The Scattering of Time

Geometric Reconstruction: From Bits to the Universe

Auric

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.

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.

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**.

Chapter 2: Time Before Time

2.1 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.

2.2 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).

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.

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.

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**.

2.3 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.

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.

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.

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.

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.

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.

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 (Physics)	Geometric Reconstruction (Geometry)	Computational Essence (Computation)	Intuitive Metaphor
Lorentz Invariance	Pythagorean sector conservation ($v^2_{ext} + v^2_{int} = c^2$)	Dynamic resource allocation	Only so much money, spent is gone
Proper Time	Internal path length (S_{FS})	Internal processing delay	Your system is busy refreshing itself
Mass	Internal phase rotation rate (v_{int})	Background process load	Objects running complex code are harder to move
Speed of Light	Geometric propagation horizon	Maximum propagation hops of logic gates	System's maximum bus frequency
Force	Gradient of distance function ($-\nabla D$)	Descent direction of optimization algorithm	Sliding to save effort (save distance)
Dark Energy	Capacity of invisible sectors	Waste heat from bit erasure	Current noise when universe is on standby

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.Part II: The Great Dispersion