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[MUSIC INTRO]

George Lee: Hi everyone and welcome to Talks at GS. I'm George Lee, the Co-Chief Information Officer at Goldman Sachs. I'm excited to welcome Avi Loeb, the Frank B. Baird Jr. Professor of Science at Harvard University's Department of Astronomy and the author of *Extraterrestrial: The First Sign of Intelligent Life Beyond Earth*. Professor Loeb, thank you so much for joining us.

Avi Loeb: Thanks for having me. It's a great pleasure.

George Lee: I suppose we should start with a seminal date in your own personal history, and perhaps the history of man, which is October 19th, 2017. Perhaps you can share with our audience what happened on that day.

Avi Loeb: Yeah, that was the day when the telescope in Hawaii called the Pan-STARRS discovered the first object from outside the solar system in the vicinity of Earth. And at first, astronomers thought it must be like the rocks we have seen before from the solar system. Except this rock was moving too fast to be bound to the sun. And therefore, it must have come from another star. But then as we gathered more data, it didn't look like anything we had seen before. It was definitely not a comet because there was no gas or dust surrounding it. And in fact, the Spitzer Space Telescope looked very deeply around it put very tight limits on carbon-based molecules in its vicinity. So, it was definitely not a comet.

And then people said, well, maybe it's an asteroid, just a rock. A bare rock without ice so that nothing evaporates from it. The problem with that was that it exhibited an excess push away from the sun. And since there was no rocket effect from evaporating gases, the only explanation I could give for that push, in addition to the force of gravity acting on it of course, was that it's due to the reflection of sunlight. But in order for that to be effective, the object had to be very thin, sort of like a sail. And in fact, as it was tumbling, the most appropriate shape or the best model of the reflected light was that of a pancake, a flat shape. So, I suggested maybe it's a very thin object that was manufactured by an extraterrestrial

civilization.

And of course, there was a lot of push back to that. Basically, nature doesn't make such objects. The question is who produced Oumuamua.

George Lee: Exactly. The object was unusual by its shape. It was tumbling in an unusual way. It had an accelerating velocity and deviated from its expected trajectory. And yet, despite all of those uncommon features, many scientific observers had a bias to fitting it into a pattern of other naturally occurring phenomena. Talk a little bit about that.

Avi Loeb: Right. So, of course the scientific mainstream very much wanted it to be a natural object. And there were four suggestions in the years that elapsed since my paper was written. There were four suggestions for natural origin. But all of them contemplated something that we've never seen before such as a hydrogen iceberg. A chunk of frozen hydrogen. We'd never seen anything like it in space. Has to be the size of a football field. The idea was that as hydrogen evaporates it's transparent, so you can't see the cometary tail. The problem with this explanation is such a hydrogen iceberg would not survive the journey through interstellar space. We showed it in a scientific paper, it would evaporate very quickly as a result of absorbing starlight.

There was a suggestion maybe it's a nitrogen iceberg. And there, the mass budget is a problem because even if you chip off all the solid nitrogen that you find on the surface of Pluto-like planets around other stars, there is just not enough chips that you would get to explain a large enough population of nitrogen icebergs to explain the discovery of Oumuamua, this object from 2017.

Then there was a suggestion maybe it's a cloud of dust particles very loosely bound, sort of like a dust bunny that you find at home, 100 times less dense than air. And the problem with that is when it gets close to the sun it will get heated by hundreds of degrees and would lose its integrity, would not be able to maintain its material strength.

So, all of these suggestions contemplate something that we've never seen before. And yet, the academic mainstream preferred to stick with those rather than contemplate the other possibility that it may have been artificial in origin, which I think is as plausible as this, and perhaps even more.

George Lee: Reminds me of a paraphrase that you offer in your book, and I think it was Galileo that said, "Evidence doesn't care about approval," which seems to be something that's meaningful to you philosophically in the way that you approach your science.

Avi Loeb: Yes. And in fact, this morning I submitted a new article to *Scientific American* that was just accepted a couple of hours ago. And the title of this essay was "Why Is Anomalous Evidence So Unpopular?" And what I mean by that is if we look a century back, quantum mechanics was discovered completely unexpectedly. And in fact, Albert Einstein resisted the fundamental principles of quantum mechanics and argued that it cannot have spooky action at a distance. And he was wrong. We now have experiments that demonstrate that he was wrong.

And quantum mechanics was sort of like a bone stuck in the--

George Lee: Throat, right?

Avi Loeb: The throat of physicists for a century now. And it was not expected. It's still a major challenge for us to understand its meaning. And it was forced upon us by experimental data, evidence.

And so, the fundamental lesson from that is we should pay attention to evidence rather than to our prejudice. You know? There used to be people that were very sure about their notion. They were the philosophers during the days of Galileo. And they said, "We don't need to look through your telescope," they said to Galileo. "We know that the sun moves around the Earth." And they put him in house arrest. Now, what did they accomplish by that? They just maintained their ignorance. And the Earth continued to move around the sun. It didn't change.

I mean, if we don't look through our windows and say, "We don't have neighbors. Just give me extraordinary evidence before I would be willing to discuss the possibility that I'm not the smartest kid on the block." If you just say, "I need extraordinary evidence," that doesn't take away the neighbors. I mean, they exist out there irrespective of whether you look through your window or not.

And my point is, reality doesn't really care how we ignore it. Ignoring it maintains our ignorance. And that, unfortunately, would come to haunt us. Because you don't get a realistic

assessment of where you are, of your environment, unless you collect all the evidence possible.

So, my point is evidence is always good. And I just cannot understand how that if you just look online right now, you see a lot of scientists resisting the Pentagon report to Congress stating that there is clear evidence that there are some unidentified aerial phenomena. And we don't know what they are.

And so, the scientists say, "Ah, forget about it. Business as usual." You just read the tweets of, not just scientists, but popularizers of science, like Neil deGrasse Tyson. And they just dismiss it, ridicule it, and get away. And the point is that leaves the public with a lot of room for speculation. And it's an unhealthy situation.

What the scientists should do is collect more evidence. Here is some intriguing anomaly that we observed. Let's find out what it's all about. Even if it's as a result of some natural phenomena that the atmosphere has that we didn't anticipate, then we learned something new.

George Lee: Fascinating. Yeah. In certain theoretical domains, absence of evidence is a feature, not a bug. But we could go on for that for quite a while.

Let's return to Oumuamua for a second and then go to the Pentagon. You've posited that a likely explanation of the shape of the nature of the object, of its trajectory, et cetera, suggests that it is a light sail. Talk a little bit about what such an object would be, what the possible function of such an object could be.

Avi Loeb: Right. So, originally, I concluded that in order for light bouncing off this object to push it, to be effective in pushing it, it has to be very thin and sort of like a sail on a boat. And I thought maybe it's a light sail. But after the UAP report came out, I had second thoughts. I thought, well, you can have a thin object for a completely different purpose.

So, in the case of Oumuamua, you can imagine it being a receiver that collected data or information from probes that are on Earth. That's one possibility. All you can say from the excess push that it exhibited is that the structure was thin. Thin enough for it to have a large area for its mass and get pushed by reflecting sunlight. But it doesn't mean that its purpose was to serve as a light sail. It could be just a structure that

serves as a transmitter, as a receiver, or maybe collecting sunlight to power the electronics in it. Who knows?

The point is we didn't get enough data because everyone thought it's a rock. And next time around, we better get as much data as possible in order to figure out the nature of such an object. And even if it's a nitrogen iceberg, a chunk of frozen nitrogen, we will learn something new because we will learn that there is somewhere, a nursery of such chunks of nitrogen that is far more productive than we could have imagined before. But that will be a completely new revelation to astronomers.

George Lee: Let's turn to the Pentagon UAP report in which the Pentagon released some findings, some very scanty findings about 18 episodes that were basically inexplicable based on current science and understanding. And so, in some ways this marks an opening of the kimono, because this is the first time that there's been a real formal report. On the other hand, it's quite inconclusive. But does it hold the prospect for you of more open data, more scientific analysis possible on these phenomena?

Avi Loeb: Well, the beauty of science is that it's based on evidence. And anyone can collect the evidence. The sky is not classified. So, my point is, the sensors that were used to collect the data are classified because they're used to protect the sky over the US. And we don't want our adversaries to be aware of the kind of technologies we use for that purpose. And that's why a lot of the data is not public.

But scientists can, in principle, conduct experiments where they deploy state-of-the-art cameras connected to wide field telescopes that basically monitor the sky and feed the data into computer systems that preserve only the transient features that are of interest. And we can have an open data set that will be analyzed by scientists.

And so, my point is that this subject of UAP is sufficiently intriguing for it to move from the talking points of politicians, military personnel, or national security advisors to the realm of science. I think we are now at a turning point where it should go and be a subject of scientific inquiry. And scientific inquiry is open to the public. It should be based on open data and a transparent analysis. And we will all know.

I mean, it's actually the duty of science to clear up the fog, just as it was the duty of science and technology to develop a

vaccine to COVID-19.

George Lee: Yeah. One of the anomalies that I think is a very explainable anomaly of the data that was observed and reported in the Pentagon report is that the vast majority of observations were in and around US military facilities. Now, part of that could be the presence of a lot of sensors there and activity there. The other part could be that, in fact, they're not extraterrestrial in nature, but rather they're unknown objects sponsored by China or Russia or others that have capabilities we're not aware of observing us there. How do you read those anomalies or that paradox?

Avi Loeb: Well, I think it's probably because we are monitoring the sky over these military facilities much more often. If this is a universal phenomenon, it should also occur in other countries. And it should also occur in other places. It's just that we don't have attention dedicated to the sky in those other places.

But the point is that some of the objects are definitely real. That was stated. Because they were detected by multiple sensors, infrared detectors, optical cameras, and many independent people identifying the same object doing the same thing. And here you have pilots that are extremely reliable in terms of what they report. And a number of them reported the same thing. And on top of that, you have infrared and optical cameras and who knows what else that is not being released publicly. And yet, you find people that are ridiculing the evidence, basically saying, "They don't know what they're talking about."

George Lee: Speaking of evidence gathering, you're working with a mutual friend, actually, Yuri Milner around the Breakthrough Starshot Initiative. Talk a little bit about that challenge, where you stand on it today.

Avi Loeb: Right. So, in May 2015, a black limousine parked in front of the Center for Astrophysics at Harvard. And out of it came Yuri Milner. He entered my office. Sat on the sofa in front of me. And asked me whether I'm willing to lead a project whose goal is to visit the nearest star, Proxima Centauri, within his lifetime. And that meant getting there within 20 years or so, because he is the same age as I am.

And I told him I need to think about it for six months because it would require a spacecraft that moves at a fifth of the speed of light, which is 1,000 times faster than chemical rockets. And

so, after six months I suggested to him that the only technology possible is a light sail pushed by a very powerful laser. And then we came up with a concept where you have a sail that is weighing roughly a gram that carries electronics like a camera, navigation device, communication device. And is being pushed by 100 gigawatt laser for a few minutes. And it reaches a fifth of the speed of light across a distance that is five times the distance to the moon. And then coasts and gets to Proxima Centauri within 20 years. And this was named the Starshot Initiative and was announced in the company of Stephen Hawking in April 2016. And we're currently working on the main challenges of this technology, which is the photon engine, this laser beam. The sail, choosing the right materials and structure for it. And then the communication between the sail and Earth at the distance of four lightyears, which is very challenging.

George Lee: Great. Well, you know, we're out of time. And Professor Loeb, thank you for showing up and giving us such an illuminating talk.

Avi Loeb: Thanks for inviting me. It was a great pleasure.