THE LIGHT BETWEEN

A Visitor's Guide to the Science of Light and the Structure of Reality

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Peachtree Valley United
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A free resource for curious minds.
No belief required. Just attention.

Welcome

You're holding a guide to something unexpected.

In 2026, we have precision instruments that can measure the age of light that has been traveling for 13.8 billion years. We can detect ripples in the fabric of spacetime. We can photograph the shadows of black holes. And buried in all of this data, there is a pattern.

This guide doesn't ask you to believe anything. It asks you to **look**. We're going to walk through a series of scientific observations—all of them established, peer-reviewed, and replicable—and when we're done, you can decide for yourself what they mean.

The only thing we ask is that you bring the same quality of attention you'd bring to a good mystery. Because that's what this is.

Part 1: The Experiment That Changed Everything

Let's start with something you can verify yourself. You'll need three pairs of polarized sunglasses (or three polarizing film squares, available online for a few dollars).

> **Try This: Take two polarizing lenses. Stack them. Rotate the back one slowly. Notice how the light dims and eventually goes completely dark when they're at 90° to each other. Now—with them still crossed—slide a third lens between them at 45°. Light comes back. You just did the three-filter experiment.**

What Just Happened?

When two polarizing filters are aligned (both at the same angle), all the polarized light passes through. When they're crossed at 90°, **no light passes through**. Total darkness.

But here's the part that has baffled physics students for generations: if you add a **third** filter between the crossed pair—oriented at 45°—light suddenly reappears. Not all of it. About 25% of the original intensity. But *something* where there was nothing.

Adding a filter increased the amount of light getting through.

This is not intuitive. This is not what common sense predicts. But it is precisely what the mathematics demands.

MALUS'S LAW

When polarized light hits a filter, the transmitted intensity follows: $I = I_0 \cdot \cos^2(\theta)$, where θ is the angle between the light's polarization and the filter's axis. At 45°: $\cos^2(45°) = 0.5$. Through two 45° steps: $0.5 \times 0.5 = 0.25$. That's where the 25% comes from. Published by Étienne-Louis Malus in 1809.

Why 45°?

Here's the key question: why does 45° work best? Is there something special about this angle, or would 30° or 60° work just as well?

The answer is mathematical and unambiguous. If you set up the transmission function for the three-filter system and take its derivative to find the maximum, you get:

THE PROOF

The total transmission through three filters is $T(\theta) = \frac{1}{4} \sin^2(2\theta)$. Taking the derivative: $dT/d\theta = \sin(4\theta) = 0$. The first positive solution is $\theta = 45°$. This is the unique maximum. No other angle transmits as much light through crossed polarizers. 45° is not a good option—it is the ONLY optimal solution.

This is not opinion. This is calculus. Anyone with a first-year physics course can verify it.

Reflect: When you placed that third filter between the crossed pair, light appeared where there was darkness. What does it mean that adding something between two opposed things can restore what was lost between them?

Part 2: What Crystals Know About Light

Certain crystals do something remarkable to light. When a beam of light enters calcite (Iceland spar), it splits into **two separate beams**, each polarized at 90° to the other. Look through a piece of calcite and you see double—two images of everything, slightly offset.

This phenomenon is called **birefringence** (literally: double-bending). It occurs because the crystal's internal structure isn't the same in every direction. Light traveling through the crystal experiences different refractive indices depending on its polarization. The crystal sorts light by perspective.

BIREFRINGENCE

A birefringent crystal has two different refractive indices: n_o (ordinary ray) and n_e (extraordinary ray). The birefringence value $\Delta n = |n_e - n_o|$ measures how strongly the crystal splits light. Higher values mean more separation. This property is fundamental to optical engineering, LCD displays, microscopy, and telecommunications.

A Historical Curiosity

Around 95 CE, a man named John—writing on the island of Patmos—described a visionary city with twelve foundation stones. He listed them by name:

> *"The wall of the city had twelve foundations, and on them were the names of the twelve apostles of the Lamb. The foundations of the wall of the city were adorned with every kind of jewel. The first was jasper, the second sapphire, the third chalcedony, the fourth emerald, the fifth sardonyx, the sixth carnelian, the seventh chrysolite, the eighth beryl, the ninth topaz, the tenth chrysoprase, the eleventh jacinth, the twelfth amethyst."*
>
> — Revelation 21:14, 19–20

Here's what's interesting: all twelve of these minerals, when identified by their modern geological names, exhibit birefringent or anisotropic optical properties. Every single one.

The science of crystal optics didn't exist until the 17th century. Erasmus Bartholinus first described double refraction in calcite in 1669. The mathematical framework for understanding birefringence wasn't developed until the 19th century.

John wrote his list approximately 1,600 years before anyone understood what birefringence was.

Stone	Mineral ID	Birefringence (Δn)	Crystal System
1. Jasper	Microcrystalline quartz	0.009	Trigonal
2. Sapphire	Corundum (Al_2O_3)	0.008	Trigonal
3. Chalcedony	Chalcedony	0.009	Trigonal
4. Emerald	Beryl	0.006	Hexagonal
5. Sardonyx	Banded chalcedony	0.009	Trigonal
6. Carnelian	Carnelian	0.009	Trigonal
7. Chrysolite	Olivine/Peridot	0.036	Orthorhombic
8. Beryl	Beryl	0.006	Hexagonal
9. Topaz	Topaz	0.010	Orthorhombic
10. Chrysoprase	Nickel chalcedony	0.009	Trigonal
11. Jacinth	Zircon	0.042–0.065	Tetragonal
12. Amethyst	Quartz	0.009	Trigonal

12 for 12. A perfect correspondence between an ancient text and a modern optical property that the author could not have known about.

We present this as data, not as doctrine. Draw your own conclusions.

> *Reflect: If you were designing a foundation for a city that symbolized the restoration of clear sight, and you had access to modern mineralogy, which stones would you choose? How does your list compare to this one?*

Part 3: The Universe Has a Perspective Problem

Here is one of the biggest unsolved problems in modern cosmology, and you've probably never heard of it.

We have two ways of measuring how fast the universe is expanding (a number called the Hubble constant, H_0). One method looks at nearby objects—supernovae, variable stars in our cosmic neighborhood. The other looks at the oldest light in the universe—the Cosmic Microwave Background, radiation released 380,000 years after the Big Bang.

These two methods should agree. They don't.

THE HUBBLE TENSION

Local measurements (SH0ES team, 2022): $H_0 = 73.04 \pm 1.04$ km/s/Mpc. CMB measurements (Planck satellite, 2018): $H_0 = 67.4 \pm 0.5$ km/s/Mpc. The disagreement is now at 5σ significance—meaning there is less than a 1-in-3.5-million chance that it's a statistical fluke. This is not a rounding error. Something fundamental is different about how the universe looks depending on where and how you measure it.

The universe appears to be expanding at different rates depending on your **perspective**. Our local measurements—from our vantage point, looking out—give one answer. The cosmic average—looking at the whole universe from the outside—gives another.

Some cosmologists believe we may be living inside an unusually empty region of space called the **KBC Void**—a local underdensity roughly 2 billion light-years across. If true, our local measurements are skewed by our environment. We're not seeing the universe as it is. We're seeing it through a local filter.

Reflect: If the universe looks different depending on where you stand and how you look, is there a "true" measurement? Or is perspective built into the structure of reality itself?

Part 4: The Oldest Light in the Universe

The Cosmic Microwave Background (CMB) is the oldest light we can observe—an afterglow from the moment, 380,000 years after the Big Bang, when the universe cooled enough for light to travel freely for the first time.

The CMB has been mapped with extraordinary precision by satellites like COBE, WMAP, and Planck. It tells us about the conditions of the early universe—its temperature, its density fluctuations, and critically, its **polarization**.

The 10% Signal

The CMB is approximately **10% polarized**.

This means that about 10% of the oldest light in the universe retains a coherent polarization pattern—a signal that survived the chaotic conditions of the early universe. The other 90% was scrambled by interactions with matter in the first 380,000 years.

The precise degree of polarization depends on the angular scale you're measuring, but the overall signal is on the order of 10% of the temperature anisotropy—the fluctuations in the CMB's temperature map.

WHAT CMB POLARIZATION TELLS US

CMB polarization comes in two types: E-modes (curl-free patterns, generated by density fluctuations) and B-modes (divergence-free patterns, generated by gravitational waves and gravitational lensing). E-modes have been detected and measured precisely. Primordial B-modes—the signature of gravitational waves from inflation—remain one of the holy grails of observational cosmology.

Think about what this means: the very first light that could travel freely through the universe carried with it a residual polarization—a partial signal, about 10% of the total, that maintained coherence through the chaos.

Not all the information was lost. A remnant survived in the signal.

Reflect: If you were looking for evidence that the universe retains a "memory" of its original state, what would that evidence look like? How does the CMB's residual polarization compare to what you'd expect?

Part 5: The Stellar Furnace

Everything you can touch—your body, this page, the ground beneath you—is made of atoms that were forged inside stars.

After the Big Bang, the universe contained only hydrogen and helium. Every heavier element—carbon, oxygen, silicon, iron, gold—was created inside stellar cores through a process called **nucleosynthesis**. Stars are the furnaces that built the periodic table.

But not all at once. It took three generations.

Three Generations of Stars

Generation 1 (Population III): The first stars, forming roughly 100–200 million years after the Big Bang. Massive—100 to 1,000 times the mass of our Sun. They burned fast and hot, fusing hydrogen into helium and then into heavier elements: carbon, oxygen, silicon. When they exploded as supernovae, they seeded the cosmos with these new elements.

Generation 2 (Population II): Stars that formed from the enriched debris of the first generation. They further refined the elemental mix, producing even heavier elements through neutron capture and additional fusion cycles.

Generation 3 (Population I): Our Sun and its contemporaries. Born from the accumulated richness of two previous generations of stellar death and rebirth. These stars contain the full periodic table—and their planetary systems include rocky worlds like Earth, built from silicon, iron, oxygen, and carbon.

SILICON: ELEMENT 14

Silicon is produced through oxygen burning in massive stellar cores at temperatures exceeding 1.5 billion degrees. It was first available in the universe roughly 200–500 million years after the Big Bang—when the first generation of massive stars exploded. The universe is 13.8 billion years old. Silicon has existed for approximately 96–97% of cosmic history. For comparison: biological life on Earth is roughly 3.5 billion years old, about 25% of the universe's age. The raw material for crystals and computation predates biology by billions of years.

Each generation of stars *refined* the previous generation's output. Raw hydrogen became carbon became silicon became the minerals that form crystals. Three cycles of death and rebirth, each one producing something more complex and ordered than the last.

Reflect: The elements in your body passed through at least two stellar furnaces before becoming part of you. What does it mean that reality refines itself through cycles of destruction and renewal?

Part 6: The Questions

This guide has presented five sets of data. All of it is established science—replicable, published, peer-reviewed. None of it requires you to believe anything. But taken together, it raises questions that the data alone cannot answer:

1. Why does adding a mediating filter at 45° restore light through crossed polarizers—and why is 45° the *only* angle that maximizes this restoration?

2. Why did a 1st-century author list twelve specific foundation stones that all happen to exhibit the optical property (birefringence) most relevant to polarization—sixteen centuries before that property was discovered?

3. Why does the universe look different depending on your perspective (the Hubble Tension)—and is "perspective dependence" built into the structure of reality itself?

4. Why did approximately 10% of the original signal survive in the oldest light in the universe—and what does it mean that a remnant of coherence persists through chaos?

5. Why did the universe refine its elements through three generations of stars, each one producing more complex and ordered materials—and what does this pattern of refinement-through-fire tell us about the nature of creation?

We don't answer these questions in this guide. That's deliberate.

If you'd like to explore further, visit our website or pick up a copy of *The Light Between*, where we trace these patterns to their full depth. You can also use the interactive Polarization Explorer on our site to see the three-filter experiment, the birefringence data, and the cosmic timeline for yourself.

But the data is here. The questions are real. And the light—as always—is doing what light does.

It finds a way through.

Further Resources

Interactive Polarization Explorer: peachtreevalleyunited.com/explore

The Science of Light (Track 1 Book): *The Light Between* — coming 2027

The Theology of Light (Track 2 Book): *Through Him* — coming 2027

Video Series: The Light Project — available on our YouTube channel

Key Sources Referenced in This Guide:

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