**INTERSTELLAR OBJECTS**

# The ‘Oumuamua Controversy

Christopher Cowie

University of Durham

That the interstellar object 1I/2017 U1 ('Oumuamua) could be an extraterrestrial artefact is an unorthodox hypothesis. From a philosophical perspective, however, the structure of the underlying argument for the hypothesis is flawed.

The interstellar interloper 1I/2017 U1 (‘Oumuamua) was detected in October 2017. It has been the subject of controversy since. In scholarly articles[1] and a public-interest monograph[2], Avi Loeb - Frank B. Baird, Jr., Professor in Harvard’s Department of Astronomy - has defended the unorthodox hypothesis that:

*Loeb’s Hypothesis (LH)*: Oumuamua is an extraterrestrial artefact.

How should we respond to this hypothesis? To some extent it is a *philosophical* question; evaluating LH requires us to think about *argumentative structure* as well as about the scientific facts. I clarify the structure of argument for LH, explain why it renders some existing criticisms of LH problematic, and offer an alternative response.

## The Argument for LH

LH is driven primarily by scepticism about orthodox, natural explanations. According to these explanations 'Oumuamua is a comet or asteroid ejected from a nearby system.[3] Scepticism of these explanations is based largely on:

i. 'Oumuamua's detection suggesting a significantly higher number-density for such objects than predicted on standard models;[4]
ii. Oumuamua's shape being non-standard; either an ellipsoid with an extreme ratio of length to width, or an extreme oblate spheroid;[5]
iii. 'Oumuamua's post-perihelion non-gravitational acceleration being seemingly unaccompanied by the 'outgassing' that explains the same phenomenon in comets, despite observation from the Spitzer telescope.

How does one get from here to LH? Loeb invokes 'the Holmesian maxim': if all of the options have been eliminated then all that remains, however unlikely, is true. This maxim accurately captures the *contrastive* and primarily *negative* nature of the case for LH, but it is also misleading. It is misleading because it is *eliminative*. Eliminative arguments work by presenting an exhaustive menu of options and eliminating all but one. The case for LH is not of this form. It is based on claiming that the orthodox, natural explanation has a *low probability*; Loeb estimates 'one-in-a-trillion give or take'. This claim is significant in two ways. Firstly, it now becomes incumbent on a defender of LH to argue that *its* prior probability (i.e. the prior probability 'Oumuamua is an extraterrestrial artefact) is non-negligible. In the absence of this argument, the orthodox natural explanation may remain the best bet *however low its prior likelihood*. Secondly, a defender of LH must be able to rule out non-negligible probabilities for *unorthodox* – perhaps presently unconceived - natural explanations; a difficult task given the abundance of true but 'unconceived' alternatives in the history of science.[6]

Focus though on just the first of these two points: a defender of LH must provide a non-negligible prior probability assignment for the claim that 'Oumuamua is an extraterrestrial artefact. Loeb supports this assignment in two ways. One is via background optimism there is, and has been, a lot of extraterrestrial life. We should then be unsurprised to find evidence of it in the form of artefacts. He writes:

> [I]t is most likely that we will encounter relics of extraterrestrial technologies... This must be kept in mind as we contemplate explanations for the mysterious properties of… 'Oumuamua.
>
> 2021, 115

The other is a positive hypothesis that 'Oumuamua behaved like a 'solar sail'. This hypothesis is supported by the fact that its rate of non-gravitational acceleration was given by the inverse square of its distance from the sun and that it was plausibly shaped as an extreme oblate spheroid.

Loeb gives more air-time to the second claim, the solar sail hypothesis. However the first, background optimism about finding extraterrestrial life, bears the greater argumentative load. To see that the first claim bears the greater load, suppose *per impossible* that the data on 'Oumuamua were re-examined and it was found to have accelerated proportional to the inverse *cube* of solar distance. The solar sail hypothesis would now be ruled out. Clearly though, it wouldn't undermine the case for LH *in any way at all*. Quite the opposite. It follows that the non-negligible prior probability assignment required for LH is *in large part* supported by prior confidence in finding extraterrestrial artefacts. Reliance on this prior confidence is a weak spot for LH; a point we return to below. Before doing so however it is worth studying the structure of *existing* responses to LH, some of which are problematic.

**The Scientific Community's Response**

Consider the recent survey piece in *Nature Astronomy*.[7] The rejection of LH is one of the central conclusions of this paper. Key to it is that prospects for natural explanations of 'Oumuamua are much better than defenders of LH have allowed. The authors write:

> Assertions that 'Oumuamua may be artificial are not justified when the wide body of current knowledge about solar system minor bodies and planetary formation is considered.

Yet it is questionable whether the article establishes this claim. The article's penultimate section identifies three 'open questions'. These concern 'Oumuamua's shape, rotation and origin. The fact these open questions remain is problematic; it is in part the very fact that they *are* open questions that motivates scepticism of orthodox natural explanations – and so LH - in the first place. The problem is even more acute with respect to non-gravitational acceleration. The authors hypothesise that non-detection of outgassing is explained by a high ratio of $H_2O$ to carbons (CN, CO, $CO_2$) in 'Oumuamua's composition.[8] Two questions now arise: *how* unusual is the ratio and *why* would 'Oumuamua have such an unusual ratio. On the first question, the authors claim the CO 'limit is within the range of measurements for known comets' whereas 'the $CO_2$ upper limit is about an order of magnitude lower.' On the second question, the authors hypothesise that 'Oumuamua may have had an unusually depleted store of carbons owing to 'repeated passages close to its host star before being ejected.' These answers play directly into Loeb's hands. The authors have posited a $CO_2$ limit *an order of magnitude* out from anything presently known, caused by conjectured, unevidenced passages around a home star. This posit is *at least* consistent with the low probability assignment to orthodox explanations that drive LH.

So how *should* one argue against LH? One would *ideally* provide a comprehensive natural explanation for 'Oumuamua. But providing such an explanation may not be possible given our current evidence. Is there an alternative?

**Arguing Against LH**

LH's weak spot is its reliance on non-negligible prior probability assignments for encounters with extraterrestrial artefacts. Consider the vast literature on the spread of detectable life in the galaxy. This literature is notoriously chaotic. Estimates of values for relevant variables vary wildly. Sandberg et al (2018) provide a clear summary. The range is enormous, covering eleven orders of magnitude (from $3x10^{-4}$ to $1x10^{8}$). Within this range the median value is 100. The shape of the distribution is roughly normal with an asymmetry toward an extremely elongated tail at the lower end and an extremely truncated tail (a 'cliff') at the higher end (a clustering of high-value assignments at the upper end, over a small range, i.e. $1x10^{6}$).

This data is bad news for LH in two ways. Firstly, both median and modal estimates for detectable species are low. Secondly, and more importantly, the above variation shows that - if we are honest - we have *very little idea* what the relevant probabilities are; whether life is widespread, let alone whether it is technology-manufacturing.[9] And yet LH depends on a background optimism *both* that we can answer these questions *and* that the answer leans strongly in a particular direction. We can represent the resulting case again LH - *the argument from uncertainty* - as follows:

(1) LH is competitive only if we can reasonably be confident there is a lot of intelligent life of a particular kind (i.e. technology manufacturing).
(2) We are very unsure how much intelligent life of that kind there is.

(3) If we're very unsure whether x, we can't reasonably be confident of x.

(4) (2, 3) We can't reasonably be confident there is a lot of intelligent life of the relevant kind.

(5) (1, 4) LH isn't competitive.

This simple way of framing the argument is reinforced by recent work that allows we *can* make estimates of the relevant probabilities *provided that* we properly factor-in high levels of uncertainty using appropriately tailored methods of statistical analysis.[10] The result is values at the *lower* end of the scale for detectable life; more bad news for LH.

The point generalises. 'Extraterrestrial hypotheses' have recently been offered as explanations of a range of naturally-puzzling phenomena, including the unusual light variations on star KIC 8462852 and the detection of 'fast radio bursts' (FRB's). The argumentative structure in these cases is the same as for LH: the 'extraterrestrial hypotheses' are tacitly reliant on high prior probabilities for encounters with extraterrestrial artefacts. So the argument from uncertainty applies to them too. Generally, we may lack a satisfying natural explanation of some phenomenon, while simultaneously – and perfectly rationally - denying that extraterrestrial explanations are competitive.

**Conclusion**

It goes without saying that 'doing the science' is usually the best way to assess astronomical hypotheses. Sometimes though, especially for non-standard hypotheses, reflection on argument-structure can be worthwhile too. Astronomers should find philosophers willing and able to help.

The authors declare the following competing interests:

The authors declare no competing interests.

**References**


[1] Bialy, S. and Loeb, A. 2018. Could Solar Radiation Pressure Explain 'Oumuamua's Peculiar Acceleration? *Astrophysical Journal Letters* 868(L1).
[2] Loeb, A. 2021. *Extraterrestrial: The First Sign of Intelligent Life Beyond Earth.* John Murray.
[3] Micheli, M., Farnocchia, D., Meech, K.J. *et al.* 2018. Non-gravitational acceleration in the trajectory of 1I/2017 U1 ('Oumuamua). *Nature* 559(7713): 223-226.
[4] Moro-Martin, A. 2019a. Origin of 1I/'Oumuamua. II. An Ejected Exo-Oort Cloud Object? *The Astrophysical Journal Letters* 157(L86).
[5] Mashchenko et al. 2019. Modelling the light curve of 'Oumuamua: evidence for torque and disc-like shape. *Monthly Notices of the Royal Astronomical Society* 489(3): 3003-3021.
[6] Stanford, K. 2006. *Exceeding Our Grasp: Science, History and the Problem of Unconceived Akternatives*. New York: Oxford University Press.
[7] Oumuamua ISSI Team., Bannister, M.T., Bhandare, A. *et al.* 2019. The natural history of 'Oumuamua. *Nature Astronomy* 3**:** 594–602.
[8] Seligman et al. 2019. On the Anomalous Acceleration of 1I/2017 U1 'Oumuamua. *The Astrophysical Journal Letters* 876(L26).
[9] Lingam, M. and Loeb, A. 2019. Relative Likelihood of Success in the Search for Primitive versus Intelligent Extraterrestrial Life. *Astrobiology*. Online first: https://doi.org/10.1089/ast.2018.1936
[10]Sandberg, A., Drexler, E., and Ord, T. 2018. Dissolving the Fermi Paradox. arXiv:1806.02404.