

# The Incompleteness of Observation

Why the Universe's Biggest Contradiction Might Not Be a Mistake

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## 1 The Problem

Physics has a contradiction it cannot resolve. Its two most successful theories—quantum mechanics and general relativity—flatly disagree about the most basic property of empty space: how much energy it contains.

Quantum mechanics says the vacuum is seething with energy. If you add up the zero-point fluctuations of every quantum field, you get an energy density of roughly  $10^{110}$  joules per cubic meter. That's an unimaginably large number.

General relativity, meanwhile, measures the vacuum's energy through its gravitational effect—the accelerating expansion of the universe. That measurement gives about  $6 \times 10^{-10}$  joules per cubic meter. A tiny number.

The ratio between them is  $10^{120}$ . That's a 1 followed by 120 zeros. It's the largest disagreement between theory and observation in all of science. For context, the number of atoms in the observable universe is only about  $10^{80}$ .

For decades, physicists have assumed this means something has gone badly wrong—that one or both calculations must contain an error, and that finding the mistake will lead to a “theory of everything” that unifies quantum mechanics and gravity.

This paper argues the opposite. **Neither calculation is wrong. They disagree because they're answering different questions about the same thing.** And they *have* to disagree, for a reason that has nothing to do with the specific physics involved.

## The Two Calculations

To see why, it helps to look at what each theory actually computes.

Quantum mechanics says that every possible vibration mode of every quantum field contributes a tiny bit of energy, even in a vacuum. Imagine an infinitely large orchestra where every instrument is humming at its lowest possible note. You add up all those hums:

$$\rho_{QM} \sim \int_0^\Lambda \frac{d^3k}{(2\pi)^3} \frac{1}{2} \hbar \omega_k \sim 10^{110} \text{ J/m}^3 \quad (1)$$

Sum up the minimum energy of every possible vibration, from the longest wavelengths to the shortest ones allowed by physics (the “Planck scale” cutoff  $\Lambda$ ). You get an enormous number.

General relativity measures vacuum energy differently—by observing how it makes the universe expand:

$$\rho_{\text{grav}} \sim 6 \times 10^{-10} \text{ J/m}^3 \quad (2)$$

Look at how fast the universe is actually accelerating, and work backwards to figure out how much energy the vacuum must contain. You get a tiny number.

The ratio:

$$\frac{\rho_{\text{QM}}}{\rho_{\text{grav}}} \sim 10^{120} \quad (3)$$

The standard view is that something must be wrong with one or both calculations. This paper proposes that neither calculation is wrong—they disagree because they are measuring *different statistical properties* of the same underlying thing.

## 2 The Core Idea: You Can’t See Everything From Inside

Consider an analogy. Imagine you want to understand the microscopic reality of a calm glass of water. You have two ways to measure its energy:

- A **thermometer**, which measures the total thermal energy of the water molecules bouncing around (their absolute kinetic energy—the “fluctuation” measurement)
- A **suspended speck of dust** (Brownian motion), which reveals the net mechanical push the water exerts on an object (the “mean-field” measurement)

The thermometer gives an enormous number, because every single molecule’s energy contributes positively to the total heat. They are all vibrating, and those vibrations add up.

The dust speck, however, barely jitters. Why? Because at any given microsecond, millions of molecules strike the speck from the left, and millions strike it from the right. Because they hit from random directions, their impacts mostly cancel each other out. The net push that actually moves the speck is just the tiny statistical residual left over after all that cancellation.

These two measurements aren’t giving you contradictory information about the water. They’re measuring *different statistical properties* of the same underlying reality. The thermometer measures the total activity (the variance). The dust speck’s movement measures the net effect (the mean). For a system with trillions of molecules pushing in random directions, the total unsigned activity is naturally enormous compared to the tiny, canceled-out net push.

The critical point is this: **these are fundamentally different operations.** The thermometer reading arises from adding up every individual impact. The net mechanical push arises from averaging over all of them. In classical physics, you can just build two different instruments. But what if you are trying to measure the very fabric of the universe from the inside, and you are forced to use the universe’s own structural projections to do it?

This paper argues that quantum mechanics and general relativity are exactly like the thermometer and the dust speck. Quantum mechanics measures the *fluctuation content* of the vacuum—the total, unsigned activity of the hidden degrees of freedom. General relativity measures the *net mechanical effect*—the aggregate, canceled-out push the vacuum exerts on spacetime. The  $10^{120}$  ratio between them is not an error. It’s the difference between an unsigned total and a canceled-out residual for a system with an astronomically large number of degrees of freedom.

### 3 The $10^{120}$ as a Measurement

If the  $10^{120}$  ratio is the variance-to-mean ratio of the hidden sector, it is possible to work backwards and ask: how many independent degrees of freedom must the hidden sector have to produce a ratio this large?

The central limit theorem provides the answer. If  $N$  independent random variables each contribute fluctuations with zero mean and variance  $\sigma^2$ :

- Total variance (unsigned sum):  $\sim N\sigma^2$
- Standard deviation of the mean (after cancellation):  $\sim \sqrt{N}\sigma$

The ratio:

$$\frac{\text{Total variance}}{\text{Mean amplitude}} \sim \frac{N\sigma^2}{\sqrt{N}\sigma} = \sqrt{N} \quad (4)$$

Setting this equal to  $10^{120}$ :

$$\sqrt{N} \sim 10^{120} \Rightarrow N \sim 10^{240} \quad (5)$$

This is the number of hidden-sector degrees of freedom.

#### The Cosmological Horizon Connection

The de Sitter horizon—the cosmological boundary beyond which light has not had time to reach observers—has a Bekenstein-Hawking entropy given by:

$$S_{\text{dS}} = \frac{A}{4\ell_P^2} \sim 10^{122} \quad (6)$$

where  $A$  is the horizon area and  $\ell_P$  is the Planck length. Notice:

$$N \sim 10^{240} = (10^{122})^2 = S_{\text{dS}}^2 \quad (7)$$

This “coincidence”—that the hidden sector has exactly  $(10^{122})^2$  degrees of freedom—suggests a deep connection to the holographic principle, the idea that the information content of a region of space is proportional to its surface area rather than its volume. The paper argues this is not a coincidence: the  $10^{120}$  is the one number where both projections make contact with the same physical reality, and it encodes the hidden sector’s structure directly.

The cosmological constant problem, in this reading, isn't a problem. It's a *measurement*—the most precise measurement available of the dimensionality of the parts of reality that cannot be seen.

## 4 What This Means

If this argument is correct, the century-long search for a unified theory that combines quantum mechanics and gravity into a single framework is asking the wrong question. It's like asking for a single instrument that simultaneously measures both temperature and pressure by being a thermometer and a barometer at the same time. The request is structurally impossible—not because physicists haven't been clever enough, but because the two measurements require fundamentally different operations on the same underlying system.

This doesn't mean physics is stuck. It means physics needs to recognize what kind of problem it's facing. The incompatibility between quantum mechanics and gravity is not a deficiency waiting to be repaired. It is a *structural feature* of what it means to observe the universe from the inside—a feature that comes with a precise numerical signature ( $10^{120}$ ), a derivable quantum framework, and testable predictions.

The universe is not broken. Observers are just observing it from within, which sets fundamental limits on the ability to unify certain projections of reality.

In 1926, Einstein wrote to Max Born: “I, at any rate, am convinced that He does not throw dice.” For a century, this has been read as Einstein being wrong—as a great mind unable to accept the fundamental randomness of quantum mechanics. This framework suggests a different reading. Einstein’s intuition was correct: the underlying reality, the full state of the universe including its hidden sector, is definite. The dice are real, but they belong to the projection, not to reality itself. What Einstein called “the secret of the Old One” is not randomness. It is the structural fact that no observer inside the universe can see the whole game—and what is called quantum mechanics is what the game looks like through the keyhole.

*This is a simplified overview of the full technical paper “The Incompleteness of Observation: Why Quantum Mechanics and Gravity Cannot Be Unified From Within” (Maybaum, February 2026). The core argument—including mathematical proofs, formal theorems, and detailed experimental predictions—is presented in the companion paper. Several of the reinterpretations explored in this explainer (the arrow of time, dark matter, quantization, String Theory) go beyond the formal results and are flagged as speculative implications in both documents.*

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