

PRINCIPIUM

The Newsletter of the Institute for Interstellar Studies™

Issue 5 | June/July 2013

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www.I4IS.org



Scientia ad sidera
Knowledge to the Stars

Introduction by Keith Cooper



Before a single starship even blasts off for alpha Centauri, interstellar research has already excelled itself by building a community.

Communities are important. They help create a sense of unity towards a common goal, allow the proliferation of ideas between like-minds and provide credibility to a field far beyond what a few scattered free-thinkers can do.

Networking and meet-ups are essential parts of being in a community and boy, there's been quite a few interstellar meet ups recently, with more just around the corner! It is these frequent symposia, conferences, workshops and informal pub meetings that help keep the topic vibrant and relatable. It's one thing to read a book or magazine article about interstellar flight, it's another thing entirely to attend a conference and sit across a table from a well-respected scientist whose research is helping to provide the groundwork for the quest to develop interstellar flight.

Talking to these scientists and engineers, the whole topic feels – ironically – a little more down to Earth when you realise there are real human beings working towards our common goal.

We have already featured the first of this year's interstellar meetings in issue four, namely Les Johnson's Tennessee Valley Interstellar Workshop. This issue we include a report from James Benford on the successful Starship Century symposium that took place at the Arthur C Clarke Center for Human Imagination at the University of California, San Diego (don't forget to pick up a copy of the accompanying book too – see Community News on page 5 for more!). May also featured I4IS' first ever symposium, in association with the British Interplanetary Society, entitled The Philosophy of the Starship. Look out for a full report next issue.

Coming up in August is Icarus Interstellar's Starship Congress, a four-day extravaganza in Texas that will include talks by many of the leading lights of interstellar research. I4IS will be present in large numbers at the Congress, with an exhibition stand and providing several speakers, so if you are attending the event be sure to stop by and say hello to our team.

Following the Starship Congress, there is a 100 Year Starship event in September before a possible sequel to the Benford's Starship Century symposium in October in association with the British Interplanetary Society in London.

With so much going on there are plenty of opportunities to become involved, particularly if you are able to travel, but what if you cannot attend any of these events? At I4IS we are keen to include as many of our members in activities as possible, including contributing to *Principium*. So far we have featured introductions from members of the Board of Directors, or invited articles about aspects of interstellar research from specific people. Now it is time to open things up. If you would like to write for *Principium*, write to me at principium@i4is.org. I'm particularly looking for introductory letters, book or other media reviews, or news about what research or work our members are conducting in the interstellar field and for I4IS. So, put your thinking caps on, place finger to keyboard, and get writing!

Keith Cooper

June 2013

News from the Institute

Beyond the Boundary

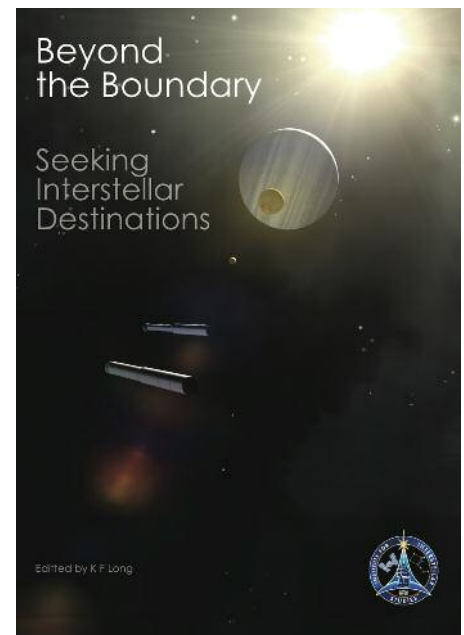
Fancy reading a real page-turner? Here at I4IS that's what we have coming up, with the publication of our very own book, *Beyond the Boundary: Seeking Interstellar Destinations*, in August. Edited by Kelvin F Long, the book tackles the different aspects and challenges of interstellar flight, with each chapter written by an I4IS team member, some who are well known authors, others who are seeing their words in print for the first time as we seek to include a cross-section of our membership and people in society, from scientists and engineers to artists and journalists to enthusiasts and musicians.

Contributing authors include Stephen Ashworth, Jonathan Brooks, Martin Ciupa, Jeremy Clark, Keith Cooper, Ian Crawford, Bill Cress, Adam Crawl, David Fields, Remo Garrattini, Angelo Genovese, David A Hardy, Andreas Hein, Kelvin F Long, Tobias Lugolobi, Adrian

Mann, Gregory Matloff, Mike McCulloch, Ken Roy, Divya Shankar, Alex Storer and Giovanni Vulpetti, discussing topics as diverse as the philosophy of star-flight, technologies for interstellar travel, nearby planetary systems and interstellar destinations, SETI, artificial intelligence and space art and music. We're also fortunate to have space artist Jon Lomberg writing the foreword. What does he have to say? You'll have to buy the book to find out!

A luxurious hard cover book, *Beyond the Boundary* is priced at £35 and all of the money raised will be going to projects, initiatives and activities related to I4IS, which we will be sure to mention in future issues of *Principium* so that readers can see how the money is being put to good use.

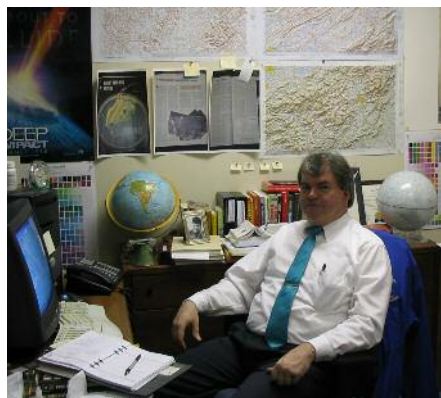
To pre-order your book, send your name and e-mail address to us via interstellarinstitute@gmail.com.



New Recruits

I4IS are pleased to announce several new team members who have joined us on our fantastic interstellar adventure.

First up, we're delighted to announce that Robert G Kennedy III has joined I4IS' Board of Directors. Having graduated from California Polytechnic in 1986 with a BSc in mechanical engineering, specialising in robotics and optical physics, he designed industrial robotics systems for Douglas Aircraft Company in Los Angeles and researched artificial intelligence at Oak Ridge National Laboratory before setting up his own business in 1992, a Russian-American company called the Ultimax Group, Inc. It has been engaged in everything from nuclear science and systems engineering to military robots, Russian space software, space affairs and missile defense. A proficient artist and author of non-fiction, he co-organised the 2013 Tennessee Valley Interstellar Workshop with Les Johnson (see *Principium* issue 4), has lectured on geoengineering at the Moscow Academy of Science and has published papers in the *Journal of the British Interplanetary Society*, *Acta Astronautica*, *Whole Earth Review* and *Smithsonian Air and Space Magazine*. He was also technical consultant on the 1998 Hollywood movie *Deep Impact*. A fluent speaker of Russian, Latin, Greek and



Robert G Kennedy III

Arabic, he currently works as a senior systems engineer at Tetra Tech and with his skills and expertise will be a valuable addition to I4IS.

Meanwhile, David Fields has joined as a Senior Researcher. The Director of the Tamke-Allan Observatory at Roane State Community College, he is a physicist who has specialised in health risks from radionucleotides and has worked with NASA's Marshall Space Flight Center to design radiation shields to protect astronauts from excessive radiation exposure from coronal mass ejections from the Sun, cosmic rays, the Van Allen belts and nuclear propulsion reactors. He

is also on the board of the Society of Amateur Radio Astronomers, which is where his current research interests lie.

Other new team members include London-based industrial designer Tom Shirley who will be working on interior concepts for a proposed I4IS HQ, Martin Ciupa who runs Cybernetics Analytics Ltd in the UK and Singapore and who will be heading up an Interstellar Ethics Group, and George Calder-Potts, who has a Masters degree in Space Technology.

Finally, space propulsion physicist Eric W Davis has joined the ranks of I4IS consultants. One of the pre-eminent names of advanced propulsion research, Davis was mentored by the legendary Robert Forward and in 2009 co-edited the book *Frontiers of Propulsion Science*. Davis has worked on space missions as varied as the Voyager probes, the Infrared Astronomy Satellite and various military satellites. He is currently Senior Research Physicist at the Institute for Advanced Studies at Austin, Texas, where he specialises in breakthrough propulsion physics.

News from the Institute

Starship Philosophy

I4IS' first official event went down a storm at the British Interplanetary Society in late May. Entitled 'The Philosophy of the Starship', the one-day symposium was attended by 30 people and featured talks on topics as diverse as 'the starship as an expander of minds', the ethical implications of cultural intervention by space-faring civilisations, 'future geopolitical scenarios and their impact on deep space, and self-replicating probes. Each presentation was followed by a spirited Q&A and discussion session, with input from everyone in the audience.

We will have a full report in our next issue.



Professor Ian Crawford spells out how designing starships can help expand humanity's horizons. Image credit: Kelvin F Long.

Project Dragonfly

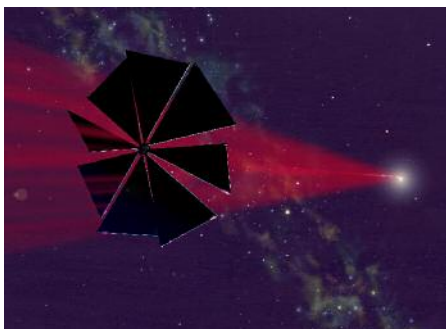
Announced at the Philosophy of the Starship symposium was Project Dragonfly, I4IS' new flagship research goal. Named after the Robert L Forward's 1984 science fiction book *The Flight of the Dragonfly* (also known as *Rocheworld*), it tells the story of a mission to Barnard's Star 5.9 light years away to visit a twin planet – Rocheworld – where the two atmospheres are actually touching and the planets stretched into ellipsoids by their mutual gravitational attraction. More pertinently the starship, named Prometheus, flew to Barnard's Star using a laser sail, where mighty 1,500 terawatt lasers are focused through a gigantic lens towards the receding starship, imparting momentum onto its enormous sails to accelerate it to a fifth of the speed of light.

Project Dragonfly is therefore an initiative to develop laser-sail propulsion demonstrators. The aim is to start with a ground vacuum chamber demonstrator and then to move towards testing with

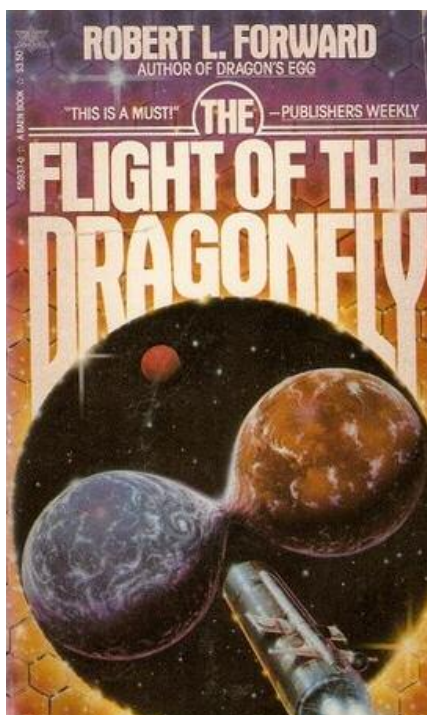
cubesats (see Issue 1 and Project CATSTAR). The ultimate aim is to one day see a low mass, high concept mission launched into deep space, past the Oort Cloud and beyond, in the direction of the stars.

"Robert Forward pioneered the development of propellant-less solutions for interstellar flight and, like the Prometheus of his story, this exciting project will point the way to the stars," says I4IS Executive Director Kelvin F Long.

I4IS are currently in the process of building the Dragonfly team and more will be announced next issue.



An artist's impression of a light sail being pushed by laser. Image: Michael Carroll/Planetary Society.



London Calling

The 2014 World Science Fiction Convention is taking place in London at the Excel Centre from Thursday 14 to Monday 18 August 2014 – notable for being the convention at which the famous Hugo Awards are handed out. This is a unique opportunity for the Institute for Interstellar Studies to reach out to some of the most imaginative people on this planet. Science fiction has been an inspiration to many in the Institute and in turn we'd like to inspire the fans, writers, publishers, editors and stars from the worlds of games, film and television who will be at the convention.

I4IS is already planning to have a presence at the convention, which will also be known as 'Loncon 3'. Aside from exhibiting and perhaps giving talks, there will be plenty of informal networking and that's where you come in! Please consider fitting the convention into your travel plans for next year. This is an opportunity to both experience the unique creative and mind-expanding atmosphere of a World Science Fiction Convention and to also help raise the profile of I4IS. Or just come along to say hello to us while mingling with the stars of science fiction!

If you are considering coming then please get in touch with John Davies via jid@flying-boat.co.uk or find him at uk.linkedin.com/in/jiduk/.

Starship Century Symposium Takes Flight

James Benford describes two fascinating days in May when interstellar science touched down at the Arthur C Clarke Center for Human Imagination in San Diego in association with a new book, *Starship Century*.



Getting to the target stars: (L–R) Ian Crawford, Geoff Landis, Bob Zubrin, Paul Davies and Adam Crowl come together for a panel, moderated by the SETI Institute's Jill Tarter (not shown). All images credit: James Benford/Starship Century.

Our principal goal for the book *Starship Century* was to collect the visions of interstellar thinking across the spectrum from physical, biological and other technical areas as well as social, political and humanistic perspectives. That includes essays, science fiction and even some poetry.

Our second objective was to fund interstellar research with the profits from the book. Therefore, for both of those reasons, we wanted to make a book that would be widely read, i.e. to communicate the perspective of 2013 on starships and

and the interplanetary economy essential to build them to, frankly, sell a lot of books so that research can be done to advance the visions.

With the book well defined, we got in touch with the new Arthur C Clarke Center for Human Imagination at the University of California, San Diego, which was looking for a kick-off event that would attract a broad audience. Our book seemed to be an obvious choice. We organised the symposium very much along the lines of the book; the overlap between symposium participants and book participants was very high.

The location was on the beautiful UC San Diego campus in La Jolla where my brother and I entered as physics graduate students 50 years ago. Attendance was quite high; the Clarke Center cut off registration at 338. It was the largest interstellar meeting that will occur this year.

The attendees were quite stellar. Everyone was glad Freeman Dyson was there. Freeman turns 90 this year, is the subject of a very good new biography and many of us wanted to be photographed with him.

On the science policy side we had Freeman Dyson, Paul Davies, Robert Zubrin and Peter Schwartz, the futurist. On the science side, John Cramer on exotic 'warp-drive' propulsion, Adam Crowl on pioneering starship ideas, Geoff Landis on nuclear rockets and Ian Crawford on destinations for starships and myself on beam-driven sails. Jill Tarter moderated a panel shown in the accompanying photo. On the science fiction side there was my brother Greg, Neal Stephenson, Allen Steele, Joe Haldeman, David Brin, Richard Lovett, Larry Niven and Vernor Vinge.

Space Towers and New Space

The first day started with the perspectives of Schwartz, Dyson, Zubrin and Stephenson. Peter Schwartz used his future thinking methods to argue that the several classes of possible fates of mankind mean that, though we may be driven by religion or by great nations or by the funding of trillionaires, starships are almost inevitable.

Neal Stephenson gave his view that civilisation isn't thinking big anymore and showed the work of his team on the possibility of constructing a tower 20 kilometres tall. This represents a big engineering challenge, forces the consideration of new factors such as adding airfoils to towers, would give us a new perspective and could have applications such as launch-to-orbit and a tethering base for a space elevator. His theme was the nonlinear potential of big ideas. For example, the USA built the Panama Canal, which aside from inter-ocean transport also supplies all the electrical power for Panama hydroelectrically.

In the afternoon we had several talks on how to develop the Solar system in the near term as a prelude to launching starships. Of particular interest was Chris



Physicists Freeman Dyson and Geoffrey Landis.



Chris Lewicki of the asteroid-prospecting company Planetary Resources, who gave an overview of the steps towards mining asteroids.

Lewicki of Planetary Resources, who described their ambitious plans and how they intend to make money on space resources. Chris then joined a panel, moderated by Peter Schwartz, made up of Dyson, Stephenson, Steele and Landis discussing the future of what is now called 'New Space'.

Because the book went on sale at the symposium for the first time, that evening and the following evening editors and authors of the book *Starship Century* signed copies. We sold about 200 books in the two days.

The morning of the second day focused on how to actually build starships: early ideas, beam-driven sails, nuclear rockets and exotic propulsion. As the day went on, a sort of harmony developed among the participants. I think it was because they were getting to know each other and could work together to explore ideas. In the afternoon, Paul Davies cautioned about the complexities of interacting biologies: 'Can we Survive Alien Biospheres?' Jill



Jon Lomberg, visionary.

Tarter moderated a terrific panel on 'Getting to the Target Stars' with Ian Crawford, Geoff Landis, Bob Zubrin, Paul Davies and Adam Cowl. Meanwhile, Gregory Benford moderated a panel of science fiction writers: Joe Haldeman, David Brin, Larry Niven, Vernor Vinge and Jon Lomberg.

Jon Lomberg gave the final talk, a real stem-winder that urged us to consider ourselves 'Citizens of the Galaxy' and gave a crowd-pleasing description of his marvelous Galaxy Garden, a model of our galaxy 100 feet across, located on the Big Island of Hawaii (look it over at <http://www.galaxygarden.net>). His talk was interrupted several times by applause.

Toward the Grandest Horizon

There was agreement on the proposition of the symposium that, now that the initial reconnaissance of the Solar System has been conducted (a probe will fly past Pluto two years from now), exploring beyond the Solar System by robotic or crewed starships, beginning with precursor probes, is the next horizon for civilisation.

The symposium ended on a very positive note; several people asked me if we were going to hold another one in future. In fact we're working on having another Starship Century Symposium in London at the British Interplanetary Society with a tentative date of 20 October.

That evening David and Cheryl Brin had a wonderful party for many of the participants at their home. About exploring the stars, David feels that "Few assumptions will hold true out there — even when we find nice, warm, watery worlds with nitrogen-oxygen atmospheres. For one thing, such an atmosphere can only have been produced by life... locally evolved and far fitter for local conditions than our dauntless settlers will be. Either the local biome will be incompatible with ours, in which case there will either be conflict or parallel ecosystems — or else compatibility will mean we can find plenty to eat in the new realm... but then they will be able to prey on us."

For further discussion of this symposium and its aftermath, buzz and blogs about the symposium, and excerpts from the book, see the website <http://www.starshipcentury.com>. The symposium videos of all the talks can be viewed there, too.



The SETI Institute's Jill Tarter



Allen Steele, a science fiction author who featured in a panel, 'The Future of New Space' with Freeman Dyson, Chris Lewicki, Neal Stephenson, Geoff Landis and Peter Schwartz.



Science fiction author Neal Stephenson raised the prospect of a 20-kilometre tall tower as an example of 'big engineering', reminiscent of Jon Lomberg's Earthport painting (see last issue!).

If you want to see an extended version of the thoughts discussed in the symposium, and the science fiction about starship ideas, get and read the book *Starship Century*, available in paperback now and in e-book in August [we'll also feature a review of it in an upcoming issue – Ed]. Between now and then, about two thirds of the purchase price of the book will go directly to fund interstellar research.

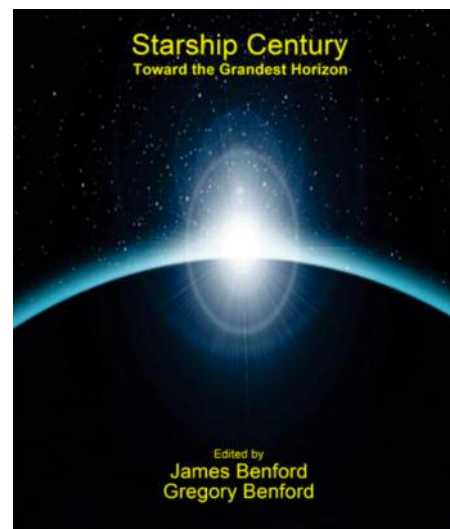
You can buy a special release of the printed book at the book's website or at <https://www.createinspace.com/4240458>.

About the author

James Benford is President of Microwave Sciences in Lafayette, California. His research includes high power microwave systems and nuclear fusion, and in 2000 he led a team that demonstrated the first flight of photon-driven carbon sails using microwave beams.



James Benford



The cover to the *Starship Century* book, featuring such illustrious authors as Stephen Baxter, James and Gregory Benford, David Brin, Freeman Dyson, Stephen Hawking, Paul Davies, Joe Haldeman, Martin Rees and many more! You can order your copy from here <https://www.createinspace.com/4240458>, or from regular book shops after its public launch date of 20 August.

Icarus' Starship Congress Gets Kick-started



Congratulations to Icarus Interstellar, who ran a wildly successful fundraising campaign on Kickstarter for their epic Starship Congress, taking place in Dallas, Texas on 15–18 August. With the aim of raising \$10,000, in the space of a month the campaign exceeded expectations and raised a whopping \$15,831, with 276 people pledging amounts from as small as \$5, all the way up to \$600.

The Starship Congress is set to become one of the biggest events of its kind, with the world's leading spacecraft designers,

theorists and engineers, representatives from international space programmes and commercial space operators, interstellar speakers and members of the public convening at the Hilton Anatole. Confirmed speakers include I4IS' Executive Director Kelvin F Long, Technical Director Andreas Hein and consultants Dr James Benford of Microwave Sciences, Inc and Dr Eric Davis, as well as the originator of the gravitational assist manoeuvre Dr Michael Minovitch, Icarus Interstellar's Andreas Tziolas, NASA's Harold 'Sonny'

White on his 'warp drive' research, Dr Rachel Armstrong on Project Persephone, Dr Armen Papazian on 'Money Mechanics for Space', Srikanth Reddy on fusion powered starships, and many more! View the full speaker schedule here: <http://www.icarusinterstellar.org/congress-schedule/>.

Tickets are still available to attend the Congress, with regular attendees priced at \$100 and students with a valid student ID at \$50. Register now at www.icarusinterstellar.org/congress-registration/.

Alpha Centauri's disappearing planet

One possible destination for our first interstellar flight may not actually exist after all. Late last year astronomers at Geneva Observatory, led by Xavier Dumusque, claimed the existence of a roughly Earth-sized body orbiting alpha Centauri B, one of twin stars in the closest stellar system to our own. However, a new assessment of the data by astronomer Artie Hatzes of Thuringian State Observatory in Germany finds that the planet has gone missing.

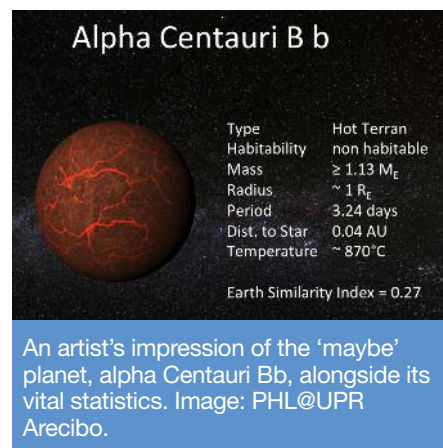
The existence for alpha Centauri Bb, which is purported to orbit its star at a distance of just 5.98 million kilometres compared to Earth's 149.6 million kilometres from the Sun, was always tentative. Dumusque's team had used one of our best planet-finding devices, the High Accuracy Radial velocity Planet Finder (HARPS) at the European Southern Observatory in Chile, to make 450 measurements of the star's radial velocity – the characteristic motion of a planet moving slightly towards and away from us as it wobbles around a centre of mass with an orbiting planet. In the case of alpha Centauri Bb, that motion was just 51 centimetres per second – an incredible measurement given that the alpha Centauri system is 4.3 light years away and right at the bleeding edge of our planet-finding capabilities.

Which means that the planet's detection was always a provisional one, a fact even admitted by Dumusque when the planet was announced. In order to find the planet's tiny signal, one has to strip away any other incidental signals, described as 'jitter', caused by activity such as starspots, stellar convection, prominences and so on. As alpha Centauri B is remarkably Sun-like (90 percent the mass of the Sun, 87 percent the radius, only half the luminosity and about 300 degrees cooler at the photosphere, i.e. the visible surface) it is easier to model such activity based on our knowledge of our own nearby star. When Dumusque's team applied the jitter reduction to the entire dataset, they were left with an unexplained 51 centimetre per second signal. However, when Hatzes broke the dataset up into smaller parts before applying jitter reduction, he found the planet signal vanished. To make sure he wasn't making a mistake, he ran the same process through simulated datasets that

carried a signal of the same magnitude. In the simulations, the signal remained. In the real data, it didn't.

Hatzes interpretation is still as preliminary as the claim for the planet's existence. For his own part, Dumusque is happy with Hatzes' work and both agree that the only way to get a definitive answer either way is to make more measurements to improve the statistical analysis.

What would it mean for our possible interstellar destination should alpha Centauri Bb turn out to be a ghost? It would not necessarily mean there are no planets in the alpha Centauri system. The claimed alpha Centauri Bb, if it exists, is very small but crucially very close to its star, meaning the radial velocity effect is more pronounced. Planets, large or small, that are further out from the star would still be very hard for us to detect – perhaps impossible with our current capabilities. Furthermore, there may be stars around alpha Centauri A, or even the companion red dwarf, Proxima. Over the next decade new planet-hunters will come online, including ESPRESSO, which is HARPS successor, the Next Generation Transit Survey and TESS, NASA's Transiting Exoplanet Survey Satellite, which will have greater sensitivity in the quest for Earth-like planets around the nearest stars.



SKYLON is £60 million richer



The British-designed SKYLON spaceplane received a dramatic boost in June when it was announced that the UK Government would be pumping £60 million into Reaction Engines Ltd's development of SKYLON's revolutionary SABRE engine. The funding comes on the back of critical tests proving SABRE to be a viable technology (see issue three of *Principium*).

SKYLON, when built, will be able to take off on a runway like a normal aeroplane and climb to an altitude of 26 kilometres at over Mach 5 using SABRE, a Synergistic Air-Breathing Rocket Engine, before switching to a conventional liquid oxygen rocket to take it the rest of the way into space. Like a normal jet engine it sweeps up oxygen from the air around it, but at such high velocities the air entering SABRE becomes rapidly heated to over a thousand degrees, which makes it far less efficient. SABRE overcomes this by using liquid hydrogen to cool the air. UK Chancellor of the Exchequer, George Osborne, was suitably impressed to include the £60 million in his budget. "Just seen SABRE – a rocket engine that cools air from 1,000 degrees to -150 in fraction of a second. We're backing the future with £60m funding," he tweeted.

The money won't be enough to fully fund SABRE and SKYLON but it is hoped that the Government funding will not only allow SABRE's development to continue, but will also attract other sources of funding. Reaction Engines' Alan Bond estimates that the cost of the entire development project will be £7 billion, with each spaceplane then cost £700 million to construct. The SKYLON, which will initially be built to haul cargo into orbit, could also be adapted to carry astronauts, or take passengers from London to Sydney in just four hours. Easy access into orbit is deemed crucial for helping to build an industrial and economic infrastructure in space that can act as a framework around which to build interplanetary and interstellar exploration.

Space Radiation Gets Serious

Astronauts heading into deep space are going to need some extra protection from space weather – but the forecast isn't too terrible.

Two NASA missions have in recent years been busily monitoring levels of radiation in deep space as they have gone about their business. On its way to Mars between 2011 and 2012, the Curiosity rover experienced a glut of radiation pervading the inner Solar System beyond the Earth's protective magnetosphere, while the Lunar Reconnaissance Orbiter exploring the Moon has also measured the radiation dose it is being exposed to.

The radiation comes from two sources: solar flares and coronal mass ejections that spew solar energetic particles (SEPs) into space, and galactic cosmic rays that are accelerated to high energies inside supernovae remnants. To a point SEPs can be avoided – close monitoring of the Sun can warn of any dangerous mass ejections, allowing time for evasive manoeuvres or to

batten down the hatches and seek shelter, but on the other hand cosmic rays penetrate the Solar System randomly from all directions, moving with high energies that can easily penetrate a spacecraft's meagre shielding. It is cosmic rays that will provide the radiation danger for interstellar voyagers moving beyond the Solar System's magnetic heliosphere (see the Voyager retrospective in issue 2 of *Principium*).

Curiosity's Radiation Assessment Detector (RAD) measured a radiation dose of 330 milliSieverts over a six month period. To put that into context, astronauts on the International Space Station receive 100 milliSieverts during a six month stay in space. Alternatively, the radiation levels are like experiencing a full body CT scan once every week. Over

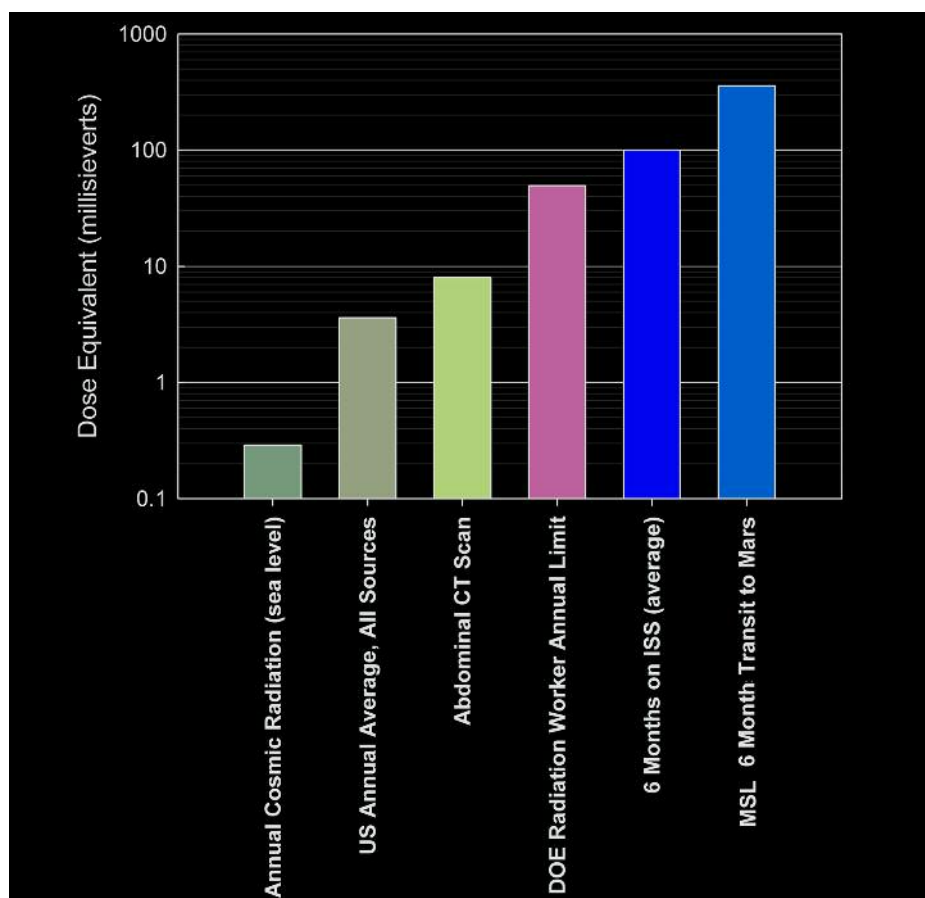


The Inspiration Mars team, led by Dennis Tito, still maintain that the radiation hazard to astronauts is not too great to prevent a manned fly-by of the red planet with current propulsion and shielding technology.
Image: Inspiration Mars.

longer timescales, a dose of one Sievert during a lifetime leads to a five percent increase in the chances of getting cancer – NASA are happy with a risk factor of three percent for their astronauts.

So these doses, reported in the 31 May 2013 edition of the journal *Science*, are not so high as to be definitely lethal; indeed, an astronaut still has a very good chance of not falling ill. However, for NASA to send astronauts to Mars the radiation dosage will have to be reduced somehow, while for future interstellar travellers the exposure over many years in deep space is still a problem that awaits a solution. Cary Zeitlin of the South-west Research Institute in Boulder, Colorado, suggests that materials with high hydrogen content – such as water or even certain foods that astronauts could store around their quarters – make the best radiation shields, far better than ineffectual aluminium. This tallies with what the Lunar Reconnaissance Orbiter discovered; it's own radiation experiment, the Cosmic Ray Telescope or the Effects of Radiation (CRA TER), found that plastics, which contain large amounts of hydrogen, do have some effect in blocking radiation.

Ultimately the best way to defend against radiation is simply to lessen the exposure time by reaching a given destination faster using advanced propulsion. Consequently research into propulsion concepts with which to go to the stars could be pioneered within the Solar System in an effort to beat the effects of radiation. Suddenly those toy spacecraft we had as children don't seem that unrealistic anymore – to the stars in a plastic spaceship!



Comparing the dose equivalent of radiation humans may come across on Earth, and the radiation dosage experienced by the Curiosity rover (MSL, Mars Science Laboratory, the name for the combined rover and its spacecraft). Image: NASA/JPL-Caltech/SwRI.

The art of music

As I4IS' Honorary Interstellar Musician, The Light Dreams, a.k.a. Alex Storer, specialises in electronic space sounds that take the listener to other worlds and other times. Coupled with his evocative brand of fantastic futuristic art, he spearheads a new wave of creators that are capturing our interstellar dreams on canvas and in sound. *Principium* spoke to Alex about his work and his inspirations.

Principium: Electronic music really came to the fore in the 1970s and 1980s. How did you come to produce electronic music for the twenty-first century?

Alex: I guess you could say I'm one of the new generation of independent artists making professional sounding music from the comforts of a home studio. ...I'm software-based, which suits my way of working, as I see my music as an extension of my digital artwork. I've no formal musical training at all, I've simply learnt along the way, out of passion and enthusiasm. I've been working under the name 'The Light Dreams' since 2006. However, I had fiddled around with music software in the past – I had a Commodore Amiga back in the day, with a program called OctaMED that was an eight-track studio. I made my first ever demos with that. My career in graphic design took over after that, but the urge to try my hand at music more seriously never really went away.

Since 2006 I've probably made close to 20 albums worth of material [Alex has released seven albums so far]. Most of them are demo albums in which I was trying to find out what I could do. It wasn't until I made an album called *Into The Light* in 2007 that I thought, "a-ha, I'm hitting the right track here," and that also coincided with the time I got into contact with [the space artist] David A Hardy, who allowed me to use some of his artwork on the album cover.



Alex Storer, a.k.a. The Light Dreams.

Principium: You recently released an album named *Future Worlds*, in association with I4IS. What will listeners experience when listening to *Future Worlds*?

Alex: Partly escapism, and I think that is what appeals to a lot of fans of science fiction, the ability to be transported to another time, another world, another place. As the album's title suggests, I wanted each track to represent a different future scenario, whether it is about mankind draining the Earth's resources, whether it is about interstellar travel, or whether it is about climate change, and all these things are recurrent throughout the album as well as the influence of various books I have read along the way, such as Arthur C Clarke's *The City and the Stars*. But the great thing about instrumental music is that you can interpret it as you want. I think it's my best work to date on a number of levels. Anyone who likes atmospheric or instrumental music will hopefully appreciate it.

Principium: Why do you think there a link between space music and electronic music?

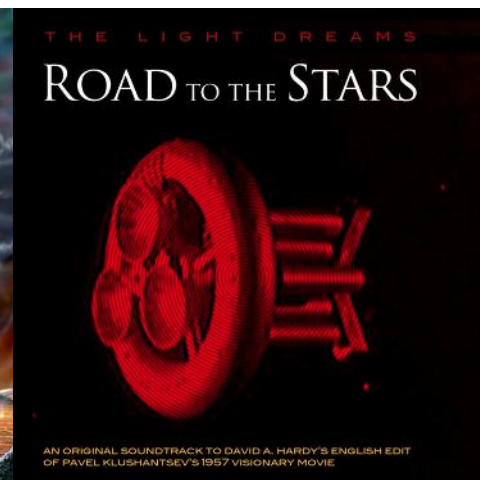
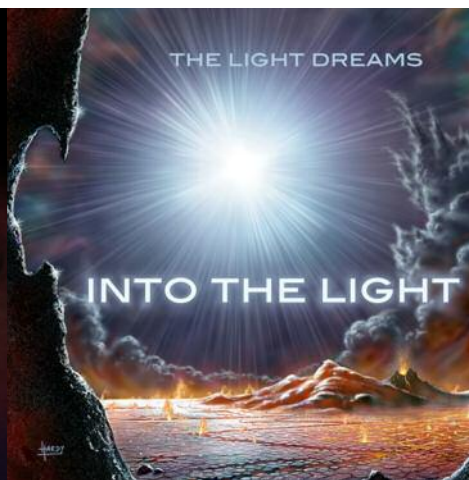
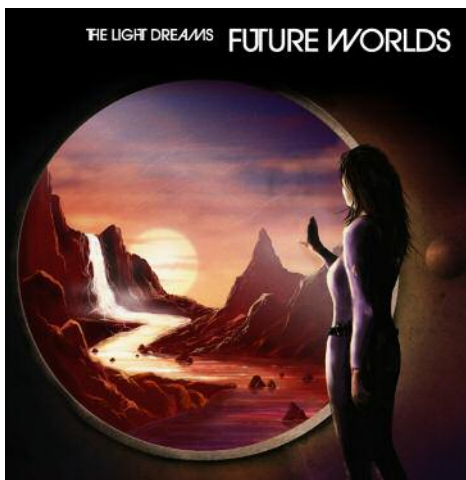
Alex: It might be the technological aspect of it. In space films the soundtracks tend to be either quite

"I don't work in very conventional ways. To me music is just like painting just with sounds instead of colours"

experimental, like Clint Mansell's soundtrack to *Moon*, which I thought was brilliant even though it was very minimal, or they are fully orchestral, but every now and then you do get electronic stuff which seems more appropriate because it is other-worldly. You get a lot of alien sounds in it and things that you can't do with an orchestra.

Principium: Do you have any favourite music associated with space?

Alex: Jean Michel Jarre's *Oxygène* is one of my all-time favourite albums. I always associated that album with space, but it's not about space at all, it is about pollution. There was also an album my father had that I liked a lot, which was an LP of space themes with a funky approach, recorded by Geoff Love and his orchestra. Although it sounds slightly comical in places, that album introduced me to a lot of famous SF film and television themes. I think Daft Punk's *Tron: Legacy* soundtrack has been the best thing I've heard in recent years; I don't remember hearing such an interesting fusion between orchestral and electronic music in a film soundtrack before, which was one of my inspirations for *Future Worlds*. It was something that I thought would be interesting to try because up to that point I'd only ever made purely electronic-sounding music. Last year, when David Hardy was making his English edit of the Russian film *The Road to the Stars*, he asked me if I was interested in making a new soundtrack for it, but he wanted it to be orchestral rather than electronic, which was new territory for me. Luckily I had just bought a virtual orchestra and the sounds are so authentic and powerful that it sounds just like you have a full orchestra in your room. I enjoyed using those symphonic sounds so much that I decided to use some of them on *Future Worlds*. My original idea was for the album to be primarily orchestral with a subtle electronic undercurrent, but it turned out more the opposite! The orchestral aspect is something I'm looking forward to exploring further in my music.



Principium: You are also an artist. Do you often paint and simultaneously write a piece of music to go with it?

Alex: Yeah, it happens both ways. Atmosphere and mood are the prevailing features in my music, which are the same elements I aspire to evoke in my artwork. Sometimes I'll make a piece of music and think "oh, I could paint that," and other times, as was the case with the cover art of *Future Worlds* [named 'The World Outside'], the concept comes first. I'll often start off with a title, because I don't have lyrics, I think about what mood, what scenario I want to put into the song. When I was writing *Future Worlds* I had the phrase 'The World Outside' in my head, which could lead off into all sorts of directions. I wanted to do a painting and music with that title, so the title came first, then the music [listen here: <http://thelighdreams.bandcamp.com/track/the-world-outside>], then the painting. I wanted the cover art of *Future Worlds* to pay homage to yesterday's visions of tomorrow – to visually sit alongside those classic album covers and vintage SF paperbacks of the 1970s.

Principium: Have you tried your hand at starship art?

Alex: Starship art is one of the things on my to-do list. I was looking at some John Berkey artwork recently [who painted many of the *Star Wars* film posters] and thought it was about time I tried something like that. It's one of the areas I've not ventured into yet so I'm keen to have a go. One of my favourite paintings is called 'Big Dog', which was inspired by a Brian Aldiss novel, *Non Stop*, and features only a portion of the spaceship on it. But I think if I was going to do a good starship painting I would need a good design. These days a lot of space art is done with 3D software, which is great because it is so much more realistic and accurate, but personally, I prefer something that has the touch of the artist's hand to it. A

painting has to evoke emotions and portray the artist's personality, and you don't really get that with 3D as an art form. If you look at John Berkey's paintings, they're often of a very rough style, but it works a treat.

Principium: Finally, what does your music mean to you?

Alex: One of my fondest childhood memories is listening to my father playing music by artists like Jean Michel Jarre and Mike Oldfield, while I'd be staring out into space through this great big print of a painted alien landscape that we had on the wall at home. The combination of that kind of music seemed to gel perfectly with the world presented to me by the painting – which turned out to be 'Stellar Radiance' by David A Hardy!

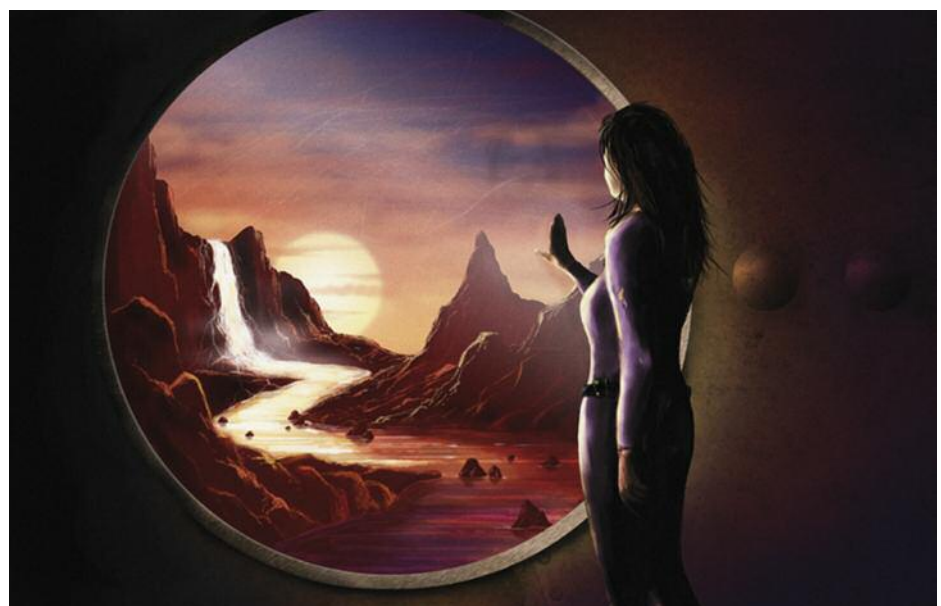
It feels like everything has come full-circle and fallen into place for me, as I'm now producing my own music and science fiction art, plus I've become good friends with David Hardy. My music certainly feels like it's found its ideal home within I4IS.

Future Worlds is available now on mp3 from Amazon (worldwide) and iTunes as well as Alex's own Bandcamp page, <http://thelighdreams.bandcamp.com/> where it comes with two exclusive bonus tracks and an illustrated booklet with a specially written introduction by David A Hardy.

You can also listen to tracks and purchase Alex's other albums. Alex has pledged his support to I4IS by donating a percentage of all sales of *Future Worlds*.

The Light Dreams' latest release, *After Hours*, is a compilation of previously unreleased tracks. Alex is currently working on two new album projects that he hopes to release in the Autumn. Alex also wrote a track-by-track introduction to *Future Worlds* on our Interstellar Index blog, <http://www.interstellarindex.com/2013/03/02/future-worlds-track-by-track-by-alex-storer/>.

You can also see Alex's super artwork on his homepage, www.thelighdream.net.



Alex Storer's painting, 'The World Outside', which also appeared as the cover artwork for his album, *Future Worlds*

Jon Lomberg's Starship adventures

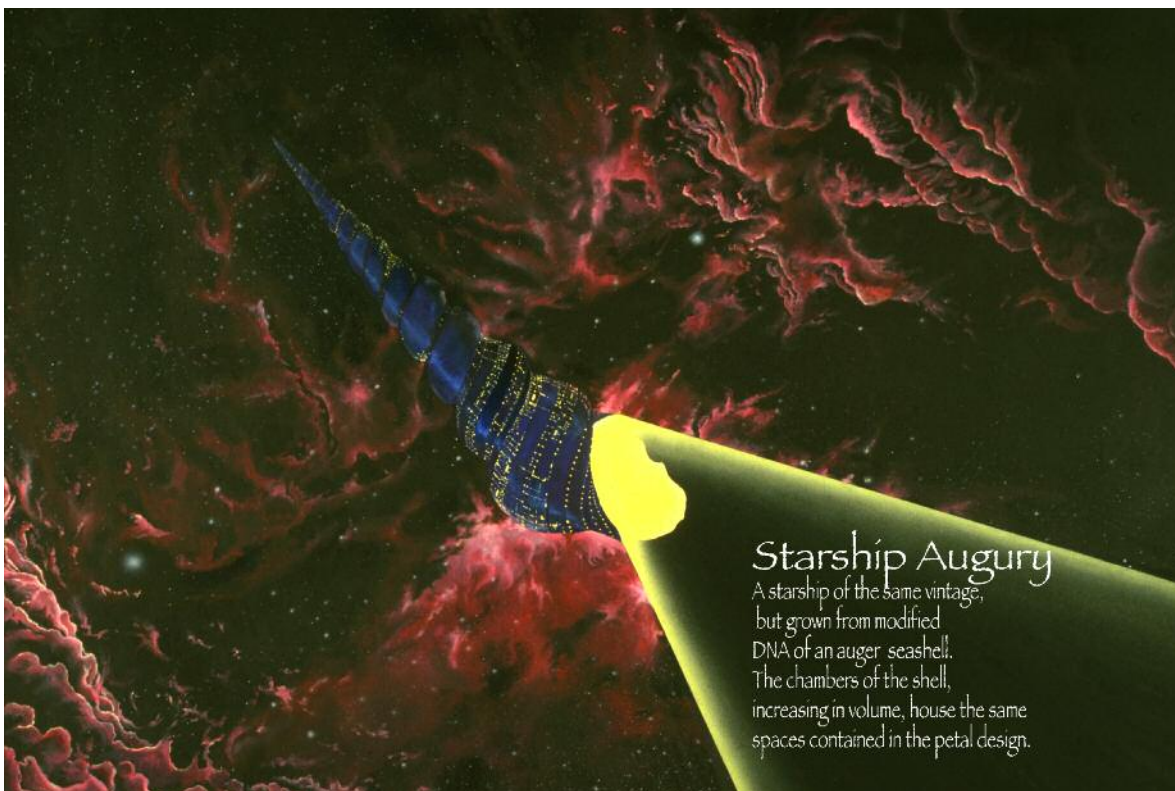
Last issue we featured the first half of famed space artist Jon Lomberg's eagerly anticipated Starship series. This issue we present – exclusively – the remaining six images in this wonderful series following the voyage of a living 'petal' starship and the civilisation that evolves with it.



Approaching the black hole in orbit around an Earth-like planet. Gravitational lensing causes the egg-shaped distortion

Black holes are one of the true enigmas of the Universe. Feared for their ferocious appetites and destructive potential, their powerful gravity able to bend the path of light like a lens, they've perhaps got a slightly undeserved reputation. Black holes can also have their uses, from providing energy sources in their accretion discs of gas swirling around them, to computing power and perhaps, with some exotic physics, even acting as doorways to other Universes. Whether one would survive such a journey into a black hole is another matter entirely.

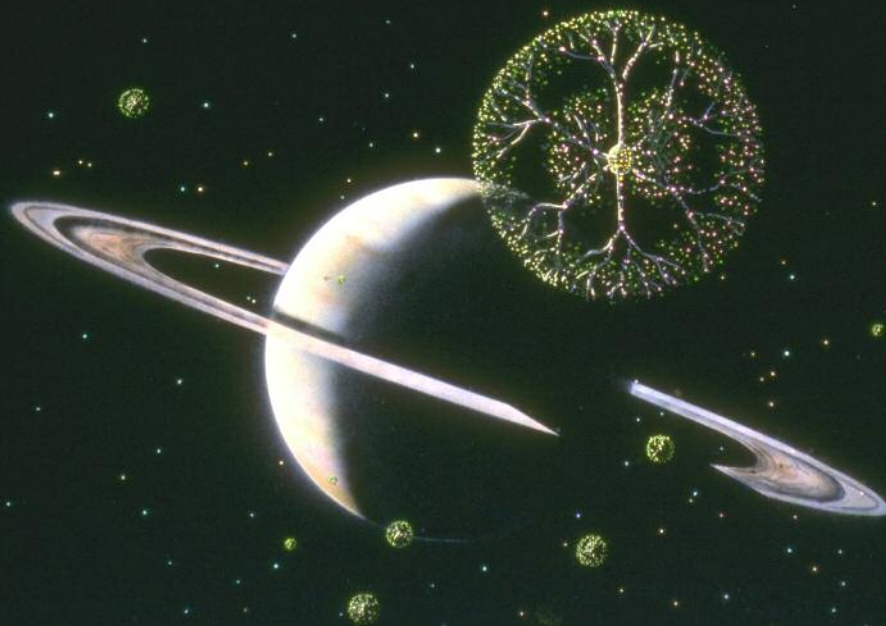
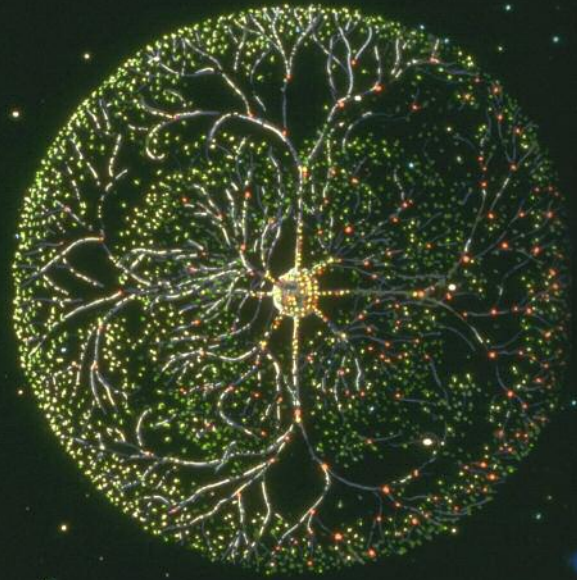
A variation of Lomberg's living petal ship – a shell ship, grown to prosper in the vacuum of space. Says Lomberg, "I got interested in doing paintings where I took biological, or marine, or other kinds of imagery and combined them with astronomy."



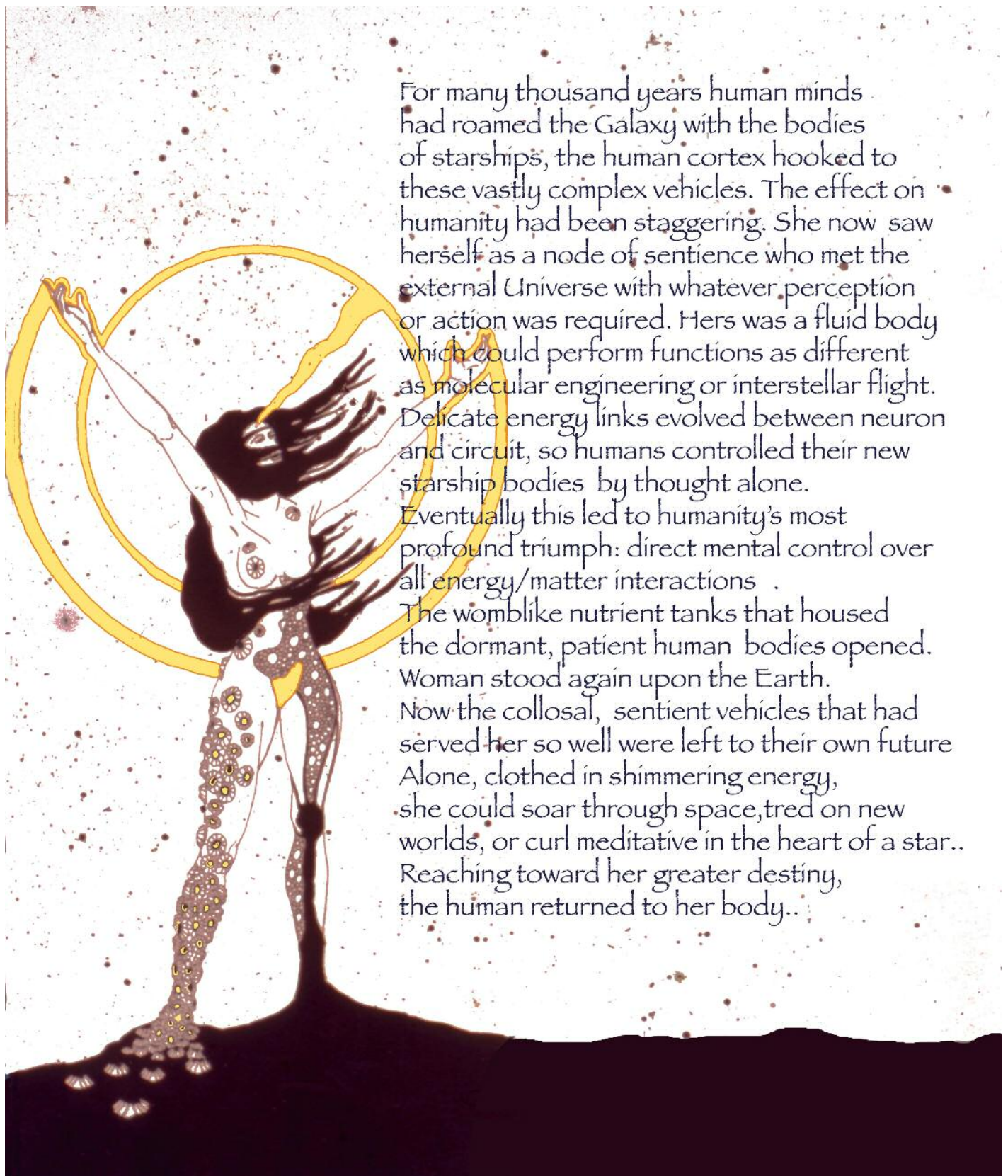
Starship Augury

A starship of the same vintage, but grown from modified DNA of an auger seashell. The chambers of the shell, increasing in volume, house the same spaces contained in the petal design.

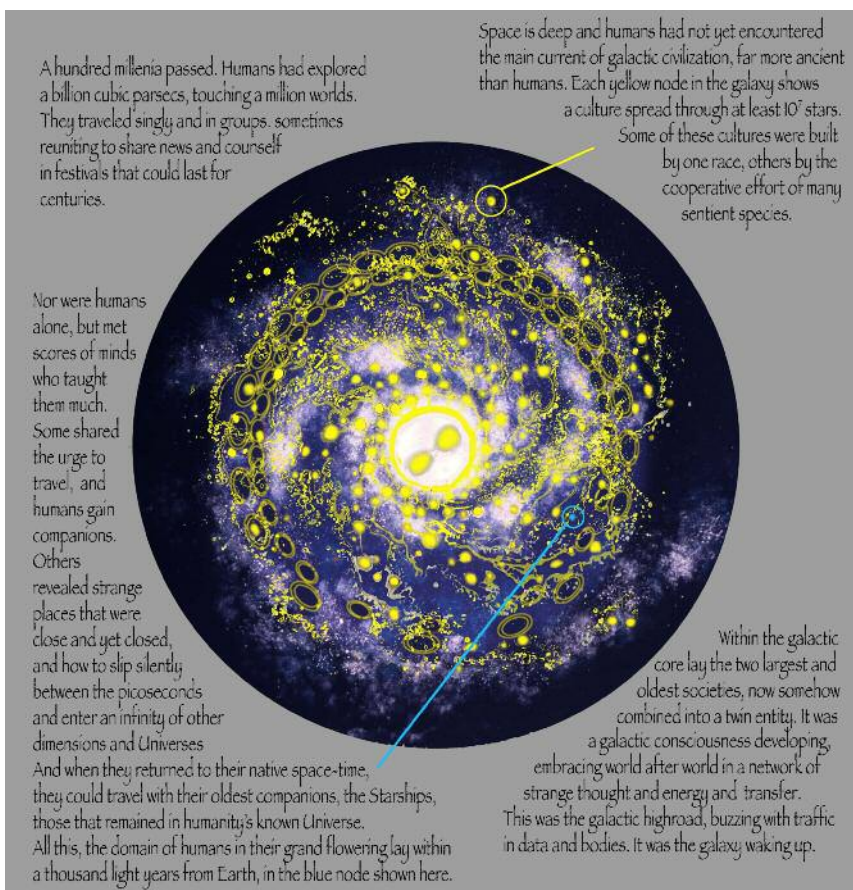
A gathering of comet trees rounding Saturn on their way out of the solar system. Each icy nucleus supported a community of humans living in gigantic trees growing out of the ice. Many such comet trees flew slowly between the stars hopping from Oort Cloud to Oort Cloud to gather fresh ice and plant new trees, in a slow greening of the galaxy.



Actually an idea from the brilliant mind of Freeman Dyson, comet trees would literally be enormous plants designed to survive in deep space. "You have a comet nucleus, where you have all this ice, a cubic mile, and genetically engineer these trees so that they can exist in a vacuum. You grow them out, for miles, and you live in the trees and they become your ship," says Lomborg.



For many thousand years human minds had roamed the Galaxy with the bodies of starships, the human cortex hooked to these vastly complex vehicles. The effect on humanity had been staggering. She now saw herself as a node of sentience who met the external Universe with whatever perception or action was required. Hers was a fluid body which could perform functions as different as molecular engineering or interstellar flight. Delicate energy links evolved between neuron and circuit, so humans controlled their new starship bodies by thought alone. Eventually this led to humanity's most profound triumph: direct mental control over all energy/matter interactions. The womblike nutrient tanks that housed the dormant, patient human bodies opened. Woman stood again upon the Earth. Now the colossal, sentient vehicles that had served her so well were left to their own future. Alone, clothed in shimmering energy, she could soar through space, tread on new worlds, or curl meditative in the heart of a star.. Reaching toward her greater destiny, the human returned to her body..



Jon Lomberg's narrative of the future continues to describe how humanity, in a range of biological starships where mind literally merges with organic, space-dwelling machines, explore the Galaxy at large in peace, ushering in a new utopia. Can interstellar flight help expand the the human mind towards peace and knowledge, reminiscent of Olaf Stapledon's *Starmaker*? "I think that this is the potential of intelligent life and civilisation, to have the capacity to reach this Stapledon, Arthur Clarke-type future where we evolve into this higher being," says Lomberg.

Art copyright Jon Lomberg 2013.
You can order signed prints of this artwork, and the first half of his Starship series as featured last issue, at http://www.jonlomberg.com/ss_gallery1.html

Retrospective: The Search for Extraterrestrial Intelligence

Is it possible to detect evidence of extraterrestrial artifacts and technology? I4IS joins the search for alien intelligence with its own unique spin on things.

When the first interstellar mission is launched from Earth towards another star, it's going to open up a whole can of worms for SETI, the search for extraterrestrial intelligence. As long as radio communication is still our primary way of reaching out to other worlds, SETI seems content with spending the majority of its time searching for radio beacons directed towards us. However, when our first starship sets sail for alpha Centauri or somewhere similar, SETI is going to have no choice but to confront an issue it has been dodging for over fifty years.

Yes, the Fermi Paradox is well-worn now, but as our interstellar capabilities develop it is only going to grow more pertinent. To understand why, let's momentarily digress. It is the year 1950 and, five years after the bomb was dropped on Hiroshima and Nagasaki, the Los Alamos National Labs in New



A starship's 'exhaust' may be visible for many light years – would it provide an even more powerful SETI signal than a radio beacon?

Image: Adrian Mann, www.bisbos.com.

Mexico are working feverishly on developing the ability to wield even greater atomic power. The best scientists on hand to the United States are here, many European who had adopted the United States as their home while war and fascism raged in Europe.

One such scientist was Italian-born Enrico Fermi. Sat in the canteen at Los Alamos one lunchtime, reading a humorous cartoon in *The New Yorker* about flying saucers abducting municipal

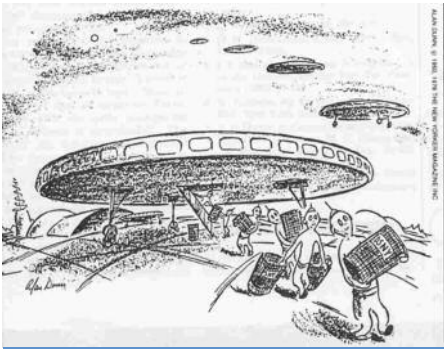
trash bins that seemed to have been going missing from the city, Fermi asked his now-famous rhetorical question, "where are they?" His logic was that the Universe was more than old enough for intelligent life to have already arisen somewhere in the Galaxy and spread throughout the stars, colonising everywhere including Earth. That they are not here has been deemed a paradox, by some at least, assuming extraterrestrial life exists. Yet it would be no paradox at all if it could be shown that interstellar travel was either impossible or unfeasible. In the 1970s the British Interplanetary Society's Project Daedalus (see issue one) suggested that there were no fundamental barriers blocking the road to the stars – the great distances and timescales involved are not insurmountable, particularly to robotic probes. However, a paper design, as good as it may be, is no substitute for really launching an interstellar mission. When those first starships begin their voyage, there will be no doubt about it; if human civilisation can go interstellar, then so too could other technologically advanced civilisations. So we're back to Fermi's question: where are they?

Perhaps they're on their way.

If so, how could we recognise their



Our radio telescopes wait and listen for a sign that we are not alone. Image: NRAO/AUI.



The cartoon from *The New Yorker* that prompted Enrico Fermi to ask his famous question.

approach? That's the mission behind Project Sentinel (SEArch for Non-Terrestrial Intelligence Near Earth Lightyears), an I4IS proposal to investigate what the signatures of approaching ships would look like spectroscopically. In all fairness, it might sound a little crazy at first, but if you accept that we are looking to build starships, then the same has to be assumed for other civilisations. To be clear, this is not about looking for flying saucers but rather about addressing aspects of the Fermi Paradox. In 1995 the Mars Society's Robert Zubrin wrote a paper discussing the possibility of detecting an advanced extraterrestrial civilisation by way of the exhaust of their starships. Zubrin liked the idea for SETI because the power required to drive a starship is many orders of magnitude above that required merely to communicate with radio waves and therefore a starship signature might have a far greater range than traditional means of interstellar communication. Zubrin describes an optimum situation wherein an antimatter-powered starship producing 120,000 terawatts with the exhaust pointed roughly towards us (although not necessarily moving away; it could be moving towards us but has reversed its engine to provide retro rockets and deceleration) would shine as a seventeenth magnitude object at a distance of one light year, visible to amateur astronomers using CCD



The Arecibo Radio Telescope in Puerto Rico, which beamed a message to M13 in 1974. Image: NAIC–Arecibo Observatory/NSF.

cameras. Meanwhile, the Hubble Space Telescope could see the vehicle at a distance of 300 light years and the exhaust would look spectroscopically different to stars in that it would contain no hydrogen lines in its spectra.

Another alternative is that they've already reached us but, instead of colonising Earth or strip-mining the Oort Cloud and Asteroid Belt (and who is to say that they haven't already been and taken some of our asteroidal resources before moving on? Some asteroid and Kuiper belts around other stars have far more mass than the belts in our Solar System – for example, in 2005 the Spitzer Space Telescope showed that the star HD 69830 has an asteroid belt 20 times more massive than the belt in our Solar System), they have happily settled down to monitor Earth from a distance, perhaps on the Moon or at a Lagrange point. Or perhaps they broke down and there is a wreck somewhere in the Solar System. Along these lines Professor Paul Davies, Director of BEYOND: Center for Fundamental Concepts in Science at Arizona State University, discussed what he coined 'archaeological SETI' in his book *The Eerie Silence*, which promoted the idea of searching the Solar System for a hidden probe, or evidence that a probe had passed this way once, long ago.

Of course, seeing the blazing exhaust of a fusion powered starship will not produce a message like radio communication would, other than inform us that the extraterrestrials have access to star-flight and were on their way. It would at least give us time to prepare for contact, unlike another activity that has spun itself off at a tangent from SETI.

Making Earth visible

“When those first starships set voyage, there will be no doubt about it; if human civilisation can go interstellar, then so too could other technologically advanced civilisations.”

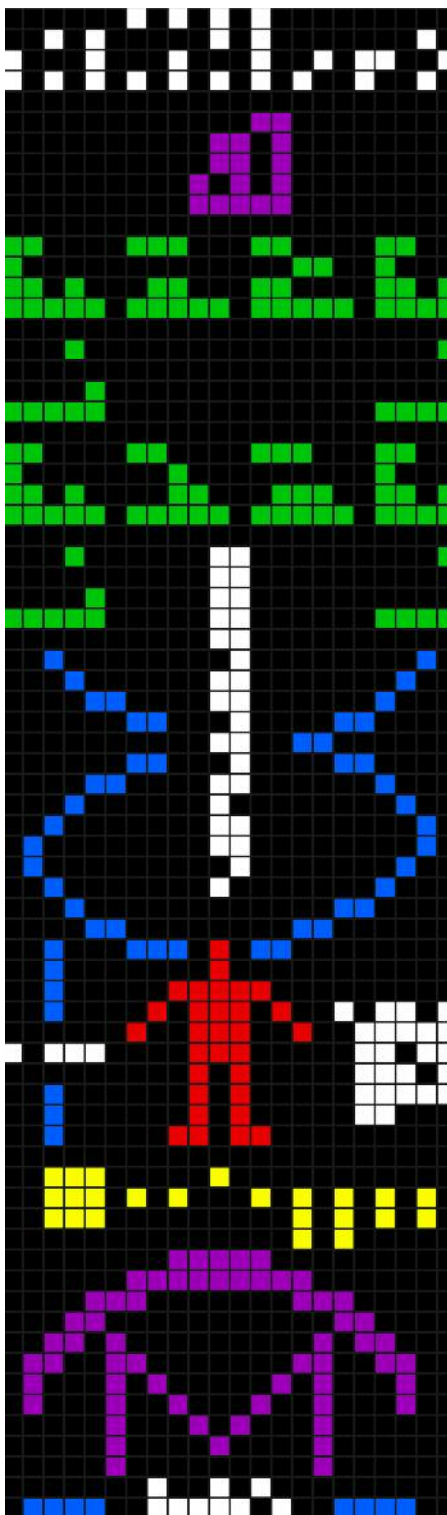
As the name implies, SETI is about searching for a voice from the stars. However in 1974 Frank Drake – one of the fathers of modern-day SETI – and Carl Sagan embarked on a quite different project, using the giant Arecibo radio antenna in Puerto Rico to transmit a message towards the globular cluster Messier 13, around 25,000 light years away. The signal contains 1,679 binary digits that, when translated, depict a rectangular strip 73 rows by 23 columns in size, upon which are crude images of a human figure, the Solar System and the



A laser shines forth into the sky as part of the adaptive optics system of the Very Large Telescope in Chile. In the future, even more powerful lasers could be pointed towards the stars as a means of communication. Image: ESO/Y Beletsky.

Arecibo telescope, as well as a DNA double helix, the numbers one to ten and the atomic numbers of the elements that make up DNA.

Messier 13 is so far away that it would take 50,000 years to receive a reply, not that globular clusters are likely to be home to life as we know it, filled as they are with densely packed ancient stars with primitive abundances of heavy elements. Furthermore, it has since been stated that the message was a stunt to illustrate Arecibo's capabilities rather than any serious attempt to communicate. Nevertheless, the precedent was set. Martin Ryle, the Astronomer Royal at the time, was concerned enough to write to both Drake and the International Astronomical Union to request a moratorium on beaming messages into space until the matter of its potential consequences had been discussed. Ryle was ignored and the practice of sending messages into space with the intention of making contact continues in ad hoc fashion today, mostly through the work of Alexander Zaitsev of the Russian Academy of Sciences in



The decrypted Arecibo message. The top row is the numbers one to ten in binary. Beneath that (also in binary) are the atomic numbers of the elements hydrogen, carbon, nitrogen, oxygen and phosphorus that make up DNA, and then in the rows beneath that the molecular formula for DNA nucleotides are shown, followed by the DNA double helix. A crude figure of a human being follows, with the average human height on the left and the size of the human population in 1974, underneath which are the planets (including Pluto) with Earth raised above the others, before finally ending with a simple depiction of the Arecibo telescope and its diameter.

Moscow, but also most recently by the Lone Signal project, which is funded by crowd-sourcing and includes astronomer Jacob Haqq-Misra of Penn State University on its team. Currently they are transmitting from the 30-metre Jamesburg Earth Station in California and their plan is to raise \$100 million to build a network of dishes to continuously send messages to various regions of the Galaxy.

The debate as to whether sending messages into space is wise, or if the practice is even scientific, is a lengthy one and a discussion for another time. Instead, another aspect is the question as to whether signals from Earth are even detectable at interstellar distances akin to the 17.6 light years that the Lone Signal is being transmitted toward the red dwarf Gliese 526.

For example, James Benford and Jon Billingham have calculated that transmissions into space by Alexander Zaitsev using the Evpatoria 70-metre dish in the Crimea would only be detectable as coherent messages by a telescope like the Square Kilometre Array out to a distance of 19 light years, while its carrier wave would be visible out to 648 light years. The size and power of the Jamesburg Earth Station would not seem comparable to Evpatoria, so if any aliens live on a planet around Gliese 526, they're going to need a receiver a lot larger than the Square Kilometre Array to detect the data within the carrier signal. To be fair, Haqq-Misra acknowledges this, claiming that the messages could be detected by a ten kilometre array radio telescope. But even if the Jamesburg transmissions – which aim to be continuous rather than sporadic, meaning energy costs will demand that their power be kept low – could be picked up by a radio telescope at Gliese 526, there is more to the story than that. Benford has pointed out that the transmitter and receiver need to be able to track each other for a long period of time in order to integrate the signal, but on a rotating planet in a short orbit around its star, this would be very difficult indeed without some sort of space-based receiver. So while it's not totally impossible that the Lone Signal could be detected, the odds are heavily weighted against it.

What do these limitations therefore say about the current radio silence that SETI is being met with from the skies? Are we simply not hearing anyone because we need an extremely large telescope to do so? Is there any other mode of communication that could penetrate deeper than radio? Let's take a

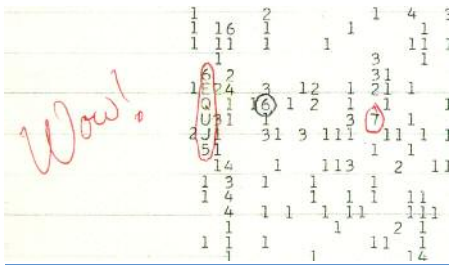
“Morrison and Cocconi's rationale was that ET would recognise that we would already be observing at 21cm and therefore would stand the best chance of detecting a signal there without going hunting for it.”

step back, over 50 years, to the origin of modern-day SETI, to better understand radio's dominance in SETI and how an alternative is waiting in the wings.

Five decades of silence

SETI didn't really kick off until 1959 and a famous paper entitled 'Searching for Interstellar Communications' by Philip Morrison and Giuseppe Cocconi of Massachusetts Institute of Technology that appeared in *Nature* describing how radio waves provide the best option for signalling between the stars. Given that the 21cm emission line of interstellar neutral hydrogen gas is routinely probed by astronomers, Morrison and Cocconi's rationale was that ET would recognise that we would already be observing at this wavelength and therefore stand the best chance of detecting a signal there without going hunting for it.

The theory was quickly put to the test. Frank Drake, who then was a young radio astronomer at Green Bank Telescope in West Virginia, USA, independently came to the same conclusion as Cocconi and Morrison and in April 1960 embarked on Project Ozma – two months of patiently studying two nearby stars, tau Ceti and epsilon Eridani, for radio signals. Alas, aside from one false alarm when he detected transmissions from an overhead U2 spy-plane (several months before the Gary Powers incident) he detected nothing. Over the past five decades similar and yet far more expansive searches have also failed to turn up a confirmed extraterrestrial signal, despite numerous unidentified radio transmissions. The most famous of course is the 'Wow!' signal, observed in 1977 by the Big Ear radio telescope – now bulldozed – at the Ohio State University Radio Observatory. A 72-second pulse of anomalous radio emissions at 1420.455 MHz from somewhere in the direction of the galactic centre in Sagittarius, it was the strongest narrowband transmission the telescope had ever seen. Upon seeing the signal on a subsequent printout, in which the transmission was described as a sequence of numbers and letters indicating the rise and fall in intensity as the sky wheeled above the fixed telescope and the transmission beam fell into the telescope's field-of-view and then back out again, scientist and telescope engineer Jerry Ehman wrote 'Wow!' in



The print-out of the Wow! signal, with Jerry Ehman's now famous scribbled reaction in the margin. Image: Ohio State University Radio Observatory and the North American AstroPhysical Observatory (NAAPO).

the margin alongside it.

Nobody knows what the signal was, and it has never been heard from again, although the amount of time spent going back to the location of the Wow! signal (there are no obvious stars at its position) has been minimal. Was it terrestrial interference, a radio echo bouncing off some of the telescope's superstructure? Was it a natural phenomenon? Was it a short beacon, cycling between worlds to conserve energy expenditure? No answers are forthcoming and, unless we detect it again, are unlikely to ever come, and so the Wow! signal descends into myth. Yet it is only the most famous of a whole slew of anomalous signals.

Director of SETI research at California's SETI Institute, Gerry Harp, says that signals like the Wow! are seen every day: anomalous bursts of radio transmission crackling above the static of the radio background. These radio transients could be anything, from black holes swallowing asteroids to glitches on neutron stars. They could also be artificial signals from intelligent extraterrestrial life. But if these signals are not seen to repeat – the golden rule of SETI – then they are disregarded. And when they are seen to repeat, thus far they have inevitably turned out to be of natural, astrophysical origin.

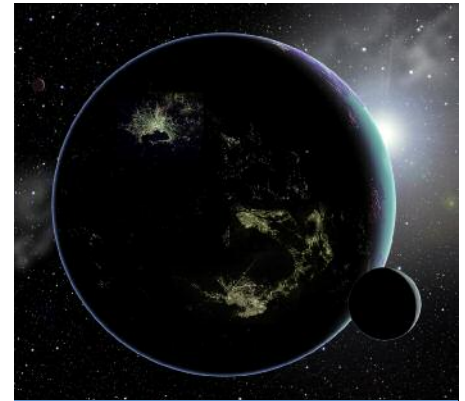
Laser power

At roughly the same time as when Drake was deep into Project Ozma, the laser was being developed by a number of competing scientists. At first, laser power was little more than the equivalent of a laser pointer and it wasn't clear what use the technology could be. Today, of course, the use of lasers is ubiquitous and they have developed to the point that they can produce tremendous power and carry huge amounts of encoded data. As such thoughts have turned to utilising lasers for interstellar communication and for searching for similar laser signals from the stars, an experiment called 'Optical SETI', or OSETI. For one, laser beams can be collimated into tightly focused beams. There is some spreading, for sure, but not as great as with radio beams and the bit rate is also far higher – just look at broadband Internet or cable television where information moves at the speed of light as lasers shine down optical fibres. In 2011 scientists at the Karlsruhe Institute of Technology in Germany succeeded in transmitting 26 terabits per second on a single laser beam by encoding the data onto different wavelengths of light, and this is still the world record.

However, optical laser light has a tendency to stall when it hits opaque objects, such as interstellar clouds of gas and dust, while radio waves can pass right through. However, this doesn't rule lasers out. Instead infrared lasers could be applied – as specialist space mission such as the infrared-seeking Herschel and Spitzer space telescopes have proven only too well, infrared light can also penetrate through dust and the longer the wavelength, the more dust it can pass through. The trouble is, infrared radiation is also absorbed by water molecules – to search for infrared laser pulses then we have to at least perch a designated search telescope atop the highest peaks above much of the atmosphere, or better still launch a dedicated space telescope.

Unfortunately, with no taxpayer funding of SETI anywhere in the world, such a mission would depend on commercial sponsorship.

It wouldn't be so hard to produce lasers powerful enough to beam to other stars – we already have them, such as the petawatt scale lasers that are in use at the National Ignition Facility at the Lawrence Livermore National Laboratory, where they are being used to

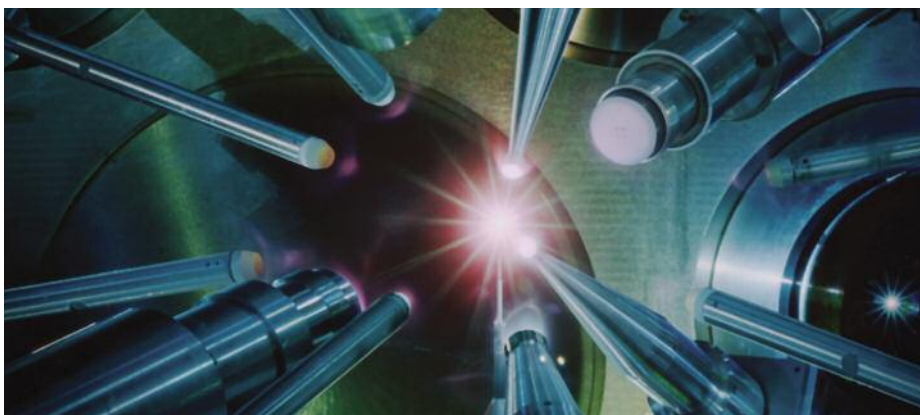


Will an extraterrestrial civilisation be sending us radio messages, or launching starships towards us? Image: David A Aguilar (CfA).

try and induce nuclear fusion in pellets of deuterium and tritium. Although there is no sign of success yet, if fusion can be achieved it will be a boon for starship concepts since this form of fusion, known as Inertial Confinement Fusion, takes up less mass than a bulky magnetic tokamak and in starship design, mass is all important. And hence, we come full circle in our discussion.

If technologically advanced extraterrestrial civilisations are using powerful laser beams to communicate across space, then those same lasers could provide fusion power, the type of power needed to drive starships at a significant fraction of the speed of light and permit interstellar travel in reasonable timescales. It's another quandary for the Fermi Paradox. Of course, the paradox makes a whole host of assumptions about the nature of extraterrestrial life and intelligence, including that they have the need or the will to spread into the Galaxy and make their presence known. But if they share in any way our human curiosity and our nature to explore then the paradox becomes relevant.

Discussions of interstellar flight and the search for extraterrestrial intelligence have always shared some DNA. Both look to the stars and towards the future of human civilisation. Success in one would be of benefit to the other and, to that end, perhaps pooling our resources wouldn't be such a bad thing.



High-powered lasers in action during fusion tests at the University of Rochester's Laboratory for Laser Energetics. Image: Lawrence Livermore National Laboratory.

Mission Statement

The mission of the Institute for Interstellar Studies is to foster and promote education, knowledge and technical capabilities which lead to designs, technologies or enterprise that will enable the construction and launch of interstellar spacecraft.

Vision Statement

We aspire towards an optimistic future for humans on Earth and in space. Our bold vision is to be an organisation that is central to catalysing the conditions in society over the next century to enable robotic and human exploration of the frontier beyond our Solar System and to other stars, as part of a long-term enduring strategy and towards a sustainable space-based economy.

Values Statement

To demonstrate inspiring leadership and ethical governance, to initiate visionary and bold programmes co-operating with partners inclusively, to be objective in our assessments yet keeping an open mind to alternative solutions, acting with honesty, integrity and scientific rigour.

Front Cover Image: Alien SETI, © David A. Hardy / www.astroart.org

Back Cover: The Horsehead Nebula, a region of dense molecular hydrogen gas around 1,500 light years away that is forming new stars, imaged in near-infrared light by the Wide Field Camera 3 onboard the venerable Hubble Space Telescope. Image: NASA/ESA/Hubble Heritage team (STScI/AURA).

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We'd love to hear from you, our readers, about your thoughts on Principium, the Institute or interstellar flight in general.

Join us on our [Facebook page](#) to join in the conversation!

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The Institute For Interstellar Studies is a pending institute in foundational start-up phase subject to incorporation in the United Kingdom

