S03E22 - What Happens if We Catch a Graviton? (It Changes Everything)

The Multiverse Employee Handbook - Season 3

The *Multiverse Employee Handbook* defines **gravity** as:

The tendency of everything to prefer everything else, particularly in a downward direction.

Operationally, gravity is not a force in the traditional sense but a geometric suggestion—mass bends spacetime, and objects follow the curve with quiet obedience. In practical terms, this means that if you drop something, it will demonstrate commitment.

Gravity is remarkably weak and impressively thorough. A small magnet can defeat Earth's pull, yet gravity assembles stars, choreographs galaxies, and ensures your phone when inevitably dropped, reaches the floor. Likely pavement or some other unforgiving material. Gravity requires no supervision, generates no paperwork, and has never once taken a day off.

Side effects include planetary formation, orbital mechanics, tides, and the persistent illusion that "up" is meaningful. Excess gravity may result in black holes. Insufficient gravity results in meetings conducted horizontally.

In summary, gravity is the universe's most reliable policy: nothing escapes accountability, and everything is, in the end, drawn together.

You're tuned into The Multiverse Employee Handbook.

Today, we are asking one of the most audacious questions in the whole of modern physics: is gravity — the thing that keeps your tea on the table, your feet on the pavement, and the Moon from simply wandering off — actually a particle?

And if so, why, in over a century of trying, has nobody managed to find one?

We will travel from a seventeenth-century Dutch clockmaker with an obsession about time, through a Victorian gentleman who discovered that electricity and magnetism were secretly the same thing all along, through to a laboratory in which a cylinder of beryllium is being cooled to a temperature so close to absolute zero that the atoms inside it have essentially given up and sat down — all in the hope of catching a single, solitary, almost impossibly shy quantum of gravity in the act of existing.

But first, gather 'round the supercooled resonator, my fellow gravitationally compliant listeners, for a cautionary tale about what happens when you ask the universe to please submit its particle documentation, and the universe — as it so often does — simply doesn't bother to reply.

In the fluorescent-lit realm of Quantum Improbability Solutions, specifically in the Department of Downward Forces — which existed in a superposition of "essential infrastructure" and "we're not entirely sure why this department exists" — Gerald Tock was having what could charitably be described as a documentation crisis.

It had started, as these things often do, with a form.

Someone on the fourteenth floor had slipped on the stairs. HR, displaying its characteristic instinct for assigning blame to something, anything, had issued a Compulsory Incident Report requiring the responsible party to be formally identified. Gerald, as junior compliance officer, had been handed the file.

The responsible party, it turned out, was gravity.

Gerald had approached this with the quiet confidence of a man who had successfully documented the thermal properties of the office kettle and once filed a risk assessment for spontaneous quantum tunnelling through the stationery cupboard. Gravity, he reasoned, would be straightforward. Gravity was, after all, famous. Gravity had been around since the beginning of everything. Gravity had name recognition.

What gravity did not have, Gerald discovered, was a particle.

He checked the standard compliance register. Electromagnetism: carrier particle confirmed, photon, lovely, signed off in 1905. Strong nuclear force: gluon, present and accounted for. Weak nuclear force: W and Z bosons, technically a bit odd, but documented. Gravity: field effect confirmed, waves confirmed, responsible particle — the graviton — status listed as *pending*.

Pending since 1916.

Gerald sent an inter-departmental memo to the graviton requesting its immediate attendance at a compliance review. The memo was returned, unopened, having apparently fallen off the desk.

He escalated to the Square-Haired Boss.

The Square-Haired Boss, who believed that all problems were fundamentally motivational in nature, peered at the file and announced that gravity was obviously a particle, because — and here he gestured at a laminated poster on the wall that read *Everything Is A Particle: Believe In Your Quantum Self* — everything was a particle. It said so right there.

Gerald explained that whilst the poster made an admirable point, the graviton remained undetected, and that a particle which had never been observed could not technically be listed as a confirmed responsible party on an incident report.

The Square-Haired Boss suggested Gerald think outside the box.

Gerald pointed out that the box itself was held together by gravity, which remained unconfirmed as a particle, and that thinking outside it might therefore be structurally inadvisable.

The Square-Haired Boss told Gerald to find the graviton by Thursday.

Gerald tried. He constructed a rudimentary detector from a repurposed beryllium paperweight, a cold brew coffee kit set to its lowest temperature setting, and a great deal of optimism. He placed it in the stairwell where the original incident had occurred, on the basis that if gravity was going to behave badly anywhere, it would probably be there.

He waited.

The beryllium paperweight sat there, inert, resolutely not detecting anything. A single graviton, had it been passing through, would have deposited an amount of energy so vanishingly small that the paperweight would have needed to be roughly the size of Jupiter and cooled to near absolute zero to notice. Gerald's cold brew kit was managing about twelve degrees Celsius. This was not, by most calculations, sufficient.

By Thursday, Gerald had filed gravity under *Pending — Awaiting Quantum Confirmation*, listed the stairwell incident as caused by *an unratified field effect operating without documentation*, and noted in the remarks column that the universe had been contacted and had not yet responded.

The form went into a drawer.

The drawer, in accordance with all known thermodynamic principles, gradually became more disordered.

Gerald made a cup of tea, watched it sit in the drawer with perfect obedience to a force that technically still hadn't signed its own paperwork, and felt, in some quiet and unnameable way, that this was a rather accurate summary of the situation.

And that brings us, with the inevitable downward momentum that gravity so reliably provides, to the science itself.

Gravity is the oldest force in human experience and, as it turns out, the least understood. It governs the orbit of every planet, the arc of every thrown object, and the precise trajectory of every biscuit that has ever fallen from a tea-dunking at the wrong angle. It has been operating continuously, without maintenance, since approximately thirteen point eight billion years ago.

It is also, by the standards of modern physics, deeply awkward.

The universe operates through four fundamental forces: electromagnetism, the strong nuclear force, the weak nuclear force, and gravity. The first three each work via carrier particles — tiny quantum messengers that communicate the force between objects. We have found them, named them, and written a considerable amount of peer-reviewed literature about them.

Gravity has not provided a carrier particle.

Gravity has provided waves — confirmed, measured, Nobel Prize-winning waves, as we shall discuss — but the particle that ought to be riding those waves, the graviton, remains the most wanted and most elusive entry in the entire catalogue of fundamental physics. It is, in every meaningful sense, the universe's outstanding invoice.

To understand why we think it must exist, and why catching it is so extraordinarily difficult, we need to go back to 1656, and to a Dutch clockmaker who was not thinking about particles at all. He was thinking about time.

Christiaan Huygens realised that a pendulum — a weight on a string, swinging back and forth — keeps an extraordinarily consistent beat, governed entirely by gravity. Regulate the swing, regulate the clock. He built the first accurate pendulum clock, and it worked brilliantly.

And then something rather interesting happened.

When these clocks were taken toward the equator, they lost time. Not because the clocks were faulty. Because gravity was slightly weaker there. The Earth bulges a little at the middle, and the gravitational field varies accordingly. A weaker pull means a slower swing. A slower swing means a clock that falls behind.

This was the first great revelation: gravity is not a fixed rule uniformly applied. It is a physical field, with different strengths at different locations. It can be measured, mapped, and felt.

Huygens almost certainly did not appreciate the full implications. He was trying to keep time, not unravel the fabric of reality. But then, the most consequential discoveries rarely announce themselves.

That pendulum was the first loose thread.

When we return, we'll follow it all the way from a Dutch workshop to a Louisiana swamp in 2015 — where two ancient black holes finally sent us a message. And we'll ask what that message implies about the smallest possible piece of the force that delivered it.

Welcome back, my gravitationally compliant listeners.

So. Huygens has given us something crucial: gravity is a field. It varies. It does things to space. But a field, on its own, doesn't tell us how gravity actually travels from one object to another. For that, we need to skip forward two centuries, to a Victorian drawing room, and a man who was doing something rather extraordinary with magnets.

James Clerk Maxwell, in 1865, was not thinking about gravity. He was thinking about electricity and magnetism, which most people at the time treated as separate, unrelated phenomena. Maxwell looked at the equations and noticed they weren't separate at all. They were two aspects of the same thing: electromagnetism.

More importantly, he proved that this force didn't act by magic across empty space. It travelled. It propagated outward in waves through an electromagnetic field. Wiggle a charged particle here, and a ripple crosses the field and influences a charged particle over there. The force has a mechanism. It has a speed. It has, in short, a commute.

In the twentieth century, quantum mechanics added the next layer: those ripples aren't just waves. They're also particles. The electromagnetic wave is carried by photons — discrete little packets of energy that are simultaneously the ripple and the thing making the ripple. The force has a messenger.

This was the template. Forces travel in waves. Waves are made of particles. And it was against this template that Einstein, in 1915, held up gravity — and asked whether it did the same thing.

His answer was both more beautiful and considerably more unsettling than anyone expected.

Einstein reimagined gravity not as a force at all, but as the geometry of spacetime itself. Mass warps the fabric of space and time around it. Other objects don't get pulled — they follow the curves. The Earth doesn't attract the Moon; the Earth bends spacetime, and the Moon follows the bend. It is, as analogies go, like placing a bowling ball on a stretched rubber sheet — except the rubber sheet is the fundamental structure of reality, so perhaps don't dwell on that too long.

But here's the critical part. If spacetime is a fabric that can curve — it can also ripple. Disturb it violently enough, and the disturbance should propagate outward as a gravitational wave, travelling at the speed of light.

For a hundred years, this was purely theoretical. And then, on the fourteenth of September 2015, the LIGO observatory — two enormous laser detectors, one in Louisiana, one in Washington state — registered something. A chirp. A tiny, fleeting oscillation lasting a fraction of a second. Space itself had stretched and squeezed by a distance smaller than a thousandth of the width of a proton.

Two black holes, each dozens of times the mass of the Sun, had spiralled into each other roughly a billion light-years away. The collision had released more energy than all the stars in the observable universe combined — and what had arrived at Earth, after a billion years of travelling, was a vibration roughly equivalent to a gravitational whisper. LIGO heard it. Gravity travels in waves. Confirmed. Nobel Prize issued.

And now we arrive at what physicists call the quantum wall.

We know light is a wave. Quantum mechanics proved it is also a particle — the photon. We now know gravity is a wave. The logic is, at this point, almost insultingly straightforward: gravity must also have a particle.

That particle has a name. The graviton.

Theory tells us what to expect of it. It must be massless — like the photon — in order to travel at the speed of light. It must have a quantum spin of two, which is unique among all known particles and is required to match the way gravity warps space symmetrically in all directions. And it would be the mediator of every gravitational interaction that has ever occurred — from the orbit of Neptune to the fall of Gerald's beryllium paperweight.

So why haven't we found it?

Because gravity is almost incomprehensibly weak. We don't tend to think of it that way — gravity feels rather emphatic when you walk into a lamppost — but on the quantum scale, it is barely a suggestion. A small fridge magnet can defy the entire gravitational pull of the Earth to lift a paperclip. The whole planet, pulling down. One magnet, pulling up. The magnet wins.

To detect a single graviton would require an instrument of almost hallucinatory sensitivity. Freeman Dyson — one of the great physicists of the twentieth century — calculated that a detector the size of Jupiter, orbiting a neutron star, would catch approximately one graviton per decade.

Which does present certain logistical difficulties.

But — and this is where it gets genuinely exciting — scientists have recently stopped thinking about Jupiter-sized detectors. They've started thinking about something much colder.

If the graviton exists — and the mathematics suggests very strongly that it does — then catching one requires rethinking the problem almost entirely. Not bigger detectors. Colder ones.

The logic runs like this. A gravitational wave passing through matter doesn't push it smoothly. At the quantum level, it deposits energy in discrete jumps — the same way light delivers energy in photons rather than a continuous stream. These jumps are called phonons. They are extraordinarily small. To have any hope of detecting one, you need a material so cold, so still, so utterly drained of thermal noise, that a single quantum nudge from a passing gravitational wave would be visible against the silence.

A team led by physicist Igor Pikovski has proposed doing exactly this using a cylinder of beryllium, cooled to a whisker above absolute zero — approximately minus two hundred and seventy-three degrees Celsius, which for context is considerably colder than anything that occurs naturally in our solar system, and roughly the temperature at which matter runs out of excuses to move. When a gravitational wave passes through this bar, it vibrates. The quantum sensors monitoring it would, in principle, catch the moment it absorbs a single quantum of gravitational energy. One phonon. One graviton's worth of disturbance.

The experiment is currently under development. The beryllium is, one assumes, being kept patient.

A parallel approach, developed in collaboration between Stevens Institute of Technology and Yale, goes one step further into the quantum strange. Superfluid helium — helium cooled until it loses all friction and behaves as a single, unified quantum object — is monitored by lasers in a gram-scale container. The target is an astrophysical event: a black hole merger somewhere in the cosmos, the kind that LIGO detects. When the wave arrives, the superfluid should register a single quantum energy jump. One discrete blip in an otherwise perfectly still fluid.

Which brings us to LIGO's new role in all this. On its own, LIGO is extraordinary — but it operates at the scale of waves, not particles. It's like hearing a symphony and knowing music exists without being able to identify a single note. The new strategy is to use LIGO as a starting gun. The moment it detects a major gravitational wave event, the quantum resonators activate and look for a simultaneous single-quantum energy jump. If the wave and the jump coincide — same source, same moment — that is, as physicists say with considerable understatement, a significant result.

Meanwhile, at CERN, the Large Hadron Collider is pursuing an entirely different angle. In certain theoretical models involving extra dimensions beyond our familiar four, gravitons could leak — actually slip sideways out of our reality into dimensions we cannot directly observe. The signature would be energy that simply vanishes. Protons smash together, the collision products are measured, and the numbers don't add up. The missing energy has gone somewhere. That somewhere might be a graviton departing quietly into a dimension that doesn't appear on any current map.

It hasn't happened yet. But they're watching.

What strikes me, standing back from all of this, is the particular moment in history we appear to be occupying. In 1905, Einstein used the photoelectric effect — the way light ejects electrons from metal — to prove that light comes not in waves alone, but in discrete packets. Photons. It was the moment electromagnetism clicked into its quantum form. Every physicist involved in the graviton search will tell you, with varying degrees of barely contained excitement, that these acoustic experiments are that moment for gravity. We have seen the wave. We are now building the instruments to catch the packet.

We haven't found it yet. The beryllium sits in its cryostat. The superfluid helium is almost perfectly still. LIGO listens to the sky.

But somewhere out there, two black holes are circling each other with the slow, inevitable patience of objects that have all the time in the universe. When they finally collide, they will send a ripple across the fabric of spacetime — and riding that ripple, if everything we understand about the universe is correct, will be the graviton.

We just need to be quiet enough to hear it arrive.

Well, my fellow gravitationally compliant listeners, we have reached the end of another quantum descent. Today we've learned that in the multiverse of fundamental forces, gravity is the one that turned up to every meeting, shaped every galaxy, held every planet in its orbit, and still hasn't submitted the relevant particle paperwork.

We've discovered that the most familiar force in the universe is also its greatest outstanding mystery — that a pendulum in a seventeenth-century Dutch workshop, a Victorian drawing room crackling with electromagnetic revelation, and a pair of Louisiana laser beams are all part of the same story, still being written, still unresolved, still waiting for a cylinder of beryllium cooled to the edge of nothing to register a single, tiny, almost inconceivably shy quantum knock at the door.

We've established that the graviton — massless, spin-2, theoretically responsible for every downward incident in the history of the cosmos — almost certainly exists. We simply haven't convinced it to be observed yet. Which, given that observation is more or less all we're asking of it, does feel a touch uncooperative.

But here is the thought I'd like to leave you with.

Every force we have ever come to understand began as a mystery. Electricity was once a parlour trick. Magnetism was folklore. The strong nuclear force was, for a considerable time, simply labelled "something is holding the nucleus together and we have absolutely no idea what." One by one, we found the messengers. One by one, the universe yielded its carrier particles.

The graviton is the last one. The holdout. The particle that would finally connect the very large — stars, galaxies, the grand sweeping architecture of spacetime —

with the very small — atoms, quantum fields, the fizzing probabilistic substrate of everything.

We are closer than we have ever been. The instruments are running. The helium is cooling. And somewhere, a black hole merger is already on its way.

That's not a bad place to be.

Want to explore more quantum mysteries that the universe is being cagey about? Visit us at multiverseemployeehandbook.com, where you'll find fascinating science news, deep dives into the universe's most stubborn unsolved problems, and our latest blog post: "Gravitons: Delulu but Make It Theoretical." And if you'd like this sort of thing delivered directly and reliably — unlike gravity's carrier particle — sign up to our mailing list. The link is in the show notes. We promise it will arrive.

If you've enjoyed today's subatomic search, why not share it with a fellow curious mind? Perhaps you know someone who has always quietly suspected that the universe was holding something back. Spread our signal like a gravitational wave — in every direction simultaneously, at the speed of light, and with a patience that borders on the geological.

This is your quantum-coherent correspondent, reminding you that in the multiverse of unsolved physics, we are all just standing on a planet held together by a force that hasn't finished its onboarding.

And somewhere in the Department of Downward Forces, Gerald Tock's form is still in the drawer. Still pending. Still awaiting quantum confirmation.

As, to be fair, are we all.