Have Starship, Will Travel

The Newsletter of the Interstellar Research Group

Issue 23
June 2021

Newsletter Contents

Go to irg.space/irg-2021/ for more info!

NEW EPISODE OF FROM HERE TO THE STARS AVAILABLE NOW

In the latest episode of From Here to the Stars, the team interviews Ken Roy and Martha Knowles, both are co-founders of the Interstellar Research Group. They discuss the challenges of interstellar spaceflight, the founding of IRG (titled the Tennessee Valley Interstellar Workshop at the time), and more.

Check it out on the IRG Youtube channel. Subscribe to be notified of all the other thought-provoking interviews and lectures coming to the IRG YouTube space in the coming months.

Recommendations for guests? Let us know!

If you prefer audio formats, From Here to the Stars is also available as a podcast.

Check out all past and future videos at https://irg.space/from-here-to-the-stars/.

CALL FOR PAPERS 7TH INTERSTELLAR SYMPOSIUM

Abstracts due June 30, 2021

The Interstellar Research Group (IRG) hereby invites participation in its 7th Interstellar Symposium, hosted by The University of Arizona to be held from Friday, September 24 through Monday, September 27, 2021, in Tucson, Arizona. The Interstellar Symposium has the following elements:

The Interstellar Symposium focuses on all aspects of interstellar travel (human and robotic), including power, communications, system reliability/maintainability, psychology, crew health, anthropology, legal regimes and treaties, ethics, and propulsion with an emphasis on possible destinations (including the status of exoplanet research), life support systems, and habitats.

Working Tracks are collaborative, small group discussions around a set of interdisciplinary questions on an interstellar subject with the objective of producing "roadmaps" and/or publications to encourage further developments in the respective topics. This year we will be organizing the Working Tracks to follow selected plenary talks with focused discussions on the same topic.

Sagan Meetings. Carl Sagan famously employed this format for his 1971 conference at the Byurakan Observatory in old Soviet Armenia, which dealt with the Drake Equation. Each Sagan Meeting will invite five speakers to give a short presentation staking out a position on a particular question. These speakers will then form a panel to engage in a lively discussion with the audience on that topic.

Seminars are 3-hour presentations on a single subject, providing an in depth look at that subject. Seminars will be held on Friday, September 24, 2021, with morning and afternoon sessions. The content must be acceptable to be counted as continuation education credit for those holding a Professional Engineer (PE) certificate.

Other Content includes, but is not limited to, posters, displays of art or models, demonstrations, panel discussions, interviews, or public outreach events.

Publications: Since the IRG serves as a critical incubator of ideas for the interstellar community. We intend to publish the work of the 7th Symposium in many outlets, including a complete workshop proceedings in book form. No Paper, No Podium: If a written paper is not submitted by the final manuscript deadline (To Be Announced), authors will not be permitted to present their work at the event. Papers should be original work that has not been previously published. Select papers may be submitted for journal publication, such as in the Journal of the British Interplanetary Society (JBIS).

Video and Archiving: All symposium events may be captured on video or in still images for use on the IRG and other sponsors websites, in newsletters and social media. All presenters, speakers and selected participants will be asked to complete a Release Form that grants permission for IRG to use this content as described.

ABSTRACT SUBMISSION

Abstracts for the Interstellar Symposium must relate to one or more of the many interstellar mission related topics, such as power, communications, system reliability/maintainability, psychology, crew health, anthropology, legal regimes and treaties, ethics, and propulsion with an emphasis on possible destinations (including the status of exoplanet research), life support systems, and habitats.

All abstracts must be submitted online **here.** Submitters must create accounts on the IRG website in order to submit abstracts.

PRESENTING AUTHOR(S) – Please list ONLY the author(s) who will actually be in attendance and presenting at the conference. (first name, last name, degree –for example, Susan Smith, MD)

ADDITIONAL AUTHORS – List all authors here, including Presenting Author(s) – (first name, last name, degree(s) – for example, Mary Rockford, RN; Susan Smith, MD; John Jones, PhD)

ABBREVIATIONS within the body should be kept to a minimum and must be defined upon first use in the abstract by placing the abbreviation in parenthesis after the represented full word or phrase. Proprietary drug names and logos may NOT be used. Non-proprietary (generic) names should be used.

ABSTRACT LENGTH – The entire abstract, (EXCLUDING title, authors, presenting author's institutional affiliation(s), city, state, and text), including any tables or figures should be a maximum of 350 words. It is your responsibility to verify compliance with the length requirement.

ABSTRACT STRUCTURE - abstracts must include the following headings:

Title – the presentation title
Background – describes the research or initiative context
Objective – describes the research or initiative objective
Methods – describes research methodology used. For initiatives, describes the target population, program or curricular content, and evaluation method
Results – summarizes findings in sufficient detail to support the conclusions
Conclusions – states the conclusions drawn from results, including their applicability.

Questions and responses to this Call for Papers, Workshops and Participation should be directed to: info@irg.space.

For updates on the meeting, speakers, and logistics, please refer to the website: https://irg.space/irg-2021/

The Tennessee Valley Interstellar Workshop (doing business as the Interstellar Research Group, IRG) is a non-profit scientific, educational corporation in the state of Tennessee. For U.S. tax purposes, IRG is a tax-exempt, 501(c)(3) educational, non-profit corporation.

EXTRATERRESTRIAL: 'OUMUAMUA AS ARTIFACT
BY PAUL GILSTER

The reaction to Avi Loeb's new book *Extraterrestrial* (Houghton Mifflin Harcourt, 2021) has been quick in coming and dual in nature. I've seen a certain animus being directed at the author in social media venues frequented by scientists, not so much for suggesting the possibility that 'Oumuamua is an extraterrestrial technological artifact, but for triggering a wave of misleading articles in the press. The latter, that second half of the dual reaction, has certainly been widespread and, I have to agree with the critics, often uninformed.

But let's try to untangle this, which I want to do while noting that what follows is emphatically a personal assessment that does not necessarily reflect the views of the Interstellar Research Group as an entity or the various people who are making IRG continue to grow. Consider what follows my own opinionated look at a book that will not cease being controversial.

Because my various software Net-sweepers collect most everything that washes up on 'Oumuamua, I've seen stark headlines such as "Why Are We So Afraid of Extraterrestrials," or "When Will We Get Serious about ET?" I'm making those particular headlines up, but they catch the gist of many of the stories I've seen. I can see why some of the scientists who spend their working days digging into exoplanet research, investigate SETI in various ways or ponder how to build the spacecraft that are helping us understand the Solar System would be nonplussed. Like them, we at IRG have always taken these matters seriously.

I would argue that the scientific community at large is, in fact, approaching the hypothesis of extraterrestrial life, even intelligent extraterrestrial life, with more interest now than ever before. But I don't see Avi Loeb saying anything that discounts that work. What I do see him saying in *Extraterrestrial* is that in the case of 'Oumuamua, scientists are reluctant to consider a hypothesis of extraterrestrial technology even though it stands up to scrutiny -- as a hypothesis -- and offers as good an explanation as others I've seen. Well actually, better, because as Loeb says, it checks off more of the needed boxes.

Invariably, critics quote Sagan: "Extraordinary claims require extraordinary evidence." Loeb is not overly impressed with the formulation, saying "evidence is evidence, no?" And he goes on: "I do believe that extraordinary conservatism keeps us extraordinarily ignorant. Put differently, the field doesn't need more cautious detectives." Fighting words, those. A solid rhetorical strategy, perhaps, but then caution is also baked into the scientific method, as well it should be. So let's talk about caution and 'Oumuamua.

Loeb grew up on his family's farm south of Tel Aviv, hoping at an early age to become a philosopher but delayed in the quest by his military service, where he likewise began to turn to physics. An early project was the use of electrical discharges to propel projectiles, a concept that wound up receiving funding from the US Strategic Defense Initiative during the latter era of the Cold War. He proceeded to do postgraduate work at the Institute for Advanced Study in Princeton, mixing with the likes of Freeman Dyson and John Bahcall, and moved on to become a tenured professor at Harvard. Long before 'Oumuamua, his life had

begun to revolve around the story told in data. He seems to have always believed that data would lead him to an audacious conclusion, and perhaps primed by his childhood even to expect such an outcome.

I also detect a trace of the mischief-maker, though a very deliberate one. To mix cultures outrageously, Loeb came out of Beit Hanan with a bit of Loki in him. And he's shrewd: "You ask nature a series of questions and listen carefully to the answers from experiments," he writes of that era, a credo which likewise informs his present work. *Extraterrestrial* is offered as a critique of the way we approach the unknown via our scientific institutions, and the reaction to the extraterrestrial *hypothesis* is displaying many of the points he's trying to make.

Can we discuss this alien artifact hypothesis in a rational way? Loeb is not sure we can, at least in some venues, given the assumptions and accumulated inertia he sees plaguing the academic community. He describes pressure on young postdocs to choose career paths that will fit into accepted ideas. He asks whether what we might call the science 'establishment' is simply top-heavy, a victim of its own inertia, so that the safer course for new students is not to challenge older models.

These seem like rational questions to me, and Loeb uses 'Oumuamua as the rhetorical church-key that pops open the bottle. So let's look at what we know about 'Oumuamua with that in mind. The things that trigger our interest and raised eyebrows arrive as a set of anomalies. They include the fact that the object's brightness varied by a factor of ten every eight hours, from which astronomers could deduce an extreme shape, much longer than wide. And despite a trajectory that had taken it near the Sun, 'Oumuamua did not produce an infrared signature detectable by the Spitzer Space Telescope, leading to the conclusion that it must be small, perhaps 100 yards long, if that.

'Oumuamua seemed to be cigar-like in shape, or else flat, either of these being shapes that had not been observed at these extremes in naturally occurring objects in space. Loeb also notes that despite its small size and odd shape, the object was ten times more reflective than typical asteroids or comets in our system. Various theories spawned from all this try to explain its origins, but a slight deviation in trajectory as 'Oumuamua moved away from the Sun stood out in our two weeks of data. That deviation also took it out of the local standard of rest, which in itself was an unusual place for it to have been until its encounter with our Sun caused its motion to deviate. Loeb points out that this occurred despite a lack of evidence for either a cometary tail or gas emission and absorption lines. All this despite an approach to the Sun of a tight 0.25 AU.

The fact that we do not see outgassing that could cause this acceleration is not the problem. According to Loeb's calculations, such a process would have caused 'Oumuamua to lose about a tenth of its mass, and he points out that this could have been missed by our telescopes. What is problematic is the fact that the space around the object showed no trace of water, dust or carbon-based gases, which makes the comet hypothesis harder to defend. Moreover, whatever the cause of the acceleration, it did not change the spin rate, as we would expect from asymmetrical, naturally occurring jets of material pushing a comet nucleus in various directions.

Extraterrestrial should be on your shelf for a number of reasons, one of which is that it encapsulates the subsequent explanations scientists have given for 'Oumuamua's trajectory, including the possibility that it was made entirely of hydrogen, or the possibility that it began to break up at perihelion, causing its outward path to deviate (again, no evidence for this was evident to our instruments). And, of course, he makes the case for his hypothesis that sunlight bouncing off a thin sail would explain what we see, citing recent work on the likelihood that the object was disk-shaped.

So what do we do with such an object, beyond saying that none of our hypotheses can be validated by future observation since 'Oumuamua is long gone? Now we're at the heart of the book, for as we've seen, *Extraterrestrial* is less about 'Oumuamua itself and more about how we do science, and what the author sees as a too conservative approach that is fed by the demands of making a career. He's compelled to ask: Shouldn't the possibility of 'Oumuamua being an extraterrestrial artifact, a technological object, be a bit less controversial than it appears to be, given the growth in our knowledge in recent decades? Let me quote the book:

> Some of the resistance to the search for extraterrestrial intelligence boils down to conservatism, which many scientists adopt in order to minimize the number of mistakes they make during their careers. This is the path of least resistance, and it works; scientists who preserve their images in this way receive more honors, more awards, and more funding. Sadly, this also increases the force of their echo effect, for the funding establishes ever bigger research groups that parrot the same ideas. This can snowball; echo chambers amplify conservatism of thought, wringing the native curiosity out of young researchers, most of whom feel they must fall in line to secure a job. Unchecked, this trend could turn scientific consensus into a self-fulfilling prophecy.

Here I'm at sea. I've been writing about interstellar studies for the past twenty years and have made the acquaintance of many scientists both through digital interactions and conversations at conferences. I can't say I've found many who are so conservative in their outlook as to resist the idea of other civilizations in the universe. I see ongoing SETI efforts like the privately funded Breakthrough Listen, which Loeb is connected to peripherally through his work with the Breakthrough Starshot initiative to send a probe to Proxima Centauri or other nearby stars. The book contains the background of Starshot by way of showing the public how sails might make sense as the best way to cross interstellar distances, perhaps like Starshot propelled by beamed energy.

I also see active research on astrobiology, while the entire field of exoplanetary science is frothing with activity. To my eye as a writer who covers these matters rather than a scientist, I see a field that is more willing to accept the possibility of extraterrestrial intelligence than ever before. But I'm not working within the field as Loeb is, so his chastening of tribal-like patterns of behavior reflects, I'm sure, his own experience.

Loeb's ideas on the deviation of 'Oumuamua's trajectory were produced according to what he describes in the book as "the same scientific tenet I had always followed -- a hypothesis that satisfied all the data ought to be considered." If nature wasn't producing objects shaped like that of a lightsail that could apparently accelerate through the pressure of photons from a star, then an extraterrestrial intelligence was the exotic hypothesis that could explain it.

The key statement: "If radiation pressure is the accelerating force, then 'Oumuamua represents a new class of thin interstellar material, either produced naturally...or is of an artificial origin."

After this, Loeb goes on to say, "everything blew up." Which is why on my neighborhood walks various friends popped up in short order asking: "So is it true? Is it ET?" I could only reply that I had no idea, and refer them to online discussions of Loeb's book. Headlines announcing that a Harvard astronomer had decided 'Oumuamua was an alien craft sprouted all over the Internet. I can see why many in the field found this a nuisance, as they're being besieged by people asking the same questions, and they have other work they'd presumably like to get on with.

So there are reasons why *Extraterrestrial* is, to some scientists, a needling, even cajoling book. But having to talk about one's work is part of the job description, isn't it? It was Ernest Rutherford who said that a good scientist should be able to explain his ideas to a barmaid. In these parlous times, we might change Rutherford's dismissive 'barmaid' to a gender-neutral 'blog writer' or some such. But the point seems the same.

Isn't communicating ideas part of the job description of anyone employed to do scientific research? So much of that research is funded by the public through their tax dollars, after all. If Loeb's prickly book is forcing some scientists to take the time to explain why they think his hypothesis is unlikely, I cannot see that as a bad thing. Good for Avi Loeb, I'd say.

And whatever 'Oumuamua is, we may all benefit from the discussion it has created. I enjoyed Loeb's section on exotic theories within the physics community -- he calls these "fashionable thought bubbles that currently hold sway in the field of astrophysics," and in many quarters they seem comfortably accepted:

> Despite the absence of experimental evidence, the mathematical ideas of supersymmetry, extra-spatial dimensions, string theory, Hawking radiation, and the multiverse are considered irrefutable and self-evident by the mainstream of theoretical physics. In the words of a prominent physicist at a conference that I attended: 'These ideas must be true even without experimental tests to support them, because thousands of physicists believe in them and it is difficult to imagine that such a large community of mathematically gifted scientists could be wrong.'

That almost seems like a straw man argument, except that I don't doubt someone actually said this -- I've heard more or less the same sentiment voiced at conferences myself. Even so, I doubt many of the scientists I've gotten to know would go that far. But the broader point is sound. Remember, Loeb is all about data, and isn't it true that multiverse ideas take us well beyond the realm of testable hypotheses? And yet many support them, as witness Leonard Susskind in his book *The Black Hole War* (2008):

> There is a philosophy that says that if something is unobservable -- unobservable in principle -- it is not part of science. If there is no way to falsify or confirm a hypothesis, it belongs to the realm of metaphysical speculation, together with astrology and spiritualism. By that standard, most of the universe has no scientific reality -- it's just a figment of our imaginations.

So Loeb is engaging on this very charged issue that goes to the heart of what we mean by a hypothesis, about the falsifiability of an idea. We know where he stands:

> Getting data and comparing it to our theoretical ideas provides a reality check and tells us we are not hallucinating. What is more, it reconfirms what is central to the discipline. Physics is not a recreational activity to make us feel good about ourselves. Physics is a dialogue with nature, not a monologue.

You can see why *Extraterrestrial* has raised hackles in some quarters, and why Loeb is being attacked for declaring 'Oumuamua a technology. But of course he hasn't announced 'Oumuamua was an alien artifact. He's said this is a hypothesis, not a statement of fact, and that it fits what we currently know, and that it is a plausible hypothesis and perhaps the most plausible among those that have been offered.

He goes on to call for deepening our commitment to Dysonian SETI, looking for signs of extraterrestrial intelligence through its artifacts, a field becoming known as astro-archaeology. And he considers what openness to the hypothesis could mean in terms of orienting our research and our imagination under the assumption that extraterrestrial intelligence is a likely outcome that should produce observables.

As I said above, *Extraterrestrial* should be on your shelf because it is above all else germane, with 'Oumuamua being the tool for unlocking a discussion of how we do research and how we discuss the results. My hope is that it will give new public support to ongoing work that aims to answer the great question of whether we are alone in the universe. A great deal of that work continues even among many who find the 'Oumuamua as technology hypothesis far-fetched and believe it over-reaches.

Is science too conservative to deal with a potentially alien artifact? I don't think so, but I admire Avi Loeb for his willingness to shake things up and yank a few chains along the way. The debate makes for compelling drama and widens the sphere of discourse. He may well be right that by taking what he calls ''Oumuamua's Wager" (based on Pascal's Wager, and advocating for taking the extraterrestrial technology hypothesis seriously) we would open up new research channels or revivify stagnant ones.

Some of those neighbors of mine that I've mentioned actually dug 'Oumuamua material out of arXiv when I told them about that service and how to use it, an outcome Ernest Rutherford would have appreciated. I see Extraterrestrial as written primarily for people like them, but if it does rattle the cages of some in the physics community, I think the field will somehow muddle through. Add in the fact that Loeb is a compelling prose stylist and you'll find your time reading him well spent.

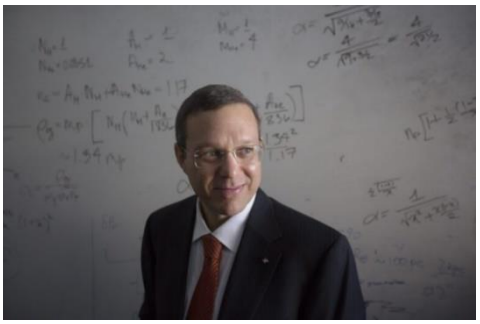

Image: Avi Loeb. **Credit**: Kris Snibbe / Harvard file photo.

A HELIOPHYSICS CONNECTION TO INTERSTELLAR PLANNING
BY PAUL GILSTER

You would think that heading toward the Sun, rather than away from it, would not necessarily fall under the purview of the Interstellar Research Group, but missions like the Parker Solar Probe have reminded us that extreme environments are ideal testing grounds for future missions. Build a heat shield that can take you to within 10 solar radii of our star and you're also exploring possibilities in 'sundiver' missions that all but brush the Sun in a tight gravity assist.

Are missions to the Sun relevant to our interstellar ambitions? At the current state of technology, the answer is yes. Consider the European Space Agency-led Solar Orbiter, which left our planet in February on a United Launch Alliance Atlas V rocket, lifting off from Launch Complex 41 at Cape Canaveral Air Force Station in Florida. Herewith the gorgeous arc of ascent:

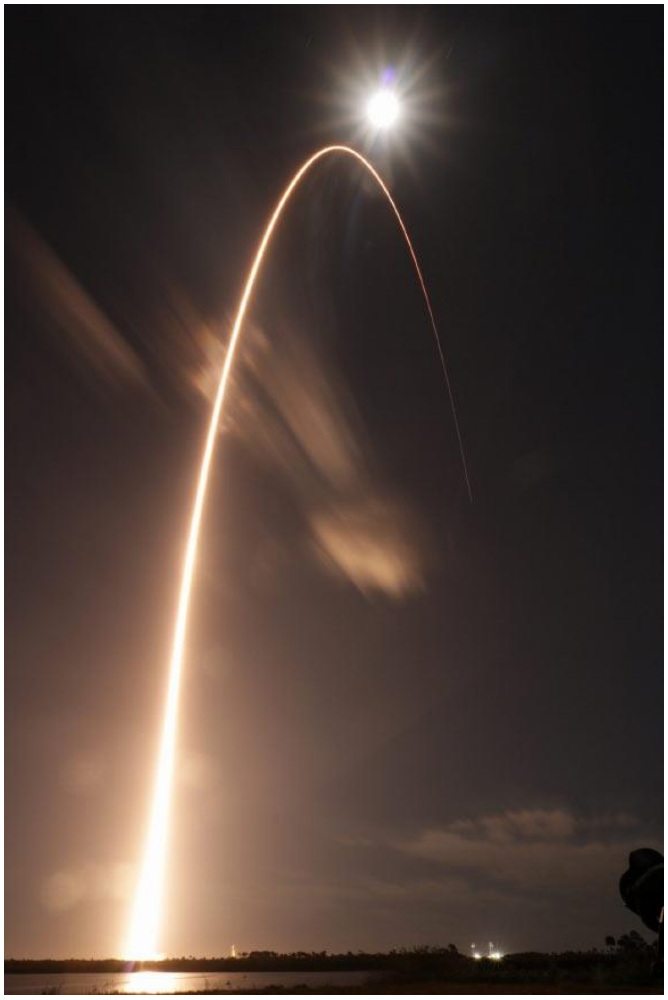

Image: Launch of the ESA/NASA Solar Orbiter mission to study the Sun from Cape Canaveral Air Force Station in Florida on Feb. 9, 2020. Credit: Jared Frankle.

The Prospects for Solar Orbiter

Missions to the Sun allow us to explore conditions close to a star and, significantly, deep in its gravity well, where interesting things can happen. When we discuss one way of propelling a sail beyond the heliosphere, the irony is that an Oberth maneuver, which takes place at a few solar radii, can bring additional chemical propulsion online at perihelion to extract the maximum push. So in propulsive terms, we go to the Sun in order to get flung from the Sun at highest speed. If we want to get beyond the heliosphere fast and with today's tools, the Sun is a major factor.

Solar Orbiter is not, of course, designed around interstellar matters, but the synchronicity here works well for us. The more data about conditions near the Sun, the better for what we will want to do in the future. Günther Hasinger is the European Space Agency's director of science:

> "As humans, we have always been familiar with the importance of the Sun to life on Earth, observing it and investigating how it works in detail, but we have also long known it has the potential to disrupt everyday life should we be in the firing line of a powerful solar storm. By the end of our Solar Orbiter mission, we will know more about the hidden force responsible for the Sun's changing behavior and its influence on our home planet than ever before."

And, I would add, we'll know a great deal more about how spacecraft operate inside Mercury's orbit. Moreover, think about all the interesting maneuvers that are involved to make this happen. Three gravity assists aid Solar Orbiter's passage, two of them past Venus in late 2020 and August of 2021, and one past Earth in November of 2021. The first close pass of the Sun will be in 2022, at about a third of an AU, with the gravity of Venus being used to push Solar Orbiter up out of the ecliptic plane. Ulysses achieved an inclined orbit in 1990, but Solar Orbiter will be carrying cameras allowing us to directly image the Sun's poles, a role for which Ulysses was not equipped. The spacecraft is to reach an inclination 17 degrees above and below the solar equator.

Solar Orbiter has much to teach us about interstellar possibilities, as does, for that matter, the continuing Parker Solar Probe mission. Along the way we learn, in addition to the significant science return about the Sun itself, about how spacecraft cope with being subjected to the solar wind and the temperatures of passage near the Sun. Solar Orbiter's 10 scientific instruments will measure electric and magnetic fields, passing particles and waves, solar atmospheric conditions and the outflow of material. We'll learn about heat shielding and how to minimize what is needed so as to maximize payload. Solar Orbiter will face temperatures of up to 500º C, 13 times that experienced by satellites in Earth orbit.

Solar Cruiser: A Large Solar Sail Near the Sun

So if we're thinking deep space today, we should also be thinking about heliophysics. Our best bet at getting a successor to the Voyager missions well beyond the heliosphere and at significantly higher speeds that Voyager 1 is a close solar pass and propulsive kick that will demand deep knowledge of conditions at perihelion. All these are factors as we contemplate the close approaches that will fling solar sails into the Kuiper Belt. In not many years, we could build a 'sundiver' mission that would

make for great heliophysics as well as data from deep space — two missions in one.

But in this pre-Sundiver era, consider two proposals NASA has been studying in the area of small satellite technologies, which grow directly out of its heliophysics program. Here, the study of the Sun's interactions with the Solar System, and the consideration of Sun, planets and heliosphere as a deeply interconnected system, takes pride of place. The first mission is called SETH — Science-Enabling Technologies for Heliophysics. One of its two technology demonstrators, the HELio Energetic Neutral Atom (HELENA) detector, involves solar energetic neutral atoms, which can provide advanced warnings of potential radiation threats to astronauts.

The other demonstrator aboard SETH is an optical communications technology expressly designed for CubeSats and other small satellites, one that could allow a hundred-fold increase in the return of deep space data. Building out a robotic infrastructure in the Solar System will involve increasingly miniaturized technologies. We can envision small satellite constellations that can network and operate one day in 'swarm' fashion to create a continuous presence around targets ranging from asteroids to the gas and ice giants that can shape their orbits.

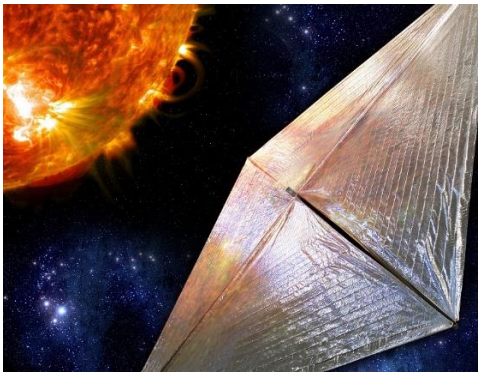

Image: Solar Cruiser will study the Sun in new ways, while teaching us a great deal about operations in this environment. Credit: NASA.

The second of these missions is called Solar Cruiser, and now the interstellar implications begin to multiply. This is a large solar sail that could maintain non-Keplerian orbits, allowing it to investigate the Sun's high latitudes. Its two technology demonstrations involve measurements of the Sun's magnetic field structure and the velocity of coronal mass ejections (CMEs), those vast explosions of plasma that can create space weather nightmares for utility grids on Earth.

Making this mission possible will be a solar sail of almost 1,700 square meters. The timing on this proposal seems propitious given The Planetary Society's success at raising the orbit of LightSail-2 using sunlight. Pushing toward much larger designs is the next step, and a path of development into deep space -- and one day interstellar -- begins to emerge:

> "This is the first time that our heliophysics program has funded this kind of technology demonstration," said Peg Luce, deputy director of the Heliophysics Division at NASA Headquarters. "Providing the opportunity to mature and test technologies in deep space is a crucial step towards incorporating new techniques into future missions."

Solar Cruiser would not only be by far the largest solar sail yet deployed, but would also experiment with using the momentum of sunlight to continuously modify its orbit. This would allow us to obtain views of the Sun that orbits involving gravity alone would not make possible.

Robert Forward explored the original concept and introduced it to the public first in the pages of *Analog* and then in his book *Indistinguishable from Magic* (1995), where he considered how we might use such spacecraft near the Earth. He called a spacecraft that uses a solar sail to hover over a region rather than orbiting the Earth a 'statite,' and explained it this way:

> …I have the patent on it — U.S. Patent 5,183,225 "Statite: Spacecraft That Utilizes Light Pressure and Method of Use"… The unique concept described in the patent is to attach a television broadcast or weather surveillance spacecraft to a large highly reflective lightsail, and place the spacecraft over the polar regions of the Earth with the sail tilted so the light pressure from the sunlight reflecting off the lightsail is exactly equal and opposite to the gravity pull of the Earth.

Here we are using a solar sail for station-keeping rather than transport, and Solar Cruiser may turn out to be the first time we experiment with the technique, which offers options that other kinds of satellite do not:

> With the gravity pull nullified, the spacecraft will just hover over the polar region, while the Earth spins around underneath it. Since the spacecraft is not in orbit around the Earth, it is technically not a satellite, so I coined the generic term 'statite' or '-stat' to describe any sort of non-orbiting spacecraft (such as a 'weatherstat' or 'videostat' or 'datastat').

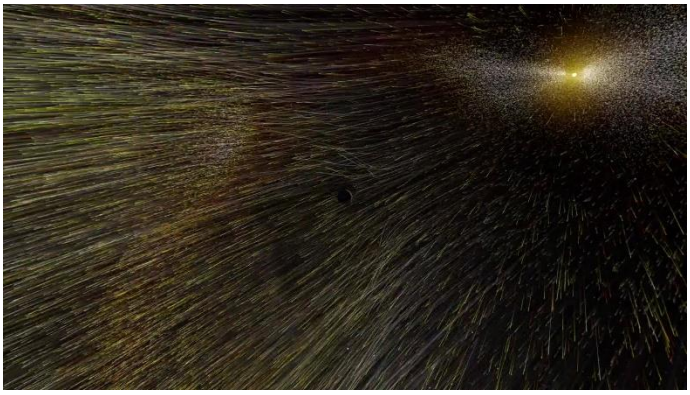

Image: The Sun is emerging as a crucial factor in next-generation thinking about leaving the Solar System. Image credit: NASA.

Can Solar Cruiser push these ideas forward in orbits near the Sun? Forward called orbits that are non-Keplerian 'displaced orbits' and also referred to such satellites as 'polesitters.' It will be fascinating to see how far Solar Cruiser will explore such capabilities as part of its larger mission, which should also teach us much about large sail materials and deployment. The mission was recently selected to share a ride into space in 2025 with NASA's Interstellar Mapping and Acceleration Probe (IMAP). Because large sails and close solar passes may be our best bet for getting new missions beyond the heliosphere, Solar Cruiser is emerging as a critical test of methods and material and a harbinger of faster, even larger sails to come.

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UPCOMING INTERSTELLAR AND SPACE EVENTS

Summer 2021. Boeing's CST-100 Starliner Orbital Flight Test 2 launch to the ISS

5 July 2021. Happy aphelion day! Earth is furthest from the sun.

15 July 2021. Roscosmos's Nauka, or the Multipurpose Laboratory Module (MLM), module will launch to the ISS

Mid-2021. China will launch the Shenzhou 12 spacecraft taking Chinese astronauts on the first crewed mission to the new Chinese space station.

25-17 September 2021. IRG 7th Symposium. Website: https://irg.space/irg-2021/

16 October 2021. NASA launches its Lucy mission to study the Trojan asteroids

25-29 October 2021. International Astronautical Congress in Dubai, United Arab Emirates. Website: https://www.iafastro.org/events/iac/iac-2021/

31 October 2021. NASA launches its James Webb Space Telescope.

November 2021. NASA's Artemis I uncrewed lunar orbital test flight