John I Davies reports on recent developments in interstellar studies

A 3rd Interstellar Object (ISO)

The third known interstellar object, 3I/ATLAS, was discovered on July 1 2025 by the Asteroid Terrestrial-impact Last Alert System (ATLAS) - fallingstar.com/ - and subsequently imaged by the veteran Palomar 200-inch telescope. In *Interstellar comet 3I/ATLAS: discovery and physical description*, Bolin et al (arxiv.org/abs/2507.05252} provide details. The new ISO appears to be a comet, like the second, 2I/Borisov, and unlike the enigmatic 1I/Oumuamua, the first discovered of these visitors from beyond our Solar System. It seems to be the largest ISO yet seen according to a paper by Colin Orion Chandler et al, NSF-DOE Vera C Rubin Observatory Observations of Interstellar Comet 3I/ATLAS (C/2025 N1) - arxiv.org/abs/2507.13409. Chandler et al report an equivalent effective nucleus radius of around (5.6 +/- 0.7) km. They use early images gathered "Serendipitously, the Rubin Observatory collected imaging in the area of the sky inhabited by the object during regular commissioning activities". It also has a fairly low inclination to the ecliptic (the plane where most of the mass of the Solar System orbits) at 5 degrees (though retrograde) while 1I is inclined at 122 degrees and 2I is at 44 degrees.

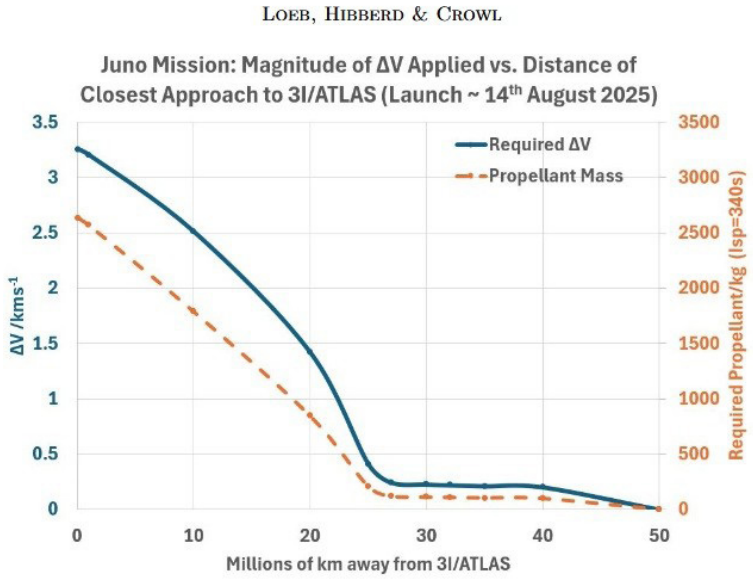
Our i4is lead astrodynamicist, Adam Hibberd, has been considering this object and he comes to an initial pessimistic conclusion about the possibility of a mission to take a closer look *Missions to 3I/ATLAS* i4is.org/missions-to-3i-atlas/. He concludes that it would be much harder to reach than 1I/Oumuamua which, in any case, looks much more intriguing than either 2I or 3I, though with a low probability chance that 3I is non-natural, see below.

1I appears to exhibit no outgassing unlike a comet yet has experienced some kind of accelerating force. More about 1I and missions to it in many previous issues of Principium beginning with *Project Lyra: Sending a Spacecraft to the Interstellar Asteroid*, in Principium 19 November 2017 and in - en.wikipedia.org/wiki/1I/%CA%BBOumuamua#Discussion.

Adam has also done some speculative investigation of the trajectory of 31 with an i4is colleague Adam Crowl and Professor Avi Loeb (Harvard) – *Is the Interstellar Object 3I/ATLAS Alien Technology?*, Adam Hibberd, Adam Crowl and Abraham Loeb arxiv.org/abs/2507.12213. They present a testable thesis of a non-natural origin. They describe their investigation very cautiously as a "pedagogical exercise" but point out that if 3I is non-natural then its trajectory might imply a threat.

The consensus within i4is is that all three ISOs are almost certainly natural but that 1I and 3I both deserve further investigation,

A later paper *Intercepting 3I/ATLAS at Closest Approach to Jupiter with the Juno spacecraft* arxiv.org/abs/2507.21402 by the same three authors shows how the Juno spacecraft, near its long extended end of mission (science.nasa.gov/mission/juno/#end-of-mission) could use its remaining fuel to encounter 3I next year (2026) with a closest distance about 53 million km (about one third of an astronomical unit) and relative velocity about 66 km/s. This was reported widely including in the well respected New Scientist magazine, *Can we send a spacecraft to intercept interstellar object 3I/ATLAS?* (www.newscientist.com/article/2490618-can-we-send-a-spacecraft-to-intercept-interstellar-object-3i-atlas/) with a rather pessimistic conclusion.



Thrust impulse ΔV (left vertical axis) and propellant mass (right vertical axis) needed for Juno to come within a range of distances from 3I/ATLAS (horizontal axis). The launch date is assumed to be August, 14 2025. Credit: *Intercepting 3I/ATLAS at Closest Approach to Jupiter with the Juno spacecraft*. Figure 3.

More recently Joan-Pau Sánchez and Colin Snodgrass have considered whether the planned ESA Comet Interceptor (CI) - (www.cometinterceptor.space/) could intercept another object with a trajectory like that of 3I. Prof Snodgrass, University of Edinburgh, is chair of the CI Target Identification Working Group. Joan-Pau Sánchez, Institut Supérieur de l'Aéronautique et de l'Espace, is a member of the Working Group. The current CI Δv capability would have meant that 3I would have had to be detected at 28 AU from the Sun and even the mighty new Vera C Rubin observatory's LSST would not have been capable of this. They conclude "A future CI-like mission dedicated to intercepting an ISO needs to have significant, but not unrealistic, Δv capability, and will still need a more co-operative ISO than 3I, that at least has a close approach somewhere near Earth."

Flying to a Potentially Hazardous Object

Adam Hibberd (i4is astrodynamicist) and T Marshall Eubanks (Space Initiatives Inc) will be presenting *Flying to a Potentially Hazardous Object – A Mission of Gravity* at the very active West Midlands branch of the British Interplanetary Society (BIS) on 20 September 2025 at 14.00. They will present their recent research into a mission to the Potentially Hazardous Object (PHO) 2024 YR4. This asteroid is now known to be unlikely to hit the Earth at its next close approach in December 2032 but currently has about a 4% chance of hitting the Moon. This would result in an explosion equivalent to moderately large nuclear weapon and a large meteor cloud in the space between Earth and the Moon. The effects on satellites and, to a lesser extent, the Earth can be imagined. We will know more when it passes at some distance in 2028. Register for the talk, in person or online, at - docs.google.com/forms/d/e/1FAIpQLSd-FNFORRjwGpvn4Fv1b1UGI6bWJ6fLabDSQkpAHvhYPnittQ/viewform.

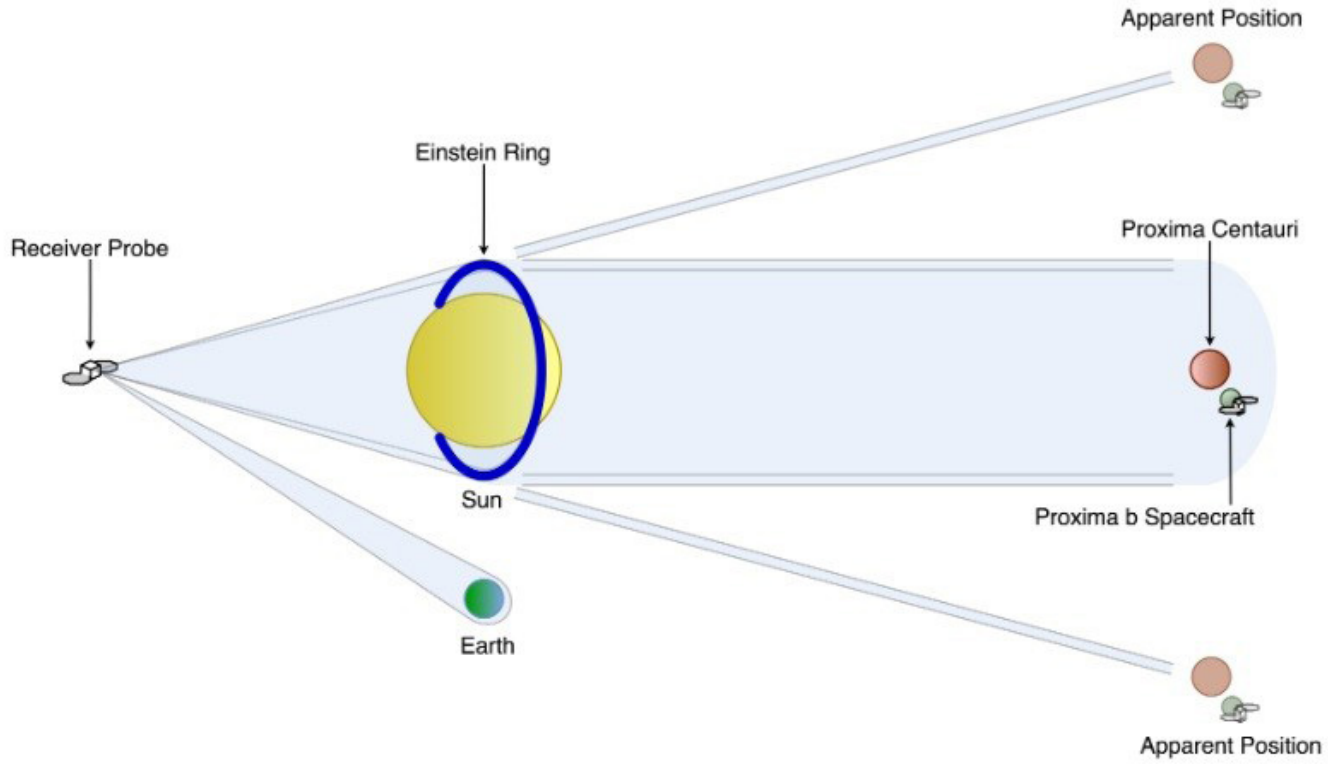
Voyager 1 – One light-day from home

The two Voyager probes are still operating, 47 years from their launch and later this year Voyager 1 will reach one light-day from its home planet. NASA updates its distance on science.nasa.gov/mission/voyager/where-are-voyager-1-and-voyager-2-now/. Recalling that our nearest neighbour star is more than one light-year from reminds us of the magnitude of the challenge we face in reaching it. So it has taken 47 years for the Voyagers to achieve one 365th of the distance to that neighbour. But we are now confident we will have the technology to reach that distance in a time comparable to the Voyagers journey so far. This is a prime objective of i4is and we will continue to advocate for it, educate for it and prepare for it.

By Fusion to Proxima b

In her thesis *Interstellar Mission Design of a Fusion-Powered Spacecraft to Proxima b*, Amelie M Lutz, Virginia Tech, presents results of her Masters research in Aerospace Engineering [1]. The thesis examines three propulsion systems: the Fusion Driven Rocket (FDR), an Inertial-Electrostatic Confinement (IEC) fusion system, and an Antimatter Initiated Microfusion (AIM) system each tailored specifically for a Proxima b mission using four possible fuels: D-D, D-He^3, D-T, and p-B^{11}. System performance was examined for a fast and slow flyby of Proxima b, and bounded orbit. It concludes that a slow flyby or bounded orbit, ideal for data collection, and can only be supported by FDR using D-He^3 with a mission time of 57 years. The thesis also examines instruments for the mission including Magnetometer, Magnetic Sounding, Thermal Emission, Imaging, Ultraviolet Imaging, Gravity and Radio Science, Mass Spectrometer, Compositional Mapping, Radar Sounding, Dust Sampling, Imaging System and Communications [2].

[1] vtechworks.lib.vt.edu/items/90b3f3e1-bb96-4006-8701-7f2e593fb009
[2] A minor error, the thesis refers to designs for a mission to Alpha Centauri, such as Breakthrough Starshot, using solar sails. This work and its predecessors suggest laser sail propulsion



The Lutz paper considers the use of solar gravitational lensing for the downlink from Proxima b.
Credit: Lutz, Figure 2.1: 2D representation of the solar gravitational lens communication system.

Do we to need understand Dolphin to understand an ETI?

Leonard David in *Space Insider draws our attention to the first award of the Coller Dolittle Challenge $100,000 annual prize to accelerate progress toward interspecies two-way communication* (www.space.com/space-exploration/search-for-life/could-deciphering-dolphin-language-help-us-communicate-with-et).
Led by Laela Sayigh from the Woods Hole Oceanographic Institution, the winning research team – including Peter Tyack from Woods Hole Oceanographic Institution, Vincent Janik from the University of St Andrews, Frants Jensen from Aarhus University, Katie McHugh and Randall Wells from Brookfield Zoo Chicago's Sarasota Dolphin Research Program – has been studying a resident bottlenose dolphin community in Sarasota, Florida.
Their report *Dolphins' use of Complex Whistle for Communication* does not yet appear to have been published. We'll be watching for it.
i4is has long been interested in ETI communication. For example Principium reviewed *Extraterrestrial Languages,* by Daniel Oberhaus in issue 31, November 2020 (i4is.org/principium-31).

Are extraterrestrials like us?

Human xenophobia inclines our species to believe that ETIs will differ greatly from ourselves but researchers may more productively look at similarities or at parallels with ourselves. In *Projections of Earth's technosphere: Scenario modeling, worldbuilding, and overview of remotely detectable technosignatures* (arxiv.org/abs/2409.00067), Jacob Haqq-Misra, George Profitiliotis and Ravi Kopparapu (of Blue Marble Space, Seattle, and NASA Goddard Space Flight Center) devise scenarios for our technological future and suggest the resultant techno-signature we would emit. Several of them would appear pre-agricultural. They suggest that such scenarios provide a vital background to our expectations of alien technosignatures.
They analyse using –

Table 1. Global factors multidimensional matrix. This matrix specifies the possible values for the economic, political, and social system factors across our scenario space (Credit: Haqq-Misra et al.

X	Economy	Y	Politics	C	Society
X1	Scarcity	Y1	Rule by one	Z1	Hierarchical
X2	Non-scarcity	Y2	Rule by few	Z2	Distributed
		Y3	Rule by all		
		Y4	Rule by none		

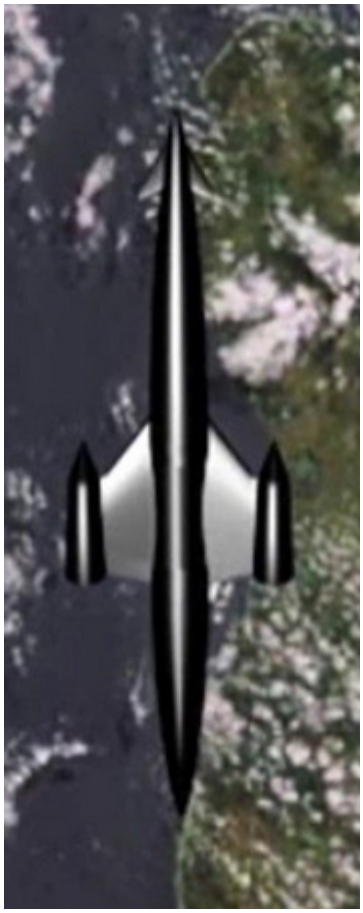
- and Anthropic's "*Claude*", a large language model (LLM) using the "Constitutional AI" process (www.anthropic.com/claude).
They construct a theoretical worldbuilding pipeline including a set of basic assumptions that are common to all scenarios:
(1) humans have not gone extinct;
(2) humans have not speciated;
(3) humans are the only terrestrial animal capable of producing technology;
(4) no extraterrestrial technology has interfered with human technological development; and
(5) the scenario takes place 1,000 years in the future.
They assert that this work pioneers the use of such Earth-extrapolation methods to envisage possible alien technosignatures.

Are Dark Comets just old rockets?

In *Study of Venera Spacecraft Trajectories and Wider Implications* (arxiv.org/abs/2506.09478), Adam Hibberd, i4is lead astrodynamicist, investigates trajectories of objects currently referred to as "dark comets" (eg www.jpl.nasa.gov/news/nasa-researchers-discover-more-dark-comets/). He notes that the Soviet Venera programme, an interplanetary campaign, centred around missions to the planet Venus, was beset with difficulties. Many are now in heliocentric orbits and Adam has found previous research speculating that these have been incorrectly identified as dark comets. He has found that several of these show invariance of their Earth Tisserand parameter (en.wikipedia.org/wiki/Tisserand%27s_parameter) suggesting they could be Venera probes.
Historically, there is no doubt that the early years of the USSR space programme put them way ahead of the competition (the USA). Nonetheless, although this was not what the Russians wished to present to the world, the interplanetary campaign, centred around missions to the planet Venus (the Venera programme) was also beset with difficulties. Many of the early Venera probes failed, despite making it to a heliocentric orbit, but naturally the success rate improved with time. The result is that there are now many Venera probes in heliocentric orbits, either completely intact, or the main bus after a successful deployment of the lander; together with the associated Blok-L upper stages. This paper is a response to some previous quite contentious research proposing that a certain member of a new class of objects, designated, may in fact be the Venera-2 probe. In this paper Adam looks into the invariance of the Earth Tisserand parameter in an attempt to establish if there are indeed any members of this class which could be Venera probes. It is found, with extremely small probability, that compared to a sample of randomly chosen NEOs, members of the class of Dark Comet have an Earth Tisserand unusually close to 3, a property shared by the Venera missions. Furthermore there are particular associations of three Dark Comets with three of these probes, the most significant being with the Venera-12 mission.

Skylon reborn?

Again, not strictly interstellar but economic access to low earth orbit is a natural precursor to human expansion into the Solar System. Followers of launcher technology including Principium readers will have been aware of efforts to develop spaceplanes as an alternative to vertical takeoff – vertical landing (such as SpaceX in the USA). The most mature of these was the air-breathing rocket using an atmosphere pre-cooler under development by Reaction Engines Limited (REL). Sadly REL fell into administration in October 2024. However consultancy Frazer Nash have now announced (www.fnc.co.uk/discover-frazer-nash/news/pioneering-new-programme-to-realise-lift-off-for-horizontal-space-launch/) that it has "welcomed a team of experts from Reaction Engines Ltd (REL) into their company who have been developing and demonstrating pre-cooler technology for more than a decade". The new vehicle concept is called *Invictus* and it looks remarkably similar to the REL *Skylon* concept –
Perhaps an aerodynamicist could comment on the move of the wing and engines to the rear?

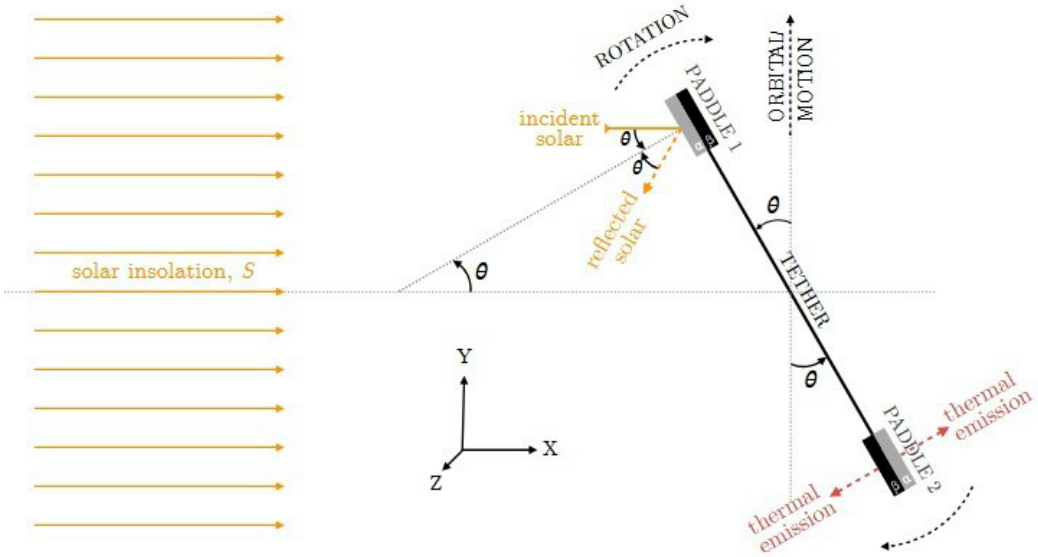


LEFT: The *Invictus* vehicle.
Credit: Frazer Nash video vimeo.com/1101204441/719f1e7261

RIGHT: The *Skylon* vehicle.
Credit: Reaction Engines Limited (REL) video *Reaction Engines Ltd* Skylon

Spinning to the stars

In *Torqued Accelerator using Radiation from the Sun (TARS) for Interstellar Payloads*, David Kipping and Kathryn Lampo of Columbia University propose to convert solar radiation pressure into rotational kinetic energy using a device which operates like a windmill to store energy as rotational momentum.
Balanced in a quasi-satellite position at constant radius from the Sun the system can store energy indefinitely, limited only by material issues. The setup looks like the Crookes Radiometer of ancient memory.
Though the usual terrestrial device does on rely on photon pressure.
The propose quasi-satellite would rely on differential pressure from sails with a reflecting side and an absorbing side.



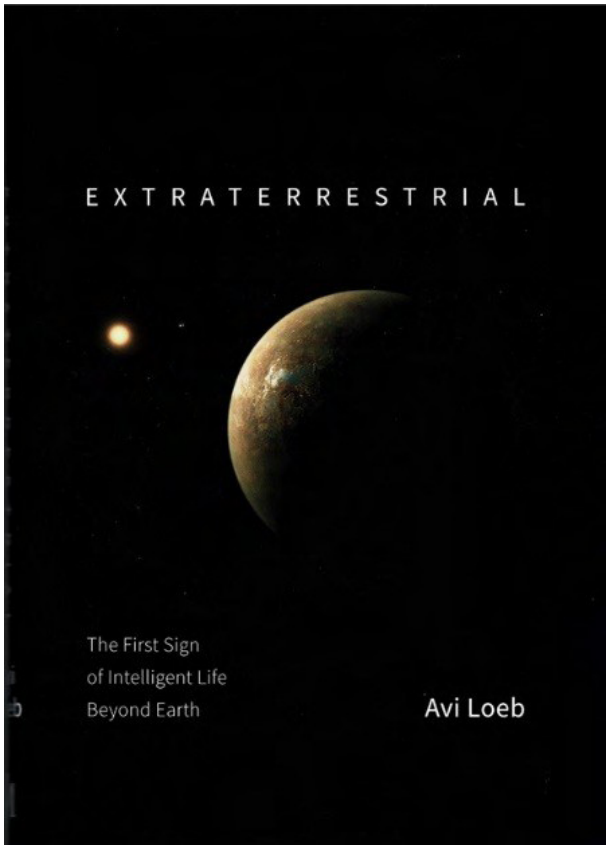
A simplified version of the TARS system. Here, the system comprises of one tether and two paddles, which together are orbiting around the Sun, with an instantaneous velocity vector along the Y -axis. Incident solar radiation is largely reflected by the α-surface (the reflective surface) of the paddles, but largely absorbed by the β-surface. This leads to a radiation pressure torque that gradually spins up TARS. Note that both paddles experience both reflection and emission; we only show one of each for the sake of visual clarity in the above.
Credit (image and caption): Kipping and Lampo Figure 1.

The parallel with the Spinlaunch idea (www.spinlaunch.com/) is fairly clear.
There will be a net outward force on the spinning TARS system and the paper proposes to balance this by orbiting the Sun at a slightly lower orbit than required for a true satellite at that radius from the Sun so that the outward force is balanced by an inward gravitational force – hence the hence quasi-satellite.
The velocities achieved at the ends of the rotating assembly are limited by the strength of the tether between them and the paper mentions graphene as a possible material but prefers carbon nanotube (CNT) sheets which have only one sixth of the strength but are already proven for the role.
The paper concludes that "Although TARS can achieve escape velocity from our solar system using the Sun's radiation pressure alone, the ejection speeds are comparatively slow and thus it is worth discussing methods by which greater speeds could be attained." and discusses improving this by use of-

- the Oberth effect (perihelion thrust to maximise velocity increase)
- gravitational slingshot – as used by all deep space missions notably Voyagers 1 and 2
- additional acceleration with laser pressure as proposed by Breakthrough Starshot, a number of i4is studies and Philip Lubin, the University of California, Santa Barbara, and colleagues
- reducing the tensile stress on the tether using electrostatic forces – discussed in detail in the paper

Who's afraid of Alien Intelligence?

In *From Extraterrestrial Microbes to Alien Intelligence: Rebalancing Astronomical Research Priorities* arxiv.org/abs/2507.17790 Omer Eldadi, Gershon Tenenbaum and Abraham(Avi) Loeb, two psychologists and an astronomer, suggest that the search for habitable exoplanets receives disproportionate public funding in comparison with SETI. They point to the public interest in the three interstellar objects (ISOs) and the absence of any funding for missions to them. Prof Loeb is, of course, a long term advocate of the possibility of artificial origin of ISOs – see *Book Review: Extraterrestrial: The First Sign of Intelligent Life Beyond Earth, Avi Loeb* by Patrick Mahon in Principium 33 May 2021 i4is.org/wp-content/uploads/2021/05/Book-Review-Extraterrestrial-Loeb-Principium33-print-2105280923opt.pdf and *A 3rd Interstellar Object* (ISO) elsewhere in this Interstellar News.



Credit: UK Publisher: John Murray Press, 2021

Near Earth SETI by looking into Earth's shadow

In *A Cost-Effective Search for Extraterrestrial Probes in the Solar System* (academic.oup.com/mnras/advance-article/doi/10.1093/mnras/staf1158/8221885) published in the Monthly Notices of the Royal Astronomical Society (MNRAS) Beatriz Villarroel, Wesley A Watters, Alina Streblyanska, Enrique Solano, Stefan Geier and Lars Mattsson describe four methods for detecting extraterrestrial artefacts and probes within the Solar System -

- use of pre-Sputnik images to search for flashes from glinting objects
- use of space-borne telescopes to search for artificial objects
- examining the reflectance spectra of objects in Earth orbit, in search of the characteristic reddening that may imply long-term exposure of metallic surfaces to space weathering.
- using Earth's shadow as a filter when searching for optically luminous objects in near-Earth space

They focus on demonstrating the latter by conducting two searches for transients in images acquired by the Zwicky Transient Facility (ZTF), which has generated many repeated 30-second exposures of the same fields. Having identified previously uncatalogued events at short angular separations from the centre of the shadow, motivating more extensive searches using this technique, they conclude that the Earth's shadow "presents a new and exciting search domain for near-Earth SETI" and thus "a new and exciting search domain for near-Earth SETI".