Overlapping voices:
"Scientists perplexed by mysterious alien spacecraft…"
"In October 2017, astronomers saw a faint point of light moving across the sky…"
"Mysterious object…"
"Is 'Oumuamua an alien spaceship?..."
"The first known interstellar object to visit our Solar System…"
"... more about interstellar …"
"... 'Oumuamua! …"

Narrator: This small rock had astronomers spinning with excitement. It was the first interstellar visitor to the Solar System that we had ever noticed — but it didn't fit neatly into any of our categories for space rocks: it didn't look like one of the asteroids or exactly like one of the comets that float through our Solar System. At first, no one knew what it was. The astronomers who discovered it called it the "first distant messenger" — in Hawai'ian, it was named 'Oumuamua.

My name is Ali Boston, and together with my teammates, Max Braun, Annika Essmann, and Ivana Kurecic, I was eager to learn more about it.

Scientists only had a few months to observe this visitor before it left us forever, so the race was on to learn as much as possible about it — but was it enough? Was it enough to determine what exactly this object is? Was it enough to know where it comes from? Was it enough to attract funding for research projects? And does it even matter if we know what it is? ... Why should we research something that we can never know the answer to? That was the question that inspired us to tell you the story of 'Oumuamua in this podcast episode.

Oli Hainaut: I have a very old friend and colleague and collaborator called Karen, Karen Meech. She works in Hawai'i, which is a very big observatory there.

Narrator: This is Oli Hainaut; he is a researcher at the European Southern Observatory and he was one of the first people to hear about and investigate 'Oumuamua.

Oli Hainaut: On the day, on the evening, I received a mail that was saying "Urgent, urgent — call me immediately! Important discovery; need immediate follow-up; the weather is crappy on Mauna Kea, we will need the VLT." And… when I received the mail, I thought — okay, this looks serious. She is usually not using that much superlatives. So the fact that, even through the e-mail, she was obviously bouncing up and down at this… So, yeah, I was excited… Then I called and I realized: oh my god, this is not the usual comet or the usual… This is something new. This is new, uncharted territory. We've never seen that before. And it became really very quickly evident that this was an object from outside the Solar System — first time that we see something entering the Solar System. So, that was really exciting.

Narrator: But it wasn't just Oli and Karen who observed this new object. They sent requests to other observatories around the world to use their telescopes. They did this to try and gather as much data as they could until the object moved out of sight. In fact, they only had a few months to do it.

Oli Hainaut: And it could not wait. I would say — this object was probably one of the dataset that has been analyzed really to the max, every photon was used. Now it's gone. We lost it in January last year, 'cause even pushing Hubble Space Telescope to its limit, we… well, we reached these limits. And we knew that we could not get one more datapoint. That was it, forever; it's gone!

Narrator: This object was also tumbling through space, which was—

Oli Hainaut: —not uncommon, especially for smaller objects. We know many asteroids that are tumbling, we know many comets that are tumbling, so it's not… it's not a complete surprise. It's just additional complexity.

Narrator: It also seemed to be rather elongated — shaped like a cigar, its one dimension stretching about ten times longer than the other two.

Oli Hainaut: The elongation… is weird. That's something that we have never observed, and so… It's not impossible, we have some objects that have the same kind of elongation, but this was really extreme.

Narrator: When we asked Oli what might have caused this strange property, what he could tell us was—

Oli Hainaut: I don't know. We have hypotheses, and… The problem is that with the data we have, we cannot say if one of them is better than the other, and it is really possible that we are missing, we are lacking the real explanation, so… The short version is: I don't know. If you want, I can go fifteen minutes into each of the hypotheses, but really, the result is, at this stage: I don't know.

Narrator: Oli and his colleagues from observatories across the globe worked in shifts for weeks to gather as much data as possible and try to pin down the exact nature and origin of this exceptional object.

We wondered: was 'Oumuamua an unusual case in scientific research? Is it normal to have such a high level of uncertainty? Do scientists often work in a world of incomplete knowledge?

Oli Hainaut: That's usual. For most of the things I do, I don't have the final answer. I move toward it. And, most of the time, all I can do is say: okay, we had a series of hypotheses. And because of my measurements and because of my study, I can rule out some of these hypotheses — I know this is wrong, I know this does not work. And so, I constrain what is possible. And once you've constrained it enough, that's it — you got it. You can always improve it, but at some point, it's not interesting to go further, you know? If you measure something with the precision of one percent or one tenth of a percent or one thousandth of a percent, you don't learn anything more. What is really interesting is to get it right… at the percent level is probably a good description. If you know you got it right at the percent level, most likely, your hypothesis is the correct one.

Narrator: But we don't hear about science directly from scientists — we usually hear about it from journalists. We read about it in the news, we hear about it on the radio, we see stories unfold on television. How do journalists think about science?

Alina Schadwinkel: Science does give us answers. So, in a certain way, it gives us truth, but it's always in development.

Narrator: This is Alina Schadwinkel, a science journalist at Zeit Online.

Alina Schadwinkel: So, with every new information I got, I have to check if this truth that I found out is still valid — or do I maybe need to do some adjustments to it. So I would think there's always a certain grade of uncertainty.

Narrator: But as soon as she heard about 'Oumuamua, she immediately knew that this case was perfect for further investigation.

Alina Schadwinkel: We get the news that there is an unknown object, from outer space. An object that's weirdly shaped, um... odd colored, does stuff nothing else we know of has done so far. So, that's kind of intriguing, right? And it's interesting, and it's exciting. At the same time, all the scientists involved cannot give the answers. And they know — we do not have enough data to actually get all the answers to all the questions that we just got, as soon as we saw this object. And then you've got scientists with a reputation claiming, or at least proposing, that it could be an alien spacecraft. And this combination — something from outer space, something we've never seen, with the keyword 'alien spacecraft' — it's just a perfect mixture for… Um, maybe a sci-fi story? But also a science story. So yes, we just had to do something on it.

Narrator: Alina told us that when journalists report on scientific discoveries like 'Oumuamua, they balance between introducing their readers to new and exciting topics and upholding their professional responsibility to communicate the latest findings in science.

Interestingly, she sees handling this kind of uncertainty around scientific facts an important part of her job. To explain that, she told us about another topic she reported on, vitamin D.

Alina Schadwinkel: I do not only report on astrophysics or astronomy topics; I also sometimes write about health topics. And… if you, for example, I don't know, it seems random now, but if you talk about vitamin D… And you need vitamin D to feel, um… Should you take vitamin D during wintertime, in order to be happier, healthier, what[so]ever? Because your body is missing it if there's not enough sun. I've been doing this job for ten years now, and within those ten years, I don't know how many hundreds of studies there have been published on this topic. And sometimes they say: yes, you have to take vitamin D — others say: no, you don't. And so, it's my job to be open-minded and ask this question every once in a while and check what… what's the state of science right now. What does it tell me right now?

Narrator: And what does this look like in practice? Alina told us that, when writing articles, her and her colleagues always try to be transparent. They provide direct links to the studies they employ, and they try to find weaknesses and counterarguments to a certain position. In short, they evaluate the material in the most balanced way that they can, and they try to show readers how they arrive at certain conclusions.

So, let's take a break here. We learned from Oli that scientists are always confronted with uncertainty because it's a usual part of science, and Alina told us that journalists have to find ways to handle this uncertainty when communicating scientific findings to the public.

But then... We had another question: how do you get someone to buy into something that isn't certain? Scientific knowledge doesn't come for free. So how do you get someone with decision-making power to see the value of ever-evolving scientific work — and to actually fund it?

Andy Williams: It's a problem for ground-based astronomy in general, that it's not often at the forefront of people's minds...

Narrator: This is Andy Williams, the Institutional Relations Officer at the European Southern Observatory — the same scientific institution where Oli does his research.

Andy Williams: I mean, we're not directly… curing cancer, or… you know, solving world peace or anything. So it's, uh… The benefits of astronomy are distant, in a way.

Narrator: There's one issue he faces when he tries to relay the importance of astronomy research to funding agencies and politicians.

Andy Williams: We've been doing… with CERN and the other big organizations… always sort of… writing position papers to the European Union and saying: okay, great that you have these missions, but we should have fundamental science for its own sake — disconnected from any political agenda or, you know, a particular topic of interest of the day or social problem. And… So, I think that maybe, this is a way just to, sort of, emphasize the importance of fundamental science. But, of course, you're always led back to justifying it in non-fundamental-science terms, like: hey, well, you know, we'll discover some interesting industrial applications later down, or… To some extent, you have to justify what you're doing and why.

Narrator: Part of Andy's job is working on asteroid defenses — that is, looking out for asteroids that might one day threaten Earth with a devastating collision.

This is one area of astronomy that does have a clear, direct value to society — in Andy's own words, it's "literally saving the planet." But he also pointed out that sometimes we just don't know how important a discovery might be in the future.

Andy Williams: One of the people that realized that electricity as a force, the force of electricity, and the force of magnetism were essentially the same force that could be described mathematically and… You know, at the time, this scientist back in — was it, like, 1860 or something? — he probably didn't think about 'Ah!; this is a good thing to work on because it's going to enable, you know, phone communications and radio, and modern electronics and, basically, modern society.' He probably didn't think about that at all. He just: 'Ah, this is pretty cool, a nice mathematical thing that it's part of the same force.' And yeah, a hundred years later, because of Maxwell's equations, every single electronic device that we have is dependent on that finding.

Narrator: Then… Could all these approaches to scientific uncertainty, like in the case of 'Oumuamua, be vehicles to establish some idea of certainty?

In their daily work, scientists continuously try to improve their hypotheses to find the best answer. The balanced approach of science journalists helps them share news of scientific facts that may still be debated or controversial within the scientific community. But, as Andy told us, the pressure to get their work recognized and funded can sometimes lead scientists to search for the stories in their research that are certain, applicable, and of general interest.

Maybe we just have to accept uncertainty as part of the journey to ultimate certainty. Science is part of this journey.

But don't we usually expect more from science? Don't we expect science to give us answers and to be able to tell us how the world works? To put it more generally, with all this uncertainty, don't we also need criteria for what is certain? For what we think of as objectively true?

To consider this question, let's take one step back, go back in time — and have a deep sip of coffee.

Café sounds.

Samuel Pedziwiatr: The Vienna Circle claimed scientific statements are meaningful if and only if we can come up with a way of checking whether or not they're true through observations.

Narrator: Samuel Pedziwiatr is a doctoral researcher studying the philosophy of science at the Munich Center for Technology in Society. We're meeting at a café — just like those eager thinkers of the early 20th century who defined criteria for what is truly scientific, and therefore certain.

Samuel Pedziwiatr: They were all based in the same town, same university and then would meet for coffee after classes and continued their discussions.

These thinkers started discussing new theories that were being proposed in physics, for example; so, this was the time in which Albert Einstein developed his theory of relativity, in which quantum physics was coming up, tons of developments within physics that were shaking the foundations of the classical-mechanical worldview.

Narrator: Samuel talked to us about exactly this topic — how the idea of scientific certainty really came to be. So we asked him: when are facts actually true? When are they certain?

Samuel Pedziwiatr: So, there used to be positions on this question that were fairly simple. They tried to give you one criteria for this.

Narrator: The criteria proposed by the Vienna Circle that Samuel talks about is known as verifiability. It claims that science is based on observable phenomena and evidence, from which we derive our hypotheses and theories. However, this isn’t as easy as it sounds in practice — the information we have isn’t always full or perfect.

Researchers observing ‘Oumuamua combed through a myriad of hypotheses — is it an asteroid, is it a comet, is it a piece of an alien spacecraft floating unattended through space? So, in practice, this criterion isn’t enough, because it allows for many plausible explanations for one phenomenon.

This is why philosophers came up with other criteria.

Samuel Pedziwiatr: So, think of Karl Popper the philosopher of science who famously said that what makes a scientific theory is its falsifiability.

Narrator: This criteria tried to establish a clear delineation between what is genuine science and what we call pseudoscience.

Samuel Pedziwiatr: What science does is it makes bold conjectures. And what scientists do is — they make observations, and the conjecture holds so long as there’s been no counterevidence; so the idea that science is speculative, in a way.

Narrator: But, wait a minute. Does that mean that science is always uncertain? Can science never provide us with certainty? Do we have to re-evaluate all scientific facts that have been established up until now, over and over again?

Back to the ‘Oumuamua case; we don’t fully know what ‘Oumuamua is, but based on our observations, we have a pretty good idea of its dimensions, its color, and how it moved while we could see it. The process of building upon what we already know is standard practice in science — or just ‘normal science’, a term coined by philosopher Thomas Kuhn.
Max

Samuel Pedziwiatr: Thomas Kuhn, the philosopher of science, termed this ‘normal science’. So, the idea that we have a certain research program or paradigm and, within this program, we can make new findings that kind of fit within the general picture of the world.

Narrator: Could we apply this to the ‘Oumuamua case? We’ve seen scientists observing the phenomenon and applying the tools and methods available within the scientific framework of astronomy to reach conclusions about it.

Samuel Pedziwiatr: ‘Oumuama so far seems to fit very well with the knowledge that we have of the universe, it’s just not clear what exactly the object is.”

Narrator: So where does this leave us? When we started researching this topic, we wanted to know was why we should study something that we will never know the answer to? After talking to Oli, Alina, Andy, and Samuel, what we really learned was that it doesn’t matter! The question is not whether we should research something that is uncertain; the question is how do we handle this all this uncertainty. And, to do so, maybe we have to break down this distinction between certainty and uncertainty. Maybe we have to get comfortable with uncertainty.

Alina Schadwinkel: In December, the first bigger follow-up study was published in the science magazine Nature Astronomy and, after this first study, others followed — and kept coming, basically until now. I mean, in the beginning of this July, we had another study that was published in a scientific magazine, a peer-reviewed one. And, um, yeah…

Oli Hainaut: We never know. We know what we don't know, but to get to the ultimate answer takes time. This object — we are not sure what it is — but, the fact that it looks like one of our comets suggests that we have understood how comets form and, most likely, they are forming the same way in other solar systems. That's good.

Andy Williams: It's… just think about: the object is here, and now it's gone, and it's going off, and where's it gonna go? And it's going really fast, and it's gonna leave the Solar System eventually, overtake the Voyager probes in the distance from the Earth, eventually… So, it's just… you know, weird to think about this object going back into interstellar space. You've seen a glimpse of it… And then we never will again. And, um… Probably, people studying physics and astronomy in the next couple of years will open up their textbooks and… they will know that they lived during the time of the first interstellar object confirmed was discovered. So, I think that's pretty cool.

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