Dr. Perry Phillips, Herman Lectures, Part 1 Podcast

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Imagine looking up at the night sky on a really clear, crisp evening, but instead of seeing that familiar spray of the Milky Way or the faint smudges of distant galaxies, you see absolutely nothing. Just a totally black sky. Yeah, exactly.

Just this endless, terrifyingly empty void. No stars beyond our own immediate dying solar system. No evidence that a wider universe even exists out there.

It's a pretty bleak picture. It really is. And the wild thing is, for a civilization living billions of years from now, that won't just be some thought experiment.

That'll be their literal reality. Right, because the very mechanics that created our universe are, well, they're slowly erasing the evidence of its birth. Right.

And that is why we are here. Welcome to another custom deep dive designed specifically for you. Today we are attempting to reverse engineer the biggest origin story of them all, the Big Bang.

And we're doing it by looking at the hard, observable physics that actually prove it happened. Exactly. So to guide us through this, we're pulling from the insights of cosmologist Perry Phillips.

And his background is honestly my favorite part of this whole thing. Oh, the Verizon thing. Yes.

Before he tackled the origins of space-time, Phillips was actually a voicemail quality assurance engineer for Verizon back in the early days of telecom. Which is just, I mean, it's perfect. It's probably too better to reverse engineer the underlying source code of the universe than a guy whose entire professional background is, you know, making sure wildly complex systems actually function and don't just crash.

Right. He's basically making sure the universe's code actually compiles. Exactly.

And the way Phillips approaches this is we are essentially setting up a cosmological crime scene investigation board, like a CSI board, but for astrophysics. I love that. The goal here is to strip away all that dizzying theoretical math that usually bogs down this topic.

Instead, we want to trace the physical clues left behind in the expanding vacuum of space. And we should probably mention the term Big Bang itself. It wasn't even meant to be a scientific term.

No, not at all. The astronomer Fred Hoyle actually coined it as a pejorative insult during a radio podcast. Because he thought it was stupid.

Right. He found the entire concept completely ridiculous. And yet it has survived literally every observational test thrown at it to become our most robust model of reality.

It's kind of ironic. Okay, let's unpack this. Because before we can talk about the spark that ignited time itself, we can't just jump straight to the beginning.

Right. You have to work backward. Exactly.

We have to look at the anomalous behavior of the universe right now. And that anomalous behavior is really the very first thread on our investigation board. To understand the crisis this caused in physics, you have to put yourself in the mindset of the scientific community back in 1912.

Oh, wow. Over a century ago. Yeah.

And the absolute unquestioned paradigm of the era was that the universe was infinite, static, and just fundamentally unchanging. Just a big still room. Basically, yeah.

Galaxies were just sort of floating there in this massive still void. But then you have this guy Vesto Slipher. He was a graduate student who decided to measure the rotation of spiral nebulae.

Which is what we now know are galaxies. Exactly. But back then, they just looked like fuzzy clouds.

And we really have to appreciate the sheer physical labor of what Slipher was doing here. I mean, he wasn't downloading digital data from some space telescope while sipping coffee. Oh, definitely not.

He was sitting in the freezing dark, night after night, capturing ancient, impossibly faint starlight on these small, physical glass plates. It took days of continuous exposure just to get a single usable spectrum. The dedication is honestly staggering, but the data he extracted from those glass plates, it completely shattered that static universe model practically overnight.

Because of the Doppler effect. Right. What's fascinating here is how Slipher applied the Doppler effect to the light he was capturing.

Okay, so assuming a baseline familiarity with the Doppler shift for everyone listening, like where waves compress as they approach you and stretch out as they recede. Right, much like packages on a conveyor belt. They bunch up if you run toward the belt and space out if you run away from it.

Exactly. Or like a car horn changing pitch as it drives past you. Yes, perfect example.

So Slipher expected a random distribution. He figured some galaxies would be blue shifted, meaning they're moving toward us, and some would be red shifted, moving away. Just random chaos.

Exactly. But that's not what happened at all. Almost every single galaxy he managed to photograph was heavily red shifted.

The light waves were stretching out; they were all moving away. Which is incredibly weird. Super weird.

Phillips uses this brilliant analogy here to contextualize how bizarre this was. Imagine you were sitting in a sealed room, right? And you have the ability to somehow observe the gas molecules in the air bouncing around. Okay, tracing the molecules.

Yeah. Statistically, in a closed static system, roughly 50% of them should bounce toward you, and 50% should bounce away. That's just basic probability.

Right. Right. But if, suddenly, every single molecule in the room is moving away from you, you don't assume the statistics are just acting weird today.

You assume someone just turned on a giant fan. A giant cosmic fan. Yes.

So the question Slipher inadvertently posed to the world was, who turned on the cosmic fan? And when Slipher presented this data to the American Astronomical Society, it was, well, the audience gave him a standing ovation. Wow, really? Yeah. But historical accounts suggest they clapped largely out of sheer overwhelming confusion.

They had no idea what they were clapping for. Pretty much. They simply didn't possess the theoretical framework to process a moving universe.

It just didn't compute. And that sheer confusion is what forces Albert Einstein to enter our story. So it's 1915, and Einstein publishes his General Theory of Relativity.

Monumental moment. Huge. He lays out these 16 notoriously complex equations that beautifully balance the geometry of space-time with matter and energy.

But the math betrays him. It really does. His own equations demand that the universe cannot be static.

Gravity dictates that it either has to be collapsing in on itself or expanding outward. It cannot just sit still. But Einstein hated that, right? Oh, he despised it.

He was so philosophically committed to a static universe that he couldn't accept what his own genius had uncovered. So to fix the quote-unquote problem, he introduced a mathematical fudge factor. The cosmological constant.

Exactly. Represented by the Greek letter lambda. He basically jammed this constant into his equations for the sole purpose of counteracting gravity.

Just forcing the math to reflect an unmoving, eternal universe. Right. He deliberately broke his own elegant theory to avoid dealing with a dynamic cosmos.

But the data doesn't care about Einstein's philosophical comfort. Because out in California, Edwin Hubble starts picking up where Slipher left off, backed by much better hardware. Yes, the heavy machinery enters the chat.

And I absolutely refuse to skip over Hubble's assistant here, Milton Humason. Oh, Humason's story is incredible. It really is.

Humason didn't start as a physicist. He started as a mule trainer. He was literally hauling heavy astronomical gear up the steep, dangerous trails of Mount Wilson on the backs of donkeys.

But he paid so much attention to the work going on around him that he eventually became Hubble's primary observational partner. It's a phenomenal historical detail. It really highlights how much of this foundational science was driven by just raw mechanical grit.

And eventually, they transitioned to the Mount Palomar telescope, utilizing this massive 200-inch mirror. The size of that thing is terrifying. Oh, it was a beast.

It was so enormous that Hubble could physically sit inside a cage suspended in the middle of the telescope tube just to take spectral photographs. Just casually hanging out inside the telescope. Exactly.

And through this sheer mechanical advantage, they solidified what we now call Hubble's law. Which proves the redshift isn't just some random movement. It's a deeply predictable mathematical relationship.

The further away a galaxy is, the faster it is receding from us. Phillips notes a specific observation in the source of a galaxy 50 million light-years away. They clocked its recession speed at 750 miles per second.

Which is moving. Yeah. Phillips jokes it's only slightly faster than the commuters driving on Highway 128.

I love that joke. But the implication of that speed was undeniable. It finally forced Einstein to travel out to California, look through Hubble's telescope himself, and basically admit defeat.

Yep. He actually later told the physicist George Camus that inventing the lambda cosmological constant to force a static universe was the biggest blunder of his life. The biggest blunder.

Wow. It was a paradigm shift of the highest order. The universe was unequivocally expanding.

But you know, this is exactly where human intuition tends to misinterpret the data. Right. Because let me play devil's advocate for a second here for our listeners.

Go for it. If I look in every possible direction, right, and every single distant galaxy is flying away from me, the most logical conclusion my brain jumps to is that Earth is sitting at the absolute dead center of a massive explosion. Oh, absolutely.

That is the instinctive conclusion. But it fundamentally misunderstands the mechanics of space itself. OK.

So how do we fix that mental model? Cosmologists rely on the raisin cake model. We really have to stop thinking of space as an empty container that objects are moving through. Like a box.

Right. It's not a box. Spacetime itself is a physical medium.

It is the dough of the cake. And the galaxies are the raisins embedded within that dough. OK.

I'm tracking. So as the cake bakes, the dough swells and expands in all directions. The raisins aren't firing their tiny engines and flying through the dough.

The dough itself is just creating more volume between the raisins. Oh, wow. So if I'm standing on literally any raisin in that entire cage, every other raisin looks like it's moving away from me.

Exactly. There is no center. Or I guess you could say everywhere is the center.

That's a trip. And it perfectly explains Hubble's law, too. How so? Imagine two raisins, let's call them A and B, and they start one centimeter apart.

After an hour of baking, the dough expands by a factor of two, so they are now two centimeters apart. Their apparent speed from each other is one centimeter per hour. But now take raisins A and D, which start out way further, say, 16 centimeters apart.

In that same hour, the dough doubles again, placing them 32 centimeters apart. They appear to have moved 16 centimeters in one hour. So the further apart they are, the faster they separate, simply because there is more expanding dough between them to stretch.

You got it. That is Hubble's law in a baking tin. OK, here's where it gets really interesting.

Yeah. If we accept that the dough is expanding, then we can run the mathematical clock in reverse. If the universe is huge today, it had to be smaller yesterday.

And because we are looking at galaxies billions of light-years away, we are inherently looking at light that is billions of years old. Time travel, basically. We are literally watching the universe when it was mathematically smaller and denser.

Though, we should probably add a quick caveat here just to be precise. Sure. Not every single object in the sky is currently redshifted from our perspective.

Gravity still operates on a local level. Oh, really? Like what? Well, the Andromeda Galaxy, for instance. It sits about 2.5 million light-years away, and it is actually blueshifted.

Wait, meaning it's moving toward us. Exactly. It's moving toward us, and it will actually collide with the Milky Way in roughly two billion years.

Local gravitational binding can overpower the expansion of spacetime if objects are close enough. But that's only in our immediate cosmic neighborhood, right? You're right. Once you look past a distance of about 250 million light-years, the sheer volume of expanding spacetime just completely overwhelms local gravity.

It just washes it out. Right. From that distance onward, the expansion takes over completely, and that universal redshift absolutely dominates.

Okay, so we run the tape backward. We shrink the universe down. The current math points to an age of roughly 13.78 billion years.

Right. Give or take. Yeah.

Roughly 14 billion. And at that origin point, all matter and all energy in the known universe was compressed into a space smaller than a single proton. It's hard to even picture.

It really is. Yeah. But this is actually where I have to push back on the standard narrative a bit.

Okay, let's hear it. If all the mass of the entire universe is compressed into something smaller than a proton, wouldn't that just be an infinitely dense singularity? Like essentially the ultimate black hole. Right.

So how does anything, let alone spacetime itself, escape a gravitational well of infinite density to spark an expansion? Like, wouldn't it just be stuck? This raises an important question, and it really highlights where theoretical physics often gets misrepresented in popular media. Okay, how so? We often hear that the Big Bang started at a singularity of infinite density at quote unquote time zero. But as cosmologists like George Ellis have articulated, infinity is not actually a number you can arrive at in the physical universe.

It's just a concept. Exactly. It is an unattainable state.

In physics, when your equations yield infinity, it doesn't mean you've discovered an infinite reality. It means your math is broken down. Oh, like the equations just throw an error code.

Precisely. It's a syntax error. General relativity works brilliantly for gravity, and quantum mechanics works brilliantly for subatomic particles, but at a singularity.

You need both to work together, and currently they just refuse to cooperate. They clash. Right.

So cosmologists do not actually start the clock at a true singularity. They start at what is known as the Planck time. Which is an incredibly small fraction of a second after the expansion began.

10 to the negative 43rd seconds, to be exact. That is absurdly brief. It is.

At that specific moment, the universe was unfathomably hot and microscopic. About 10 to the negative 33rd centimeters across. But it was finite.

Okay, so it had a limit. Yes. It was measurable.

It wasn't infinite. And that finite moment is where our laws of physics actually turn on. It's a staggering concept though, right? Starting the story a fraction of a millisecond after the actual spark.

But what gives cosmologists the confidence to claim they know what the universe looked like at that exact microscopic fraction of a second? Well, because we can recreate it. Right. Really? We can recreate the Big Bang.

We can. At the Large Hadron Collider in Switzerland, physicists smash protons together at velocities approaching the speed of light. Oh right, the LHC.

Yeah. And the resulting collisions generate a microscopic, localized plasma that perfectly matches the exact temperatures, densities, and exotic particle formations that the Big Bang equations predict existed at 10 to the negative 13th seconds after the origin. That is just wild to me.

We build a massive underground tunnel in Europe, smash those atoms together, and the resulting physics perfectly mirrors the fiery birth of a 14-billion-year-old cosmos. It's poetry, honestly. It proves that the fundamental rules of the universe are uniform, whether you are at the beginning of time or sitting on Earth today.

And it anchors the cosmic models in hard, reproducible data. It pulls the Big Bang out of the realm of abstract philosophy and places it firmly in the realm of experimental science. Now, before we look at the ultimate fate of this expanding space-time, the source material points out a linguistic parallel that is just too fascinating to ignore.

Oh, the ancient texts. Yeah. Phillips highlights imagery found in ancient nomadic texts, specifically verses in the books of Job and Isaiah.

And again, we are looking at this purely as a historical and linguistic observation here, totally separate from any specific worldview. Right, just looking at the language itself. Exactly.

These texts describe the heavens being stretched out like a curtain and spread out like a tent. It's a brilliant topological metaphor when you think about it. Because of the culture.

Yeah. These were nomadic cultures. Their entire architectural reality was based on unrolling heavy fabric and stretching it outward over poles to create a volume of living space where absolutely none existed before.

Right. They fundamentally understood that you don't just move objects around inside a pre-existing space. You can actually stretch the material to create the space itself.

It is incredibly poignant that thousands of years before Einstein ever wrestled with general relativity or Hubble sat in his little telescope cage, the nomadic imagery of pitching a tent perfectly mapped to the modern astrophysical understanding of stretching space-time. It really shows how human intuition, when anchored in physical mechanics, can sometimes beautifully mirror cosmic reality. Exactly.

But that actually brings us to the final and arguably most shocking twist in this whole cosmological investigation. The Great Acceleration. Yes.

For the better part of the 20th century, physicists just assumed gravity was the ultimate arbiter of the universe's fate. Which makes sense. It totally makes sense.

The logic was sound. The universe is filled with mass. Mass exerts gravity, and gravity pulls things together.

So the assumption was the expansion would eventually have to slow down. The universe was either closed, meaning gravity would eventually halt the expansion and pull everything back into a massive, collapsing Big Crunch. Right.

Reverse Big Bang. Yeah. Or it was coasting at a critical velocity, slowing down infinitely over time, but never quite collapsing.

That was the absolute consensus. But then, in the late 1990s, teams of astronomers were studying distant supernovae, which act as the standard cosmic candles for measuring immense distances. And they realized the light wasn't behaving as predicted.

The expansion of the universe was not slowing down. Since about 9 or 10 billion years ago, the expansion has actually been accelerating. So the space-time dough between the raisins is swallowing faster and faster every single day.

Exactly. It's picking up speed. So what does this all mean for Einstein's biggest blunder? Because this feels like the ultimate irony.

He invented that cosmological constant, lambda, purely as a mathematical sledgehammer to force a static universe. Right. But when cosmologists realized the universe is accelerating outward, didn't they have to revive that exact same variable to make the new math work? They did.

Einstein's discarded variable is now the exact mathematical placeholder we use to represent dark energy. Which is what's causing the acceleration. Precisely.

Dark energy is this mysterious, invisible driver making up nearly 70% of the universe, and it is actively pushing space-time apart. That is hilarious. It is.

Einstein's equations were essentially smarter than he was. He created the perfect mathematical tool for the totally wrong reason, only for cosmologists to realize a century later that it was exactly what they needed to describe the real universe. We have spent a century solving the mystery of the redshift, mapping the early plasma of the Big Bang, only to discover that the vast majority of our universe is dominated by dark, invisible forces we barely even comprehend.

It's deeply humbling. It really is. We are far from having the complete picture.

And you know, if we connect this accelerating expansion to the bigger picture of our cosmic future, we run into a profoundly unsettling reality. Oh boy, Kay. I want to leave you with a thought drawn from the final Q&A of Philip's lecture regarding the cosmic horizon.

The balloon analogy. Yes. Imagine you are a two-dimensional dot on an inflating balloon.

There is no edge to your universe, but because the balloon is expanding, there is a horizon to what you can see. Makes sense. Because dark energy is causing the universe's expansion to accelerate, the physical space between distant galaxies is stretching faster and faster.

Eventually, the rate at which space-time itself is expanding will exceed the speed of light. Which doesn't violate physics, right? Because nothing within space can travel faster than light. But space-time itself doesn't have a speed limit.

Space-time can expand at whatever rate it wants. And when that expansion exceeds the speed of light, distant galaxies will cross over our cosmic horizon. Meaning what, exactly? The light they emit will literally never be able to cross the expanding gulf of space to reach our telescopes.

They will simply wink out of existence from our perspective; sayonara, they are gone forever. Which brings us all the way back to that terrifyingly empty night sky from the intro. Exactly.

Fast forward a few billion years. A future civilization living in our solar system will look up, and the sky will be completely black. All other galaxies will have been pulled beyond that cosmic horizon.

They won't have Slipher's glass plates to look at. No. They won't be able to measure a redshift.

They will have absolutely zero observable evidence that the universe is expanding or that a Big Bang ever occurred in the first place. The evidence of the Big Bang is literally being erased by the very expansion it caused. It's a sobering thought.

We just happen to live in a highly privileged, incredibly lucky window of cosmic time where the distant galaxies are still visible, and the fingerprints of our origin can still be seen. Wow. So the question I really want you to mull over tonight is this: if the fundamental truth of the Big Bang will eventually slip entirely beyond our horizon, what other massive fundamental truths about the nature of our universe have already slipped beyond our horizon before human beings even evolved to look for them? That is a staggering thought to end on.

The chalk outlines at our cosmological crime scene are stretching out and fading into the dark right before our eyes. We are so lucky to be here to see them at all. Thank you for joining us on this custom deep dive.

We hope this gave you a solid, grounded understanding of the mechanics driving our incredible expanding universe. Keep looking up while the evidence is still there to see.