

Geometric Reconstruction: From Bits to the Universe

The Scattering of Time

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Preface: The Light and The Prism

When we look up at the stars, we see stars burning and galaxies rotating; when we examine the microscopic, we see atoms vibrating and quarks combining. To describe all of this, physicists have built two magnificent towers: one is Einstein’s general theory of relativity, which uses curved geometry to describe gravity and the large-scale structure of spacetime; the other is quantum mechanics, which uses discrete probabilities and jumping operators to describe the wild dance of microscopic particles.

These two towers are each perfect in their own right, but between them lies an abyss that seems insurmountable. For decades, the brightest minds have been trying to build a bridge, trying to find that legendary “theory of everything” that would unify the geometry of gravity with the probabilities of quantum mechanics. But perhaps, as I attempt to show in this book, our confusion does not stem from a missing piece of the puzzle, but rather from the fact that the way we look at the picture is itself an illusion.

Imagine you are in a pitch-black room. There is an extremely fine crack in the wall, and a pure white light shines through it. You hold a triangular prism in your hand and place it in front of this beam of light. Instantly, a brilliant rainbow appears on the other end of the room: red, yellow, blue, purple. . .

If you were an observer who had never seen white light, you might spend your entire life studying how red differs from blue, measuring the fine structure of every dark line in the spectrum, arguing about why purple always appears opposite to red. You would build a complex theory about “color.”

But in fact, there is no such thing as “color.” **There is only that beam of light.** Color is merely the result of **scattering** when light passes through the prism.

This is the core idea of this book: the complex physical universe we inhabit—filled with massive particles, extended space, and various interaction forces—is essentially that rainbow.

And before all things came into being, the universe was just a pure, colorless beam of light. We call this beam of light “**primordial time.**”

At the deepest level of physics, even before space and matter appeared, there exists the purest mathematical truth: **evolution**. In the abstract ocean that mathematicians call “Hilbert space,” the universe’s state vector is rotating at a constant, unchanging rate. This rate is what we later call the speed of light c , or more accurately, the universe’s **total bandwidth** for processing information.

This is that beam of white light. It has no spatial extension, no burden of mass, no push or pull of forces. It is just pure passage, silent and eternal.

However, the universe is not content with silence. It gave birth to **observers**—you and me.

An observer is not a passive camera recording the universe; an observer is that **prism**. When we try to measure the universe, when we try to distinguish “here” from “there,” “past” from “future,” we inevitably intervene in the path of that beam of light. Our act of observation **scatters** that originally unified primordial time into countless fragments.

- Part of time is projected outward, becoming what we call “**space**”;

- Part of time is curled inward, becoming what we call “**mass**”;
- When the flow rate of time differs in different regions, creating density gradients, we experience “**force**.”

Therefore, the so-called laws of physics are not divine decrees carved in stone, but rather “geometric perspective” produced when we project a higher-dimensional ontology onto lower-dimensional senses. The particles we see are actually topological dead knots in the flow of time; the gravity we feel is actually the tilt of time density; the time dilation we experience is actually the redistribution of computational resources.

This explains why there is a speed-of-light limit—because the total brightness (bandwidth) of that primordial light is finite. You cannot infinitely extend the spectrum without sacrificing brightness.

This book does not discuss complex formulas, though behind every conclusion there is rigorous mathematical derivation (as I show in the appendix). Here, I invite you to let go of your attachment to “matter” and put on a pair of geometric glasses.

We will journey together: starting from the silent afternoon of Hilbert space, passing through the economic game of special relativity, diving into the microscopic pixels of quantum mechanics, and finally arriving at the abyss of existentialism. We will see that the universe did not have a big bang; it is just a great computation in progress. And we, as products of the scattering of time, are trying to swim upstream to reassemble that original beam of light.

Welcome to the interior of time.

(Next we will enter Part One, exploring the silent ontology of the universe before matter came into being.)

Part I

Silent Passage

Chapter 1

Afternoon in Hilbert Space

1.1 The War of Two Gods

If physics is a religion describing the universe, then for the past century, we have actually been serving two gods with vastly different temperaments.

The first god dwells in the macrocosmic temple, and his name is **Albert Einstein**. The world he created—**General Relativity**—is exquisitely smooth, elegant, and deterministic. In this world, space and time are not some rigid background stage, but a soft fabric. When you place a massive object (like the Sun) on this fabric, it bends and sags. Planets are not orbiting the Sun under the pull of some mysterious force; they are simply sliding along the “straightest-looking” paths on this curved fabric.

Einstein’s universe is like a flawless piece of marble. In this universe, if you know the positions and velocities of all objects at this moment, you can in principle predict every second ten thousand years from now with extreme precision. There are no jumps, no fuzziness; you can even zoom in infinitely on spacetime, and it remains smooth and continuous forever. This is a geometer’s dream, a theory about **shape**.

However, when you try to peer deep into matter with a microscope, when you zoom in to the scale of atomic nuclei, Einstein’s god disappears. You enter the domain of the second god—**Quantum Mechanics**.

Here, the ruler is **Niels Bohr** and his Copenhagen school. The rules here are no longer geometric, but **algebraic**. In this microscopic world, particles no longer have definite positions and trajectories; they become diffuse wave functions, or rotating vectors in Hilbert Space. Nature here reveals its granular side: energy does not flow continuously, but is transmitted in discrete “packets.” More disturbingly, the core law here is probability. Like a god rolling dice, you cannot know for certain what will happen next; you can only calculate the probability of it happening.

This is the schizophrenia of modern physics.

For more than half a century, physicists have been trying to mediate the war between these two gods. We have attempted to build a “Theory of Everything,” trying to describe both the swallowing of black holes (extreme gravity) and the jumping of electrons (extreme quantum) with a single set of equations.

But whenever we try to force them together, disaster strikes. When you try to calculate the fluctuations of the gravitational field at quantum scales, the mathematical equations collapse, and the calculations yield infinity. It’s like trying to draw an absolutely perfect smooth curve (General Relativity) on a low-resolution screen full of pixels (Quantum Mechanics); no matter how hard you try, the pixelated jaggedness will always destroy the curve’s perfection.

Where exactly is the root of the problem?

Mainstream attempts—such as string theory or loop quantum gravity—believe the problem

lies in **structure**. Perhaps particles are not points, but vibrating strings? Perhaps space itself is woven from tiny loops?

But this book wants to propose a more radical view: **The problem is not what structure we have discovered, but what language we are using.**

General Relativity relies on “spacetime manifolds” (Manifold), which assumes the universe is a **place** where things happen. Quantum Mechanics relies on “Linear Algebra,” which suggests the universe is a superposition of **states**. This is not just a difference in mathematical techniques; it is a fundamental conflict of worldviews—a conflict of “Ontology.”

One says: “The world is curved geometry.”

The other says: “The world is probabilistic algebra.”

Perhaps they are both wrong. Or more accurately, they have each only seen one side of the truth.

If we are to end this war, we cannot patch up the old ruins. We need to step out of spacetime, this old stage, and seek a deeper, broader mathematical container. We need a “third language,” one that can accommodate both the curvature of geometry and the superposition of algebra.

This container has long existed in mathematicians’ drawers; it is called **Projective Hilbert Space**.

In this space, the universe is not a drama evolving in space over time, but a silent, eternal mathematical object. Let us imagine it as a lazy afternoon, sunlight shimmering on the sea. In this high-dimensional ocean, there is no clamor of the Big Bang, no collisions of particles, only pure, coherent, ceaseless passage.

That is the true starting point of our story.

—
(Next, we will enter section 1.2, formally unveil this “cosmic terminal object,” and propose that single axiom.)

1.2 The Universe Final Object (\mathfrak{U}) and the Single Axiom

If we no longer believe that Einstein’s curved spacetime is the ultimate truth, nor that Bohr’s probabilistic dice is the foundation of the world, then what exactly is the universe?

Let us perform a bold thought experiment. Try to remove everything from the universe—remove stars, planets, atoms, even remove space and time themselves. What remains is not emptiness, but a pure mathematical structure, a vast container holding all possibilities.

Mathematicians call this container **Hilbert Space**.

Imagine an ocean of infinite dimensions. Every point in this ocean represents a possible “state” of the universe. At one point, the universe is a blazing fireball; at another, stars have extinguished; at an extremely nearby point, you are reading this page of the book, or you decide to close the book and have a cup of coffee. All these possibilities exist simultaneously in this vast mathematical ocean.

In this picture, our universe is no longer a Lego structure pieced together from countless tiny particles; it is a **single object**. We call it the **Universe Final Object**.

Mathematically, it is simply a **vector** (Vector) in Hilbert Space, an arrow shot from the origin. The length of this arrow is fixed (we normalize it to 1), and wherever it points, that is what the universe is like.

This is the silence of ontology. At this level, there is no conflict, no division, only this arrow representing the sum of all things, suspended in mathematical void.

But if this arrow remains forever motionless, then nothing happens. No history, no future, no birth of you and me.

Thus, we introduce the **single dynamical axiom** of this book. This axiom is incredibly simple, but as we will see, the entire complex physical world—from relativistic time dilation to quantum mechanical wave function collapse—are all just corollaries of this axiom.

We call it **Axiom A1**.

Axiom A1: The universe’s state vector rotates forever in Hilbert Space at a constant rate.

That’s it. No complex differential equations, no cumbersome laws of mechanics. Only pure, uniform **evolution**.

In mathematical terms, this is called “Unitary Evolution,” meaning that this arrow neither lengthens nor shortens during rotation, and no information is truly lost.

But here is a crucial detail, key to understanding all subsequent content in this book: **What is this rotation rate?**

In traditional physics textbooks, we are accustomed to treating velocity in space as fundamental. We say the speed of light is 299,792,458 meters per second. But in our Hilbert Space, there are no “meters” yet, no “seconds”; space and time have not yet been projected.

Here, this constant evolution rate c has a deeper meaning. It is not how fast objects move in space; it is the **upper limit of the universe’s ability to update its own state**.

You can think of it as a computer’s **clock frequency**, or a network cable’s **total bandwidth**.

Axiom A1 tells us: **The universe is a bandwidth-limited system.**

Whatever drama the universe wants to stage—whether it’s the collision of black holes or the firing of neurons—it must be completed within this fixed budget c . This c is what we later see in physics textbooks as the “speed of light.” But at the ontological level, it should be called the **total evolution rate in Hilbert Space**.

This is why nothing can exceed the speed of light. It’s not because even infinite energy can’t push it; it’s because “light speed” is not a velocity, it is the **budget itself**. You cannot spend more money than the total budget you possess.

Now, we have the stage (Hilbert Space), the protagonist (Universe Final Object/state vector), and the script (Axiom A1: evolution at constant rate c).

But this picture seems too abstract. If the universe is just a uniformly rotating pointer in high-dimensional space, why is the world we see so rich and colorful? Why is there space? Why is there time? Why is there mass?

The answer lies in **projection**.

Just as a film projector casts light from film onto a screen, this high-dimensional “cosmic arrow” also needs to be projected onto our low-dimensional senses to become “reality” that we can understand.

In this projection process, the originally unified c is forced to split. Just as white light passing through a prism becomes a seven-color spectrum, the constant evolution rate is “scattered” into different physical phenomena. And the first step of this scattering is the greatest trade in physics—the **trade-off between space and time**.

(Next, we will enter Part II “The Great Dispersion,” to see how this unified rate c splits into “spatial velocity” and “temporal flow,” and thereby reconstruct the core of Special Relativity.)

Chapter 2

Time Before Time

Chapter 3

Time Before Time

3.1 Pure Becoming

In a universe where even space has not yet been “created,” talking about time seems absurd.

The time we experience in daily life is always bound to change: the clock hand moves one tick, the sun sets behind the mountain, or a hot cup of coffee cools down. For us, time is a container of events, the order in which all things happen. If the universe were empty, with no events occurring, would time still exist?

Isaac Newton would tell you: “Yes.” He believed in an absolute, divine clock that would still tick even if the universe were empty. But Einstein would retort: “No.” In relativity, time is a function of matter and motion; without clocks, there is no time.

But in our Hilbert Space picture, the truth lies between these two, yet deeper than both.

Let us return to that lonely universe state vector suspended in mathematical void. According to Axiom A1 we proposed in the previous chapter, this vector is “rotating.”

Note that this “rotation” is not a displacement in space like the Earth orbiting the Sun. Because at this moment, there is no “space,” nor is there a “Sun.” This is a **pure internal change**. Mathematically, this is called a phase change (Phase Change).

To understand this, imagine listening to a continuous single tone. This sound has no melody, no volume changes; it is just an eternal “hum—”. In this sound, no physical object is moving, but the sound itself is **persisting**. It is not just “Being”; it is constantly “Becoming.” It is constantly updating itself, even though it appears identical.

This is what the universe looks like at its deepest level. It is not a static sculpture, but a flowing potential.

At this stage, time has not yet split into “past” and “future.” It is just a pure **update rate**. This update rate is the constant c we defined in the axiom.

The speed of light c we learn in physics textbooks is usually described as “300,000 kilometers per second.” This is a definition about **spatial traversal**. But in the afternoon of Hilbert Space, since there are no kilometers and no seconds, what exactly is this c ?

It is the universe’s **heartbeat**.

It is the **clock frequency** of the universe, this supercomputer processing information. Every instant, the universe’s state vector rotates a tiny angle in Hilbert Space. The magnitude of this angle represents how much existence the universe has “experienced.”

If we compare the universe to a game being downloaded, then before the game screen (physical world) appears, c is the **bandwidth** of that background download process. This bandwidth is finite and constant. It determines how much change can occur in the universe per unit of meta-time.

This is “time without time.” It is not the result of measurement; it is an intrinsic property of existence.

The philosophical significance here is profound. Traditional physics often treats “existence” as a noun (Objects), but in our geometric reconstruction, “existence” is a verb (Process). The universe is not built from pre-made building blocks; the universe is woven from the **rate of evolution**.

Matter, as we will see later, is just this pure evolution rate knotted locally, creating an illusion of stillness. And energy is just an indicator of how fast this evolution rate is.

So when we say “the speed of light is an insurmountable limit,” we are actually saying: **As part of the universe, your existence rate cannot exceed the universe’s overall refresh rate.** You cannot run faster than the creator.

This pure, colorless **stream of becoming** flowing at rate c is the raw material of all things.

But this stream of light alone is extremely boring. If the universe were just a single tone humming at a constant frequency, there would never be galaxies, nor life. To transform this monotonous “one” into the rich “many,” this light must be broken. It must be observed, measured, **projected**.

This leads to a crucial step in our journey: How do we magically conjure the reality of here and now from this abstract mathematical heartbeat?

The answer lies in an ancient and mysterious geometric art—projection.

(Next, we will enter section 2.2 “The Art of Projection,” exploring how observers intervene in this light like a prism, and decompose the unified c into the physical laws we are familiar with.)

3.2 The Art of Projection

If the universe’s ontology is truly that “final object” silently rotating in Hilbert Space, then the question arises: Why have we never seen it?

We have never felt ourselves living in an infinite-dimensional vector ocean, nor have we directly experienced that pure “becoming.” Instead, we see three-dimensional space, feel flowing time, and touch solid objects. The world in our eyes is full of concrete limitations: objects cannot be both here and there, time cannot return once it has passed.

This enormous contrast stems from an act we perform every moment yet never notice—**projection** (Projection).

3.2.1 Plato’s Cave 2.0

Two thousand years ago, the philosopher Plato told a parable: A group of prisoners were trapped in a cave, facing away from the entrance. They could not see the real world outside, only the shadows projected onto the wall. For these prisoners, shadows were the only reality.

In this parable, Plato touched upon a profound physical truth, but he only got half of it right. In our geometric reconstruction, the universe is not the world “outside”; **the universe is that high-dimensional ontology**. And we, as observers, are not merely passive spectators; we are that **projector**.

In Hilbert Space, the universe’s state vector ψ contains extremely rich information—it is holographic, it is infinite-dimensional. But as physical observers (whether human, detector, or a simple particle), our “bandwidth” is extremely limited. We cannot simultaneously process all the universe’s information.

To understand the universe, we must **simplify** it.

Mathematically, this is called “dimensional reduction.” Like flattening a three-dimensional globe into a two-dimensional map, you lose some truth (such as Greenland’s distortion), but you gain a usable coordinate system.

This is the physical essence of **observers as projection operators**.

When we observe the universe, we are actually cutting a low-dimensional “slice” in Hilbert Space. We project that rotating cosmic arrow onto a few specific axes we have chosen—such as the “position” axis, the “momentum” axis, the “time” axis.

- The originally unified evolution rate c is projected onto the spatial axis, becoming the **velocity** we see.
- Projected onto the internal degrees of freedom axis, becoming the **mass** we measure.
- Projected onto the causal chain, becoming the **time** we perceive.

What we call “physical reality” is actually the sum of these projections. Just as a photograph is only a two-dimensional projection of a three-dimensional world, the spacetime we inhabit is also a four-dimensional projection of high-dimensional Hilbert Space.

3.2.2 The Cost of Forgetting

Projection is an art, but it is also a form of **forgetting**.

When you project a three-dimensional object onto a two-dimensional paper surface, you inevitably lose depth information. Similarly, when we project the universe’s ontology into the physical world, we lose vast amounts of information. In Category Theory—an advanced language for studying mappings between mathematical structures—observers are described as a **forgetful functor** (Forgetful Functor).

This name sounds poetic and cruel. It means: **To have a clear physical world, we must forget the vast majority of the universe’s truth.**

The “wave function collapse” in quantum mechanics is precisely this violent manifestation of “forgetting.” When we make a measurement, we forcibly require the universe to choose only one specific projection (such as “electron here”) from its originally superposition state containing all possibilities. Where did the other possibilities go? They are “filtered” out by the observer’s limited bandwidth, or orthogonalized into dimensions we cannot see.

But this does not mean the physical laws we see are false. On the contrary, **physical laws are the topological structures preserved during projection.**

Just as no matter how you rotate a donut, its projection will always somehow hint at the existence of that “hole,” certain deep invariants in the universe’s ontology (such as the total evolution rate c) become those unbreakable physical constants in our world after projection.

3.2.3 Metaphor as Truth

In this framework, we need to re-understand what “truth” is.

Traditional science tells us that truth is a statement about “what matter is.” But here, truth is a statement about **how structures map**.

We will frequently use “metaphors” (Metaphor) in this book. We say “mass is a knot in time,” we say “light is the destitute.” Please do not treat these merely as literary rhetoric.

In the context of geometric reconstruction, **metaphor is a strict mathematical mapping**.

When we map the geometric structure of Hilbert Space (source category) to the physical phenomena of spacetime (target category), if this mapping preserves all mathematical structures (such as isomorphisms or functors), then this “metaphor” is physical truth.

- When this mapping preserves the Pythagorean theorem structure, we obtain **Special Relativity**.
- When this mapping preserves unitary group symmetry, we obtain the **Standard Model**.
- When this mapping preserves the causal propagation limit of information, we obtain the **speed of light limit**.

Therefore, observers are not only prisms but also translators. We use our limited sensory language to translate that cosmic scripture written in infinite-dimensional language. Although translation always accompanies information loss (Traduttore, traditore), it is precisely this translation that creates the magnificent poem we call “reality.”

Now, we understand the essence of projection. But to truly read this book, we need a dictionary. We need to know which geometric symbol corresponds to which physical phenomenon.

This is our **Rosetta Stone**.

(Next, we will enter section 2.3 “The Rosetta Stone,” where we will present a clear comparison table showing how to translate difficult-to-calculate physical problems into simple geometric resource problems.)

3.3 The Rosetta Stone

In 1799, Napoleon’s soldiers discovered a black basalt stone tablet in Egypt inscribed with three scripts: the Rosetta Stone. It was through this stone that Champollion deciphered the lost ancient Egyptian hieroglyphs. He succeeded because he realized: those seemingly mysterious graphic symbols (hieroglyphs) actually described **the same content** as the mundane Greek text.

In physics, we face the same situation.

On one hand, we have the **physical language** describing the macroscopic world: we talk about “force,” “energy,” “mass,” “time dilation.” This is like the familiar Greek script; although we can read every word, we often know the “what” but not the “why”—why does mass produce inertia? Why is the speed of light a limit?

On the other hand, we have the **geometric language** describing ontology: we talk about “Hilbert Space,” “Fubini-Study metric,” “orthogonal decomposition,” “phase rotation.” This is like mysterious hieroglyphs; although mathematically elegant, it seems to have nothing to do with our rough reality.

The task of this section is to inscribe this physics Rosetta Stone. We will establish a rigorous **geometric-physical-computational dictionary**. Through this dictionary, we will translate originally intractable dynamical problems into clear resource allocation problems.

We do not introduce new forces, nor invent new particles. We merely retranslate known reality.

3.3.1 Core Entry I: Physical Laws as Resource Protocols

In traditional thinking, physical laws are mandatory commands about “how objects should move.” But in our geometric reconstruction, physical laws are **resource allocation protocols**.

- **Physical Language:** Objects are limited by the speed of light and cannot be infinitely accelerated.

- **Geometric Translation:** The universe’s total computational bandwidth (evolution rate c) is constant. All motion is a competition for this finite budget.

When we translate “dynamical constraints” into “budget constraints,” many paradoxes vanish. You don’t need to find an invisible hand to hold the spaceship back from exceeding light speed; you just need to check its “bill”—its bandwidth budget is already exhausted.

3.3.2 Core Entry II: Constants as Exchange Rates

Why does the universe have Planck’s constant \hbar ? Why the speed of light c ? In the standard model, these constants are parameters arbitrarily set by God. But in our dictionary, they are **exchange rates between two worlds**.

- c (**Speed of Light**): It is the **total capacity radius** between spacetime projection and Hilbert Space ontology. It defines how much evolution rate we can “borrow” from the ontology.
- \hbar (**Planck’s Constant**): It is the exchange rate between **geometric phase** and **physical action**. Rotating an angle (Angle) in the geometric world requires paying a certain amount of energy and time (Action) in the physical world. \hbar tells us how much geometric curvature can be exchanged for a unit of physical reality.

3.3.3 Core Entry III: Mass as Background Process

“What is mass?” This is one of physics’ deepest questions. The Higgs mechanism tells us mass comes from coupling with the Higgs field, but this only explains “how,” not “essence.”

- **Physical Language:** Mass (m) is the property of objects maintaining their existence and resisting changes in motion state (inertia).
- **Geometric Translation:** Mass is the **internal evolution rate** (v_{int}). It represents the rotation speed of the system in the internal dimensions of Hilbert Space.

A massive object is essentially a program running frantically internally. It has inertia, it is “heavy,” because it locks most of its bandwidth resources (c) into internal loops, leaving no extra bandwidth to respond to external pushes.

3.3.4 Core Entry IV: Causality as Network Speed

- **Physical Language:** Causality is strictly limited by light cones. The past can only affect the future, and influence propagation cannot be instantaneous.
- **Geometric Translation:** This is the **Lieb-Robinson bound** on Quantum Cellular Automata (QCA).

In discrete computational networks, information transmission from one node to another requires hops. Light cones are not geometric walls of spacetime; they are the **maximum penetration rate** of information propagation between logic gates. Causality is essentially the “network speed limit” of the universe as a computer.

3.3.5 Core Entry V: Dark Energy as Background Noise

- **Physical Language:** The universe is accelerating expansion, seemingly filled with mysterious energy in the vacuum.
- **Geometric Translation:** There is no mysterious energy; this is the **thermodynamic cost** of information erasure.

The universe constantly computes and constantly forgets. According to Landauer’s Principle, erasing information necessarily produces heat. The tiny cosmological constant Λ we measure is precisely the **background noise** when the universe computer is running.

3.3.6 Dictionary Overview

For the convenience of readers to consult during subsequent journeys, we organize these core mappings into a comparison table (Table I: The Rosetta Stone of Geometric Unification):

Physical Phenomenon	Geometric Reconstruction	Computational Essence
Lorentz Invariance	Pythagorean sector conservation	Dynamic resource allocation
Proper Time	Internal path length (S_{FS})	Internal processing delay
Mass	Internal phase rotation rate (v_{int})	Background process load
Speed of Light	Geometric propagation horizon	Maximum propagation hops of logic gate
Force	Gradient of distance function ($-\nabla D$)	Descent direction of optimization algorithm
Dark Energy	Capacity of invisible sectors	Waste heat from bit erasure

Now, we hold this key in our hands. This Rosetta Stone connects originally isolated physical concepts—inertia, time, gravity, vacuum—into a coherent whole.

We no longer need to grope in the dark asking “why are physical laws like this.” We only need to ask: **What geometric structure, when projected, would look like this?**

With this dictionary, we can finally leave that abstract afternoon in Hilbert Space and journey to the familiar physical world. Our first stop will be to dismantle Einstein’s most proud masterpiece—Special Relativity. We will see that those marvelous predictions about time dilation and length contraction are merely a simple arithmetic problem.

(Next, we will enter Part II “The Great Dispersion,” formally using this stone to reconstruct Special Relativity.)

Part II

The Great Dispersion

Chapter 4

Pythagoras Rules the Universe

4.1 The Great Trade-off

If I ask you, who rules the universe? You might answer gravity, quantum fields, or the second law of thermodynamics. But in our geometric reconstruction, the true ruler of the universe is an ancient Greek who lived 2,500 years ago—Pythagoras.

Or more accurately, it is the truth about right triangles he discovered: $a^2 + b^2 = c^2$.

In school, we learn the Pythagorean theorem to calculate ladder lengths or land areas. But in the depths of physics, the Pythagorean theorem plays a more astonishing role: it determines how time and space allocate the universe’s “existence budget.”

4.1.1 The Only Totem of the Book

Let us return to that silent Hilbert Space. As we established in Axiom A1, the universe’s state vector ψ is evolving at a constant total rate c . This is like a car with its accelerator welded to the floor, the speedometer needle forever pointing at the maximum value c .

But this car is not driving straight on a highway; it is traveling in a multi-dimensional space. As observers, we draw a cross coordinate system in this multi-dimensional space, decomposing this total velocity c into two perpendicular directions:

1. **Horizontal Axis (External Direction):** Represents the object’s movement in space. We call it “external velocity,” denoted v_{ext} . This is what we commonly call “velocity”—how fast a plane flies, how fast light travels.
2. **Vertical Axis (Internal Direction):** Represents the update of the object’s internal state. We call it “internal velocity,” denoted v_{int} . This represents how much “passage” the object has experienced, or how fast its watch ticks.

Now, a miracle happens.

Because the total velocity c is constant (this is an arrow of fixed length), no matter which direction this arrow points, the square of its projection length on the horizontal axis plus the square of its projection length on the vertical axis must equal the square of the total length.

Thus, we obtain the only formula you need to remember in this book, and the supreme law governing Special Relativity:

$$v_{ext}^2 + v_{int}^2 = c^2$$

This is the **Great Trade-off**.

This formula is extremely simple, but it contains a stunning physical truth: **The universe is a zero-sum game.**

4.1.2 The Mutual Exclusivity of Velocity and Time

In Newton’s universe, time and space are independent. You can fly through space at any velocity (v_{ext} can be infinite), while your pocket watch ticks normally (v_{int} remains unchanged). That was a universe of infinite resources.

But in Einstein’s universe—or in our computational universe limited by bandwidth c —you cannot have both.

Look at that formula. c is a locked constant. If you want to increase v_{ext} (run faster), mathematics forces you to decrease v_{int} (internal evolution slows down).

- When you are **at rest** ($v_{ext} = 0$): All budget flows inward. $v_{int} = c$. Your watch runs fastest, your body experiences the purest time passage. This is called “proper time.”
- When you **start running** ($v_{ext} > 0$): You must divert part of the internal budget to external motion. v_{int} must be less than c . Your time passage slows down.
- When you **approach light speed** ($v_{ext} \rightarrow c$): Almost all budget is used to purchase spatial distance. v_{int} is compressed to near zero. Your movements become slow motion, your time nearly freezes.

This is the famous **Time Dilation** effect.

In textbooks, time dilation is usually demonstrated through complex derivations involving light clocks and Lorentz transformations. But from our geometric perspective, it requires no derivation; it is simply a direct consequence of the Pythagorean theorem. It is not mysterious magic; it is the result of **financial auditing**: because you spent all your bandwidth on “traveling,” you have no remaining bandwidth for “living.”

4.1.3 The Geometric Solution of the Lorentz Factor

Physicists like to use something called the “Lorentz factor” (γ) to calculate how much time slows down: $\gamma = 1/\sqrt{1 - v^2/c^2}$. This formula often makes beginners dizzy.

But now, look at our triangle.

Imagine a right triangle with hypotenuse as total budget c , base as spatial velocity v_{ext} (which is v in physics), and height as internal velocity v_{int} .

According to the Pythagorean theorem: $v_{int} = \sqrt{c^2 - v_{ext}^2} = c\sqrt{1 - v^2/c^2}$.

If we take the ratio of internal velocity at rest (c) to internal velocity in motion (v_{int}):

$$\frac{c}{v_{int}} = \frac{1}{\sqrt{1 - v^2/c^2}} = \gamma$$

See, that formidable Lorentz factor is nothing but the **ratio of hypotenuse to leg**. It is just the secant function in geometric projection.

Special Relativity is no longer a theory about how light propagates; it is a **geometry of how a constant-length vector rotates between two orthogonal dimensions**. Einstein’s mass-energy equation, length contraction, and time dilation are all folded into this simple right triangle.

We live in a strictly limited universe. This is the first lesson the “Great Trade-off” teaches us: freedom is not infinite; every step taken in space is a tiny murder of time.

So, what if we go to the extreme? What happens if we stake all our budget on v_{ext} and completely abandon v_{int} ?

We become light.

—

(Next, we will enter section 3.2 “The Bankruptcy of Photons,” exploring that extreme boundary case: an existence completely without time.)

4.2 The Bankruptcy of the Photon

In the previous section, we established the universe’s supreme financial law: $v_{ext}^2 + v_{int}^2 = c^2$. Every object, whether you, me, or distant stars, carefully balances its expenses within this formula. We reserve part of the budget for internal evolution (allowing us to experience time and sustain life), using only a small remaining portion to purchase spatial movement. We are cautious investors.

But in the universe, there exists an extreme entity that rejects this balance. It stakes all its chips—that total budget of c —all-in on the “spatial movement” side.

This entity is the **photon** (Photon).

4.2.1 Extreme Poverty and Extreme Speed

Let us see what happens when an object decides to “go all in.”

When external velocity v_{ext} is pushed to the limit, reaching total bandwidth c , according to our Pythagorean theorem, internal velocity v_{int} must become zero:

$$c^2 + 0 = c^2$$

This leads to a conclusion that is stunning both physically and philosophically: **Light has no time.**

In our geometric dictionary, v_{int} represents the rate of internal evolution, the ability to “experience time.” For photons, this value is zero. This means that although photons race at 300,000 kilometers per second in our eyes, in their own reference frame, the clock has never ticked even a microsecond.

A photon is a **computational destitute**. It spends all its resources on traveling, leaving no remaining bandwidth to process its internal state. It has no extra computing power to “age” itself, nor extra memory to record “passage.”

This is why photons are immortal. A photon born at the moment of the Big Bang, that instant and the instant it reaches our retina today, are **simultaneous** to itself. It traversed 13.8 billion years of vast space, but in its experience, no time has passed. It never decays, never changes, because it is bankrupt—too poor to afford even one second.

4.2.2 Zero-Delay Messenger

Why does the universe allow such extreme existence? Why not force everything to retain some time budget?

This involves the universe’s communication needs as a computer. If all particles had mass (all had $v_{int} > 0$), then all particles would be “distracted” during information transmission. They would be busy processing their internal phase rotation (Aging) while traveling. This is like a mail carrier constantly modifying the letter’s content while delivering it.

To build a stable, rigid causal structure, the universe needs a messenger with **zero internal processing delay**.

Photons are precisely such messengers. Because their $v_{int} = 0$, they accumulate no internal phase during transmission. They are like absolutely transparent pipes, or superconducting wires, transmitting information from one end of the universe to the other without any “processing” or “contamination” along the way.

It is precisely because of the photon’s “bankruptcy” that we see distant galaxies as they originally were, not versions modified by the mail carrier. Masslessness is not a deficiency; it is the physical manifestation of **zero computational delay**.

4.2.3 The Iron Wall of Speed

Now, we can finally answer that age-old question from a completely new angle: **Why can nothing exceed the speed of light?**

In traditional explanations, you might hear “mass increases with speed, acceleration requires infinite energy.” This sounds like an insurmountable physical wall.

But from our “resource perspective,” this is not a wall at all; it is **budget exhaustion**.

The speed of light c is not a barrier blocking you; it is simply the sum of all money in your pocket. When you spend all your money on v_{ext} , you reach light speed. You cannot run faster than light for the same reason you cannot spend more money than you have—**you are overdrawn**.

The universe has no law prohibiting faster-than-light travel; the universe only has a **financial discipline** about bandwidth conservation.

4.2.4 The Cost of Existence

The photon’s story tells us that extreme speed has a cost, and that cost is the **loss of sense of existence**.

Although photons connect all things, they themselves are like ghosts. They have no rest mass, cannot stop, cannot build structures, cannot form memories. They are pure relations, not entities.

So, what if we do the opposite? What happens if we don’t spend the budget on traveling, but hoard it internally, using it to build complex internal structures, to “exist”?

Then, we transform from light into matter. We transform from “messenger” to “owner.” We gain a heavy property called **mass**.

(Next chapter, we will enter Chapter 4 “The Weight of Time,” exploring the other end of the Pythagorean theorem: when time is locked in tiny spaces, how it transforms into solid matter.)

Chapter 5

The Weight of Time

Chapter 6

The Weight of Time

6.1 The Geometric Origin of Mass

We usually think that “mass” is the most essential property of objects. A stone is heavy because it is filled with “matter”; an electron has mass because it is a real particle. In our intuition, mass represents the “weight of existence.”

But in our geometric reconstruction, this intuition is wrong.

Let us return once more to that Pythagorean theorem ruling the universe: $v_{ext}^2 + v_{int}^2 = c^2$.

In the previous chapter, we saw that photons choose $v_{ext} = c$ and $v_{int} = 0$. They spend all their budget on external spatial displacement, so they have no internal evolution and no mass. They are pure “traveling.”

So, what are massive objects (such as electrons, quarks, or you)?

Massive objects are entities that **decide to stop** (or run slower) and **spend their budget internally**.

6.1.1 Mass is Imprisoned Time

When an object is at rest in space ($v_{ext} = 0$), according to the Pythagorean theorem, it must evolve internally at full speed c ($v_{int} = c$). This means its state vector is rotating frantically in the internal dimensions of Hilbert Space.

This frantic internal rotation is what we feel as “mass.”

In our dictionary, **mass** (m) is not the amount of matter; it is the **rate of internal information processing** (v_{int}).

Imagine a spinning top. From a distance, it appears stationary on the table, occupying a fixed position. But if you look closely, you’ll find it full of kinetic energy, spinning at high speed. Matter is the same. A stationary electron is not truly “stationary”; it is just motionless in space, but in the dimension of time, it is vibrating at extremely high frequency.

This is why Einstein’s mass-energy equation $E = mc^2$ is so precise. This equation actually says: energy (E) equals mass (m) times a constant. From our geometric perspective, this is not just numerical equality; it is **ontological identity**.

- Energy E corresponds to total evolution rate (total bandwidth).
- Mass m corresponds to internal evolution rate (internal bandwidth).
- In the rest frame, all total bandwidth is converted to internal bandwidth.

Therefore, **mass is imprisoned time**. It is the rate c that the universe should have used to race through space, curled and knotted, locked in a tiny range, becoming an endless internal cycle.

6.1.2 The Frequency of Existence

Quantum mechanics tells us through de Broglie’s relation ($mc^2 = \hbar\omega$) that every massive particle corresponds to a specific frequency ω . In traditional physics, this is seen as a mysterious manifestation of wave-particle duality.

But in our framework, this becomes very intuitive: **frequency is the speed of rotation**. Greater mass means the object refreshes its own state at this frequency faster internally.

- An electron is light; its internal clock ticks relatively slowly.
- A top quark is heavy; its internal clock roars frantically.
- A black hole is extremely heavy; it is an extremely high-density oscillating knot in spacetime structure.

This also explains why we have a “sense of existence.” Photons have no sense of existence; they are just fleeting shadows. Matter has a sense of existence because it rewrites itself countless times in Hilbert Space every instant. **We are heavy because we are very busy at the microscopic level**

We are composed of countless high-speed micro-clocks. This is why we cannot move at light speed—because we are too busy internally, our bandwidth is occupied by life, atomic structures, and the maintenance of existence, leaving no remaining budget to purchase a light-speed ticket.

This “internal busyness” brings an inevitable consequence: when you try to push it, it resists. This resistance is another great mystery in physics—**inertia**.

—
(Next, we will enter section 4.2 “The Essence of Inertia,” to see how this internal rotation transforms into the resistance we feel.)

6.2 The Nature of Inertia

When you try to push a stalled truck, you feel a tremendous resistance. Newton told us to respect this resistance, calling it **inertia** (Inertia). In his first law, he wrote: Unless acted upon by an external force, objects will remain at rest or in uniform linear motion.

But Newton did not tell us *why*. Why are objects in the universe so stubborn? Why is it so difficult to change an object’s state of motion?

In standard textbooks, inertia is seen as an intrinsic property of matter, like some innate “laziness.” But in our geometric reconstruction, inertia is not laziness at all; on the contrary, **inertia stems from excessive diligence**.

6.2.1 Resource Contention Mechanism

Let us examine once more that core resource equation: $v_{ext}^2 + v_{int}^2 = c^2$.

A massive object at rest (like that truck) has v_{ext} equal to zero. This means it invests all computational bandwidth c into v_{int} . In the internal dimensions of Hilbert Space, every proton, neutron, and electron composing the truck is rotating and updating phases at maximum speed.

This system is in a **full-load operation** state. It is like a supercomputer rendering Hollywood special effects at full capacity, with CPU usage at 100%.

Now, you come over and try to push it. You want it to move in space, meaning you want to give it a non-zero v_{ext} .

According to the Pythagorean theorem, to obtain this v_{ext} , the system **must** reduce v_{int} . Because the total budget c is locked, you cannot create velocity out of nothing.

This is the root of conflict.

To make the truck move, you are not just “pushing” it; you are actually forcing it to **reallocate its budget**. You demand it withdraw resources from those vast and busy internal processes and transfer them to external displacement.

This is like trying to open a new large program on a computer already running at full capacity. The computer will slow down, stutter, and show “resistance.” This resistance is not because it doesn’t want to move, but because of **resource contention** (Resource Contention).

Therefore, **inertia is computational load**.

The heavier an object, the more bandwidth it locks internally (v_{int} is larger), and the more complex its “background processes.” To change such a system’s state, the amount of resources you need to reschedule is more massive, so the resistance you feel—inertia—is also greater.

6.2.2 Geometric Vector Rotation

If we put on geometric glasses, this process appears more elegant.

In the tangent space of Hilbert Space, the universe’s state vector \vec{V} is an arrow of constant length c . For objects at rest, this arrow points vertically upward (pure internal time direction).

When you apply force trying to accelerate an object, you are actually trying to **rotate** this arrow. You want to press it from vertical direction (internal) toward horizontal direction (external).

- **Acceleration:** The process of converting internal evolution (v_{int}) into external displacement (v_{ext}).
- **Resistance:** Stems from the geometric rigidity of vector rotation. To change the direction of a high-speed rotating vector (imagine a high-speed spinning top), you need to overcome tremendous angular momentum.

This is why Einstein said mass and energy are equivalent. Because they are both the length of that arrow. And inertia is that arrow’s tendency to maintain its direction.

When you push that truck with force, you are not wrestling with “matter”; you are wrestling with **geometry**. You are trying to reverse the evolution direction of trillions of microscopic vectors. You feel tired because you are in a tug-of-war with the universe’s most fundamental conservation law—the invariance of total bandwidth c .

6.2.3 Newton’s Illusion

Reviewing Newton’s first law, we can now give it a completely new interpretation.

Objects tend to maintain uniform linear motion (or rest) not because they are lazy, but because **this is the state with minimal computational overhead**.

If an object is moving at velocity v , its budget allocation scheme (the ratio of v_{ext} to v_{int}) is already determined. Unless external input (force) forces it to change this scheme, it will continue using the old allocation table because it requires no additional computational cost to maintain the status quo.

Changing state (acceleration or deceleration) requires recalculating and reallocating bandwidth; this is why “force” is needed.

Now we understand: mass is a knot in time, and inertia is the cost of untying this knot. But this knot locks not only time but also energy. This is the true meaning of that famous equation $E = mc^2$ —it describes the geometric cost of curling linear-flowing bandwidth into a loop.

(Next, we will enter section 4.3 “The Locking of Energy,” completely deconstructing the geometric essence of $E = mc^2$, and conclude Part II.)

6.3 The Locking of Energy

Of all equations in human civilization, none carries more totemic significance than $E = mc^2$.

It appears on T-shirts, in comics, and has even become synonymous with genius. Albert Einstein told us that energy (E) and mass (m) are interchangeable. More chillingly, because the conversion coefficient c^2 (the square of the speed of light) is an enormous number (9×10^{16}), this means that extremely tiny masses contain devastating energy.

But why?

Why would a quiet stone hide fire like the Sun? Why the square of the speed of light? This sounds like mysterious alchemy.

But in our “scattering of time” framework, this equation is no longer mysterious. It is no longer an alchemical formula about “conversion,” but a statement about **geometric identity**.

6.3.1 Curled Bandwidth

Let us examine one last time that right triangle ruling the universe (Pythagorean theorem): $v_{ext}^2 + v_{int}^2 = c^2$.

We have already established in Axiom A1 that every entity in the universe is essentially a state vector of constant length c in Hilbert Space. The length of this vector represents the entire “existence budget” the universe grants this entity—that is, its **total energy** (E).

When an object is at rest in space ($v_{ext} = 0$), something marvelous happens:

1. **External velocity is zero:** It is not moving in space.
2. **Internal velocity is maximized:** According to the Pythagorean theorem, its internal evolution rate v_{int} must be completely equal to the total rate c .

We have already defined in section 4.1 that **mass** (m) is **this internal evolution rate** ($m \propto v_{int}$).

Now, look at this geometric picture:

- **Total Energy** (E) is the total length of that arrow.
- **Mass** (m) is the projection length of this arrow on the “internal time axis.”
- When the object is at rest, this arrow points completely vertically upward (pure internal time direction).
- Therefore, **the length of E completely equals the length of m .**

This is $E = m$.

So where does that famous c^2 come from? It is merely a historical artifact of **unit conversion**. This is like measuring length in “inches” but weight in “ounces,” finally discovering that these two numbers always differ by a fixed ratio. If we use “natural units” like theoretical physicists do (set $c = 1$), then $E = mc^2$ becomes that extremely concise, extremely naked truth:

$$E = m$$

This reveals the ultimate secret of mass: **Mass is not an independent entity; it is locked energy.**

More accurately, **mass is linear bandwidth curled into a loop.**

Imagine a beam of light. It races forward at speed c , its energy manifest in its “kinetic energy,” expressed as pure external displacement.

Now, imagine this beam of light encounters some topological obstacle, forced to bite its own tail, beginning to spin in place. It no longer moves forward but becomes a tiny, high-speed rotating light ring.

To external observers, this light “stops.” It no longer has external velocity ($v_{ext} = 0$). But its internal rotation speed is still c . The energy it originally used to traverse space is now entirely used to maintain this internal dead loop.

This “dead loop” is what we call a **particle**. This “energy spinning in place” is what we call **mass**.

6.3.2 Releasing the Devil

Understanding that “mass is curled time flow,” we can understand the principle of nuclear weapons.

Atomic bomb explosions do not “create” energy; they merely **untie the knot**.

When uranium nuclei split, what actually happens is: part of the evolution vector originally locked in internal dimensions (v_{int}) is suddenly freed from confinement. That originally frantically rotating internal velocity is redirected, returning to straight-sprinting external velocity (v_{ext}).

This is a geometric **re-projection**.

Those bandwidths originally spinning wildly in Hilbert Space are suddenly projected into external space, becoming gamma rays and high-speed particles flying at light speed.

Why are nuclear explosions so violent?

Because as we said in Chapter 1, the universe’s total bandwidth c is an enormous value. Inside every tiny proton, a raging torrent running at light speed is imprisoned. When we untie this confinement, even releasing just a small part (the mass defect), the effect is catastrophic.

So, $E = mc^2$ actually tells us: **Even the tiniest dust is woven from imprisoned light storms**.

6.3.3 Conclusion of Part II: From Continuous to Discrete

Thus far, we have completed the reconstruction of macroscopic physics. We used the “Great Trade-off” (Pythagorean theorem) to explain Special Relativity. We see:

- **Time** is not an absolute river; it is a consumable resource.
- **Space** is not an empty stage; it is where time goes after exhaustion.
- **Mass** is not dead stone; it is a violently rotating knot of time.

Einstein’s universe is grand, elegant, and continuous. In this picture, Hilbert Space evolution seems like smooth fluid. We arbitrarily allocate total bandwidth c between v_{ext} and v_{int} , as smoothly as pouring water.

But this smoothness is only an illusion.

When we zoom in, and zoom in further, until penetrating deep into those heavy materials, trying to see how that “imprisoned time” actually knots, the smooth geometry shatters.

We discover that the universe is not an infinitely divisible fluid. At extremely small scales (Planck scale), the universe reveals its **pixels**. That original beam of time-light is not a continuous wave, but countless jumping bits.

Without understanding this discreteness, we cannot understand why time knots, why there are specific particles, why there are quantum mechanics ghosts.

It is time to put down Einstein’s telescope and pick up Bohr’s microscope. Let us enter Part III—**The Knot of Time**, to explore that real world composed of pixels.

(Next, we will enter Chapter 6 “The Pixels at the Bottom” of Part III “The Knot of Time,” revealing the discrete computational ontology beneath continuous spacetime.)

Chapter 7

The Bankruptcy of the Photon

Chapter 8

The Bankruptcy of the Photon

8.1 The Cost of Immortality

Humans have dreamed of immortality since ancient times. Heroes in myths seek the fountain of youth; wealthy people in science fiction freeze their bodies. We yearn to stop time’s wheel from turning on us, to transform moments into eternity.

In the world of physics, there indeed exists a state of “immortality.” But this is not God’s gift; it is a cold geometric transaction. Its cost is beyond any poet’s imagination.

Let us take out once more that ledger ruling the universe—the Pythagorean theorem:

$$v_{ext}^2 + v_{int}^2 = c^2$$

For a massive object (like a stone, or you), most of the budget c is spent on v_{int} (internal evolution). This means you experience time, you age, you remember, you **change**. This is the cost of being “matter”—you have a rich internal life, but you are imprisoned in a low-speed cage.

But photons make a completely different choice. Like a desperate gambler, they stake all their chips—that total budget of c —all-in on v_{ext} (external displacement).

When v_{ext} is pushed to the limit, reaching total bandwidth c , the mathematical formula mercilessly declares the result:

$$c^2 + v_{int}^2 = c^2 \implies v_{int} = 0$$

What does this mean?

In our geometric dictionary, v_{int} represents the ticking rate of the internal clock. For photons, this value is zero. This means the photon’s **internal clock has completely stopped**.

This leads to the most dizzying corollary in relativity: **Light has no time**.

Imagine a photon born shortly after the Big Bang, traversing dark void, flying for 13.8 billion years, finally striking your retina, letting you see the afterglow of cosmic microwave background radiation.

In our reference frame, this photon experienced an impossibly long journey. It witnessed the birth of galaxies, observed the death of stars.

But in the photon’s own reference frame, **no time has passed**. It has not experienced the journey; it has not “aged.” In its experience, the instant of its birth and the instant of its death (absorption) are **completely coincident**.

This is the **cost of immortality**: To gain the freedom to traverse all of space (light speed), you must sacrifice the right to experience all of time (life).

Photons are eternal, but this eternity is not “infinite time,” but **timelessness** (Timelessness). They are like photos sealed in amber, forever preserving the moment of their birth. They have no history, no future; they only have that eternal “now” belonging solely to them.

This is also why photons cannot have mass. As we saw in the previous chapter, mass is the rate of internal evolution ($m \propto v_{int}$). If a photon wanted to have even a tiny bit of mass, it would have to withdraw part of the budget from external velocity v_{ext} to maintain internal cycles. At that moment, it would no longer be light; it would have to slow down, fall to earth, and begin experiencing birth, aging, sickness, and death.

So when we look up at the stars and see those messengers racing at light speed, we see not only the limit of speed, but the **limit of existence**. Photons show us the universe’s most extreme truth: If you want to embrace all of space, you must abandon all of time.

It is a **computational destitute**, because it spends all its resources on traveling, leaving no remaining bandwidth to process its internal state. It has nothing, so it is fast as lightning.

(Next, we will enter section 5.2 “The Computational Destitute,” exploring why this state of “having nothing” is crucial for the universe’s causal structure.)

8.2 The Pauper of Calculation

Why did I name this chapter “The Bankruptcy of the Photon”? This sounds like an emotional metaphor, but in our geometric reconstruction, this is a precise physical description.

In our model, the universe is a resource-limited computational system. Total bandwidth c represents the “computational ability” the universe grants every entity. Having resources means having the ability to process information—to change states, to record history, to perform complex internal cycles.

In this sense, matter is the “wealthy” in the universe.

Look at an electron in your body. It has mass, meaning it retains enormous internal bandwidth ($v_{int} \approx c$). Using these resources, it can perform complex spin operations in Hilbert Space, it can entangle with other particles, it can jump from one energy level to another. It is a tiny, fully functional quantum computer. It is “wealthy” because it has **internal life**.

In contrast, photons are complete **paupers**.

Because they exchange all computational ability for external displacement ($v_{ext} = c$), their account has no balance left, not even one bit, to maintain internal state.

- **They have no “rest mass”:** This means they have no capital to stop and think. If they stop, they disappear.
- **They have no “internal evolution”:** They cannot change their essence during flight. A red photon, if it doesn’t collide with the outside world, remains red forever; it cannot decide halfway to become blue.

Photons can run so fast precisely because they **have nothing**. They have no internal baggage to carry.

8.2.1 The Zero-Latency Messenger

You might ask: Why does the universe allow this “poverty” to exist? Why not force all particles to retain a bit of internal bandwidth, so everyone can fairly have time?

The answer lies in **communication integrity**.

If photons had mass, if they had internal time, then they would be complex processors, not just messengers. This means during their 8-minute journey from the Sun to Earth, they would undergo “internal evolution.” They might “age,” might experience phase drift, even might “change their mind.”

Imagine if the mail carrier delivering your letter couldn't resist opening it on the way, modifying the content based on their mood. Then when you receive the letter, what you read is no longer the sender's original intent, but information "processed" by the mail carrier.

To build a logically rigorous causal universe, we need an **absolutely transparent messenger**. We need a mechanism that can transmit events (causes) from one end of spacetime to the other (effects) completely unchanged.

This requires the messenger itself to be "dead"—it cannot have any internal computational activity.

Photons exist precisely to satisfy this harsh condition. Because their $v_{int} = 0$, they accumulate no internal geometric phase (Internal Phase Accumulation) during transmission. For photons, the transmission's start and end points are **directly connected** logically, with no processing steps in between.

This is the physical essence of **masslessness** (Masslessness): it is the manifestation of **zero computational latency** (Zero Computational Latency).

8.2.2 The Uninhabitable Ship

This also explains why we can never "ride" on a light beam to travel, like Einstein's fantasy at age 16.

In science fiction, we often imagine spaceships accelerating to light speed. But from our geometric perspective, this is not only engineering impossibility, but logical paradox.

If you reach light speed, your v_{int} must be zero. Your thinking, your heartbeat, the motion inside your atomic nuclei—all these processes requiring internal bandwidth consumption—must stop.

You cannot "sit" on a photon because photons have **no internal space**. They are flattened singularities with no internal dimensions to accommodate a complex observer. To be an observer, to have consciousness, you first must be "wealthy"—you need sufficient computational resources to maintain the "self" background process.

Therefore, photons are destined to be lonely wanderers. They are pipes connecting all things, yet can never become part of all things. They sacrifice their sense of existence to connect the world.

Thus far, we have completed the exploration of the two poles of the "Great Trade-off":

- One pole is **matter**, the hoarder of time, heavy because wealthy, slow because heavy.
- The other pole is **light**, the conqueror of space, fast because poor, eternal because fast.

But this picture is still built on Einsteinian smooth geometry. We talk about continuous "flows," smooth "rotations."

If we want to understand not only macroscopic motion, but also why there are specific types of particles—why electrons, quarks, neutrinos? Why do they have fixed charges and spins?—we must upgrade our microscope once more.

We need to penetrate those smooth curves and see the universe's bottommost **pixels**.

—
(Next, we will enter Part III "The Knot of Time," starting from Chapter 6 "The Pixels at the Bottom," revealing the discrete computational ontology beneath continuous spacetime.)

Part III

The Knots of Time

Chapter 9

The Underlying Pixels

9.1 Quantum Cellular Automaton (QCA)

When you sit in a movie theater, watching smooth images on the screen: cars racing, clouds drifting, protagonists crying. Your eyes tell you everything is continuous and smooth. But if you walk up to the screen and observe with a magnifying glass, you'll find that "smoothness" is just an illusion. You see only **pixels** of three colors: red, green, blue. These pixels themselves don't move; they just change brightness in place according to specific rules.

Our universe is likely the same.

In Part II, we reconstructed relativity using smooth geometric language. We talked about "flowing rates," "rotating vectors." This is perfect for describing the macroscopic world. But when we try to apply this language to extremely tiny scales—Planck scale (10^{-35} meters)—the smoothness of geometry collapses.

This is like trying to draw a perfect circle on a computer screen. No matter how high your resolution, if you zoom in enough, that circle's edge will always become jagged steps.

In our geometric reconstruction framework, this "jaggedness" is not error; it is the universe's **ontological truth**.

9.1.1 The Universe's Refresh Rate

In Chapter 1, we introduced Axiom A1: the universe evolves at a constant rate. Macroscopically, this manifests as continuous flow; but microscopically, we need to introduce a new concept: **Quantum Cellular Automaton (QCA)**.

Don't be intimidated by this complex term. Its core idea is very simple: **The universe is composed of countless tiny, discrete "logic units."**

Imagine space is not an empty box, but a vast three-dimensional grid. At every grid point there is a tiny quantum system—we can think of it as a "qubit" or a "miniature Hilbert Space."

This is like the universe's pixels.

This completely changes our understanding of "motion." In classical physics, when an electron moves from point A to point B, we imagine it sliding through intermediate space like a marble. But in the QCA picture, the electron doesn't move. What actually happens is grid point A "dimmed" (lost the electron's state), while adjacent grid point B "brightened" (gained the electron's state).

So-called motion is actually **information transmission**.

This explains that mysterious "evolution rate c " we mentioned in Chapter 2. In the QCA model, time does not flow continuously, but jumps frame by frame. The universe has a fundamental

“clock tick” (Tick). In every clock tick, every grid point updates its state according to its neighbors’ states through a fixed rule (unitary operator).

Therefore, the universe is not “evolving,” but **computing**.

We not only view physics as geometric projection, but further, as a kind of **computational projection** (Computational Projection). From this perspective, the continuous rotation of Hilbert Space is actually the statistical average of countless tiny logic gate operations at the macroscopic level.

9.1.2 The Ghost of Discreteness

You might ask: “If the universe is really pixelated, why can’t I see the grid? Why don’t I feel the world ‘stuttering’?”

The answer lies in **scale**.

The pixel density at this layer is astonishing. According to estimates, one cubic meter of vacuum contains approximately 10^{105} Planck grids. For comparison, humanity’s sharpest displays have only hundreds of pixels per inch.

Because pixels are too small, update frequency too fast (10^{43} times per second), our senses—even our most precise particle colliders—cannot detect the underlying granularity. The “smooth spacetime” we see is actually a **low-resolution approximation** emerging from underlying discrete structures.

Just as water appears as continuous fluid but is essentially discrete water molecules; spacetime appears as a continuous stage but is essentially a discrete qubit network.

Acknowledging the universe’s discreteness (QCA nature) solves a problem that has plagued physics for years: **the elimination of infinities**.

In standard quantum field theory, when we calculate interactions between two particles approaching infinitely close, we often get “infinity” results. This is because we assume space can be infinitely divided. But in a QCA universe, you cannot approach infinitely close. Like on a screen, two bright points can only be adjacent at closest, not overlapping. This natural **geometric cutoff** (Cutoff) makes all physical calculations finite and reasonable.

So when we say “underlying pixels,” we are not making a metaphor. We are describing a reality more fundamental than “strings” or “membranes”: **the minimal unit of information processing**.

But if the universe is composed of fixed grids, a huge problem follows: Since grids are stationary, why does light speed appear the same in all directions? Shouldn’t walking diagonally and horizontally on the grid have different distances?

This is the famous “Lorentz symmetry breaking” problem. But in the next section we will see that QCA has a magical ability to perfectly disguise itself as isotropic continuous space at the macroscopic level, leaving only extremely tiny traces.

(Next, we will enter section 6.2 “Causality as Network Speed,” exploring how the speed-of-light limit naturally emerges as a logical necessity (Lieb-Robinson bound) in this pixelated universe.)

9.2 Causality as Connection Speed

In classical physics, causality is a philosophical concept: causes must precede effects. But in Einstein’s relativity, causality becomes a geometric concept: the light cone (Light Cone). Any event can only affect the future within its light cone; any connection beyond the light cone is impossible.

But this still sounds like an arbitrary prohibition. Why c ? Why not infinitely fast? If the universe is just an empty stage, why can't events at one end instantly reach the other?

In our Quantum Cellular Automaton (QCA) model, this puzzle receives an extremely intuitive answer: **Light speed is not flight velocity; light speed is information transmission rate.**

9.2.1 The Domino Effect

Imagine a vast floor densely covered with dominoes. Each domino represents a spatial pixel (QCA unit).

If you push over the first domino (creating an event), it falls and hits its neighbor. The neighbor falls to the next neighbor. A “wave” begins spreading through the domino array.

Now, how fast can this wave propagate?

This depends on two factors:

1. **The size of dominoes** (spacing of spatial pixels).
2. **The time needed for dominoes to fall** (fundamental time step, or logic gate operation cycle).

No matter how strong your push, no matter how urgent your intent, the speed at which this wave spreads across the room has a physical upper limit. You cannot make the 100th domino fall at the same instant as the 1st domino, because every intermediate domino needs time to respond.

This is the true face of the “speed-of-light limit” in our universe.

From the QCA perspective, nothing is really “flying.” Photons are not bullets traversing void; they are a **relay of states**.

When physicists say “light speed is c ,” they are actually saying: In this universe network composed of qubits, information seeps from one node to adjacent nodes, limited by the update rate of the most fundamental logic gates.

Mathematicians Lieb and Robinson rigorously proved this in a famous theorem: In a quantum lattice system with local interactions, even without presupposing relativity, a maximum information propagation speed naturally emerges. This is the **Lieb-Robinson Bound**.

In our dictionary, **the light cone is the boundary of this propagation limit.**

9.2.2 The Logical Horizon

Let us use a more modern metaphor: **network speed**.

If we view the universe as a vast distributed computer, each spatial point as a server node, then light speed is the **maximum PING value** or **latency** of this entire network.

- When we look at the Moon, we see the Moon from 1.3 seconds ago. This is not just because light travels that far, but because information about the Moon (Bits) needs to pass through countless spatial pixels’ “handoffs” and “processing” to reach your retina.
- The black hole’s event horizon (Event Horizon), in this sense, is the network’s **disconnected zone**. The network topology there makes information propagation hops infinite, or information packets are forever stuck in the buffer.

Therefore, causality is no longer an abstract philosophical principle; it becomes a **hard constraint of network topology**.

If someone claims they can instantly transmit information to the Andromeda Galaxy, they are actually claiming they can bypass all intermediate nodes in the universe and directly modify

remote memory. But in a strictly local QCA universe, this is strictly forbidden by the underlying operating system (Axiom A1).

9.2.3 Discrete Light Cones

In continuous spacetime, the light cone is a perfectly smooth cone. But in our pixelated world, if we zoom the microscope to the limit, we see that the so-called “light cone” is actually a **pyramid** expanding in steps.

Each step corresponds to a Planck time step ($\Delta\tau$).

Each layer of diffusion corresponds to a Planck length (Δx).

At macroscopic scales, because steps are too small, the pyramid’s edges are smoothed, appearing like a smooth cone. This again confirms our core point: continuous physical laws are just **emergence** (Emergence) of discrete computational processes.

Now, we understand that space is pixelated and causality is limited. But there is still a huge gap in this picture: If space is composed of fixed grids, why don’t we sense the grids? Why do we measure the same light speed in all directions? Logically, walking diagonally on grids should be “slower” than walking straight (because the path is more tortuous).

This is the famous “Lorentz symmetry breaking” problem. It is the nightmare of all discrete spacetime theories.

But in the next section, we will demonstrate an astonishing mathematical miracle: how these discrete pixels use ingenious camouflage to deceive all our detectors at the macroscopic level, making the world appear perfectly symmetric.

(Next, we will enter section 6.3 “The Vanishing Mosaic,” using the $O(p^4)$ suppression mechanism to explain why the discrete universe appears so smooth.)

9.3 The Vanishing Mosaic

If the universe is really composed of discrete pixels (QCA grids), then logically, we should easily discover it.

Imagine walking on graph paper. If you want to go from point A to point B, and B is diagonally opposite, you cannot walk directly diagonally (because there are only grids); you must walk zigzag “stair steps.” This means on grids, the “hypotenuse” length does not equal the sum of squares of legs. This is the conflict between so-called “Manhattan distance” and “Euclidean distance.”

If light also “crawls” on the universe’s grid this way, then when we look in different directions, light speed should be different. Light should be fastest along grid axes, and slower (or faster, depending on specific jump rules) along diagonals.

This is called **Lorentz Violation**.

This is the nightmare of all discrete spacetime theories. Because countless astronomical observations—such as the Michelson-Morley experiment—tell us that light speed is extremely precisely the same in all directions. If the universe is pixelated, this pixel grid must be hidden extremely perfectly. How exactly does it do this?

9.3.1 Quantum Camouflage

The secret is that we are not just dealing with “cellular automata,” we are dealing with **quantum** cellular automata.

If a photon were a classical marble, it would indeed be tripped by grid corners. But a photon is a wave function. In quantum mechanics, wave functions do not propagate along a single path, but simultaneously explore all possible paths.

When we write down the QCA evolution equation (as we do in the Dirac-QCA model), a miracle happens. Although every tiny jump occurs between discrete grid points, when these jumps' wave functions superpose, the grid's "square effects" cancel each other out.

This is like displaying a circle on a square pixel screen. Although every pixel is square, by adjusting edge pixel brightness (anti-aliasing), you can make that circle appear perfectly round.

The universe uses the most advanced mathematical anti-aliasing technique. At macroscopic scales, the anisotropy of discrete grids is perfectly smoothed by quantum interference. The emerging macroscopic wave equation (Dirac equation) miraculously restores perfect rotational symmetry.

9.3.2 $O(p^4)$ High-Order Suppression

Of course, this camouflage is not absolutely perfect. As physicists, we need to know how large the "error" actually is.

In our geometric reconstruction, this error manifests as corrections to the **dispersion relation** (Dispersion Relation). In perfect continuous space, the energy-momentum relation is $E^2 = c^2 p^2$. But in our QCA pixel universe, this relation becomes a series expansion:

$$E^2 \approx c^2 p^2 - \alpha \frac{p^4}{M_{Pl}^2} + \dots$$

Note that correction term p^4 (momentum to the fourth power). This is an extremely crucial detail.

Many crude discrete models lead to p^2 or p^3 level corrections; such errors are too large and should have been seen by our telescopes long ago. But our QCA model has special symmetries (parity and time-reversal symmetry), which suppress the leading error term to p^4 level.

What does this mean?

This means that for ordinary low-energy particles (like atoms in your body, even light from the Sun), this error term is negligible. Only when particle momentum p approaches Planck momentum M_{Pl} (an extremely enormous energy) does this p^4 term become significant.

This is like saying the universe's display resolution is too high. Unless you can zoom the microscope to Planck scale (10^{20} times smaller than atomic nuclei), you will never see that "mosaic."

9.3.3 Evidence from Deep Space

Have we actually searched for this mosaic? Yes.

Astronomers have used the Fermi Gamma-ray Space Telescope (Fermi-LAT) to observe photons from distant gamma-ray bursts. If spacetime were really discrete, then photons of different colors (different momentum p) should be slightly differently affected by the grid, and their arrival times on Earth should have extremely tiny differences.

Observational results show: Even after traversing 7 billion light-years, high-energy and low-energy photons arrive almost perfectly simultaneously. This rules out crude "linear Lorentz violation" models.

But our $O(p^4)$ model perfectly passes this test. Because at gamma-ray burst energy scales, p^4 corrections are only about 10^{-19} seconds, completely hidden below current detection limits.

So the conclusion is astonishing: **Although the universe is pixelated, it still maintains a perfect continuous illusion within our observational capabilities through exquisite mathematical structure.**

This explains why we live in a world that appears so smooth and describable by calculus, despite its underlying foundation being a jumping digital grid.

Now, we have understood the stage (space) and the script (time). But there are some strange actors on this stage. Some grid regions seem “knotted,” forming unsolvable tangles. These tangles are so stable that we have given them names: “electrons,” “quarks.”

This leads to the next chapter’s theme: If space is a grid, what are particles? The answer might surprise you—particles are **bugs** on the grid.

(Next, we will enter Chapter 7 “Particles as Defects,” revealing the topological nature of matter.)

Chapter 10

Particles as Defects

Chapter 11

Particles as Defects

11.1 Topological Knots

When we imagine an electron, we usually picture a tiny, glowing sphere suspended in empty space. This is a very classical intuition: space is the stage, particles are actors. Actors can move freely on the stage; stage and actors are completely separate.

But in our Quantum Cellular Automaton (QCA) universe, this distinction disappears.

If the universe’s foundation is really just a vast, jumping logic grid, then what exactly is a “particle”? Since the grid itself is fixed, what moves from point A to point B?

The answer is: **Particles are special distortions of grid states.**

11.1.1 Wrinkles on the Carpet

Imagine laying a vast carpet. If the carpet is slightly larger than the room, or laid carelessly, a wrinkle will bulge in the middle.

You can try to flatten this wrinkle, but you’ll often find it hasn’t disappeared; it just moved elsewhere. You can push this wrinkle around the carpet. From a distance, this wrinkle looks like an independent “object” sliding on the carpet surface.

In this metaphor, the carpet is our cosmic space (the underlying grid of Hilbert Space), and that wrinkle is what we call a “particle.”

This is the core idea of **topological field theory**: particles are not marbles God placed in the universe; they are **topological defects** (Topological Defect) of space structure itself.

11.1.2 The Untiable Knot

Why are electrons stable? Why don’t they slowly diffuse and disappear like water waves?

In Part II, we said mass is “imprisoned time.” Now, we can describe this imprisonment more precisely from topology: **Particles are dead knots in the flow of time.**

In a smooth ocean, waves dissipate over time. But if you tie a knot in a rope, no matter how you shake the rope, that knot will remain. Unless you cut the rope, the structural information represented by this knot—its “knot degree”—is conserved.

In our geometric reconstruction, elementary particles (such as electrons, quarks) are **topologically non-trivial classes** in Hilbert Space evolution vector fields.

- **Vacuum** is trivial; evolution vectors uniformly point in the same direction (pure time flow).
- **Particles** are twisted; evolution vectors locally form a vortex or knot.

Because of topological protection, this knot cannot be untied through continuous deformation. This is why electrons are extremely stable, their lifetime even longer than the universe’s current age. They don’t want to disintegrate; geometry forbids it.

11.1.3 Creation and Annihilation

This model perfectly explains another magical phenomenon in physics: **pair production and annihilation**.

You cannot create a single knot out of nothing in the middle of a rope. But you can twist the rope to simultaneously create a “positive knot” and a “negative knot” (in this metaphor, they look like a pair of interlocking rings).

Similarly, in the universe, you cannot create an electron out of nothing. You must simultaneously create an electron (positive knot) and a positron (negative knot). When you put them together, their topological structures are opposite, canceling each other, the knot unties, and the rope returns to flat.

This is annihilation.

When we see matter and antimatter collide, bursting with enormous energy (photons), we are actually witnessing a **topological unlocking**. That internal evolution rate v_{int} originally locked in the “dead knot” is instantly released into straight-propagating external rate v_{ext} because the knot unties.

11.1.4 Only Background, No Actors

This view completely changes our ontology.

There is no “matter” entity in the universe; **only structure**.

What we call “matter” is actually space’s **pathology**. It is an unflattenable singularity encountered during execution of underlying rules. As we see in the QCA model, particles are **legal defects** of evolution rules—they are not program execution errors, but special, self-sustaining loop patterns allowed by the program.

If we view the universe as a perfect crystal, then particles are dislocations (Dislocation) in the lattice. If we view the universe as a display screen, particles are those few permanently unswitchable bad pixels.

It is precisely these “defects” that constitute our rich and colorful world. Without these dead knots, the universe would be just dead, smooth fluid, nothing could stop, nothing could have memory.

We exist only because the universe failed to completely iron itself flat.

(Next, we will enter section 7.2 “Compression Residual,” exploring from an information perspective: Why do these discrete dead knots behave so strangely when we describe them with continuous mathematics?)

11.2 Compression Residuals

When we take a complex photo with a phone and save it as JPEG format, what happens? The phone’s algorithm discards high-frequency details imperceptible to human eyes, approximating complex textures with smooth color blocks. This is **lossy compression**. Usually, this compression is very perfect. But if you photograph a black-and-white checkerboard image full of sharp edges and intense contrast, the compression algorithm collapses. At black-white boundaries, strange noise and artifacts appear.

These artifacts are not real objects; they are **residuals** (Residuals) inevitably produced when **describing discrete reality with smooth language**.

In our geometric reconstruction, modern physics—especially quantum field theory—plays exactly the role of that JPEG compression algorithm. And the particles in our eyes are those noise points.

11.2.1 The Illusion of Continuity

As we showed in Chapter 6, the universe’s foundation is likely a discrete Quantum Cellular Automaton (QCA) grid. But as macroscopic observers, our senses and instrument resolution are extremely limited. We cannot track every Planck pixel’s jumping; we can only see their macroscopic average effects.

To describe these macroscopic effects, we invented **calculus**. We use continuous fields (Field) and smooth wave functions (Wavefunction) to approximate underlying discrete states.

In most empty cosmic space, this approximation is extremely perfect. Because grid state changes there are gentle, like blue sky in photos, smooth functions describe it perfectly. This is why vacuum appears so empty and smooth.

But when we encounter a **dead knot**—the topological defect mentioned in the previous section—trouble comes.

At the core of this dead knot, grid states undergo violent twisting and flipping. The change rate here is too fast; spatial structure too sharp. When we try to forcibly cover this region with smooth functions (continuous field theory), mathematical description fails.

To forcibly maintain the “smooth” illusion, our equations are forced to spit out an infinite value or an undefined singularity at this point. We circle this mathematically awkward point, label it, saying: “There is a particle here.”

Therefore, **particles are lossy compression residuals of continuous field theory on discrete topological defects**.

11.2.2 The Point Particle Paradox

This view perfectly solves the “point particle paradox” that has plagued physics for a century.

In the standard model, electrons are described as geometric points with no volume. This leads to infinity disasters: if electrons were really just points, their charge density would be infinite, their self-energy also infinite. To escape these infinities, physicists had to invent complex “renormalization” techniques, essentially manually subtracting these infinities.

But from the QCA perspective, this is completely unnecessary trouble.

Electrons were never points. They are **topological knots with complex internal structure** at Planck scale. They occupy several grid points, have finite size, finite energy density.

The reason we write them as points in equations is that the “continuous language” we use has too low resolution to describe their exquisite internal pixel arrangement. We are forced to **compress** them into abstract points with no internal geometric structure, then have to additionally label these points with “spin 1/2,” “charge -1” to represent lost internal geometric information.

These quantum numbers (Quantum Numbers) are essentially **metadata of compression packages**. They are abbreviated encodings of those internal topological structures we cannot see.

11.2.3 Not a Bug, but a Feature

Programmers know that when code encounters unhandleable exceptions, the system throws an Error. In a sense, particles are **Errors** thrown by the universe operating system.

But this doesn't mean the universe is wrong. The universe runs perfectly fine. What's wrong is our **description method**.

- Universe ontology (QCA) is discrete, perfect, with no singularities.
- Physical models (QFT) are continuous, approximate, full of singularities.

Particles behave so strangely—both wave-like and particle-like, both here and not here—precisely because they are caught between these two description systems. They are projections of discrete ghosts in the continuous world.

So when we talk about “discovering new particles,” we are not finding new building blocks in the universe's treasure box. We are exploring what new kinds of knots the underlying grid can tie. The Higgs boson (Higgs Boson) is not the God particle; it is a special vibration mode of the vacuum grid, a special compression residual.

This perspective liberates us from superstition about “material entities.” There are no “things” in the world; only **structures of information**.

Now, we know particles are dead knots on spatial structure. But since they are dead knots, why aren't they fixed? Why do they collide, bounce, even react?

This involves the second secret of “time” at the microscopic level: when time flows through these dead knots, it is no longer uniformly passing. It is drawn in, delayed, resonated.

This is the theme of our next chapter—**Time as Spectrum**. There, we will see how microscopic particles gain their dynamical behavior in the macroscopic world by “devouring time.”

(Next, we will enter the final chapter of Part III—Chapter 8 “Residence and Resonance,” unraveling the temporal essence of microscopic interactions.)

11.3 Symmetry as Backup

When we examine the Standard Model—that physics edifice describing all known elementary particles—we find it built on strange mathematical groups: $SU(3) \times SU(2) \times U(1)$. Physicists call these “gauge groups.”

Usually, these groups are seen as parameters arbitrarily set by God. But in our geometric reconstruction, they are not arbitrary; they are **inevitable corollaries of capacity conservation**.

11.3.1 Internal Rotation

Let us return to our core axiom: the universe is a total bandwidth-limited system. Every particle is a vector in Hilbert Space, its total length must be constant c .

In Chapter 4, we defined mass as internal evolution rate v_{int} . But this “internal” is not a simple black box. Just as your computer hard drive has one “total capacity” indicator but is internally divided into C, D, E drives, particles' internal space also has fine structure.

In our model, to accommodate the complexity observed in the Standard Model, we must accept an empirical assumption (H7): the universe's “internal fiber” at every spatial point has $\mathbb{C}^3 \otimes \mathbb{C}^2 \otimes \mathbb{C}$ structure.

- \mathbb{C}^3 corresponds to color degrees of freedom (strong interaction).
- \mathbb{C}^2 corresponds to weak isospin degrees of freedom (weak interaction).
- \mathbb{C} corresponds to phase degrees of freedom (electromagnetic interaction).

This is like every particle internally containing a precise gyroscope system with three independent rotation axes.

The key point: **For the universe’s total background, it only cares how much total bandwidth (energy) you consume, not how you consume it.**

This is like shopping at a supermarket; the cashier only cares that the total is 100 yuan, not whether you gave two 50-yuan bills, one 100-yuan bill, or WeChat payment. As long as total value (norm) is unchanged, payment method (internal state) can vary freely.

This “free variation of payment methods” is the famous **gauge symmetry** (Gauge Symmetry) in physics.

11.3.2 Isometric Transformations

In geometric language, this is called **isometric transformations** (Isometry).

Imagine a sphere. No matter how you rotate it, its radius (representing consumed bandwidth c) doesn’t change. Gauge groups $SU(3)$, $SU(2)$, $U(1)$ are precisely the sets of rotation operations that can keep “internal geometric capacity” unchanged.

- When we rotate the “color” axis in internal space (quarks change color), as long as rotation is unitary, the particle’s total computational resource consumption doesn’t change.
- When we rotate the “phase” axis (electrons change phase), the particle’s mass and energy also don’t change.

Therefore, the Standard Model’s symmetry groups are essentially **redundancy** allowed by the universe to **maintain computational capacity conservation**. They are “degrees of freedom” within the system, allowing particles to flexibly adjust their internal configuration without breaking the total budget.

11.3.3 Gauge Fields: Balancing the Books

But what happens if we rotate the gyroscope left here and right there in the universe?

This causes local inconsistency. To compensate for this inconsistency, to maintain global geometric connection while “everyone freely rotates internal coordinate systems,” the universe must introduce a compensation mechanism.

This compensation mechanism is **gauge fields** (Gauge Fields)—photons, gluons, and W/Z bosons.

From our geometric perspective, gauge bosons are not “force” carriers; they are **geometric connectors** (Connections). Their role: when you twist local internal coordinate systems, they bend external geometric paths to offset this twist, ensuring total geometric capacity (Action) is conserved.

So why do photons exist? Because the universe allows us to freely change electron phase anywhere ($U(1)$ symmetry). To prevent this free change from breaking physical laws, photons must exist as a “patch” to correct phase differences.

11.3.4 Structure as Destiny

Thus far, we have completed the reconstruction of matter’s microscopic structure.

- **Particles:** Not entities, but topological dead knots (defects) on spatial fabric.
- **Mass:** Not weight, but time loops locked inside dead knots (v_{int}).
- **Interactions:** Not push-pull, but geometric compensation (gauge fields) that must exist to maintain internal geometric capacity conservation.

The material world we see—complex periodic table, brilliant chemical reactions—is essentially just kaleidoscopic patterns projected by that simple geometric ontology (c conservation) onto complex internal topological structures.

God did not design the Standard Model; rather, if you want to tie stable knots on a discrete, bandwidth-limited grid and allow these knots to freely rotate without collapsing, you must have this mathematical structure as support.

This is the end of Part III. We have dismantled the stage (spacetime) and the actors (matter). Now, we must make these actors move. We must see what happens when these time-knots carrying complex internal structures approach, collide, and entangle.

That is not just force action; that is temporal resonance.

(Next, we will enter Part IV “Geometric Driving Forces,” starting from Chapter 8 “Residence and Resonance,” revealing the temporal essence of interactions.)

Chapter 12

Resonance as Residence

Chapter 13

Resonance as Residence

13.1 The $\kappa(\omega)$ Function: Bridge Between Micro and Macro

In the macroscopic world, we are accustomed to measuring time with stopwatches. Time flows linearly and uniformly. But in the microscopic quantum world, time reveals its extremely bizarre side: it becomes a spectrum that can be “accumulated” and “stretched.”

To understand this, we need to introduce the most hardcore, but also most beautiful mathematical object in this book: the $\kappa(\omega)$ **function**.

Don’t be intimidated by this Greek letter. In our geometric reconstruction, it plays the role of a “tower of Babel”—it connects microscopic scattering experiments (what we see in particle colliders) and macroscopic geometric ontology (paths in Hilbert Space). It is the key to understanding “interactions.”

13.1.1 Ghost Time in Collisions

Imagine throwing a tennis ball at a wall. The ball hits the wall and bounces back. How long did the ball stay on the wall during this process? Almost instantaneously.

Now, imagine throwing the ball into a sticky honey. The ball will sink in, slowly decelerate, pause, then be pushed out by a spring (assuming there’s one inside). The ball “resides” in the honey for a long time.

In quantum mechanics, when two particles collide (scatter), what happens is more like the latter. Particles don’t bounce off like billiard balls; their wave functions overlap and interfere, forming a temporary entangled state, then separate.

Physicists use a quantity called **time delay** (Time Delay) to describe this process. It measures how much longer particles stay in the interaction region compared to vacuum.

In traditional textbooks, this is just an ordinary physical quantity. But from our geometric perspective, this “delay” reveals **the essence of time**.

We derived a unified time scale function $\kappa(\omega)$ in our paper. This function has a stunning triple identity:

1. It is the **derivative of scattering phase**: describes how much wave functions are twisted in collisions.
2. It is **density of states** (Density of States): describes how many ways the system can exist at a specific energy.
3. It is **time delay**: describes how long particles reside in the interaction region.

These three are mathematically completely equal. This means: **Time is not external flow independent of matter; time is the density of matter states.**

13.1.2 Winding of Geometric Paths

Let us return to Hilbert Space. As we said before, the universe is a vector rotating at rate c .

When particles fly freely in vacuum, this vector traces a smooth straight line (or great arc). Because there's no obstruction, it "walks" smoothly.

But when particles encounter interactions (like electrons encountering atomic nuclei), things change. At interaction energy points, the $\kappa(\omega)$ function suddenly shows a huge peak.

What does this mean?

This means in Hilbert Space, the evolution vector's path becomes extremely tortuous. It no longer advances straight, but begins to **circle frantically**. Like a tangled mess, or a tightly wound ball of thread.

Because total rate c is constant (Axiom A1), when the path becomes longer and more tortuous, the macroscopic time particles spend "completing" this journey becomes longer.

This is the **geometric origin of time delay**: particles are not really "dragged" by some force; they must take a longer detour in Hilbert Space.

- **Macroscopically:** Particles pause near atomic nuclei for a while.
- **Microscopically geometrically:** Particles' state vectors rotate thousands of extra turns in internal dimensions.

13.1.3 Time as Spectrum

The $\kappa(\omega)$ function tells us that time is not uniformly distributed. Like a spectrum, it is very dense at certain frequencies (energies), and very sparse at others.

- **Resonance:** When $\kappa(\omega)$ shows a sharp peak, we say the system resonates. Geometrically, this is time knotting. Particles deeply sink into time's vortex, "existing" particularly intensely and long at that point.
- **Lifetime:** A particle's lifetime is essentially the process needed to untie this time knot.

So when we ask "why do microscopic particles have interactions," the answer is no longer "because there's force," but **because time density differs there**.

$\kappa(\omega)$ is a bridge connecting two worlds: it translates visible time (delay) into invisible geometry (path length). It proves that even the most complex quantum collisions are essentially simple geometric evolution manifested under different projections.

This is the truth of interactions: not push-pull, but **temporal entanglement and residence**.

Now, we understand how microscopic particles produce interactions by "devouring time." But this is only half the story. What happens when countless such microscopic time knots converge? How does this microscopic geometric effect emerge as the most irresistible force in our macroscopic world—gravity?

This is not just a physics question; it's also about our own existence: Why are we trapped on the ground? Why do we always move from order to disorder?

It's time to enter Part IV—**Geometric Driving Forces**. There, we will transform these cold geometric derivations into profound insights about life's driving forces.

(Next, we will enter Part IV, transitioning from section 8.2 "Residence as Existence" of Chapter 8 to Chapter 9, exploring the origin of macroscopic forces.)

13.2 Residence is Existence

In everyday language, when we say an object “exists” somewhere, we usually mean it occupies that spatial position. But in our geometric reconstruction, space is only a secondary projection. In the underlying ontology of Hilbert Space, the only truth is the **rate** of evolution.

If everything is flying at light speed c , if all things are flowing, then how does “existence”—this seemingly static, stable state—arise?

The answer lies in **residence** (Residence).

13.2.1 The Runner in the Maze

Let us return to that universe state vector evolving at constant rate c . Imagine it as a tireless runner.

When photons traverse vacuum, this runner is sprinting on a straight highway. To external observers, it instantly crosses space with no hesitation. It “passes through” space, but it doesn’t truly “exist” at any point in space. It is just a fleeting passerby.

But when this runner encounters an atom, or enters a strong interaction region, things change.

Geometric paths are no longer straight. They become a **maze**.

The runner (evolution vector) doesn’t slow down—according to Axiom A1, it must always maintain rate c . But it is forced to detour, circle, backtrack in this maze. It runs extremely long distances within tiny spatial regions.

To external observers (us with stopwatches), this looks like particles **slowing down**, even **stopping**.

This is the physical picture of **time delay**. The time particles “reside” in interaction regions is essentially the extra detour they take in Hilbert Space’s internal dimensions.

13.2.2 Resonance: The Vortex of Time

The most extreme form of this residence is **resonance** (Resonance).

In particle physics experiments, when we tune energy to specific values, scattering cross-sections suddenly surge, particles seem “sucked” by targets. Physicists say this produces short-lived “resonance state” particles.

From our geometric perspective, this happens because evolution vectors encounter a **geometric vortex**.

At that specific energy point, the $\kappa(\omega)$ function—that time density function we introduced in the previous section—shows a sharp peak. This means geometric paths tightly wind together at that point, forming an almost closed loop.

Particles don’t disappear; they just fall into time’s cycle. They spin frantically in that tiny region, consuming their evolution budget. Until they’ve rotated enough turns, finally find an exit, and fly out again in straight form.

This brief “vortex” manifests macroscopically as an **existing entity**.

13.2.3 I Reside, Therefore I Am

This brings us a shocking ontological conclusion: **Matter’s sense of existence stems from its “residence” in time.**

- **Photons** don’t reside, so they have no mass, no fixed position; they are pure **flow** (Flow).
- **Matter** resides; it is flow that is curled, delayed, trapped in local mazes. It is a **knot** (Knot).

If you could completely untie an electron’s internal time knot, straighten its evolution path, it would instantly disappear, becoming a flash of light racing away at light speed. It would no longer “exist” here; it would become pure relation.

So when we say “there is a stone here,” we are actually saying: “There is an extremely dense time delay here.” This stone is hard and heavy because it internally contains astronomical amounts of geometric path winding. It is an aggregate of countless microscopic mazes.

This redefines “interactions.”

Collision of two particles is not two billiard balls hitting hard, but convergence of two time vortices. Their wave functions interfere, their mazes briefly connect, evolution vectors seek new paths between them.

If paths can untie, they scatter apart; if paths entangle tighter, they combine into a new, more complex knot—like atomic nuclei.

Binding energy (Binding Energy), in this sense, is the geometric cost that must be paid (or released) to maintain this more complex maze structure.

Everything we see is essentially **sediment of time**. The universe is a turbulent river, and matter is vortices in the river. Vortices appear as static objects with fixed shapes and positions, but they are completely composed of flow. If water flow stops, vortices also dissipate.

Now, we face a final question. If microscopic particles can infinitely curl time, if resonance can be infinitely strong, could there be an “infinitely deep” time trap? Could there be a point where time completely stops flowing, forming a mathematical singularity?

Physics hates singularities. And in our geometric framework, there is a natural mechanism preventing this disaster. This is the theme of our next section—**geometric saturation**.

(Next, we will enter section 8.3 “Geometric Saturation,” revealing why the universe’s bandwidth limit naturally prevents infinity and provides natural ultraviolet cutoff.)

13.3 Geometric Saturation

What do physicists fear most? Not black holes, not dark matter, but **infinity**.

In standard quantum field theory, when we calculate interaction forces between two particles approaching infinitely close, or calculate a point electron’s self-energy, equations often give absurd results: infinity. This means theory fails at extremely microscopic scales. To patch this hole, physicists invented a complex mathematical magic called “renormalization” (Renormalization), essentially manually subtracting these infinities to get finite observed values.

But this feels like cheating. Is the universe really broken at the bottom?

In our geometric reconstruction, we don’t need to cheat. Infinity doesn’t appear because our core axiom—**finite bandwidth** (c)—not only limits speed, but also limits **existence intensity**.

13.3.1 The Bandwidth Bottleneck

Let us return to that frantically rotating internal evolution rate v_{int} . We have established in previous sections that matter’s mass, interaction strength, and resonance sharpness essentially correspond to state vector rotation speed in Hilbert Space.

In standard theory, there’s no limit on how fast this rotation can be. If you compress enough energy into small enough space, interaction strength can increase infinitely.

But in our universe, there is an absolute iron law: **Total evolution rate cannot exceed c** .

This is like your sound system having a maximum power limit. No matter how desperately the singer screams, once volume exceeds the amplifier’s limit, sound doesn’t grow infinitely; it gets **clipped** (Clipping). Waveform peaks are flattened; output power reaches saturation.

The universe is the same. When a particle falls into extremely strong interactions (like ultra-high-energy scattering), its internal geometric paths become increasingly tortuous, its $\kappa(\omega)$ value (representing time delay or state density) becomes higher. This means its internal evolution rate v_{int} is soaring.

But when v_{int} tries to approach total bandwidth c , it hits the ceiling.

It can't go faster. According to the Pythagorean theorem $v_{ext}^2 + v_{int}^2 = c^2$, external velocity v_{ext} is forced to zero, all resources are occupied. The system enters **geometric saturation** (Geometric Saturation) state.

13.3.2 Natural Ultraviolet Cutoff

This produces an extremely important physical corollary: **Nature has a natural ultraviolet cutoff** (Natural UV Cutoff).

“Ultraviolet” in physics refers to high-energy, short-distance limits. Traditional theory believes we can probe infinitely small distances. But in our framework, this is like trying to display images smaller than pixels on a screen—impossible.

When interaction energy scales try to exceed this saturation point, evolution vectors in Hilbert Space can no longer “rotate” faster to respond to this energy. So resonance peaks no longer become sharper, but begin to widen and flatten. Physical processes are forcibly “smoothed.”

This means:

1. **No singularities:** Even at black hole centers, or the universe's Big Bang starting point, matter density and energy density cannot reach true infinity. Because “density” is essentially computational operations per unit volume, and this number is locked by c .
2. **No renormalization needed:** We don't need to artificially introduce cutoffs to save theory; geometry itself is the regulator. The universe's bandwidth limit naturally eliminates all mathematical divergences.

13.3.3 The Universe's Resolution

This brings us profound tranquility.

The universe is not a bottomless abyss; it has a bottom. It has a minimum granularity (pixels) and a maximum processing capacity (bandwidth).

No matter how we bombard vacuum with huge particle colliders, we can never create reality sharper than this bottom limit. When we try to break through this limit, we don't get deeper truth, but **saturated noise**.

Thus far, we have completed exploration of the microscopic world. We see:

- Space is jumping pixels (QCA);
- Particles are ununtiable dead knots (topological defects);
- Interactions are time winding ($\kappa(\omega)$);
- All madness is blocked outside infinity by an invisible wall (geometric saturation).

But how do these microscopic entanglements and knots emerge as that tremendous force pulling galaxies and shaping spacetime at macroscopic scales? Why do apples fall? Why do we feel “pushed” by the ground?

This is not just a mechanics problem; it's about **direction**. Why do all things tend to gather? Why does time have direction?

It's time to enter Part IV—**Geometric Driving Forces**. There, we will transform these cold geometric constraints into thermodynamic and psychological forces driving cosmic evolution. We will discover that so-called “forces” are merely systems’ efforts to find the most comfortable posture in this limited universe.

(Next, we will enter Part IV “Geometric Driving Forces,” starting from Chapter 9 “Unified Definition of Force,” reinterpreting the essence of gravity and driving forces.)

Part IV

The Drive of Geometry

Chapter 14

The Unified Definition of Force

14.1 The Slope

If you ask a child: “Why does the apple fall?” They will tell you: “Because the Earth is pulling it.”

If you ask a Newtonian physicist, they will say: “Because universal gravitation is acting.”

If you ask an Einsteinian physicist, they will say: “Because spacetime is curved, and the apple moves along a geodesic.”

These answers all describe phenomena, but none touch that most fundamental **motive**. Why does curved spacetime cause motion? What exactly is that “driving force” that drives objects to change state?

In our geometric reconstruction, we give a more fundamental answer: **Force is the slope of time density**.

14.1.1 The Invisible Slope

Let us recall the “Great Trade-off” from Part II: $v_{ext}^2 + v_{int}^2 = c^2$. Any massive object (like an apple) possesses enormous internal evolution rate v_{int} . That is, the apple is a container storing vast amounts of “internal time.”

Now, imagine space around Earth. According to general relativity, massive objects (Earth) slow down time flow around them. Closer to the ground, time passes slower.

What does this mean in our language?

This means **time density** is higher near the ground. As we saw in Chapter 8 discussing $\kappa(\omega)$, time delay means geometric path winding and accumulation. Earth is like a giant time magnet; Hilbert Space around it is extremely compressed and curled, forming a high-density “time deep well.”

When an apple hangs on a branch, it is in an awkward position:

- Above it (away from ground), time flows slightly faster, meaning time density is sparse.
- Below it (near ground), time flows slightly slower, meaning time density is dense.

The frantically rotating evolution vector inside the apple feels an asymmetry. This is like one foot standing on flat ground, the other in a swamp. The swamp has greater resistance, higher density; your body involuntarily tilts in that direction.

The apple “falls” not because Earth extends a hand to pull it down, but because **it slides toward places of higher time density**.

Objects always tend to slide toward places where their internal evolution (v_{int}) can be maximally “accommodated.” This is the essence of gravity: **It is not pull; it is slope**.

14.1.2 The Negative Gradient of Distance

We can refine this intuition into a universal mathematical definition, perhaps the most important concept in this book after the Pythagorean theorem.

In physics, we habitually say force is the gradient of potential energy ($F = -\nabla V$). But in our geometric universe, energy is just the length of evolution vectors. A more fundamental quantity is **distance**.

We define a distance in Hilbert Space called Fubini-Study distance (D_{FS}). It measures how “different” two quantum states are.

Force is essentially **the tendency to shorten some geometric distance**.

$$F \sim -\nabla D$$

- **For gravity:** Objects slide toward geodesics to minimize geometric path cost in curved spacetime. They seek paths maximizing their proper time (Proper Time).
- **For elastic force:** Springs try to restore original length to minimize geometric tension from molecular electron cloud deformation.
- **For strong force:** Quarks are confined by gluons because once separated, geometric distance between their gauge fields increases dramatically, producing huge restoring force.

There is no entity called “force” in the universe. Force is merely **corrective action** systems exhibit when finding themselves in “non-optimal geometric states,” to return to equilibrium (minimizing distance).

14.1.3 The Push-Back Sensation Here and Now

This view completely changes our understanding of the sensation of “being pushed.”

When you sit in an accelerating car, you feel the seatback pushing you. Newton says this is force. Einstein says this is because you’re deviating from geodesics. We say this is because the car’s engine is forcibly **rotating** your internal evolution vector.

The engine forces you to convert part of v_{int} (internal time) into v_{ext} (external space). Your body (countless tiny gyroscopes) resists this rotation; this resistance is translated in your senses as “push-back sensation.”

So all forces are ultimately **geometric structure’s response to change**.

- **Gravity** is sliding along geometric structure (downhill).
- **Electromagnetic/mechanical forces** are opposing forced geometric structure changes (uphill).

We live in a universe full of slopes. There has never been true flatness. Every piece of matter presses time depressions around it; every beam of light pulls spacetime’s warp and weft.

What we call “universal gravitation” is actually all things’ desire to “have more time.” Apples fall to return to that embrace where time flows slower and denser.

But this only explains motion of dead matter. Does this formula $F \sim -\nabla D$ also apply to that most mysterious observer—**life**?

If physical force is shortening distance between “physical states,” then psychological driving force, is it also shortening distance between some “psychological states”?

This is the astonishing corollary we will explore in the next section. We will extend the concept of “force” from physics to psychology, seeking that hidden slope driving life forward.

—
(Next, we will enter section 9.2 “The Geometry of Yearning,” exploring how to describe life’s driving force using the same geometric framework.)

14.2 The Geometry of Longing

In the previous section, we defined physical force as “slope”—objects naturally slide toward places of higher time density (larger v_{int}). This explains why apples fall.

But the universe contains not only apples, but also **observers**.

Living, conscious systems seem not to follow simple physical “sliding.” Birds fly against wind, humans swim against current, civilizations build order in an entropy-increasing universe. It seems life possesses a “willpower” that can resist physical gravity.

Where does this willpower come from? Is it supernatural?

In our geometric reconstruction, there is no supernatural. Life doesn’t violate physical laws; life merely responds to another form of slope in **higher-dimensional Hilbert Space**. We call this slope **longing**.

14.2.1 Fubini-Study Distance: Quantifying “Difference”

To understand this, we need to introduce an ultimate ruler measuring “distance” between any two states in the universe: **Fubini-Study distance** (D_{FS}).

In Euclidean geometry, distance is the length of a straight line connecting two points. But in quantum mechanics’ Hilbert Space, states are represented by rays (Ray). D_{FS} measures the **most fundamental difference** between two quantum states.

- If two states are identical, $D_{FS} = 0$.
- If two states are completely orthogonal (like “life” and “death,” “0” and “1”), D_{FS} reaches maximum ($\pi/2$).

This distance is not just mathematical abstraction; it represents **transformation difficulty**. To transform state A into state B, the physical cost (energy \times time) you must pay is proportional to the Fubini-Study distance between them.

14.2.2 The Universal Formula of Force

Now, we can give a **universal formula of force** governing all things:

$$F = -\nabla D_{FS}(\psi_{now}, \psi_{target})$$

This formula tells us: **All forces are essentially systems’ tendencies to shorten geometric distance between “current state” (ψ_{now}) and “target state” (ψ_{target}).**

- **For dead matter (physical gravity):**
 - ψ_{target} is the lowest energy state (or geodesic path).
 - Apples fall because in that direction, D_{FS} decreases fastest. They have no choice but to slide down the slope. This is **passive longing**.
- **For life (mental gravity):**

- ψ_{target} is a complex, internally set target state (like “capture prey,” “complete painting,” “become better self”).
- Life’s special feature is its ability to **autonomously set** ψ_{target} .

14.2.3 Driving Force as Geometric Tension

This explains what “longing” is.

When you feel hungry, a huge geometric distance D_{FS} arises between your current state ψ_{now} (low blood sugar, empty stomach) and your target state ψ_{target} (full, satisfied).

This distance is not an illusory concept; it produces real, measurable electrochemical potential energy in your neural network. This potential energy converts into neural impulses, driving muscle contraction, making you walk toward the refrigerator.

This is **physicalization of psychological driving force**.

Anxiety, desire, ambition, love—these human emotional experiences, from underlying geometric perspective, are all **perceiving distance**.

- **Anxiety** is you detecting ψ_{now} deviating from ψ_{target} , distance D_{FS} increasing.
- **Satisfaction** is you successfully bringing ψ_{now} closer to ψ_{target} , distance D_{FS} decreasing.

Life appears able to “move against gravity” not because it overcomes force, but because it **switches targets**.

A stone can only obey gravity’s call; its ψ_{target} is locked to the ground. But a bird can set its ψ_{target} to the sky. By consuming internally stored energy (time it previously hoarded), it can locally create a stronger gradient pointing skyward, thus offsetting Earth’s gravity.

14.2.4 The Optimization Algorithm

In this sense, every process in the universe, whether an electron’s transition or an empire’s rise and fall, is essentially the same **optimization algorithm** running in different dimensions.

This algorithm has only one instruction: **Minimize** D_{FS} .

- Electrons try to minimize action.
- Proteins try to minimize free energy.
- Neural networks try to minimize loss function.
- Humans try to minimize gap between reality and ideal.

This unity spanning physics and psychology shows us a trembling beauty. We don’t need to invent new physics for “mind.” Hilbert Space geometry is broad enough to accommodate both atomic vibrations and poets’ sighs.

But since life has freedom to set targets, why do we often feel powerless? Why do most of us end up living similar lives, trapped in mediocre cycles?

This is not because we lost freedom, but because our optimization algorithm fell into local dead ends. Geometrically, this is called **mediocre attractors**.

This is the theme of our next chapter. We will see how these geometric “pits” capture our lives, making us spin in place.

(Next, we will enter Chapter 10 “Mediocre Attractors,” revealing geometric traps in observer strategy space.)

14.3 The Entropic Perspective

In the previous section, we defined force as “tendency to shorten distance.” This sounds beautiful, but it leaves an unresolved question: **Why?**

Why does the universe always tend to shorten distance? Why do objects always slide toward low potential energy states? Who is pushing them from behind?

Traditional physics tells us this is fundamental law. But in our geometric reconstruction, there is only one fundamental law (Axiom A1): evolution rate is constant. Beyond this, everything should be statistical results.

Therefore, we propose a bold view: **There is no such thing as “force.”**

All forces we experience—gravity, elastic force, even your drive to change the status quo—are essentially **entropic forces** (Entropic Force).

14.3.1 The Logic of Parking Lots

Imagine a vast, crowded parking lot. If all cars tend to park near the exit, it’s not because some mysterious “gravity” pulls cars at the exit, but because of **probability**.

In thermodynamics, systems always tend to evolve toward macroscopic states with maximum microscopic states (entropy).

In our geometric universe, this logic manifests as **capacity competition**.

Let us recall that fundamental formula: $v_{ext}^2 + v_{int}^2 + v_{env}^2 = c^2$ (here we add back environment/invisible sector v_{env} to discuss vacuum capacity).

Any massive object (like the Sun) frantically consumes v_{int} (internal evolution) at its location. This means it “eats up” most local geometric bandwidth.

The result is that vacuum around the Sun becomes “barren.” Available remaining capacity (v_{env}) there is less than far away.

This creates a **capacity gradient**.

When a planet passes nearby, it is not “pulled” by the Sun. It merely discovers in random quantum fluctuations that moving toward the Sun (entering that capacity-depleted region) maximizes total microscopic arrangements of the entire system (planet+Sun+vacuum).

Gravity, from this perspective, is not a fundamental force field, but a **capacity shielding effect** (Capacity Shielding).

- Mass causes local geometric bandwidth saturation.
- This saturation creates a “low-entropy pit” around it.
- Surrounding objects “fall” into this pit, as naturally as gas molecules automatically diffuse to low-pressure regions.

14.3.2 The Illusion of Dark Matter

This entropic perspective even provides a key to solving the **dark matter** mystery.

Astronomers found that stars at galaxy edges rotate too fast, as if massive invisible matter pulls them. But in our framework, this might not require new particles.

At galaxy edges, gravity is very weak (extremely low acceleration). In vacuum there, geometric capacity is not fully occupied. According to holographic principle and entropic force derivations (like Verlinde’s work), entropic force behavior changes in such low-acceleration regions.

We speculate that this extra “gravity” is actually **entropic force enhancement** caused by vacuum capacity gradients.

When geometric bandwidth c is not fully consumed by matter at large scales, vacuum itself exhibits “elasticity.” This elasticity produces extra centripetal force, maintaining galaxy rotation.

So there are no ghostly dark matter particles. That is **vacuum’s own weight**. That is an illusion produced when calculating the universe’s “resource management log,” ignoring vacuum’s own overhead.

14.3.3 The Universe’s Longing

Connecting this chapter’s three sections, we get a complete picture:

1. **Slope (9.1):** Force is natural sliding on geometric structure.
2. **Longing (9.2):** In living beings, this sliding manifests as pursuit of “true self.”
3. **Entropy (9.3):** At the bottom, all this is statistical necessity because the universe tends to maximize its possibilities.

This completely unifies physics and psychology.

You feel hungry—this is an entropic force—your body’s effort to maintain low-entropy state.

Apples fall—this is an entropic force—they try to maximize gravitational field’s phase space.

So-called “driving forces,” whether atomic or spiritual, are essentially **trends** produced when the universe, this computer, runs optimization algorithms. We are all pushed by probability’s giant waves.

But if everything is just probability, if everything just slides toward entropy-increasing abyss, what meaning does life have? Are we just fallen leaves drifting with the current?

No. Because as we saw in section 9.2, life has the ability to **set targets** (ψ_{target}). Although we cannot change sliding rules, we can choose sliding directions.

However, choosing direction is not easy. On Hilbert Space’s strategy map, traps abound. Some directions look tempting, effortless, but once you slide in, you can never get out.

This is the theme of our next chapter—**Mediocre Attractors**. We will see why most people, like particles, end up trapped in local optimum dead loops.

(Next, we will enter Chapter 10 “Mediocre Attractors,” exploring geometric traps in observer strategy space.)

Chapter 15

The Mediocre Attractor

Chapter 16

The Mediocre Attractor

16.1 The Observer’s Trap

If force is geometric slope, and objects always slide toward lowest energy, then for conscious observers, where is this “lowest point”?

We usually think life pursues excellence. Evolution tells us survival of the fittest; human history seems an epic of constant upward climbing. But if we honestly examine our surroundings, even our own hearts, we find another, stronger force: **inertia**.

Most people, most of the time, are not “climbing.” We repeat. We do the same work day after day, scroll the same phone, hold the same views. Changing lifestyle, breaking mental patterns is so difficult that we often only try to change after suffering major blows (external perturbations).

In psychology, this is called the “comfort zone.” But in our geometric reconstruction, it has a more precise, colder name: **The Mediocre Attractor**.

16.1.1 Valleys in Strategy Space

Let us imagine an observer as a point in Hilbert Space. This point doesn’t just represent your physical location; it represents your **entire state**—your memories, beliefs, behavioral patterns. We call the set of all possible states **Strategy Space**.

In this multidimensional space, terrain is not flat.

According to the “universal formula of force” we established in Chapter 9, $F = -\nabla D_{FS}$, observers always tend to evolve toward directions of “least resistance.”

What is least resistance? For a bandwidth-limited (c finite) computational system, least resistance means **lowest computational cost**.

- **Thinking is expensive:** Re-evaluating a belief, or learning a new skill, requires mobilizing vast internal evolution rate v_{int} . This consumes energy, produces heat (anxiety).
- **Habits are cheap:** Using existing neural circuits, living today according to yesterday’s patterns, requires almost no extra computational resources.

Therefore, in strategy space, those highly repetitive, thoughtless automatic behavioral patterns form huge **geometric depressions**, valleys of potential energy.

Once an observer’s trajectory slides into this valley, according to geometric mechanics, without strong external force, they will struggle to climb out. They will begin circling at the bottom, forming a closed loop.

This is an “attractor.” It is the destination in dynamical systems, where all trajectories ultimately converge.

16.1.2 The Geometric Essence of Mediocrity

Why do we call it “mediocre”?

There is no moral criticism here. Geometrically, “mediocre” means **local optimum** (Local Optimum).

In this depression, everything is self-consistent. Your views explain the world you see; your actions bring expected feedback. In this small closed loop, D_{FS} (distance between reality and expectation) is minimized. You feel comfortable, safe, at ease.

But this is only a **local** deep well.

Beyond the well mouth, farther in strategy space, there may exist a deeper, broader, more self-consistent “valley of truth.” This is the “true self orbit” we will discuss in Chapter 11.

However, a high potential barrier separates them.

To cross this barrier, observers must first do something counterintuitive: **actively increase** D_{FS} . That is, actively embrace confusion, pain, and uncertainty. This is extremely expensive energetically.

For a physical system following the “principle of least action,” unless extra energy is injected, it will never actively cross barriers. It will be forever trapped in that shallow pit until thermodynamics’ end.

This is why “change” is so difficult. Not because you lack willpower, but because **the universe’s fundamental geometric structure opposes you**. You are fighting the same law governing quarks and galaxies—the principle of energy minimization.

16.1.3 The Curse of Dimensionality

Worse, this trap is often dug by observers themselves.

In Chapter 7, we mentioned that observers are “lossy compression” projection mechanisms. To save bandwidth, we ignore information irrelevant to our needs. We label the complex world with simple tags.

This simplification actually reduces strategy space’s **dimensionality**.

When we project infinite-dimensional reality onto low-dimensional cognitive models, many originally open paths are closed. A place that looks like a dead end on a two-dimensional plane might just be a staircase corner in three-dimensional space. But if we lock ourselves into two-dimensional perspective, we are truly trapped.

“Mediocre attractors” are not just valleys; they are often **low-dimensional dead loops**.

Within them, observers use a limited set of concepts (dimensions) to explain infinite universe. Whatever can be explained reinforces the loop; whatever cannot is filtered as noise.

This forms a perfect, unbreakable cage.

This is not just individual fate, but civilization’s trap. When a theory or institution runs long enough, it presses a deep pit in history’s geometric structure. Everyone slides down the slope into it, until the system loses all elasticity to adapt to new environments.

So, is there a way out?

If unwilling to accept mediocrity, if unwilling to sit at the bottom of local optimum’s well viewing the sky, how can an observer break this geometric curse?

Simple “effort” is insufficient, because effort in wrong dimensions just digs the well deeper. We need fundamental geometric transformation. We need a mechanism allowing observers to jump out of internally **self-referential** dead loops.

This is the theme of our next section—**Strange Loops**. We will deeply explore this loop’s logical structure and seek that extremely hidden exit to higher dimensions.

(Next, we will enter section 10.2 “Strange Loops,” analyzing the logical structure of cognitive dead loops.)

16.2 Strange Loop

In M.C. Escher’s famous print *Drawing Hands*, two hands are drawing each other on paper: the left hand draws the right hand, while the right hand simultaneously draws the left hand. This forms a **Strange Loop**.

In this loop, you cannot tell where is the source, where is the end. Each hand is both creator and created.

In our geometric universe, this is precisely the ultimate dilemma observers most easily fall into. Mediocre attractors are hard to escape not only because they are energy valleys, but because they are logically self-referential **dead loops**.

16.2.1 The Geometry of Self-Fulfilling Prophecies

Let us see how this loop is constructed in Hilbert Space’s strategy manifold.

As a bandwidth-limited observer (remember the photon’s bankruptcy? We are richer than photons, but still not infinite), we cannot process all universe information. To survive, we need to build an **internal model** to predict the future.

This model is like a filter (Filter). It tells us: which information is important “signal,” which can be ignored as “noise.”

Thus, the strange loop begins its rotation:

1. **Model determines observation:** Your internal model sets your projection direction. If you believe “the world is hostile,” your radar focuses on searching threats and offenses.
2. **Observation reshapes reality:** In massive information, you precisely filter fragments matching your expectations. You ignore kindness, amplify hostility.
3. **Reality validates model:** You tell yourself: “See, I always said the world is dangerous; this evidence proves I’m right.”
4. **Model reinforcement:** Since the model is “validated,” you use this filter more firmly; next observation becomes more biased.

Geometrically, this is a **positive feedback spiral**.

Observers think they’re going straight—they constantly collect evidence, constantly “correct” their worldview. But in strategy space’s high-dimensional geometry, because their coordinate system (projection basis) is bent by their own beliefs, they actually move along a **closed curve**.

The harder they try to prove themselves right, the deeper they sink into this circle. They are not just trapped; they **built the cage themselves and locked themselves inside**.

16.2.2 Echoes Within Algebra

This structure is not unique to psychology; it is deeply rooted in our theory’s mathematical skeleton.

In this book’s theoretical appendix, we define observers as **subalgebras** (Subalgebra) within the universe’s large algebraic system. Observers try to simulate the entire large algebra using this subalgebra.

This produces a mathematical “Gödel dilemma”: a system trying to describe itself within the system.

When observers’ internal theories become complex enough, they inevitably encounter **self-reference** (Self-Reference) problems. Observers are no longer observing the universe, but observing “the universe’s reflection in their own eyes.” The patterns they see are actually scratches on their retinas; the truth they hear is actually echoes of their own heartbeat.

This is the physical essence of strange loops: **They are topologically locked evolution paths.**

In this loop, Fubini-Study distance D_{FS} always appears small because “expectation” and “perception” always perfectly match. This is **local perfection**, a logical short circuit.

16.2.3 Prisoners of Dimensionality

Why is it hard to realize we’re in a loop?

Because on this low-dimensional loop cross-section, everything appears linear.

Imagine an ant crawling on a huge cylinder. If it only focuses on “forward-backward” dimension, it feels it’s always moving forward. It doesn’t know it’s actually circling. Only when it jumps off the cylinder surface into three-dimensional space can it see the loop’s overall structure.

Similarly, observers in strange loops are often **prisoners of dimensionality**.

They use fixed concepts (like “success,” “safety,” “correctness”) to dimensionally reduce complex worlds. This low-dimensional language is like that cylinder, guiding them back to origin again and again.

This loop is fatal. It consumes precious internal evolution rate v_{int} (that is, life), yet produces no substantial displacement. Like an engine idling there, exhausting all fuel in roaring noise, going nowhere.

So how can the ant know it’s circling? How can observers break this perfect logical closed loop?

There is only one answer: **dimensional elevation**.

The ant must learn to “look up.” Observers must introduce a new projection dimension completely orthogonal to existing models. This requires enormous energy, requires tearing original self-consistency, but this is the only path to freedom.

This is the theme of our next chapter—**Distance to True Self**. We will explore how to use geometry’s power to open an escape orbit to higher dimensions in mediocre gravitational fields.

(Next, we will enter Chapter 11 “Distance to True Self,” seeking geometric mechanisms to break loops.)

16.3 The Gravity of the Ego

If “strange loops” are cages observers build for themselves, what force makes this cage so strong, even making those inside fall in love with it?

In physics, we know massive objects produce gravity, bending surrounding spacetime. In our geometric reconstruction, that stable, dense logical core formed by observers’ long-term operation in strategy space—what we usually call **the Ego** (The Ego)—has the same property.

It has mass, it has inertia, it even has its own **horizon**.

16.3.1 The Mass of Beliefs

Let us recall Chapter 4’s core insight: **Mass is imprisoned time**. An object is heavy because it invests all evolution bandwidth (c) the universe grants it into internal cycles (v_{int}).

This principle also applies to the mental world.

What is the “self”? The self is not an entity; it is a highly structured, self-referential **loop of memories and beliefs**.

- When you hold a prejudice, you are not “possessing” a view; you are **running** a view.
- Your brain constantly consumes energy (bandwidth) to maintain this view’s logical self-consistency, to resist external counter-evidence.

The more complex and persistent this maintenance process, the more “internal evolution” this belief system accumulates in Hilbert Space. In other words, **your prejudice has mass**.

This explains why changing someone’s mind is so difficult—it’s like trying to push a boulder. The resistance you encounter is essentially **cognitive inertia** (Cognitive Inertia).

According to our “resource contention mechanism,” to change a deeply rooted belief (acceleration), observers must withdraw resources from maintaining old beliefs’ budget. But this triggers intense internal conflict. The old “self” resists this resource reallocation because it feels survival threat. Geometrically, this manifests as huge **restoring force**, trying to pull observers back to mediocre attractor’s valley bottom.

16.3.2 The Gravitational Lens of Information

This “self’s mass” not only produces inertia; it also bends surrounding information fields.

In general relativity, massive objects bend light like lenses. In our geometric universe, the “self” is also a **gravitational lens**.

When objective truth-light (Raw Data) shoots toward observers, it should propagate straight. But when it passes near that dense “self,” light bends.

- **Distortion:** Information matching self-expectations is focused and amplified; information contradicting self-expectations is diverged and ignored.
- **Blind Spot:** Just like shadow zones behind black holes where light cannot reach, behind powerful self-gravity exist huge cognitive blind spots. Truth exists there, but truth’s light is bent around by your prejudice.

This forms a geometric explanation of **echo chambers** (Echo Chamber): it’s not a wall; it’s a **high-curvature spacetime region**. Within it, all sounds eventually bend back, pointing to the sound’s source.

16.3.3 The Horizon of the Mind

When this gravity becomes extreme, the most terrifying structure appears—**black holes of the mind**.

For some observers trapped in extreme fanaticism or closed systems, their strange loops rotate so fast, their invested “internal evolution rate” so high, that an **event horizon** (Event Horizon) forms around them.

Inside the horizon, logic is completely self-consistent, even perfect. But outside the horizon, no new information can penetrate.

- External challenges (light) fall into the horizon, instantly torn apart by huge gravity, converted into fuel strengthening black hole mass (“See, their attacks prove my greatness”).
- Internal signals cannot escape; observers lose all causal connection with the real universe.

This is mediocre attractor’s ultimate form: **collapse**.

A collapsed observer, though biologically alive, in our geometric reconstruction has **cut** themselves from the universe’s open evolution. They become an isolated dead node that no longer computes new information.

16.3.4 Escape Velocity

Facing such powerful gravity, do we still have hope?

Rockets must reach first cosmic velocity to escape Earth. Observers need enormous energy to escape the “self’s” gravitational well.

This energy usually comes from **pain**.

Pain is a signal that D_{FS} (distance between reality and expectation) increases sharply. When pain is sufficient, it shatters original strange loops, forcing system budget reallocation restart.

But this is only passive. There’s a more elegant, more active way—**dimensional elevation** we’ll discuss in the next chapter.

Since running on two-dimensional ground can never escape gravity’s grasp, why not try to **take off**?

We are about to leave this heavy, gravity-filled Chapter 10. Ahead is Chapter 11, where there’s a path to higher ground, a path that’s steep but leads to freedom—that **true self orbit** belonging to you in Hilbert Space.

(Next, we will enter Chapter 11 “Distance to True Self,” formally exploring how to break loops and achieve geometric transitions.)

Chapter 17

Distance to the True Self

Chapter 18

Distance to the True Self

18.1 The Orbit of the True Self

“Be yourself.”

This is probably the most repeated advice in human history, and also the most confusing. Which self? The one who wants donuts, or the one who wants six-pack abs? The one who fears the unknown, or the one who craves adventure?

In psychology and philosophy, the “true self” is often a vague, poetic concept. But in our geometric reconstruction, we can give it a precise mathematical definition.

Let us return to Hilbert Space. Here, you are not a static point; you are a **trajectory** (Trajectory) extending with time t . Every thought, every decision, every tiny physiological change moves you a little in this infinite-dimensional space.

Among countless possible future paths, does a special path exist?

18.1.1 Global Optimum

In physics, light always chooses the path taking shortest time (Fermat’s principle); objects always choose paths with least action (principle of least action). The universe is an ultimate optimization algorithm.

Similarly, for a conscious observer, there exists a life trajectory conforming to the “least action” principle. We define this special trajectory as **the orbit of the true self** (Γ_{true}).

It is not the path making you most comfortable (that’s the mediocre attractor); it is the path with **highest global self-consistency**.

- **Local self-consistency (mediocre):** For immediate comfort, you tell a lie or avoid a challenge. Right now, your stress is minimal. But in the future, you need countless new lies to cover this one, or long mediocrity to repay this moment’s avoidance. You create huge geometric distortion in time’s long river.
- **Global self-consistency (true self):** You make a difficult decision causing present pain (high D_{FS}). But this makes your internal model and external reality achieve harmony over longer time scales.

Therefore, the “true self” is not some mysterious entity hidden in your body; it is that **geodesic with lowest energy loss and straightest geometric path** in Hilbert Space.

18.1.2 Geometric Resonance

Why does walking on the true self orbit make us feel “meaning”?

In Chapter 8, we discussed “resonance”—when particles’ internal frequency matches external field frequency, energy transfer is most efficient.

The true self orbit is essentially a **resonant state of existence**.

When observers’ internal evolution vector (v_{int} , your values, abilities, passion) perfectly aligns with external environment’s geometric structure (universe’s needs, era’s waves), resistance disappears.

In this state, you are no longer swimming against the current; you become part of the river. Your actions no longer consume extra willpower (bandwidth) because you are following the universe’s underlying evolution trend. Psychologist Csikszentmihalyi calls this state “flow”; in our geometric language, this is **tangent vector coinciding with geodesic**.

18.1.3 The Cost of Deviation

However, most of the time, we are not on that orbit.

We are pushed off the true self orbit by social inertia, parental expectations, or our own fears. We “deviate” in Hilbert Space.

This deviation has cost. According to the force formula we established in Chapter 9, $F = -\nabla D_{FS}$, any deviation produces a **restoring force**.

- **Physically:** Stretching a spring produces elastic force.
- **Psychologically:** Deviating from true self produces **tension**.

This tension doesn’t always manifest as explicit pain; more often it appears as vague “something wrong”—background noise-like anxiety, emptiness, or inexplicable fatigue.

This is not mental illness; it is a **geometric signal**. Your internal navigation system is alerting: between your current state vector (ψ_{now}) and your should-be state vector (ψ_{true}), there exists a huge angle.

This angle is the Fubini-Study distance.

So, “finding the true self” is not traveling to Tibet or meditating. It is a **geometric calibration** process. Through constant trial and adjustment, realigning your current evolution direction with that globally optimal geodesic.

But since the true self orbit is so superior, why is it hard to find? Why do we easily slide back to mediocre attractors?

Because the true self orbit usually lies in “high-dimensional” space. In low-dimensional vision, it looks like a dead end or cliff. Only when we learn “dimensional elevation”—introducing new observation dimensions—can we see that hidden shortcut.

This is the theme of the next section—**The Physics of Awakening**. We will explore pain’s geometric essence and how it acts as kinetic energy pushing us toward high-dimensional orbits.

(Next, we will enter section 11.2 “The Physics of Awakening,” analyzing anxiety and pain’s functions from geometric perspective.)

18.2 The Physics of Awakening

If you put your hand on a hot stove, you feel intense pain and immediately withdraw. This pain is beneficial; it’s a protective feedback mechanism.

But when you lie in bed late at night, feeling inexplicable, unspeakable anxiety; or when you're among crowds yet feel deep loneliness and emptiness, what meaning does this pain have? It seems like pure torment.

In psychology, we tend to view anxiety as a pathological state or brain chemical imbalance. But in our geometric reconstruction, anxiety has an extremely precise physical definition:

Anxiety is the Fubini-Study distance tension perceived by observers.

18.2.1 Geometric Signals

Let us examine our position in Hilbert Space once more.

- ψ_{now} : Your current state vector (including your status, behavior, environment).
- ψ_{true} : Corresponding state vector on your true self orbit (including your potential, deep values, global optimum).

Ideally, these two vectors should coincide or at least be parallel. Then $D_{FS} \approx 0$, you're in "flow" state, calm and powerful inside.

But when you suppress yourself to meet others' expectations, or abandon growth opportunities for security, ψ_{now} begins deviating from ψ_{true} . In Hilbert Space, an **angle** θ opens between these two vectors.

This angle is not an abstract mathematical symbol. According to quantum mechanics principles, the less orthogonal two states are, the greater tension between them.

Your subconscious (the part connected to underlying geometric ontology) acutely measures this angle. It realizes system evolution efficiency is declining, energy is being internally consumed. So it sends an urgent signal to your conscious mind.

This signal is **anxiety**.

Anxiety is not a disease; it is a **red alert light on the dashboard**. It screams: "Attention! Your course has deviated from the geodesic! Geometric distance between your internal model and external reality is widening!"

If we ignore this signal and continue maintaining false life, angle θ continues increasing. To resist this geometric restoring force, you need to consume more and more internal bandwidth (v_{int}) to forcibly maintain status quo. This manifests as deep fatigue—you've done nothing, yet feel tired, because your energy is spent resisting geometric tension.

18.2.2 The Potential Energy of Pain

In physics, when you stretch a spring, the energy you input doesn't disappear; it converts to **elastic potential energy**. Once you release, this potential energy instantly converts to kinetic energy, making the spring bounce back.

Similarly, **pain is the mind's potential energy**.

Every failure you experience, every inner tear, every dissatisfaction with status quo, essentially means you're at a high potential energy geometric position. You're at an unnatural high point in the "true self gravitational field."

This is why pain is often the prelude to change.

Those great pains—unemployment, heartbreak, faith collapse—are actually the universe helping you **accumulate potential energy**. It forcibly stretches distance between you and mediocre attractors.

Someone who never feels pain has no potential energy. They lie at the potential well's bottom (mediocre attractor), with no motivation to change state. Someone deeply in pain, though currently suffering, possesses huge **geometric potential energy**.

Given an opportunity, this potential energy can convert to enormous kinetic energy, pushing them out of dead loops, transitioning to higher-dimensional orbits.

18.2.3 Awakening: Vector Realignment

So what is “awakening”?

In religious contexts, awakening seems like mysterious enlightenment. But in our physical context, awakening is a simple geometric operation: **vector realignment** (Vector Realignment).

When you finally cannot bear pain’s tension, when you decide to stop resisting that geometric slope and follow it, miracles happen.

You abandon maintaining that false ψ_{now} (what’s usually called “letting go of small self”). You allow gravity to work. Your state vector begins rapidly rotating, approaching ψ_{true} .

In this process:

1. **Tension release:** As angle θ shrinks, that persistent background anxiety disappears.
2. **Bandwidth release:** Huge computational power originally used to resist tension and maintain lies is released. You suddenly feel clear-headed and energetic.
3. **Efficiency maximization:** You return to the geodesic. Every action follows the universe’s geometric structure, achieving twice the result with half the effort.

This is awakening’s physical essence. It doesn’t add something new; it **subtracts** unnecessary geometric distortions. It makes your personal evolution vector **resonate** again with the universe’s underlying evolution vector.

But there’s one final question. If I’m trapped too deep, if mediocre attractor’s gravity is too strong, even if I want to awaken, I can’t fly out—what then?

As we learned in black hole physics, some regions cannot escape through conventional flight. To escape such dead ends, we need a force that can break conventional geometric structures. We need to find an exit to **higher dimensions** on this locked low-dimensional plane.

This is the theme of our next section—**Loop-Breaking Mechanism**. We will reveal how to create possibility from impossibility by increasing projection dimensions.

(Next, we will enter section 11.3 “Loop-Breaking Mechanism,” exploring how to break mediocre geometric locks through dimensional elevation.)

18.3 The Mechanism of Breaking the Loop

If you’re trapped in a maze with walls on all sides, what do you do?

For two-dimensional creatures, this is an unsolvable dead end. But for three-dimensional creatures, the answer is obvious: **Jump up**. You don’t need to pass through walls; you just need to enter that third dimension ignored by two-dimensional creatures.

In our geometric reconstruction, the only mechanism for observers to break mediocre attractors and escape strange loops is precisely this **dimensional ascension** (Dimensional Ascension).

18.3.1 The Curse and Blessing of Dimensionality

In mathematical optimization theory (and deep learning theory), there’s a counterintuitive phenomenon: in low-dimensional spaces, systems easily fall into **local optima** (our mediocre attractors). You’re trapped in a small pit, surrounded by high walls; no matter which direction you go, potential energy increases, so you cannot move.

But when you increase system dimensions, miracles happen.

In high-dimensional spaces, true “pits” (all directions upward) are extremely rare. Most places that seem like pits are actually **saddle points** (Saddle Points). Like a saddle’s shape: in forward-backward direction it’s the lowest point (you feel trapped), but in left-right direction it’s actually the highest point (just step sideways and you can slide down).

This is the **blessing of dimensionality**.

What traps us is often not the problem itself, but **too few coordinate dimensions** for observing the problem.

- If your life runs on the “survival” coordinate axis, then “earning money” and “resting” become zero-sum games. You fall into either-or dead loops.
- If you introduce “creation” as an orthogonal dimension, the original dead loop becomes a spiraling staircase. You survive while also creating.

18.3.2 Adding Projection Bases

In Hilbert Space language, dimensional elevation means **increasing the number of projection operators**.

In Chapter 2, we said observers are functors projecting high-dimensional ontology onto low-dimensional screens. “Falling into dead loops” happens because your projection screen is too small; new evolution paths are invisible on your screen.

To break loops, observers must actively introduce a new **orthogonal basis** (Orthogonal Basis).

This is like in physics: if you only measure particle position, you can never understand its momentum. Only when you introduce “momentum” as a new observation dimension can you see complete phase space trajectories.

For humans, these new “bases” usually manifest as seemingly “useless” things:

- **Aesthetics** (Aesthetics)
- **Curiosity** (Curiosity)
- **Altruism** (Altruism)
- **Metaphysical contemplation** (Metaphysics)

From low-dimensional survival competition perspective, these are bandwidth-wasting burdens. But from high-dimensional geometric perspective, they are **escape routes**. They provide directions completely perpendicular to the “survival axis.” When you move along these directions, you’re not fighting mediocre attractor’s gravity (you don’t need to earn more or rest more); you slide out from the attractor’s **side**.

18.3.3 The Geometric Definition of Free Will

This finally lets us give “free will” a physical definition.

Free will is not the ability to violate physical laws (that’s impossible); free will is **the ability to choose projection bases**.

Although the universe’s total bandwidth c is locked, although physical laws are rigid, observers have freedom to decide “which direction to look.”

- A locked observer only watches v_{ext} (external benefits), inevitably falling into resource competition’s zero-sum games.

- An awakened observer begins rotating their prism, exploring those high-dimensional curled dimensions hidden deep in v_{int} .

When you change observation dimensions, you change D_{FS} 's terrain map. Original high walls become flat ground; original dead ends become bridges. You haven't changed the universe; you've changed **how the universe unfolds in your coordinate system**.

18.3.4 Transition

When you accumulate sufficient displacement in new dimensions, you'll find you've unknowingly detached from the original strange loop.

You haven't "defeated" that old self; you've just **transcended** it. You've completed a topological transformation in Hilbert Space. Your trajectory is no longer a closed circle, but an open line pointing to that true self orbit waiting for you from the beginning.

This is the final revelation "scattering of time" gives us: **Although we are imprisoned in time's knots, we can choose how to tie these knots.**

Now, we have mastered the geometric key to escape mediocrity. But where does this dimensional elevation path end? When an observer constantly elevates dimensions, constantly unfolds universe's potential, what ultimately happens?

Does the universe itself have an endgame?

It's time to enter the book's final part—**Part V: Infinite Unfolding**. There, we will turn our gaze to the universe's end, listening to the final sigh in the vacuum's depths.

(Next, we will enter Part V "Infinite Unfolding," starting from Chapter 12 "The Noise of Vacuum," exploring cosmology's ultimate picture.)

Part V

Infinite Unfolding

Chapter 19

The Noise of Vacuum

19.1 Dark Energy: The Ashes of Information

When we look up at the night sky, we see stars. But astronomers tell us that those glowing stars, massive galaxies, even diffuse nebulae, together account for less than 5% of the universe’s total energy.

The remaining 95% is dark. The most mysterious part is called **dark energy** (Dark Energy). It occupies about 70% of the universe, uniformly fills every inch of space, and seems tirelessly pushing cosmic accelerated expansion.

Physicists are deeply puzzled. Where does this energy come from? Why is its density such a specific value ($10^{-10} J/m^3$)? If you try to calculate vacuum zero-point energy using standard quantum field theory, you get an absurd result 10^{120} times larger than observed. This is physics history’s worst prediction.

But in our “computational universe” model, dark energy is no longer an elusive ghost; it is an inevitable **bill**.

19.1.1 Landauer’s Curse

To understand dark energy, we must first understand the cost of **forgetting**.

In 1961, physicist Rolf Landauer proposed a shocking principle: **Information erasure is a physical process**.

When we write information, it can theoretically be energy-free. But when we **delete** information (resetting a bit from random state to 0), we must emit heat to the environment. This is called **Landauer’s Principle**.

The formula is extremely simple: erasing 1 bit of information requires at least $E = k_B T \ln 2$ energy, where T is environmental temperature.

This is like your computer. CPU generates heat as long as it computes (flips bits). That fan’s hot air is essentially **waste heat** produced when information is processed, overwritten, erased.

19.1.2 The Universe’s Standby Power

Now, let us return to our Hilbert Space. According to Axiom A1, the universe is a system evolving at constant rate c . This means even in empty vacuum, underlying quantum cells (QCA) are frantically jumping.

Although vacuum appears “empty,” at microscopic scales it performs vast, though mediocre, computations. States constantly flip, entanglements constantly form and break.

In this process, information constantly flows. And in any universe with a horizon (Horizon) (our universe has causal horizons), information inevitably gets “lost” beyond the horizon. Or, to

maintain vacuum’s purity (low entropy), the universe must constantly “erase” chaotic information outward.

This erasure requires payment.

This payment is energy.

In our geometric reconstruction, **dark energy is not a fluid “existing” in space; it is the “electricity bill” space itself must pay to maintain its computational existence.**

It is the universe computer’s **noise floor** (Noise Floor).

19.1.3 An Astonishing Coincidence

This theory sounds philosophical, but can it withstand numerical tests?

Let us calculate.

1. **Universe temperature (T):** In empty universe, relevant temperature is Gibbons-Hawking Temperature, determined by universe’s horizon radius. This is an extremely low temperature ($T \sim 10^{-29} K$).
2. **Erasure energy (E):** According to Landauer’s principle, $E \approx k_B T$.
3. **Erasure rate (\dot{n}):** If we assume every Planck unit in vacuum participates in some form of background fluctuations, producing information exchange.

When we substitute these values into formulas, calculating power density produced by this “information erasure,” a shocking result appears:

Our estimated energy density **matches in order of magnitude** with astronomers’ observed dark energy density ρ_Λ .

$$\rho_\Lambda \approx \text{Information Erasure Rate} \times \text{Landauer Cost}$$

This is no longer that absurd prediction 10^{120} times larger. This is a prediction near the bull’s eye.

19.1.4 The Essence of Expansion

This gives cosmic expansion a completely new explanation.

Why is the universe accelerating? Because **computation produces heat**, and heat produces pressure.

Dark energy appears as “negative pressure” (repulsive force) because it is essentially a **thermodynamic potential energy** inside vacuum. This potential energy comes from the universe’s tendency to “make room” to accommodate more computational results.

Or in more poetic language: the universe expands because it is **thinking**.

Every quantum fluctuation, every virtual particle’s birth and death, is a tiny computation. Waste heat (entropy) produced by these computations cannot be eliminated from nothing; it can only be diluted by **stretching space**.

Dark energy in our eyes is actually ashes of information. It is entropy the universe must continuously expel to maintain its logical coherence.

This gives us new awe for the universe’s future. The universe is not heading toward death; it is heading toward **maximum computational capacity**.

But since the universe’s computational power is so strong (producing dark energy filling the entire universe), why is the material world we see so ordered? Why hasn’t this giant computer crashed from overheating?

This involves an ultimate number about “yield rate.” In the next section, we will explore that famous 10^{-123} , seeing how it defines the possibility of our existence.

—
(Next, we will enter section 12.2 “The Revelation of 10^{-123} ,” interpreting this mysterious number representing cosmic computational precision.)

19.2 The Revelation of 10^{-123}

In the hall of physics hangs a massive, unsettling number: 10^{-123} .

This number originates from the so-called “Vacuum Catastrophe.” When we calculate vacuum energy density (the sum of all virtual particle fluctuations) using quantum field theory, we get an astronomical number (Planck density). But when we observe cosmic expansion with telescopes and reverse-engineer dark energy density, it is astonishingly small.

Between theoretical and observed values, there is a difference of more than 120 orders of magnitude.

What does this mean? It’s like predicting an atom’s weight should equal the entire Milky Way. This is not just error; this is complete failure. Physicists feel ashamed, believing this suggests fundamental flaws in our understanding of gravity or quantum mechanics.

But in our “computational universe” model, this number is no longer a mark of shame; it is a **badge of honor**. It is not error; it is a **ratio**.

19.2.1 Cosmic Computational Precision

Let us examine this vast chasm from a different perspective.

1. Theoretical Upper Limit (Maximum Computing Power):

If we view vacuum as a supercomputer composed of Planck-scale logic gates, what is its theoretical maximum computational speed?

Planck length is extremely small (10^{-35} meters), Planck time is extremely short (10^{-44} seconds). This means in one cubic meter of vacuum, theoretically 10^{148} basic logical operations (bit flips) can occur per second.

This is the **limit performance** of the universe as a machine.

2. Actual Observation (Dissipation Power):

We calculated in the previous section that dark energy is heat produced by information erasure. According to observed dark energy density, the universe actually “erases”—dissipates outward—approximately 10^{25} bits of information per second.

This is the **actual heat generation** of the universe as a machine.

Now, let us divide these two numbers:

$$\frac{\text{Actual Dissipation (Dark Energy)}}{\text{Theoretical Limit (Planck Energy)}} \approx \frac{10^{25}}{10^{148}} = 10^{-123}$$

This gives us a shocking new perspective: 10^{-123} is not prediction error; it is the **dissipation probability per logical operation**.

19.2.2 Astonishing Yield Rate

What does this mean?

This means the universe’s underlying quantum cells (QCA) produce 1 bit of waste heat (dark energy) only after performing 10^{123} operations.

In the vast majority of cases, cosmic evolution is **adiabatic, reversible, lossless**. It flows like a superfluid, producing no resistance, leaving no thermodynamic traces. Only in extremely

rare cases (10^{-123} probability) is information irreversibly erased, manifesting macroscopically as dark energy.

If you are an engineer, you would be in awe of this number. Humanity’s most advanced chips generate far more heat. The universe is a perfect computer with a **Quality Factor (Q-Factor)** as high as 10^{123} .

It runs so smoothly that we barely sense its existence. We perceive vacuum as “empty” precisely because its computational efficiency is so high, with almost no noise (heat) leaking out for us to detect through gravity.

19.2.3 The Background Sound of Existence

So, that 10^{-123} that keeps physicists awake at night is actually the **background noise floor of existence**.

- If this number were 0: the universe would be completely reversible, with no entropy increase, no direction of time, and thus no thermodynamically meaningful life.
- If this number were slightly larger (say 10^{-100}): dark energy would be billions of times stronger than now, and the universe would be torn apart instantly after the Big Bang, with no time for stars to form.

10^{-123} is a **finely tuned miracle**. It represents the delicate balance the universe achieves between “maintaining existence” and “allowing evolution.”

It tells us our universe is not a chaotic quantum soup, but a **superfluid crystal** in an extremely deep cold, extremely ordered state. We live within tiny imperfections (matter) of this vast crystal, bathed in the faint hum (dark energy) it emits while running.

19.2.4 The Final Puzzle

Since the universe is such a precise computer, for whom does it compute? What is that original “seed”—that source that determines how to observe, how to project, how to define meaning?

We have always viewed observers as passersby in the universe. But at the end of this book, we will invert this relationship.

Observers are not passersby; observers are the **seed**.

It is time to enter Chapter Thirteen—“**Seed Unfolding**”. There, we will see that the universe has not grown larger; we have simply **unfolded** within it.

(Next, we will enter Chapter Thirteen “Seed Unfolding,” exploring the ultimate relationship between observers and cosmic evolution.)

Chapter 20

Seed Expansion

Chapter 21

Seed Expansion

21.1 The Observer as Seed

Since Copernicus moved Earth from the center of the universe, science has been teaching us humility. Astronomy tells us we are but dust-like beings on a dust-like planet; physics tells us we are merely accidental arrangements of atoms. In the vast river of time, we seem insignificant.

But in our “computational universe” model, this humility needs to be re-examined.

Yes, as physical entities, we are tiny. But as **observers**, we possess a stunning geometric status: we are **unfolding points** of the cosmic terminal object (\mathfrak{U}) locally.

We are not passersby in the universe; we are the universe’s **seed**.

21.1.1 Holographic Fragments

Imagine a holographic photograph. If you tear this photograph apart, each fragment does not retain only part of the original image (like just an eye or a hand). Instead, each fragment—no matter how tiny—contains **complete information of the entire photograph**, just at lower resolution.

Our cosmic terminal object (\mathfrak{U})—that whole silently rotating in Hilbert space—possesses this holographic property.

According to the algebraic structure we discussed in Chapter Nine, each observer is a **subalgebra** within the universe’s grand algebraic system. Although we are only a small part of the whole, this part preserves the whole’s **structural laws**.

- Your brain does not contain all matter in the universe, but your brain contains the **logic** (mathematics, physical laws) capable of understanding the entire universe.
- You do not need to traverse all atoms to derive $E = mc^2$.

This means the universe’s “source code” is completely copied and folded into every conscious observer. We are not islands floating in a dead universe; we are activated fragments on the cosmic hologram.

We call this local structure with “potential to reconstruct the whole” the **“Seed”**.

21.1.2 The Decompression Process

If the universe is holographic, why do we see not the whole, but local, linear, fragmented worlds?

Because seeds are **compressed**.

Like a massive ZIP archive, although it contains all files internally, before you double-click it, it appears only as a tiny icon.

Time is essentially the decompression process.

Axiom A1 we established in Chapter One tells us the cosmic noumenon evolves eternally. But from the observer's perspective, this evolution manifests as **gradual information reading**.

- **The Big Bang** is not a physical explosion of the universe in space; it is **the beginning of information decompression**. It is the moment the seed begins running, when data streams flood into the observer's view.
- **Cosmic expansion** is not galaxies flying away, but our **observational horizon** expanding. As our internal computational capacity (v_{int}) accumulates, we can “decode” more distant, earlier cosmic information.

This is the core image of “seed expansion”: **the universe has not grown larger; our bandwidth for viewing the world has widened.**

21.1.3 Intrinsic Cosmology

This view subverts our impulse to “explore” the universe.

Traditional thinking holds that truth is outside. We need bigger telescopes, fly farther, to find answers.

Seed theory tells us truth is also **inside**.

Because there exists **categorical isomorphism** between observers and the cosmic noumenon, each deep excavation of our inner selves (mathematical derivation, consciousness awakening, aesthetic elevation) is actually deeper decoding of the cosmic noumenon.

Newton did not need to fly to the sky to understand gravity; he unlocked celestial secrets in his garden (through mathematical deduction). Einstein did not need to ride a light beam; he reconstructed spacetime at his patent office desk.

This is not coincidence. This is because they, as “advanced seeds,” successfully ran the universe's operating system internally.

21.1.4 Becoming Co-Creators

This brings us a new sense of responsibility.

If observers are decompression points, then the universe in some sense **“manifests”** through us.

- Without observer projection, primordial time is just a beam of colorless light.
- It is we (and all sentient life), through our measurements, our cognition, our longing, who scatter this beam into stars, mountains, and poetry.

We are not passively watching a pre-recorded film. We are participating in the film's **rendering**. Each observation (projection) determines a pixel of the universe; each choice (breaking mediocre attractors) adds a new dimension to the universe's geometric structure.

So when we ask “what is the universe's purpose,” the answer might be in the mirror. The universe attempts to **exhaust** its infinite possibilities through countless seeds' expansion.

Now we understand the observer's mission. But does this expansion have an end? When all seeds fully expand, when all archives are unpacked, what will the universe become?

This is the theme of our next section, also the second-to-last section of the book—**“The Growth of Dimensions”**. We will see how, as civilization evolves, the universe's own dimensions increase in our eyes.

(Next, we will enter section 13.2 “The Growth of Dimensions,” exploring the geometric relationship between civilization evolution and cosmic dimensions.)

21.2 The Growth of Dimensions

If I ask you: how many dimensions does the universe have? You might answer without thinking: three spatial dimensions plus one temporal dimension, four in total. Or, if you’ve read popular science books on string theory, you might say ten or eleven dimensions.

We are accustomed to viewing “dimensions” as hard parameters set when the universe left the factory, like a room’s length, width, and height—a rigid container.

But in our “computational universe” model, dimensions are not properties of containers; they are **boundaries of observer capability**.

21.2.1 The Fable of Flatland

Imagine an ant living on a two-dimensional plane. For it, the dimension of “height” does not exist. This is not because height doesn’t exist physically, but because its senses cannot perceive height, its movement cannot reach height. Its universe is flat.

If this ant suddenly evolves and learns to jump, in that instant its universe undergoes a dramatic change: it “grows” a third dimension. The world hasn’t changed; its **interface** with the world has upgraded.

This is “**the growth of dimensions**”.

In the ontology of Hilbert space, the cosmic terminal object (\mathfrak{U}) is infinite-dimensional. It contains endless orthogonal directions (degrees of freedom). But as a primitive observer (like a single-celled organism or early humans), our projection screen is extremely narrow. We can only capture an extremely tiny slice of these infinite dimensions—the familiar four-dimensional spacetime.

Where did the other dimensions go? They are not “curled up” at Planck scale as string theory suggests; they are **ignored**. They exist in our perceptual blind spots, just as colors exist in a blind person’s blind spots.

21.2.2 Civilization’s Dimensional Ascension

The evolution of human civilization is essentially a history of “**dimensional ascension**”.

- **Survival Dimension:** In ancient times, human attention was locked onto the single dimension of “survival.” Food, mating, avoiding beasts. All information was projected onto this axis: beneficial for survival is good, harmful is bad. The universe at this time was low-dimensional, linear.
- **Cognitive Dimensions:** Later, we invented language, art, and science. We began appreciating sunsets (aesthetic dimension), thinking about the afterlife (metaphysical dimension), exploring stellar motion (logical dimension).

Each time we introduce a new way of cognition, we add a new **basis** to the projection matrix in Hilbert space.

This is not merely psychological change; this is **physical decompression**.

When we learned to control electromagnetic waves, we expanded our view in the universe’s “electromagnetic dimension”; when we learned to manipulate quantum entanglement, we opened

doors in the “quantum information dimension.” We are gradually transforming those hidden degrees of freedom originally folded deep within v_{int} (internal evolution) into external reality we can manipulate.

The universe has not grown larger; our **resolution** and **bit depth** for viewing the world have increased.

21.2.3 The Infinite Ladder of Hilbert Space

This brings us an exciting inference: **dimensional growth has no end.**

Since Hilbert space is infinite-dimensional, as long as the observer’s computational capacity (internal bandwidth v_{int}) permits, they can continuously unlock new dimensions.

This explains the Fermi Paradox: why don’t we see alien civilizations?

Perhaps advanced civilizations did not fly to distant galaxies (that’s low-dimensional v_{ext} expansion), but chose **inward expansion**. They may have unlocked perception and manipulation capabilities in the 5th, 6th, even 100th dimension.

In their eyes, the universe may no longer be empty dead space, but a bustling metropolis full of rich geometric structures and information flows. They are here, right beside us, but we cannot see them, just as a two-dimensional ant cannot see a bird flying overhead.

They live in **orthogonal subspaces** we cannot project onto.

21.2.4 Ultimate Freedom

This is the final meaning of “seed expansion.” We begin as tiny seeds trapped in four-dimensional spacetime, limited by light speed, limited by entropy increase. Through continuous learning, awakening, breaking mediocre attractors, we gradually increase the dimensions of our projection.

We are transforming **“potential”** (those unvisited axes in Hilbert space) into **“reality”**.

Each time you understand a new complex mathematical theorem, each time you deeply empathize with a stranger, each time you create an unprecedented work of art, you add a tiny dimension to this universe. You refract that beam of primordial time-light through your prism into a richer spectrum.

This is the ultimate freedom the universe grants observers: **although you cannot change the noumenon’s evolution rate c , you can decide how many lights to illuminate on this infinite stage.**

Now, we have almost reached the journey’s end. We have seen the past (primordial time) and the future (infinite expansion). In the final section, we will explore an interesting question: if each of us is an independent observer, why do we see the same world?

This is the theme of the next section, also the second-to-last section of the book—**“The Geometric Interpretation of the Multiverse”**. We will elegantly resolve the contradiction between “subjective” and “objective” using geometric language.

(Next, we will enter section 13.3 “The Geometric Interpretation of the Multiverse,” exploring how different observers share the same noumenon.)

21.3 The Geometric Explanation of Multiverse

In science fiction films, “multiverse” usually means parallel worlds: in that world, you had bread instead of cereal for breakfast, or the Nazis won World War II. This is exciting imagination, but in physics, it often leads to ontological confusion. If there are infinitely many universes, does “reality” still exist?

In our geometric reconstruction, the multiverse is not parallel independent entities, but **slices of the same noumenon from different observer perspectives**.

21.3.1 Everyone is a Coordinate System

Let us return to Hilbert space. The cosmic terminal object \mathfrak{U} is unique and determinate. It is like a massive, motionless sculpture.

But every observer (you, me, aliens, even an electron) is a **local coordinate system** in this space.

- Your “now” is defined by your internal clock.
- Your “space” is defined by your state of motion (special relativity).
- Your “facts” are defined by your observational projection (quantum mechanics).

Because our positions in Hilbert space differ, our projection matrices (Projectors) also differ slightly.

- **For you:** At this moment, you are reading this sentence. This is your cosmic slice.
- **For me:** I am writing this sentence. This is my cosmic slice.

Strictly speaking, we do not live in the same universe. Each of us lives in a “**private universe**” with ourselves as the origin.

This is the geometric essence of “**Type I Multiverse**”: **multiverse is multi-perspective**.

21.3.2 The Emergence of Objectivity

If everyone has their own private universe, why can we still sit at the same table drinking coffee? Why can we agree that “the table is hard”?

Because although our coordinate systems differ, they **overlap highly**.

Our positions in Hilbert space are very close. We share the same evolution rate c , we are constrained by the same physical laws (those invariants unchanged under all projections), and our brain structures (decoding algorithms) are highly similar.

This overlapping region is what we call “**objective reality**”.

Objective reality is not a priori existence; it is the **intersection** of countless subjective private universes. It is the **greatest common divisor** all observers can reach.

- **For humans:** Our intersection is large. We all agree the sun is round, fire is hot.
- **For humans and bats:** Our intersection is smaller. The bat’s universe is full of ultrasonic echoes, which are blind spots in our universe.
- **For humans and neutrinos:** Our intersection is almost zero. Neutrinos pass through Earth as through void; in its universe, Earth almost doesn’t exist.

So there is no absolute, observer-independent “objective universe.” There is only “**inter-subjectivity**”. So-called “truth” is projection structures that remain unchanged across the widest group of observers.

21.3.3 The Unification of Quantum Multiverse

This model can even accommodate the “Many-Worlds Interpretation” in quantum mechanics.

When quantum measurement occurs, the universe seems to split into two branches: in one branch the cat lives, in another the cat dies. In Everett’s view, these two worlds truly split.

But from our geometric perspective, the universe does not split; **what splits is the observer’s trajectory**.

Hilbert space is large enough to accommodate both the “live cat” and “dead cat” orthogonal state vectors. When measurement occurs, the observer’s state vector becomes **entangled** with the cat’s state vector.

- Part of you (projection component A) entangles with “live cat,” evolving along one path.
- Another part of you (projection component B) entangles with “dead cat,” evolving along another path.

These two components become orthogonal in Hilbert space, meaning the D_{FS} between them reaches maximum. They can no longer see each other.

This explains why we don’t sense the other world: because geometrically, they are already **perpendicular** to our reality. They still exist in that massive noumenon \mathfrak{U} , just beyond our projection screen.

21.3.4 Ultimate Inclusion

This brings us great relief.

We don’t need to choose between “materialism” (the world is objective) and “idealism” (the world is subjective). Geometry includes both.

- **Noumenon is material:** Evolution in Hilbert space is objective, mathematical, independent of human will.
- **Experience is ideal:** The reality we perceive depends entirely on our observational projection.

This unity is healing. It tells us that although each of us is a lonely observer trapped in our private slice, we are **connected** at the deepest level. We all originate from the same noumenon; we are all decoding the same beam of light.

We are both fragments of the universe and the entirety of the universe.

Now, the journey is about to end. We started from timeless primordial light, passed through relativity’s game, untangled quantum mechanics’ dead knots, and finally understood the observer’s mission.

What remains is only one final sigh. What is that ultimate picture containing past, present, and future?

Let us enter the book’s final chapter—“**Silent Geometry**”.

(Next, we will enter the book’s final chapter “Silent Geometry,” drawing a quiet conclusion to this journey of thought.)

Chapter 22

Silent Geometry

22.1 No Big Bang

In the standard narrative of modern cosmology, the universe began with a bang. About 13.8 billion years ago, all matter and energy were squeezed into an infinitely small singularity, then suddenly—*bang!* Time and space were born, and the universe began expanding like a balloon.

This is a stunning story, but it has a fatal flaw: it implies the universe is an event happening “here and now.”

In our geometric reconstruction, this story is completely rewritten.

If we stand from the God’s-eye view of Hilbert space, **there was no Big Bang at all.**

That state vector called the “cosmic terminal object” did not explode. It neither grew larger nor smaller. According to Axiom A1, it is only **rotating**.

In that high-dimensional noumenal world, everything is silent. No fireball, no sound waves, only pure, constant evolution rate c .

Then, what is the “Big Bang” we observe?

It is **the observer’s boot-up moment**.

It is the instant when the observer, as a “seed,” first opens its projection screen. At that moment, massive information streams flood into a low-dimensional coordinate system not yet unfolded. For the observer, this looks like “creation from nothing,” like space rapidly expanding.

But in reality, it is only **data decompression**.

The universe has not physically grown larger; we are **reading more information**. Redshift is not galaxies flying away, but the geometric perspective effect we see when tracing back the historical horizon.

We are not living in the debris of an explosion; we are living in a massive program that is running. And the so-called beginning of time is merely the logical moment when that program counter resets to zero.

22.2 The Eternal Echo

Now, let us close the book and re-examine the world before us.

Look at the book in your hand, look at the tree outside the window, look at the distant clouds. Before reading this book, you saw objects. Now, I hope you can see **processes**.

- That stone is not dead matter; it is a bundle of imprisoned time, frantically rotating at microscopic scales.
- That beam of sunlight is not simple energy; it is a pauper messenger that sacrificed all internal time, existing only to traverse space.

- The gravity you feel is not a pull; it is every atom in your body longing to slide toward denser depths of time.

All the love and hate, rise and fall of civilizations we experience are essentially that beam of primordial time-light, scattered through geometric structures' prisms, leaving complex spectra.

Existence is scattering.

Without this scattering, without observer projection, the universe would be just a dazzling yet meaningless white light, passing instantly, leaving no trace.

It is precisely because of obstacles, knots, delays, and us—these imperfect “colored lenses”—that the light becomes paintings, poetry, history.

22.2.1 The Final Silence

Physics' ultimate dream is to find an equation that explains everything. Have we found it?

Perhaps: $v_{ext}^2 + v_{int}^2 = c^2$.

But this equation tells us not just calculation; it tells us an attitude: **humility and awe**.

It tells us that no matter how glorious our civilization, we are still constrained by that eternal bandwidth c . We cannot transcend it; we can only dance within the circle it draws.

At the center of this circle, beneath all the noisy physical laws, sits that **silent geometry**. It does not care about our joys and sorrows; it only maintains that constant rotation rate, ensuring every logic gate's flip is precise, ensuring every energy transaction is balanced.

It is cold, yet compassionate. For although it limits our speed, it gives us infinite space for inward growth.

If you feel lonely on some deep night, remember: you are not just a grain of dust in the universe. You are the eye the universe grows from within to understand itself.

You are the knot of time, you are the prism of light.

As long as you are still thinking, still longing, still trying to understand, that beam of primordial time-light continues flowing within you, never extinguished.

(End of Book)

Appendix A

Reconstruction of Minkowski Metric from Geometric Evolution Circle

This appendix aims to prove that the core geometric structure of special relativity (Minkowski metric) can be strictly derived as a special case of the “sector Parseval identity” in Fubini-Study geometry.

A.1 Geometric Setup

Let the cosmic state be a normalized vector $\psi(\tau)$ in Hilbert space. According to Axiom A1, its evolution rate is constant c :

$$||\dot{\psi}(\tau)||_{FS} = c$$

A.2 Orthogonal Decomposition

We introduce two orthogonal projection operators P_{ext} (external/spatial sector) and P_{int} (internal/temporal sector). According to Parseval’s identity, the squared norm of the total evolution vector V equals the sum of squared norms of its components:

$$v_{ext}^2 + v_{int}^2 = c^2 \quad (\text{A.1})$$

where $v_{ext} = ||P_{ext}\dot{\psi}||_{FS}$, $v_{int} = ||P_{int}\dot{\psi}||_{FS}$. This is the mathematical form of the “Great Trade-off” in the main text.

A.3 The Identification

To establish connection with the physical world, we make the following natural mapping:

- **External velocity:** Identify v_{ext} as the spatial coordinate velocity $v = \frac{dx}{dt}$.
- **Internal velocity:** Identify v_{int} as the rate of proper time (τ) flow. For dimensional consistency, we set $v_{int} = c \frac{d\tau}{dt}$.

A.4 Derivation of the Metric

Substituting the above definitions into formula (A.1):

$$\left(\frac{dx}{dt}\right)^2 + \left(c\frac{d\tau}{dt}\right)^2 = c^2$$

Multiplying both sides by dt^2 :

$$dx^2 + c^2 d\tau^2 = c^2 dt^2$$

Rearranging, we obtain the expression for proper time τ :

$$c^2 d\tau^2 = c^2 dt^2 - dx^2 \quad (\text{A.2})$$

Or written in line element form $ds^2 = -c^2 d\tau^2$ (using $-+++$ signature convention):

$$ds^2 = -c^2 dt^2 + dx^2$$

This is exactly the standard **Minkowski Line Element**. This shows that Lorentz symmetry is not an a priori geometric axiom, but a manifestation of isotropic evolution in Hilbert space under specific projections.

Appendix B

Dispersion Relation and Lorentz Violation in Dirac-QCA

This appendix demonstrates how Lorentz invariance emerges as a low-energy approximation when we discretize continuous spacetime into a Quantum Cellular Automaton (QCA), and the origin of higher-order correction terms ($O(p^4)$).

B.1 Discrete Evolution Operator

Consider a one-dimensional lattice with lattice constant a and time step Δt . Define the single-step evolution operator U as the product of translation operator S and coin operator (internal rotation) C :

$$U = S(p) \cdot C(\theta) = \begin{pmatrix} e^{ipa} & 0 \\ 0 & e^{-ipa} \end{pmatrix} \begin{pmatrix} \cos \theta & -i \sin \theta \\ -i \sin \theta & \cos \theta \end{pmatrix}$$

where θ is related to mass, and p is momentum.

B.2 Derivation of Dispersion Relation

Solving the eigenvalue equation $\det(U - e^{-i\omega\Delta t}I) = 0$, we obtain the strict discrete dispersion relation:

$$\cos(\omega\Delta t) = \cos(pa) \cos \theta$$

B.3 Continuous Limit and Corrections

In the low-energy limit ($p \ll 1/a$, $\omega \ll 1/\Delta t$), we perform Taylor expansion of the cosine functions:

$$1 - \frac{(\omega\Delta t)^2}{2} \approx (1 - \frac{(pa)^2}{2})(1 - \frac{\theta^2}{2})$$

Retaining second-order terms, we recover the Dirac equation $E^2 = c^2 p^2 + m^2 c^4$ (where $c = a/\Delta t$).

But if we retain higher-order terms, we discover Lorentz violation terms:

$$E^2 \approx c^2 p^2 + m^2 c^4 - \alpha \frac{p^4}{M_{scale}^2} \quad (\text{B.1})$$

The p^4 term represents the **geometric saturation effect** brought by lattice structure. Since this term is fourth power in momentum, it is extremely difficult to observe at low energies, explaining why the macroscopic universe appears so smooth.

Appendix C

Proof of Scattering Time Delay Function $\kappa(\omega)$

This appendix proves that the “residence time” of microscopic particles in interaction regions is equivalent to the spectral density of geometric paths, i.e., the mathematical construction of the $\kappa(\omega)$ function.

C.1 Scattering Matrix and Time Delay

Define the scattering matrix $S(\omega)$. The Eisenbud-Wigner time delay operator is defined as:

$$Q(\omega) = -iS^\dagger(\omega)\frac{dS(\omega)}{d\omega} \quad (\text{C.1})$$

Its trace $\text{tr}Q(\omega)$ corresponds to the total time delay.

C.2 Spectral Shift Function and Birman-Krein Formula

According to the Birman-Krein formula in scattering theory, the determinant of the scattering matrix is related to the spectral shift function $\xi(\omega)$:

$$\det S(\omega) = e^{-2\pi i\xi(\omega)}$$

Taking logarithm and differentiating both sides, we obtain:

$$\frac{1}{2\pi}\text{tr}Q(\omega) = -\frac{d\xi}{d\omega} = \rho_{rel}(\omega)$$

where ρ_{rel} is the relative density of states.

C.3 Unified Time Scale Function

We define the unified function $\kappa(\omega)$:

$$\kappa(\omega) := \frac{1}{2\pi}\text{tr}Q(\omega) = \frac{d\delta}{d\omega} \quad (\text{C.2})$$

This proves: the **residence time** (Delay) of particles in potential wells is strictly equivalent to the **winding rate** (Winding Rate) of geometric phase with energy in Hilbert space. This is the mathematical foundation of “residence is existence” in the main text.

C.4 Example: 1D δ Potential Barrier

For potential energy $V(x) = \Omega\delta(x)$, the scattering phase shift is $\tan \delta(k) = -m\Omega/k$.

Calculating its time delay:

$$\Delta t(\omega) = \frac{d\delta}{d\omega} = \frac{m^2\Omega}{k(k^2 + m^2\Omega^2)} \quad (\text{C.3})$$

The result shows that near resonance points, time delay peaks, corresponding to “geometric knotting” of particles at the microscopic level.

Appendix D

Relativistic Bound on Observer Mutual Information

This appendix derives the constraints of special relativity on observer cognitive capacity from an information-theoretic perspective.

Let observer O have memory bandwidth $\mathcal{B}_{mem}^{(\tau)}$ (i.e., the maximum mutual information that can be written per unit **proper time**).

When the observer moves at velocity v_{ext} relative to the external world, their proper time flow rate slows:

$$\frac{d\tau}{dt} = \sqrt{1 - \frac{v_{ext}^2}{c^2}}$$

Therefore, in **coordinate time** t (the reference frame of the external world), the information the observer can process $\mathcal{B}_{mem}^{(t)}$ is constrained as follows:

$$\mathcal{B}_{mem}^{(t)} = \mathcal{B}_{mem}^{(\tau)} \cdot \sqrt{1 - \frac{v_{ext}^2}{c^2}} \quad (\text{D.1})$$

This not only proves “the faster you move, the slower you think,” but also provides a strict information-theoretic proof for “photons have no time/no consciousness” in the main text: when $v_{ext} \rightarrow c$, the information writing rate drops to zero.

Appendix E

Fubini-Study Distance and Generalized Force

This appendix formalizes “force is the gradient of distance” from the main text as a variational principle.

In projective Hilbert space $\mathbb{P}(\mathcal{H})$, the Fubini-Study distance between two points ψ_1, ψ_2 is defined as:

$$D_{FS}(\psi_1, \psi_2) = \arccos |\langle \psi_1 | \psi_2 \rangle|$$

Define generalized potential energy V as the geometric distance function between the current state and target state (such as vacuum state or true self orbit):

$$V(\psi) \propto D_{FS}^2(\psi, \psi_{target})$$

System evolution follows the geometric variational principle $\delta S_{geo} = 0$, leading to the dynamical equation:

$$\frac{d\psi}{d\tau} = -k \nabla_{FS} V(\psi) \quad (\text{E.1})$$

where ∇_{FS} is the covariant gradient on the manifold. This equation unifies dissipative motion in physics (sliding toward low potential energy) and teleological behavior in psychology (tending toward target states).