

# Have Starship, Will Travel

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### A RESPONSE TO DARK SKIES REVIEW BY KEN ROY

Dark Skies: Space Expansionism, Planetary Geopolitics, and the Ends of Humanity

**By Daniel Deudney\*** 

\*Professor Deudney teaches political science, international relations, and political theory at Johns Hopkins University.

This is a hard book to read, in large part due to the academic writing style. Although there are a number of interesting arguments in the book, the lack of clarity and conciseness make them somewhat difficult to access. Once you get past the writing style, Deudney argues that humanity's expansion into space will decrease the probability of human survival. Deudney raises some good questions relative to the future of Earth and actually makes a few good points applicable to humanity's expansion into the solar system and beyond. Science fiction readers and space enthusiasts will not enjoy this book, but it is important that we try to understand and evaluate Deudney's arguments, rather than dismiss them out of hand. You should appreciate your enemies, they will point out things that your friends and allies will never mention, things that you probably need to know.

Prometheans argue that scientific and technological advances allow for the total transformation of the human condition, a realization of utopia, with material abundance and even individual immortality. Starting with the industrial revolution, this trajectory seems to be leading to a very positive future for humanity. But around the mid twentieth century a number of concerns surfaced suggesting a much more pessimistic end to the Promethean vision. The concerns include nuclear and biological weapons, genetic engineering, artificial intelligence, environmental collapse, and even new forms of despotism based on advanced surveillance and coercion technologies. But all technology is always a two-edged sword capable of great good and great harm depending on the intentions and even wisdom of the humans that utilize them. This is this dilemma on which Dr. Deudney bases his central argument. He seems to suggest that because the sword can indeed harm the owner, perhaps he is better off without it. Or if he absolutely must have a sword, he should made it as harmless as possible. He argues that humanity should be able to discern which technologies offer more risk than reward and should thus be proscribed while pursing technologies and policies that offer great reward for only minor risk. He argues that colonization of space and the exploitation of space-based resources belongs in the former category and should be prohibited.

But Deudney isn't entirely anti-space. He advocates Earthcentered space activities focused on nuclear security and environmental protection. He is okay with communication and weather satellites. He believes that space activities should be used to protected the Earth rather than expand the militarization and colonization of space. **Newsletter Contents** 

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## IRG's 7<sup>th</sup> Interstellar Symposium

Tucson, AZ 25-27 September 2021 More details on Page 6

### ARECIBO: Losing our tenuous INTERSTELLAR CONNECTION BY DAVID FIELDS

#### ABSTRACT

For over 50 years, the most sensitive radio telescope on the planet has been the single dish and associated facilities located at Arecibo, Puerto Rico. On December 1, this fine instrument suffered extensive damage as the suspended observation platform collapsed onto the primary dish. This was also our primary instrument for RADAR examinations of celestial objects and for pulsar studies. Numerous radio astronomy research programs were impacted -- these included astronomical observation, RADAR transmission and reception, pulsar research, and mentoring/training. Implications of these activities continue to be important in basic physics research, stellar evolution, outreach and training. The Arecibo functionality should be restored. It is proposed that one option for this restoration is the implementation of a more modest Arecibo2 radio telescope. configured to preserve most of the functionality of its predecessor.

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### A RESPONSE TO DARK SKIES (CONT'D) REVIEW BY KEN ROY

Advocates of humans expanding into space and exploiting the resources there Deudney terms "space expansionists." He describes space expansionism as a "complex and captivating ideology...that extrapolates and amplifies the Promethean worldview of technological modernism into a project of literally cosmic scope." He considers space expansionism to be a science-based and technology dependent religion. Space expansionists advocate for human expansion into space and that such expansion is desirable both for those lucky enough to work and live in space but also for humanity in general and the Earth in particular. According to Deudney, space expansionists promise humanity a permanent final frontier, as well as knowledge, and material and energy resources almost beyond measure that can help address Earth's environmental problems. Deudney disagrees and offers a number of arguments that are discussed below.

Two worrisome technologies that Deudney identifies as being advocated by space expansionists are genetic and cybernetic technologies. The first is also termed transhumanism or the improvement of human beings through genetic manipulation. The second is machine enhancement of human bodies and minds or possibly complete replacement of humans with machines with greater intellectual and physical capability. These two developing technologies do indeed pose many ethical questions. They would be useful but not necessary for successful expansion of humanity into space. But even if the human (or transhuman or cybernetic beings) expansion into space were to be completely banned, the issue does not go away. The transhumanism movement and the development of cybernetic technology will proceed on Earth completely independent of space activities. There is simply too much advantage to be had for those who possess it. Humans of 2020 are not the final evolutional product and Nietzsche's ubermensch (or Star Trek's Khan Noonien Sing and his augments) pose important ethical and even existential problems. But these technologies will not be avoided by restricting space expansionism.

A third technology that worries Deudney is nanotechnology. This technology enables construction of materials and machines from basic molecules. The big fear of nanotechnology is the construction of tiny machines that dissemble anything and everything they encounter and use the resulting molecules to make more of themselves, without end, until the entire planet is covered with them. This is known as the gray goo scenario and it terminates humanity and indeed all life on the Earth. But nanotechnology is actively being pursued by numerous companies and countries because it has such tremendous potential. Nanotechnology would be very useful for space development but again, not essential.

Artificial intelligence is yet another technology Deudney, and others, are very concerned about. It offers great promise and great peril. Again, because of the potential advantages, it will be developed, and while potentially very useful for space activities is not essential.

These four technologies are intertwined, very powerful, and very dangerous. But because they are potentially so valuable, and so

useful, they will be developed by someone at some point. Deudney's fear that space expansion will accelerate their development, while possible true, is irrelevant. They will be developed, unless a totalitarian world government using advanced surveillance and coercive technologies prevents it. In that case, the cure would be bad. Very bad, but in this particular case perhaps not as bad as the disease. Deudney fails to recognize that space expansionism offers some prospects for mitigating the risks of these technologies by allowing them to be developed in space at isolated research facilities that can be obliterated should something dangerous escape.

Deudney spends some time discussing the militarization of space. He seems to have associated nuclear tipped missiles and the resulting nuclear annihilation risk with space expansionism simply because such weapons of mass destruction travel through space and can arrive at any point on earth minutes after launch. He doesn't acknowledge that the first nuclear weapons were first delivered by piston engine aircraft and that today hypersonic cruise missiles can deliver such warheads just fine without going into space. The Russians have a nuclear tipped torpedos capable of destroying large harbors. Squashing the dreams of space expansionists will not in any way reduce the threat of nuclear war, and can arguably increase it due to resource depletion with increasing population pressures. Ronald Reagan's Star Wars initiative was actually intended to prevent nuclear weapons from traveling through space, but Deudney views this effort as simply another effort at the militarization of space and thus something to be resisted.

Space (including Earth orbit) is currently effectively demilitarized. No nuclear weapons are stationed in space and no kinetic or beam weapon systems exist that can operate from space. Space technology offers the possibility of Earth orbit being filled with beneficial infrastructure such as communication, surveillance, weather, and positioning satellites, along with solar power stations and even some dirty industries. Deudney points out that with the ability to place this infrastructure in orbit comes the ability to place large weapon systems as well. Orbital weapon systems would be capable of striking any point on Earth with nuclear, kinetic, or energy beam weapons within minutes of the decision to do so. It is the ultimate high ground and the nation that can achieve unchallenged military control of Earth orbit can dictate to the other nations of Earth, resulting in a de facto world government. But nuclear weapons can be delivered without having to travel through space, somewhat undermining Deudney's argument.

While a world government would probably use space-based weapons to exert control over troublesome provinces the argument that space-based weapons would lead to a world government is somewhat weak. The question of the desirability of a world government is very real but is effectively independent of the space colonization question. North Korea stands as a stark warning of what a world government might look like. Its citizens endure starvation and concentration camps while the rulers demand not just total compliance in all actions but sincere correct beliefs. Of course, the ruling elite will live very well indeed. And the North Korean political system cannot be overthrown from within. Only external forces. can remove the current system or force it to moderate its actions. A world government based on the North Korean model with advanced surveillance and coercive technologies would have no external threats to force it to

moderate its actions or ever remove it from power. One possible exception to this is human colonies on Mars or in the asteroid belt. They might serve to act as the outside force keeping the world government in check, at least somewhat.

Asteroids are common throughout the solar system and occasional will smash into Earth. Sometimes with negative consequences. Just ask the dinosaurs how that turned out for them. It has been said that asteroids are nature's way of asking, "How is your space program coming?" Space expansionists claim asteroid protection as one reason to go into space in a big way: to protect the Earth. But Deudney points out that the ability to deflect an asteroid also implies the ability to direct an asteroid to a specific destination. With such an ability in the wrong hands this actually increases the probability of a massive asteroid impact with Earth, rather than reducing it.

Deudney suggests that space settlements have a dark side. The term space settlements as used by Deudney includes lunar colonies, artificial space habitats (O'Neil cylinders, Stanford Tori, Bernal spheres, etc), asteroid settlements, and terraformed worlds. Building space settlements involves material engineering and high energies suitable for warfare. This represents a variant of the asteroid problem: in the wrong hands, this technology could do terrible things.

Terraforming is the transformation of a planet, such as Mars or Venus, to resemble the Earth and support human and other Earth life forms. Terraforming requires high energies, long time periods, and the transport of large masses around a solar system. Deudney points out that the ability to make a dead planet live also implies the ability to make a living world sterile.

In addition, space settlements individually will contain thousands, or at most a few million individuals. The life support systems and structural integrity are fragile things requiring a high degree of trust and/or control of the population to identify and remove unstable or dangerous individuals. Rather than being islands of freedom, space settlements could become, and maybe must become, micro-totalitarian states. And like the Greek city states of antiquity, they may find reasons to war amongst themselves, and perhaps with Earth. And they will war with weapons far deadlier than anything carried by the Greeks.

As space settlements are built further and further out into the outer edges of the solar system, perhaps around gas giants and their moons, they become isolated. Over time, humanity could branch into new species, perhaps unable to breed with each other. Rather than encounter aliens, we will create them. With the aid of genetic engineering and cybernetics, discussed above, this divergence could occur relatively quickly. Even with the Central Earth government and most space settlements agreeing to forgo genetic engineering and cybernetic modification of humans, it only takes one isolated space settlement to pursue this line of research to produce something quite alien and perhaps anti-human.

To the best of my ability, I have tried to identify and list here all arguments that Deudney has identified as reasons that space expansionism can decrease the probability of humanity's survival. Many of his issues are indeed existential threats to humanity but not because of what the space expansionists propose. But they are deserving of serious consideration. These include genetic engineering, cybernetics, nanotechnology, and AI. They are real threats but also real opportunities.

Expanding into space places god-like destructive powers into the hands of those moving asteroids or large mass space freighters. In all likelihood, propulsion systems will utilize fusion power of some type again giving god-like destructive powers of a different nature. Interstellar missions will be capable of moving large masses at some percentage of the speed of light. Take a space shuttle, run it up to only10% the speed of light and you have a planet killer. We should ensure that individuals embarking on the interstellar missions have a deep respect for, and love of, Earth. How do we protect Earth from the even one slightly deranged or evil individual who has control of an asteroid (or star ship) and can direct it at a target of his, or her, choice? Space expansionists need to address this question. Are we looking at a priest-hood type space patrol, or something else?

But perhaps the big takeaway from Deudney's effort involves government and how humanity will choose to govern itself. Globalists view a single world government as a means to reduce violence and warfare on Earth, perhaps ending the existential thread of nuclear war once and for all. Other view a single world government as a threat to freedom and a short journey to a totalitarian nightmare. But can a single world government control a solar system with dozens of lunar settlements, thousands of asteroid settlements, perhaps a couple of terraformed planets each with a growing population in the millions or even billions, and thousands of space settlements some of which exist in the Oort cloud? Then add in genetic engineering, cybernetics, and Al, and you have something new in human experience. How is conflict resolved? Are there indeed dangerous technologies that should be proscribed and if so how is that done? How does all of this relate to the Fermi Paradox? Once interstellar missions are underway, the questions only multiply. It is unclear what the answer is to this problem, which does not mean that there is no solution. The space expansionist's dreams face countless problems and this needs to be added to the list.

Deudney perhaps overstates his case and many of his arguments are flawed, but he does raise some valid points. Points that space expansionists need to address. Looking into the future, questions of how humanity deals with Star Trek's Khan Noonien Sing and his augments (or if you like, Nietzsche's ubermensch) are very real and very important but separate from the space expansion question.

Deudney is also correct in that Earth is vital to future human expansion into the solar system and must be preserved at all costs. Space settlements and asteroid settlements will probably depend on living systems that must be renewed periodically by importing plants and animals and bacteria and viruses from Earth. Terraforming planets depend on life from Earth and even space settlements and terraforming efforts around distant stars will depend on life imported from Earth. Earth must be preserved for space expansionists to realize their visions.

The Universe has a number of methods available to it to sterilize entire planets. Deudney mentions asteroid impacts. He doesn't address gamma ray bursts (GRBs). If we can deal with the unstable or evil individual problem then space expansionists can protect Earth from asteroids and comets, and even the occasional runaway space freighter. But GRBs arrive with little warning and can irradiate Earth and other terraformed planets with intense levels of gamma rays, that will destroy the ozone layer, leading to an environmental disaster with eventual mass extinctions. But space settlements can be built with very heavy shielding and have no ozone problem. They could survive a GRB far better than a planet. Space based colonies could then render aid to Earth, repairing the ozone layer and restoring the biosphere using techniques developed for terraforming.

Yes, Deudney is correct, the dreams of the space expansionists represent a two-edged sword for humanity. But sometimes a sharp sword is all that stands between you and eternal darkness.

### ARECIBO: LOSING OUR TENUOUS INTERSTELLAR CONNECTION BY DAVID FIELDS

#### INTRODUCTION

Our tenuous interstellar connection is photonic. Astronomy has provided hints and exquisite details of very distant objects and from these hints and details, we have constructed a mostly selfconsistent view of the history and contents of our universe. Most revelations of the past 50y have come not from optical astronomy, but from radio astronomy. To an astronomer, those decades of electromagnetic radiation are just light of course, but visible light occupies but a single decade of the spectrum.

Our local environment is sunny and very noisy. In comparision, the interstellar radio signal is almost unperceptively weak. Signals are measured in Janskys (Jy), where one  $Jy=10^{-26}$  watts/m2/Hz. Assume a bandwidth of 10GHz and average signal intensity of 1JY and you'll find that the entire planetary sphere of the earth captures only about 2x10<sup>-18</sup>W. A better and more poetic scientist might say this [1]:

"The total amount of energy from outside the solar system ever received by all the radio telescopes on the planet Earth is less than the energy of a single snowflake striking the ground."

Requirements for signal collection, sensitivity, noise rejection, and sophisticated signal processing make a radio astronomy facility a special place – something of a national asset, a museum, and a training facility combined. For over 50y, our most sensitive and highest-resolution single dish radio telescope for an important band of frequencies was the Arecibo, Puerto Rico facility. It has been bettered in size by the FAST radio telescope (Tianyan) in China, and in resolution (at mm-wave frequencies) by the VLA in Socorro. The Arecibo telescope was the most sensitive component of the planetary telescope array, which applies Very Long Baseline Interferometry (VLBI) to realize details such as the structure of accretion disks orbiting black holes.

The Arecibo facility has a noble scientific history [2]. The 1974 discovery of the binary pulsar PSR B1913+16, contributions to the interpretation of the general theory of relativity, investigation of gravity wave generation and propagation, discovery of the first known extrasolar planetary system, PSR B1257+12, contributions to VLBI (very long baseline interferometry) and the High Sensitivity Array projects, contributions to SETI (search for extra-terrestrial intelligence), RADAR mapping and investigation of mineralogy of Venus, Mercury, our moon and Jupiter's moons [3], Saturn's rings and many asteroids [4], and ionospheric research – these notable successes have contributed to the stature of the Arecibo facility and made it a world-class scientific

and educational resource. Arecibo became the outstanding museum, outreach, and research facility of Puerto Rico.

A statement from the NAIC [5] summarizes the importance of the Arecibo facility, depicted in Figure 1:

"This giant telescope has scrutinized our atmosphere from a few kilometers to a few thousand kilometers where it smoothly connects with interplanetary space. With its radar vision it studies the properties of planets, comets and asteroids. In our Galaxy it detects the faint pulses emitted hundreds of times per second from pulsars. And from the farthest reaches of the Universe quasars and galaxies emit radio waves which arrive at earth 100 million years later as signals so weak that they can only be detected by a giant eye like this one."



Figure 1. Prior to cable failure and platform collapse, the Arecibo was a premier research and training center.

## Collapse of the Arecibo Gregorian feed, cryogenic facility, and RADAR system

Collapse of the suspended observation platform, which contained the Gregorian focus, low-temperature receivers, a 1 MW RADAR transmitter, suspension and positioning systems, was unanticipated until days before this event. The actual collapse was recorded by fixed and airborne cameras on December 1, 2020 [6]. The platform, with Gregorian dome, receiver systems, and RADAR systems was an almost total loss and the dish was significantly damaged. A smaller 12m support dish and the LIDAR facilities are still functional [4] [7].

## Possibility for restoration of basic Arecibo structure and functionality

Restoration of Arecibo to prior levels of functionality is highly desirable. From the standpoint of planning, control, and ongoing research, there exist some advantages to restoration of the facility to prior configuration and function.

Initial primary dish accuracy was governed by operational design to 430 MHz, and the dish configuration was accurate to about 1/20 wave, or 3 cm. Later requirements, extending operation to S-band, required dish accuracy to 3mm. Some receivers operated beyond the 1/20 wave limitation, as high as 10 GHz. Dish configuration has now been lost, and must be restored if the facility is to be restored to historic function.

Alternatively, there exists an opportunity for redesign of the facility to implement additional functionality, including higher frequency operation, enhanced multi-pixel measurements, and higher-power radar. This might be done at a significant cost saving, if the instrumentation could be located at ground level, rather than suspended above the primary reflector.

## Arecibo2: Large-aperture functionality, ground-level instrumentation

Restoration of the Arecibo scientific and educational capabilities is important. Should funds not be available, there may be less expensive alternatives that would capitalize on the surviving structure. It may even be possible to redesign the facility to implement additional functionality, including higher frequency operation, enhanced multi-pixel measurements, and higherpower radar. This might be done at a significant cost saving, if massive receiver, cryogenic, and RADAR instrumentation could be located at ground level, rather than suspended above the primary reflector. Massive equipment, including line-feed antennas, cooling systems, RADAR systems, and positioning hardware would be located central to the primary dish. Angular (pointing) agility of such a ground-level system would be required.

The optical path for the Arecibo configuration has used a Gregorian concave secondary reflector located beyond (above) the focal point of the spherical primary reflector. Arecibo2 might use a Cassegrain configuration, which would facilitate ground-level placement of more massive components. The Cassegrain approach would require a suspended convex reflector. The figure of this secondary reflector would be hyperboloid.

Suspension height of a new Cassegrain secondary reflector would follow in part from the surviving tower structure. The original configuration consisted of two towers of 80m height and one tower of 110m height [5]. Considering this height to be 80m above datum, the remaining elements of the former 80m towers appear sound to 60m elevation, so a new Cassegrain secondary could be supported from tower caps located at 60m elevation. If cable angle were kept constant, then the platform height would be lowered by 20m. The old platform was 150m above the dish, and the new platform would be about 10m high. This is actually close to the upper limit to permit Cassegrain operation. But going lower limits signal capture from the primary dish. A good (lowerlimit) secondary mirror beam width into a ground-level receiver is 10 degrees. If the Cassegrain platform is at 130m, then the Cassegrain mirror should be about 20m in diameter. If the platform is positioned at 100m, then the Cassegrain mirror should be about 16m in diameter. From beam considerations, a circular (hyperboloid) reflective structure is ideal, although a mechanical superstructure would have some triangular symmetry imposed by mechanical considerations.

The Cassegrain mirror might be composed of aluminum plates with lightning holes, backed with aircraft-grade honeycomb for stiffness. We might assume then, that stiffened 2mm aluminum panels might suffice, backed by honeycomb affixed to an aluminum or steel superstructure. If the surface density of this structure of 8m radius averages to 0.5cm thickness of aluminum, then the platform mass would be about 3 metric tons, which is a factor of 300 lower in mass than the prior structure, and comfortably attainable using the surviving 60m towers.

Some differences in the past and proposed Arecibo configurations are provided in Table 1

Table 1. Differences in the past and proposed Arecibo configurations			
System parameter	Arecibo (prior to Dec. 1 event)	Arecibo 2 (example, see text)	
Tower Height above datum	80m	60m	
Secondary Reflector	Gregorian (convex)	Cassegrain (concave hyperboloid)	
Platform height above dish	150m	100m	
Platform mass	900 tons	3 tons	

The platform for Arecibo 2 must be capable of being positioned at will in the actively-used sky image area above the primary dish. The ground level instrumentation for Arecibo 2 must be capable of being aimed toward the platform. A Gregorian approach to the tertiary optics might be taken, which would permit using an aperture stop to reduce sky noise. Alternatively, choke rings could be employed in the design to minimize noise.

The configuration of Arecibo 2 might resemble that shown in Figure 2.

This arrangement is far from optimal in transferring the energy collected by the surviving primary dish to the ground-level receiver – but this particular configuration happens to be a good starting point for discussion. Anyone wanting to discuss other interesting configurations is invited to contact the author.

Figure 2. Restoration of the facility might resemble the configuration shown here, with the hyperboloid Cassegrain secondary reflector shown as yellow, and the ground level receiver/radar facility shown as a central blue feature. [8]



#### CONCLUSION

The purpose of this paper is to acquaint IRG readers with what has been lost, and to encourage discussion of restoration of the Arecibo radio astronomy research facility. It is not to support any particular facility design, but to show that alternative approaches are possible, and to outline one such approach. The approach discussed is unlikely to be the best overall approach, but it may be a step toward restoring a part of what was lost in the first days of December, 2020. There is a high level of support from the scientific community for restoring Arecibo [9] and supporting petitions have been sent to the U.S. Congress [10].

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### FROM HERE TO THE STARS AND MORE!

Check out the latest From Here to the Stars episode where host Stephen Euin Cobb sits down with Scholarship winner Hayden Morgan: https://www.youtube.com/watch?v=ZHn2W7J7hKY

Once there, check out the many other thought-provoking interviews and lectures this team and others have brought to the IRG YouTube space.

Recommendations for guests? Let the team know!

If you prefer audio formats, From Here to the Stars is also available as a podcast; available for streaming across many platforms, like iHeartRadio, Spotify, and Stitcher.

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

### IRG 7<sup>TH</sup> SYMPOSIUM

The Interstellar Research Group's 7th Interstellar Symposium will be taking place September 25-27, 2021 (with pre-symposium seminars taking place on the 24th) in Tucson, AZ at the Tucson Marriott University Park. This symposium will directly follow the NASA Innovative Advanced Concepts (NIAC) symposium at the same hotel, and will take place along with the "Art of Planetary Science" art show.



Keep checking back on the IRG site; there will be more information here as time goes on!

As planning for the event continues, we have already announced a stellar cast of keynote speakers. Esther Dyson is a well-known writer, speaker, investor, and entrepreneur. Beyond that, she is a trained cosmonaut: she spent six months (2008-2009) training as backup to space tourist Charles Simonyi in Star City outside Moscow. She is also an investor in Space Adventures/ZeroG (which organized her training), NanoRacks, and SpaceXSpace, as well as in the Space Angels fund. She is a patron of the Commercial Spaceflight Federation and a past member of NASA's Advisory Council. In 2006 and 2007, she hosted the Flight School conference, focused on New Space and air taxis.

Dr. Mark Shelhamer is a renowned expert in the area of vestibular and oculomotor adaptation. Starting at MIT, he worked on sensorimotor physiology and modeling, including the study of astronaut adaptation to space flight. At Johns Hopkins he continued the study of sensorimotor adaptation with an emphasis on the vestibular and oculomotor systems. He has had support from NASA to study sensorimotor adaptation to space flight, amassing a fair amount of parabolic flight ("weightless") experience in the process. He also serves as an advisor to the commercial spaceflight industry on the research potential of suborbital space flight. From 2013 to 2016 he was on leave from his academic position to serve as NASA's Chief Scientist for human research at the Johnson Space Center.

Dr. Abraham (Avi) Loeb is the Frank B. Baird, Jr., Professor of Science at Harvard University. He received a PhD in Physics from the Hebrew University of Jerusalem in Israel, led the first international project supported by the Strategic Defense Initiative, and was subsequently a long-term member of the Institute for Advanced Study at Princeton. Dr. Loeb has written 9 books and over 800 papers on a wide range of topics, including black holes, the first stars, the search for extraterrestrial life and the future of the Universe. His latest title, Extraterrestrial, has climbed high on the New York Times bestseller list. Dr. Loeb serves as Chair of the Board on Physics and Astronomy of the National Academies and is an elected fellow of the American Academy of Arts & Sciences, the American Physical Society, and the International Academy of Astronautics. He also chairs the Advisory Committee for the Breakthrough Starshot Initiative and serves as the Science Theory Director for all Initiatives of the Breakthrough Prize Foundation.

Over a four-day period, speakers and panels will focus on all aspects of interstellar travel (human and robotic), including:

- Power
- Propulsion
- Sensors
- Communications
- System reliability / maintainability
- Psychology
- Crew Health
- Anthropology
- Ethics
- Legal regimes and treaties

In 2021, to take advantage of the Tucson ecosystem, the symposium will have a special emphasis on possible destinations (including the status of exoplanet research), life support systems, and habitats.

We have issued a call for papers for the 7th Interstellar Symposium. If you are interested in submitting a paper for presentation at the Symposium, click here to see the submission instructions and deadlines for submission.

https://irg.space/wp-content/uploads/2020/12/2021-7th-Interstellar-Symposium-Call-for-Papers-V2.pdf

If you are in Arizona and would like to be involved in preparing for and administering this symposium, please fill out our "get involved" form.

https://irg.space/get-involved/

### **USE AMAZONSMILE TO BENEFIT TVIW / IRG**

An exciting opportunity to support the great work that TVIW is doing is to use the AmazonSmile program. Every dollar counts for non-profit groups. TVIW can benefit from each purchase you make at no additional charge to you. Amazon donates 0.5% of each purchase to the non-profit organizations of your choice and the TVIW is one of those organizations. This is a painless way to support us.



To participate, go to <u>smile.amazon.com</u>. Sign into your account and a "pop up" page will appear. On the right side of the page, at the bottom is a "search" window. Type in: Tennessee Valley Interstellar Workshop and click the search button. Click on the top one and you are done. Your donations will be automatic for any purchase within the Amazon Smile program (which is most merchandise). You can also use the following link.

https://smile.amazon.com/ch/46-4572727

### UPCOMING INTERSTELLAR AND SPACE EVENTS



**20 April 2021.** SpaceX Crew Dragon Crew-2 launch to the ISS **April 2021.** China will launch Tianhe 1, the core module for a

- Chinese space station in low Earth orbit.
- Summer 2021. Boeing's CST-100 Starliner Orbital Flight Test 2 launch to the ISS
- May 2021. China's Tianwen-1 Mars rover will arrive.
- **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 7<sup>th</sup> 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