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Avi Loeb photographed at his home in Massachusetts. Michael Marcelle for The New York Times

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By Seth Fletcher
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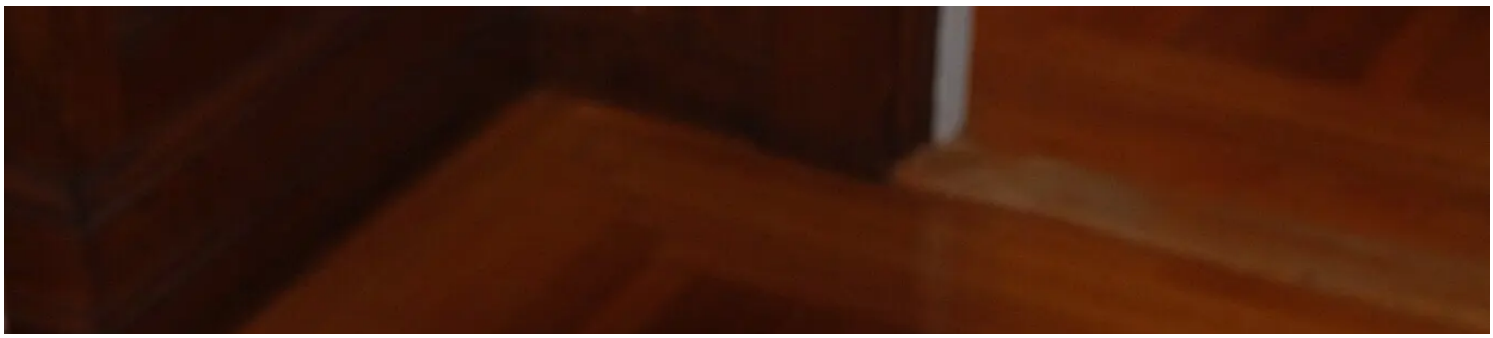
On Oct. 19, 2017, a telescope in Maui detected something that had entered our solar system from elsewhere in the galaxy. Astronomers named it Oumuamua, Hawaiian for "scout" or "messenger," because it was the first interstellar object they had ever recorded — the only known traveler to have crossed the vast distance between another star system and our own. Where it came from was only part of its mystery. Oumuamua fit none of the well-understood astronomical categories. If it was a rock — an asteroid — it was an extremely strange one. Researchers estimated that it was at least the length of a football field; its shape was hard to determine, but it seemed to be long and thin, like a cigar. "No known objects in the Solar System have such extreme dimensions," wrote the group of astronomers who discovered the object.

The more that scientists studied Oumuamua, the weirder it seemed. Analysis of its trajectory showed that, in the weeks before its detection, Oumuamua sped up as it approached the sun, and its acceleration couldn't be explained by the sun's gravity alone. That extra kick would be normal for a comet. Comets are rocky snowballs, and when they get close to the sun, ice within them turns to vapor, releasing gas and giving them a boost. But Oumuamua lacked a comet's signature tail, and none of the telescopes that observed it detected water vapor, carbon monoxide or other telltale signs of sublimating ice. Scientists started inventing wild ideas to explain Oumuamua's observed characteristics, things like hydrogen icebergs and gigantic dust bunnies less dense than air. They were reaching.

Avi Loeb, a theoretical astrophysicist at Harvard University, followed the news about Oumuamua for months. Then one morning in the fall of 2018, he had an idea. For Oumuamua to accelerate as it did, something had to have given it a push. What if that thing was sunlight? For years, scientists have theorized that sunlight, properly captured in the vacuum of space, could exert enough force to boost an object to incredible speeds. Nature doesn't make anything that harnesses light quite so well, but Loeb thought he might have the answer. "One possibility," he and a postdoctoral researcher wrote in a paper, "is that Oumuamua is a light sail." Light sails have long been proposed as a method of space travel, though as of now they are mostly hypothetical. (Japan's space agency successfully tested one in 2010.) The idea is that a superthin metallic sheet could catch sunlight the way a ship's sail catches wind, propelling a craft through space. Loeb's hypothesis could explain some of Oumuamua's strange behavior, but if he was right, it meant the object was not a natural phenomenon. It was an extraterrestrial artifact.

Loeb was known in the scientific community for his openness to unconventional ideas, but he was an establishment figure who had published hundreds of papers over three decades on traditional astronomical subjects. He had a reputation for finding creative ways to subject hard-to-study phenomena to the rigors of the scientific method. "Avi is very good at picking problems to work on that have testable results," Robert Wilson, a Nobel Prize winner in physics, told The Times in 2014. By the time Loeb published his Oumuamua hypothesis, he had collected a stack of impressive titles at Harvard: chairman of the astronomy department, director of the Institute for Theory and Computation, director of the Black Hole Initiative. Loeb could not have been any more mainstream or credentialed, yet here he was, saying that maybe an alien spaceship had arrived. It only took a few days for camera crews to show up at his house.

Since then, Loeb has made extraterrestrial life his primary research focus. In thousands of news media appearances and near-daily online essays, he has called for scientists to seriously consider the possibility that aliens, or hardware they built, have visited our planet. He says scientists have a responsibility to investigate astronomical oddities like Oumuamua as well as reported sightings of U.F.O.s, which have recently been rebranded as U.A.P., for unidentified anomalous phenomena. "Two-thirds of the American public believes there is extraterrestrial life, more than the 56 percent that believes in the God of the Bible," Loeb told me. Dismissing their questions as unworthy of consideration, he argues, is not a good way to earn back the trust of an American public that has become skeptical of science and scientists.



Loeb holds his 3-D printed model of Oumuamua. Michael Marcelle for The New York Times

In 2021, with funding from private donors, Loeb co-founded the Galileo Project, a research program at the Harvard-Smithsonian Center for Astrophysics dedicated to the search for alien technology near and on Earth. Its aim is to bring the scientific method to the realm of eyewitness testimonies, grainy Polaroids and shady former military guys who end every debate by saying "that's classified."

Loeb is far from alone in hypothesizing that the universe could be filled with life. In the past decade and a half, astronomers have found Earth-like planets around nearly every sunlike star they have observed. They now estimate that the Milky Way is home to 100 billion planets, a couple billion of which are similar to our own. It's not particularly controversial to posit that some of these planets may be home to civilizations more intelligent than we are. Because microbial life emerged soon after Earth cooled and most star systems are billions of years older than our sun, it's reasonable to imagine that life in other star systems could have begun evolving eons before the first protobiological goo formed here. Where Loeb departs from almost all of his colleagues is in thinking that aliens on other planets could have already made their way to us.

Loeb maintains that looking for alien spacecraft is less speculative than a lot of mainstream science. His go-to foil is fundamental physics. Since the discovery of the Higgs boson particle more than a decade ago, the multibillion-dollar particle colliders that physicists built to find postulated forces and fields have mostly come up empty, and still, Loeb says, scientists believe with quasi-religious faith that if they just build even bigger colliders, their theories will be redeemed. He reserves most of his scorn for string theorists, who, after assembling a theory of nature based on tiny hypothetical entities, have spent decades postulating extra dimensions and parallel universes trying to make the math work. These same people, Loeb claims, refuse to consider anomalies like unexplainable interstellar objects. Out of fear or intellectual rigidity, these scientists have retreated into their own minds while ignoring strange phenomena in the real world.

Loeb's outspokenness about extraterrestrial life has made him the most famous practicing astronomer in the country. His 2021 book about Oumuamua, "Extraterrestrial," debuted on The Times's nonfiction best-seller list; a new book, "Interstellar," which presents contact with extraterrestrials as the next big step on humankind's evolutionary ladder, comes out this month. He has become the sort of academic star who gets invited to Richard Branson's private island and other exclusive gatherings of rich and powerful patrons interested in heterodox ideas. He is being followed by a Netflix documentary crew.

Yet many in his own field consider Loeb a pariah. His more polite critics say that he is distracting from the horizon-expanding discoveries astronomers are making with new instruments like the James Webb Space Telescope. The more outspoken ones accuse Loeb of abandoning the scientific method and misleading the public in pursuit of fame. Loeb says he gets attacked from both sides: by his colleagues in the mainstream and by the U.A.P. "crazies" who get upset when he dismisses their most ridiculous theories by pointing to the laws of physics. He sometimes talks about himself as a martyr. "I'm putting my body on the barbed wire," he told me.

One morning in January, I visited Loeb at his three-story clapboard house in the wealthy, historic suburb Lexington, Mass. He was working from home but wearing a tailored suit, as he does most days. At 61, he is energetic and trim from a low-carb diet and a morning jogging routine that he often mentions in his emails and essays — the predawn ritual where the day's ideas arrive. He offered me a bowl of blueberries and an enormous cup of coffee, which he says he doesn't drink because it would amplify his already manic pace of speaking. After talking for a couple of hours in a tidy front sitting room, he drove us to see an installation built to fulfill one of the Galileo Project's main goals: getting a high-resolution image of a U.A.P.

Students and volunteers assembled the Galileo Project's first "observatory" on the roof of the Harvard-Smithsonian Center for Astrophysics, but they recently moved it to university-owned land in the Boston suburbs. He asked me not to identify the location because he was worried about "hackers" disrupting or stealing the equipment. After a while, we pulled into a wooded area, parked by a stand of conifers and walked across a snowy lawn to what looked like a high-tech Boy Scout weather station. Metal antennas stood on tripods. Eight infrared cameras were embedded within a synthetic dome the size of a charcoal grill, staring at the sky. There were visible-light cameras, ultrasensitive microphones, spectrum analyzers and other sensors, including a Geiger counter, all of it connected to the cloud, where machine-learning algorithms would scan the data for anything unusual. It was, in a sense, an elaborate wildlife camera for aliens.

Astronomers have been conducting the Search for Extraterrestrial Intelligence (SETI) since 1960, using telescopes to watch for signals from space. NASA scientists are drawing up plans to look for primitive life on certain moons of Jupiter and Saturn. Astrobiologists talk about searching for artificial light or industrial pollution on planets orbiting other stars. None of these endeavors carry stigma because they assume that, if life is out there, it's out *there*. The boundary between mainstream astrobiology and the fringe is the idea that extraterrestrials have crossed the abyss of space to come see us — and that the governments of the world have somehow kept the evidence a secret. But governments do keep secrets, and secrecy has long fueled conspiratorial thinking about aliens and U.A.P.s. Leaked videos of unidentified objects taken by cameras on fighter jets are hard to make sense of, in part because those cameras are classified. The idea behind Loeb's observatory is to start building a library of unclassified data that scientists can use to study U.A.P.s.

Loeb told me that he has always had a speculative disposition. As a kid growing up on a farm in Israel, he had an uncomfortably hyperactive mind. "It was like flies buzzing around in a metal box, bumping up against the wall," he said. He wanted to be a philosopher or a writer, but compulsory military service led him to science. In the Israeli Defense Forces' elite Talpiot program for academically promising recruits, Loeb studied physics and mathematics while learning to drive tanks and jump out of planes. In graduate school he did

research on weaponizing electromagnetic fields and plasmas before moving to the United States for a postdoctoral position in astrophysics at the Institute for Advanced Study in Princeton. Starting at Harvard in the early 1990s, he published prolifically on subjects such as infant black holes, the large-scale structure of the cosmos and the universe's first stars.

In 2015, Yuri Milner, a billionaire Silicon Valley investor and philanthropist, showed up at Harvard hoping Loeb could figure out how to send a probe to another star during his lifetime. Loeb was game to try. A year later he was standing on top of One World Trade Center alongside Milner and Stephen Hawking announcing Breakthrough Starshot, a plan to attach tiny probes to micrometer-size sheets of reflective material — light sails — and blast them with ground-based lasers, propelling them to Alpha Centauri in a couple of decades. Breakthrough Starshot, which is still in an early research phase, was what got Loeb thinking seriously about the mechanics of interstellar travel.

Right around the same time that Oumuamua appeared in the sky, in a cosmic coincidence, the U.S. government started talking openly about U.A.P.s. It began on Dec. 16, 2017, with a story in The New York Times that revealed the existence of a shadowy military U.A.P. research program called the Advanced Aerospace Threat Identification Program. In an accompanying article, two Navy pilots described a mystifying 2004 encounter with a flying object off the coast of San Diego: an oval-shaped craft that appeared to hover 50 feet above the frothing ocean surface before bolting out of sight. More reported sightings of unidentified phenomena soon went public. In a 2019 Times article, Lt. Ryan Graves, a Navy pilot, described repeated encounters with unexplained aircraft off the East Coast of the United States. "These things would be out there all day," he said. Marco Rubio added language to the Intelligence Authorization Act of 2021 asking the Director of National Intelligence to submit a report to Congress on the subject.

The Princeton astrophysicist Edwin Turner, a close friend of Loeb's, says that during the first few years of this efflorescence of U.A.P. interest, they both watched with skeptical curiosity. "Our conversation about U.A.P. was very much along the lines of, Who knows, it's not obvious," he said. "It didn't seem plausible that there were extraterrestrials visiting the earth." What made Turner think U.A.P.s were worth investigating, he said, was the report that the Office of the Director of National Intelligence delivered to Congress in June 2021. The nine-page document described the "threat posed by unidentified aerial phenomena," which included a "handful" of U.A.P. that "appeared to remain stationary in winds aloft, move against the wind, maneuver abruptly, or move at considerable speed, without discernible means of propulsion." Loeb came across an interview in which Bill Nelson, the NASA administrator and former U.S. senator from Florida, said that he saw classified material while serving in Congress that made the hair on the back of his neck stand up. "Now, I don't know how frequently the hair stands up on the back of Bill Nelson's neck," Loeb told me. "But to me it was intriguing."

If Loeb's mother had been around at that point, he said, she would have tried to dissuade him from his late-career turn toward alien hunting. "She would say, 'Why would you give up on everything you accomplished?'" Loeb has described his mother, Sara, as an "interrupted intellectual" whose family pulled her from college in Bulgaria to move to Israel upon its founding. When he and his two sisters were old enough, she continued her studies, and in Loeb's adolescent years she took him along to college philosophy classes. They were very close; until her death in 2019, they spoke on the phone nearly every day. "I sort of realized on a personal level that, up until that point, I tried to make everyone happy," he said. "After my parents passed away, I said: 'The hell with it, I'll focus on substance. I don't care how many people like me or not like me, I would just do what seems to me is the right thing to do.'" Criticism from other astronomers only hardened his commitment. "The more pushback that I got," he said, "the more appropriate it looked to me."

Mainstream scientists might have been distancing themselves, but Loeb was discovering a different world of allies, fans and patrons. The newly revealed government interest in U.A.P.s got wealthy people wondering how to invest in the search for alien life. That led them, naturally, to Loeb. "I started getting money without soliciting it," he told me. In May 2021, the Harvard astronomy-department administrator told Loeb that an anonymous donor had given him $200,000 in research funding. Within a few days, they determined that it came from a wealthy software engineer named Eugene Jhong. Loeb arranged a Zoom call with Jhong and got another $1 million. Around the same time, Frank Laukien, the chief executive of the scientific-instrument manufacturer Bruker, who had read Loeb's book "Extraterrestrial," showed up on his front porch in Lexington. Together they decided to establish the Galileo Project.

The observatory near Boston had been running for several months, and they were still training the machine-learning algorithms to identify birds, planes and other common airborne objects. The goal is to install up to 100 such observatories around the world; so far Loeb has obtained funding to install five more stations in the United States. While the dream is to get the first megapixel-quality photo of something anomalous, he says he expects almost everything these instruments detect to be mundane. "The Galileo Project is completely agnostic, has no expectations," he told me. I asked him how an experiment like this could ever deliver a convincing negative result. A

failure to photograph a U.A.P. would never convince a believer that there are no alien ships in the sky, only that the aliens were smart enough to avoid Loeb's camera trap. "If we search the sky for five years, 24/7, and see nothing unusual except for birds and drones and airplanes, and we do it at tens of different locations, maybe 100 locations," he said, "then we move on."

The week after Loeb showed me the observatory, I joined a planning meeting for another Galileo Project initiative — an effort to retrieve an unusual meteorite that had fallen to Earth. Several years ago, Amir Siraj, a Harvard undergraduate working with Loeb, identified a curious entry in a government meteor database: On Jan. 8, 2014, an object exploded near Papua New Guinea. Its orbit suggested an origin outside our solar system, though it was impossible to say for sure because the government satellites that detected it were classified. In 2022, after a lot of prodding from Loeb, the U.S. Space Command released a letter saying with "99.999 percent confidence" that the Papua New Guinea fireball was interstellar. The government also published the meteor's light curve, a graph of its brightness over time. From this, Loeb concluded that it had exploded so close to the Earth's surface that it must have been made of something much harder than normal meteors, maybe even an artificial alloy like stainless steel. Which made him wonder: What if it was an extraterrestrial probe? And could he find its remains?

If anything was left of this meteor, or extraterrestrial probe, it was scattered across the seafloor north of Papua New Guinea. When meteors burn up in the atmosphere, the molten remains condense into sand-grain-size orbs called spherules that cascade to earth like glitter. The logistics of searching for those spherules under several thousand feet of water were daunting, but there was reason to think it could be done. In 2018, scientists used remotely operated vehicles and a "magnetic rake" to find spherules from a meteor that had fallen off the coast of Washington. Encouraged by that project, Loeb and Siraj started thinking about going after the Papua New Guinea meteorite. Charles Hoskinson, a mathematician who made a fortune in cryptocurrency, heard Loeb talking about the meteor on a podcast and pledged $1.5 million for the search. To figure out the logistics, they hired EYOS Expeditions, the company that helped the director James Cameron dive to the Pacific Ocean's 36,000-foot-deep Mariana Trench. They planned to go to sea later in the spring.

Loeb ran the planning meeting on Zoom from his home office. He started by telling the group about a conversation he just had with Hoskinson, whose $1.5 million donation was, until that week, an undeposited promise. Loeb met with him two days earlier to get a final commitment. "It was quite nerve-racking," Loeb said. Hoskinson asked hard questions about their chances of success. The plan was to drag a magnet-studded sled along the seafloor to collect the spherules. But what if the remains weren't magnetic? Loeb explained that they would have nets attached to the sled to catch particles the magnets missed. Hoskinson was not reassured. Could they do better than nets? Could they dredge, or use some sort of sluicing device? To appease Hoskinson, Loeb agreed that the magnet-sled engineers would design a supplementary sluicing device. Loeb got the go-ahead; he told the group that the money would soon be transferred to the expedition's bank account. Still, Loeb seemed a little shaken by the difficulty of closing the deal. "Anyone who knows me knows that I'm task-oriented rather than promise-oriented," he said. It was as if he was only then internalizing the idea that private donors expect a return on their investment. "The nightmare scenario is that we go there and find only muck."

The first step in avoiding the nightmare scenario was to search the right area, and that would be difficult enough. The location data they had for the meteor came from military satellites that watch for incoming nuclear missiles. Every measurement on every instrument has some margin of error, which is why a huge amount of scientific work involves calibrating instruments and working with uncertainty. But the margin of error for the missile-spotting satellites was classified. If they relied solely on government data, they would be left searching 50 square miles with a magnetic sled smaller than a golf cart. Loeb told the group that he and Siraj thought they had found a way to shrink the search area using seismometer readings and a lot of math. Even so, Rob McCallum, the cheerful New Zealander who runs EYOS, later conceded to me that the hunt would be challenging. "The complexity lies in the fact that no one knows what it is we're looking for," he said. "We assume that it's a few shovels full of small black particulate, spread over a mile, two miles, 10 miles." The expedition would depend to an unusual degree on luck.

"Two-thirds of the American public believes there is extraterrestrial life, more than the 56 percent that believes in the God of the Bible," Loeb says. Michael Marcelle for The New York Times

Loeb's theory about Oumuamua — the baffling interstellar object that set him on his late-career course as an alien hunter — was always controversial among his colleagues, and not just because it invoked alien technology. Karen Meech, an astronomer at the University of Hawaii and the lead author on the Oumuamua discovery study, had a long list of complaints about Loeb's paper. First was its rhetorical mode. "I would have been OK with that first paper had at the very end they said: 'This is puzzling, we don't have a very good explanation. Let's speculate on what would it take to provide enough evidence for us to go the route of extraterrestrials.'" Instead, she said, Loeb's case consisted of "I'm just declaring that it is with no evidence whatsoever." She pointed out that Oumuamua's light curve showed that it was wobbling like a top. "I'm not a sailor, but you've got to keep the sail pointing in the correct direction," she said.

Beyond that, Loeb's critics argued that his proposal was physically unrealistic. Even if Oumuamua was made of the least dense artificial solid material known to humans, it would still be roughly 10 times denser than his math required and was preposterously slow for an interstellar spacecraft. "You don't leap to 'it's alien technology' before you've exhausted everything thoroughly," Meech said, "and I get the feeling that Avi's so excited about his ideas that he picks out bits of the observations that fit and discounts the others that do not." She continued, "That's what we're trying not to teach young students to do, because that's not science."

In late March, as Loeb was preparing for his trip to the South Pacific, two American scientists published a paper in Nature proposing a new, natural explanation for Oumuamua. The study described how a small comet that had spent eons drifting among the stars could become something like Oumuamua and how, in the little time they had available to study it, astronomers wouldn't have been able to figure that out. It was written by Jennifer Bergner, an astrochemist at the University of California, Berkeley, and Darryl Seligman, a postdoctoral researcher in astrophysics at Cornell University. Together they made the following case: In the unimaginable cold of interstellar space, the ice in a comet takes on a fluffy, amorphous form. When this porous ice is cooked by radiation, which happens continuously in the cold furnace between stars, bubbles of hydrogen form inside. As Oumuamua got close to the sun, the warmth rearranged the molecules in the ice, releasing some of the trapped hydrogen. The escaping gas gave Oumuamua a shove, causing the unexplained acceleration.

Headlines around the world declared the mystery of Oumuamua all but solved. In a news release from the University of California, Berkeley, Seligman said, "We had all these stupid ideas, like hydrogen icebergs and other crazy things, and it's just the most generic explanation."

Under the norms of polite academic discourse, if Loeb disagreed with Bergner and Seligman, he would have welcomed their contribution and promised to explain his objections in due course in a peer-reviewed journal article. Instead, Loeb went on the attack. The day after the paper came out, he emailed me saying he found an error in their work. Loeb accused Bergner and Seligman of ignoring the cooling effect of evaporating hydrogen in their model, a grave mistake that he said dominoed through the rest of their calculations and made their proposal untenable. He asked Nature to correct the original paper; they declined to do so. He wrote to The Times, The Daily Beast and The Times of London and other outlets asking them to correct their stories about the study. When The Times of London agreed to look into Loeb's objection, he forwarded me the exchange, adding, "The Brits have integrity!"

Bergner and Seligman declined to respond on the record to Loeb's critique of their paper, which he has continued to make loudly and often; it even appears on the third page of his new book. These days, few American astronomers want to enter a public debate with Loeb, particularly if they are untenured. So I asked Aurélie Guilbert-Lepoutre, an expert on comets with the French National Center for Scientific Research, to walk me through the problem. She said that Bergner and Seligman's choice to omit the variable of evaporating hydrogen was reasonable given the lack of laboratory data on hydrogen ice. You could debate it, she told me, but she probably would have done the same. No mathematical model of an astronomical body will ever be perfect: "You have to make assumptions." Next Guilbert-Lepoutre directed me to an equation in Loeb's response paper, where, she said, Loeb had made a mistake. When Loeb and his co-author added in hydrogen — a gradually vanishing substance — to their calculations, they should have written the variable to evolve with time. But they kept it static, and that was wrong.

When I ran Guilbert-Lepoutre's criticism by Loeb, he brushed it off as irrelevant, but she maintained that this error mathematically forces Loeb's model to produce the low temperatures that contradict Bergner and Seligman. Guilbert-Lepoutre told me that she spent a lot of time going through the Bergner and Seligman study and related data and scientific literature. "And then I went to Avi's paper, and I was like, 'Jeez, I just lost two hours, because that's so stupid,'" she said. "That's a stupid mistake."

What should the field of astronomy do with someone like Avi Loeb? David Spergel, the astrophysicist leading a NASA study group on U.A.P.s, told me that Loeb was too quick to jump to exciting conclusions and that he wished he would be more careful in his statements to the news media but that he saw value in his work. "There's a lot of elements in the Galileo Project that look like a good approach to what I view as high-risk, high-return science," he said. Loeb is known to be kind and nurturing to his students and postdocs, but the number of scientists who refuse to talk to the media about him is telling. "So many of my colleagues would just prefer to ignore him until he makes an ass of himself and goes away," the Arizona State University astrophysicist Steve Desch told me. "But he has a high threshold for shame."

The more time Loeb has spent in the scientific borderlands, the more speculative his ideas have become. One day when we were talking in his office, he started considering the possibility that an ancient Martian civilization might have terraformed Earth a billion years ago. We would never see the evidence on Earth, he said, because meteorite bombardments and plate tectonics would have destroyed it all, but there could still be archaeological remains on Mars, and we could always look for them. In March, he and Sean Kirkpatrick, director of the Pentagon's new office coordinating a "whole of government" approach to demystifying reports of unidentified objects, wrote a paper claiming that alien "motherships" could be lurking in our solar system and sending "dandelion seed" probes to explore Earth.

One of Loeb's sayings is an inversion of Carl Sagan's famous dictum, "Extraordinary claims require extraordinary evidence." Loeb believes that the discovery of alien life would be so important that even the tiniest possibility of success justifies a tremendous investment in research. "Avi says extraordinary evidence" — like, say, widespread reports of unexplained flying objects — "requires extraordinary funding," Turner, the Princeton astrophysicist, told me. Turner is an active member of the Galileo Project, though he has a reputation as the house skeptic. "We're not mounting scientific investigations into ghost stories, right?" Turner said. "There has to be some level of skepticism where you say, 'That's just too outlandish to be worth our time investigating.'"

Loeb often speaks dismissively of unnamed "administrators" or "colleagues" who refuse to see the interstellar light. His sense of being slighted, dismissed or overlooked bubbles up frequently and spontaneously. If you get him talking for more than an hour or so, invariably his mood turns dark, his eyes narrow and he starts listing resentments and perceived injuries. He sometimes describes the Galileo Project as a direct response to insult. "The Galileo Project was in a way a substitute to NASA not acting on my white paper," he told me. In 2021, Loeb sent Thomas Zurbuchen, a NASA administrator, a paper proposing a working group to study U.A.P.s. He says he never heard back. The next year, Loeb was celebrating his 60th birthday with some former students and postdocs on Martha's Vineyard when someone emailed him saying that NASA had convened the U.A.P. study group led by Spergel. He hadn't been invited. "I wrote an email to Thomas Zurbuchen basically saying, 'This is really surprising, and you basically ruined my week,'" he said. " 'I had a celebration here, and now I learned that you decided to establish this study.'"

Some of Loeb's grievances go back decades, to well before the alien-hunting began. In our first meeting, he brought up an arcane mathematical link between the masses of supermassive black holes and the velocities of stars within their host galaxies — the sort of correspondence that astronomers detect in data and then generalize into a formula. He said that he mentioned this possible cosmic relationship at a conference in 2000, "and it was immediately dismissed by the experts in the audience." Soon thereafter, two young scientists, Laura Ferrarese and Karl Gebhardt, came to Harvard for job interviews. Each was studying galaxies at the time with data from the Hubble Space Telescope. In those interviews, Loeb encouraged them to look in their data for evidence of this link between black holes and stars. They did. It checked out. They each published landmark studies on what became known as the M-sigma relation for black holes — a big discovery. With Loeb's agreement, they put him in the acknowledgments. Now, 23 years later, Loeb was ruefully telling me: "Look, I suggested it in that conference, I could have written it myself, I was completely discouraged from pursuing it by the people at the conference. And then I suggested it to these young people just to say, 'Look, you can check it and then let me know, and we will write together the paper.' And then it ended up in a different way." On a document linked to his Center for Astrophysics website, the M-sigma relation for black holes is No. 11 on a list of Loeb's "Top 20 Confirmed Predictions."

I contacted Ferrarese and Gebhardt. Both were surprised I was asking about something that happened more than 20 years ago. At the time, Ferrarese said, comparing the mass of a galaxy's black hole with the velocities of the stars around it was just an obvious thing to do. "I wouldn't even call it an idea," she said. Similarly, Gebhardt said he would have done the measurement that confirmed M-sigma anyway, but Loeb's enthusiasm made him push a little harder, so he acknowledged him in the paper. When I told him that Loeb felt excluded from the discovery, Gebhardt seemed taken aback. He quickly cycled through surprise and disappointment ("I thought we had a really positive exchange with him") to clarity. "To be blunt, and I would say this to him as well, if he thinks he owns the M-sigma relation, that's basically nonsense."

On a Sunday in early June, Loeb boarded Charles Hoskinson's private jet at a small airport outside Boston for the flight to Papua New Guinea. When I talked to him two days earlier, he sounded paranoid. A whistle-blower named David Grusch had just gone to Congress claiming the government ran a decades-old secret program for studying crashed alien spacecraft. This news made Loeb worry that the U.S. Navy might beat them to the site of the object, which they had named IM1. If the government decided to search the site, Loeb told me, they would be looking for large, intact fragments of a space probe, probably with remotely operated vehicles. On the flight between Australia and Papua New Guinea, they took a detour for a quick aerial inspection of the patch of ocean they were set to trawl. They saw no competitors.

After another short flight, they landed near the port town of Lorengau, where Rob McCallum, the expedition leader, was waiting with their aluminum catamaran, the Silver Star. Some 60 miles north of their launch point, they lowered the magnet sled from a winch on the deck of the ship and started dragging the meteorite's likely landing path. Over the next six days, they hauled in a manganese-platinum wire, a paint bucket, some nails, shards of shock-resistant steel and lots of volcanic ash. Loeb began to get anxious. They were preparing to use the sluicing sled later that week in case the particles they were looking for weren't magnetic after all. Then, finally, an expedition team member filtered some volcanic ash through mesh, placed the remains under a microscope and saw a tiny metallic pearl: the first spherule.

As they kept searching, their spherule collection expanded. When they reached a milestone of 50 spherules, they opened a case of Moët & Chandon Champagne they had waiting in a refrigerator. Using the ship's Starlink connection, Loeb did interviews with podcasters and journalists, declaring victory. His Medium posts grew exuberant and occasionally snide. A post headlined "What a Wonderful World" took a swipe at "a so-called 'Harvard astrophysicist" who in 2022 told The Harvard Crimson that he didn't expect Loeb's efforts to be "terribly scientifically productive."

Loeb on an expedition to the sea off Papua New Guinea to hunt for debris from a meteor. Interstellar Expedition Team, via Avi Loeb

Back at home a couple of weeks later, in an interview with NBC, Loeb made bold claims about their discovery. Though it was still unclear whether the spherules came from any meteor, let alone the first interstellar meteor or an alien probe — the planet is covered with spherules produced by processes ranging from volcanism to iron smelting — he told the NBC interviewer that this was "the first time that humans hold material belonging to a big object that came from outside the solar system." In an expedition summary posted on Medium, he wrote of the possibility of returning to Papua New Guinea to search the site with new equipment. If IM1 was a piece of extraterrestrial technology, Loeb reasoned, maybe the spherules come from the melting of its outer layer; if so, they might trace a path to intact remains.

On Zoom in late July, the day before a conference in Cambridge celebrating the two-year anniversary of the Galileo Project, Loeb was more subdued. An article on the Papua New Guinea expedition was published in The Times earlier that week, and it quoted meteor experts who were highly skeptical of Loeb's claims. He was still brooding about it. "It's just unfair," he told me. "I'm doing the best I can to go to the Pacific Ocean, putting a lot of my time and energy into collecting the materials, just following the scientific method and then doing the analysis with the best instruments. And all they're doing is sitting in their chairs and saying negative things about me. That's unfair. And they're saying I'm distorting the way science is done. I'm just following exactly the scientific method, collecting and analyzing."

He shared his screen and showed me some of that analysis in progress. First was a map of the suspected IM1 crash site overlaid with a grid of color-coded cells showing the distribution of spherules. "Per unit mass, the number of spherules appears to be correlated with the meteor path," he said. "That's interesting, because it says that we didn't just collect crap." Next he pulled up some new electron-microscope images of spherules that had been magnified to nearly atomic level. Whether they were from interstellar space or a volcano, they were gorgeous. To figure out where they came from, Galileo Project-affiliated laboratories across the world were measuring the amounts of elements and isotopes within them. Loeb said that analysis should determine first whether the spherules originated in space, and if so, whether they were from our own solar system or elsewhere. He said the labs had been working through a few spherules per day, but that the pace should soon increase, and he hoped to have results within a few weeks.

Before long, though, he came back to the criticism in the Times piece, which he couldn't shake off. He told me it was strange that people who didn't have access to the spherules would have such strong opinions about them. "I mean, I'm talking about scientists, who call themselves scientists but yet are not willing to wait until the evidence comes out," he said. I asked if his critics could have been annoyed that he went straight to the press with such preliminary findings. "OK, just to explain," he said. "I didn't go straight to the press. I wrote my essays. I just gave a diary about the expedition, because that's an unusual opportunity to educate the public about how science is done. I'm just doing it the scientific way." The scientific way, I suggested, might have been to keep things quiet until the results are peer-reviewed and published. "That's another way to do it," he said. "But it was not a crime. I didn't do a crime."

Loeb says he doesn't care what his critics say, but he spends far too much time complaining about them for that to be entirely true. It's probably more accurate to say that he's betting that if he's right, any transgressions against scientific norms and protocols will be forgiven. That's a sentiment that I heard in various forms even from some of Loeb's harshest critics. They were tired of Loeb's antics, his bullying, his delusions, but it was hard not to wonder ... what if? A good scientist can never completely dismiss a nonzero possibility. When I spoke to Karl Gebhardt, one of the astrophysicists who discovered the M-sigma relation, he told me wearily that he wished the news media would stop indulging Loeb's over-the-top ideas and let the field get back to doing science. Then Gebhardt paused. "Now, that being said, if he finds something, it's life-changing," he said. "It will change everything."

Seth Fletcher is the chief features editor at Scientific American. He last wrote for the magazine about the astronomers who took the first picture of a black hole.
Michael Marcelle is a photographer whose work plays off a contrast between fantasy and reality and the natural and the synthetic. His forthcoming second book is called "The Living End" and focuses on American spectacle and oblivion.
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