

S03E23 - Why The Renewed Interest in Uranus?

The Multiverse Employee Handbook - Season 3

The Multiverse Employee Handbook has this to say about Uranus:

Uranus is, by any reasonable measure, one of the more interesting planets in the solar system. It rotates on its side, generates almost no internal heat despite being enormous, and possesses a magnetic field so geometrically eccentric that it appears to have been installed by someone reading the wrong schematic. These are genuinely remarkable qualities. They have received, relative to their remarkableness, very little attention.

Humanity visited once, briefly, in 1986. The data returned was extraordinary. The follow-up mission is currently scheduled for the 2040s, pending funding, review, and the kind of institutional momentum that tends to dissipate between administrations.

Exosociologists studying human civilisation from a comfortable distance have noted that this pattern — discover something astonishing, produce a thorough report, file the report, convene a working group, lose the working group — is not specific to planetary science. It appears to be a foundational feature of the species. The humans call it process. The Handbook calls it what happens when a civilisation becomes sophisticated enough to organise itself, and then cannot stop.

The planet, meanwhile, continues its tilted, heatless, magnificently strange orbit, entirely unaware that a committee somewhere has it on the agenda. It has been doing this for four and a half billion years without approval, without funding, and without once submitting the paperwork.

The Handbook finds this, on balance, admirable.

You're tuned into The Multiverse Employee Handbook.

Today, we're exploring the entirely genuine scientific possibility that one of our solar system's most reliably labelled planets has been mislabelled since before most of our listeners were born — using science, satire, and the kind of logic that only makes sense if you're willing to trust forty-year-old data from a spacecraft running on less computing power than a digital wristwatch.

Uranus — seventh planet, ice giant, magnificently sideways — has had a very eventful 2025. The James Webb Space Telescope found a moon that Voyager 2

missed entirely during its only visit. And two astrophysicists in Zürich published a paper suggesting that Uranus may not, in fact, be an ice giant at all — but rather a rocky world wearing a very convincing disguise.

We have, it turns out, been confidently describing a planet we have visited precisely once, with 1970s electronics, and then filed away.

The universe, characteristically, waited until now to mention this.

But first — gather round the quantum expense terminal, my fellow auditors of the poorly understood, for a tale that begins, as so many great stories do, in the Finance Department.

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In the fluorescent-lit realm of Quantum Improbability Solutions, specifically in the Finance Department (which existed in a superposition of overworked and technically closed for lunch), a junior accounts intern named Philippa was having what could charitably be called a filing crisis.

It had started, as these things often do, with a very old piece of paperwork.

"There's an expense report here," said Philippa, with the careful tone of someone who has found something they very much wish they hadn't. "It's been sitting in the system since 1986."

Finance went quiet.

Not because the amount was large. The amount, relative to the operational budget of an interplanetary reconnaissance mission, was remarkably modest. It was more the employee details that gave everyone pause.

Employee: Voyager 2. Department: Interplanetary Reconnaissance. Travel Claim: Uranus. Date of visit: January 24, 1986. Current location: interstellar space.

The Square-Haired Boss was summoned.

"Why," he asked, studying the form with the measured calm of a man who has learned to approach administrative anomalies the way one approaches a dog of uncertain temperament, "did it take forty years to submit a six-hour site visit?"

Someone had anticipated this question. The answer, it emerged, involved physics.

Voyager 2's onboard computer has roughly the processing power of a modern

digital wristwatch — and not a particularly ambitious one. It communicates with Earth using a radio transmitter generating twenty-three watts of power, which is somewhat less than a refrigerator lightbulb. The expense report therefore had to travel three billion kilometres at the speed of light, through a Deep Space Network that, on occasion, had other things to attend to.

Hence the delay.

Finance began reviewing the claim line by line.

Item one: Atmospheric analysis. Voyager reported the temperature at approximately minus two hundred and twenty-four degrees Celsius, making Uranus the coldest planetary atmosphere in the solar system — colder, in fact, than Neptune, which is considerably further away and therefore has, frankly, less excuse.

Finance wrote in the margin: *Temperature outside acceptable range for casual inspection. Claimant should have worn something.*

Item two: Magnetic field anomalies. Voyager noted that the magnetic field was tilted approximately fifty-nine degrees from the rotational axis and offset from the planet's centre, producing a magnetotail twisted into an enormous corkscrew shape extending millions of miles into space.

Finance added: *Magnetic field appears to have been installed by someone consulting the wrong schematic. Flagged for facilities.*

Item three: Rings. Voyager discovered a faint system of rings — narrow, dark, understated.

Rings present, wrote Finance. *Shy.*

Item four: Moons. Several logged, including Miranda, Ariel, Titania, and Oberon.

Finance paused here. Someone raised a hand to observe that the entire Uranian satellite system appeared to be named after characters from Shakespeare. And, upon further inspection, Alexander Pope.

No satisfactory explanation was located. The margin note simply read: *Charming. Unactionable.*

It was during the review of item four that Philippa quietly raised another matter.

Voyager 2, she noted, was the only employee ever dispatched to Uranus. Which

meant the entire planetary file — the atmosphere, the magnetic field, the rings, the moons, the everything — rested on a single six-hour flyby, conducted with 1970s electronics, by a spacecraft that had to shout its findings across three billion kilometres before continuing immediately to Neptune.

There had been no follow-up audit.

No second inspection.

No peer review from anyone who had actually been there.

Just the one memo, fired back across the void, and then forty years of scientific consensus built carefully on top of it.

The Square-Haired Boss considered his options. He could approve the expense report, or he could request that Voyager return for clarification.

Voyager 2, Finance confirmed, was currently beyond the heliosphere, travelling at seventeen kilometres per second in the direction of interstellar space, and would not be available for follow-up queries for several billion years.

The expense report was approved.

Reluctantly.

Philippa filed it.

And somewhere out there, past the edge of everything we've built and everywhere we've been, Voyager 2 continues drifting into the dark — still transmitting, still technically on the clock — blissfully unaware that someone finally processed its paperwork.

And that brings us to the fascinating science behind Uranus — which, unlike the various ice planets of science fiction, does not have a dramatic reveal, a hidden civilisation, or even a decent tourist infrastructure. What it has is considerably stranger.

Let us begin with the basics, delivered without ceremony, because the basics are already sufficiently alarming.

Uranus is the seventh planet from the Sun, orbiting at a distance of approximately 2.9 billion kilometres. It is four times wider than Earth. A day on Uranus lasts seventeen hours. A year lasts eighty-four Earth years, which means Uranus has completed fewer than three full orbits since William Herschel discovered it in 1781

— and he initially thought it was a comet, which is the sort of first impression that takes a while to recover from.

Its most immediately striking feature is its axial tilt: ninety-seven point seven seven degrees. Most planets spin like tops. Uranus rolls through the solar system like a marble someone flicked sideways. The leading hypothesis is that a planet-sized body collided with it during the early solar system, knocking it over. Uranus has, in the approximately four and a half billion years since, declined to right itself. One can respect that.

A consequence of this tilt is that Uranus experiences the most extreme seasons of any planet we know. For roughly twenty-one Earth years at a time, one pole faces the Sun directly while the other sits in complete darkness. Decades of uninterrupted night. And because we are all adults here who can be trusted with accurate scientific information, it is worth stating plainly that this tilt also means that for a considerable portion of every eighty-four-year orbit, the Sun is positioned directly behind Uranus — which is not a joke, not an embellishment, and not something we added for comic effect. That is simply where the Sun goes. Astronomers have confirmed this. Repeatedly. With peer review.

The atmosphere is the coldest of any planet in the solar system — minus two hundred and twenty-four degrees Celsius at the tropopause — which is genuinely remarkable given that Neptune is further from the Sun and yet warmer. Nobody is entirely certain why Uranus retains so little internal heat. It is one of several things about this planet that the current models describe with the quiet confidence of people who have not quite worked it out yet.

Then there is the magnetic field. On most planets, the magnetic axis aligns reasonably sensibly with the rotational axis. Earth's is offset by about eleven degrees — awkward, but manageable. Uranus's is tilted nearly sixty degrees and offset from the planet's centre by a third of its radius, producing a magnetotail that corkscrews behind it into space for millions of miles. The standard model has always struggled to explain this fully. We will return to that point in some detail.

All of which brings us to the label: ice giant. Beneath that hydrogen-helium atmosphere, the standard model places a vast, hot, pressurised mantle of so-called ices — water, methane, ammonia — not solid, but superheated fluid at thousands of degrees. "Ice" here is a compositional term, not a description of what you would encounter if you fell in, which you would not survive long enough to characterise. This mantle was thought to account for most of the planet's mass. That is what the textbooks say. That is what has been taught, published, and confidently repeated for four decades.

The question — and this is where we are going after the break — is how confident

any of us should be, given that the textbooks are working from a sample size of one six-hour visit conducted in 1986.

When we return, we are going inside Uranus. Scientifically. And what we find down there may require us to update rather a lot of paperwork.

Welcome back, my fellow auditors of the cosmically misfiled.

Now. Before we go any further, we need to address a fundamental problem — not with Uranus specifically, but with how planetary science works when the planet in question is approximately three billion kilometres away and nobody has visited since the Reagan administration.

How do you model the interior of a world you cannot reach?

The answer is: very carefully, with mathematics, and with a set of external measurements that are doing an enormous amount of heavy lifting. Scientists work from four observable quantities — mass, equatorial radius, rotation period, and the planet's gravitational field, expressed as a series of values called gravitational moments. These moments describe subtle variations in how the planet's gravity pulls on orbiting objects. Measure those variations precisely enough, and you can begin to infer what must be inside.

Voyager 2 gave us the first gravitational moment measurements for Uranus in 1986. They have since been refined using observations of the rings and moons. These numbers are the foundation of everything we think we know about what's down there.

The problem is what you do with them.

Historically, interior models have come in two varieties, and both have significant flaws. Physical models are internally consistent — they give you a complete picture of density, pressure, temperature, and composition throughout the planet. The catch is they depend entirely on the assumptions you put in at the start. If you assume the interior is predominantly water-ice, the model will produce a water-ice interior. You haven't discovered anything. You've confirmed your own starting position. As a methodology, it has a certain circularity that philosophers might find bracing.

Empirical models take the opposite approach — fewer assumptions, more mathematical freedom. But when you then try to extract the temperature and composition from those models, the results frequently violate thermodynamics in

ways that are, shall we say, unhelpful. Impossible temperature jumps. Density gradients that cannot physically exist. The model fits the data, but the interior it describes couldn't.

This is the state of play that two astrophysicists at the University of Zürich decided to do something about.

Luca Morf and Ravit Helled published their paper — *Icy or Rocky? Convective or Stable? New Interior Models of Uranus and Neptune* — in October 2025. Their approach was, in a word that scientists deploy with great reverence, agnostic. Rather than beginning with an assumed composition, their algorithm starts from randomly generated density profiles — physically plausible, but uncommitted — and then iterates. It runs and runs until it converges on models that simultaneously satisfy hydrostatic equilibrium, match the observed gravitational moments precisely, and remain thermodynamically consistent throughout. No pre-loaded answer. No inherited assumption. Just: given everything we can measure from the outside, what could Uranus actually be?

They ran the algorithm. They examined the full solution space. And here is what they found.

The models that perfectly match all observational data for Uranus do not describe a single interior. They describe a wide range of possible interiors — and crucially, that range includes configurations that are heavily, predominantly, rock-dominated.

The rock-to-water mass ratio for Uranus, their models show, could be anywhere between 0.04 and 3.92. At the lower end, you have something broadly consistent with the traditional picture. At the upper end — the end that also satisfies all the same observational data — Uranus is not an ice giant at all. It is a massive rocky world, clad in a relatively thin layer of water-fluid and a hydrogen-helium envelope.

Same gravity measurements. Same mass. Same radius. Completely different planet inside.

The paper's conclusion is stated with the measured calm of people who understand exactly what they're saying: the classification of Uranus as an ice giant may be, in their words, a historical artefact rather than a robust physical classification.

Which means the label has been on the tin for forty years. It just may not accurately describe the contents.

And if you're wondering how this connects to that magnificently peculiar magnetic

field we mentioned earlier — the corkscrew, the sixty-degree tilt, the offset that nobody could fully explain — we'll get to that now.

Let's begin with the magnetic field. Because it has been waiting patiently for an explanation since 1986, and it has, frankly, earned one.

Recall the problem: Uranus's magnetic field is tilted nearly sixty degrees from the rotational axis, offset from the centre, and generates a magnetotail twisted into an enormous corkscrew. The standard ice giant model could not cleanly account for this. A working planetary dynamo requires a convecting, electrically conductive fluid — and the traditional "icy mantle" picture placed that fluid in the wrong location, at the wrong depth, to produce the field Voyager 2 actually measured.

Morf and Helled's models resolve this rather elegantly.

Every single valid model their algorithm produced — regardless of whether it leaned icy or rocky — contains deep convective regions where water exists in what is called an ionic or superionic state. Under extreme pressure and temperature, water molecules are torn apart. Hydrogen ions flow freely through a lattice of oxygen. The result is a fluid that conducts electricity exceptionally well, and that convecting fluid is your dynamo.

Crucially, their models indicate that Uranus's dynamo operates deeper in the interior than Neptune's — the outer edge of the dynamo region sits at roughly sixty-nine to seventy-four percent of the planet's radius. A deeper, more enclosed dynamo, it turns out, naturally produces a lopsided, multipolar magnetic field. The corkscrew. The offset. The tilt.

The thing that baffled planetary scientists for forty years appears to be a straightforward consequence of where the engine is running. The mystery wasn't that the magnetic field was strange. The mystery was that the model everyone was using placed the engine too close to the surface.

Now. The reason all of this matters enormously beyond our own solar system.

Sub-Neptunes — planets between Earth and Neptune in size — are the most commonly detected category of planet in the galaxy. We have found thousands of them. We have been modelling them, categorising them, estimating their compositions, largely by analogy with what we assumed Uranus and Neptune to be. Our local ice giants have served as the reference template for an entire class of world.

If the template is wrong — if Uranus is actually a rocky body with a gas and fluid envelope rather than an icy one — then the mass-radius relationships used to characterise those thousands of distant planets need to be reconsidered. The universe may contain far more rocky super-Earths dressed in gas than current models suggest. Which is, depending on your perspective, either a profound revision of our understanding of planetary formation, or confirmation that the universe has been quietly doing something different to what we put in the textbook.

Either way, it bears looking into.

And this is precisely where the James Webb Space Telescope enters the story — because JWST has, in the past year alone, demonstrated rather forcefully that Uranus still has things to show us.

In February 2025, a team led by Dr. Maryame El Moutamid of the Southwest Research Institute pointed Webb's Near-Infrared Camera at the Uranian system and took ten forty-minute exposures. When they examined the results, there was a small object — about ten kilometres across — orbiting quietly between two already-known moons, Ophelia and Bianca, at roughly 56,000 kilometres from the planet's centre.

A moon. Previously unknown. Sitting right there in the inner system, invisible to every instrument previously aimed at it.

It has been provisionally designated S/2025 U1. It awaits an official name from the International Astronomical Union, which will almost certainly be Shakespearean. The team has noted they are, and I quote, "getting a lot of culture" trying to decide what to call it.

This brings Uranus's total moon count to twenty-nine — which, I think you'll agree, is a very respectable number for a planet people have historically struggled to take seriously. Yours is doing just fine.

The discovery of S/2025 U1 illustrates precisely why the Morf and Helled paper ends with such urgency about what comes next. Because both findings — a hidden moon and a potentially rocky interior — point to the same conclusion: what we know about Uranus fits on a single six-hour receipt, and it is well past time we went back.

The Planetary Science Decadal Survey — the document by which the scientific community formally tells NASA what it considers most important — named a Uranus Orbiter and Probe its highest-priority flagship mission. Above everything

else. A spacecraft that would orbit Uranus for years, map its gravitational field with precision sufficient to finally break what the paper calls "compositional degeneracy" — the frustrating fact that a rocky Uranus and an icy Uranus produce nearly identical signatures from a distance.

Current projections suggest a launch window around 2031, a Jupiter gravity assist, and arrival somewhere in the early 2040s. Thirteen years of travel. To answer a question we should arguably have gone back to answer sometime around 1987.

As of today, the mission has not been formally approved or funded.

The planet, meanwhile, continues its tilted, heatless, magnificently strange orbit. Entirely unbothered. Entirely unaudited.

Exactly as the Handbook predicted.

Well, my fellow victims of institutional momentum, we've reached the end of another quantum misclassification. Today we've learned that in the multiverse of planetary science, every ice giant exists in a superposition of icy and rocky until someone in Zürich runs an agnostic algorithm and declines to assume the answer in advance.

We've discovered that forty years of textbook confidence can rest, quite comfortably, on six hours of data from a spacecraft with the computational resources of a slightly jet-lagged digital watch — and that the universe is under no obligation to correct us until it feels like it. Which appears to be now.

I suspect somewhere in the quantum foam of reality there is a version of this story where Uranus received a follow-up mission in 1990, we sorted all of this out decades ago, and Quantum Improbability Solutions processes its interplanetary expense reports within a standard thirty-day window. In that universe, Finance is considerably less stressed, and Philippa the intern has moved on to something more straightforward, like auditing a black hole.

But in this universe, we are still waiting. The Uranus Orbiter and Probe sits at the top of the scientific priority list, formally recommended, not yet funded, not yet built, not yet launched. The compositional degeneracy remains unbroken. The seventh planet keeps its secrets with the serene composure of something that has been doing this for four and a half billion years and has absolutely no interest in our timeline.

There is something quietly instructive in that. Science at its best is not the

confident announcement of settled answers. It is the willingness to look at a forty-year-old file, read it carefully, and conclude — with rigour, with method, with an agnostic algorithm and a very good telescope — that the original report may have been incomplete. That what we called ice might be rock. That what we called known might be, in the best possible way, still open.

The universe handed us a planet. We visited it once, briefly, with equipment that was already a decade old at the time. We did our best. And now, slowly, we are doing better.

Want to explore more of the cosmically unresolved? Visit us at multiverseemployeehandbook.com where you'll find science deep dives, episode extras, and our latest blog series: "Planets We Were Fairly Sure About Until We Weren't: A Retrospective."

If you've enjoyed today's compositionally ambiguous adventure, share it with a fellow curious mind — perhaps someone who has ever confidently labelled something enormous and later had cause to reconsider. Spread our signal like ionic water through a superionic mantle — which is, as it turns out, exactly how magnetic fields are made.

This is your quantum-coherent correspondent, reminding you that in the multiverse of planetary science, we are all just temporary models awaiting better gravitational data.

And somewhere beyond the heliosphere, travelling at seventeen kilometres per second toward the permanent dark, Voyager 2 continues its drift into interstellar space — still transmitting, still technically employed, and entirely unaware that Finance has finally, after four decades, closed the file.

The expense report has been approved.

The planet remains unexplained.

We'll call that progress.