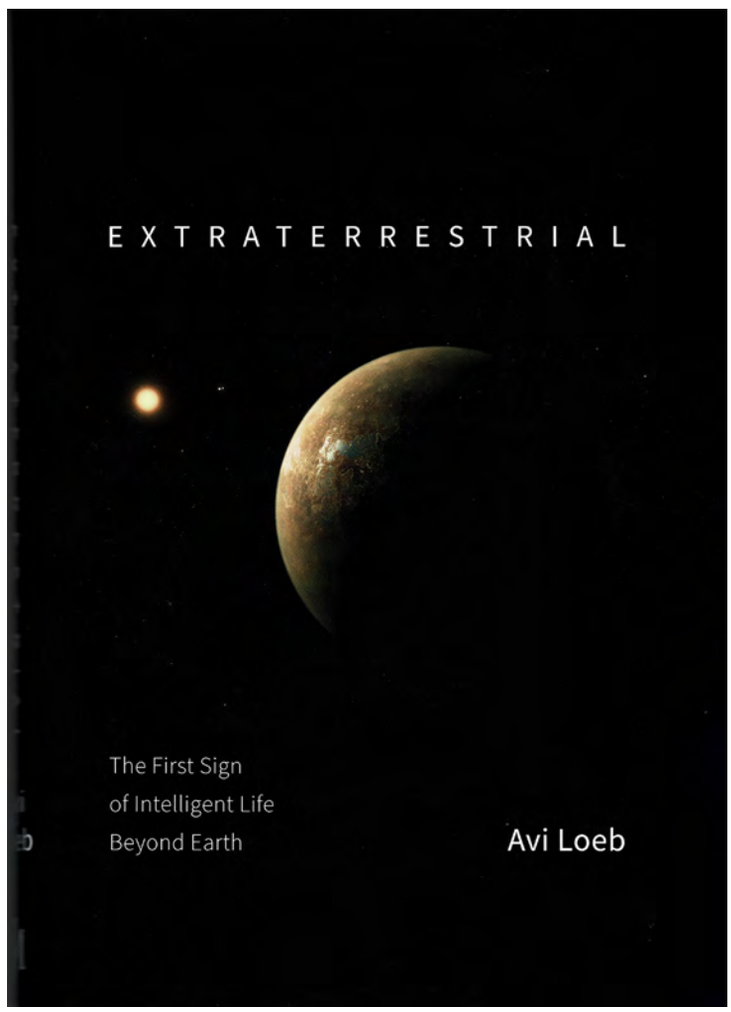
Book Review: *Extraterrestrial: The First Sign of Intelligent Life Beyond Earth*, Avi Loeb

Patrick Mahon

Professor Avi Loeb's views on the possible nature of 1I/'Oumuamua have been controversial for some time and his recent book has both stoked controversy and set out his views in detail, Here Principium Deputy Editor Patrick Mahon gives us his analysis of the book and the views it articulates.

Regular readers of Principium may recall the excitement, some three and a half years ago, as the scientific community announced the first ever detection of an interstellar object flying through our solar system [1]. What became known as 1I/'Oumuamua made worldwide news in October 2017 when astronomers announced its unusual nature: it appeared to be five to ten times as long as it was wide, famously being portrayed in an artist's impression as a long, thin cigar-like shape, not unlike the alien spacecraft portrayed in Arthur C Clarke's 1973 novel *Rendezvous with Rama*. This prompted me to speculate on the apparent parallels between 'Oumuamua and Rama in a review of that novel published in Principium issue 21 [2], while i4is colleagues quickly created Project Lyra, which explores the possibilities for sending a scientific probe to 'Oumuamua, despite its high velocity as it leaves our solar system [3].



Credit: UK Publisher: John Murray Press, 2021

Someone else who found the nature of 'Oumuamua particularly intriguing is Professor Abraham (Avi) Loeb of the Centre for Astrophysics at the University of Harvard. Loeb is a decorated scientist with five books and over 800 published papers to his credit, as well as being a member of the President's Council of Advisors on Science and Technology. Of most relevance to this story, however, is his role as Chair of the Advisory Committee to Breakthrough Starshot, the $100 million programme to send tiny laser sail-powered probes to Alpha Centauri at one-fifth of the speed of light.

In the year following the detection of 'Oumuamua, Loeb read the scientific papers which set out the observational data that had been collected over a brief 11 day period between the first observation and the point at which the object became too faint to detect. Like many others, he noted the various anomalies which marked 'Oumuamua out as unusual. But while most other professional astrophysicists eventually concluded that, though unusual, 'Oumuamua was an entirely natural asteroid or comet that just happened to have come from outside our solar system, Loeb reached a different conclusion.

In *Extraterrestrial: The First Sign of Intelligent Life Beyond Earth* [4], Loeb explains how he came to a profound difference of view with the vast majority of his colleagues in the scientific community, and why he thinks it is so important that all of us consider seriously not just the radical hypothesis he puts forward, but the implications that follow from it.

In summary, Loeb's argument goes like this: there is general agreement in the astrophysics community that the observations made of 'Oumuamua display several unusual features. This makes it unlike 2I/Borisov, our second interstellar visitor, which travelled through the solar system in 2019. Borisov is universally agreed to be interstellar in origin, but otherwise looks very similar to a normal comet [5]. 'Oumuamua doesn't. Loeb highlights four of 'Oumuamua's features in particular:

• The aspect ratio (the ratio of length to width) was high, indicating that the object was either shaped like a cigar or, alternately, a pancake;

• Even when relatively close to the Sun, it was cold (as the Spitzer Space telescope could not detect it in the infrared), so must be small, perhaps only 100 metres long by 10 metres in width;

• It was very bright – up to ten times brighter than a typical solar system asteroid or comet – suggesting something that was highly reflective; and

• As it travelled through the solar system, its trajectory deviated slightly from the hyperbolic orbit that would have been expected if it was purely moving under the influence of the Sun's gravity. Instead, there was a small excess acceleration which diminished with the square of the object's distance from the Sun.

It is this fourth feature that Loeb found most intriguing. The reasons why are two-fold. On the one hand, the various explanations put forward by his colleagues for this deviation from the expected trajectory seemed to get ever more convoluted over time. The first explanation was outgassing from the object as the Sun heated it up, as you'd expect if it were a comet. Yet no outgassing was detected, and Loeb calculated that to achieve the excess acceleration that had been measured, the object would have had to lose about 10% of its mass in outgassing, which surely would have been observed? Then it was proposed that 'Oumuamua was made of pure hydrogen ice, something never seen before. Next, the suggestion was made that the object had broken up when it got to its closest approach to the Sun, changing its trajectory as it retreated. But as far as Loeb could see, none of these theories seemed to fit all of the observational evidence.

On the other hand, Loeb and his postdoctoral fellow Shmuel Bialy did some calculations, based on Loeb's work with Breakthrough Starshot, and found that the excess acceleration could be reproduced if 'Oumuamua was a highly reflective, extremely thin disc-like object which was reflecting solar radiation. In other words, something that looked an awful lot like a solar sail. They did not conclude that it had to be artificial, but it was difficult to conceive of any natural mechanism that would produce an object with the required characteristics of high reflectivity and extreme thinness. Thus, the paper they published in late 2018 included the phrase 'one possibility is that 'Oumuamua is a lightsail, floating in interstellar space as debris from advanced technological equipment' [6].

Clearly, Loeb's hypothesis is extremely exotic. And many other scientists insist that they have been able to generate natural explanations for all of the anomalies that Loeb highlighted. Indeed, Emeritus Professor Alan Aylward gave an extended explanation of the 'case for the defence' in the last issue of Principium [7]. If you haven't yet read it, I'd urge you to do so.

However, Loeb's argument, on my reading, is not that he thinks he's definitely right and everyone else is definitely wrong. Rather, he thinks that the evidence is sufficiently indefinite that both hypotheses remain possible. And in his view, those putting forward a 'natural' explanation are having to go to extreme lengths to account for all the anomalies simultaneously. He believes that Occam's Razor favours his simpler alternative hypothesis, if you're only able to get over what he sees as an unhelpful conservatism within the mainstream of career scientists, which biases them against any explanation that requires an, admittedly huge, leap of the imagination.

Carl Sagan's phrase 'extraordinary claims require extraordinary evidence' is often raised at this point, the implication being that any hypothesis that depends on the existence of an intelligent alien civilisation (the creators of the lightsail that Loeb has hypothesized) needs to be able to produce a 'smoking gun' if it's to be taken seriously.

Loeb's response to this is to note that different standards of proof seem to apply to several other areas of physics, including string theory and the theory of the quantum multiverse, where physical proof appears unlikely if not impossible to obtain. Yet this does not seem to prevent work in these areas. On the other hand, he points to historical examples where radical hypotheses were initially rejected by the mainstream, yet later turned out to be correct. Examples include Galileo's observations of Jupiter's moons in 1610, which

he used as evidence that the Earth was not the centre of the Universe, and for which he was put under house arrest by the Catholic church. More recently, Einstein's 1905 Theory of Special Relativity was rejected in the UK physics community for several years because it directly contradicted the existence of the ether, the hypothetical medium that British scientists believed at that time to fill all of space.

Much of the second half of Loeb's book is taken up with an exploration of what might happen if more people – not just scientists, but the general public too – were to take his hypothesis seriously. So just for a second, let's suppose that 'Oumuamua really is an alien solar sail. How might that change what we think and what we do?

For starters, we would surely want to invest more in the technologies that would allow us to take a closer look at any further interstellar interlopers that enter our solar system in the future, following on from 'Oumuamua and Borisov. The team at i4is certainly wouldn't disagree with this, as our work on Project Lyra attests.

Equally, accepting 'Oumuamua as potential proof that life has emerged elsewhere than on the planet Earth would surely attract a lot more money and attention to the study of exoplanets and the science of astrobiology. Indeed, we might see more money made available for missions to the various places in our own solar system where primitive life may exist, including Jupiter's moon Europa and Saturn's moon Enceladus.

More radically, projects like Breakthrough Starshot and our own Project Dragonfly might be accelerated, so that we could find out whether the exoplanet orbiting the nearest star to our own Sun, Proxima Centauri, harbours life, not in a few hundred years, but in the next few decades.

So that's Avi Loeb's argument. Does he make it well?

To be honest, when I started reading this book, I was ready to side with the scientific mainstream, who have labelled Loeb as yet another formerly respectable physicist who is suffering from a very public mid-life crisis. I'd rather got that impression from the discussion of Loeb's position in the popular science media. But that's not how he comes across in this book.

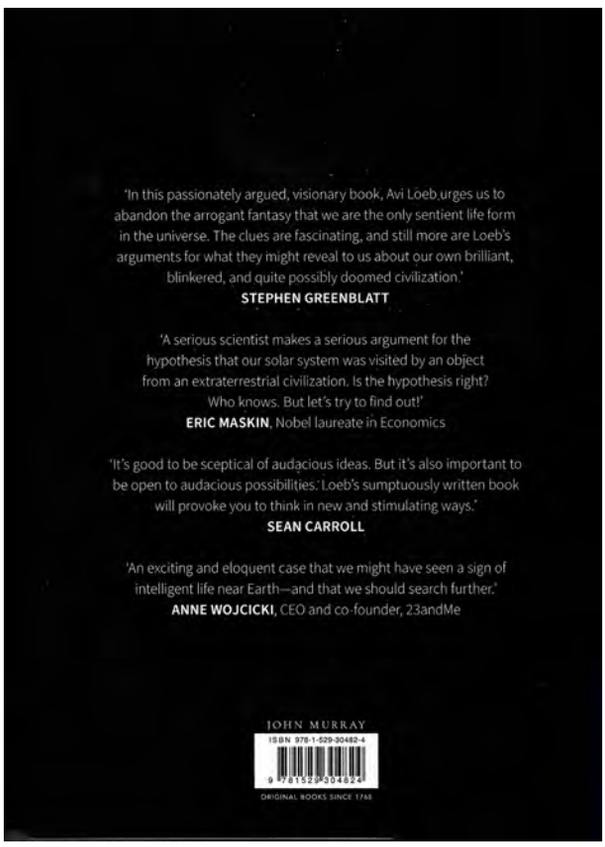
There are some points I could find fault with here. On several occasions, the book's narrative over-simplifies the conflict between Loeb's view and the more mainstream alternative. I don't know whether Loeb wrote it that way originally, or whether the publisher, wanting to maximise the book's potential audience, has taken out some of the subtleties.

On the right - Avi Loeb, Frank B Baird Jr Professor of Science, Harvard University - at the public announcement of Breakthrough Starshot , April 12, 2016 with Yuri Milner, Stephen Hawking, and Freeman Dyson.
Credit: Harvard University lweb.cfa.harvard.edu/~loeb/Loeb_Starshot.pdf

Taken as a whole, though, the book suggests an author who is calm, thoughtful, reflective and self-aware. He knows that the hypothesis he's putting forwards is radical. He just thinks that it explains the data better than the rival ideas that have been proposed. And on that basis, he thinks that the hypothesis – and its implications – are worthy of serious consideration, even though he's well aware that saying so in public is likely to result in criticism from many of his peers, due to the inherent conservatism of the scientific establishment.

I have a lot of sympathy with this aspect of Loeb's argument. As someone who has worked in and around large bureaucracies for most of my professional life, I'm well aware of the difference between the open and nuanced discussions which fellow professionals may be prepared to have in private, and the carefully worded and conventional statements that they and their institutions are prepared to have ascribed to them on the record.

Do I believe, after reading this book, that 'Oumuamua is an alien solar sail? Honestly, I don't know. I still think it's unlikely. But Loeb is right to point out that our current understanding of planetary formation, revolutionised by the extraordinary variety of exoplanets that have been discovered in the last quarter of a century, suggests that potentially habitable planets may be common across our galaxy. Even if only a tiny proportion of these turned out to be able to support life, that's still lots of opportunities for non-human lifeforms to evolve. Perhaps one (or more) such species has advanced as far as humanity, or even beyond. Is that inconceivable? Surely not.



Rear cover with publisher's quoted reviews

If you're reading this review, then you are presumably interested in what is to be found outside our solar system. We're lucky enough to live at a time when our observational equipment is good enough to detect an object flying through our solar system from outside it, for the very first time. Perhaps 'Oumuamua is just an asteroid or a comet of a rather unusual kind. Or perhaps it's the first piece of evidence to cross our path, demonstrating that our solar system is not the only source of life in the universe.

If that last sentence intrigues you, then I'd urge you to read Avi Loeb's book. You probably won't agree with everything he says – I certainly didn't – but I found him a credible author with a reasonable story to tell. And while the implications of his hypothesis are revolutionary, I think they are ones that many Principium readers will find worthy of serious consideration.

References:

[1] 'Small asteroid or comet 'visits' from beyond the solar system', NASA/JPL, 26 October 2017. www.nasa.gov/feature/jpl/small-asteroid-or-comet-visits-from-beyond-the-solar-system

[2] Review of Rendezvous with Rama, Principium issue 21, pp.30-32 (May 2018).

[3] 'Project Lyra: Sending a Spacecraft to 1I/'Oumuamua (former A/2017 U1), the Interstellar Asteroid', A.M. Hein et al., Acta Astronautica 161, pp. 552-561 (Aug 2019). arxiv.org/abs/1711.03155

[4] Extraterrestrial: The First Sign of Intelligent Life Beyond Earth, Avi Loeb (John Murray, London, 2021).

[5] 'Comet 2I/Borisov', NASA Solar System Exploration, April 2020. solarsystem.nasa.gov/asteroids-comets-and-meteors/comets/2I-Borisov/in-depth/

[6] 'Could solar radiation pressure explain 'Oumuamua's peculiar acceleration?', S. Bialy and A. Loeb, Astrophysical Journal Letters (12 Nov 2018). iopscience.iop.org/article/10.3847/2041-8213/aaeda8/pdf

[7] 'An interstellar visitor: sorting the fact from the speculation', Alan Aylward, Principium issue 32, pp.53-59 (Feb 2021).