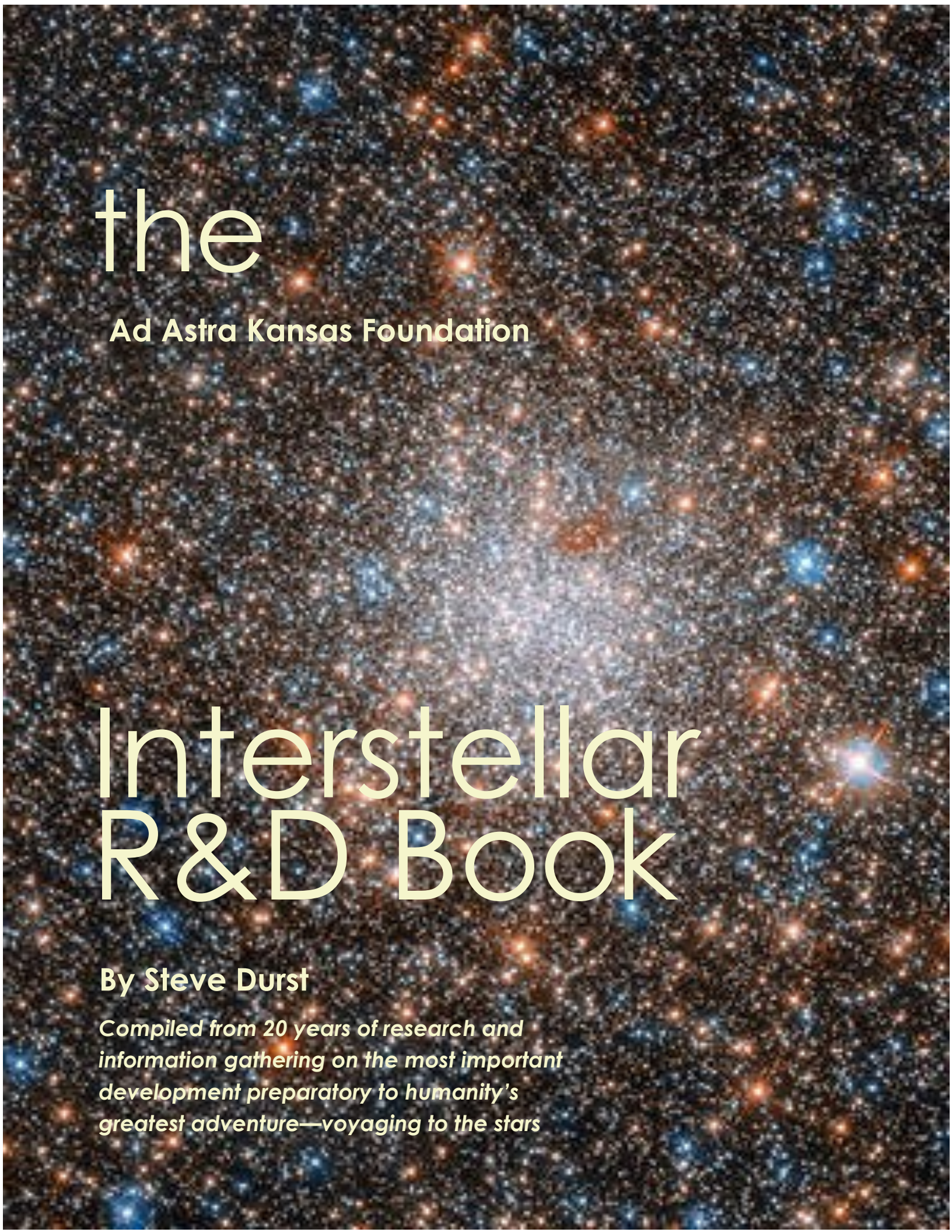

the

Ad Astra Kansas Foundation

Interstellar R&D Book

By Steve Durst

Compiled from 20 years of research and information gathering on the most important development preparatory to humanity's greatest adventure—voyaging to the stars

Issue I Spring 2002

INTERSTELLAR R & D

Observation

Observation is the first point of contact between our world and its neighboring star systems

Ground-Based Observatories

To get the most out of ground-based observing, a high-altitude site that can limit interference from the atmosphere is needed.

- Mauna Kea, Hawaii, whose summit is located at 4,206 m, is home to 13 telescopes. Major scopes include Kecks 1 and 2, 10 m mirrors and adaptive optics, Gemini North 8.1 m, use infrared technology to penetrate gas clouds, and Japan's Subaru 8.2 m.
- In Chile, European Southern Observatory owns 627 km2 at Las Silla mtn at 2,400m. Currently, 9 of 18 scopes are in use. ESO also operates facilities at Paranal, 2,635 m atop Cerro Paranal. Cerro Tololo Inter-American Observatory, east of La Serena at 2, 200 m, operates four scopes. The int'l operated Gemini South is located nearby, 2,737 m atop Cerro Pachon.
- The Indian Astronomical Observatory, in Hanle, open in 2001, sits at 4,517 m, making it the world's highest observatory for optical/infrared/submillimeter observing.
- Tibet's ARGO International CosmicRay Observatory at Yangbajing is located at 4,300 m.

Space-Based Observatories

To really escape the effects of light and radio wave interference one must leave Earth entirely.

- Hubble Space Telescope: Launched 24 April 1990 aboard Space Shuttle *Discovery,* orbits Earth at 612 km altitude. The mission, which cost $2.2 billion at launch, may last 20 years.
- Chandra X-Ray Observatory: Launched 23 July 1999 by Space Shuttle *Columbia* to observe X-rays from high energy regions of the universe, such as the remnants of exploded stars. Chandra is expected to stay aloft for 25-50 years, though the scientific mission will last only 15 years.
- SIRTF, the Space Infrared Telescope Facility: to be launched from KSC 9 January 2003. Its 2.5-year mission is to obtain images and spectra by detecting the infrared energy radiated by objects in space between wavelengths of 3 and 180 microns. Most of this infrared radiation is blocked by the Earth's atmosphere and cannot be observed from the ground.
- NGST, the Next Generation Space Telescope: Scheduled for launch in 2009, will replace HST for a 5-10 year mission to explore the origins of the universe. It is expected to cost $1 billion to manufacture and $2 billion to operate.

Moon-Based Observatories

An international lunar-based observatory / science facility is proposed by several researchers like David Schrunk and Paul Lowman as an optimal location for work that cannot be done from Earth. Ongoing projects and efforts continue to push for this development.

Communication

The SETI Institute, located in Mountain View CA, was founded in 1984 by Thomas Pierson and Dr. Jill Tarter to study the origin, nature and distribution of life in the universe. Board members have included Dr. Carl Sagan and current Chairman Dr. Frank Drake. Project Phoenix, led by astronomer Seth Shostak, uses the 305 m radio scope in Arecibo, Puerto Rico to listen for signals of intelligent life. SETI@home allows people to donate computing time on their PCs to help the search. The Allen Telescope Array, now being constructed near Mt. Lassen in CA, will soon let SETI listen for signals of life 24 hours a day.

Transportation

"Interest and commitment to humanity's greatest adventure meets the new decade with a wave of growth unmatched since the nuclear-power interstellar scenarios of the 1950s-60s."—From Space Calendar, December 2000 / January 2001

Now a year later, new NASA Administrator Sean O'Keefe introduces a breakthrough 21st century space nuclear power research and development—$1 billion over the next 3 years.

In February 2002, another instance of the renaissance of interest in interstellar travel is the widespread attention given the discussion by Dr. Geoffrey Landis, Glenn RC, of multi-generational space travel at the AAAS meeting in Boston.

NASA now operates programs established by the end of the 1990s:

- The Interstellar Propulsion Research Center, Marshall SFC, Huntsville:; Les Johnson, anti-matter
- New Millennium Program Interstellar Probe / Gossamer Spacecraft / Interstellar Trailblazer, JPL, Pasadena; Sarah Gavit, solar microwave, laser
- Breakthrough Propulsion Physics, Glenn RC, Cleveland; Marc Millis, gravity modification and quantum teleportation
- Advanced Space Transportation Program; Gary Lyles, Glen Mucklow; Institute of Advanced Concepts, Robert Casano

Internationally, 21st century interstellar R & D is progressing in St. Petersburg, Russia (wormholes), Japan (BESS anti-matter project), and Germany's Max Planck Institute. Other promising interstellar transportation initiatives include Mini-Magnetospheric Plasma Propulsion, Robert Winglee, University of Washington; and the work of 'October Sky Rocket Boy' Homer H. Hickham, who sees "fusion, fission, anti-matter opening the entire solar system"; then magnetospheric plasma, laser propulsion to follow our Pioneers and Voyagers...to the Stars.

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INTERSTELLAR R & D

Observation

Earth-based, space-based and lunar-based observatories provide varied and comprehensive capabilities for studying our stellar environs and learning about the cosmos.

Earth-based Observatories

- Hawaii Island —Mauna Kea Summit 4,206 m; Keck I and II, Gemini North 'cyber observatory', and Subaru-Japan pioneer Adaptive Optics; AO developed by Jerry Nelson; produces "eightfold improvement" in image, says Keck's Frederick Chaffee; AO 'laser guide stars' being perfected.
- Chile, North — Atacama Desert; European Southern Observatory four 8.2m optical telescope interferometers make Very Large Telescope VLT "able to see a man on the moon"; 64 -dish Atacama Large Millimeter Array ALMA at 5,400m+ by 2011; 100m Overwhelmingly Large Telescope OWL may follow.

Space-based Observatories

- Space Infrared Telescope Facility to launch 9 Jan 2003 and follow Chandra X-ray and Hubble Optical in NASA Great Observatory program, as reported in *Interstellar R&D*, Ad Astra Kansas News #1.
- Gamma-ray Large Area Space Telescope 2006 launch to measure intergalactic magnetic fields, and help understand how galaxies form and evolve, and how little-understood origins of powerful cosmic rays determine production of gamma rays.

Lunar-based Observatories

Any and all astronomical and astrophysical observations are superior from the Moon compared to Earth. And one of the first elements of a lunar base will be an international lunar observatory. A Lunar Optical interferometer proposed by Kondo, Oliversen, Lowman and Chen in 2002 could search for those cold, dark rocks" that threaten Earth, says Moonwalker John Young, and also for extrasolar planets.

Communication

SETI: The Search for Extraterrestrial Intelligence

The SETI Institute is a non-profit organization founded in 1984 by Thomas Pierson and Dr. Jill Tarcher. Its origin was partly inspired by work done in the early '60s by Dr. Frank Drake, now a SETI trustee, who created the Drake Equation to calculate the likely prevalence of life in the universe. The Institute's two branches are: the SETI Center, led by Tarcher, and the Center for the Study of Life in the Universe, led by Dr. Christopher Chyba, who also holds the Carl Sagan Chair. There are over 100 scientists working on the SETI project. The organization has administered over $150 million in funds during its 18-year history.

The first grant, received by SETI in 1985, was from NASA for a targeted search program using microwaves to detect signs of intelligent life. The ongoing search uses a transportable system that can be moved between telescopes around the world. It is currently housed at Arecibo Observatory in Puerto Rico. The $26 million Allen Telescope array to be built in the Cascade Mountains is a joint project with UC Berkeley that will aid in the search for life's origins. SETI is working on establishing a $100 million ongoing endowment.

Many disciplines are involved with SETI. The work of social scientist Dr. Doug Vakoch is but one example. Vakoch studies cultural aspects of contact with an extraterrestrial civilization, especially communications. He focuses on ways an alien culture might try to create messages suitable for travel across interstellar space and also possible psychological and religious responses to detecting a signal from extraterrestrial intelligence.

Transportation

What's Ahead for Space Propulsion?

One of the most forward looking projects at NASA may be the In-Space Propulsion Program (ISP) focusing on developments that will advance propulsion technologies by significantly reducing cost, mass and travel times. Ground has been broken on the New Propulsion Research Laboratory at Marshall Space Flight Center in Huntsville, Ala., slated to open in April 2004. And the NASA Office of Space Flight has given the go-ahead to several development ideas in advanced propulsion. Major areas of research include:

- **Nuclear Electric Propulsion / Power Conversion:** Uses nuclear reactors to generate heat which is converted to electrical power for high-performance electric thrusters. Projected budget is $33 million through 2004.
- **Aerocapture:** Used a planet's atmosphere to slow spacecraft and capture it into orbit. This means there is no need for on-board propulsion; saves mass and requires a smaller, less expensive launcher.
- **Solar Sails:** Membrane-thin sails made of strong composite material; requires no fuel; propelled through space by solar wind, the photons emitted by the Sun. Projected budget for aerocapture and solar sails combined is $37 million through 2004.
- **Maglev Technology:** Used to give initial boost to craft; can accelerate a craft up to 965 km/hr on a specially designed track prior to firing traditional rockets. Significantly decreases amount of propellant needed for launch, thus reducing mass or allowing for heavier payloads.

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INTERSTELLAR R & D

Observation

The Galactic Center of our Milky Way

Fairly typical of the countless billions of galaxies expanding throughout the cosmos, our local Milky Way Galaxy, about 100,000 lightyears in diameter, consists of 200-300 billion stars revolving around its central core.

The center of our galaxy, some 25-30,000 lightyears from our star (solar) system, has become an area of intense interest in recent years to astrophysicists and astronomers worldwide. Scientists observe in far-infrared and radio wavelengths to image through the dust and gas that block optical telescopes. Using wide field radio imaging of the National Radio Astronomy Observatory's Very Large Array to observe the galaxy's "central parsecs" (about 1,000 lightyears), scientists from the Naval Research Laboratory noted unusual phenomena at the galactic center—including a compact, yet extremely strong radio source Sagittarius* (Sgr A*) at the exact center of our galaxy. Astronomers increasingly believe this point-like source to be a massive black hole, equivalent to millions of Suns.

Many astronomical instruments, both space-based (Hubble, Chandra, Compton, RXTE, ROSAT, MSX) and Earth-based (Gemini North and South, Keck, Subaru, NRAO VLA and VLBA, ESO VLT) operate in a great variety of wavelengths (from radio, millimeter, submillimeter, infrared and optical to ultra-violet, x-ray, gamma-ray and neutrino) observing such galactic center phenomena as dark matter annihilation, central star orbital accelerations, molecular gas and stellar iron abundances.

An electronic newsletter, launched at a Galactic Center workshop in La Serena, Chile, in 1996 is available at gcnews@astro.umd.edu and at www.astro.umd.edu/~gcnews. A Galactic Center international conference meets biannually, and galactic consciousness is growing around the globe.

Communication

Seth Shostak: A Scientific Approach to Listening for Signs of Life in the Universe

A senior astronomer with the Mountain View CA-based SETI Institute, Dr. Seth Shostak's job involves always having one ear tuned to the sky. Dr. Shostak oversees the Phoenix Project, a comprehensive survey examining signals from space in an attempt to determine if those signals arise from potential intelligent sources. Dr. Shostak earned a BA in physics from Princeton and a Ph.D. in astronomy from Caltech. He spends much of his time educating the public about SETI, always emphasizing the scientific basis for the work rather than the more speculative or fringe aspects. While he believes it is quite possible that other intelligent civilizations exist somewhere within the vast universe, Shostak does not think that ETs have actually visited Earth. "Few scientists are convinced that the ETs are joy-riding through our atmosphere," he said during an ABC sponsored Q & A.

With Project Phoenix, Shostak and his colleagues can observe Sun-like stars for relatively long periods of time at a wide range of frequencies and signal types. This allows them to follow up on any interesting signals within minutes of first detection—an advantage not found in other observing programs where researchers must sometimes wait weeks for a second look.

However, the most exciting and effective work in looking for signs of intelligent life is still to come. The $40 million Allen Telescope Array to be built in the Cascade Mountains in California is a joint project with UC Berkeley that will be 100 times quicker than the search being done now. It will have a total collecting area of about 10,000 square meters, and its frequency range—from 0.5 to 11 gigahertz—will be wider than any previous SETI telescope. It will be able to image segments of the sky 2.5 degrees wide at a time, instead of just a single point. Whereas current operations allow scientists to search a few thousand stars, the Allen Array will allow hundreds of thousands and possibly millions of stars to be searched. Speaking with *New Scientist* about the Allen Array Shostak said, "This is the first instrument I think has a real chance of detecting a signal within our lifetimes. This instrument changes the rules of the game."

Transportation

NASA Head Promotes Nuclear Propulsion

Dubbed *Project Prometheus,* the program to develop a nuclear reactor and propulsion system is receiving support from NASA Administrator Sean O'Keefe. In a NASA TV address, O'Keefe denied rumors of plans to use the technology for a human mission to Mars in the near future. Instead, the government has signed of on *Jupiter Icy Moons Orbiter* mission slated for 2009 / 2010. The mission will use nuclear-powered electric propulsion to allow the craft to "jump" between the orbits of the jovian moons. The cost of Jupiter Tour is expected to be at least $3 billion.

Antimatter Propulsion for Interstellar Travel

NASA Institute for Advanced Concepts is studying the use of antimatter propulsion for space voyages. Researcher Steve Howe is working on a sail which generates energy in two ways: it can trap ions and trigger matter-antimatter explosions, and the antimatter can also react with the sail's coating of uranium-235 to generate nuclear fusion. "We're trying to find an architecture to do really deep space exploration, technology that might allow interstellar missions," Howe told space.com recently.

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INTERSTELLAR R & D

Observation

Cosmic Rays

High-energy "particles and high-energy light that bombard the Earth from *anywhere* beyond its atmosphere are known as cosmic rays", according to NASA. Galactic cosmic rays, coming from outside the solar system and / or galaxy; anomalous cosmic rays, from interstellar space at the edge of the heliopause, and solar cosmic rays from solar flares and other energetic solar events, hit the Earth from every different direction in space with a wide range of energies up to 10^{20} electron volts. Such ultra high energy particles can be created only by astrophysical phenomena which are investigated as to their origin and composition by scientists worldwide.

Cosmic rays were discovered in 1912 by Austrian physicist Victor Hess, who later received the Nobel Prize in Physics for the work involving high-altitude balloon research. Colliding with neutrons and other particles in Earth's atmosphere, high-speed mostly proton cosmic rays produce an "air shower" of many secondary particles such as meson, pions, muons, photons, etc. which arrive and can be detected and measured on Earth's surface. Cosmic rays may affect upper atmosphere weather and individuals involved in high-altitude airflight.

Advanced research is ongoing at The Institute for Cosmic Ray Research (University of Tokyo), the International Cosmic Ray Observatory at Yangbajing, Tibet (Chinese Academy of Sciences, Tibet University and University of Tokyo), the Utah High Resolution Fly's Eye, Japan Akeno Giant Air Shower Array, the Pierre Auger experiment in Argentina (a collaboration of 250 scientists from 16 nations), and with Europe's Extreme Universe Space Observatory to be mounted on the International Space Station NET 2005. Cosmic ray research from the Moon's surface is expected to have obvious advantages.

Communication

Could Dolphins Help Humans Understand Signs of Extraterrestrial Intelligence?

Could an ability to decipher communication patterns of dolphins or other animals one day help humans in the search for extraterrestrial intelligence? Some SETI researchers think it might. Dr. Laurance Doyle, a principal investigator at the SETI Institute has analyzed dolphin whistles for patterns of complexity and found they are as complex as human speech—a sign of intelligence. He believes that this analysis may also be applied to signals detected from space to help distinguish between truly purposeful communication and inconsequential space noise.

Another SETI researcher, Dr. Lori Marino, is examining the relationship between brain size and body weight across several species to help determine whether evolution of intelligence is a common process, environmentally linked and driven by natural selection, or whether it is a random phenomenon. An understanding of how intelligence arises on Earth may help researchers uncover just how likely it is for intelligence to arise elsewhere in the universe.

Transportation

Solar Sails

In his 1963 short story "Sunjammers," Arthur C. Clarke wrote about solar sail "yachts" participating in a race around the Moon. Today the solar sail idea is getting closer to making the leap from science fiction to fact as several experts, including Clarke, suggest it is a valid method for interstellar travel. Propelled by sunlight, these gigantic, yet gossamer-thin sails would travel through space due to photons from the Sun hitting their reflective surfaces and exerting enough force to give the sails a gentle push. Although the acceleration rate is small (acceleration for a typical sail could be five ten-thousandths meter per second per second), over time the cumulative effect would lead to a speed of 16,000 km per hour after 100 days or 160,000 km per hour in 3 years. At that speed a craft would be able to reach Pluto in less than 5 years.

In a conversation in Astrobiology Magazine, physicist Freeman Dyson, Planetary Society Chairman Bruce Murray and Executive Director Louis Friedman all speak in favor of the Cosmos 1 solar sail project being sponsored by the Planetary Society and Cosmos Studios, a media company headed by Carl Sagan's widow Ann Druyen. The Cosmos 1 project recently completed a major launch readiness milestone in August 2003 as the Russian Volna Launch vehicle successfully passed a test of the entire launch sequence using an engineering model of the solar sail payload. Cosmos 1 is expected to launch from a nuclear submarine in the Barents Sea between October 2003 and Spring 2004.

Another group looking at solar sails is Team Encounter LLC, which has just been awarded $6.5 million from NASA to fly the Inertial Stellar Compass navigation device on Team Encounter's Flight One solar sail demonstration launch set for 2005. The demonstration will be followed by the first official launch projected for 2007 aboard an Ariane 5 rocket. Dubbed "Humanity's First Starship" the craft will carry messages, drawings, photographs, and biological signatures (hair samples) submitted by up to 4.5 million people.

Interstellar transportation research received a blow recently when budget cuts stalled funding for NASA's Breakthrough Propulsion Physics led by Marc Millis at Glenn Research Center. On a brighter note however, is the 11 September notice that NASA Marshall Space Flight Center is soliciting industry partners in a solar sail flight validation experiment as part of NASA space Technology 9 New Millennium Program.

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INTERSTELLAR R & D

Observation

Astronomy From the Moon / Lunar-Based Astrophysics

The human quest to the stars, that begins with observation, takes a giant leap forward and upward with our return to the Moon, robotically at first, permanently and for good. Every single astronomy or astrophysics observation made from Earth is superior from the Moon, and the reasons for this advantage are well known: Absence of obscuring and distorting atmosphere,; stable surface; long, cool nights (1/2 lunation, or 14.5 days), low gravity (1/6 Earth g), far side radio frequency silence.

From Luna's surface, a large variety of astronomical and astrophysical instruments and observations are possible—radio, infrared and optical telescopes and interferometers; interferometry from ultraviolet to submillimeter wavelengths and for very long baselines, including Earth-Moon VLBI; X-ray, gamma-ray, cosmic ray and neutrino detection; very low frequency radio observation; and more.

Celestial research of special interest for lunar-based observation includes detection of Extra Solar Planets and of Earth / Moon Approaching Objects, the Search for Extra Terrestrial Intelligence SETI, and the study of our Galaxy and its center.

Astronomical technologies with special advantages for lunar-based observation include interferometry of all kinds benefitting from lunar stability, infrared enhanced by crater cold trap cooling, radio free of interference through far-side lunar shielding, optics' capacity increased through ultra light weight materials in low gravity. Submillimeter, as well as high-energy ultraviolet, X, gamma and cosmic ray wavelength technologies, among others, all have enhanced atmosphere-free performance on the Moon.

Interstellar R & D grows through astronomy and astrophysics development, and in turn, astrophysics and astronomy progress through the growth of interstellar R & D. To the Stars via the Moon, and to the Moon via the Stars.

Communication

SETI: The Search Intensifies

The Search for Extra Terrestrial Intelligence (SETI) Institute in Mountain View, Calif., announces that the Allen Telescope Array (ATA-32) will be conducting scientific research by the end of this year. The ATA is a private-public partnership between the SETI Institute and the Radio Astronomy Laboratory of the University of California, Berkeley. The first step in the three phase project, with the two initial phases funded by Paul G. Allen, ATA-32 will expand to ATA –206, and then to ATA-350 by the end of the decade. Dr. Jill C. Tarter, ATA project leader and director of the Center for SETI Research there states, "Finally, our tools are becoming commensurate with the size of our task."

But even with 300 times the observational capabilities available, what are the possibilities that life exists elsewhere in the universe? Dr. Christopher Chyba, principal investigator for the SETI Institute lead team of the NASA Astrobiology Institute (NAI) heads a team which examines the interaction between life and planetary evolution. If the potential for life can be ascribed to planets other than earth, that potential may be noted in bodies within a proximity to Earth which would facilitate investigation, such as Europa, one of Jupiter's icy moons, which likely has a subsurface of water.

Cynthia B. Phillips of the SETI Institute started her "change comparison" analysis of Europa as part of her PH.D. thesis. Phillips' comparison of the 1979 Voyager images with Galileo's images of the late 1990's was limited by low resolution from Voyager and revealed no geological changes. She conjectures that there is a greater likelihood of detecting smaller changes by comparing the much higher resolution Galileo images, over their five-year timespan.

Kevin Hand, Dr. Chyba's graduate student at Stanford University, is conducting related research by finding abiotic ways that electron donor and acceptor pairs could theoretically be produced through the action of radiation on the surface of Europa. Microbes utilize that energy which is liberated by combining electron donors and acceptors. Hydro-thermal activity, as well as organics and oxidants provided by radiation chemistry on the surface, could reach the liquid substrate through geological movement as electron donors and acceptors needed to fuel an ecosystem.

Proximity allows the examination of Europa, research into possible ecological scenarios and contemplation of that which may be occurring throughout the universe—the synthesis of life.

Transportation

Power Issues Heating Up

Recent discoveries raise demands for increased power to propel more sophisticated exploratory equipment to distant sites of interest. Engineers at NASA Marshall Space Flight Center are looking to nuclear-powered propulsion to satisfy these demands. In a series of non-nuclear tests utilizing small stainless steel pipes, structured in a hexagonal configuration, which are superheated in a vacuum chamber, engineers evaluate material reactions which will occur when excess heat must be dissipated in outer space.

"Heat has to be turned into electricity and whatever excess dumped off the spacecraft. We have to find materials that can stand up to the massive heating," says Marshall engineer Ron Porter. For the first time in 45 years of space travel, spacecraft sensor design must also be modified to accommodate the immense heat of nuclear reactors.

Gene Austin, retired Marshall manager, says, "If we go to Mars in any meaningful way, then I don't see how we can do it without bring nuclear propulsion and research back. We brought it to a very high state of readiness in the late 1960s, and then the mission went away. It can be done again."

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INTERSTELLAR R & D

Observation

Earth's Astronomy Frontiers and Centers: Development Update

The National Radio Astronomy Observatory, operated for the National Science Foundation and based in Charlottesville, VA, continues pioneering interstellar frontiers and making remarkable discoveries,. NRAO, currently directed by Dr. Fred Lo, oversees the Green Bank Observatory WV (which this year celebrated its 30th anniversary discovery of the Sagittarius A* black hole signature at our Milky Way Galactic Center), the 27-dish Very Large Array in Socorro, NM, the 10-dish Very Long Baseline Array VLBA across the USA, and the American contribution to the future 64 -dish Atacama Large Millimeter Array ALMA in Chile.

The VLBA radiowave ability to penetrate surrounding stardust plasma and measure within the dense black hole some 24,000-26,000 light-years from Earth is not the only Hawaii observatory focused on the galactic center. The Canada-France-Hawaii Telescope, the 7-nation Gemini North Telescope, the Smithsonian Astrophysical Observatory Submillimeter Array, and among still others, the twin Keck 10-meter telescopes are producing the clearest, highest resolution images and widefield mosaics of the radio, micro, millimeter and submillimeter, infrared, optical, and ultraviolet waves, and gamma and x-rays in the region near a black hole. Still higher energy cosmic rays and neutrinos are the focus of astrophysics research in Antarctica, another emerging frontier of 21st century Earth-based astronomy. Using the Antarctic ice sheet as a giant continental telescope to study elusive neutrino particles, University of Hawaii physicist Peter Gorman hopes to learn more about the universe's most explosive events.

Besides Hawaii and Antarctica, the Arecibo radio observatory in Puerto Rico and the Cosmic Ray Telescope Array in Delta, Utah, are also pioneering Earth-based astrophysics.

Communication

Mysterious Signal Misinterpreted

A recent article in New Scientist magazine states that a new signal, SHGb02+14a, detected through UC Berkeley's Seti@home project, may be from 1,000 light years away. At the time, expectations were raised by NASA's announcement of a new class of non-gaseous planets, and astronomers worldwide were excited by the revelation. However, according to Dan Werthimer, head of the Berkeley project, excitement was misplaced because reporters were unaware of the scope and probabilities associated with this work.

Seti@home data is received from Arecibo radio telescope, which operates constantly, piggybacking onto other observations. There are 15 million signal reports each day which come from Seti@home. A list of candidate signals, based on persistence, frequency and location, are then evaluated individually, as were 200 last February. Of that group, only one signal, SHGb02+14a, was again confirmed.

While the persistence of this signal brought some attention, Paul Horowitz, head of Harvard SETI efforts, points out that statistical probability alone suggests at least one of the candidates would reappear. The conjecture that the signal comes from a distance of 1,000 light years was based solely on a lack of known stars of closer proximity within the swath of the beam.

Transportation

Advanced Propulsion to Enable Stellar Missions

The future of space exploration will lead out of the solar system and to the stars beyond. To realize missions of such scope, advanced propulsion systems are being developed which will dynamically enhance the cost effectiveness and capabilities of future space vehicles.

NASA is currently touring Starship 2040, a space transportation exhibit featuring full-size control, passenger and engineering compartments, with audio effects to stimulate the ambiance of outer space. The revolutionary innovations visitors view are all concepts and technologies currently being studied at NASA centers and partnering institutions across the nation. Advanced propulsion tops that list.

Antimatter propulsion is the ultra high-energy technology which may be needed to travel to the stars, and is currently being investigated at Marshall Space Flight Center. Minimally one hundred times the energy of fission fusion, antimatter propulsion technology would put the Moon at 7.5 minutes away, Mars only a day trip, and other galaxies within our reach.

University of California scientists have teamed with Northrop Grumman Space Technology to develop a way to use sound waves to generate electrical power. The thermoacoustic system is similar to current thermoelectric generators, but twice as efficient and reliable enough for deep space probes. An adaptation of the Stirling engine, heating and cooling helium creates sound waves, just as lightning causes thunder, to drive a single piston.

But other forces appear at the edge of the solar system. Pioneers 10 and 11 are experiencing unexpected drift. A follow-up mission is planned to probe the "Pioneer anomaly." There is some conjecture that both have developed fuel leaks. Others suggest that the laws of physics may change over great distances.

Voyagers 1 and 2 are also experiencing drift. The heliosheath, a bubble-like vestige of solar gravity, may be tugging at the probes. Voyager 1 was believed to have passed through the heliosheath, however since the probe is no longer able to measure the speed of the solar wine, this has not been confirmed and the magnetic field did not increase, as expected based on current theoretical models.

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INTERSTELLAR R & D

Observation

Multi-Wavelength Imaging of the Milky way Galaxy: A Case Study

Reality of the observed universe is relative to the wavelength / frequency on the electro-magnetic spectrum (EMS) in which the observation is made. There is more to our majestic cosmos than meets the eye (visible wavelengths): In addition to the light radiated by stars, galaxies, quasars and other celestial objects, there is the invisible energy of infrared and ultraviolet light, x– and gamma-rays and micro waves.

Interstellar gas, the molecular 'dust' between the stars, was seen by astronomy 50 years ago as a nuisance, blocking visible light-only observation of 'real' objects of interest, the stars. Today the gas between the stars is seen by science and astrophysics as important to studying and understanding the evolution of the galaxy as are the stars themselves.

Imaging the interstellar gas of the Milky Way Galaxy produces different information when using different wavelengths along the EMS (from longest/ slowest to shortest / most energetic): Radiowave Continuum 400MHz—reveals fast-moving electrons, especially at sites of past supernovae; Microwave Continuum 2.4-2.7 GHz—Warm, ionized gas and high-energy electrons; Far-infrared 12-100 microns—Dust warmed by starlight, especially in star-forming regions; Mid-infrared 6.8-10.8 microns—Complex molecules in interstellar clouds, as well as reddish stars; Visible Light 0.4-0.6 micron—Nearby stars and tenuous ionized gas, dark areas are cold and dense; X-ray 0.25-1.5 kiloelectron-volt—Hot, shocked gas from supernovae; Gamma Ray > 300 megaelectron-volt—High-energy phenomena like pulsars, cosmic ray collisions.

The universe is "as we sense it", notes Larry Kellogg regarding Ronald J. Reynolds's analysis above. "new ideas and new ways of looking at what is around us can be most exciting."

Communication

SETI in Japan, Dialing Direct, QE

Japan's first government-backed SETI took place over five days in March 2005. The Hydra constellation was the focus of joint efforts by the Nishi-Harima Astronomical Observatory, using a 2 meter reflector telescope to detect light, and the Mizusawa Astrogeodynamics Observatory, which used a 10 meter radio telescope to detect radio waves.

Available on the internet, www.TalkToAliens.com offers a $3.99 per minute telephone number that directly routes the user's voice through a 10.5 parabolic dish antenna. The "Intergalactic Transmitter" is aimed at the Milky Way and, according to Christopher Rose at Rutgers University, can transmit up to approximately two light years away. The nearest star to our solar system is approximately four light years away.

Interstellar communications are receiving a high-tech boost from a principle called quantum entanglement, or QE. Entangled photons are "inseparable," meaning that when one photon is described, the other is described simultaneously. At NASA Glenn Research Center, two entangled photons were sent on separate paths, of of which passed through a double slit. The image of that slit was detected in both photons, "quantum faxed" to the photon which never passed through the slit.

Transportation

Speed is of the Essence

Voyagers 1 and 2, launched in 1977, will be Earth's first emissaries to leave the solar system. Traveling at 17,163 km per second, Voyager 1 is 8.7 billion miles from Earth. It appears to be crossing the termination shock of the solar winds and should reach the heliosheath within ten years. Both voyagers may be operational until 2020. Yet when they enter interstellar space, will they do so without NASA? NASA's 2006 budget does not include the $4 million annual funding to monitor the Voyagers' data.

New technologies and current science have funding appeal. NASA is currently working with the Southwest Research Institute (SwRI) on a new probe called the Interstellar Boundary Explorer (IBEX) which will image the outer boundaries of the solar system. IBEX is expected to launch in 2008 and cost approximately $134 million. But the vast distance to the edge of the solar system demands breakthrough technologies to reach interstellar space before missions become outmoded.

The European space Agency (ESA) commissioned a study on anti-gravity devices in 2001. While ESA determined to pursue more conventional methods, the possibilities of anti-gravity propulsion remain open. Clovis de Matos of ESA points out, "We do not understand the gravitational interaction at the quantum level." Marc Millis, founder of NASA's Breakthrough Propulsion Physics program, also sees potential in examining "gravitational or inertial manipulation."

Mark Waldron, writing for *Astrobiology Magazine*, suggests quantum entanglement as a viable concept for deep space propulsion. Entangled atoms maintain the same quantum states, no matter how they may be separated. If an entangled atom experiences a change in quantum states, the change will be transferred to the other entangle atoms by quantum teleportation." This relationship is already being exploited for the communications and computer sciences.

If applied to propulsion, fuel mass ratios would be obsolete. A small core of entangled atoms could receive energy teleported from their counterparts on Earth. Energy introduced to the Earth-located atoms could be from any source. The energy could then be converted into power to propel the craft and supply electricity for such power-hungry systems as radar.

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INTERSTELLAR R & D

Observation

Submillimeter Astrophysics

Submillimeter wavelengths enable astrophysicists to study the cosmos with extraordinary sensitivity, allowing sharpest views yet of obscured cold and dusty regions of the universe where stars and planets are being formed. Receiving submillimeter and millimeter radiation in wavelength 0.25 to 1.7 millimeters, submillimeter technology can resolve the complex chemistry of molecular clouds which generate organic molecules, precursors of life.

Earth's first submillimeter array SMA, an eight 6-meter antenna dish interferometer operational November 2003 at 4,140 meters atop Hawaii's Mauna Kea, literally has "seen what Hubble can't see". The first scientific paper on SMA observations published March 20, 2003, reported on the "flaring emission from the radio source surrounding the black hole in the center" of our Milky Way Galaxy.

Submillimeter astronomy is coming of age, and the SMA, operated by the Harvard Smithsonian Center for Astrophysics, enabled "exquisite resolutions" of the molecules released by NASA's Deep Impact on the nucleus of Comet Tempel 1 on July 4, 2005. The SMA also is used to monitor Mars weather and atmospheric chemistry, and to analyze Titan's thick, hazy atmosphere, climate and seasonal change—which is highly important for astrobiology and studying new planets around the stars.

The future of submillimeter astrophysics is upward, toward higher and drier places where les and less water vapor in the atmosphere blocks incoming submillimeter radiation. At 5,500 meters above the sea on Chile's northern desert, The European-North American-Japanese Atacama Large Millimeter Array ALMA of sixty-four 12-meter antenna operational late this decade will achieve a resolution of 10 milliarcseconds—10 times better than the SMA and Hubble Space Telescope.

Communication

M Stars Hold New Promise for SETI

The discovery of a planet orbiting an M star only fifteen light years from Earth may identify a new class of planets as good candidates for SETI activities. Jill Tarter, director of the Center for SETI Research at the SETI Institute, points out, "Simple theory said that terrestrial planets in orbit around M stars will be uninhabitable and uninhabited. But we are not confined to a simple theory any more."

M stars were previously considered unsuitable SETI candidates because they were thought to be too small to host planetary systems similar to our own. New observations, however, indicate that rocky planets with mass similar to that of Earth can be found orbiting M stars. "It may well be that there are far more habitable planets orbiting M dwarfs than orbiting all other types of stars combines," states the Director of the SETI Institute's Center for the Study of Life in the Universe, Frank Drake.

A series of workshops conducted by the SETI Institute will bring together forty participants from academia and NASA Astrobiology Institute (NAI) to determine whether M stars should be included in SETI observation. "Most of the stars out there are M stars," Tarter notes. "They haven't been on our target list. Maybe they should be. And if that's the case, the list just got a whole lot bigger."

Transportation

Will Opposites Propel?

Steven D. Howe, a nuclear engineer from Los Alamos National Laboratory, is now acting as founding director at the Center for Space Nuclear Research. The Center opened 19 September 2005 in Idaho Falls, Idaho, and will be coordinating a small grant program to promote research focused on nuclear power and propulsion.

"We have to have nuclear for a Mars mission," Howe states. Much of his career at Los Alamos was focused on a human mission to Mars. However, in 2000 How left Los Alamos and founded Hbar Technologies, LLC. There he focused on a solar sail spacecraft capable of reaching Alpha Centauri. The solar sail was driven by a power pack of 17 g of antihydrogen, a mirror image of ordinary hydrogen.

The NASA Institute for Advanced Concepts (NIAC) provides six month seed grants for feasibility studies of concepts which may be decades ahead of their time. Positron Drive is a propulsion concept which NIAC believes may offer a quantum leap forward in travel capabilities throughout the solar system and beyond. The positron is the mirror twin of the electron. Positrons are extremely rare due to their attractions to electrons, which culminate in annihilation and a burst of gamma rays. However the energy from the burst of gamma rays can be controlled and utilized for a wide variety of applications.

Gamma rays can be applied to a propellant or shot into tungsten plates to superheat and push air out the back of aircraft. Gerald A. Smith, principle investigator for Positronics Research, LLC of Santa Fe, New Mexico, points out that, "the energy density of antimatter is ten orders of magnitude greater than chemical and three orders of magnitude greater than nuclear fission or fusion energy." This is significant in that fuel would no longer comprise over half the weight of spacecraft.

Electron-positron pair production is accomplished by acceleration of an electron beam through dense tungsten. According to Smith, "Only one millionth of the positrons survive. Our long-range goals are five quad-trillion positrons per second. At this rate we could fuel up for our first positron-fueled flight into space in a matter of hours."

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Observation

New Astrophysics Technologies Increase Cosmos Understanding: Laser Guide Star Adaptive Optics: HESS Array

Reality of the material infalling to the Galaxy Center black hole and cosmic rays, emanating from it are more clearly observed and understood through utilizing the latest astronomy technology advances. The Laser Guide Star adaptive optics at Hawaii's 10-m Keck 2 Observatory enables the clearest picture yet of the center of our Milky Way Galaxy including the area surrounding the supermassive black hole and detailing dramatic infrared light variation. The High Energy Stereoscopic System (HESS), an array of four gamma-ray telescopes sited in Namibia, provides the first direct evidence for recently accelerated cosmic rays coming from the Galaxy center.

The Laser Guide Star (LGS)adaptive optics allow astronomers to "generate an artificial bright star" exactly where they want it, which reveals the atmosphere's distortions. LGS professor / researacher Andrea Ghez of UCLA notes that in overcoming these distortions in the atmosphere and producing high-res images, astropshysicists can use differing wavelengths to study the infrared light coming from the very hot material about to be pulled through the black hole's 'event horizon' at the center of our Galaxy some 26,000 light-years distant. "We are learning the conditions of the infalling materials," she observes, "and whether this plays a role in the growth of the supermassive black hole. The infrared light varies dramatically from week to week, day to day and even withing a single hour."

The HESS array enables astrophysicists to observe very-high-energy gamma ray emissions from gas clouds near the Galaxy center—radiation likely the result of cosmic rays interacting with these gas clouds. HESS scientists think this cosmic-ray signature may be produced in a single supernova remnant.

Communication

Terrestrial Communications Spur Interstellar Travel

Centauri-Dreams.org is the website of Raleigh, North Carolina author Paul Gilster, a computer specialist who has decided to pursue his childhood dream and reach for the stars. "Centauri Dreams goes back to when I was a kid. I was fascinated with the whole idea of deep space travel," he states.

Gilster intends to continue the work of NASA's Breakthrough Propulsion Physics Project, a short-lived effort in the 1990s to identify means of propulsion which could realistically go to the stars. "The site is really aimed at the scientific community so they could use it as a sort of clearing house specifically on interstellar flight issues," notes Gilster. Primarily a news site, Gilster updates six days a week. His dedication has led some scientists to send their papers before they are actually published.

Gilster is often surprised by new contacts through the site. A colleague of the late Carl Sagan provided him with a description of how a "worm hole" might look, based on research for the film "Contact."

Gilsters's site builds off his hardcover book, "Centauri Dreams: Imagining and Planning Interstellar Exploration." The web site includes Recent Posts, Archives, and specific categories such as Sail Concepts and Antimatter.

Transportation

Ion Thruster Innovations Place Stars Within Reach

Ion thrusters utilize an electric field to accelerate a beam of ions away from the spacecraft. Perhaps when NASA began examining the technology in the 1960s, it seemed as exotic as Positron Drive or quantum entanglement do today. Nonetheless, ion thrusters are in use and improvements in that technology may make a trip to the stars a real possibility.

Former astronaut Franklin Chang-Diaz led development of ion thruster technology while at NASA and currently is with Ad Astra Rocket Company, continuing work on the Variable Specific Impulse Magnetoplasma Rocket (VASIMR). VASIMR uses magnetic force fields to control the exhaust jet and prevent the nozzle from melting. The potential commercial applications include re-boost of large, orbiting platforms, satellite delivery, and cargo transport to the Moon.

"The promise this system holds could dramatically reduce the travel time for interplanetary missions, cutting trip times to Mars by one half or better," indicates Chang-Diaz. NASA's agreement with Houston-based Ad Astra Rocket Company allows for some funding over the next two years to facilitate a smooth transition for the project.

An Australian National University team designed and built the Dual-State 4-Grid (DS4G) thruster in less than four months. It is based on a concept British mathematician David Fearn suggested in 2001. The DS4G may offer tenfold speed compared to the Hall thruster which propelled SMART -1 to the Moon.

Ion thrusters generally use a one step process to extract ions from the reservoir and expel them. DS4G was designed as a two step process. Ions are extracted via two closely-placed grids that operate at about 3000V-5000V. Acceleration of those ions occurs between the second and third grids, where an extremely high voltage is applied. A fourth grid, again at low voltage, prevents stray electrons in the exhaust plume from moving backward.

This design allows for differences up to 30,000V to accelerate the ions. In testing, the exhaust plume traveled at 210 km per second. "And there's even talk of interstellar missions [beyond the solar system], states Orson Sutherland, who led the team that built the engine.

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Observation

Antarctica Astrophysics

The quest to the stars, and to the moon, increasingly lies through Earth's South Pole ice / rock "science" continent of Antarctica. Now host to activities from some 50 nations—about 30 with permanent staffed science research stations, Antarctica will observe International Polar Year 2007, fifty years after the birth of Antarctica Astrophysics (AA) during the IGY International Geophysical Year of 1957.

Twenty-first century AA projects, such as Caltech's BICEP in 2005 and the National Science Foundation's IceCube, follow 1990s advances by Center for Astrophysical Research in Antarctica (CARA, using infrared, submillimeter and radio wavelengths) and Antarctic Muon and Neutrino Detector Array (AMANDA), both operating from the "Dark Sector" near the Amundsen-Scott South Pole Station.

BICEP (Background Imaging of Cosmic Extragalactic Polarization) will operate at 100-150 GHz at angular resolution 1.0—0.7 degrees, and is designed to measure the polarization of the Cosmic Microwave Background, to provide answers about the beginnings of the Universe. IceCube, NSF's $272M multi-national cosmic neutrino telescope, is partially operational in 2006, and will encompass a cubic kilometer of ice under the South Pole when complete in 2011.

Also advancing in the 21st century, VLF Antarctica research on Earth's electromagnetosphere continues under direction of Stanford professor Umran Inan with the HAIL (Holographic Array for Ionospheric Lightning) study of sprites, blue jets, elves and other geomagnetic phenomena.

Internationally, increasing research activity in numerous scientific domain by many nations is highlighted by China preparations for its 3rd Antarctica permanent station (after coastal Great Wall and Zhongshan Stations) in the continent's unexplored hinterland and pristine crystal –clear air, atop highest ice cap zone Dome A.

Communication

Laser /Communication Tech Advances Lead the Way for Interstellar Use

NASA's measured focus on sustainable exploration advances in support of the Vision for Space Exploration will create an infrastructure for communications within the solar system which can be extended to the stars and beyond. Increased need for reliable transmission of large amounts of data on a continuous basis from the Moon and Mars has brought new focus on laser communications.

Laser communications can accommodate transmission rates that are 10 to 1,000 times higher than radio waves. The small size of the equipment takes up less payload space on a spacecraft and the narrow beam of the laser enhances security, also allowing for reduced antenna area and less power.

SETI involving laser communications is known as optical SETI and received the support of Arthur C. Clarke. Laser transmissions can reach across the galaxies with almost no interference and the equipment for transmission is inexpensive. Optical SETI is not hampered by terrestrial interference and is highly distinctive from natural processes which produce noise which is picked up in the search for radio waves.

As laser communications come into common use within the solar system, the refined technology will set the groundwork for communications which will be needed for interstellar exploration and travel in the future.

Transportation

Tau Zero Foundation and EnergyUSA Seek Interstellar Propulsion Possibilities

"The Tau Zero Foundation will establish itself as the dependable venue through which the visionary goals of interstellar flight can be advanced through imagination coupled with intellectual rigor," states Marc Millis, one of the founders of the organization.

The Foundation calls for philanthropic support, modeled on the SETI Institute and Biosphere 2. Millis, an employee at Glenn Research Center keeps the quest for revolutionary modes of interstellar travel entirely separate from his work at NASA. His Breakthrough Propulsion Physics Project lost funding in 2002, but NASA covers his time to maintain awareness and publish assessments of ideas for interstellar travel.

Millis reviews papers focused on antigravity, which he does not believe is a viable option, "a transient inertia effect" called the Woodward effect, and a gravitomagnetic effect which exceeds the bounds of general relativity. "The bottom line," say Millis, "is that there are no breakthroughs that appear imminent, but there are definitely small steps that can be taken to continue to look into these things. "

Norm Hansen, President of EnergyUSA, hopes to begin using "mirror Energy," utilizing matter / antimatter, to bring flights to the Moon by 2016. Long considered a candidate for interstellar propulsion, five grams of the fuel would power 1,000 round trips to the Earth's nearest neighbor.

"Mirror Energy" is based on positrons, which are costly to create and difficult to store. Nonetheless, EnergyUSA anticipates technological advances bringing costs down dramatically. The same improvements in production and control of positrons open the door to use in interstellar travel.

Dr. Louis Crane, a researcher at Kansas Sate University, is working to compute quantum effects in experiments involving gravity. He hopes to apply this to small, artificial black holes and test the feasibility of using them as energy sources for interstellar travel.

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Observation

The International Lunar Observatory Association (ILOA) Will Emplace and Operate the Multi-Function ILO Near the Moon's South Pole

Originating in Hawaii near the center of the Pacific hemisphere, the ILOA in 2007 has been endorsed by and seeks membership from institutes, individuals and enterprises to realize, place and operate a multifunction astrophysical observatory near the Moon's south pole as early as 2010, and to help support a follow-on human service mission to that facility. The ILOA is an Earth Moon Interglobal enterprise with projected membership from major spacefaring powers Canada, China, India, Japan, Europe, Russia, Brazil, Crescent Moon Countries, USA and others representing the great majority of the planet's people.

Primarily an observatory for radio, submillimeter, infrared and visible wavelength astrophysics, for other non-astronomical observations, and for some geophysical science, the ILO also will function as a solar power station (with silicon photovoltaic research), communications center (with varied commercial broadcast possibilities), site characterizer (solar wind, radiation, temperature, duration; micrometeorites, ground truth), property claim agent, virtual dynamic nexus, toehold for lunar base build-out and settlement, and Hawaii astronomy booster.

ILO astronomical objectives under consideration include observation of the Galactic Center; Extra-Solar Earth-Like Planets; Near Earth-approaching Objects; Earth, Sun and Earth-Sun system; Mars, Europa, Titan atmosphere / weather and that of other solar system bodies; obscured, cold and dusty regions of the universe where stars and planets are being formed from molecular clouds which generate organic molecules, precursors of life; and countless other extragalactic phenomena. Every astronomical and / or astrophysical observation, in fact, made from Earth, also can be made from the Moon, with consistently superior results.

Communication

Fermi's Paradox and No Desire to be Found

Rasmus Bjork of the Niels Bohr Institute calculates that 8 probes, each launching up to 8 smaller probes, and moving at one-tenth the speed of light, could explore an area of space containing 40,000 stars in about 100,000 years. Applying this math to our galaxy means that 10 billion years are required for a thorough search.

Bjork responds to Fermi's Paradox by asserting that ET and humans have not had time to find one another. But it's also possible that ET doesn't use the beamed radio or light transmissions which researchers monitor in their searches. ETs utilizing advanced systems, possibly with quantum mechanical effects to encode messages, may be undetectable. ETs utilizing something similar to carrier pigeons would be equally undetectable

Transportation

Pioneers and Voyagers: Bound for the Stars

In a little over 2 million years, Pioneer 10, launched in 1972, will reach its final destination: the red star Aldebaran which is the eye of the constellation Taurus. The distance is about 68 light years. Sister ship Pioneer 11 will travel for about 4 million years before passing near the constellation Aquila, The Eagle.

Reaching the stars has always fascinated humans, and we are just gaining momentum in that arena. Five years following the launch of Pioneers 10 and 11, Voyagers 1 and 2 launched to study the outer planets of this solar system, like the Pioneers. But even with a half-decade lead, Voyager 1 passed both Pioneers, becoming Earth's most distant emissary

Voyager 1 has traveled about 9 billion miles to date. Quite an accomplishment for a propulsion system the size of a coffee can.

Launched in 1977, it passed close to Jupiter and took advantage of a strong gravitational boost. Voyager 1 passed by Voyager 2 (which had, in fact, been launched one month earlier) and by 1998 had passed both Pioneers.

As the first spacecraft leave the solar system, new questions arise about forces present in deep space travel. The Pioneer Anomaly, a phenomenon which causes the Pioneers to seem to be pulled toward the Sun, is the subject of international research and debate. While possible that the effect stems from design considerations, there may be evidence of unidentified forces of physics.

Some conjecture that the mass of the Milky Way may be exerting a gravitational tug. Others suggest that Pioneer's dish antenna is behaving like a solar sail as it is struck by infrared photons from the radioisotope thermal generator. But with both Pioneers 400,000 km from where Newton's Law would place them, answers are needed.

Previously, the anomaly was being analyzed from limited data sets covering 11.5 years of Pioneer 10 and 4 years of Pioneer 11. Following a search sponsored by the Planetary Society, 400 magnetic tapes have been located in storage at JPL. Now utilizing 30 years of Pioneer 10 data and 20 years for Pioneer 11, researchers have been transferring the information to a digital format for clearer analysis.

This information will be important to a new mission, the Innovative Interstellar Explorer, which will launch in 2014 and travel 20 billion miles by 2040. Dr. Ralph McNutt of Johns Hopkins University states, "The real key is speed." IIE will take a cue from the success of its predecessor, Voyager 1, and use Jupiter's gravity as a slingshot to boost its velocity. IIE will travel to the outer edge of the Sun's influence, called the heliopause, and perhaps reveal the path our Solar System follows through the galaxy.

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Observation

JDEM SNAP Space Observatory to Study Dark Energy Phenomenon for NRC Beyond Einstein Program.

The Joint Dark Energy Mission JDEM is to be the first of NASA's Beyond Einstein cosmology missions to be developed and launched around 2015 according to the September 5 recommendation by the National Research Council. A team of UC Berkeley physicists hopes to win the JDEM three-project competition to build the billion-dollar NASA - DOE funded Supernova / Acceleration Probe SNAP and discover how and why the universe is expanding faster than Einstein thought possible. The SNAP team hopes to answer the questions: What is the dark energy accelerating the expansion of the universe? What is the universe made of? Is the universe infinite? Will it last forever? Dark energy is the unknown entity believed to constitute about 75% of all the energy in the universe and is considered "among the very most compelling of all outstanding problems in physical science."

SNAP is a multifunctional space-borne observatory with a powerful 2-meter class telescope and a half-billion-pixel imager, designed to study dark energy by recording the distance and redshift of about 2,000 Type Ia supernovae per year. Using the "weak gravitational lensing" phenomenon, SNAP will make a high-resolution map of the heavens covering an area 2,000,000 times larger than the Hubble Deep Field.

Other competing JDEM projects are the Dark Energy Space Telescope DESTINY of the National Astronomy Observatory in Tucson and the Advanced Dark Energy Physics Telescope ADEPT of Johns Hopkins University.

Communication

In Deep Space, Is A Number Worth A Thousand Words?

SETI demands examination of modes of communication just as much as hardware considerations. If that signal arrived, how would it be analyzed, and responded to?

Many suggest that mathematics would be a common factor for any civilization using radio telescopes. Dutch mathematician Hans Freudenthal published Lingua Cosmica, his own attempt at an interstellar language, in 1960.

Sundar Sarukkai, physicist and philosopher at the National Institute of Advanced Studies in India, has his doubts. "Their (scientists) belief that nature is written in the language of mathematics actually reflects their belief that mathematics is a universal language," he cautions. "Even if numbers or counting can be a common genesis, who is to say that calculus is a universal, necessary consequence of mathematical thought?"

Sarukkai suggests there may be no "language" ready for use and researchers should not seek a one-to-one correspondence for communication, but rather "some kind of mapping which allows us to understand vaguely rather than with certainty."

Transportation

Antimatter Research Paves Path to the Stars

The possibility of travel to the stars hinges on identifying and harnessing revolutionary propulsion methods. Fuels which currently launch satellites and carry astronauts to the International Space Station…even to the Moon…are far too heavy and inefficient to carry humans out of the solar system.

But scientists are already working with a fuel that may be ideal for starships: antimatter. Only one gram of antimatter, reacting with one gram of matter, releases energy comparable to that of a 20-kiloton bomb.

However, significant research must be accomplished to realize these possibilities. Currently, only nanograms of antimatter are produced annually, with its containment and storage being a major stumbling block.

At this point, the Penning Trap, Penn State's Mark I, and NASA's High Performance Antiproton Trap (KiPAT) represent cutting edge technologies for storage of antimatter. All are dependent on magnetic fields, add significant weight, and hold very little antimatter.

Masaki Hori, a researcher from Japan working at the Max Planck Institute, has taken a new perspective on this problem. He is examining using radio waves, instead of magnetic fields, to store antiprotons. Hori calls his receptacle a "superconducting radiofrequency quadrupole trap" and believes it can be realized in a size commensurate with a wastebasket. Hori began his work by careful analysis and measurement of the anti-proton, to determine whether the exact level of symmetry between matter and antimatter conjectured by researchers is accurate.

His work has captured the interest of the European Science Foundation, which has granted Hori a EURYI Award, with financial benefits similar to a Nobel Prize, which will allow his groundbreaking work to continue.

NASA's Institute for Advanced Concepts has awarded Phase I & II awards to Steve Howe of Hbar Technologies, who is also working with antimatter.

Howe has developed a concept for making even tiny quantities of antimatter useful for propulsion in space by bringing his interest in the solar sail into the mix.

Howe's Antimatter Sail utilizes a sail coated with uranium-235, against which milligram quantities of anti-hydrogen react. He believes that velocities exceeding 100 km per second might be attained and that a 10kg payload would take only ten years to reach the Kuiper Belt.

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Observation

Galaxy Forums 2008 Advance Interstellar Observation and Understanding

A series of Galaxy Forums sponsored by Space Age Publishing Company and the International Lunar Observatory Association starts July 4 in the Northern California San Francisco Bay Area, then 26 July in Vancouver, Canada, mid-October in Beijing, China, and possibly later in the year elsewhere, and will accelerate both scientific and general knowledge of our local, neighborhood Milky Way Galaxy.

A new domain for human understanding and exploration, mid-size between a finite Solar System and an infinite Cosmos, the Galaxy — with its 200 billion+ stars, 100,000 lightyear length, 270 million year period of revolution, and massively energetic center — provides a compelling focus and direction for 21st Century consciousness, education, and endeavor.

Astrophysical observation through galactic, sometimes dusty, interstellar space advances through multi-wavelength imaging — radio, microwave, submillimeter, far infrared, infrared, near infrared, optical, ultra violet, x ray, gamma ray — of the Galaxy's salient features: galactic center and bar, spiral arms, halo.

Galaxy education and interstellar learning 2008 is expanding rapidly through activities by Teacher in Space / astronaut educator Barbara Morgan, Galaxy Garden creator / artist Jon Lomberg, Virgin Galactic entrepreneur Richard Branson, among many others.

Communication

Bracewell Probes and Other Nodes

The Search for Extraterrestrial Intelligence has been on the minds of philosophers, scientists and visionaries since before humans were capable of reaching space. Consequently, many well considered and creative plans for advancing communication throughout our galaxy and others still wait for the needed technology to move forward.

In 1960, scientist Ronald Bracewell suggested sending robotic messengers -now known as Bracewell Probes-on interstellar missions to search for intelligence. The probe would target a host star and, upon arrival, go into a circular orbit in that star's "habitable zone." It would then scan the region for communications-type transmissions and - if any were found - broadcast those transmissions back to their source to draw attention to itself.

The benefits are numerous. The probe would be delivering a powerful signal, easily noticed even if the other culture were not monitoring deep space transmissions in search of other life forms. The probe would also be able to broadcast along a wider frequency range in its closer proximity.

A Bracewell Probe would utilize artificial intelligence to conduct preliminary "introductions" with the new culture. This could be accomplished in real time, without waiting for transmissions to cross interstellar distances, and may even include artifacts or gifts which could be carried in the probe.

Other benefits include the probes' ability to provide a continuous beacon in one locale, waiting for nearby life to develop radio technology. The probe could also contact unknown life forms and screen for compatibility prior to disclosing the location of its makers.

Conceivably, Bracewell Probes and other communications devices might serve as nodes to facilitate deep space communications as our culture advances into the cosmos. Fred Bourgeois, founder of Google Lunar X Prize Team FREDNET, hopes to land a tiny roving communications device on the Moon, and follow on with landings on asteroids. He believes that emplacing these potential nodes will open new possibilities and pave the way for intergalactic communications.

Transportation

Evolving Deep Space Missions

Careful planning is a key to success for long trips, so if you are developing a Deep Space mission - where distances are measured in light-years - there will be a lot of planning. But in this scenario where options are as numerous as the stars in the sky, how can the best path be identified?

A complex math algorithm called "differential evolution" is being applied by researchers at the University of Missouri to identify the most effective routes for space missions. Craig Kluever, an aerospace engineer at MU, along with former MU grad student Aaron Olds, applies the evolution simulating algorithm by treating possible solutions as individuals within a population.

As the population develops, individuals "mutate" and swap traits, with only the most successful surviving to the next round. With each repetition, the process narrows in on the best spacecraft trajectories.

Kluever and Olds tested their use of the algorithm against four actual space missions and were encouraged by their findings. "The Cassini results were actually very close to what was actually flown. A lot of event times and flybys were right on the same day or just off by one day," said Kluever.

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Observation

Galaxy Education in the 21st

Century Galaxy Forum USA 2009 is planned for July 4 at the New Venture Hall, Tech Museum of Innovation, San Jose, California, and follows the exploratory, proof-of-concept, first such forum July 4, 2008, in Santa Clara, Calif. Sponsored again by the International Lunar Observatory Association of Hawai'i and Space Age Publishing Company, Galaxy Forums in 2009 also may develop for Canada, China and elsewhere, similarly building on the successes of 2008 exploratory meetings.

The theme 'Galaxy Education in the 21st Century' suggests development and introduction of a teaching / learning Unit on Galaxy Education throughout the USA education system — primary and secondary, public and private, university and advanced — and throughout the education system of any nation.

Leading space education organizations such as the Federation of Galaxy Explorers, the Challenger Center, the International Space University, and the UCLA Galactic Center Group; and galaxy education projects such as the "Galaxy Garden" in Hawaii and the new and expansive "Galaxy Zoo" are making Galaxy awareness and consciousness, knowledge and learning, inspiration and direction a transcending reality for the coming New Decade.

'Galacticity', or 'galactivity' — awareness of the galaxy infrastructure of the universe and humanity's place in it — may be as influential and formative a force for the 21st century (and for Ad Astra Kansas interests) as is 'Relativity' for the 20th.

Communication

Cepheids Pulse: Binary Code Of A Galactic Internet?

Cepheids are rare, variable stars that dim and brighten in a regular pattern, related to how bright they are. They have been observed in galaxies over 100 million kilometers from the Milky Way.

This natural phenomenon caught the attention of University of Hawaii researcher John Learned. The blinking Cepheids' beacon-like quality could be observed for very long distances…even in interstellar terms. If it were possible to manipulate the timing of the pulses, might the stars be used to send out data in binary code by some advanced civilization?

The blinking of Cepheids is caused by the atmosphere expanding and deionizing. This results from buildup of ionized helium, which causes the star to dim. Learned points out that a high energy neutrino beam, aimed at the star's core, would artificially cause the Cepheid to brighten and enable binary data transmission.

SETI senior astronomer Seth Shostak has reservations, comparing the theory to the Russia concept of using the 100-200 supergiant stars to create anomalous radiation signals. Based on the estimate that Cepheid transmissions would use a millionth of a Cepheid's energy, Shostak points out that a high-powered radio beacon could transmit more data over the same distance.

Learned agrees that the chances of identifying a message are very slim. A Cepheid with a one day cycle would only be able to transmit around 180 bits each year.

Princeton physicist Freeman Dyson calls the theory "an interesting idea that can be tested." With 100 years of data already available, it is worth taking a look. "Analyzing that data would take a graduate student a couple of months…the implications would be astounding," notes Learned.

Transportation

Nanotechnology and Interstellar Propulsion

Imagine zero friction nanomachines whose parts levitate. In the amazingly tiny world of nanotechnology, this possibility is being examined. It could result from control of the Casimir effect, the ultimate cause of friction at the nano scale.

The Casimir effect was identified by Hendrik Casimir of the Netherlands. Casimir suggested that placing two parallel mirrors within a vacuum, and then moving them closer together, would result in a greater concentration of electromagnetic waves around the mirrors than between them, causing a tiny attractive force. This "Casimir cavity"—the space between the mirrors—would be considered an area of "negative energy density," since the surrounding vacuum is defined as an area of zero energy and the cavity excludes some electromagnetic waves.

Negative energy density was conjectured as the key to Star Trek's "warp drive" by Mexican theoretical physicist Miguel Alcubierre. He envisions a scenario where a traveling spacecraft would expand space/time in its wake and contract the space/time in its path. Yet technically, the spacecraft would be "at rest."

Most important is that the Casimir effect shows that a vacuum can be used as an energy reservoir. A propulsion system which can make use of that energy is still a long way off, however.

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Observation

Galaxy Zoo as Citizen Science

More than 200,000 internet explorers have participated in galaxy observation and classification since the July 2007 launch of what has grown to be the biggest citizen science experiment on the web. Inspired by the NASA Stardust@home Project, Galaxy Zoo is a collaboration between Oxford, Portsmouth, Johns Hopkins and Yale Universities and Fingerprint Digital Media, Belfast, and utilizes data compiled by the Sloan Digital Sky Survey, SDSS.

Galaxy Zoo 2 began in February 2009 to focus on some 250,000 of the brightest, most interesting galaxies of the tens of millions in the Galaxy 1 database. Beyond classification of galaxies into elliptical, spiral or merging, and clockwise or counterclockwise, Galaxy Zoo 2 observers are adding detail of shape and intensity of the galactic core, and on galaxy distribution, evolution and behavior. The goal of 30 individual classifications per galaxy greatly enhances accuracy and reliability of the database.

Individual participation is encouraged and facilitated by a 5-10 minute online tutorial, which, according to Oxford astronomer and Galaxy Zoo co-founder Chris Lintott, enables each galaxy classification in about 30 seconds on average. Galaxy Zoo core member Anse Slosar, a UC Berkeley cosmologist, confirms public response "astounding" from what MSNBC's Cosmic Log Alan Boyle terms "galaxy zookeepers".

To date, Galaxy Zoo has produced 7 or 8 published scientific papers with more to follow. Kitt Peak Observatory in Arizona and the IRAM millimeter antenna in Spain, among other observatories are being used to further Galaxy Zoo discoveries.

Communication

METI?

Chances are that if the house next door is vacant, you are keeping an eye out for who might move in. You may plan to take over a pitcher of lemonade as a friendly gesture, but would you leave off a dinner invitation or an extra house key before you had even seen the new occupants?

METI (Messaging to Extra-Terrestrial Intelligence) is also referred to as "Active SETI." METI typically involves radio transmissions, such as Cosmic Call 1999, Teen Age Message 2001 and Cosmic Call 2003, which are all transmitted from the Evpatoria Planetary Radar facility in the Ukraine.

Broadcasting scientific information—hoped to be a universal language—as well as personal messages from the public, these transmissions were aimed at constellations such as Andromeda, Orion, Ursa Major and Sagitta. The earliest projected arrival of these messages is 2036. Interstellar spacecraft such as Pioneer and Voyager also carry messages.

METI is surrounded by controversy for a variety of reasons. Some would say that it is not scientific, but highly qualified researchers spend time creating codes and messages that transcend any need for language. Like the Rosetta Stone, the same message is repeated in different formats to facilitate abilities to decode and interpret. The transmissions are carefully planned, evaluating the best wavelengths and the most likely targets for success.

Some also question the time frame for METI. Is there any value in a response that is received 200 years after the message has been sent? Carl Sagan would describe it as "an optimistic and far-seeing act" which expresses hope about the future, however he also notes "for those who have done something they consider worthwhile, communication to the future is an almost irresistible temptation."

METI is also questioned as a possible danger. While METI researchers sneer at this concept, calling it the "Darth Vader Scenario," questions have been raised. A 2005 survey found that 78% of respondents were in favor of METI. Did any of these respondents speak for cultures which were decimated by invasion from other cultures? Had any of the respondents ever lived in an environment where they might be considered food or property?

In 2007, the SETI Permanent Study Group of the International Academy of Astronautics adopted the San Marino Scale, developed by Professors Ivan Almar and H. Paul Such, to quantify the importance of these transmissions based on the information they contain and the strength of the signal. This suggest that some future parameters might be considered regarding METI.

Transportation

Shielding Innovation

Transportation of water is a concern in space due to the expense of its weight, but interstellar travel might see a reversal on this issue, thanks to the innovative thinking of Oleg Semyonov of the State University of New York at Stony Brook.

Shielding from high energy cosmic rays and dust is imperative and now it has been suggested that frozen water (an ice bulge) in front of the starship may be the best strategy. A metal shield would become brittle via bombardment of nucleonic radiation, but ice would not be subject to this problem. The ice would even be lighter than metal and serve double duty as a water transport.

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INTERSTELLAR R & D

Observation

GigaGalaxyZoom Takes Breathtaking Dive into the Milky Way

As part of the International Year of Astronomy 2009, GigaGalaxyZoom, a 3-image project of the European Southern Observatory in Chile, aims to "help people rediscover their place in the Universe through the day- and night-time sky," notes ESO project coordinator Henri Boffin, and "to link the sky that we can all see with the deep 'hidden' cosmos that astronomers study on a daily basis."

The first immense image is a magnificent 800-million-pixel panorama of the sky from ESO observatories at La Silla and Paranal by astrophotographers Serge Brunier and Frederic Tapissier: The view is at the front of our galaxy with the Galactic Plane running horizontaly through the image —as if looking at the Milky Way from the outside. The general components of our spiral galaxy come clearly into view, including its disc marbled with both dark and glowing star -studded nebulae, and the galaxy's central bulge with it satellite galaxies.

A second image for GGZ is a 34– by- 20 degree wide 340-million-pixel remarkable true-color mosaic of the heart of the Milky Way Galaxy Center. Using his personal 10-cm telescope from Paranal for more than 200 hours over 29 nights to take 1,200 images, ESO engineer and amateur astronomer Stephane Guisard enthuses, "The area I have depicted in this image is an incredibly rich region of the sky, and the one I find most beautiful."

Completing the GGZ trio of images, the Lagoon Nebula offers an eye-opening dive into our galactic home through the Wide Field Imager of ESO's 2.2 meter MPG telescope at La Silla—a gorgeous starscape more than 1.5 degree square, an area 8 times larger than the full Moon. "With the trilogy complete," affirms Boffin, millions of viewers "will be able to explore a magnificently detailed cosmic environment on many different scales."

Communication

Hello From Earth!

Last summer, COSMOS Magazine celebrated National Science Week in Australia and the International Year of Astronomy by inviting people around the world to post greetings to the HelloFromEarth.net website for an active SETI transmission to the Gliese 581 solar system. The actual SETI transmission was done by NASA, using the 70-meter main antenna at Canberra Deep Space Communications Complex in Australia.

Gliese 581 is a low-mass red dwarf star which is 194 trillion km (20.3 lightyears) from Earth in the Libra constellation. Gliese 581d is an earthlike planet discovered by Stephane Udry of the Geneva Observatory in Switzerland and considered one of the most likely possibilities for harboring life. On Friday August 28th, 25,878 messages traveling at a frequency of 7.145 gigahertz headed off to Gliese 581. They should be arriving in a little over 20 years, but considering the return trip, a response can't be expected until 2051.

Participants don't need to worry about hanging on till 2051 to reply to a response, though. It's strictly prohibited. The SETI Post-Detection Taskgroup of the International Academy of Astronautics chairman, Paul Davies, points out, "The protocol says nobody on Earth should attempt to reply until international consultations have take place. To safeguard this, the sky coordinates of the transmitting planet should be kept secret."

One thing that is not a secret, however, is the interest and adoration Earthlings have for ET. And while we may not be allowed to reply to a nonhuman transmission, there seems to be "no holds barred" when it comes to what can be sent out. Take Katelyn, in Australia, who wrote: "I just want to know what's with all the abductions? If you need a volunteer, please take my brothers!" And wouldn't she be surprised if they did…

But the majority of messages were very "neighborly" in nature, often making comparisons and asking advice.

Richard from Houston, Texas, asked: Does your society live in an environmentally sustainable manner? Are you, like us, living beyond your ecological means?"

A New Zealander named Jodie, got right to the point with, "Bet you didn't think we actually existed aye."

And, perhaps in the Gliese 581 system, some angst-filled poetic ET will find a cosmic connection with Jeff from Australia, who quoted Oscar Wilde: "We are all lying in the gutter, but some of us are looking at the stars."

Transportation

Keeping Up With the Expanding Universe

Juliana Kwan, a researcher at the University of Sydney in New South Wales, Australia, wonders how far deep space exploration can go in our constantly expanding universe. In a recently published paper, Kwan points out that even an astronaut traveling close to light speed would be left behind by the expansion.

Kwan's team estimates that changes in dark energy and other parameters—such as total density of matter—would cause a 15 billion-light year journey to take only 30 years, from the perspective of the astronaut traveling nearly the speed of light. Due to relativity, however, a return trip would be out the question; the passage of time on Earth would approximate 70 billion years.

Even our view of the universe will be diminishing, as cosmologists believe that distant regions are accelerating so quickly that they will eventually not even be visible through telescopes, since the light will no longer be able to reach us.

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INTERSTELLAR R & D

Observation

Optical SETI Complements Radio and Microwave Search Technologies

New advances in laser technology by the start of the 21st century have enabled searches for extra-terrestrial life to be conducted in the optical, visible wavelengths of the electro-magnetic spectrum, adding to radio and microwave SETI capabilities operational since the early 1960s. A high-energy nanosecond pulse optical laser transmitting with a 10-meter focus mirror on Earth would appear as an interstellar beacon thousands of times brighter than the sun to a distinct civilization in the narrow beam's line of fire. Possible detection of powerful optical laser nanosecond pulses have led to several search initiatives to receive optical communications through interstellar distances.

Systems to detect nanosecond optical pulses from extraterrestrial civilizations are now operational at UC Berkeley, home of SERENDIP and SETI@home, with collaboration from Geoffery Marcy, and at the Leuschner Observatory, with direction from Dan Wertheimer. UCB scientists, along with those from UC Santa Cruz and the SETI Institute, also have coupled Lick Observatory's 101-cm Nickel Telescope with a new nanosecond pulse detection system capable of finding laser beacons from civilizations many lightyears distant. This system, unlike other optical SETI searches, is largely immune to false alarms (cosmic rays, muon showers, radioactive decays) due to a new approach using three light detectors / photomultipliers — "perhaps the most sensitive optical SETI search yet undertaken," notes SETI pioneer Frank Drake.

Optical SETI searches also are being conducted at the Harvard-Smithsonian Observatory 155-cm telescope, with direction from Paul Horowitz, and in collaboration with Princeton University and its 91-cm instrument; also at Columbus, Ohio, and Sydney, Australia. More recently, the world's first 180-cm All-Sky OSETI telescope was unveiled by the Planetary Society, made operational by Harvard University, and is dedicated to finding that one high-energy pulse of unidirectional light that might be a communication.

Communication

FOCAL—New and Novel Equipment in the Search for ET

In its early incarnation, the Search for Extra Terrestrial Intelligence was made with a single 26 meter radio dish. Over the following half century, more sensitive and numerous dishes have been employed. Now, the FOCAL Mission seeks to utilize the largest object in this solar system, our Sun, as part of the apparatus that may bring the messages of other life-forms to our ears.

Italian physicist and visionary, Claudio Maccone, memorialized this groundbreaking concept in his 1997 book *The Sun As A Gravitational Lens: Proposed Space Missions.* Maccone points out that "each civilization has been given a single great gift: a lens of such power that no reasonable technology could ever duplicate or surpass its power. This lens is the civilization's star."

Predicted by Einstein's Theory of Relativity, gravitational lensing refers to very distant light being bent around a massive object that exists between the light and the viewer. As the massive object's gravity bends the light, a line of focus is created on the viewer's side of the object. Dr. Maccone cites the distance of this focus at 550 AU and beyond.

Utilizing gravitational lensing would require significant innovation, namely a deep space mission involving sending a spacecraft to 550 AU from the Sun. The resulting magnification, however is about 10^8. The benefits could be applied to radio astronomy observations, as well as communications.

Numbers have been examined for interstellar scenarios including Alpha Centauri, Barnard's Star and Sirius A. Even if life forms outside of our solar system are not broadcasting any detectable communications, FOCAL opens the door to interstellar exploration by making reasonable communications with the exploration crew or probe possible.

Transportation

Fill-Er Up with Less Than Nothing!

The natural desire to explore interstellar space remains frustrated by the vast distances involved. Our nearest star, Proxima Centauri, is the equivalent of 50 million round trips to the Moon and our fastest moving probe, Voyager 1, would take 74,000 years to make the trip.

This is why interstellar pioneers must turn to the cutting edge of physics theory to identify a power source, or fuel, which can propel a starship at the speed of light. Only a fuel which does not weigh down the vehicle will allow such speeds. Only a fuel which is available along the route can be trusted to make such a voyage.

New York University physicist Jia Liu may have identified a source for such energy: Dark Matter. It is believed that dark matter is about six times more prevalent than visible matter in the universe and, inspired by Robert Bussard's 1960 "ramjet" design, Liu may have found the key to utilizing it for interstellar travel.

One of the leading theories about the nature of dark matter is that it is comprised of "neutralinos"...particles with no electric charge that are their own antimatter. Theoretically, when two meet, they annihilate each other and the subsequent energy released is equal to the total mass of the particles.

Liu has envisioned a simple 100 square meter chamber which can open at either end and also compress its contents. Simply, with the front of the chamber open, the starship would collect dark matter in its path. Then the chamber would close and compress the contents, naturally increasing the speed of reactions within. When the back of the chamber opens, the energy rockets out, propelling the ship forward.

Liu has put some numbers on this scenario. If the starship weighs in at 100 tonnes, Liu believes the starship could easily reach the speed of light in just a few days. These speeds place Proxima Centauri within just a few years' travel.

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INTERSTELLAR R & D

Observation

The Exoplanet Revolution and the Kepler Mission

Officially totaling about 500 by October 2010, exoplanets — or 'extrasolar' planets, for planets beyond the Solar System — have long been speculated and anticipated (by G. Bruno in the 16th century, and I. Newton in the 18th), but their confirmation through science has occurred only in the few years before, and now in, the first decade of this new millennium.

The first definitive exoplanet detection by M Mayor and D Queloz of 51 Pegasi b in October 1995, confirmed by G Marcy and P Butler, opened the modern era of exoplanetary discovery — accelerated by technological advances such as high-resolution spectroscopy which enables Doppler or Radial Velocity, and Transit methods of detection. Microlensing, Astrometry and Pulsar Timing also are current detection techniques.

The launch of NASA's Kepler spacecraft in March 2009 on a 3-6 year mission to discover Earth-like planets orbiting other stars is sparking expectations that many hundreds of such worlds may soon be confirmed.

With brightness of more than 150,000 main sequence stars continually monitored through Ames Research Center mission control, multiple exoplanets transiting the same star recently have been discovered, and a Harvard scientist predicts a 50% likelihood that the first habitable exoplanet will be confirmed by May 2011.

Notable exoplanets besides 51 Pegasi b include 55 Cancri, COROT-Exo-7, Fomalhaut b, Gliese 581c, d and e, HD 189733b, HD 80606b, HD 209458B, HR 8799, VB 10b. A Carnegie Institute of Science researcher estimates there may be a "hundred billion" terrestrial planets in our Galaxy, many simple life forms, and that there could be thousands of civilizations among them.

Communication

What's Taking THEM So Long?

In 2008, Johns Hopkins researcher Richard Conn Henry addressed the American Astronomical Society, postulating that our first contact with Extra Terrestrial Intelligence will most likely occur when a signal is sent to Earth by a civilization that has spotted our planet's transit across the Sun.

He was making explicit reference to the ecliptic, the plane of Earth's mean orbit around the Sun.

In relation to the Galactic Disk, the ecliptic sits at a 60 degree angle, delineating a specific and limited area of 3% of the sky. The two points of intersection are in Sagittarius and in Taurus, marking out a prime territory for SETI. Researchers in a star system close to the ecliptic could reasonably have already observed Earth as it crossed the disc of the Sun, and a simple spectroscopic analysis of our atmosphere would confirm that Earth reeks with life.

But just in case ET doesn't notice us, the ecliptic will keenly focus a new search of tremendous power. To date, about 2,000 stars have been studied. The Allen Telescope Array (ATA), under construction in northern California, currently consists of 42 dish antennas. Upon completion, there will be 350 dish antennas conducting radio interferometry and examining up to 10 million stars in the next ten years. Coupling the vast power of ATA with the focus of searching less than 3% of the sky — the ecliptic between Sagittarius and Taurus — would provide a more detailed search than has ever been available before. SETI-Quest, which calls on the power of the internet community to examine information and participate in SETI, will certainly have a role in processing the huge amount of data generated.

So if you are tired of waiting for ET to "call," go to the SETI Institute's SETIQuest website and learn to use the tools that could make you the first person to discover a civilization in another star system.

Transportation

Moving Beyond the Solar System

In light of the amazing journeys of Voyagers 1 and 2, heading out of the solar system and flirting with the heliopause and interstellar space, one must wonder what the possibilities are for a true, dedicated interstellar mission at this time. Where can our current technology take us?

A properly powered spacecraft could reach the heliopause in about 20 years, with another 30 years of life for exploration in interstellar space. A small, nuclear fission reactor would be needed to supply electricity for communications and science functions, but the electricity could also be used to fuel an electric ion propulsion system. The constant, slight acceleration of such a system would eventually offer incredible speed, possibly even ample to overtake the Voyagers.

If the spacecraft were constructed in Earth's orbit, much of the work could take place at a space station. It would take weeks, once the electric ion propulsion system was activated, for the spacecraft to escape the gravity of Earth. During that time, the probe could be pulled back to the space station if it became apparent adjustments were needed.

Once the spacecraft passed the Moon, it would probably examine some of the host of small worlds—some with unusual orbits—that populate the Kuiper Belt, 30-50 times Earth's distance from the Sun. The probe could measure and map particles, study gravitational properties, and begin its journey into interstellar space. When the probe has traveled a distance of 1 light year from our Sun, it may reach the Oort Cloud, an area of space where dormant comets are believed to exist.

This would be true exploration. Speculation based on mathematics would be tested, as would the very laws of physics. New understanding and infinite possibilities await.

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INTERSTELLAR R & D

Observation

Galaxy Forums in 2011 Advance 21st Century Education Globally

Expanding in 2011 to Shanghai, New York and Cape Town, the Galaxy Forum program of the Hawaii-based International Lunar Observatory Association (ILOA) continues pioneering 21st Century Education with its focus on observing and understanding our Milky Way Galaxy, our place in it, and beyond. Dynamic and unique Galaxy Forums since July 4, 2008, have developed in Hawaii in Kona, Hilo, Waimea and Honolulu; across the USA in California and Kansas, and around the world in Canada, China, India, Europe and Japan.

Observation of our galaxy, its hundreds of billions of stars, and beyond, is most excellent in Hawaii, where the next generation Thirty Meter Telescope is advancing the Island's astrophysical leadership and renown as "Galaxy Central." Observation of the cosmos made knowable through communication forms the foundation of Galaxy / 21st Century Education, which enable Galaxy enterprise, Galaxy exploration and Galaxy development. As Virgin Galactic CEO George Whitesides recently noted. "It is our destiny...to access the solar system and eventually the rest of the galaxy."

And what a galaxy of superlatives is our Milky Way home, as we daily learn. The Kepler Space telescope now estimates 2 billion worlds similar to Earth and its life-nurturing conditions are possible galaxy neighbors. New measurements by the VLBA ten 25-meter antenna array are redrawing the map of our galaxy and its star-forming regions—confirming four spiral arms not two—and offering new possible explanations for the nature of dark energy; and the enormity of our galaxy can be sensed in knowing that the record attached to the Voyager Interstellar spacecraft has a projected lifespan of 1000 million years, which means those recordings of Earth sounds will never travel beyond our finite but immense Milky Way Galaxy.

The increasing discoveries in astronomical observation assure diverse, complex, and exciting 21st century growth of the ILOA Galaxy Forum architecture in America and Asia, Europe and Africa, Antarctica and beyond.

Communication & Transportation

A Starship in 100 Years?

Early this year, DARPA and NASA Ames brought in a small, specially chosen group to assess possibilities of creating a starship in 100 years. DARPA funded the study, which examines organizational development only.

The study was conducted by a group of about 30 participants, with half chosen from NASA and DARPA. The other participants represented some of the most recognized space organizations—including SETI, Tau Zero Foundation, the Planetary Society and the X Prize Foundation—as well as members of the science fiction and entertainment industry.

The first issue examined was, "Why go to the Stars?" The attendees' votes favored Human Evolution, with the possibility of Contacting New Life coming in second. They believe that the general public would view Contacting New Life as the priority, with Human Survival running second. An assessment of funding sources, however, would place the priority on Discovery, with Human Survival running a very close second. It was agreed, though not unanimously, that an international effort was the most appropriate strategy.

The attendees also defined a number of logistical and technological milestones or goals that they believed would put them on track for a 100 Year Starship. In the near term, they recommended a five year milestone consisting of four accomplishments. First would be proof that habitable worlds exist. This would be followed by a credible plan, which would then be marketed to promote an international view of hope and produce a mainstream movie with huge receipts.

A decade out, goals would be much more technologically oriented, including human landing on Mars, communications at faster - than-light speeds, the ability to generate life from computer code, and to sink carbon on Earth faster than it is being created.

At twenty years, things seem to get easier, with the goals being an image of another Earth-like planet, a robotic / telepresent probe on Jupiter's moon, Europa, and closed system life support known as ECLSS. At twenty-five years, the ability to reflect energy off of an exoplanet would be required and at thirty years, a satellite to the Oort cloud which is propelled, not by fuel, but by groundbreaking discoveries in physics. These new forms of propulsion will not only solve the problem of access to fuel while on a long journey, but also dramatically reduce the weight of the spacecraft.

Unfortunately, discussions of funding resources fell back on typical ideas that some "wealthy supporters" would establish lasting endowments and that deficit might be filled in by branding the "100 Year Starship" name and making huge, mainstream films with astronomical profits. Certainly one must question the credibility of using the entertainment industry as a "fundraising mechanism". Many big budget films are not money-makers. It may seem easy to make a "Star Wars" in retrospect, but the huge investment is always a gamble.

Likewise, it might seem reasonable to find "wealthy supporters," but these are invariably shrewd business people who will want to support a well conceived and developed plan. It is not reasonable to look to wealthy individuals in the hope some of them will be willing to impulsively gamble with funding that has the capacity to do a huge amount of good wherever it is applied. When the 100 Year Starship has a well conceived and developed plan, funding will be obtainable from many sources.

Marc Millis, of Tau Zero, points out that a number of organizations—Tau Zero included— already working to develop a vehicle for interstellar travel. He rightly questions funding a million dollar study to create a new organization.

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INTERSTELLAR R & D

Observation

Dark Energy: A New Phenomenon Masked in Many Mysteries

Within the last 15 years, one of the greatest revolutions in astronomy and the understanding of our Cosmos was made possible through Hubble Space Telescope observations of Cepheid variables and Type Ia supernovae as reliable distance markers to measure the Universe's expansion rate. The findings—confirmed in May 2011 by the space-based Galaxy Evolution Explorer telescope survey of 200,000 galaxies—indicated that the Big Bang expansion of the Universe was not slowing over time due to gravity, as everyone assumed, but has actually been accelerating. Astronomers were thrown for a loop.

Theories to explain this accelerating expansion, first noticeable about 7.5 billion years ago when objects began flying apart at a faster rate, proposed a mysterious, dark force that is overpowering gravity and pulling galaxies apart, that astronomers call "Dark Energy." "The action of dark energy is as if you threw a ball up in the air, and it kept speeding upward into the sky faster and faster, " said Chris Blake of Swinburne University in Australia. Dark energy, now believed to make up an amazing 70-75% of the Universe, remains largely a mystery with three or four leading possible explanations: that it's a property of space, agreeing with early Einstein gravity theories, containing a cosmological constant; that it's a new type of matter "quintessence" (partially disproven); that it does not occur uniformly in space and derives from the quantum theory of matter; or, that our current theory of gravity (Einstein) is not correct, requiring a new one.

The findings of NASA's Hubble and GEE space telescopes, complemented by those from the Wilkinson Microwave Anisotropy Probe (WMAP) in 2001 and ESA's Herschel Space Observatory in 2009, consistently reveal the Universe composition to be only 4-5% of 'normal' atomic or Baryonic matter (atoms in life, planets, stars), 20-25 % of also mysterious "Dark Matter" and the remaining 70-75% Dark Energy. Solving the mystery of dark energy and dark matter is a major challenge for astrophysics and cosmology requiring ever-more and ever-better data as the 21st century progresses.

Communication

World Ship Diaspora

Pat Galea, a Project Icarus designer, made a presentation to the recent World Ship conference entitled "Communications Between World Ships." He described the Project Daedalus communications system, derived from Project Cyclops, which was originally intended for SETI use. In this scenario, a 40m transmitting antenna with 1MW power output would download data to Earth at 864 kbps from a distance of six light years. Switching from a dish antenna to a laser would allow much smaller transmitters and receivers.

For network topology configuration, Galea harkened to Claudio Maccone's concept of using the Sun as a gravitational lens to significantly improve reception from more distant World Ships. The Earth would act as a router, forming the basis of an interstellar internet, or "DiasporaNet."

Transportation

World Ship Pioneers

In 1949, Robert Enzmann developed a bold concept and strategy for moving civilization throughout the Galaxy: the World Ship. A world ship is a mega-spacecraft housing a crew of hundreds or thousands. It is an inverted world of its own, in many ways, some even designed with interior oceans. It is a spacecraft, which is more like a "BioSphere" than a "Noah's Ark" transport scenario.

The British Interplanetary Society (BIS) held a conference on 17 August 2011 on the world ship concept. Many of the presenters were Project Icarus participants, including Kelvin Long, founder of Project Icarus.

Long's presentation was "The Enzmann Starship: History and Engineering Appraisal" and included every drawing known to exist on the topic. He spoke about a 30,000 tonne structure, utilizing 3 million tonnes of Deuterium fuel, cruising at 27,000km/sec on a 60 year journey and then extrapolated that to a 300,000 tonne structure on a 150 year journey at 13,500km/sec and finally to a 3,000,000 tonne world ship on a 350 year journey at only 4200km/sec.

These conceptualizations would start with 200, 2,000 and 20,000 human inhabitants, respectively. By the end of the journey, the numbers would approximate 2,000, 20,000 and 200,000 inhabitants. Comparing each scenario's final population, in relation to the mass of the World Ship, it was determined that the ship's mass per person ranged from 150 tonnes to 50 tonnes. It is interesting to note that previous NASA space settlement studies suggested a ratio of 65 tons per person to be optimum.

Andreas Hein, also a Project Icarus participant, addressed the possibilities and probabilities for this form of human migration. He considered what he called "push" and "pull" factors. The "push" factors were those of survival and necessity such as wars, genocide or extreme poverty. The "pull " factors included education, wealth, security and job opportunities. He also felt a key factor would be the distance to a habitable planet.

Speaker Stephen Ashworth suggested the human race may reach extinction prior to launching a World Ship. His calculations roughly estimate the possibility of a World Ship by the year 2357, however this assumes consistent progress in life support and propulsion systems. If propulsion system development speeds up, a ship could launch significantly sooner. However, if propulsion does not evolve as hoped, and the main progress is only in life support, a Would Ship launch would probably be pushed back to at least 2450.

Key to all of this is economics, and perhaps a devastating war would not spur escape to other parts of the Galaxy, since it would eat up all the resources needed to build and outfit the spacecraft. Frederik Ceyssens noted that a World Ship would be an ultra-long project at a great cost, comparing Project Apollo at $100 billion and the Manhattan Project at $22 billion to a $10,000 billion World Ship.

Increasingly, some participants went so far as to suggest that the World Ship might ultimately prove to be the preferred habitat, as opposed to the new habitable planet chosen to be its destination. Many disagreed with this thought, but if humans continue to find comfort in the familiar, this may well be the case. The effort it will take to make a life off of Earth may be best used to create an entirely nomadic culture, never again held back by gravity.

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INTERSTELLAR R & D

Observation

Active Galactic Nuclei

Galaxy studies continuing growth out through the 21st century is matched by parallel growth in black hole / singularity / active galaxy nuclei (AGN) research.

AGN are supermassive black holes at the centers of some galaxies that are accreting surrounding matter at extraordinary rates causing the AGN to radiate profusely across the entire electromagnetic spectrum. Excessive luminosities of these gravitationally compact regions have been observed in the radio, submillimeter, infrared, optical, ultraviolet, and X-ray and gamma ray wavebands. AGN, often outshining their host galaxies, are the most luminous durable sources of electromagnetic radiation in the cosmos, and thus can be used to discover distant objects and determine relative distances.

Several main types of Active Galaxies, such as Quasars, Blazars and Seyferts, have different distinguishing characteristics, though many astrodynamicists believe that while appearing different they are essentially the same phenomena though observed from different directions. Quasars, or quasi stellar objects QSOs, are very distant active galaxies, up to 12 billion light– years away; blazars are radio-loud—very bright/ energetic in the radio band—whose accretion discs produce and eject massive bi-directional plasma jets; Seyferts are radio-quiet, closer to us and characterized by fluctuations in luminosity at their cores.

Observations of AGN are made across the electromagnetic spectrum in all wavelengths. The European Space Agency INTEGRAL X-ray Observatory and the NASA multi-wavelength Swift Observatory are pioneering high energy x-ray and gamma ray research, which provides astronomers unique x-ray information into the processes occurring at the centers of galaxies and gamma ray observations on the nature of particle acceleration in the jets of quasars. The newly-operating high altitude millimeter / submillimeter ALMA facility at Chajnantor, Chile, is already making x-ray observations of AGN.

Communication

ATA: What Once Was Lost, Now is Funded

The Allen Telescope Array (ATA) has resumed operations in the Search for Extra-Terrestrial Intelligence and is being enhanced by the launch of a new citizen science program called SETI Live.

Thanks to private donors, the 42-telescope radio interferometer came back online December 2011 after an 8-month blackout resulting from loss of National Science Foundation and state funding. With a staff of 10 the array costs $2.5 million per year to operate. The objective of SETI Institute CEO Tom Pierson is to maintain funding so ATA can scan the 2,321 newly discovered exoplanets identified by NASA's Kepler mission.

Led by Dr. Jill Tarter, the Center for SETI Research has teamed up with Zooniverse to create SETI Live, a web-based system that enables members of the public to contribute to the project by searching for patterns and anomalies in the ATA data stream that might indicate the presence of intelligent civilizations. The first 2 weeks saw more than 40,000 volunteers sign up and 1 million radio samples analyzed. These citizens scientists could be the first Earthlings to receive communications from our interstellar neighbors.

Human pattern recognition could be used to fine-tune the software algorithms that continuously inspect the 1 to 10 gigahertz swath of the radio spectrum data collected by ATA. Of course, there's no telling what type of signal an alien civilization might emit. Radio broadcasts are a possibility, but so also may be signals based on pulsed lasers or quantum entanglement.

As the cost of optical electronic detectors has fallen over the last decade SETI experiments at optical frequencies have begun. Soon these will expand into the infrared portion of the spectrum.

Transportation

Mae Jemison to Lead 100 Year Starship Project

The "100 Year Starship" project, a research initiative by the US Defense Advanced Research Projects Agency (DARPA) to develop a sustainable and multigenerational model for long-term private-sector investment to advance interstellar travel, will be led by former NASA astronaut Mae Jemison, along with Icarus Interstellar, and the Foundation for Enterprise Development.

Jemison's winning proposal, "An Inclusive Audacious Journey Transforms Life Here on Earth and Beyond," was the top-choice from over 520 entries vying for the US $500,000 grant. A true pioneer in space travel, a physician and Peace Corp volunteer, Mae Jemison, became the 1st African-American woman to travel to space in 1992 and went on to pursue several successful ventures, including an education project based group known as The Dorothy Jemison Foundation for Excellence, and the Jemison Group, a technology design and consulting company.

As outlined in the 100 Year Starship Study RFI, proposals needed to describe the organizational structure, governance mechanism, investment strategy, as well as a business model for long-term self-sustainment. To cover these criteria, The Dorothy Jemison Foundation will handle the educational and broader social objectives, Icarus Interstellar will cover the technical aspects of the project, and the Foundation for Enterprise Development will contribute to innovative organization of operations.

Icarus Interstellar also heads related research projects such as Project Icarus, which will continue with its interstellar fusion propelled probe design, due sometime in 2014.

With the ability to lead two successful organizations as well as her own person al accomplishments, Jemison may well be qualified for the position to direct a multi-generational mission towards the next century.

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INTERSTELLAR R & D

Observation

European Southern Observatory: Jewels in the Andes Sparkle at 50

Chile's Atacama Desert hosts Earth's preeminent international science and technology organization for astronomy—the European Southern Observatory—supported by 13 European countries, Chile and Brazil, and observing its 50th anniversary with confidence and excited anticipation of revolutionary cosmic discoveries ahead. ESO has built and operates the planet's largest and most technically advanced telescopes, enabling Chile early in the 21st century to eclipse Hawaii as center of world astronomy.

ESO's three unique world-class observing sites—La Silla, Paranal and Chajnantor—span some 800 km rising north from La Silla on the Atacama Desert (Earth's driest), bordering the 7,000-meter Andes mountain chain. At 2,400 m, La Silla hosted ESO's first telescopes in the 1960s and now operates several 3.6 m optical instruments, including the New Technology Telescope NTT and the world's foremost extrasolar planet detector HARPS—High Accuracy Radial velocity Planet Searcher. At 2,600 m, Paranal is site of ESO's flagship facility VLT— the Very Large Telescope, with four 8.2 m Unit Telescopes and four 1.8 m moveable Auxiliary Tlescopes. One of Earth's highest astronomy sites at 5,000 m, the Atacama Large Millimeter /submillimeter Array (ALMA) at Llano de Chajnantor will consist by 2013 of an array of 66 12 m and 7 m antennas, in a partnership between Europe, East Asia, North America and host Chile. After VLT and ALMA, a fourth ESO site at Cerro Armazones, near Paranal, is destined for Europe's 39 m Extremely Large Telescope (ELT), the world's largest by 2020 and expected to revolutionize astronomy as much as Galileo's telescope 400 years ago.

Recent ESO pioneering discoveries include detection of the farthest gamma-ray burst, confirmation of the supermassive black hole at the center of our galaxy, and the first picture of an extrasolar planet, by the VLT in 2004. There can be no doubt that ESO's revolutionary advances in astronomy, humanity's oldest science, and evolving views towards the majestic Milky Way band of stars will continue to be awe-inspiring to people in the 21st century as those sights have been to people and cultures of all ages passed.

Communication

Neutrino Communication

Communications are key to any type of exploration and even with the small distances we've traveled in space to date, we are plagued by time delays which threaten vital transmissions of code. Interstellar exploration will require an entirely new mode of communication, in an environment where information is crossing light years to reach its target.

The neutrino is a subatomic particle, electrically neutral and with a mass so small that it has never been accurately measured. In fact neutrinos quite literally pass through normal matter unimpeded. Detecting neutrinos requires a very large mass. An early detector utilized 400,000 liters of perchloroethylene, buried deep underground in a South Dakota gold mine.

Obvious parallels led researchers to examine possibilities for neutrino communications with submerged submarines and then to a groundbreaking experiment done at Fermilab in March of 2012. Scientists from North Carolina State University and the University of Rochester utilized the NuMI beam to fire pulses of neutrinos at MINERvA, a detector weighting 170 tons and located 100 meters beneath the Earth's surface. They sent their message in binary code; it was a single word ..." neutrino."

Use of neutrino communications in deep space is obviously decades away and it is important to note that a detector—as we currently know it—would not be able to ride aboard spacecraft due to the huge mass involved. Neutrino communications would, however, be very appropriate for planet-to-planet messaging, no matter what the distance. Also, neutrino communications would safeguard what Star Trek fans have come to know as the "prime directive" of not interfering with the development of budding cultures, since only scientifically advanced beings would even be aware of neutrinos.

Transportation

Plasma Thruster Technology Advances

Travel to the stars, and even to the outer Solar System, will require significant advances in propulsion. The distances that must be crossed are so vast as to make it impossible to carry enough fuel to complete the trip...at least by the standards of current technology.

Ion and Plasma Thrusters have drawn much attention for their potential to bridge the gap between our spacecraft and deep space. In a plasma thruster, fuel is heated electrically and then electric and / or magnetic fields accelerate the charged particles to provide thrust.

An example of this concept was SMART-1, an ion-thruster propelled spacecraft which orbited and explored the Moon during a three-year mission, ending in 2006. The mission utilized Xenon as fuel and carried only 82 kg at launch.

One drawback of Plasma Thruster technology, however, is that the higher the kinetic energy produced, the more quickly corrosion will begin to damage the propulsion system and contaminate sensitive instruments. In response to this, a private propulsion design company, the Elwing Group, is developing an electrodeless plasma thruster.

Developed by Gregory Emsellem and based on research by the French Atomic Energy Commission, the Electrodeless Ionization Magnetized Ponderomotive Acceleration Thruster (E-IMPAcT) utilizes ponderomotive force, which is what a charged particle experiences in an oscillating magnetic field.

Electromagnetic waves from radio frequency to gamma rays serve to ionize the fuel. While noble gases...such as Xenon...have been a standard fuel for plasma thruster, this new technology opens the door to alternative propellants which may be made in situ or more easily transported on missions.

NASA MSFC will be conducting tests on E-IMPAcT under a Space Act Agreement, hoping to confirm positive results from previous testing at Electric Propulsion and Plasma Dynamics Laboratory at Princeton University. Following baseline tests with noble gases, a variety of alternative propellants will also be examined.

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INTERSTELLAR R & D

Observation

Kansas, USA
Astronomy Resources

Ad Astra State Kansans mindful of the state motto, "Ad Astra Per Aspera" or "To the Stars Through Difficulties," naturally look up to the sky and to the galaxy stars beyond.

The ample number of Kansas astronomy societies, observatories, university astrophysics centers and astro-related activities reflect general public awareness and appreciation for the state's inspiring motto.

Astronomy clubs in Kansas that feature meetings, star parties and astronomy programs include the Astronomy Associates of Lawrence, North Central Kansas Astronomical Society of Manhattan, Salina Astronomy Club, Heartland Astronomical Research Team , Northeast Kansas Amateur Astronomers League of Topeka (NEKAAL) and Kansas Astronomical Observers (KOA) of Wichita.

Many of the clubs, colleges and universities own and / or operate astronomical facilities such as Mabee Observatory at Bethel College in North Newton, Earl Bane Observatory at Cloud County Community College, Farpoint Observatory at Eskridge, Pittsburg State University Astronomical Observatory of Greenbush, Banner Creek Science Center / Observatory in Holton, Powell Observatory in Louisburg, Crane Observatory of Washburn University in Topeka and Lake Afton Public Observatory of Wichita State University.

Higher and professional astronomy education is offered by the physics and astronomy departments of the University of Kansas in Lawrence, Washburn University in Topeka, and Fort Hays State University and related aerospace education by Wichita State University.

The Kansas Cosmosphere and Space Center of Hutchinson is astounding both for its very existence in the modest farm town, and for its extraordinary world class collections and exhibits of space transportation, space suits, and space-age technologies.

Communication

Optical Communications
Steadily Improve

Interstellar communications is clearly one of the key technologies required for humans to explore and populate deep space. The signal received from Voyager 2—as it passed Neptune—would have been 81 million times weaker if it had been sent from Alpha Centauri. Already, the Voyager Spacecraft's 23-watt signal has spread to over 1,000 times Earth's diameter by the time it reaches us.

"Optical", or "laser" communication systems offer a number of benefits for interstellar travel. First, data could be transmitted as much as 100 times faster, while antennas could be reduced to be only 1% of their current size. The reduction in weight alone makes the laser systems attractive for deep space missions.

Laser data transmissions also offer enhanced security, due to the narrowly focused beam. It is this same narrow beam that requires additional fine tuning however, as the pointing mechanism must be highly accurate. For interstellar applications, pointing may be based on the Sun-illuminated Earth or background stars. An even greater benefit may be gained from deploying a FOCAL probe, which would utilize the natural gravitational lens of the Sun.

Recent testing on the Moon has yielded encouraging results. NASA's LRO (Lunar Reconnaissance Orbiter) recently received an image of the Mona Lisa via laser transmission. More testing will be done with the Lunar Atmosphere and Dust Environment Explorer (LADEE) and the Laser Communications Relay Demonstration (LCRD) is scheduled for 2017.

Transportation

Kansas: An Interstellar
Exploration Center?

There's a spot in Lebanon, Kansas which is marked as the geographic center of the contiguous United States of America; the creators of Google Earth have chosen Lawrence, Kansas as the center point of planet Earth. While these designations are to some extent arbitrary, there is no doubt that Kansas is central—both historically and geographically—to the dreams, hopes and aspirations of this country.

The Kansas Historical Society lists eight major industries in Kansas, including aviation, mining and railroads. These particular industries seem to complement the state motto—"Ad Aspera Per Aspera"—and almost form a natural framework for interstellar exploration to eventually be the defining industry in Kansas, especially with Wichita's dominance as an aircraft manufacturing hub.

Someday, interstellar spacecraft will carry humans to a new frontier of opportunity—as did the railroads—and mining along the frontier will provide sustenance.

A mathematician at Kansas State University, Dr. Louis Crane, believes the ability to create and control black holes may be the key to interstellar transportation. He wonders how one might convert radiation output from a black hole into an exhaust stream with useful properties.

Already, the first spacecraft to leave the solar system and traverse deep space is being closely monitored by University of Kansas Professor Emeritus Tom Armstrong, who worked with Van Allen and designed one of the key science instruments on Voyager, which launched in 1977. Today, his Lawrence-based company, Fundamental Technologies, still analyzes Voyager's transmissions.

The 100-Year Starship Project features these words on its website: "All the capabilities needed to accomplish human interstellar travel are the same ones required for successful human survival." With the future of the human race in the balance, a central repository—such as Kansas—may be the key to the future. The 100-Year Starship Project might look to Kansas as a resource and consider holding their next major conference there.

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INTERSTELLAR R & D

Observation

ILOA Hawai'I 2013

The International Lunar Observatory association, based on Hawaii Island, seeks to expand human understanding of our galaxy, cosmos and solar system through observation from the Moon.

The first of the ILOA 4 Moon Missions, collaboration with the National Astronomical Observatories of China to use the Ultra-Violet 15-cm Telescope aboard the China Chang'e-3 Moon Lander this December, should result in advancing international cooperation, in Galaxy First Light Imaging and in the development of Galaxy 21st Century Education through the ILOA Galaxy Forum Architecture in Hawaii, across the USA and around the Earth.

The two intermediate ILOA Missions, ILO-X and ILO-1 should expand Galaxy First Light Imaging and Galaxy / Astronomy exploration, pioneer lunar broadcasting of both astrophysical and commercial data, and establish a toe-hold for lunar base build-out at the Moon South Pole / Malapert Mountain area.

The last of the ILOA Moon missions, the Human Service Mission to the International Lunar Observatory ILO-1 in this decade, should result in first astronaut servicing of the ILO-1 and of nearby instruments and labs, of validation of Golden Spike Company, Shackleton Energy Company, and / or other Earth-Moon, Cis-Lunar human transportations systems, and in amplification and build-out of a permanent Moon South Pole human settlement.

The ILOA main outreach vehicle for Astronomy—21st Century Education is the global Galaxy Forum Architecture, which should enable many enterprises, such as the Ad Astra Kansas Foundation and the Interstellar R & D Center, to flourish on all 7 or 8 continents of Earth.

Communication

Civilization Sends Its Own Signal

When the home next door appears vacant—and you really want to know whether or not you have neighbors—you may start by watching the trash cans. Like the nosy neighbor, we constantly watch and wonder if anyone else is "at home" in our galaxy. And like the nosy neighbor, we may not have the nerve to rap on the door and expose our nosy nature.

Earlier this year, the article "How to Find ET with Infrared Light" was published by Jeff Kuhn, Svetlana V. Berdyugina, David Halliday and Caisey Harlingten. They are convinced that a survey out to 60 light years could offer a definitive answer as to whether other civilizations exist in our vicinity, and they plan to do it by examining waste heat radiation.

To accomplish such a broad survey, they are looking at creating a telescope called "Colossus," with a primary mirror of 77 meters.

Through their company, Innovative Optics Ltd., new technologies will enable this sensing giant, including fire-polishing (in place of abrasive-based techniques) and controlled slumping of the hot glass to desired shapes which are incredibly thin and lightweight. Also employed are new "Live Mirror" technologies which provide adaptive optics to neutralize atmospheric distortion.

Once completed, Colossus would be able to sweep hundreds of planets in the habitable zone which are Earth-size and larger—to determine if civilizations are present—without announcing our own presence.

Transportation

PLT: Photonic Laser Thruster

In the 1990s, Goeffrey Landis suggested the beautiful image of a "light bridge" which would connect nearby solar systems. Today physicist Young K. Bae sees that "light bridge" as a photonic railway that would "...bring about a quantum leap in the human economic and social interests in space…" Bae hopes to realize this concept via his work on a Photonic Laser Thruster, or PLT, and then use the concept to build a space railroad to the stars.

Laser propulsion has long been a promising concept. In 2005, The Planetary Society funded COSMOS, a solar sail which would test the effects of a microwave beam from the Deep Space Network bouncing off the sail. A launch failure scuttled the test. Also, laser propulsion has always been hindered by diffusion of the laser beam, and for interstellar travel, lenses the size of Texas would have to be installed beyond the orbit of Saturn to maintain a fine-enough focus for interstellar travel.

Bae's innovative photon thruster, however, exploits a resonant optical cavity which is formed between two mirrors to create the laser. This gives a thrust to power ratio comparable to electrical thrusters and a specific impulse which is orders of magnitude greater than other conventional thrusters. Carried by dual spacecraft, the laser source can be taken anywhere.

Bae envisions the photonic railway as having a permanent infrastructure which would link nearby stars with a transportation system. Self-directed robotic spacecraft would put together and activate the system at destination locations, utilizing structural parts from Earth.

The space trains would be very lightweight and consist mostly of human transport habitats and safety systems, with small thrusters for attitudinal control. Each would require four thrusters: one pair for acceleration and one pair for deceleration. New developments in X-ray laser and material sciences will reduce engineering requirements.

Young K. Bae believes the propulsion systems could be within reach by the end of this century.

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INTERSTELLAR R & D

Observation

New Frontier for Astrophysics
NAO China LUT, ILO-X, ILO-1

The Moon after Earth and Space is rising as another center for 21st century astronomy. The National Astronomical Observatories NAOC Lunar Ultraviolet Telescope LUT atop China's Chang'e-3 Lander, the first spacecraft on Luna in almost 40 years, has been operating since shortly after the 14 December 2013 touchdown at Mare Imbrium 44.12N 19.51W, near Sinus Iridum "Bay of Rainbows". LUT is the first robotic telescope on the Moon and adds to the Apollo 16 first astronomy achievements of Commander John Young in 1972. The Moon telescope has projected operations of at least 1 year, with an RTG power source lifespan of 30 years, and may mark the beginning of permanent human-directed operations on the Moon.

The 150-mm near-violet / optical instrument is capable of tracking and monitoring objects continuously for up to 10 days at a time. The first published image of the LUT consisted of 23 bright stars of the Draco constellation. It has conducted sky surveys and variable star observations in a 200-square-degrees field of the celestial N hemisphere and captured more than 22,000 astronomical images by the end of Chang'e-3 Lunar Day 3 on 23 February 2014, according to LUT principal investigator Professor Jianyan Wei.

The International Lunar Observatory Association ILOA, based on Hawai'I Island, participates in LUT operations through exchange agreements with the National Astronomical Observatories NAOC and the Chinese National Space Administration CNSA that call for reciprocal NAO use of ILOA telescopes ILO-X planned for lunar landing 2015, and ILO-1 at the Moon South Pole region NET 2016. The mission of these Moon telescopes, like the many that hopefully will follow, is to expand human understanding of the cosmos through observation from Earth's closest neighbor, the '8th Continent' of the Moon.

Transportation

Interstellar Research & Development Initiative

The Ad Astra State has attracted new interest from an idea that is bound to set a path for Kanas to actually reach for the stars: The Interstellar Research & Development Initiative. Conceived and organized by educator, NewSpace entrepreneur and publisher Steve Durst, the IR&D Initiative seeks to pursue 21st century exploration imperatives beyond our solar system and take a step toward humans becoming an interstellar species.

To date, the IR&D initiative has lent support to Kansas researchers who are delving into esoteric questions of the cosmos, such as Wichita State's Professor Nick Solomey, who is doing cosmic ray research. Solomey has also worked with the Ad Astra Kansas Foundation (AAKF), making science presentations at Galaxy Forum Kansas. Durst, a co-founder and also a member of the board of directors of the Ad Astra Kanas Foundation, hopes that the organizations will work together to bring the first Starship Conference to the state of Kansas.

Most high-profile among interstellar exploration organizations is the 100YSS (100 – Year Starship), which sprang to life as a joint DARPA-NASA grant project to a private organization. The inaugural symposium was held in 2011 in Orlando, FL and—following naming Astronaut Mae Jemison's foundation the recipient organization—symposiums were held in Houston, TX in 2012 and 2013. Former President Bill Clinton served as honorary chair during the 2012 event.

100YSS "exists to make the capability of human travel beyond our solar system a reality within the next 100 years." Appropriately, the SETI Institute will hold a permanent seat on the 100YSS Advisory Council. Support will also come from experts in a vast array of fields, including artists, government and business leaders, economists, sociologists and specialists in ethics and public policy. 100YSS also hopes to engage government space programs, as well as NewSpace Initiatives and entrepreneurial efforts.

Icarus Interstellar teamed with the Foundation for Enterprise Development and the Dorothy Jemison Foundation for Excellence to develop the winning proposal for 100YSS. The title of that proposal is: An Inclusive, Audacious Journey Transforms Life Here on Earth and Beyond. Mae Jemison has stated, " If my language is dramatic, it is because the project is monumental. This is a global aspiration. And each step of the way, its progress will benefit life here on Earth."

Rising from Project Daedalus of the 1970's, a new international group called Icarus Interstellar, incorporated as a nonprofit organization in 2011. Their mission is to "realize interstellar flight before 2100" and they have already voiced some commitment to fusion-based propulsion. Co-founders Drs. Richard Obousy and Andreas Tziolas serve as president and vice-president. Affiliates include the British Interplanetary Society, Institute for Interstellar Studies, Tau Zero Foundation, Global Starship Alliance and Star Voyager.

Icarus Interstellar holds a Starship Congress on alternate years, with the next congress taking place in 2015. The Starship Congress of 2013 was organized by timelines, with priorities for the next 20 years examined during the first day of the event, under the title of "Interstellar Now." The second day was titled "Interstellar This Lifetime" and covered the span from 20-50 years, and the third, called "Interstellar Future" examined advances appropriate beyond 50 years in the future.

It is a big universe out there, and...difficult or not...everyone is invited to reach for the stars.

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INTERSTELLAR R & D

Observation

Mars-Based Astronomy

A growing fleet at Mars—in September 2014—of orbiters and landers is enabling Mars observation of both astronomy matters and other developments. Joining the Mars Reconnaissance Orbiter (2006), Mars Express (2003), and Mars Odyssey (2001), newly-arrived orbiters MAVEN from NASA and MOM from India / ISRO along with landed rovers Curiosity (2012) and Opportunity (2004) will continue alien observations of Earth (magnitude –2.5) and Luna (1.0), of Jupiter (-4), and of Mars moonlets Phobos (-9) and Deimos (-5) orbiting the "5th rock from the Sun".

Earth seen from Mars is an inner planet like Venus, a 'morning star'. Appearing like stars to the naked eye, the Earth and Moon would be seen as crescents through telescopes, Jupiter at opposition would blaze at greater than magnitude -4, with all four Galilean moons at mag 1 and their dance visible to the naked eye. Phobos and Deimos are too small to produce total eclipses seen from Mars, but their transits across the Sun can be observed.

The unique Martian atmosphere and sky presents observation challenges for future Mars spacecraft and astronomers. Magnetite dust particles about 1 % of the atmosphere produce the reddish-pink, sometimes violet sky, and remain suspended by windstorms for long periods, reducing the surface to twilight for many months. The lack of an ozone layer makes UV stellar observation possible from the surface.

Mars Science Laboratory Curiosity in April 2014 observed Ceres and Vesta, first and third largest in the asteroid belt, and the transit of Mercury across the Sun on June 4. Comet Siding Spring C/2013 A1 on October 19 may approach Mars as close as 41,300 km at magnitude –6 in constellation Ophiuchus, and be monitored for spacecraft-damaging dust particles. An observer on the slopes of Elysium Mons can witness the transit of Earth, the Moon and Phobos all in front of the Sun on November 10, 2084.

Communication

SETI Discussions at 100YSS

One of the most highly regarded speakers at the 100-Year Starship Symposium in Houston, Tex., on September 18-21 was SETI founder Jill tarter. At this year's event, she spoke about the importance of breadth versus intensity, stating, "Better to do more small but different things. For now, the philosophy is to go for deliberate signals and try to be affordable."

Tarter noted trends in optical communications and a need for larger apertures and more processing power. Individual photon counting can be done with a large aperture and has the capacity to identify very distant signals.

Tarter noted that SETI is involved with the Square Kilometer Array in South Africa, planned for 2023-2025. The new generation of telescopes, such as the European Extremely Large Telescope in Chile and Thirty Meter Telescope on Hawaii might provide opportunities for detectors of optical communications.

Transportation

100YSS Gets a "Kick" Out of KickSat and Tennessee Valley Looks to the Stars

At the 100 Year Starship Pleneary Session entitled "State of the Universe," Cornell University's Mason Peck spoke about KickSat and the tiny "Sprites" which may pave a tiny road to the stars.

Inaugurated in 2011, KickSat was a mission in which a cubesat would deploy a large number of "Sprites" or femtosatellites. The Sprites are the size of a large postage stamp and work as a group to accomplish a goal, with each Sprite contributing its own tiny share of the work.

Mason Peck affectionately refers to the Sprites as "Sputnik on a microchip" and sees many possibilities in their use as a small scale / low cost approach to exploration. For instance, a cubesat solar sail mission carrying Sprites could provide direct sensor readings in distant places.

SETI founder Jill Tarter posited that the tiny Sprites may even be used to form a "starshade" which would be deployed about 20,000 km from a large space telescope, to filter out some of the glare of a large parent star when looking at an exoplanet. This would enable spectroscopy to examine the exoplanet's atmosphere.

Tarter went on to suggest that the Sprites may be an excellent tool for studying cryovolcanoes, such as those on Europa and Triton. A swarm of Sprites could be deployed to actually fly through the ejecta. Peck responded that a large number of Sprites would not only increase the chance of some surviving the flight, but would provide "a stochastic look at the target."

The Tennessee Valley Interstellar Workshop is gearing up for their annual event November 9-12 in Oakridge, Tenn. Originally conceived as a regional event, the TVIW sprang into international prominence almost immediately upon its inception. The name "Workshop" was chosen to signify that TVIW is not just a conference, but an incubator for actual projects and an opportunity to collaborate.

Workshops will be led by some of the top visionaries in interstellar exploration. ISU's Chris Welch and Vanderbilt's Cassidy Cobbs will discuss "Evolution's Pace in Very Small Exosystems like the Worldship" in the B-for-Bio session, and Kelvin Long will examine "near-term and far-term concepts for traveling at interstellar ranges."

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INTERSTELLAR R & D

Observation

Galaxy Astrophysics 2014-2015

Human understanding and study of the Milky Way has progressed exponentially since Edwin Hubble's revolutionary discoveries almost a century ago. This snapshot of significant MW Galaxy observations this past year alone reflects both the pace of Galaxy revelations and the enormity of its still unknowns.

Along with new knowledge of extreme stars at the Center of the Galaxy, of the strong role played by magnetism in galaxy evolution, and of the naming "Laniakea" ("immense heaven") for our Galaxy's neighboring supercluster, three Galaxy discoveries – each being partially enabled through Hawai`i astronomy resources – invite special comment.

A mysterious gas cloud G2 discovered in 2002 appeared traveling to and destined for destruction by the Galaxy Center supermassive black hole. Instead, its failure to be torn apart amidst flaring and fireworks was confirmed in 2014 from observations by Dr. Andreas Eckart using the Very Large Telescope VLT in Chile and by Dr. Andrea Ghez with the Keck Observatory in Hawaii, who both concluded G2 more likely to be a dust-shrouded young star than a coreless dust cloud.

That the Milky Way may be much larger than previously estimated is the conclusion of an international team led by Rensselear Polytechic Institute astrophysicist Dr. Heidi Jo Newberg using data from the Sloan Digital Sky Survey and in collaboration with the National Astronomical Observatories of China.

"What we found is that the disk of the Milky Way isn't just a disk of stars in a flat plane – it's corrugated", extending the known width of our Galaxy from 100,000 light-years in diameter to 150,000, or 50% larger than commonly estimated.

Finally, US708, ejected by a thermonuclear supernovae to become the fastest unbound star ever observed in the Galaxy, was confirmed this year to be traveling at 1,200 kilometers per second and will eventually leave the Milky Way.

Communication

Fast Radio Bursts (FRB)

Since 2011 there have been eleven instances of FRB detection, prompting a piece in New Scientist entitled, "Is this ET? Mystery of Strange Radio Bursts from Space."

These FRBs are identified by a powerful burst of radio waves which cover a wide range of radio frequencies, but last only milliseconds. The energy of the bursts has been compared to the amount of energy the Sun releases over a month's time. To date, almost all of the FRBs have been recorded at the Parkes Radio Telescope in New South Wales, Australia, though some have also been detected at the Arecibo telescope in Puerto Rico.

That they seem to follow a mathematical pattern has sent researchers scrambling to determine whether the origin is from within the Milky Way Galaxy. Utilizing the dispersion measure (DM) which seek to describe the space between the emission and Earth, researchers have come up with numbers that would place the origin at cosmic distances, yet the consistency of the numbers seems to indicate they are, in fact, coming from within our galaxy, as travel through intergalactic dust would tend to randomize the numbers.

Transportation

A Call For Interstellar Propulsion

In the final moments of the March 4, 2015 House of Representatives' discussion of NASA's Asteroid Redirect Mission (ARM), Texas Representative John Culbertson made a startling and inspirational statement: "I'd encourage you to focus on the development of the next-generation of the rocket propulsion. The fact that we're still flying rocket engines that have fundamentally been designed by Robert Goddard in the 1920s is just inexcusable."

Culbertson has long been a proponent of deep space exploration, having stated 10 years ago that he hopes to see the first interstellar missions take place before NASA's 2058 Centennial.

Early April of this year, NASA announced grants of $400,000 to $3.5 million per year for as long as 3 years to develop deep space propulsion technologies. The three winning companies were Ad Astra Rocket Company, Aerojet Rocketdyne and MSNW LLC. These companies are already working on nuclear fusion rockets and electric propulsion systems.

Even more amazing, much work is being done to realize the Star Trek technology known as "warp drive." Dr. Harold "Sonny" White, Advanced Propulsion Team Lead at NASA, describes warp drive as being similar to a moving walkway, which increases one's walking speed by the speed of the surface on which you travel. White is currently working experimenting with a toroidal (doughnut-shaped) ring of negative vacuum energy. He hopes to show that a spacecraft with the ring would have the capacity to contract space in front and expand space behind it.

Work he did for the 100 Year Starship Symposium suggests that the previously preclusive amount of negative vacuum energy needed to do this may no longer be a factor when the toroidal shape is utilized. He has designed a warp field interferometer test bed and hopes to generate a micro warp bubble for testing.

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INTERSTELLAR R & D

Observation

Astronomy from the Moon in the 21st Century

Pioneering a new frontier for astronomy, building on the advancing successes and growth of earth– and space-based observatories, the first accomplishments for astronomy from the Moon point to 21st Century possibilities including a "condominium of observatories", a Moon ringed with observatories, and ultra-large as well as extra-small lunar-based telescopes.

From the pioneering Far Ultraviolet Camera / Spectrograph emplaced by Apollo 16 commander John Young in April 1972 at the Descartes Highlands, to December 2013 / current operations and observations by the Lunar Ultraviolet Telescope atop the China Chang'e-3 Moon Lander at Mare Imbrium / Sinus Iridum, astronomy from the Moon is now increasingly projected by Chang'e-4, -5, -6 landers, India Chandrayaan-2, Japan SLIM-1, ILO-1, Moon Express and Shackleton Energy Company.

A lunar astronomy / robotic village may arise mostly at and from the Moon South Pole / Aitken Basin region, much like a first experimental 60 cm telescope tested by Gerard Kuiper atop Mauna Kea Hawai'I led to an astronomy village / complex and a late 20th century global center of earth-based astronomy. With no significant atmosphere to distort light imagery, firm stable platform for long duration observation, and far-side radio free environment, astronomy from the Moon can be conducted in many varying wavelengths with far superior results than earth-based observatories and at least equal to space-based ones.

Astronomy from the Moon, while not a sufficient reason by itself for the vast resource investment necessary for maintaining lunar surface operation, is now validating its enduring potential as the first sustained human directed activity on Luna. Its catalytic capability to enable expanding lunar development and eventual lunar base buildout for a thriving multi-world species should be increasingly apparent and highly valued as the 21st century progresses.

Communication

Interstellar Power Signal

SETI has long listened for radio or TV transmissions which might indicate an unknown culture, but the distance between stars is so vast as to render such signals imperceptible. Alternatively, one might ignore broadcast signals and search instead for leakage from intense power sources, indicative of a society with advanced technology.

Harvard researchers James Guillochon and Abraham Loeb have published a paper entitled "SETI via Leakage From Light Sails in Exoplanetary Systems" which is the first to quantify power-beaming leakage as a detectable indicator of advanced technology.

Power beaming commonly uses lasers, millimeter-wave beams and high-power microwave beams, providing a powerful, tightly focused signal. From a distance of 326 light years (100 Parsecs), the intensity of these beams would be 100 times easier to detect than SETI radio searches.

Power beams also carry their own signature. A radio telescope would register a signal that rises and falls as the beam begins to pass, the drop resulting from the sadow of the sail It is even possible for a message to be imbedded on the beam.

Transportation

Icarus Interstellar Drexel Chapter and Project Tin Tin

Icarus Interstellar's mandate is to train the next generation of interstellar engineers, and students at Drexel University in Philadelphia, have taken steps to be the first in line for that honor.

Undergrad Damien Turchi reached out to classmates John Breslin, Michael Daily and Zachary Block to start the Interstellar Research Club at Drexel, and then formally propose the first collegiate chapter of Icarus Interstellar in 2013. The chapter has since grown to over 60 students and hosted the 2015 Starship Congress.

The Drexel Chapter now has its sights on Project Tin Tin, the first mission to our closes star system, Alpha Centauri. Students are working to develop propulsion designs for Cubesats, tiny research spacecraft valued for their cost-effective approach to revolutionary exploration opportunities.

At the 2015 Starship Congress, sophomore Noah Alessi's poster presentation focused on work he had done through the Office of Undergraduate Research's STAR (Students Tackling Advanced Research) Scholar's Program which examined experimental use of a field emission electric propulsion system.

Additionally, ME major David Evinshteyn spoke at the Congress about the Plasma Jet Magneto Inertial Fusion (PJMIF) propulsion system which is a highlight of the Drexel Chapter's theoretically designed spacecraft called Zeus.

During the Congress, students also had the opportunity to network with interstellar propulsion visionaries such as Harold "Sunny" White, who is the Advanced Propulsion Team Lead at NASA and sustainability innovator Rachel Armstrong.

At this time, the only mission that may reach another solar system is Voyager, probably taking tens of thousands of years to do so after its launch in 1977. Tin Tin will be flying with a revolutionary new propulsion system and may be the first salvo into interstellar exploration.

Issue 29 Spring 2016

INTERSTELLAR R & D

Observation

Galaxy Center Phenomena

First Light / First object for many new observatory grand openings, the center of our Milky Way Galaxy and its supermassive black hole Sgr A* continues attracting study and wonder with barely-known astrophysics such as cosmic ray acceleration and dark matter annihilation providing galacticity breakthrough discoveries.

Cosmic rays / particles, since their 1912 discovery, have been known to carry energies up to 100 teraelectronvolts (TeV), but their source of origin has long remained one of the most challenging mysteries of the 20th century. Now, 21st century deep-space observations with the High Energy Stereoscopic System (HESS) in Nambia, southern Africa, confirm that the center of the Galaxy is the location from where even higher energy petaelectronvolt (PeV) cosmic gamma rays are emanating. Several objects at the galactic center such as supernovas and pulsars are capable of producing PeVs, though HESS astrophysicists now point to the supermassive black hole Sgr A* as the PEV's most likely engine of creation.

The Galaxy Center also is being observed as the place where dark matter / antimatter annihilation occurs, resulting in very high energy cosmic gamma ray emissions.

If confirmed, this finding would be a significant breakthrough in the understanding of the nature of dark matter, which now is thought to constitute more than 95% of all matter in the universe.

Transportation

Interstellar Organization Matters, TVIW Workshops

The rise of starship conferences and interstellar organizations, certainly one of the more significant space movement phenomena in this still-young 21st century validates the timing and relevance, and enhances outreach and growth prospects for the Ad Astra Kansas Newsletter and Foundation. AAKF considerations to host a major interstellar conference are resulting in closer observation and interaction with leading interstellar enterprises such as the Tennessee Valley Interstellar Workshop, and some of the more prominent interstellar organizations such as Icarus Interstellar, Starship Century, Tau Zero Foundation, Initiative for Interstellar Studies, and 100-Year Starship.

TVIW hosted its 2016 workshop, "From Iron Horse to Worldship: Becoming an Interstellar Civilization", February 28-March 2, in Chattanooga, Tenn. With much organizing direction provided by Les Johnson, and limited to some 100 participants, TVIW included such stellar luminaries as John Lewis, Chris Welsh, Rhonda Stevenson, Gerald B. Cleaver, Al Jackson, Cameron Smith, Kelvin Long, Greg Matloff, Jim Benford, Philip Lubin, amongst others. James Schwartz, of Wichita State University, helped represent the Ad Astra Kansas Foundation (AAKF). Planning for the next TVIW in Huntsville, Alabama, already is progressing towards early October 2017, around the 60th observation of Sputnik 1. Representatives from TVIW, Tau Zero and Icarus Interstellar, according to Dr. Schwartz, are interested in AAKF considerations to help host and Interstellar Conference after 2017 in the Ad Astra State of Kansas.

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INTERSTELLAR R & D

Observation

The Exoplanet Revolution and Hawai'i Astronomy

The exponential acceleration of the exoplanet revolution (Ad Astra Kansas News, Fall 2010) totals 3, 532 exoplanets, as of 1 October 2016 and since 1988, in 2649 planetary systems and 595 multiple planetary systems, as listed in the Extrasolar Planets Encyclopedia (not including 'rogue' planets which may number in the billions, or more, in our galaxy). First speculated by 16th-century philosopher Giordano Bruno and then by Isaac Newton in the 18th, exoplanets are the prime objective of Kepler's space telescope mission (2009) and follow-on K2 (2014) with over 2,000 confirmations and thousands more candidate planets.

This accelerating discovery of exoplanets is intensifying the search for life on other worlds and the question of planetary habitability, where habitable or "Goldilocks zone" location (relative to the parent star), and liquid surface water, radiant heat and protein substance are among prerequisites for extraterrestrial life. Kepler has determined about 20% of Sun-like stars have an Earth-sized planet in the habitable zone, or about 10-40 billion potentially habitable Earth-sized planets in our Milky Way. The recent confirmation that the nearest known extrasolar planet, Proxima-b, is about Earth-sized and orbits in Proxima Centauri's habitable zone, has placed Proxima-b at the top of the list of prospects in the Breakthrough Watch project being considered to search for life beyond the solar system.

According to Breakthrough director Pete Worden, more Proxima-b information is likely to come from the large Gemini and Keck observatories atop Mauna Kea, Hawai'i, which has long pioneered in exoplanet discovery. The July 2016 Exoplanet Mauna Kea Inventory compiled by ILOA student intern Rishab Gupta of Scarsdale High School, NY, notes Canada-France-Hawai'i Telescope exoplanet instruments ESPaDOnS and SPIRou, Subaru Telescopes instruments HICIAO and SEEDS, Gemini North survey GPIES to image Hot Jupiters around 600 stars, and Keck I and II spectrometer HIRES have all enabled the newest frontier in this science: Using a next generation of large telescopes such as the Extremely Large Telescope in Chile, JWST and the proposed 74-meter Colossus Telescope to characterize extrasolar planets' atmospheres.

Communication

Breakthrough Listen, announced in 2015 by Stephen Hawking, Yuri Milner and others focused on searching for extraterrestrial alien radio communications in the universe. The project will search for alien communications in the form of artificial radio and / or optical signals that may come from the nearest stars at the center of our galaxy, or from the 100 nearest galaxies.

To find alien radio signals, Breakthrough Listen will analyze thousands of hours of data collected every year by two large steerable radio telescopes: Green Bank Observatory in West Virginia and Parkes Observatory in Australia. To discover alien optical signals, the project will analyze data collected by the Lick Observatory Automated Planet Finder. Astronomer Frank Drake, SETI Institute founder, arranged for SETI to analyze Listen Project data with a team of scientists from UC Berkeley headed by Andrew Siemion, Director, Berkeley SETI Research Center.

The initial results of Project Listen were made publicly available on Breakthrough Initiative's website in April, 2016. The Open-Source results are for data from most of the stars that are 16 light years away and a sample of the stars that are 16 to 160 light years away: including data from Alpha Centauri (4 light years away) and Giselle (15.8 light years away). For more about this project or to view results, http://breakthroughinitiatives.org

To send signals to alien civilizations in space, Breakthrough will fund a smaller project 'Breakthrough Message' which will give $1 million in prizes to the best designs of a digital messaging system than can transmit radio or optical messages from Earth to outer space. Developing a message that can be understood by alien cultures is an exciting project, requiring insight into mathematics, art, linguistics, psychology and culture. The competition is open to all. Competition details are expected to be announced by 2017.

Transportation

Pete Worden, chairman of the Breakthrough Prize Foundation and former director of NASA Ames Research Center will manage the new $100 million Breakthrough Starshot project to develop a proof-of-concept that gigawatt lasers can be used to propel gram scale robots / nanocraft to travel in space at 20% of the speed of light. If this technology is proven, small robots could be beamed into space and would be able to transmit images of possible planets and other scientific data in our closest stary system, Alpha Centauri, which is **40 trillion km** (4.37 light years) away from Earth. With today's technology, it would take **30,000 years** to reach Alpha Centauri: Breakthrough Starshot laser-propelled nanocrafts would reach it in about 20 years.

Breakthrough Starshot's board consists of Stephen Hawking, Yuri Milner, Mark Zuckerberg. Scientists on the project include Dr. Kevin Parking who invented the Microwave Thermal Rocket; Pete Klupa, former director of engineering, NASA Ames; and Jim Benford, president of Microwave Sciences as well as two Nobel Laureates, Saul Perlmutter from UC Berkeley and Steve Chu from Stanford University.

Starshot has received mixed reviews. While many scientists believe it will help propel space travel through the 21st century, others have raised concerns which include: (1) lack of funding, (2) using powerful 100 gigawatt lasers to send tiny nanocraft into space could destroy satellites and other objects in the lasers' path and (3) maintenance and data transmission of robots that are light years away still need to be worked out.

Issue 31 Spring 2017

INTERSTELLAR R & D

Observation

Seven Worlds of Trappist-1 and Starlife Possibilities

Trappist-1 is an ultra-cool dwarf star, about as large as Jupiter and some 10% the size of our Sun, located 39.5 light-years away in the direction of the Aquarius constellation.

Trappist-1 (T-1) is orbited, and transited, by at least 7 Earth-sized planets, all with rocky composition, possibly hosting liquid water on their surface, with at least 3 in the "Goldilocks" or "habitable" zone.

Three planets of the T-1 system were first discovered in 2015 by astronomers led by Michael Gillon at the University of Liege in Belgium using the Transiting Planets and Planetesimals Small Telescope (TRAPPIST) at the La Silla Observatory in Chile. Additional planets were then identified using TRAPPIST and the Spitzer Space Telescope, the Very Large Telescope, UKIRT, the Liverpool Telescope and the William Herschel Telescope.

Ultra-cool stars are the most frequent kind of star in our Galaxy. Choosing to study common stars, the TRAPPIST team discovery of T-1 Earth-like planets may enable understanding of the frequency biology has emerged in the Cosmos. Ultra-cool stars are small. Their small size results in transit signals produced by Earth-sized planets that are 80x more pronounced compared to similar planets transiting a Sun-like star. The transit signals allow calculation of the orbital periods, sizes, masses, densities, climates and atmospheres of the terrestrial-like planets beyond the Solar System, which were found to be comparable to Earth and Venus in size, mass, and light received. The 4th, 5th and 6th T-1 planets lay in the habitable zone, where oceans could be supported.

Study of the T-1 system is just beginning, and is being enhanced with the reproposed Kepler K2 satellite observatory and additional Spitzer observations, which may detect more T-1 planets. Soon the Hubble Telescope will make first attempts to detect the atmospheres of the T-1 planets, followed by James Webb Space Telescope and EELT deeper investigations and spectroscopic analysis of the atmospheres' chemical composition. They may also be able to assess greenhouse gas content and biosignatures like ozone and methane and confirm if life may be present.

Communication

Icarus Interstellar Communications Design

Icarus Interstellar is an international project aiming to design human- kind's first interstellar communications mission as a global effort.

Project Icarus was initiated by the British Interplanetary Society (BIS) and the Tau Zero Foundation (TZF) and is currently being managed by Icarus Interstellar Inc., a nonprofit foundation. During a recent Icarus meeting to study interstellar communications, scientists included Robert Freeland, Nathan Morrison, Lukas Schrenk, Bruno Doussau, Matt Johnson and Larry Papincak. The group initially considered using lasers to communicate between Earth and Alpha Centauri. However they concluded that using radio frequency seems likely to be the only viable approach because using lasers would be very difficult due to the very accurate pointing precision needed for laser communications.

This meeting's proposed interstellar communications design was by Peter Milne (and provided by Robert Freeland) and required a one kilometer diameter antenna at the Alpha Centauri end and a 40 kilometer diameter antenna on Earth. They debated whether both antennas could be in mesh form, or solid form, and whether the remote antennas would be built in space, or constructed from materials extracted and refined in space.

The idea of using an array of smaller antennas was also considered. No conclusions were reached, but more discussions of interstellar communications will continue at Icarus Interstellar. To find out about future interstellar communication discussions at Icarus, please visit http://icarusinterstellar.org/

Transportation

Icarus Project Tin Tin and Icarus Project Forward

Two Icarus Interstellar transportation studies include Project Tin Tin and Project Forward. Project Tin Tin aims to launch the first inter- stellar spacecraft to Alpha Centauri by the end of this decade.

In the 2012 paper "Interstellar Nanosat Mission to Alpha Centauri" presented at the 63rd International Astronautical Federation, Dr. Andreas Tziolas and other Icarus Interstellar scientists discussed their theories and prototypes for an interstellar precursor mission using a 10 kg Cubesat. Their paper included a discussion of the cost-effective technologies and innovative design of Cubesat missions to accomplish this. Dr. Tziolas described the concepts for design and launch of a set of nanosat-sized spacecraft, or "Tins" and how they will be used on a flight to Alpha Centauri.

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INTERSTELLAR R & D

Observation

Exoplanet Atmosphere Spectroscopy

Enabled by next-generation 30-meter Earth telescopes and 6-meter space telescopes, the leading 21st century astronomy focus on the "Likelihood of Biosignature Detection in the Spectra of Exoplanets" was the Sagan Meeting topic at October's 2017 Tennessee Valley Interstellar Workshop in Huntsville, Ala. The TVIW 2017 theme was "Step by Step: Building a Ladder to the Stars". TVIW and its co-organizers Tau Zero and Starship Century are representative of a most salient and remarkable space phenomenon of our time—the rise of the Interstellar Community.

"Centauri Dreams" editor Paul Gilster along with Greg Benford and Angelle Tanner spoke at the TVIW first-day Sagan Meeting about the James Webb Space Telescope's expected intense scrutiny of nearby red dwarf stars, and the possible spectroscopic detection of oxygen and methane in their atmospheres, providing strong indication of some kind of metabolism. Tanner's description of planet-finding techniques and methods available varied from radial velocity to direct imaging and transits, especially in regards to distinguishing stellar noise from terrestrial mass planets. Imaging exo-Earths with a 500 AU solar gravitational lens was another Sagan Meeting topic.

An additional method for exoplanet analysis and understanding is long-distance passive sensing in the electromagnetic spectrum, as proposed by Doug Loss, a TVIW chair. He suggests this technique could be used in the solar system to examine bodies from a distance to determine their composition and orbital characteristics, which could be useful in deciding which bodies would be economically viable to visit for mining, scientific study, etc. This passive sensing would also be useful in receiving transmissions from interstellar missions.

Communication

NASA Solar Sail Communications Platform Launches in 2018

To find out whether low-cost solar sail technology would work as an interstellar communications platform, scientists will follow NASA's upcoming NEA Scout Solar Sail mission which will test relay communication and imaging systems from asteroids. The NEA Scout will launch as a secondary payload on the inaugural flight of NASA's Space Launch System (SLS), the world's most powerful rocket, in mid-2018. It will separate from the SLS in the lunar vicinity, where it will perform image and instrument calibrations. Cold gas will provide the initial propulsive maneuvers for the NEA Scout's solar sails which will then use solar exposure to complete its 2-year voyage to the target asteroid 1991VG.

Once it reaches its destination, NEA Scout will send back a series of low (50 cm/pixels) and high resolution (10 cm/pixels) images. The images will help determine the global shape, spin rate, pole position, regional properties, spectral class, and other environmental characteristics of 1991VG. The mission will also determine whether solar sails could be used as reliable communications platforms. The success of the NEA Scout Solar Sail will help improve the future design and operations of interstellar communications systems.

Transportation

Solar Sail and Ion Thrusters for Interstellar Transportation

Many planetary scientists believe that solar sails, ion thrusters and laser transport will be used for future interstellar transportation. NASA scientists working on solar sails experimented with photon "pressure" force on thin, lightweight reflective sheets to produce thrust. They found that the reflection of sunlight from the surface of solar sails produces 9 Newton/sq.km at AU with one component of the energy produced directed outward and the other component tangential to orbit. Les Johnson, NASA's solar sails expert pointed out that, "as a propulsion system that doesn't require any propellant, solar sails have a lot of potentials."

NASA's NEA Scout lightweight solar sail consists of three 3D printed spools—an oblong spool that contains the sails material and two smaller spools, each containing two booms, or arms. The booms—which will unfold the sail and hold it in place—are strong, yet flexible. The sail's material, a strong plastic with an aluminum coating is as thin as a human hair and has to be folded and wrapped around the oblong spool. Once in space, the booms—each attached to a different corner of the sail—will extend, unpacking the solar sail.

NASA Glenn designed and has been testing The NEXT ion thruster for about 5 years. This thruster can provide 30 Million-Newton-Seconds of total impulse to a spacecraft and would permit future space vehicles to travel to destinations such as extended tours of multi-asteroids, comet, and outer planets and their moons.

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INTERSTELLAR R & D

Observation

IAU100 Illuminates
International Century of Astronomy

The International Astronomical Union, preparing to celebrate its first century of pioneering science / astrophysics research and education with theme "Uniting our World to Explore the Universe", is the planet's largest body for professional astronomers, with about 13,000 individual members in over 100 countries, at PhD level or beyond, 83% male and 17% female.

Founded in Brussels, Belgium, in 1919 and now headquartered in Paris, the IAU mission is to "promote and safeguard the science of astronomy in all its aspects through international cooperation".

The primary activity of the IAU is the organizing and hosting of scientific meetings, with 9 international Symposia yearly, and a triennial IAU General Assembly -- this year in Vienna, Austria.

More well known, the IAU also functions as the internationally recognized authority for assigning names and designations to celestial bodies – galaxies, stars, planets, asteroids, comets -- and the surface features on them.

IAU100 centennial celebrations will highlight the major accomplishments of astronomy over the past century, with a major emphasis on the use of astronomy as a tool for education, development, and diplomacy.

The IAU100 activities will take place at global and regional levels, with special focus at the national and local levels. An IAU100 Secretariat at Leiden University, Netherlands, will coordinate 9 comprehensive Flagship Programs on specific Astronomy / Education themes.

The official launch of IAU100 celebrations will be held at the 30th IAU General Assembly in Vienna in August 2018, and will include the Kick-off Ceremony, a Special Centenary Ceremony, and the opening of the IAU100 exhibition, "Uniting our World to Explore the Universe". IAU President-Elect Ewine van Dishoeck will serve as IAU100 Task Force Chair.

Communication

Paul Gilster on Centauri Dreams advocates Paul Zubrin's idea that interstellar communication could be effectively accomplished using microscopic high density data storage packages, or bacteria, that vary between 1 and 10 microns.

Numerous varieties of these and propagating devices for Interstellar Communication could be more effective than the radio communication in the 12-cm wavelength (1.42 GHz) range, that hamicroscopic microbes are all around us and are capable of acting as data storage systems that could carry enormous amounts of information to distant galaxies.

If these bacteria could be propagated into space on spacecraft, they could be catapulted by the Sun across galaxies and in 10,000 years would probably be able to propagate humanity's "kind of life" across the universe.

In his paper, *Interstellar Communication Using Microbes: Implications for SETI*, Dr. Gilster mentions that one of the reasons that SETI has not been successful in detecting any communication across interstellar distances is that they relied on using electromagnetic wave detection. Using microbes as data storage has been used by SETI since the1960s.

Transportation

Recent 2018 reports indicate that NASA is planning its first interstellar mission in 2069 to commemorate the 100th anniversary of the Apollo 11 mission.

This interstellar mission is expected to be to Alpha Centauri, our closest stellar neighbor, which is about 40 trillion km away from Earth.

To prepare for this mission, scientists at NASA are working on developing a new interstellar propulsion system that would travel at about 10% of light speed, or about 1,079,253,000 kph. At this speed, NASA's first interstellar space craft would reach Alpha Centauri about 44 years after launch.

If NASA begins this mission in 2019, the speed of the NASA space craft would have to increase by 2,200 times over the current speed of 48,280 kph. At current space flight speeds of about 48,280 kph, a space craft would reach Alpha Centauri in about 80,000 years.

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INTERSTELLAR R & D

Observation

New Hubble-Lemaitre Law
IAU 2018 Resolution B4

The newly-proclaimed Hubble-Lemaître law is the result of intense discussion at the International Astronomical Union 30th General Assembly in Vienna, 20-31 August 2018. Resolution B4 was proposed to rename the Hubble law as the "Hubble-Lemaître law" to recognize Lemaître's research on the expansion of the Universe, and to pay tribute to both Georges Lemaître and Edwin Hubble for their most fundamental contributions to modern cosmology.

A non-binding poll at the concluding session of the IAU GA indicated 74% of the 385 attending individual Members agreed with Resolution B4. Given the importance of the Hubble law, the IAU Executive Committee decided to put Resolution B4 to an electronic vote of all IAU Members, with voting to conclude 26 October 2018.

According to historical sources, Lemaître and Hubble both attended the IAU 3rd General Assembly in Leiden in 1928, where they exchanged ideas on the perceived correlation between the distance and radial velocity of extragalactic nebulae. This developing realization led to the scientific theory of the expansion of the Universe and the then-named Hubble law ($V = H_o D$) and Hubble constant (H_o), with galaxy redshift / recession of 71 km/s per megaparsec (as now determined with WMAP data).

The IAU B4 Resolution is a significant precedent for revising century-old conventions when both science and society require updating to advance astronomical accuracy and social betterment, as should be the updating of the Precession-advanced Aquarius equinox epoch.

Communication

In their paper, Interstellar Mission Communications Low Background Regime, Philip Lubin, David Messerschmitt, and Ian Morrison discussed interstellar communications using low-pass probes accelerated to relativistic speed by a ground-based beam that would have wavelengths designed to work with varying probe speeds.

Data would be transmitted back to Earth via optical communication downlink. For data to be transmitted from Proxima Centauri which is 4.243 light years away, we would need to design Earth-based large-area aperture receivers and build highly selective optical bandpass filters to reduce radiation from target star.

Authors suggested using spread spectrum modulation to design these receivers. Spread spectrum is used in digital wireless terrestrial radio systems. Due to its wider bandwidth, spread spectrum would reduce ambiguity in interstellar communication, and parameters like bandwidth and carrier frequency will be easily determined. The authors believe that using spread spectrum modulation techniques for interstellar communication suggests a promising new direction in this field.

Transportation

In Roadmap to Interstellar Transportation", UC Santa Barbara Professor Philip Lubin discussed some of the challenges for propulsion systems for interstellar transportation. We need to achieve relativistic speeds and design systems to transport varying masses from sub grams to scalable, larger weights. Factors that would moderately help design better systems include improving laser efficiencies; these are now above 50% - increasing efficiencies to 80% or more would help design more reliable systems. However, factors that would revolutionize transport include free space phase control over big distances and reflector stability during acceleration.

Transportation in space requires reducing the weight and improving efficiency of radiators; current radiators have a mass to radiated power of 25 kg/kw, for radiated temperatures near 300K. Improving these efficiencies over the next 5 years would help design better systems for space deployment. Lubin works with NASA Innovative Advanced Concepts (NIAC) on Directed Energy for Interstellar Missions. His paper, Interstellar WaferSats, outlined sending several wafer scale craft with a range of sizes and instrumentation to Alpha Centauri; sizes would vary from 1 gm to 1 kg and would be designed to reach destination in about 100 years.

Issue 35 Spring 2019

INTERSTELLAR R & D

Observation

Observation from the Moon, Rotation of the Earth, and Earth Axial Precession

The IAU Commission on Rotation of the Earth highlights the major importance for astronomy and for the International Astronomical Union of increasingly precise values for Earth axial rotation. Long-duration, high-resolution observation of Earth meteorology, magnetosphere and rotation can produce enhanced, unique and highly valuable data across a wide spectrum of interests and applications. From solar weather, to navigation accuracy, to commerce, aerospace, defense, as well as astrophysics and precession information needs would contribute to increasingly precise values and expressions for the Rotation of the Earth. Observation from the Moon, including interferometry and VLBI, provides a new entire world for perspectives on the infinite universe.

Observations from the Moon by a lunar observatory of Earth axial precession, called “Earth’s 3rd Motion” by Copernicus, and of the resulting precession of the equinoxes, may more accurately determine the amount of shift of constellation boundaries since Eugene Delporte delineated the IAU-designated 88 constellations in 1928 along strict lines of declination and right ascension as they existed at epoch 1875.0. This higher rotation / precession accuracy may help better determine the apparent arrival of the Sun on the ecliptic in the constellation of Aquarius at the time of the March equinox, which is now calculated at about 2597 AD using the IAU 1928 / current map. As constellation boundaries are the result ultimately of arbitrary human choice, as psychologist / anthropologist Carl Jung noted in 1940 when first referencing the Aquarius equinox epoch, the updating of the Aquarius-Pisces constellation boundary might place the arrival of the Sun in constellation Aquarius in 2000 AD, to great advantage for the IAU, Astronomy and Humanity.

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Communication

In October 2018, Parker Solar Probe (PSP) became the closest object to reach the outer corona of the Sun; it is now almost as close as Mercury is to the Sun. PSP is the size of a small car, shaped as a light-bulb and travels at 343,000 km per hour. It is the only spacecraft, after Voyager 2, to carry Faraday Cup instruments for testing atmosphere in space and interstellar regions. The first Faraday Cup tests were done at MIT in 1961. PSP is protected from extreme temperatures of about 1,370 °C (2,500 °F) by a 4.5 inch carbon-composite shield.

PSP collects and sends data about solar winds, the chemistry of the wind particles, their energy, and magnetic fields. The Faraday Cups on PSP and Voyager 2 will be measuring data from opposite ends of the solar system, from as close to the Sun as is possible to as far away as the local interstellar medium. This data will assist in understanding space and interstellar weather.

Transportation

Astronaut Mae Jemison’s 100 Starship project aims to help make Interstellar Travel possible over the next 100 years. Astronaut Jemison advocates teaching science, space technology, astronomy; her 100-Year Starship project features Voyager 2, the first plutonium-powered spaceship to cross to interstellar space in December 2018. Voyager 2 launched in 1977 and as it passed the Sun, NASA scientists were able to estimate the size of our heliosphere, the bubble of gases emanating outward from the Sun; data showed that our heliosphere pushes against interstellar winds of the Milky Way.

As Voyager 2 reached 18 billion miles away from Earth, it was learned that at greater distances, solar wind diminishes and is overtaken by magnetic fields of interstellar region; the number of galactic cosmic rays from outside our solar system increased as well. Astronaut Jemison may talk about Interstellar Travel at ILOA Galaxy Forum NY at the American Museum of Natural History in Fall, 2019.

Issue 36 Fall 2019

INTERSTELLAR R & D

Observation

Exosphere Spectroscopy Is Main Objective for Hawai'i Big Telescope

Exoplanets populate the 21st century astrophysical frontier with thousands of newly-discovered worlds inviting science explorations of the highest importance: Do habitable, Earth-like planets exist? Is life ubiquitous in our Galaxy? What science techniques and instruments are available to identify and characterize extrasolar planets and their atmospheres?

To recognize planet atmospheres like Earth's with water vapor, oxygen, ozone and carbon dioxide, spectroscopy advances in astronomical telescopes now enable exoplanet atmosphere retrieval and analysis. Detection of biosignature gases of oxygen, methane, methyl halides, sulfur compounds and thousands of other molecular gases have been achieved, according to MIT exoplanet pioneer Sara Seeger. Astrophysicist Seeger has developed a parallel version of the Drake equation to estimate the number of habitable planets in the Galaxy by focusing on simply the presence of any detectable exoplanet biosignature gases.

Atop Hawai'i Island's 4,200-meter Mauna Kea — the clearly superior site for astronomy in the northern hemisphere— the kama'aina agreement to develop the Hawaii Big Telescope (accurately but inconsiderately named Thirty Meter Telescope) will lead to astounding advances. HBT (TMT) exoplanet experts such as Kansas native Thayne Currie expect great capabilities in imaging and spectroscopy, using radial velocity methods of entire planetary systems, over a wide range of masses and wavelengths, with potential to detect molecular oxygen in temperate terrestrial planets.

Communication

Several new initiatives are underway to create Interstellar Educational Institutes.

These include starting an Interstellar University in the Ad Astra State; this university will be discussed by Steve Durst, at 8:15 am on Wednesday, November 13, 2019, during the 6th Interstellar Symposium / TVIW Conference in Wichita, Kansas.

The project is proposed by Space Age Publishing Company, with a mission to provide interstellar education, observation, communication and transportation research and leadership opportunities. Other speakers at the 6th Interstellar Symposium who will discuss education include Deana Weibel, Kelly Smith, and David Burke; they will participate in the Tuesday, November 12, session which will focus on societal, religious and ethical considerations for interstellar travels.

Les Johnson is the symposium chair for long-range planning, and is a physicist who has held several positions at NASA. He is a leading advocate for science and interstellar education.

Leading organizations in Interstellar Education and Communication today include Icarus Interstellar founded by Andreas Tziolas, The Interstellar Community Foundation, started by astronaut Edgar Mitchell of the Apollo 14 mission, and the Initiative for Interstellar Studies founded by Kelvin F. Long and Robert Swinney. Also, the 100-Year Starship started by astronaut Mae Jemison.

Transportation

Innovation in Interstellar Transportation is one of the main themes at the Interstellar Symposium / TVIW Conference in Wichita, Kansas, from November 10-15, 2019.

Speakers include: Marc Millis, who will summarize NASA's Breakthrough Propulsion Study and discuss Assessing Interstellar Flight Challenges and Prospects;

Geoff Landis' paper is on Power Systems for Miniature Interstellar Flyby Probe; Gerald Jackson's talk features Antimatter-Based Interstellar Propulsion, and Artur Davoyan will give a talk on Light Sails for Interstellar Travel.

Other talks will focus on new ideas for Light Sails propulsion, which include the "Halo Drive" effect, advocated by David Kipping, an astrophysicist at Columbia University. With the Halo Drive effect, spaceships could use black holes as powerful launch pads to travel towards the stars. Kipping discussed firing laser beams that would curve around a black hole and return with enough extra energy to help propel a spaceship to near the speed of light.

His work was influenced by Freeman Dyson's ideas that the combined speeds of two neutron stars in a tight enough orbit would help accelerate a spacecraft to almost the speed of light. Kipping extended this concept to black holes.

Issue 37 Spring 2020

INTERSTELLAR R & D

Observation

Interstellar University To Advance Astrophysics as Well as Astronautics

A considered Interstellar University (IU) in the Ad Astra State of Kansas should include astronomy, 'the king of sciences', in its curriculum along with classic interstellar disciplines such as astrodynamics, astromaterials research, starship design and construction, propulsion, generational and relativistic travel, and more.

Astronomy in Kansas reflects a natural uplooking manner in a state whose motto "Ad Astra Per Aspera" has been a cultural foundation since Kansas became the 34th star on the USA banner on January 29, 1861. Ad Astra Kansas Foundation President Jeanette Steinert confirmed that Kansas astronomy tradition in her opening remarks at the Interstellar TVIW / NASA Symposium in Wichita in November 2019.

IU astronomy / astrophysics studies relevant to and enabling interstellar astronautics and mission design may inspire creation of such study, working groups and commissions within the American Astronomical Society and the International Astronomical Union, such as "SETI Advanced by Starship".

An announcement of the official founding of the Interstellar University is planned in Topeka on January 29, 2021,160 years to the day of Kansas statehood-- possibly accompanied by a proclamation from Kansas Governor Laura Kelly, and by science / astronomy ceremonies in Topeka. The first IU course(s) may be on Ad Astra Kansas Day, April 24, 2021.

Communication

Tennessee Valley Interstellar Workshop (TVIW) and NASA held the 6th Interstellar Symposium and Advanced Interstellar Propulsion Workshop in Wichita, KS, in November 2019. Wichita State University and Ad Astra Kansas Foundation also helped organize this workshop, which focused on propulsion using beamed energy, fusion and antimatter. In January 2020, Phil Lubin (UC Santa Barbara), David Messerschmitt (UC Berkeley), and Ian Morrison (Curtin University, Australia) updated their NASA Starlight publication on communication downlinks from low mass interstellar probes, "Challenges in Scientific Data Communication from Low-Mass Interstellar Probes." Their update discussed new technologies for interstellar communication, including: (a) Better optical compression and low-mass light sources in transmitters or receivers. David Fields (TVIW) helped design five algorithms for receivers. (b) Improved low-mass transmit aperture and pointing adjustment accuracy. (c) New multi-probe multiplexing to reduce inaccuracies in time, speed, and distance, including the Doppler shift. (d) Better adaptive optics in optical sub-array to counter turbulence, and star radiation and (e) Low-mass and low-power compression to counter turbulence. Messerschmitt believes electromagnetic radiation leaked from the Earth to outer space from radio and TV programs, would have traveled 100 lightyears over the past 100 years and that intelligent life in the 100 lightyear radius might detect them. Messaging Extraterrestrial Intelligence (METI) President, Doug Vakoch advocates for multi–disciplinary research on interstellar messages that would include people from astrobiology, engineering, and the arts.

Transportation

Breakthrough Starshot and NASA Starlight projects are leading international efforts to develop StarChips for Interstellar Transportation. StarChips are thousands of wafer-sized chips attached to large, silver lightsails. At launch, intense Earth-based lasers would accelerate the lightsails with a force of about 100 GW for two minutes, allowing StarChips to travel at .2c, propelled by high-powered pulses of photons from these ground-based lasers. At this speed, StarChips would and reach the nearest star in nearly 20 years.

Starshot Executive Director Pete Worden, former director of NASA Ames, hopes to raise $10 billion for this project. Starshot plans to use quantum computing to process data returned from Alpha Centauri, 4.37 lightyears away. Quantum Computing would process data from several StarChips 100 million times faster than supercomputers.

Gerald P. Jackson of Fermi Labs is developing an antimatter thruster that can reach the nearest star at 5% of the speed of light, or better. At Fermi Labs, Jackson's team successfully developed 2 gms of antimatter per year for 14 years; their work was encouraged by Congressman Bill Forester (IL), who helped approve the antiproton Recycler ring at Fermi Labs. In 2017, Jackson started crowdfunding the design of a particle accelerator that can produce antiprotons. Details are on the Antimatter Drive website http://antimatterdrive.org.

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INTERSTELLAR R & D

Observation

Event Horizon Telescope EHT

The EHT is an expanding global consortium of dozens of world-class radio telescopes, observatories and organizations involving hundreds of astrophysicists that uses VLBI technologies to create an Earth-diameter sized capacity for imaging black holes and their accretion disks, testing general relativity, understanding jet genesis, and instrument collimation.

First image of a black hole at the center of supergiant elliptical galaxy Messier 87 was announced and published April 10, 2019, by the EHT Collaboration at six simultaneous press conferences worldwide. EHT continues to win many awards for the M87 project, which provides powerful confirmation of the Einstein general relativity theory. EHT hopes next to image high priority Sagittarius A*, the supermassive black hole at the center of the Milky Way.

Pioneers leading EHT include Shep Doeleman, Founding Director; Geoff Bower, Project Scientist; Jessica Dempsey, EAO / JCMT; Huib van Langevelde, Project Director; Heino Falcke, Radboud University; Recent EHT highlights note that Smithsonian Astrophysical Observatory has partnered with National Society of Black Physicists to form the SAO / NSBP EHT Scholars Program.

Earth-Moon VLBI could result in massive expansion of black hole imaging capability appropriate for relativistic considerations of the Interstellar age.

Communication

Interstellar University
First Planning Meeting,
Cosmosphere, Hutchinson, KS

A long-standing goal of the AAKF, especially board member Steve Durst, has been to promote space science in Kansas. Durst suggests "the potential establishment of an Interstellar University (IU), a collection of rich international interstellar R&D resources, could be a timely consideration for early 2020s decade to realize the long-range vision to innovate, educate, inspire and achieve Interstellar observations, communications, transportation in the 21st Century."

Kansas seems an appealing location and the time right to launch a modest beginning for this important venture, planning for next the 5 years and decades beyond. Perhaps first starting with an existing university department and expanding to a regular curriculum, the IU would build on in-state resources. IU may be similar to the International Space University, and see participation from the Interstellar community. A hybrid online organizing meeting will occur on Oct. 24 , to gauge support for this ambitious and far-reaching goal.

Agenda Considerations:

Why an IU in Kansas?

-Geography: Mid-Way USA

- National Attributes, Character: Heartland, Breadbasket;

-State Motto: Ad Astra Per Aspera, "To the Stars Through Difficulties;"

- University Science & Research, Industry Technology Capabilities

- **Introduction to the Interstellar Community:**

-100-Year Starship, Icarus Interstellar, IRG/TVIW, i4iS, Tau Zero Foundation, Centauri Dreams, Ad Astra Kansas Foundation, Breakthrough Starshot / Initiatives, et al …

- **Curriculum Considerations:**

-Ad Astra Kansas News / Interstellar R&D 38 Features 2001-2020 on Interstellar Observation, Communication, Transportation

-Founding Statement of Purpose

-First Course(s) – 2021, in

Topeka, Wichita, Hutchinson,

Lawrence, Manhattan, Emporia?

-Professors, Teachers, Instructors

-IU Home Campus Location

-Organization

-Funding First Year(s)

Transportation

Relativistic Travel to Proxima B

Proxima b, in Alpha Centauri, is attracting researchers interested in finding out if it is as habitable as it seems. Breakthrough Initiatives is planning to send probes to study it, so is Douglas Vakoch, who leads the Messaging Extraterrestrial Intelligence (METI), and Gerald Jackson of Hbar Technologies. The METI initiative will look for laser pulses emanating from Proxima b, which, if detected, would be a sign that there may be life on this planet.

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INTERSTELLAR R & D

Observation

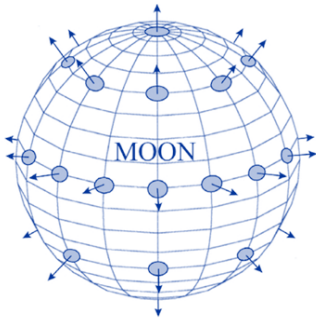
Global Placement of Telescopes on the Moon

Earth's Moon – Humankind's first giant leap toward Galaxy Stars – is becoming a new center for 21st Century Astronomy, and a new sphere of interest for an Interstellar University rising from the Ad Astra State.

Astronomy from the Moon, lunar-based telescopes of all wavelengths and all instrument technologies globally placed will enable astrophysical observation and study of the entire Cosmos with unprecedented capabilities.

"The Moon is the ideal site in the Solar System for making astronomical observations and measurements, and it will inevitably become humankind's principal scientific base for astronomy. For this reason alone, the Moon should be given a high priority for human development." *

An Interstellar University originating from Kansas may consider Lunar Observatories with VLBI / Event Horizon Telescopes for Interstellar Observation, Communication and Transportation utilizing zettabyte data transmissions – as may be discussed at the IRG 7th Interstellar Symposium in Tucson AZ, 25-27 September 2021.



Global placement of telescopes, observatories on the Moon

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* D. Schrunk, The Moon; B.Sharpe, Graphic / Title

Communication

Interstellar Rosetta Stone

International collaboration on Cosmic Call 1 & 2 in 1999 and 2003 sent a noise-resistant message from Earth to extra-terrestrial intelligence including Interstellar Rosetta Stone (IRS), with Cosmic Call 2 totaling 220+ megabytes over 11 hours and 53 minutes.

Canadian scientists Y. Dutil and S. Dumas designed the IRS to include a bilingual glossary of English and Russian. The message had more information about global mathematics and science (building on the 1974 Arecibo Message written by SETI's Frank Drake, also included in Cosmic Call) with several questions on its final page, hoping extraterrestrials would respond and begin communications.

Team Encounter, a Texas startup, funded sending the first IRS message in 1999 from an RT-70 radio telescope in Yevpatoria, Crimea; the second transmission followed in 2003. IRS transmission will reach nine stars in Cancer, Sagittarius, Cygnus, Andromeda, Orion, Cassiopeia, and Ursa Major.

NASA funded Carl Sagan's *Golden Records* in Voyager 1 and 2 and the Arecibo Message; however, NASA and government agencies declined to fund IRS. IRS is the first crowdsourced international, interstellar effort led by Charlie Chafer – currently CEO of Space Services Holdings in Texas. Canadian astrophysicist Yvan Dutil advised Chafer that a radio message would not be comprehensible to extraterrestrials without an introduction explaining our number system, planet makeup, and biology. Dutil teamed with Stephane Dumas, a Canadian physicist, to write the message. Since 2018, several papers on Interstellar Communication Networks were published in the Astronomical Journal outlining benefits of using probes to send and receive interstellar messages on a distributed interstellar network.

Transportation

Low-Cost Interstellar Precursor

In 2017 Breakthrough Initiative proposed launching a fleet of microprobes carried by solar sails weighing about 1 gram each, pushed by radiation pressure from an immense 100 GW laser plant; the laser would provide speed up to 0.15 - 0.2c, allowing microprobes to reach Proxima Centauri in 20 years. This design requires building an immense laser plant on Earth, and directing the microprobe would have to be monitored from Earth with great accuracy at the beginning because there is no way to correct direction later.

A new international proposal for *Low-cost Precursor of an Interstellar Mission* was published in the Journal of Astronomy and Astrophysics, September 2020, by René Heller at Max Planck Institute, Guillem Anglada-Escudé at Inst de Astrofisica de Andalucía, Michael Hippke at Breakthrough Initiatives, and Pierre Kervella at Paris Observatory. The authors propose replacing the Earth-based laser power plant with solar radiation, ready for use and available in unlimited amounts. The prototype would cost about $1 M, with each sail built for $1,000; and $10 M budgeted to launch the interplanetary mission. Participants in the 7th IRG Symposium, September 24-27, 2021, in Tucson AZ, plan to discuss interstellar transportation; their proposals could be the foundation at Transportation Courses, Interstellar University in Kansas.

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INTERSTELLAR R & D

Observation

USA Astronomy Centers
and Interstellar University Development

Scan QR code to view poster in more detail

The first human interstellar science and technology ages ago, Astronomy provides continuity, sustainability, information, inspiration, direction, and is the essence of these endeavors – the Stars themselves. An Interstellar University in the Ad Astra State of Kansas may develop astrophysics curriculum building on the excellence of Kansas universities physics / astronomy departments and identifying and interacting with astronomy resources and centers in all 50 states, and globally beyond.

For USA, astronomy centers in Hawai'i, California, Arizona, New Mexico, Massachusetts, and DC Metro have outstanding astrophysics capabilities. Briefly, Hawaii: Mauna Kea Summit at 4,206 meters with a dozen world-class observatories and universally-acknowledged best site for astronomy in the northern hemisphere; California: Hale, Palomar, Lick, Big Bear, ATA observatories and world-class State University system; Arizona: Kitt Peak, Mt Graham, Steward, Lowell observatories, U of AZ astronomy; New Mexico: NRAO Very Large Array, National Labs, many observatories; Massachusetts: Harvard, MIT, Haystack Observatory; DC Metro: NASA, Space Telescope Science Institute, National Air and Space Museum.

Astronomical assets of all 50 stars of the American constellation and national astronomical resources of all nations will richly complement Kansas' natural up-looking manner and cultural foundation for the developing Interstellar University – Ad Astra Per Aspera.