Have Starship, Will Travel

The Newsletter of the Tennessee Valley Interstellar Workshop

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Over the past couple of years, many breathtaking interstellar news stories have come to light, from the announcement of Breakthrough Star Shot in April of last year to the 7 Earth-size planets in the TRAPPIST-1 system orbiting a dwarf star discovered by NASA in February of this year. On a smaller scale, this newsletter will share some of the news close to the heart of TVIW, such as the new 2017 Board of Directors.

Additionally, with TVIW 2017 fast approaching, some highlights are shared. Quite excitingly, the invited speakers for first day, sponsored by Starship Century, are members of the Breakthrough Star Shot project.

Following this, an invited article was created by Dr. John Rather on his "personal space odyssey" and some of the Interstellar technologies that he is working on.

The final pages wrap up with some additional news, including news from TVIW's sister organizations and the announcement of the new TVIW student Scholarship Program.

Newsletter Contents

New 2017 TVIW Board of Directors

In January 2017, TVIW elected a new Board of Directors. They will serve through the coming 2017 Symposium, which is a collaboration between TVIW, Starship Century, and the Tau Zero Foundation. Following are the profiles of the new board.

John Preston

President; Chair of Recordings

John has been President since the incorporation of TVIW and has been involved in recording all four of the previous symposia and the TVIW "From Here to the Stars" video casts. You may reach the TVIW Channel at YouTube.com/TVIW. He had a 35 year career in Oak Ridge before retiring in 2012. In his first job after graduating from Georgia Tech in 1968, he worked on a proposed space shuttle insulating tile at MDAC-East under NASA contract. He lives in Oak Ridge, TN.

Martha Knowles

Secretary/Treasurer; Chair of Scholarship Program

Martha has been Secretary/Treasurer since the TVIW was incorporated and has been the Administrator and Registrar for the previous four symposia (2011, 2013, 2014, and 2016). She is very much involved in the planning for the 2017 Symposium. In her career, she was a professional librarian and records management specialist. She is active in the Society for Creative Anachronism, as well as several science fiction conventions, including LibertyCon in Chattanooga, TN. She lives in Oak Ridge, TN with her husband and two cats.

Ken Roy, PhD

Director at Large

Ken has been a Director since the incorporation of TVIW. He is engineer living and working amidst the relics of the Manhattan Project in Oak Ridge, TN. He invented the "Shell Worlds" concept and in 1997 made the cover of the Proceeding of the U.S. Naval Institute for his forecast of anti-ship, space-based, kinetic energy weapons. He has appeared multiple times in JBIS and Acta Astronautica, as a co-author on papers concerning terraforming and space colonization. He is a graduate of the Illinois Institute of Technology and the University of Tennessee-Knoxville in engineering.

David Fields, PhD

Director at Large

David has rejoined the TVIW Board after a brief hiatus. He is the Director of the Tamke-Allan Observatory, the ORION founder/president, and Senior Researcher at I4IS. He has presented papers at the 2011, 2013, and 2014 TVIW Symposia. In addition to a research career at ORNL, he has had visiting scientist appointments in Germany and Brazil, served as an IAEA "technical expert", and was a Consulting Physicist at ISSI for NASA. In addition to being a past president of the Tennessee Academy of Science, he has taught at UW, RSCC, PSTCC, and UFMG. He holds two US patents and his current interest is in RASDR, a computer-interfaced radio astronomy instrument. He lives in Knox County, TN.

Edward "Sandy" Montgomery

Director at Large

Sandy has also rejoined the Board of TVIW after a brief hiatus. He has over 35 years commercial and civil service in the Huntsville aerospace community. He retired from civil service in 2015 and is now consulting on NASA's Near Earth Asteroid Scout solar sail mission and the James Webb Space Telescope, both planned for 2018 launch. He gave a talk at TVIW 2014 titled "Solar Power Pipeline for Interstellar Travel". He has a Bachelor in Aerospace Engineering from Auburn University and a Masters of Engineering from University of Alabama in Huntsville. He is married with three adult sons and lives in Lacey's Spring, near Huntsville, AL.

ANNOUNCING THE TVIW 2017 SYMPOSIUM

The TVIW 2017 Symposium, entitled "Step By Step: Building a Ladder to the Stars," will be held Oct. 4-6, 2017, at the Embassy Suites in Huntsville, Alabama. The workshop was founded in 2011 by NASA physicist and author Les Johnson; physicist, educator, and author Dr. Greg Matloff; and professional engineer Robert Kennedy III.

TVIW 2017 will include featured presentations from renowned professionals; plenary talks; interdisciplinary working tracks; seminars; and Sagan workshops. Named for visionary researcher Dr. Carl Sagan, the latter include a combination of short presentations, panel discussions, and general floor debate — an approach adopted by TVIW for the first time for 2017.

TVIW continues to seek contributions for the upcoming symposium from aerospace technologists, communicators, psychologists, anthropologists, and other researchers and visionaries whose work could vitally impact the future of humanity's interstellar adventure. Abstracts for plenary talks, papers, and posters are due April 30, 2017. Additional deadlines and requirements are detailed on the website.

"It's our mission to bring together as many practical, grounded professional minds as possible to pursue the multifaceted challenges of journeying beyond Earth's solar system," said TVIW President John Preston. "We seek not just technical solutions to achieve long-distance, long-duration spaceflight but also a proper, holistic understanding of the expectations, potential impact, and long-term value associated with such missions."

For 2017, TVIW partners with Starship Century, an interstellar starship development symposium coordinated by the Arthur C. Clarke Center for Human Imagination in San Diego, California, and Tau Zero Foundation, a coalition of scientists, engineers, journalists, artists, and science fiction writers seeking to expand the boundaries of conventional research and pursue practical, high-value solutions for interstellar exploration.

Sponsors of the Tennessee Valley Interstellar Workshop for 2017 include Baen Books and Digital Oilfield Solutions.

The following sections detail some of the featured presentations and the pre-symposium seminars. More information about those presentations can be found at tviw.us/2017-symposium.

TVIW 2017 DAY 1 (4 OCT): BREAKTHROUGH STAR SHOT FEATURED PRESENTATIONS PRESENTED BY STARSHIP CENTURY

Are We Alone?–Searching For Life in the Universe

Pete Klupar
Chief Engineer
Breakthrough Initiatives

Breakthrough Foundation is working to help humanity investigate the possibility of life forms on other planets, and how scientists can get involved. The Star Shot initiative—a plan to send a spacecraft to another star in the next 25 years—will be the main topic of the presentation. Mr. Klupar will also discuss the foundation's other major initiatives: Listen and Watch. Listen is the search for extraterrestrial intelligence using RF (1 GHz to 30GHz) and visible light. Watch is the search for earth-sized planets in the habitable zone of nearby stars.

SPEAKER BIO: Prior to his role at the Breakthrough Foundation, Mr. Klupar was Director of Engineering at NASA's Ames Research Center. While at Ames he developed the Aquila, LADEE, TESS, Pharmasat, OREO and other small spacecraft missions while aiding in the development and operation of the Kepler and SOFIA projects.

Breakthrough Star Shot System Model and Trade Studies

Kevin L. G. Parkin
Parkin Research LLC

A constraint-based system model has been built to represent beam-driven relativistic sails. The model is solved by inference engine and uses 1-DOF RK45 trajectory integration nested within several bisection and golden section solvers in order to minimize the capital cost of the beam director while holding fixed the sail velocity at beam cutoff. A Goubau beam is assumed, the energy spillage of which is recalculated on every integration step, forming the core of the key tradeoff between beam director effective diameter vs. transmit power vs. sail diameter vs. beam duration. This key tradeoff is driven by user-provided technology figures of merit for beam director areal cost ($/m^2), transmit power cost ($/Watt) and energy storage cost ($/kWh) as well as sail areal density (g/m^2) and optical properties. Since March 2016, the system model has been used to conduct parametric trade studies for a 0.2c mission to Alpha Centauri, a 0.01c precursor mission to a closer objective and a 70 km/s ground-based vacuum tunnel test facility. The results from these trade studies are presented.

SPEAKER BIO: Dr. Parkin is the Systems Director of Breakthrough Star Shot, founder of Parkin Research LLC and the inventor of the microwave thermal rocket. In 2005 he was awarded the Korolev Medal by the Russian Federation of Astronautics and Cosmonautics for his ground-breaking work in microwave thermal propulsion. In 2007, Dr. Parkin founded the Mission Design Center (MDC) at NASA Ames. From 2009 to 2015, he was a Research Faculty member at Carnegie Mellon Silicon Valley. In this role, he served as Principal Investigator of a $5M NASA-funded project to conduct innovative research to implement a sustainable and extensible vision for space exploration in the long term. From 2012-2014 he additionally served as Principal Investigator and Chief Engineer of a $3M DARPA-instigated project to build a small millimeter-wave thermal rocket and launch it. This resulted in the first millimeter-wave absorbent refractory heat exchanger, the first millimeter-wave thermal rocket, and the first high power cooperative target millimeter-wave beam director. These elements were combined to achieve the first millimeter-wave thermal rocket launch in early 2014. He is a member of the Institute of Physics (IOP) and holds an M.Phys. from the University of Leicester (1999), an M.S. from Caltech (2001) and a Ph.D. from Caltech (2006).

The Star Shot Propulsion System

Robert Q. Fugate

The key concept for going to the stars in the Star Shot Project is to minimize the mass of the spacecraft by leaving the apparatus that propels the spacecraft on Earth. The force that accelerates the payload is light pressure generated by a laser system producing a controllable, coherent beam of light having an average power of the order of 100 GW. A 1-gram mass payload would experience an acceleration about 60,000 gees when subjected to the radiation pressure from this system (assuming imperfections). This talk addresses the many challenges confronting us in conceiving, designing, building, and operating such a propulsion system. Chief among these are developing a plan to coherently combine many millions of laser beams at the sail target in the presence of laser phase noise, large optical path length differences, and atmospheric refractive index fluctuations caused by turbulence, while maintaining a specified irradiance profile on the sail with sub nanoradian pointing jitter as it travels from high earth orbit to a distance equivalent to ten times the range to the Moon, all in a few hundred seconds.

SPEAKER BIO: Dr. Robert Q. Fugate is internationally recognized as the first to demonstrate the concept of laser guide star adaptive optics and to develop and apply needed technologies to make the concept practical on large ground-based telescopes. This technology allows researchers to overcome the limitations on image resolution set by the Earth's atmosphere. Dr. Fugate spent over 35 years in the Air Force Research Laboratory and retired as the Senior Scientist for Atmospheric Compensation in 2006. He created the Starfire Optical Range as the premier research organization in the DoD for correcting atmospheric effects on the propagation of light.

He championed the transition of this technology from DoD to the astronomy community. From early 2006, he was the Senior Technical Advisor on the staff of New Mexico Tech and retired with Emeritus status at the end of 2011. He now serves as a part-time consultant, speaker, and advisor to the Air Force and other US Government agencies and private organizations. His latest endeavor is serving on the advisory board for Breakthrough Star Shot and as Chairman of the Laser Subcommittee. He is a member of the National Academy of Engineering, has published over 100 papers and book chapters, presented dozens of invited talks, served on numerous international astronomy and telescope committees, and has received many honors.

Our First Starships: Sails & Payloads for Star Shot

James Benford
Microwave Sciences

Star Shot reduces the sail mass down to about a gram and sail scale to a few meters. The acceleration is driven by lasers with total power of 10-100 GW; accelerations are 10,000-100,000 gravities. Acceleration times are about 1-10 minutes. Constructing a laser light sail sufficient to propel a one-gram class spacecraft to 0.2c within a few decades using a laser beam director of approximately one-kilometer scale with a beam power of 10's of GW requires thin and light-weight materials, perhaps metamaterials, meaning fabrication of meter-scale sails no more than a few hundred atoms thick. The material must be light enough yet highly reflective. Properties that influence material choice and fabrication are its reflectance, absorptance, and transmittance, tensile strength and areal density. Stability of the sail on the beam is influenced by sail shape, beam shape and the distribution of mass, such as payload, on the sail. The laser system interacts with the sail through its power density distribution on the sail, duration of the beam, width of the beam, pointing error of the beam as well as its pointing jitter.

SPEAKER BIO: James Benford is Sail System Director of Breakthrough Star Shot and President of Microwave Sciences, Inc. in Lafayette, California. His interests include high power microwave systems from conceptual designs to hardware, microwave source physics, electromagnetic power beaming for space propulsion, experimental intense particle beams and plasma physics. He is co-author of the textbook, High Power Microwaves, 3rd Edition (Taylor & Francis, 2016). He has a Ph.D. in Physics at the University of California San Diego. He is an IEEE Fellow and an EMP Fellow.

Data Return from Star Shot Probes: Live from Alpha Centauri!

David Messerschmitt
Professor Emeritus of Electrical Engineering and Computer Sciences, UC Berkeley

Returning scientific data from a Star Shot mission will be challenging due to many factors, including limited available energy, transmit and receive antennas, pointing accuracy, and speed. This talk examines an optical downlink communicating image data. Available energy has to be beneficially allocated among attitude control, processing, and communications functions. The profile of the available power varies widely during and after an encounter. Especially relevant is the rapidly changing distance to a target star, and the impact of this distance on available solar energy. Based on known fundamental limits, the maximum total returned data is estimated for a set of alternative assumptions. For best-available coding algorithms, energy-balance tradeoffs between processing for source and channel coding and transmitted optical power are considered. For the benefit of audience members not well versed in communications theory, we include a brief tutorial on the fundamental limits to image coding and communications. This talk reports on joint work with Philip Lubin of the University of California at Santa Barbara and Ian Morrison of Swinburne University, Australia, and draws heavily on near-Earth optical communications research at Jet Propulsions Laboratory and elsewhere.

SPEAKER BIO: David Messerschmitt is the Roger A. Strauch Professor Emeritus of Electrical Engineering and Computer Sciences (EECS) at the University of California at Berkeley. The first ten years of his career wer spent at Bell Laboratories, where he participated in the exploratory development of digital communications. At Berkeley he has done research in digital communications and audio and video encoding, and has served as the Chair of EECS and the Interim Dean of the School of Information. He is the co- author of five books, including Digital Communication (Kluwer Academic Publishers, Third Edition, 2004). His doctorate in Computer, Information, and Control Engineering is from the University of Michigan, and he is a Life Fellow of the IEEE, a Member of the National Academy of Engineering, and a recipient of the IEEE Alexander Graham Bell Medal recognizing "exceptional contributions to the advancement of communication sciences and engineering"

TVIW 2017 DAY 2 (5 OCT): FEATURED PRESENTATIONS PRESENTED BY TAU ZERO FOUNDATION

Marc Millis
Founder, Tau Zero Foundation

Marc Millis lead NASA's visionary "Breakthrough Propulsion Physics" project and created the milestone book, Frontiers of Propulsion Science, a compendium of scholarly research on propellantless space drives and faster-than-light flight. Earlier in his NASA career, Millis designed ion thrusters, electronic instrumentation for rockets, cryogenic propellant equipment, and even a cockpit display for free-fall aircraft flights. After 31 years with NASA, he retired in 2010 to devote full time to interstellar research and education via the Tau Zero Foundation.

Tau Zero is a place for thinking about the long-range future of space exploration. While others work on the next big thing, Tau Zero looks at emerging possibilities that could change our future. Instead of advocating a specific mission or vehicle, Tau Zero builds a foundation of reliable information from which future vehicles and missions can be created. This includes investigating ideas on the infrastructures for expanding human presence in space, launching interstellar probes, and all the way to advancing the physics of faster-than-light flight.

Jeff Greason
Board Chairman, Tau Zero Foundation

Jeff Greason has over 25 years' experience managing innovative technical project teams at XCOR Aerospace, Rotary Rocket and Intel Corporation, and now as CEO of Agile Aero. He has worked on many projects, notably: long-life, highly-reusable liquid-fueled rocket engines; a low-cost liquid propellant piston pump; and two manned reusable rocket aircraft. Jeff is a recognized expert in reusable launch vehicle (RLV) regulations, and he has been a member of the COMSTAC RLV working group since 2000. He was one of the architects of the regulatory policy embodied in the 2004 Commercial Space Launch Amendments Act; following which he co-founded what became the Commercial Spaceflight Federation. In 2009 he was named by the White House to a panel of independent experts that examined alternatives for advancing the US human space exploration agenda.

Greason was cited as one of the "Inventors of the Year" in 2001 by Time magazine. He was awarded the Space Pioneer Award for Entrepreneurial Business in 2016 from the National Space Society. He holds 25 U.S. patents.

TVIW 2017: PRE-SYMPOSIUM SEMINARS (OCT 3)

Three pre-symposium seminars will be offered on Tuesday, October 3 on a single subject, providing an in-depth look at that subject. These are separate from TVIW 2017 Symposium, and you can sign up for one or two seminars without attending the Symposium. More information can be found at tviw.us/2017-symposium/pre-symposium_events.

Conflict in Space

Presented by **Major Brent D. Ziarnick**, *USAFR*

This seminar will survey the state of conflict in space today, including the players (focusing on the United States, Russia, and China) as well as the technologies and concepts that exist now or are expected in the near future. The state of space weapons in policy and strategy will be discussed, as well as the possible goals of each player in the space environment. This seminar will not discuss science fiction or historical concepts but will arm attendees with the latest unclassified and open-source understanding of the state of the militaries of the great space powers. Those who attend this seminar will be well-prepared to assess international space news and separate the real from the ignorant – and the realistic from the sensational – in modern debates about space conflict.

Laser Propulsion: An Introduction to Laser Propulsion and Assessment of Relevant Current Technologies

Presented by **Edward. E. (Sandy) Montgomery**

This Seminar will address both Earth-to-Orbit and In-Space applications of lasers to propel space vehicles. Its particular relevance to interstellar travel is often noted in reference to advanced conceptualizations such as StarWisp by Robert Forward. The fundamental mission concepts, system mechanizations, trajectories, and key performance parametrics will be presented for Laser thermal rocketry, Laser photon momentum exchange, and Laser ignited fusion/fission.

A summary of the historical perspective on the development of high power lasers and advanced beam directors will be provided. Current on-going technology development initiatives in the United States and Australia will be described. Some questions to be addressed include: Is a gigawatt laser needed? How could it be constructed? Where will the power for the laser come from? How far can a laser be projected? What laser propulsion systems have been designed and built? What do they look like? How does the cost of laser propulsion compare to conventional propulsion technologies? How does its cost compare with other future propulsion technologies? Can laser propulsion enable us meet and maybe exceed the goals of Breakthrough Star Shot?

Human Life in Space: Separating Reality from Wishful Thinking

Presented by **Dr. Robert E. Hampson** *(aka Speaker to Lab Animals), neurophysiologist and SF writer*.

Most fiction, even hard science fiction, glosses over the problems that humans will have adapting to environments other than Earth. Good Science Fiction addresses a few of the problems, such as the body's adaptations to zero-G or microgravity, but there are so many issues that a body evolved in a constant 1-G field, with plentiful air and water will have adapting to space, that no one story can address them all. So we guess, and we invoke wishful thinking that all of the problems will somehow be solved by the time we get there.

This seminar will examine many of the real medical and physiological problems encountered by the few humans who have spent more than a handful of days in space. From fluid balance to vertigo, from radiation to immune deficiencies, Dr. Hampson will lead participants in discussions of the real problems facing humans as we move out into space and potentially other planets.

SPACE AGE: A PERSONAL ODYSSEY

A SPECIAL INVITED ARTICLE FROM DR. JOHN RATHER

Recently I completed my seventy-ninth orbit of the sun, and I'm happy to be launched on my eightieth. It has been a wonderful experience to live through the entire history of our first steps and Giant Leaps into space. Since I was privileged to play some minor roles in our fledgling reach for the stars, the Tennessee Valley Interstellar Workshop has kindly asked for some reminisces. It is surely a pleasure to express my appreciation to the fine folks who created TVIW and have made it a significant catalyst for innovation and outreach toward the eternal destiny of our human species. So here are some bits of personal history, ending with some advice and opinions about the best ways to escape from our earthbound difficulties.

I have clear memories of how my interest in space began in 1944 when I was an avid six-year-old reader. During and after World War II, my parents subscribed to Life magazine, the most popular news weekly of that era. I was both horrified and fascinated by the accounts of the German V-2 rockets that terrorized London in the last year of the War. They were the first rockets that reached into space on hundred mile high trajectories and impacted at supersonic speeds: People nearby would feel the explosion and then hear the rocket approaching. The dawn of those super weapons added urgency to the Allied invasion that ended the war in Europe in April 1945; but the United States was still deeply engaged in a terrible conflict with the Japanese in the vast Pacific theatre of the war. Imagine the astonishing surprise in August 1945, when the world learned about the Manhattan Project, the Top Secret crash program that produced the first Atomic Bombs in three years of incredible science and engineering effort. After the bombings of Hiroshima and Nagasaki, the Japanese surrendered unconditionally within a month. The war ended years earlier than anticipated, probably saving over a million lives on both sides. This singular accomplishment demonstrated beyond debate how fast the future can change when there is a top-down decision to get the job done.

Two decades later in the 1960s, the Apollo moon program was the next incredible example. I'll return to this theme below in the context of speculations about future transformations that are now within reach. But first let me relate some different personal history because I want to emphasize the important cross-fertilization between science fiction and science fact. This is crucial because SciFy engenders widespread enthusiasm for future space development far beyond the arcane world of hard-nosed science and engineering, and it brings people together from very different viewpoints to a common interest in changing the future. Consensus grows from melding many viewpoints.

Figure 2. John working with space artist Chesley Bonestell.

Shortly after WW II ended, I became fascinated with another formerly secret technology, Radar, while also following my father's interest in electronics and Ham radio. Then, when an eighty-year-old lady taught me basic Astronomy, I spent every clear night outside learning to identify the constellations and planets. The defining objectives of my life soon coalesced when I discovered in Life magazine color pictures by the creator of great space art, Chesley Bonestell. His paintings look like real photographs of other planets. There were views of Saturn as it would look from its satellites, and a wonderful depiction of a

Figure 1. Chesley Bonestell's painting for Collier's magazine in 1952 showing Wernher von Braun's proposal for a Space Shuttle, a rotating Space Station, and a "Hubble" Telescope being serviced by astronauts.

rocket trip to the moon. Soon his work was everywhere, in many magazines, books, and movies (Fig. 1) But I couldn't begin to imagine that a quarter-century later Chesley would become one of my dearest friends for the rest of his life (Fig. 2). He was exactly fifty years older than I was in 1964 when we met in Berkeley, where I was pursuing my Ph.D. in Astronomy. I told him I was there because of his inspiration, and he said, "Great, come over and let's have a drink!"

In the late 1940s, Planet Comics became my fantasy companion. It cost ten cents per month, and featured hideous green aliens with huge exposed brains threatening beautiful women. The monthly serial about alien conquest of the Earth by Voltans featured an arch villain who was the exact prototype of Darth Vader. (I'll bet George Lucas also cut his teeth reading Planet!) By age ten I was completely hooked by Robert Heinlein's short stories and books, particularly Space Cadet, Between Planets, Red Planet, and Farmer in the Sky. (I was delighted by innovative technology concepts in Space Cadet: The young protagonist wore an amazing portable phone on his belt that he used to report to his mother; and the rockets all landed on their own exhaust thrust like SpaceX has finally made practical sixty years later.) I got in trouble in the fourth grade by gluing to my desk paper spring-buttons and a home-made view-screen of space combat so I could play imaginary games through the boring hours in class. Again I had no idea that Robert Heinlein would become a close personal friend beginning in the 1970s.

By the time I was a sophomore in High School, the world was deep into the Cold War. Leaping under our desks to "duck and cover" was supposed to enable us to survive a nuclear attack. (Go figure!) I sought refuge in astronomy in the form of building a series of planetarium projectors, complete with a twelve-foot diameter dome in my parents' house. I entered my project in the local science fair, and won the trip to the 1953 National Science Fair. It was hosted in the science capital of the known universe, Oak Ridge, Tennessee, of Manhattan Project fame. Much to my amazement, I won First Prize in the Physical sciences. This led a few years later to my first full-time job at Oak Ridge National Laboratory. I worked there in the Controlled Thermonuclear Fusion Division for five years while getting my BS in Physics at the University of Tennessee (UT) in Knoxville. To pursue graduate studies in astronomy, I then moved to Berkeley while also continuing to work in plasma physics at the nearby Lawrence Livermore National Lab.

While I was a student at UT in 1957, Sputnik 1 was launched by the Soviet Union. The orbit was widely reported, and I was out before dawn trying to spot it in front of my rooming house. A police car screeched to a stop, and two cops came at me with a gun and blackjack shouting, "What're yew doi'n here???" I told them about Sputnik. One grabbed my sweater and said, "Are yew one of them Commies?" I said, "No sir, I'm an astronomer." I then pointed upward and named a few stars, and they got interested. I guess astronomy saved me to write this article.

The post-Sputnik hysteria was incredible. President Eisenhower, hero General of WW II, was now the dunce who had allowed our country to be disgraced. The obvious threat of Soviet ICBMs with nuclear warheads prompted thousands of people to build fallout shelters underground in their back yards. The outcry was amplified tenfold when Yuri Gagarin was the first to orbit the Earth in 1961. JFK had just been elected President, and John Glenn didn't fly until a year later. It was a decision of great wisdom and courage when Kennedy announced that we would go to the moon within a decade wearing a civilian hat. Our allies breathed much easier when our country proved again that it could do the impossible in a hurry when challenged. It is human nature not to understand real threats until the genie is out of the jug. Then it is a major challenge to find the best path forward. This requires confidence in Giant Leaps.

I got the message. I flew my three kids from Berkeley to be present at the launch of Apollo 11. We had a close-up tour visiting the rocket in twilight thirty-six hours before the launch, followed by a great view of the magnificent lift-off from straight across the water on July 16, 1969 (Fig. 3).

Figure 3: John's three children (Dana, Rick, and Gray) on a tour before the launch of Apollo 11.

My ten years of work in mainstream astronomy involved many topics ranging from Jupiter's satellite Io to the interstellar medium to active galaxies to quasars. I built the first successful receiver for radio astronomy of extragalactic sources at 1 millimeter wavelength. But I continued to feel the calling of space travel beyond our little planet. I have a knack for creating and innovating new technology that led to my career in aerospace companies and defense "think tanks." The press identified me with the development of high-energy lasers, which had unexpected consequences for my career.

As Vice President of an aerospace company, I proposed a laser pointing and tracking experiment that grew into a huge five year Strategic Defense Initiative (SDI) program called StarLab. We realized that a laser can't track a target at a range of thousands of miles using gimbals, so we proved that the wavefronts of light have to be constantly steered with adaptive optics to correct for pointing errors and "windage" for the finite speed of light. Since our project was intended for a Shuttle mission, I asked the Administrator of NASA to make Marshall Space Flight Center the technical focus; and I was fortunate to get astronauts Harrison Schmitt and Jack Lousma to be principal consultants. Our adaptive optics system worked perfectly, achieving 10 nanoradian pointing accuracy in the lab. StarLab was scheduled to launch two Shuttles after the ill-fated Challenger; but the Cold War ended during the subsequent three-year stand-down, and the mission was cancelled. Ultimately our instrument package was donated to the University of Chicago Yerkes Observatory, where it became the first adaptive optics system for astronomy. Now, thirty years later, all large telescopes are equipped with laser guide star projectors and adaptive optics, enabling much better resolution from the ground than the smaller Hubble optics can achieve in space.

After that, I was recruited to NASA HQ to become Assistant Director of Space Technology, Program Development, for much of the 1990s. Two highlights of my time there were: First, serving in 1992 as Chairman of the first study of how to protect the Earth from impacts of asteroids and comets; and Second, creating the SELENE (Space Laser Energy) program to develop capabilities for beaming laser power from the Earth to expedite development of colonies on the moon. I'll discuss power beaming with illustrations below, but first let me make a few comments about asteroids and the impact threat.

The astronomy community realized correctly that although life-threatening impacts are rare, they are a significant threat that must be addressed. A program to detect and catalog all asteroids greater than 100 meters in diameter that might strike the Earth has been proceeding well for a quarter of a century, but more than half of several thousand predicted dangerous candidates still remain unidentified. My charge at NASA HQ in 1992 was different: I was tasked by the U.S. House of Representatives Subcommittee on Space to perform a study of how to achieve Near-Earth Object Interception to prevent impacts. Having worked for years at National Labs and in Defense technology, I knew that this is not child's play. I convened workshops at Los Alamos, Livermore and Sandia National Labs to study the difficulties in-depth and make recommendations. I think we did a good job as documented in our final report to Congress, although there still remains an important Joker in the deck: The threat of very high velocity comets from the Oort Cloud is real and very important, but it is not considered vital in present cataloging efforts of relatively low velocity Near Earth Objects (NEO) that permit years of reaction time. Comets, on the contrary, may be an equally important threat, and they can approach with relative velocities up to seventy kilometers per second with little or no warning. So we still need a defensive system with very fast response. Since comets can be sun-grazers coming from the day sky, much more sophisticated systems are definitely needed. Incidentally, when Steven Spielberg was making his film Deep Impact, I told his people this fact, and that is why the movie threat was a comet.

A possible effective non-nuclear defense against impacts may be viable if very small NEOs can be cataloged and captured to orbit the Earth in the L4&5 regions on our Moon's orbit. There are likely hundreds of thousands of 10 meter diameter candidates, many having low relative velocities. I will describe below how they can be captured and utilized for several high-value purposes. A few could be quickly moved in front of incoming dangerous objects to produce million-megaton disruption events before large fragments could strike the Earth.

I might have made the rest of my career at NASA, but a terrible new challenge intruded. My dear wife Ruth was diagnosed with a very dangerous cancer in 1988. A very experimental treatment prolonged her life but caused many collateral problems. Changing careers, in 1997 I became Director of Innovation & Development at a large Comprehensive Cancer Center affiliated with Wayne State University in Michigan, where I subsequently became University Professor of Physics until I moved back to my favorite town, Oak Ridge, in 2006. The key to curing many types of carcinomas in the internal organs is to identify them very early before they metastasize from the primary site. Millions of lives can be saved by automated early detection. The problem is like detecting submarines in the ocean: smart hardware and software can detect subtle signatures, made possible with innovative technologies. I have pursued this quest ever since, authoring seven patents on the needed technologies. It is exciting that the same automated system can easily detect cardio-vascular problems before they cause heart attacks or strokes.

A very nice astronomical surprise occurred in 1998 when astronomer Eleanor Helin named her recently discovered asteroid 7290 Johnrather in honor of my sixtieth birthday. The dedication says thoughtful things about my changing careers to work on cancer cure, and don't overlook the fact that automated medical diagnostics of many different pathologies, in addition to cancer, will be of great importance for years-long deep space missions.

In the decade since returning to Oak Ridge, I have founded two small companies to develop cutting-edge technology for medical diagnostics, energy storage, and space development. Even if I'm now an opinionated old curmudgeon, let me relate some heartfelt views about our near-term and future space prospects.

I believe it is a major travesty that we got to the moon fifty years ago, while humans have been trapped in low Earth orbit ever since. The "reasons" always cited are that it is too expensive to go back to the moon and Mars, but the real reason is protecting huge budgets supporting business-as-usual. In fact, perpetuating *Evolutionary* progress is vastly less efficient and more expensive than *Revolutionary* breakthroughs. New jobs for all kinds of expertise will quickly evolve with Great Challenges. It is great that wealthy visionaries like Elon Musk and Yuri Milner are finally breaking through decades of intransigence by funding visionary efforts outside the box.

In spite of current good signs for long-overdue progress, I feel strongly that there are near-term game-changing technologies that can greatly accelerate human space development. Following are some examples. First, building giant telescope interferometers in nearby space using relatively simple new technology that is vastly less costly than conventional optics would allow us to observe details of exoplanets more quickly than projects such as Star Shot. I patented the PAMELA (Phased Array Mirror Extendable Large Aperture) technology in 1988 & '89, and a large experiment at Marshall Space Flight Center proved its feasibility. Second, I did a detailed study of laser light sail propulsion for JPL forty years ago. The findings of that analysis are just as daunting now as then. I know how difficult and expensive it will be to launch interstellar micro-probes with lasers and light sails. I think, however, that there is a very competitive alternative launch method known as StarSling that can be achieved easily with robotic hierarchical Von Neumann machines to capture and industrialize very small near-Earth asteroids. For more information, I gave a colloquium lecture titled "Ultra-lightweight Probes to Catalyze Interstellar Exploration" at the SETI Institute on June 15, 2015 that you can find on their website or by following this link: seti.org/weeky-lecture/ultra-lightweight-probes-catalyze-interstellar-exploration.

So now, to finish this rambling narrative, let's cut to some specific examples of game-changing technology concepts that I believe can enable rapid and safe human space development. Since pictures are worth thousands of words, I'll use them to convey my ideas for colonization of the solar system that will catalyze our reach for the stars. The proposed technologies can save many years and countless dollars while greatly expediting permanent colonies on the Moon, Mars, Asteroids, and then the Jovian and Saturnian satellites. Initial implementation capabilities can be achieved within a decade by re-programming about half of NASA's annual budgets. The prime motivational question is this: **How can we expect humans to reach the stars if we can't first establish our permanent presence throughout our own solar system?**

Earth to Space Laser Power Beaming

This concept occurred to me in 1989, and it was thoroughly studied and justified by several parallel efforts funded by NASA and DoD. It solves the problem of the two-week lunar night while also providing ample power to process regolith materials and run high-thrust plasma-propelled transfer spacecraft from the Earth. If implemented, it can lower the cost of developing a permanent colony on the moon by nearly a factor of ten. The basic idea is to keep the heavy and difficult-to-maintain components of the power-supply technology on the ground at four desert sites around the Earth (Fig. 4). The power is transmitted from reasonably priced PAMELA (Phased Array Mirror Extendable Large Aperture) telescopes designed to handle megawatt laser beams without frying the optics. The photovoltaic cells that receive the power are "tuned" to the narrow-band laser light, so their efficiency is about 60% instead of less than 20% for solar cells.

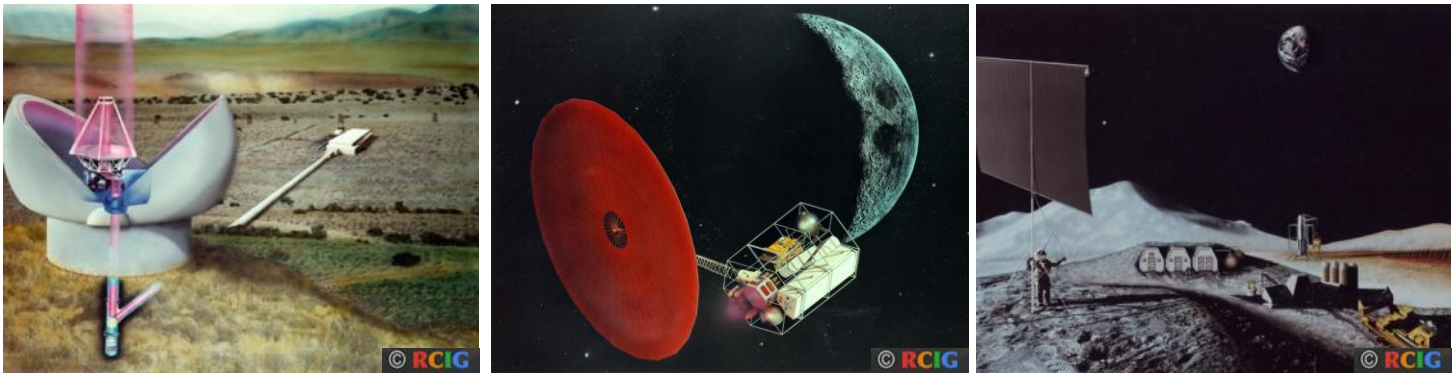


Figure 4. Earth-based lasers can supply a megawatt of laser power for propelling high-thrust plasma engines on transfer spacecraft from low Earth orbit to low Lunar orbit. They can also power lunar bases both day and night, processing regolith for oxygen, nitrogen, and hydrogen to sustain humans and plants and to refuel a shuttle craft to low lunar orbit.

Superconducting Technologies: Key to Transformative Space Development

A great hero of technology innovation is Dr. James Powell, who pursued much of his career at Brookhaven National Laboratory. I have been privileged to work with Jim in creative efforts for four decades. In 1968, Jim and Gordon Danby invented superconducting Magnetic Levitation, which enables game-changing applications in transportation, launch, and energy storage. A relatively simple spin-off application is called MIC, for Magnetically Inflated Cable. Let's look at some implications of the technologies in remainder of this article.

Earth to Space Electromagnetic Launch and StarTram

Using the Powell/Danby technologies, the Japanese have built superconducting trains that travel at 600 km per hour levitated by linear induction aluminum coils. Very similar technology can catapult rockets from mountain tops to greatly enhance payload fraction and thus reduce costs of space development. This MagLifter concept is shown in Fig. 5. Superconducting wire with liquid nitrogen cooling will transform electrical system technology in the next few decades. It will enable StarTram, which can be thought of as an inverted suspension bridge stably levitated by magnetism to support a launch tube twelve miles above the Earth. Electro-Magnetic acceleration will take humans into space at costs a hundred times less expensive than rockets. This concept is shown in Fig. 6.

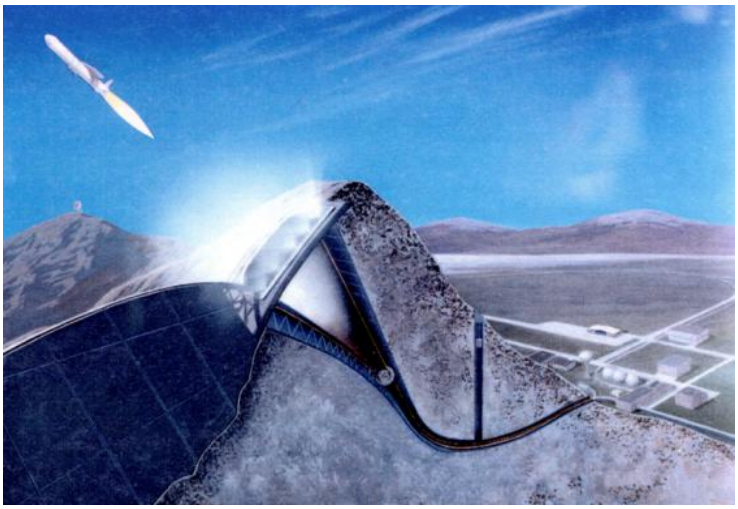


Figure 5. The *MagLifter* concept for catapulting rockets from mountain tops.

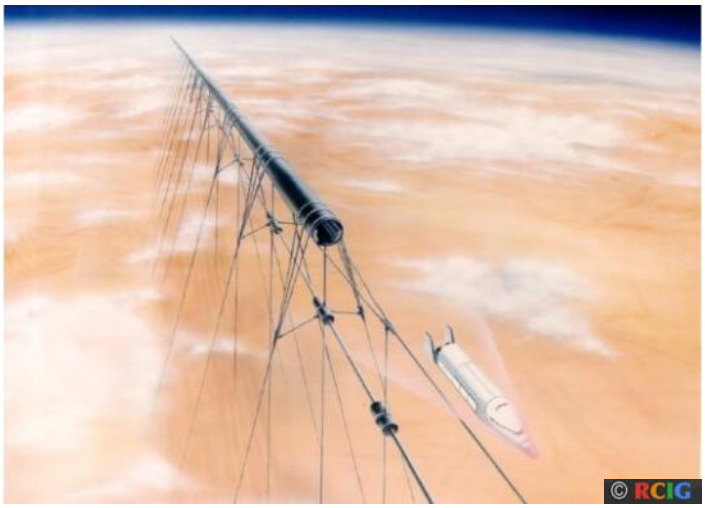


Figure 6. The StarTram launch concept for human launch with 3.5G acceleration.

MIC: The Key to Capturing and Engineering Small Asteroids

Magnetically Inflated Cable (MIC) Technologies can deploy precisely-formed very large, low weight structures. Ampere and Faraday did experiments in the 1830s that demonstrated that the magnetic fields of currents in closed loops of wire cause the wires to repel, thus potentially forming rigid circular rings. With the availability of second-generation high-temperature superconducting wire, thousands of amperes of current can be induced by solar cells to inflate large structures in space. This enables launch of thirty-meter diameter solar concentrators that can heat high-thrust monopropellants (Fig. 7) to rendezvous with small (10 meter diameter) asteroids that visit the vicinity of the Earth quite frequently. The focused solar heat can evaporate the surface, gently propelling the asteroid into high Earth orbits where they can be robotically engineered for very important applications enabling safe and comfortable human spaceflight through the Van Allen belts or on lengthy flights to Mars. (Fig. 8, 9, 10)The following graphics are example applications for MIC technologies, including transforming asteroids for propulsion, habitats, radiation shielding, and accelerator systems like the StarSling.

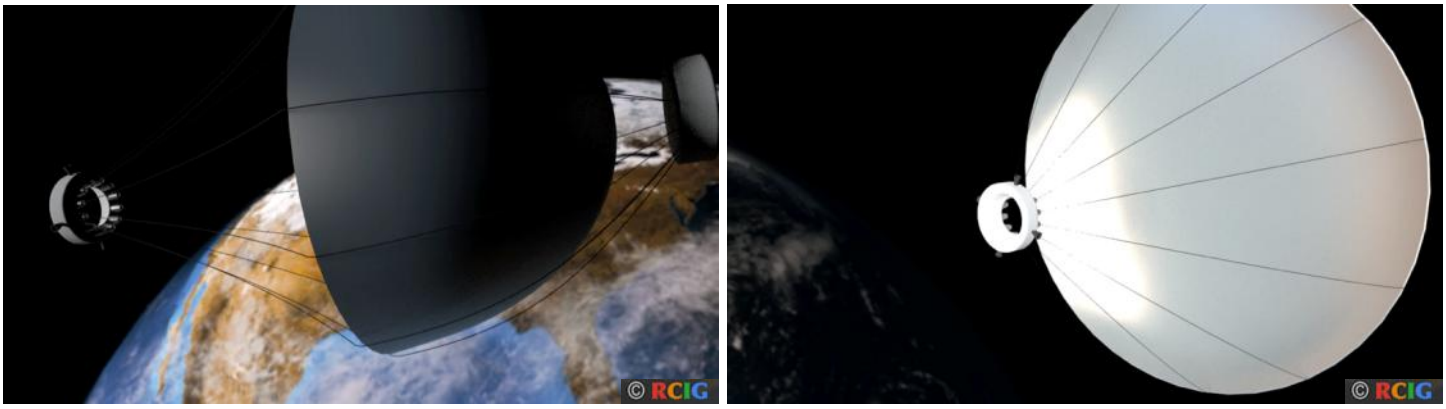


Figure 7. MIC superconducting wire loops position a low-mass solar concentrator using carbon filaments. The hot ring near the focus contains propulsion and maneuvering fuel. This concentrator and engine can be used to capture small asteroids.

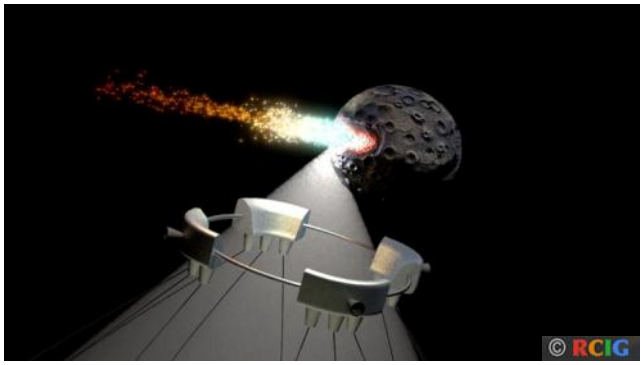


Figure 8. Focused sunlight heats a 10 meter asteroid to 3000 degrees K. The hot gas provides thrust to capture it to a stable L4 point on the moon's orbit. Robotic machines can then hollow it out and line it with an inflatable habitat. Transferred then into Low Earth to Low Lunar elliptical orbits, this massive enclosure gives perfect shielding from dangerous radiation from solar flares and the Van Allen Belts in a protected environment.

Figure 9. Two asteroids 500 meters apart can be joined by carbon filament cables and revolved around the center for artificial gravity. This solves the dangerous health problems associated with zero G and exposure to cosmic radiation.

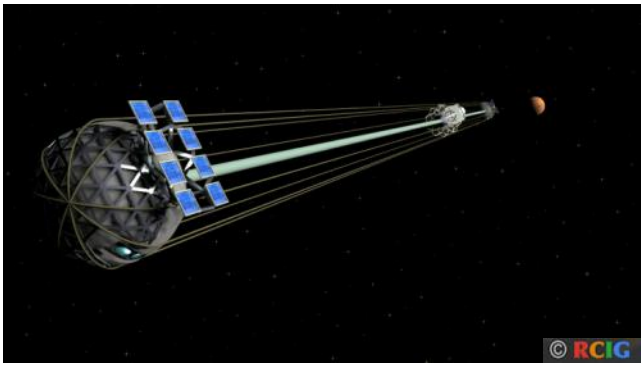


Figure 10. As robotic engineering of asteroids matures, they can be combined to form huge systems. This figure shows a *StarSling* accelerator anchored to ten-meter asteroids in polar orbits 50,000 km above the Earth. These can potentially launch human or unmanned payloads for safe transit to other planets.

NEWS FROM OUR SISTER ORGANIZATIONS

Initiative for Interstellar Studies (I4IS)

The Initiative for Interstellar Studies (I4IS) has announced a workshop on the Foundations of Interstellar Studies to take place in New York City from the 13th to the 15th of June 2017. The workshop is a collaboration between I4IS and the Physics Department and the Center for Theoretical Physics at New York City College of Technology.

They are currently looking for submissions by authors that attempt to solve existing problems or at least describe a pathway towards those solutions. The technical sessions will be held over three days to discuss the following:

• Day 1 Energetic Reaction Engines: Any engines that involve the ejection of matter or energy rearwards from the vehicle for thrust generation. E.g. electric, plasma, nuclear thermal, fission, fission-fragment, fusion, antimatter catalyzed fusion, antimatter.

• Day 2 Sails & Beams: Any concept which involves the transfer of momentum via photons or particle beams, e.g. solar sails, laser sails, microwave sails, particle beamers, stellar wind pushers.

• Day 3 Breakthrough Propulsion: Any breakthrough propulsion concepts, an area of technology development that seeks to explore and develop a deeper understanding of the nature of space-time, gravitation, inertial frames, quantum vacuum, and other fundamental physical phenomena with the overall objective of developing advanced propulsion applications and systems that will revolutionize space exploration.

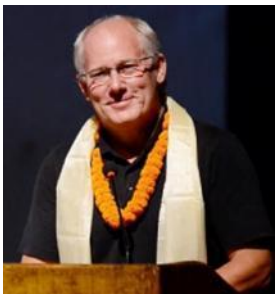
Further details about the workshop, including registration and submission, can be found at the website address: http://www.citytech.cuny.edu/physicsworkshop/

About I4IS

The Initiative for Interstellar Studies (i4is) is a limited by guarantee company, not having a share capital, incorporated in the United Kingdom, which makes us an effective non-for-profit organization. Their long term ambition is to enable both robotic and human exploration and colonization of the nearby stars.

Tau Zero Foundation

Tau Zero Foundation Selects Dr. Andy Aldrin as Chief Strategist



Dr. Andrew Aldrin was selected to serve as chief business strategist on the Tau Zero Foundation board of directors to provide pragmatic objectivity and insight for the nonprofit's mission. He currently serves as the Director of the Buzz Aldrin Space Institute (BASI) and is an Associate Professor at Florida Institute of Technology.

"The frequency of the discovery of exoplanets around the nearby stars to the Sun highlights the importance of our mission," said Rhonda Stevenson, president and CEO of Tau Zero Foundation. "We invited Dr. Aldrin to join the Foundation's board because his retained objectivity and pragmatic approach will be helpful to narrowing our focus to the development of technologies with the greatest potential for practical application in the near future. As a space industry veteran with an exceptional talent for strategic management and assimilating advanced technology concepts into viable programs, Dr. Aldrin brings immeasurable value to our Foundation, and we are very excited to have him on our team."

About Tau Zero Foundation

Tau Zero is a 501(c) non-profit organization dedicated to accelerating progress toward the scientific breakthroughs required to support interstellar flight. The Foundation's efforts, driven by the experts most capable of addressing the formidable challenges of interstellar flight, include fundamental scientific research, encouraging and supporting academic involvement in sciences related to its goals, empowering youth in this quest, forging collaborations for cross-fertilization, and engaging governmental and industry support on a global scale.

TVIW STUDENT SCHOLARSHIPS

This year, with the support of Baen Books and Digital Oilfield Solutions, TVIW has developed a new scholarship program for deserving students. There will be two undergraduate scholarships for high school seniors and undergraduate students, and one graduate scholarship. The scholarships will be awarded on a merit-basis in the amount of $2500 per recipient.

The application not only includes the student's accomplishments, but also requires an essay on topics including: the rationale for humanity to become an interstellar species; A near-term plan (within 20 years) for building advocacy toward interstellar space exploration; what the student can do to help further humanity's expansion into space; and why space development is important.

The deadline for all applications is May 15. Applicants for the undergraduate scholarships must be high school seniors in the southeast United States (Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina or Virginia) who plan to pursue their first undergraduate degree in mathematics, engineering or science at any accredited, four-year American college or university. Applicants for the graduate scholarship must be full-time college or university students majoring in math, engineering or the physical or social sciences, and must plan to seek a graduate degree in science from an accredited college or university in any of the nine southeast American states.

For more details or to apply, visit the website: tviw.us/scholarships.

UPCOMING INTERSTELLAR OR SPACE EVENTS

April 10 (Earth). Jupiter and the moon will make an especially close pairing.

June 13-15 (New York City). I4IS Workshop on Interstellar Flight. Website: citytech.cuny.edu/physicsworkshop/

June 27-29 (Torino, Italy). International Academy of Astronautics 10th Symposium. Website: http://spaceexplor.iaaweb.org/?q=leaflet

August 21 (Earth). Total Eclipse of 2017. Websites: eclipse2017.nasa.gov or www.greatamericaneclipse.com

September 15 (Saturn). NASA's Cassini will end remarkable mission by entering and burning up in Saturn's atmosphere.

September 22 (Earth). Northern hemisphere autumnal equinox. Southern hemisphere vernal equinox.

October 3-6 (Huntsville, AL). TVIW 2017 Symposium (TVIW5). Website: tviw.us/2017-symposium/

October 24-26 (Glasgow). 15th Reinventing Space Conference. Website: rispace.org

November (Moon). China to launch robotic mission to return samples from the lunar surface.

November 10-11 (Austin, TX). New Worlds 2017 Symposium. Website: newworlds2017.com

November 13 (Earth). Venus joins Jupiter

December (Earth). Launch of NASA's TESS (Transiting Exoplanet Survey Satellite) space telescope.

December (Earth). Launch of ESA's CHEOPS (CHaracterizing ExOPlanet Satellite).

December 5-7 (Houston, TX). SpaceCom. Space Commerce Conference and Exposition. Website: spacecomexpo.com

December 13 (Earth). Geminid Meteor Shower

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To participate, go to **smile.amazon.com**. 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

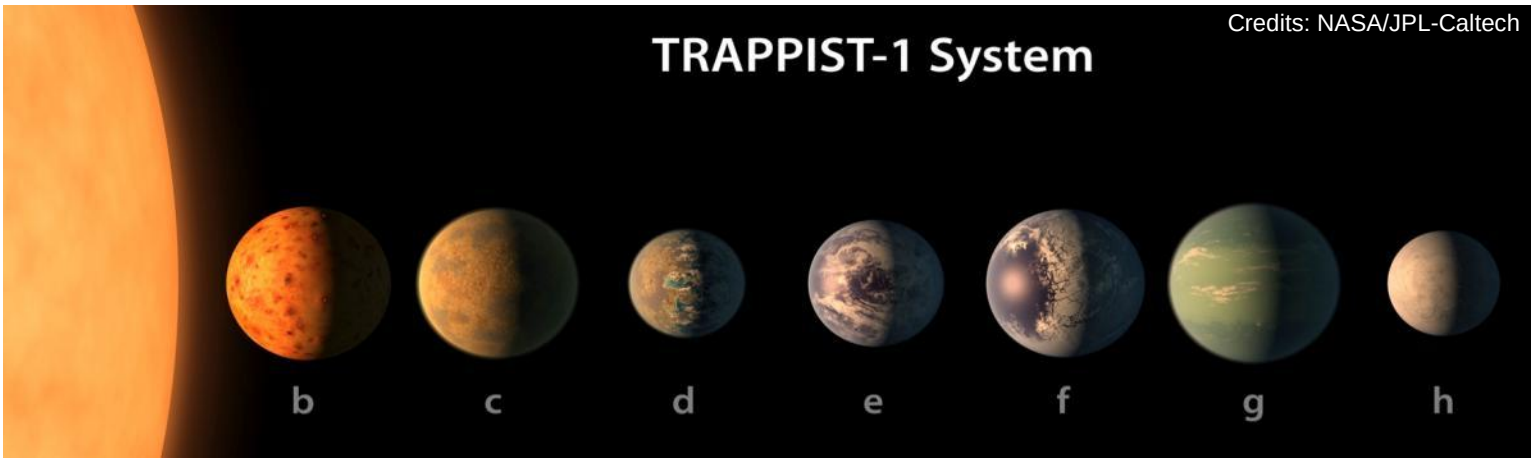
FEEDBACK

What would you like to hear about in the next newsletter? Suggestions? Comments? Do you have a technical note or an article that you would like to share with the TVIW community? Or comments on an article in the TVIW newsletter or other publications? Just drop us an email at info@tviw.us, connect us via social media or by regular mail at: TVIW, Inc., PO Box 4171, Oak Ridge, TN 37831.

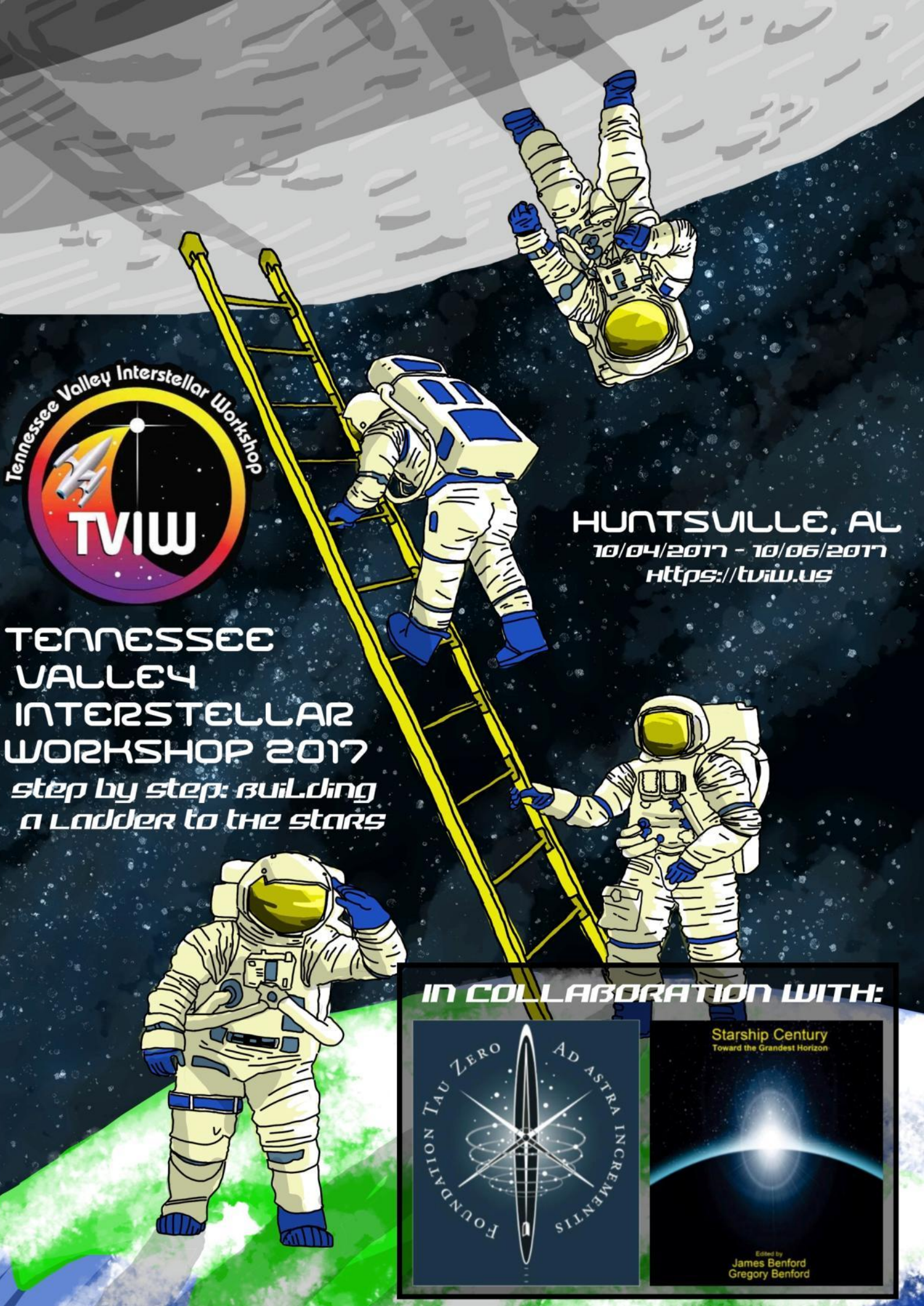
A NOTE FROM THE EDITOR

I sincerely hope that you have enjoyed the content we have been able to share. We try to provide interesting and succinct information about the ongoing activities in the interstellar community. With the wonderful events and announcements of the past year, the future of an interstellar civilization – though distant – looks bright. I am looking forward to meeting you at TVIW 2017 in Huntsville this upcoming October!

- Abigail Sherriff, *Editor*



Until Next Time…
Look Up at the Stars and Dare to Dream Big.
Something Really Big!


Tennessee Valley Interstellar Workshop
TVIW
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10/04/2017 - 10/06/2017
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TENNESSEE VALLEY INTERSTELLAR WORKSHOP 2017
step by step: building a ladder to the stars
IN COLLABORATION WITH:
FOUNDATION TAU ZERO
AD ASTRA INCREMENTIS
Starship Century
Toward the Grandest Horizon
Edited by
James Benford
Gregory Benford