P}_{\text{high}} \cup \mathcal{P}_{\text{low}}, \quad \mathcal{P}_{\text{high}} \cap \mathcal{P}_{\text{low}} = \varnothing$ (Probability stratification)
2. $C_{\text{reach}}(P) = C_0 \cdot P^{-\alpha}, \quad \alpha > 0$ (Reach cost, dimension $[E \cdot T]$)
3. $f(\beta_1) = e^{\kappa\Delta A}, \quad \kappa = \dfrac{12}{11}$ (Risk-avoidance response function, traceable to 001/002)
4. $\Delta x \cdot \Delta p \geq \dfrac{\hbar}{2} \cdot e^{\kappa\Delta A}$ (Modified uncertainty principle)
5. $\lim_{t\to\infty} \dfrac{\Delta\phi_{\text{avoid}}}{\Delta\phi_{\text{total}}} = \dfrac{12}{11}$ (Risk-avoidance ratio)
6. $\text{Collapse} \iff \int_0^T \text{Disturbance}(t)\, dt > D_{\text{tolerance}}$ (Black swan breach)

Quantitative predictions: - Prediction 1: The uncertainty product systematically exceeds $\hbar/2$ under high-energy detection, with the deviation growing exponentially. - Prediction 2: There exists a fixed 12/11 systematic shift in microscopic transition probabilities.

Addressing ultimate problems: - Black hole information paradox: Information falls into P_{low} and is locked by β_1. - Dark matter and dark energy: β_1 topological hidden mass effect + risk-avoidance expansion phase effect.

Final verdict:

Probability is not ignorance. Probability is a stratified property of the ontological structure of the cosmos.

Small probability is not noise. It is the safety barrier behind which the β_1 subject hides.

Uncertainty is not a principle. It is the observational appearance of β_1's risk avoidance.

The black swan is not an accident. It is the only evidence of the subject being breached.

β_1 is not a particle, not a field, not a force. It is the dynamic intrinsic driving mode of the 11D bicone topological system, the source of dynamic shifts in vacuum zero-point energy. In low-dimensional projection (4D), it appears as quantum uncertainty, weak interaction, and vacuum fluctuations. In high-dimensional ontology ($\geq 11D$), it is the topological subject manifold for self-stabilization, self-avoidance, and self-regulation.

It has no fixed static form and forever remains in the crevices of probability, unable to be statically measured or completely captured by formulaic valuation. Yet its existence is jointly evidenced by probability stratification, reach cost, risk-avoidance motion, and black swan breach.

This theory transcends the cognitive framework of traditional probability theory and quantum mechanics, relying on self-consistent axioms, rigorous mathematical derivation, multi-scale empirical evidence, and clear falsifiability boundaries to complete the transformation from philosophical speculation to quantitative physical theory.

Truth is not a fixed, unchanging standard answer but a self-consistent logical system that conforms to objective laws. Uncertainty is not a defect of physical laws but a key component of the objective existence of the living primordial cosmos.