The PLANETARY REPORT

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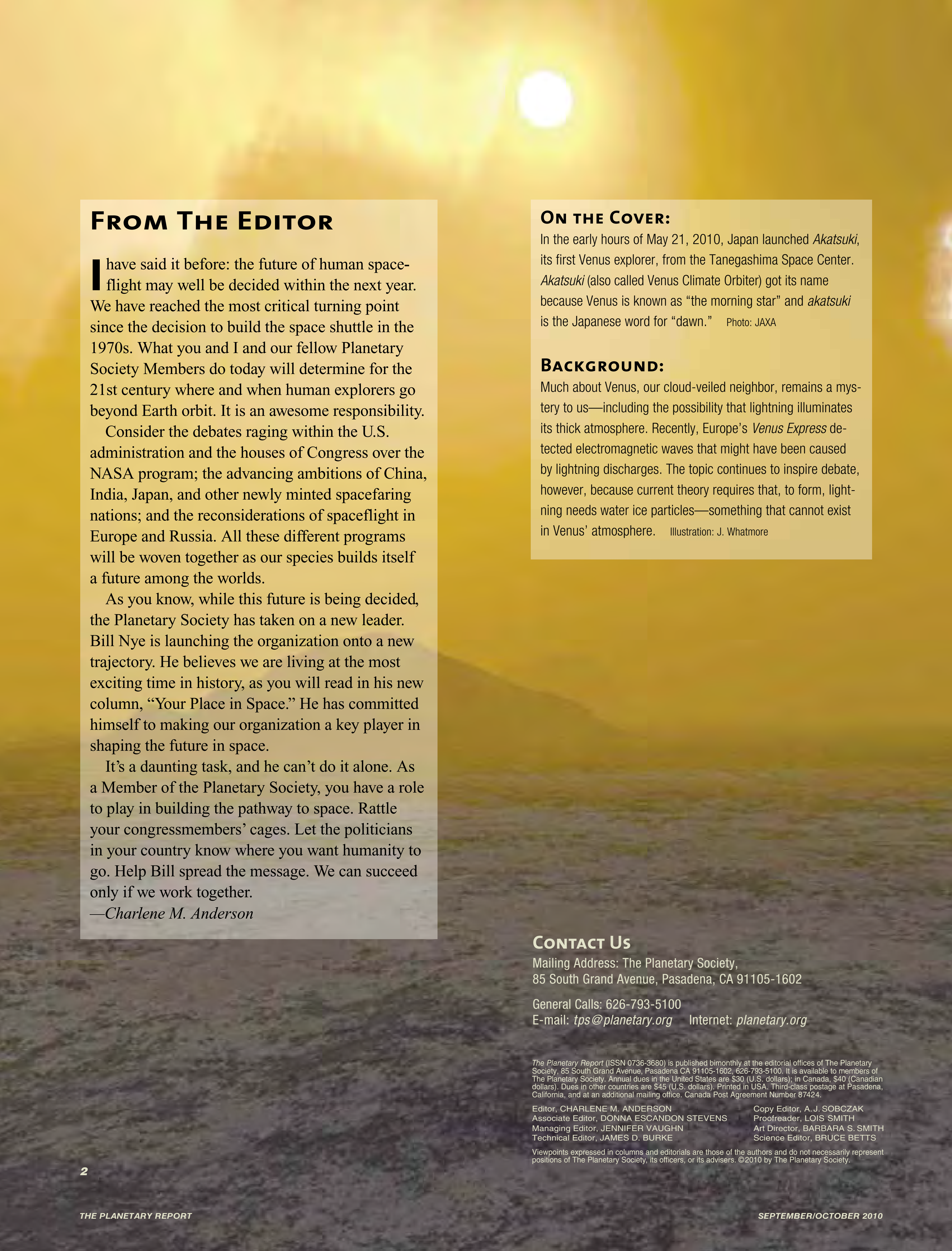
Akatsuki to Venus



From The Editor

I have said it before: the future of human spaceflight may well be decided within the next year. We have reached the most critical turning point since the decision to build the space shuttle in the 1970s. What you and I and our fellow Planetary Society Members do today will determine for the 21st century where and when human explorers go beyond Earth orbit. It is an awesome responsibility.

Consider the debates raging within the U.S. administration and the houses of Congress over the NASA program; the advancing ambitions of China, India, Japan, and other newly minted spacefaring nations; and the reconsiderations of spaceflight in Europe and Russia. All these different programs will be woven together as our species builds itself a future among the worlds.

As you know, while this future is being decided, the Planetary Society has taken on a new leader. Bill Nye is launching the organization onto a new trajectory. He believes we are living at the most exciting time in history, as you will read in his new column, "Your Place in Space." He has committed himself to making our organization a key player in shaping the future in space.

It's a daunting task, and he can't do it alone. As a Member of the Planetary Society, you have a role to play in building the pathway to space. Rattle your congressmembers' cages. Let the politicians in your country know where you want humanity to go. Help Bill spread the message. We can succeed only if we work together.

—Charlene M. Anderson

On the Cover:

In the early hours of May 21, 2010, Japan launched *Akatsuki*, its first Venus explorer, from the Tanegashima Space Center. *Akatsuki* (also called Venus Climate Orbiter) got its name because Venus is known as "the morning star" and *akatsuki* is the Japanese word for "dawn." Photo: JAXA

Background:

Much about Venus, our cloud-veiled neighbor, remains a mystery to us—including the possibility that lightning illuminates its thick atmosphere. Recently, Europe's *Venus Express* detected electromagnetic waves that might have been caused by lightning discharges. The topic continues to inspire debate, however, because current theory requires that, to form, lightning needs water ice particles—something that cannot exist in Venus' atmosphere. Illustration: J. Whatmore

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Contents

A PUBLICATION OF THE PLANETARY SOCIETY

YOUR PLACE **IN SPACE**

Learning More, Faster... Like Rocket Science

BY BILL NYE

Launch photos, always breathtaking, distill the excitement and beauty of rocket science into one glorious image.* Cassini-Huygens, *the most complex, ambitious mission ever, was launched into our solar system atop a Titan IVB/Centaur on October 15, 1997.
Photo: NASA/JPL/KSC

The next time you hear, or indeed use, the expression "rocket science," I hope you'll take a moment and reflect on what a fantastic idea that is.

Bear—or launch—with me for a moment. The fundamental question in rocket science goes roughly like this. Let's say you have a payload (paid for by a customer) that you want to get up in space. You'll especially want to know how much it weighs. Once the engine is lit, with every moment—with every instant—that goes by, the rocket weighs less. So how much fuel do you start with? This is the essence of the business. The rate at which fuel is used depends on how much you have at any given time. How much you have depends on the rate at which you use it. In math, we observe that it's governed by exponents, and we call it an *exponential*.

The growth of human knowledge is also exponential. Our knowledge—our understanding of the world around us—increases with every passing moment, just as a rocket's fuel decreases at every moment. This is the case whether measured in number of known facts, number of scientifically literate people, or number of testable hypotheses we have pending—questions that have yet to be answered. This has been true since the beginning of human history. It is no wonder that you and I are living at the most exciting time in history, and most especially, the most exciting time in space exploration (and in rocket science).

To many, the expression "rocket science" carries with it something scary and complex, rather than something exciting and beautiful. For me, rocket science includes not only the understanding of flight powered by expanding gas but also the diligence needed to learn how to pull (or push) it off. After all, the first step in rocket science isn't that hard: you get one end of the thing burning, and you point it where you want it to go. After that, it gets exciting—an adventure in both discovery and the elegance of mathematics. It's why you're a Planetary Society member, and it's why this is the most exciting of times.

New Propulsion, Ancient Maneuvers

The Japanese Aerospace Exploration Agency (JAXA) successfully deployed a solar sail in deep space, between Earth and Venus: *IKAROS* (Interplanetary Kite-craft Accelerated by Radiation Of the Sun). JAXA not only got it to unfurl without tangling, but also for the first time in history, the sail can be steered. The scientists aren't using ropes and pulleys; they're using light-emitting diode displays to control how much the sail reflects. It takes the better part of an Earth day to turn the *IKAROS* spacecraft just a few degrees. Nevertheless, it's proof of an idea that dates from the earliest days of the discovery of relativity. The spacecraft is being steered with the momentum of massless photons. Remarkable.

As I hope you know, the Planetary Society, entirely with your financial support, is going to launch our own solar sail in the coming year. Unlike the *IKAROS* spacecraft, our *LightSail-1* will be capable of completely changing its attitude in space in just a few minutes. We will tack and change the sail's direction,

Left: On July 10, 2010, the European Space Agency's Rosetta *captured this close-up of 21 Lutetia, the largest asteroid ever visited by a spacecraft.* Rosetta*'s Optical, Spectroscopic and Infrared Remote Imaging System (OSIRIS) took this picture less than five hours before closest approach.*

Right: Using the Wide Angle Camera (WAC) on OSIRIS, Rosetta *imaged this portion of its home world on the night of November 13, 2007.* *Images: ESA*

just like a sailing ship. *LightSail-1* will have enough control torque and force to orient itself toward the Sun, coaxing our small craft along with the momentum of the flow of photons. It is much the way ancient sailors steered their ships in a steady breeze. We'll steer to get the most sail area pushed by light from the Sun as we move in the direction away from the Sun, and then edge-on as we move back toward the Sun.

Meanwhile, another JAXA mission, *Hayabusa*, is teaching us about asteroids—and perhaps even tiny bits of asteroids. The European Space Agency is successfully steering its more conventionally powered *Rosetta* spacecraft around asteroids and learning to understand them. They'll be at it well into the year 2014. Soon after that, the *New Horizons* spacecraft will make its amazing flyby of Pluto, which was once the last of the traditional planets and is now the first of a new class of objects we call *Plutoids*.

Meanwhile, Back on Earth . . .

While these exciting things are happening around our world (and around other worlds), back in the United States, human space exploration is coming to a standstill. The National Aeronautics and Space Administration (NASA) is haggling with the U.S. Congress about how much money it needs and what to do with it. This is the organization that put people on the Earth's Moon 41 years ago. It's also the organization that can't sell what seems like an obvious step forward to those who fund its work.

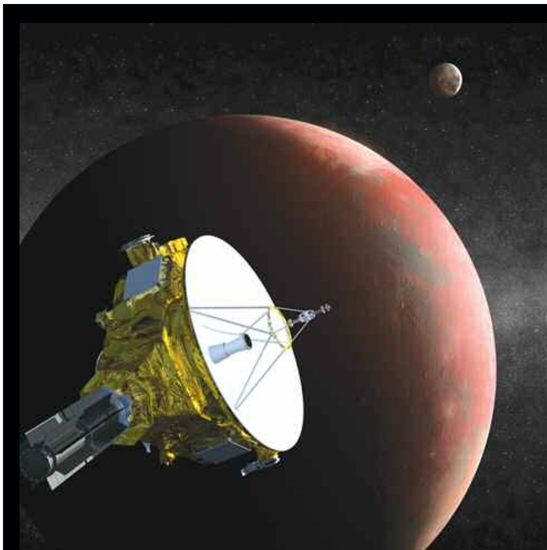
I wrote what became a somewhat controversial editorial for *Space News*. I pointed out that for the United States to move forward in space, NASA has to move forward. For better or for worse, NASA is still the biggest player in space exploration. The space shuttles have done their job. It's time to do new things and take our instruments and our explorers to new places. Humans who stop exploring will not make discoveries. They will step off the exponential curve of human knowledge. They will be, for better or for worse, part of the past. If you take space exploration as an indicator of some of our species' best work, deciding to step off the curve is very much a sobering thought.

Our lives have been enriched by the discoveries made by space explorers around the world since the beginning of recorded history. I refer to the ancient Greek observers, Copernicus, Galileo, Hubble, contemporary astronomers, astronauts, cosmonauts, and taikonauts, along with the thousands of engineers and scientists who design and build our elegant spacecraft with their remarkable cameras, instruments, antennae, and roving wheels.

As a Planetary Society member, you are part of that tradition. You and I are part of the next discovery. Thanks for your support. Let's change the world.

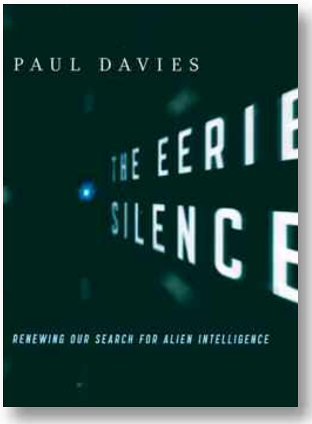
Bill Nye

Bill Nye
Executive Director



In less than five years, we will see Pluto and Charon at close range. Scheduled to arrive in July 2015, New Horizons *will characterize their global geologies, map their surface compositions and temperatures, and take detailed measurements of Pluto's atmosphere.*
Illustration: JHUAPL/SwRI

OUT OF THIS WORLD BOOKS



The Eerie Silence: Renewing Our Search for Alien Intelligence

by Paul Davies
Houghton Mifflin Harcourt, 241 pp.
$27.00, hardcover

Almost everyone I know believes in extraterrestrial life. Extraterrestrial intelligence, however, is more problematic.

The SETI folks define intelligence as a civilization, more or less like ours, that manufactures communication devices that send signals we can detect with the equipment we (humans) manufacture.

SETI scientists now have two big problems. First, despite 40 years of searching, we haven't discovered anything (hence the title *Eerie Silence*), so if there are signals being sent, we are not able to detect them. Second, there is no scientific approach to searching—one simply has to look everywhere in every way.

Paul Davies points out that SETI does not search in every way and in fact searches in only a very narrow way based on that very restricted definition of intelligence. He concludes, "biological intelligence is only a transitory phenomenon, a fleeting phase in the evolution of intelligence in the universe." He also states, "If we ever encounter an extraterrestrial intelligence, I believe it is overwhelmingly likely to be post-biological in nature."

At the same time, he also hypothesizes about biological signals. The book contains an extensive discussion of genetics and how DNA signals could be embedded in the manipulation of microbes so that they would be evident over interstellar differences. As our ability to look at extrasolar planets improves, we might see signals embedded in other biospheres, for example.

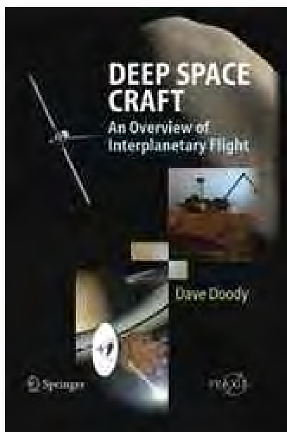
Such thinking shows how the intellectual center of studying extraterrestrial life has shifted dramatically away from SETI in the past two decades. One shift came from discoveries on Earth: life in extreme environments. It was learned that there was a lot more to life than the phrase "as we know it" had come to mean. The second shift came from the *Voyager* and *Galileo* spacecraft discoveries of relatively warm oceans beneath the surface of the moons of outer planets. Astrobiological interest, once focused only on Mars, now seems everywhere in the solar system. A third—perhaps the biggest—shift came from the burgeoning discoveries of extrasolar planets (we're up to 400 now). They expanded the number of locales for possible searches to an uncountable, perhaps not even finite number.

Davies deals with all of these and also discusses the biggest uncertainty about life: not its origin, but its evolution. Life may be easy to start (although we don't know for sure), but getting it to evolve with complexity might be accidental and rare.

Planetary exploration seems to be leading us to many more places where life might have started, but the mystery of the sudden step from single-cell to multiple-cell organisms on Earth is as deep as ever. In a section titled "Life as a Bizarre Fluke," Davies says, "life looks to be a little short of magic: all those dumb molecules conspiring to achieve such clever things."

SETI is badly in need of testable hypotheses that can steer it in favorable directions and away from unfavorable ones. *Eerie Silence* provides a welcome intellectual challenge to that end. The book concludes with a discussion of "why do SETI?" There seems to be no good answer to that except "because we can." It is relatively inexpensive, advances technology in valuable ways, and still tests that most improbable of all hypotheses: the universe is teeming with civilizations communicating just like us. It would be a shame if we missed out on discovering that because we didn't try.

—Louis D. Friedman, Cofounder and Board member of the Planetary Society



Deep Space Craft: An Overview of Interplanetary Flight

by Dave Doody
Springer, 440 pp.
$99.00, hardcover

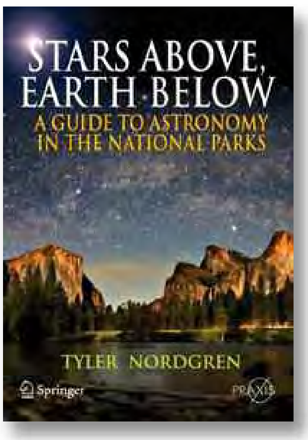
Deep Space Craft is a textbook—a very well-written and enjoyable one—full of technical information, background material, history, examples of interplanetary spacecraft and mission design, equations, spectral graphs, and charts.

It is not light reading, but if you want to learn or understand more about the design of missions and their spacecraft, this book is excellent. It draws on the author's long involvement and practical experience at JPL. Although the material is indeed technical, the book is written in understandable fashion. Doody plows through such subjects as navigating and controlling spacecraft, communications, propulsion, data handling, and then all the science instruments that represent the spacecraft payload and *raison d'être*.

The book will have value for students and aerospace engineers both as a text and as a reference and will be valuable to interested amateurs who want to delve deeply into explanations of such questions as "What does autonomous navigation mean?," "How do you calculate how much data a spacecraft can send?," or even "What is rocket science, anyway?" The many examples from deep-space missions, including *Voyager*, *Galileo*, *Deep Impact*, Mars missions, and *Cassini*, enrich the discussion of the topics and provide context and history for planetary exploration.

Dave Doody is not only an excellent mission analyst but also an experienced amateur astronomer, a model builder (known at *spacecraftkits.com*), and a great friend of the Planetary Society. He just donated a quarter-scale model of *LightSail* to hang in our new headquarters. If you want to learn about the design of interplanetary missions and spacecraft, Dave is the guy to teach you.

—LDF



Stars Above, Earth Below: A Guide to Astronomy in the National Parks

by Tyler Nordgren
Praxis, 300 pp.
$29.95, softcover

A photo essay on a years-long journey to see the natural wonders of dark skies over America's most beautiful landscapes; a primer on geology, astronomy, and planetary science; tales of past explorers; and visions of future exploration of the planets—*Stars Above, Earth Below* is all of these.

Those of you who visit the Planetary Society's website will recognize this book as resulting from a sabbatical adventure taken by Tyler Nordgren, who reported on his travels at *planetary.org/explore/topics/planetary_analogs.html*. The book is like those updates, of course, but much better. In addition to Nordgren's lyrical narrative and breathtaking photos of the Milky Way arching over dramatic mountains, deserts, and shorelines, there are detailed explanations of the current thinking about how landscapes—both Earthly and alien—are crafted by the physical processes that operate in and above the surface. The geologic story of America's landscapes is seamlessly interwoven with the stories of landscapes found across the solar system, from Mercury to the Moon and from Io to Enceladus.

Nordgren's text is accompanied by a truly exorbitant number of photos and diagrams, all printed in full color. The figures don't just illustrate the text; they expand on it. For example, in the chapter about the lunar eclipse he witnessed and photographed in Grand Teton National Park, there are photos of the eclipse, maps showing its extent, maps showing the locations of future lunar and solar eclipses, and, for good measure, time-series photographs taken by the Mars Exploration Rovers *Opportunity* and *Spirit* of eclipses of the Sun by Phobos and of Phobos by Mars.

The book is intended to be read in order, but the chapters stand well enough on their own that you can use it in "field guide" fashion. If you are planning a visit to any of the dozen or so national parks specifically discussed in the text, you can discover some of the same amazing sights he did, either by day or at night.

The book will delight space fans, but I think that it will do a greater public service by exposing those people who already love the wonders of America's national parks to the amazing discoveries made and new places seen throughout the Space Age. And I think it will leave them with the appreciation that the modern exploration of the solar system, and beyond, continues the tradition of the explorers, scientists, and artists who returned the first reports of Americans exploring the thrilling beauty of our gorgeous land.

—Emily Stewart Lakdawalla, Science and Technology Coordinator

Confessions of an Alien Hunter: A Scientist's Search for Extraterrestrial Intelligence

by Seth Shostak
National Geographic, 320 pp.
$27.00, hardcover

I have a confession to make: I was once a closet alien hunter. In my spare time, I scanned the skies for alien life. No, I don't own a radio telescope, but several years ago I downloaded a program, called SETI@Home, that exploits idle time on PCs to process data collected by radio telescopes engaged in the search for a sign, a signal, a squeak in the cosmic silence that might be the first testable piece of evidence that intelligent life exists outside our lonely blue planet.

Another confession: I haven't been running the SETI@Home program all that much lately. The longer we wait for a signal, the more discouraged I get that we will ever hear one, at least in my lifetime. With fewer years ahead of me than behind, my interests have turned in other directions. But once in a while, something comes along that gives me the itch to go prospecting for alien signals again. A few months ago, that something came in the form of a book, *Confessions of an Alien Hunter* by Seth Shostak.

Shostak is not just a scientist, he's a storyteller, and he tells the story of humankind's quest to answer one of its greatest questions with both eloquence and humor. He begins by reviewing the history of scientific and religious views of the possibility that humankind is not alone. For much of that history, it was widely accepted that other worlds, including those in our own solar system, were populated by intelligent beings. During the 20th century, the growing absence of evidence to support this view led most scientists to conclude that intelligent life in yonder universe is rare, if it exists at all.

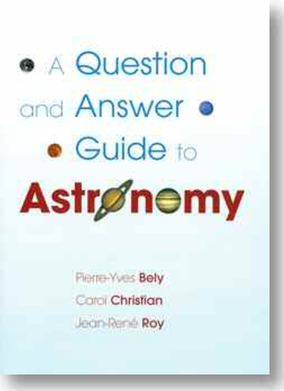
Of course, absence of evidence is not evidence of absence, and Shostak goes on to explore how much we've learned about the resiliency of life in the last few decades. Places on Earth that once were assumed to be utterly sterile—deep-ocean trenches, arctic ice floes, boiling hot springs—have been shown to be teeming with life. If life on Earth is capable of surviving in such extreme environments, surely there must be many biologically friendly places beyond our planet. Add to this the fact that the number of known planets orbiting other stars has been growing exponentially since the first such world was revealed in the mid-1990s, and the prospects for hearing from Little Green Men (or Women) seem to be rising.

Radio telescope searches for ETs phoning our home have so far turned up nothing definitive, but as Shostak points out, we've barely begun looking, considering the scope of the search that would be needed to conclude that no such signals exist. In nontechnical language, Shostak makes a rigorous and convincing argument that we've just begun to scratch the galactic surface. More encouraging still, SETI technologies and search strategies are improving by leaps and bounds every year. By the end of the book, I was convinced that our chances of hearing a signal from ETs in the next 20 years were better than the "slim to none" I would have assumed before.

Shostak sprinkles his narrative with interesting and amusing anecdotes from his years at the SETI Institute, as well as personal profiles of some of his esteemed colleagues. He even gives due consideration to arguments offered by UFO hunters that ET is already here. Although Shostak doesn't accept this claim, he shows the people who make it much more respect and consideration than they typically give SETI scientists.

This is a most enjoyable book, highly recommended to anyone interested in learning about how and why SETI is such a valuable and—I would say, indispensable—program.

—Andre Bormanis, Writer and Producer



A Question and Answer Guide to Astronomy
by Pierre-Yves Bely, Carol Christian, and Jean-René Roy
Cambridge University Press, 294 pp.
$28.99, softcover

In this book, the authors present answers to 250 common and not-so-common questions in astronomy and space science. The breadth of topics covered is impressive. The authors answer questions related to our solar system, deep space, telescopes and their construction, and the history of astronomy. Questions range from the tangible, such as why we don't tan late in the afternoon, to the most profound of questions: "Are we alone in the universe?" or "What was before the Big Bang?" Topics also address history, such as asking how ancient astronomers could predict eclipses, and even offer advice on which telescopes you should consider for amateur astronomy.

Another nice aspect of the book is that topics range from easy and commonplace to challenging and specific. Because the answers stand alone, readers can focus on only those that most interest them and can read them in any order they want. The authors nicely refer to related answers for more detail, but each answer is self-contained.

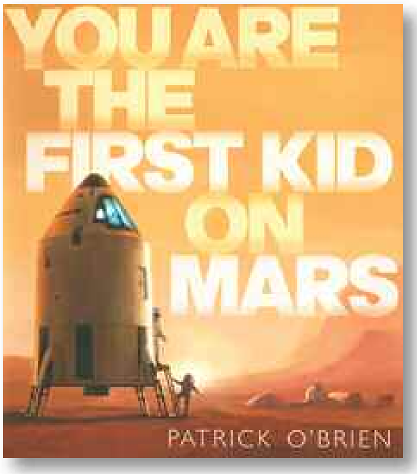
Although one can read questions in any order, they are organized by topic for convenience, so you can focus on what most interests you, or what you know the least about. The sections are "Stars," "The Solar System," "The Earth," "The Moon," "Celestial Phenomena," "The Universe," "Life in the Universe," "History of Astronomy," "Telescopes," and "Amateur Astronomy." Sections usually start with big-picture or overview questions, such as "Why do stars shine?" and "How did the solar system form?" and move on to more detailed questions later.

The authors have done a very good job with the content, hitting major concepts accurately, not overstating our current knowledge, and explaining concepts in an understandable way. With the huge variety of questions, it is not surprising that there is a huge variety in the length and depth of answers, as well as the extent to which we know the answers to the questions. Also adding to the book's value are lots and lots of pictures and illustrations, including images of physical phenomena, pictures of key scientists who have been involved with a topic, and, of course, spectacular space pictures.

Overall, the book is well done, informative, and noteworthy for its breadth. It would be a good book to read in depth, to browse, or to serve as a resource for those questions that pop into our heads periodically about the worlds and universe around us.

—Bruce Betts, Director of Projects

BOOKS FOR KIDS

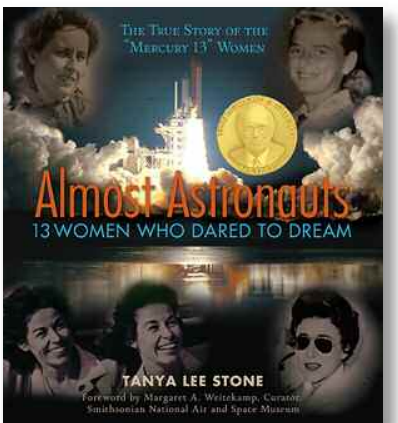


You Are the First Kid on Mars

(ages 4–8)
by Patrick O'Brien
Putnam Juvenile, 32 pp.
$16.99, hardcover

This terrific book, told in the second person, asks "Would you like to go to Mars?" Then it takes you, the reader, up a space elevator, to a space station, to a space ship, to another station, and down to a habitat on Mars' surface, where you see how scientists and engineers use robots to maintain their colony, explore the world, and search for microscopic life.

By addressing his audience so directly, O'Brien effectively pulls the reader—or kid listening to the story—into this imagined future. O'Brien's 42 paintings are fully realized concepts of future technology and have a dimensional reality that adds to the immersive feel of the book. *—ESL*



Almost Astronauts: 13 Women Who Dared to Dream

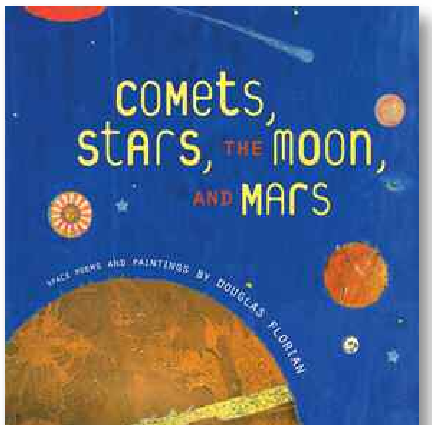
(ages 9–12)
by Tanya Lee Stone
Candlewick, 144 pp.
$17.99, softcover

Almost Astronauts is by turns inspiring and enraging. It is the story of 13 women pilots who were selected, in 1961, to undergo the same (and in some cases, more stringent) harrowing physical and psychological testing that the seven Mercury astronauts underwent, and who passed these tests with flying colors. The project was the brainchild of Randolph Lovelace, the NASA doctor who tested the Mercury Seven. He wanted to know whether, with their lower body mass and lower oxygen requirements, women would be more cost-effective astronauts than men. By embarking on a scientific program to answer this question, he and the 13 women astronaut candidates plunged into the 1960s' swirling maelstrom of prejudice and politics.

Of course, those 13 women never made it to space, and it was not until 1999 that 8 of the surviving 11 were able to witness the first American space launch to be piloted by a woman.

The second half of the book details the tumultuous social changes in both the public and military spheres that were necessary before women could be admitted to the inner core of the American space program, first as mission specialists and later as shuttle pilots.

Although this story is often frustrating, the book is no feminist rant against past injustice. Instead, the reader is left with admiration for how brave, resourceful, strong, and capable these 13 women were; how they competed on a very unequal playing field to achieve thousands of hours in the air as civilian pilots; and how, once they were finally admitted into a program where they were tested no differently from the men, they rose to the challenge and demonstrated that they, too, had the legendary Right Stuff. They may never have made it to space, but because of their courageous struggle, later generations succeeded. *—ESL*



Comets, Stars, the Moon, and Mars

(ages 4–12)
by Douglas Florian
Harcourt Children's Books, 56 pp.
$16.00, hardcover

Short, cute poems about each of the planets and other objects in space have an almost Shel Silverstein–like rhythm to them. They are accompanied by brightly colored, witty collage illustrations that have the same spirit as the poetry. As with any poetry collection, some items are better than others, but several made me laugh out loud, such as "Pluto was a planet./ But now it doesn't pass./ Pluto was a planet./ They say it's lacking mass./ Pluto was a planet./ Pluto was admired./ Pluto was a planet./ Till one day it got fired."

I think the book is suitable for kids down to age 3 or 4. It would be an excellent resource for teaching poetry or collage in a language or visual arts class, and it would sneak in a little science! *—ESL*

LightSail **UPDATE**

THE INTERNATIONAL SOLAR SAILING SYMPOSIUM

BY LOUIS D. FRIEDMAN

Japan's *IKAROS* team stole the show at the International Solar Sailing Symposium in New York City, where they announced that their spacecraft had achieved controlled solar sail flight. The meeting was held at the New York College of Technology in Brooklyn, but I think the *IKAROS* team should have been given a ticker-tape parade in lower Manhattan. The timing would have been appropriate, as the meeting started on July 20, 2010: the 41st anniversary of humankind's first step on the Moon.

IKAROS deservedly stole the show, but the Planetary Society's *LightSail* garnered some great applause as well. I, along with *LightSail* engineers Chris Biddy and Matt Nehrenz from Stellar Exploration, reported on the final design of our spacecraft (now fixed, after our June critical design review) and on our long-term plan for three *LightSail* missions leading into interplanetary space.

LightSail-1 has moved into the manufacturing stage—we have ordered all the parts, including the sail. The three-unit cubesat structure is now at Stellar Exploration, as is the engineering model of the spacecraft cameras. Following our formal design review, we made a major decision: we will build a second flight-capable spacecraft as a spare for the project. A duplicate spacecraft is a cost-effective form of insurance. If we need it because of any type of accident, then we have it; if we don't need it for flight, then it will serve both for ground tests and for eventual future uses as we develop *LightSail-2*.

To save money, we will procure the parts now for the spare, while we are building the prime spacecraft. Our anonymous donor supports the second spacecraft and has provided an additional matching donation, challenging our members to help us with this undertaking.

While at the New York meeting, our *LightSail* team met with the *IKAROS* team to discuss our different designs and approach to deployment. Our two spacecraft could not be more different, each tailored to our individual flight objectives and space environment.

IKAROS spins using a novel method of attitude control: turning on and off LEDs embedded in the sail to change reflectivity and create an imbalance of the solar pressure force. Doing this provides a slow turning capability, suitable for flight in interplanetary space but probably not as suitable for turning more quickly in Earth orbit.

LightSail-1 turns by use of powering up a reaction wheel, changing the angular momentum of the spacecraft. It is also an ultralight spacecraft, testing pure solar sail flight for the future, whereas *IKAROS* is a technology test vehicle—much heavier, with many other technological elements to create a hybrid propulsion unit for planetary missions. Despite its smaller size (or because of it), *LightSail-1* will have greater characteristic acceleration.

Our methods of deployment are also very different. *IKAROS* used centrifugal force to pull the sail out, whereas *LightSail-1* will have lightweight booms for deployment while the spacecraft stays relatively motionless. Years ago, most aerospace engineers had rejected spinning solar sails because they thought that control and deployment were too complicated. The Japanese team proved differently.

Another big difference between our two solar sail projects is funding: *IKAROS* is a government-funded mission; ours is, of course, funded privately by members of the Planetary Society.

A number of the presentations at the symposium focused on using sails for atmospheric drag, not as solar "sailers." As orbital debris becomes ever more important, simple atmospheric drag additions for spacecraft have become a vital technology to explore. Drag causes the spacecraft orbit to decay (shrink and come closer to Earth), eventually to a region where the debris will burn up in the atmosphere. Hanging out a sail at the end of a spacecraft's mission might be a relatively inexpensive way to provide such drag. Demonstrating this, after all, was the goal of *Nanosail-D*, the spacecraft development that stimulated us to come up with the *LightSail* design.

Orbital debris is now a major environmental and political issue. Some of the commonly used low Earth orbits are becoming relatively crowded and the risk of collisions greater. *LightSail*'s mission objective requires an orbit without atmospheric drag, and we will certainly want to be in an orbit that has a long lifetime—unless, of course, we can be clever and use the sail after its nominal mission of solar sail flight to help the orbit decay. We also intend to investigate the atmospheric drag brake as a by-product of our solar sail development. That is one of the purposes of our Space Act Agreement with NASA Ames Research Center.

All these considerations and developments make me more excited than ever about the new ground we are breaking with *LightSail*. "We" includes our *LightSail* team and you—all the members of the Planetary Society. Without your crucial support, we wouldn't be embarking on this bold venture.

Louis D. Friedman is cofounder and board member of the Planetary Society.

Explore MORE

Keep up with progress on the Planetary Society's *LightSail* mission at ***planetary.org/programs/projects/solar_sailing/***

World Watch

The NASA budget, with the revolutionary new plan for human spaceflight proposed by the Obama administration, is now making its way through the U.S. Congress—and that way is tortuous. Both the House of Representatives and the Senate are considering authorization of the NASA program and the appropriation of funding for the budget. This year being an election year and with many controversial subjects on the congressional agenda, it is not clear whether either the authorization or the appropriations bill will be passed, or what will happen if they aren't.

The table below describes the status in August of the congressional consideration of the administration's proposed budget for NASA.

The details in the Senate and House columns are those passed by the individual authorizing committees. In its last week before a six-week recess, the full Senate passed its committee bill. House authorizers made a last-minute attempt to suspend rules and pass the House bill without debate. The move was thwarted when many in the space community, including the Planetary Society, protested and asked that consideration be postponed until a full and open debate on the provisions could be held.

The Senate appropriations bill is very similar to the Senate authorization bill. The House appropriations bill is devoid of specifics; representatives have said they are awaiting the authorization action first. The single bright light is that there is unanimous agreement to fully fund NASA's science program.

When the administration proposed its new plan for human spaceflight, congressional critics decried the "vagueness" of the new plan; some said that without a timetable and destinations, the new plan was a "mission to nowhere." Now the administration's plan is the only one with destinations and a proposed timetable, whereas congressional bills are all silent on these. I consider the congressional situation a mess.

The congressional bills represent separate patchwork attempts to quilt together a program focused on jobs and contracts to maintain the status quo, rather than to explore beyond Earth's orbit. Even if they are successful, that success will be short-lived. The congressional plans discourage commercial investment in launch services and inadequately fund government investment in technology. Furthermore, building a deep-space rocket (the heavy-lift launch vehicle) before its destination has been set will lead to inevitable delays and likely cancellation—as has happened several times in the past two decades.

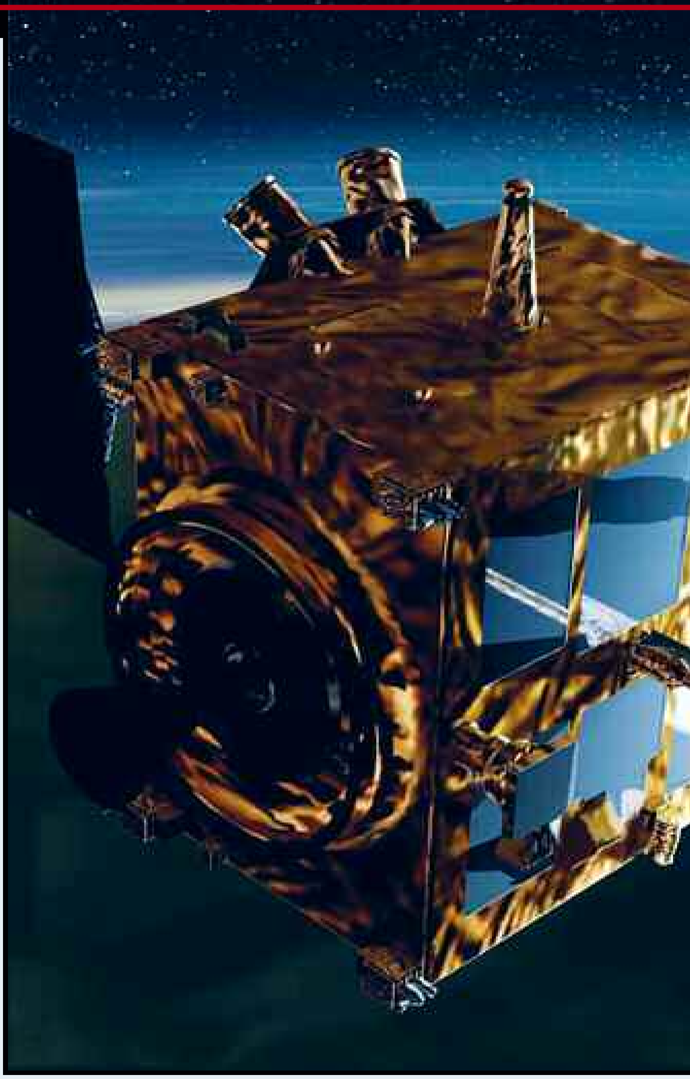
At the beginning of August, Congress recessed and did not reconvene until September 13. It will recess again early in October so its members can campaign for re-election. Even if, sometime between recesses, the Senate and House pass their individual versions of the two bills, the bills still will have to be reconciled by a conference committee.

We will keep you informed (watch your e-mail and visit *planetary.org*), and we will remain involved—fighting for human and robotic exploration of other worlds.

Louis D. Friedman is cofounder and board member of the Planetary Society.

Policy	Administration	Senate	House
Shuttle retirement	Current manifest—last flight February 2011 (STS-134)	1 additional flight, funding provided	1 additional flight, subject to NASA approval and transfer of funds from ISS and Exploration
Shuttle replacement	- Commercial crew, goal of 2014–2015 - *Orion* as lifeboat only	- Continue development of *Orion* to support ISS and beyond Earth orbit - FY2011 start for development of deep-space rocket (no technology investment) - Crew missions to ISS goal: December 2016 - Reduced funding for commercial crew, subject to conditions	- 180-day study to restructure Exploration program, maximum use of Ares and *Orion* encouraged - Crew missions to ISS goal: December 2015 - Effectively eliminates new commercial contracts
International Space Station (ISS)	- Extend operations to 2020 - Increase ISS science	- Same	- Same
Deep-space rocket	- 5-year technical development with flagship demos -2015 development start for 2020 flight	- FY2011 start for development of deep-space rocket. Prescribes performance (70–100 tons). Maximum use of shuttle, Ares, and *Orion* workforce and investments is encouraged	- 180-day study, maximum use of Ares (Constellation) is encouraged
Exploration goals	- Beyond the Moon - Asteroid by 2025 - Mars flyby by mid-2030s	- Broad goals (Moon, Mars, asteroids, etc.), no timelines	- Broad goals (Moon, Mars, asteroids, etc.), no timelines
Robotic precursors	- Several beginning with Moon, then asteroid - Integration with Mars science program	- 20% reduction in funding	- Eliminates robotic precursors
Exploration technology	- Technology and flagship demonstrations (fuel depots, inflatables, advanced life support systems, etc.) - Propulsion R&D - Human research (radiation, etc.)	- Reduced funding for demos (50% cut) - Eliminates propulsion R&D - Reduced human research (25% cut)	- Eliminates tech and flagship demos - Eliminates propulsion R&D - Fully funds human research
Science	- Strong support to Earth and space science (including planetary)	- Fully funded	- Fully funded

Akatsuki: Toward the Morn



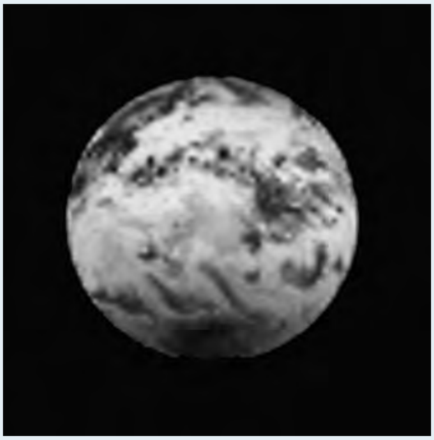
By Takeshi Imamura

On the morning of May 21, 2010, Japan's first Venus explorer, *Akatsuki*, launched from the Tanegashima Space Center of Japan, beginning its journey toward the morning star, Venus. The name of the spacecraft is, appropriately, the Japanese word for dawn.

Initial tracking of the spacecraft progressed quite smoothly, so the mission team oriented the cameras on board *Akatsuki* toward Earth just half a day after launch. The first light images, which were taken from a distance of 250,000 kilometers (150,000 miles), clearly showed the basic characteristics of the Earth's climate: solar radiation (365 nanometers and 0.9 micrometers) is partially reflected by clouds and partially absorbed by the surface; the deposited energy is distributed over the globe by winds and ocean currents; and, finally, the energy is radiated out into space from the entire globe at infrared wavelengths (10 micrometers). This is the type of observation we expect from *Akatsuki* at Venus after it arrives on December 7, 2010.

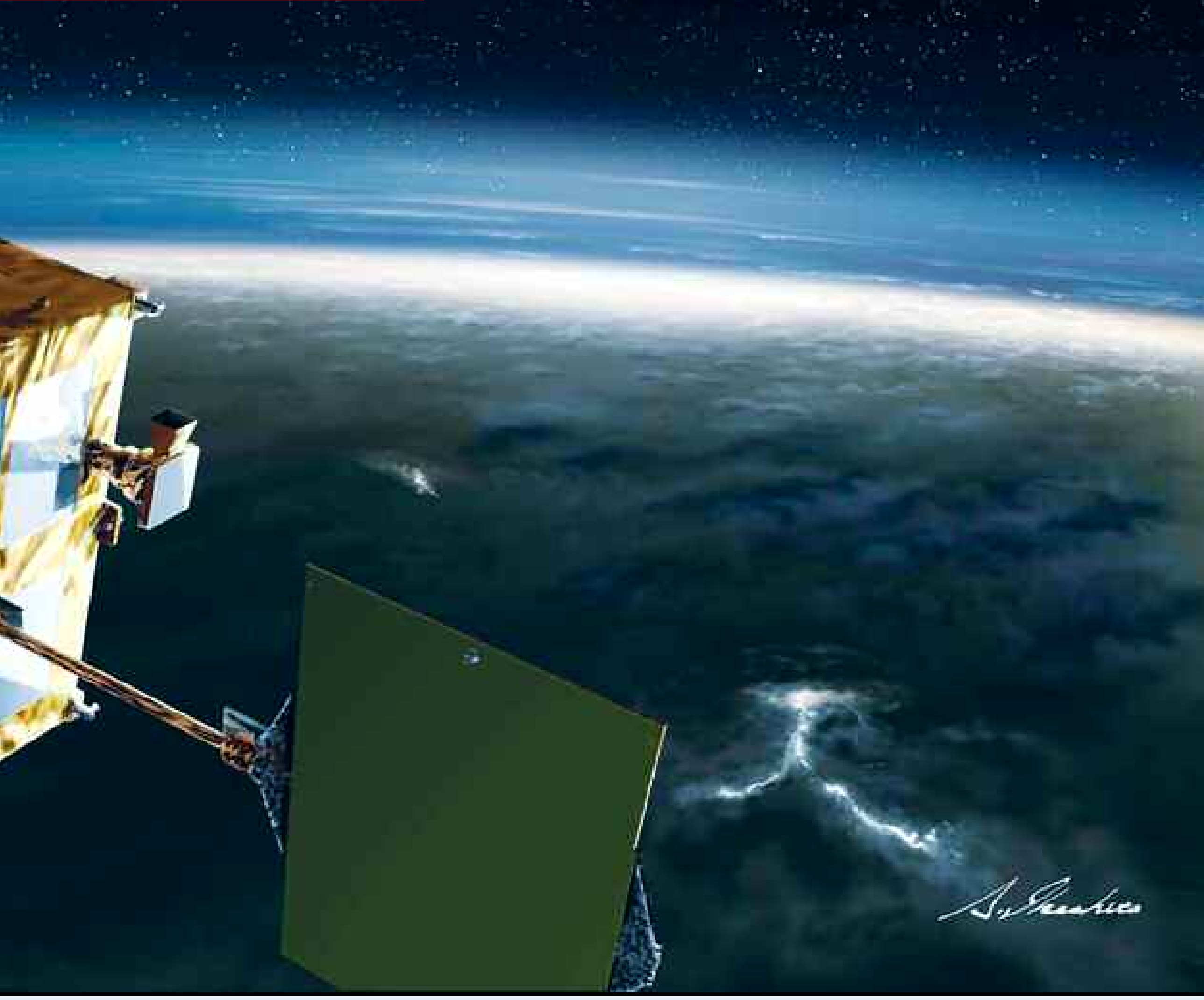
Venus, our nearest planetary neighbor, is similar in size to Earth, but beyond that initial similarity, it's an entirely different place. Previous spacecraft missions discovered an extremely dense and dry carbon dioxide atmosphere with sulfuric acid clouds floating at around 60 kilometers (37 miles) altitude, as well as exotic volcanic features covering the whole planet. The abundant carbon dioxide produces a high atmospheric temperature (740 kelvins, or about 470 degrees Celsius, 240 degrees Fahrenheit) near the surface as a result of the greenhouse effect. This is despite the fact that Venus, with a high albedo (reflectivity) because of its clouds, absorbs less energy than does Earth.

Venus holds the key to understanding the mechanism of the differentiation of terrestrial planets into a variety of states. The Venus explorers that the former Soviet Union and the United States sent from the 1960s to the 1980s taught us the basics about Venus. After these missions, Venus exploration stopped for more than 10 years, despite the fact that most of the fundamental questions that had been raised remained unanswered. Among these are "How was Venus formed?," "How did



Half a day after launch,* Akatsuki *team members tested the spacecraft's cameras on Earth. Taken at a distance of 250,000 kilometers (150,000 miles), the image at left shows how some solar radiation is reflected by clouds, while some is absorbed by the surface (center) and, finally, radiated back to space at infrared wavelengths. Thermal emissions from our planet's clouds and surface are evident in the image at right. *Images: JAXA*

ING STAR



Venus and Earth are nearly twins in composition and size. That, however, is where their similarities end. Here, Japan's Akatsuki, *also known as Venus Climate Orbiter or Planet-C, flies over Venus' murky, noxious cloud tops on its mission to find out how these two planetary siblings turned out so very differently.*

Illustration: Akihiro Ikeshita for JAXA

the solid planet and the atmosphere evolve?," "How was any water (ocean) that it had lost?," and "How does the climate system differ from that of Earth?" Fortunately, the beginning of the 21st century brought about a resurgence of Venus exploration, with the launch of the European Space Agency's (ESA) *Venus Express* in 2005 and *Akatsuki* this year.

Mysterious Meteorology

Planetary meteorology is essential to understanding the mysteries of how the climates of the planets evolved. In the case of Venus' meteorology, much remains unknown to us, including what drives the unusual atmospheric circulation, what causes the sulfuric acid clouds, and whether lightning strikes on Venus.

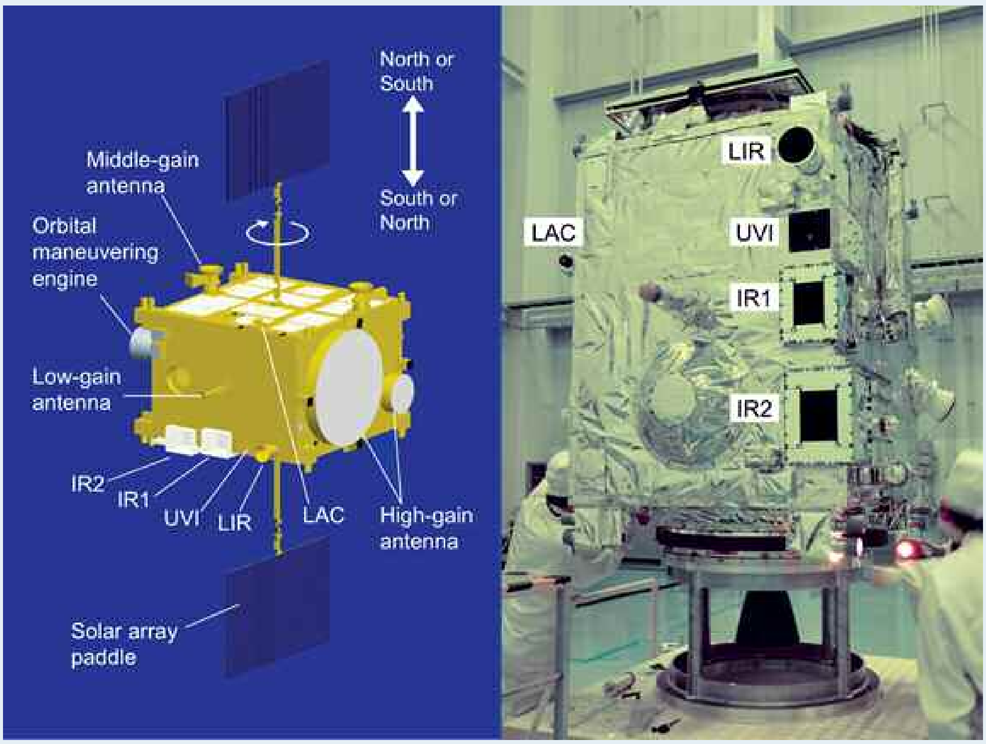
The former Soviet Union's Venera 13 *was the third spacecraft to provide images from the surface of Venus. The spacecraft returned this panorama (which has been processed and colorized, with data gaps filled in by hand) of the planet's hidden surface on March 3, 1982.* *Image: Brown University/Vernadsky Institute/O. de Goursac*

Venus and Earth are often called "sister worlds." As any parent or teacher knows, to understand the behavior of one child, you must consider the siblings. For example, Venus and Mars, worlds without oceans and life, provide simpler test beds for scientists to study interactions among atmospheres and hard surfaces and, in the process, refine hypotheses about how our more complex climate behaves. From observations of the present states of planets, scientists can work backward to try to determine how they evolved into such inhospitable places. Images: NASA

A westward circulation of the entire atmosphere, called the *super-rotation*, characterizes the meteorology of Venus. The wind speed increases with height, reaching 100 meters per second near the cloud top. This is 60 times the 1.6 meters/second speed at which the solid planet rotates at its equator, which corresponds to a rotational period of 243 Earth days. Such a wind system is considered strange: standard meteorology predicts that large-scale winds should blow at speeds comparable to or less than the planetary rotation speed. The Earth's westerly wind (around 30 meters per second), for example, is localized in the midlatitudes and is much slower than the Earth's rotation (460 meters/second at the equator). Recent studies suggest that Mars has a wind system similar to the Earth's and that Titan has a super-rotating atmosphere.

We don't yet know the origin of these two dynamical regimes, but scientists have proposed various mechanisms to explain the super-rotation. One is the combination of a Hadley circulation and planetary-scale waves that transport westward momentum from the high latitude to the equatorial region. Hadley circulation—which may exist in Venus' atmosphere—is a planetwide flow driven by solar heating, with ascending motion in the tropics and descending motion at higher latitudes. In the presence of the planetary-scale waves, the ascending branch transports momentum larger than that of the descending branch, thereby accumulating momentum at higher levels to produce the super-rotation.

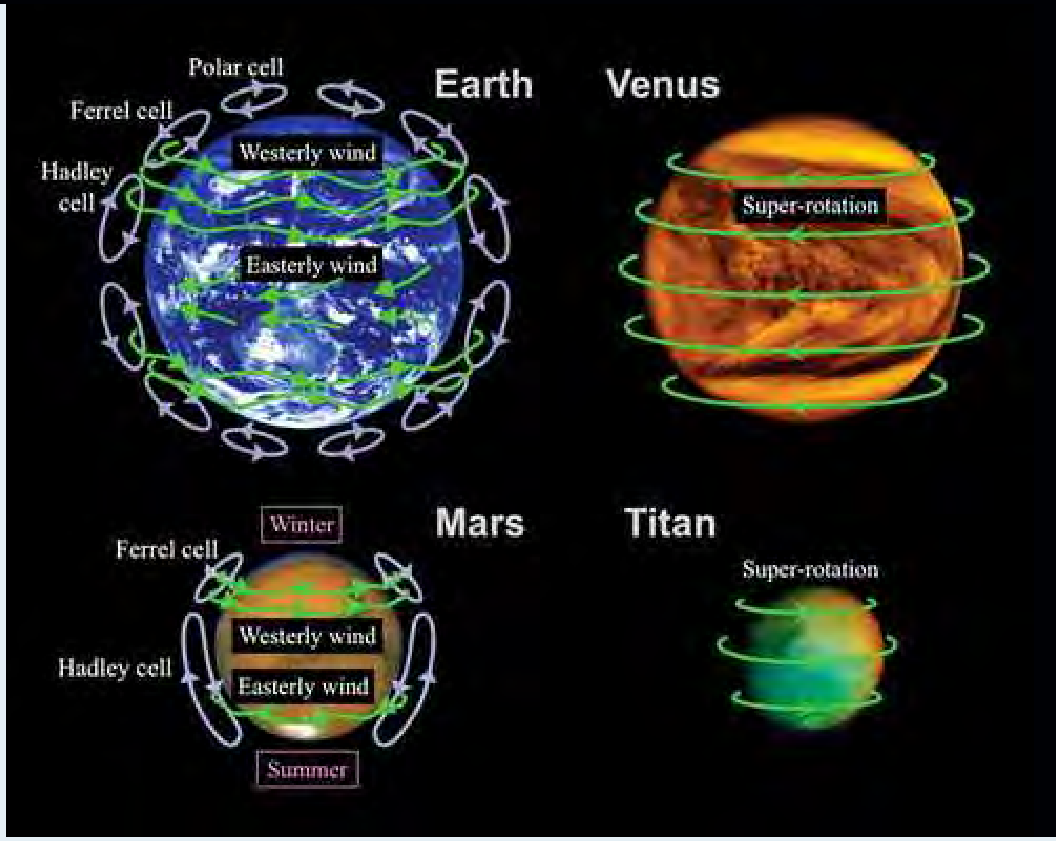
Vertically propagating waves might also drive the super-rotation. Planetary-scale waves, called *thermal tides*, might be generated in the cloud layer by periodic solar heating and then propagate upward and downward. As they reach the surface, these waves would give eastward momentum to the solid planet, and at the same time the atmosphere would be accelerated westward. Other types of waves also have been proposed as momentum carriers.



Akatsuki*'s cameras—specially designed for meteorological observations—will face Venus most of the time, while its solar array paddles are flexible about their north-south axis so that they can face the Sun no matter how the main spacecraft body is oriented. At right, engineers prepare to carry the spacecraft to the launch site.* Graphic and photo: JAXA

How the sulfuric acid clouds that completely cover the planet formed is another mystery. The origins of the cloud features seen in ultraviolet—such as the planetary-scale dark region near the equator, bright bands near the poles, and cell-like structures in the subsolar region—are mostly unknown. Sulfuric acid is produced near the cloud top via the oxidation of sulfur dioxide and water vapor in the presence of ultraviolet radiation. Thus, the clouds have characteristics of photochemical aerosols, which also exist in the Earth's stratosphere. To explain the observed thick clouds, condensation caused by atmospheric motions also is needed. The heating of the cloud base by infrared radiation emitted by the hot lower atmosphere might drive thermal convection. The role of planetary-scale vertical circulation might also be important.

Various observations suggest that lightning occurs in Venus' atmosphere. Lightning discharge is closely related to cloud formation and can be an indicator of vigorous convective activity. Recently, the magnetometer on board *Venus Express* detected electromagnetic waves that might have come from lightning discharges. The occurrence of lightning remains under debate, however, because the standard theory of charge separation in terrestrial thunderstorms requires water ice particles, which cannot exist in Venus' atmosphere.



The circulation of Venus's atmosphere (as well as Titan's) is markedly different from that of Earth (or Mars). Venus' and Titan's entire atmospheres circulate around their globes—a process called "super-rotation." Scientists do not yet know how these two dynamical regimes originated. *Illustration: JAXA*

First Planetary Meteorological Satellite

Akatsuki is the first planetary explorer that deserves to be called a planetary meteorological satellite, meaning that it will conduct continuous global monitoring from high equatorial orbits to measure winds and other variables. Five cameras specially designed for meteorological observations will be oriented to Venus most of the time via the attitude control of the main body of the spacecraft.

The solar array paddles have freedom of rotation about the north-south axis, and their orientations are controlled so that they face the Sun, independently of the orientation of the main body. The two flat, high-gain antennas, one for transmission and one for reception, are oriented toward Earth when communicating with the tracking station. During the cruise to Venus, *Akatsuki* will observe the zodiacal light from various viewing points without any contamination from the sky light, and it will map out the spatial distribution of the interplanetary dust cloud.

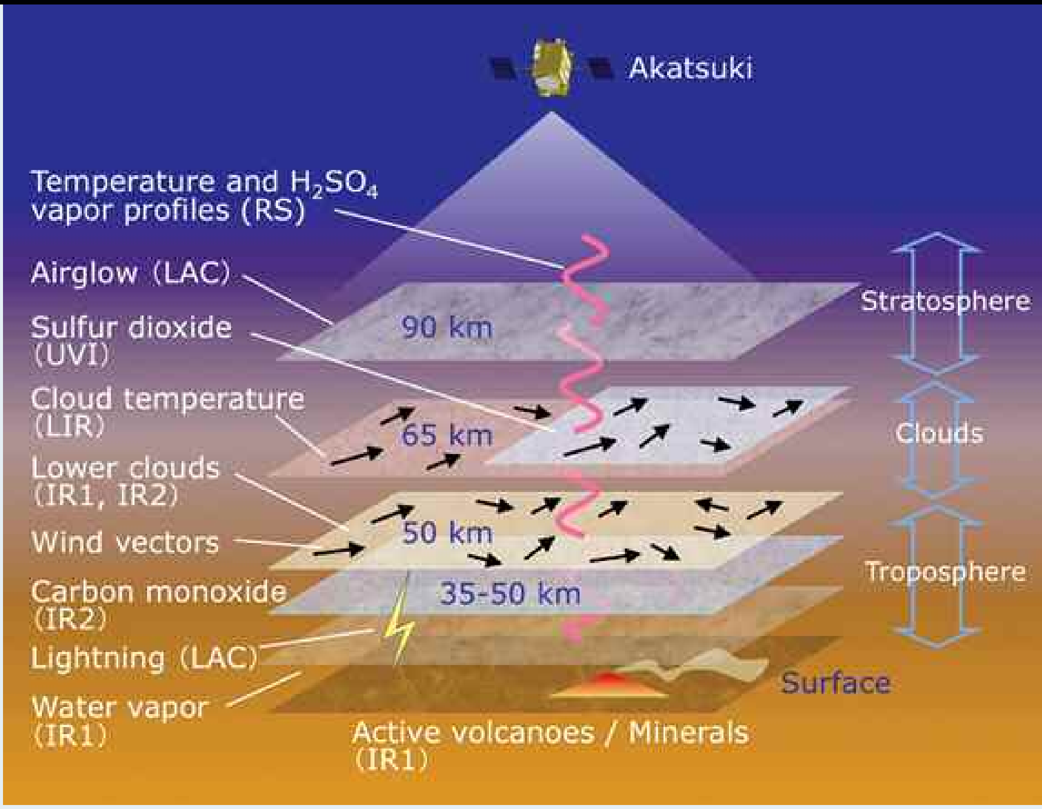
The mass of the spacecraft is about 500 kilograms (1,100 pounds), including fuel, and the science payload weighs 35 kilograms (75 pounds). Because of its low mass, *Akatsuki* was launched together with a solar sail spacecraft called *IKAROS* and four small piggyback satellites.

The planned path around Venus is a 30-hour elliptical orbit near the equatorial plane. This differs from most planetary missions, which adopt polar orbits. The direction of orbital motion is from east to west, which is the same as the atmospheric super-rotation. The periapsis altitude is several hundreds of kilometers, and the apoapsis altitude is 78,500 kilometers (49,100 miles), or 13 Venus radii, so that the angular motion of *Akatsuki* is roughly synchronized with the super-rotational flow at the cloud level for roughly 20 hours centered at the apoapsis. Seen from this quasi-synchronized portion of the orbit, cloud features below *Akatsuki* will be observed for more than 20 hours, and thus the precise determination of atmospheric motions is possible. This portion of the orbit corresponds roughly to the region where the angular diameter of the Venus disk is smaller than the typical camera field of view of 12 degrees, enabling continuous global monitoring.

Applications of *Akatsuki*'s concept and technology to other planets is under discussion. The concept of meteorological satellites will be useful for the study of other planets as well. For example, Mars has a unique climate that is influenced by suspended fine dust particles and the phase transition of the atmosphere near the poles; the meteorological processes there, such as global dust storms, are not well understood. Using what is learned from *Akatsuki*, a Martian meteorological satellite would enable continuous monitoring of full life cycles of dust storms and other disturbances.

Science Instruments for 3-D Observations

The combination of five meteorological cameras—including ones that watch the thermal emissions from the subcloud atmosphere and the surface by using atmospheric "window" wavelengths in infrared—together with the radio occultation technique, will reveal the three-dimensional structure of the atmosphere and its dynamics. The cameras will obtain global images every 1–2 hours with wide-field angles of 12–16 degrees, thereby visualizing atmospheric motions in the form of movies and providing cloud-tracked wind vectors at multiple elevations. Using such wind data, together with cloud and minor gas maps, we will study the structures of deep circulation, midlatitude jets, and various atmospheric waves. We will consider close-up and limb observations near the periapsis for a detailed look at small-scale structures. *Akatsuki*'s comprehensive meteorological data will enable us to evaluate the momentum transport related to the super-rotation and to clarify cloud dynamics.



Data from* Akatsuki*'s five cameras—which will include infrared imagery—along with radio occultation measurements will reveal the three-dimensional structure and dynamics of Venus' atmosphere. *Graphic: JAXA*

• 1-µm Camera (IR1)

IR1 will map the surface and the lower atmosphere at infrared wavelengths of 0.90, 0.97, and 1.01 micrometers as well as upper clouds at 0.90 micrometers. These wavelengths are located in the atmospheric windows. The surface imaging not only will provide information on the surface material but also will enable a search for hot lava ejected from active volcanoes, which have, so far, never been detected. IR1 and the subsequent IR2 and UVI have megapixel detectors.

• 2-µm Camera (IR2)

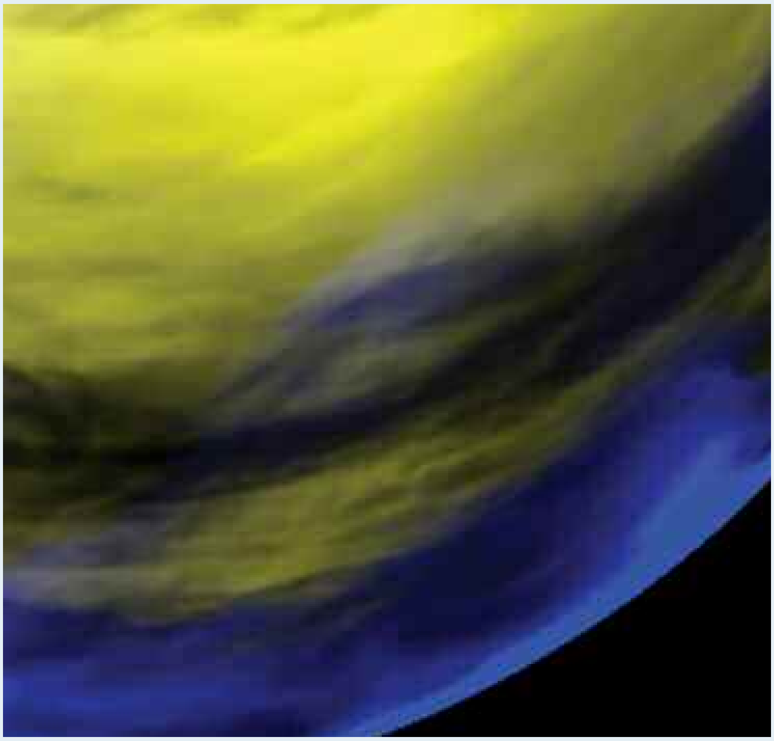
IR2 also will utilize the atmospheric windows. It will map low-level clouds and their microphysical properties using infrared wavelengths of 1.73, 2.02, and 2.26 micrometers, as well as subcloud carbon monoxide at 2.32 micrometers. Carbon monoxide is produced in the upper atmosphere and subsequently transported to the lower atmosphere. An additional wavelength is 1.65 micrometers, intended for observing the zodiacal light during the cruise to Venus.

• Ultraviolet Imager (UVI)

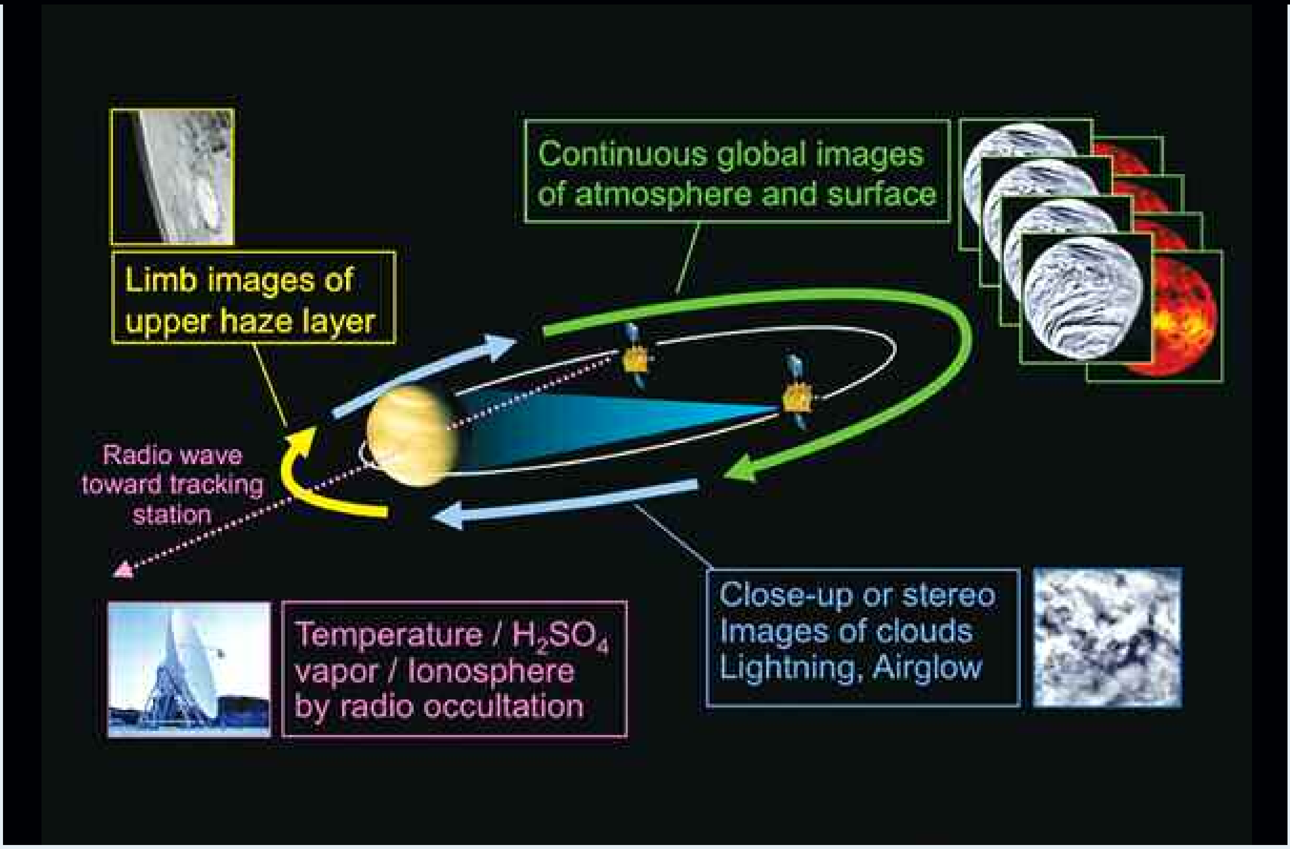
The UVI will observe the brightness pattern at the cloud top using two ultraviolet wavelengths. The 283 nm (nanometer) channel is for observing sulfur dioxide, from which sulfuric acid clouds are produced via chemical reactions, whereas the 365-nm channel is for an ultraviolet absorber whose chemical property is not identified. The distributions of these gases reflect cloud-forming chemistry and dynamics inside clouds.

• Longwave Infrared Camera (LIR)

The LIR will map the cloud-top temperature at



Akatsuki and Venus Express mission teams are coordinating their spacecrafts' complementary observations. The Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) on board Venus Express captured this false-color view on August 26, 2006 from 65,000 kilometers (about 40,000 miles) above the planet's surface. The bright blue denotes Venus' airglow, which is produced when oxygen atoms "migrate" from the dayside to the nightside of the atmosphere and recombine into molecular oxygen (O_2), emitting light. *Image: ESA/VIRTIS/INAF-IASF/Paris Observatory-LESIA*



Akatsuki's mission operations in Venus orbit. Graphic:JAXA; Photos: NASA

an infrared wavelength of 10 µm. The temperature map will reflect the cloud height distribution, which is mostly unknown. The detector has 80,000 pixels.

• Lightning and Airglow Camera (LAC)

The LAC will search for lightning flashes with high-speed sampling using the 777.4-nm-wavelength line emission of atomic oxygen. Laboratory experiments simulating Venus' atmosphere show this line to be the strongest emission from lightning discharges. The LAC also will observe atmospheric fluorescence called *airglows* at wavelengths of 552.5 nm (emitted by oxygen molecules) and 557.7 nm (emitted by oxygen atoms) to enable study of the dynamics of the upper atmosphere. The detector has 8 by 8 pixels.

• Radio Occultation (RS)

RS will determine the vertical structure of the atmosphere, to complement imaging observations. In its observations, the spacecraft transmits radio waves toward the tracking station on Earth and sequentially goes "behind" (as viewed from the tracking station) the planet's atmosphere and the solid surface, then reemerges in the reverse sequence. During such occultation events, the atmosphere causes changes in the frequency and power of the traversing radio wave. The signal is recorded at the tracking station and analyzed offline. *Akatsuki* is equipped with an ultrastable oscillator as a radio source for this experiment.

Collaboration with *Venus Express*

The ESA's *Venus Express*, which has been in orbit since 2006, also is studying the environment of Venus. Its science payload consists of three spectrometers, an imager, a plasma analyzer, a magnetometer, and an ultra-stable oscillator. The two missions complement each other, so our mission teams coordinated observation plans using the two spacecraft.

A striking difference between *Akatsuki* and *Venus Express* is that the former focuses on fluid dynamics with imaging observations from equatorial orbit, whereas the latter focuses on chemistry with spectroscopic observations from polar orbit, although two instruments on *Venus Express* have imaging capability. The combination of these observations could reveal the circulations of chemical species that determine the chemical state of the Venus atmosphere.

Toward the Future

After *Akatsuki*'s arrival at Venus, we will begin to learn more about the meteorological phenomena occurring in the thick Venus atmosphere—information that has been hidden by overlying upper-level clouds. These findings, along with comparisons with Earth, ultimately will lead to an understanding of fundamental processes that determine the planetary-scale winds and cloud distribution on Venus and other terrestrial planets.

Takeshi Imamura is project scientist for JAXA's Akatsuki *mission.*

NEW DESIGN COMPETITION: HUMAN MISSION TO AN ASTEROID

by Bruce Betts

In February 2000, the NEAR spacecraft visited the near-Earth asteroid 433 Eros. This image of Eros' northern hemisphere is a mosaic of six images.

Image: NASA/JHU APL

After months of space travel, humans approach an asteroid for the first time. To the astronauts, Earth appears as no more than a small bluish orb. The astronauts explore the asteroid, doing science, collecting samples, and acting as surrogates for the human species as we take our first step beyond the Earth-Moon system.

This sounds great, doesn't it? But what will it take to make this dream a reality? How will we get humans to this next stepping-stone? How will astronauts deal with the extremely long mission times? How will they work in the low-gravity environment of an asteroid? The Planetary Society will engage the world in a prize competition to help contribute to the answers to these questions and more.

Why Go to NEAs with Astronauts?

For many years, near-Earth asteroids (NEAs) have been recommended by various panels and groups as human destinations, and they are gaining support as potential destinations for human missions. In August, my colleague Jennifer Vaughn and I attended a NASA workshop about human missions to asteroids. There, I delivered an invited talk about how to involve the public in such missions. I also unveiled a new Planetary Society activity: a competition to design a human mission to an asteroid.

NEAs are inspiring as new targets for human exploration. Nearby asteroids represent a logical step beyond the Earth–Moon system, and although they are easier to reach and much closer than the surface of Mars, they offer opportunities for experience in deep-space environments. We also know that NEAs represent a threat to Earth, should one be found to be on a collision course with our home planet. A human mission to an asteroid, along with robotic precursors, would give operational experience at one of these potentially dangerous bodies as well as detailed scientific information about their makeup and structure.

RANDOM SPACE FACT

It takes less fuel (delta *v*, or change in velocity, in orbital mechanics–speak) to go to and return from a near-Earth asteroid than it does to go to and return from the surface of the Moon due to the much higher gravity of the Moon.

Only a few studies have addressed aspects of how humans might best explore NEAs, and the area is ripe for additional work and innovation to bring humans closer to being able to carry out such missions. Our competition is one piece of that process.

Competition, Prizes, and Goals

The Planetary Society will carry out the competition in partnership with several other organizations, including NASA and the European Space Agency. Our cosponsor, Google, will award generous prizes totaling $20,000 for the open competition. An additional $10,000 will be available for two student categories: a university design competition and an essay competition for students in high school and lower grades. The prizes will include travel money to present the top entries at professional conferences.

The purpose of the competition is to gather a large, diverse suite of entries that can make creative and useful contributions to space agencies' future human missions to asteroids. In addition, the competition and its supporting materials are intended to inspire innovative thought, help popularize the idea of a human asteroid mission, educate people about NEAs and other near-Earth objects (NEOs), and help grow a grassroots understanding of the context of such a mission in the bigger picture of solar system exploration and science.

Competition Process

The competition will be similar to the Planetary Society's Apophis Mission Design Competition. You can find out more about our Apophis competition at *planetary.org/apophis*. The Apophis competition was quite successful at generating high-quality entries from international companies and from university students and classes. Its emphasis was different, focusing on "tagging" a potentially dangerous asteroid, but the process of the new competition will be similar.

The teams that provided the winning entries for the Apophis competition are still involved with space agencies in related studies and activities. The Apophis competition was open to all—with some limitations on use of government funding—and had prizes for an open category as well as a student category. The human mission to an asteroid competition will be similar, though we are excited to be adding a category for 12th grade and below that will allow more young people to get involved.

Questions To Be Addressed by Studies

Planning a human mission to an asteroid involves many potentially fruitful areas of study. The competition will focus on mission design near and on the asteroid. Details of required elements and breadth of the requirements will be determined with the assistance of the competition advisory committee. The types of questions we may challenge competitors to answer include:

• What is the best way to approach and depart from the asteroid?

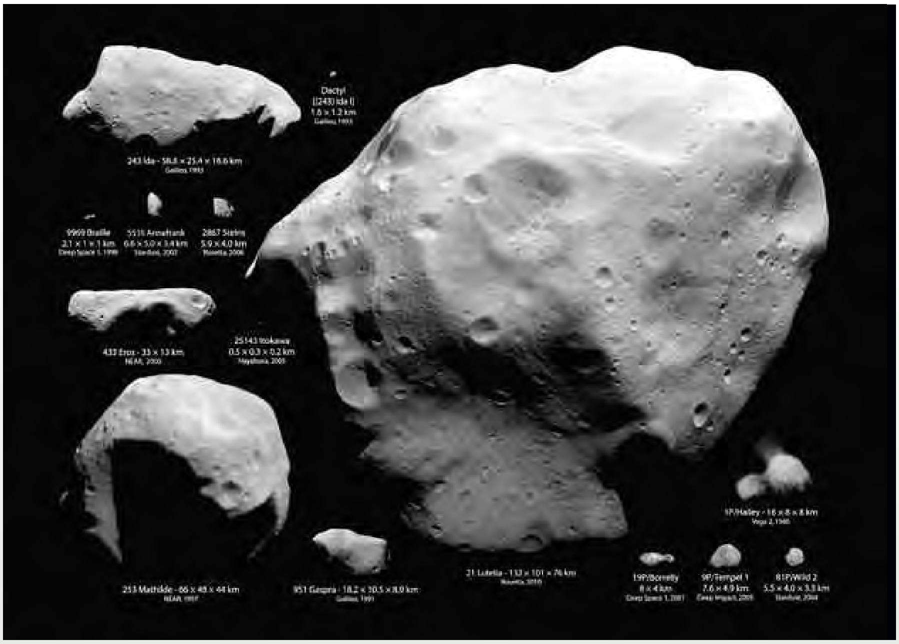
• How do you operate in a very-low-gravity environment? Do you anchor your spacecraft orbit nearby, and how do astronauts do EVA (extravehicular activity)?

• How do you collect samples, including from the subsurface?

• How do you deal with the general challenges of deep-space human exploration, such as radiation and communication delays?

• How do you handle operations in deep space? Near the asteroid? On the asteroid?

• What science and technology demonstrations do you perform at the asteroid?



The total of four comets and nine asteroid systems (including ten separate bodies) that have been examined up close by spacecraft are shown here to scale with each other (100 meters per pixel, in the fully enlarged version). Most of these were visited only briefly, in flyby missions, so we have only one point of view on each; only NEAs Eros and Itokawa were orbited and mapped completely. We have much still to learn about these rocky bodies. *Image: Montage by Emily Lakdawalla. Ida, Dactyl, Braille, Annefrank, Gaspra, Borrelly: NASA/JPL/Ted Stryk. Steins: ESA/OSIRIS team. Eros: NASA/JHUAPL. Itokawa: ISAS/JAXA/Emily Lakdawalla. Mathilde: NASA/JHUAPL/Ted Stryk. Lutetia: ESA/OSIRIS team/Emily Lakdawalla. Halley: Russian Academy of Sciences/Ted Stryk. Tempel 1: NASA/JPL/UMD. Wild 2: NASA/JPL*

Preparations Under Way

As this issue of *The Planetary Report* goes to press, we are assembling and working with an expert advisory committee to help us determine details of the competition rules, including the aspects of the mission and the questions on which we will focus. We are also determining the exact timing of the competition. I'll let you know here in *The Planetary Report* and on our website, *planetary.org*, when details are finalized and the competition is open.

Bruce Betts is director of projects for the Planetary Society.

WHAT'S UP?

In the Sky—October and November

Extremely bright Venus is visible low in the west after sunset through mid-October. Dimmer reddish Mars is just to Venus' upper right. In November, Mercury is near Mars low on the western horizon after sunset. The crescent Moon joins them on November 7. Very bright Jupiter dominates the eastern sky in the evening. The Moon appears near Jupiter on October 19 and November 15. Saturn is low in the predawn eastern sky in October, joined by Venus in November.

Random Space Fact

Jupiter's mass is two and one half times the mass of all the other planets in our solar system combined.

Trivia Contest

Our March/April contest winner is Kelly Goodnight of Paxton, Illinois. Congratulations!

The Question was: Commonly used to assist in the classification and characterization of stars, an H-R diagram is a plot of the temperature of many stars against their luminosities. What does H-R stand for?

The Answer is: Hertzsprung-Russell. The diagram was created around 1910 by Ejnar Hertzsprung and Henry Norris Russell.

Try to win a free year's Planetary Society membership and a Planetary Radio T-shirt by answering this question:

What was the name of the first cat in space?

E-mail your answer to *planetaryreport@planetary.org* or mail your answer to *The Planetary Report*, 85 South Grand Avenue, Pasadena, CA 91105. Make sure you include the answer and your name, mailing address, and e-mail address (if you have one).

Submissions must be received by December 1, 2010. The winner will be chosen by a random drawing from among all the correct entries received.

For a weekly dose of "What's Up?" complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to Planetary Radio at *planetary.org/radio.*

Questions and Answers

After reading your January/February 2010 issue on planetary defense, I notice that no mention was made of using solar sails to divert near-Earth objects from hitting our planet. Is any work being done in this field? If so, what?
—Suzanne Rathburn
Mendocino, California

The concept of using a solar sail to tow or tug a large asteroid has been proposed, but to do so would require an unrealistically large solar sail—larger than 1 kilometer (0.6 miles) on each side. Also, to assemble such a large solar sail in space would not be an easy task. Furthermore, it would not be feasible to attach an extremely large solar sail to a tumbling asteroid.

Solar sails do, however, have the potential to provide cost-effective, fuelless propulsion that would enable longer mission lifetimes and increased payload mass. Solar sails also could reach previously inaccessible orbits, such as retrograde heliocentric and non-Keplerian.

Propellantless solar sail propulsion, therefore, appears to be a realistic option for helping to solve the technically challenging problem of deflecting and/or exploring near-Earth objects, even if we can't attach the sail directly to the asteroid.
—BONG WIE,
Iowa State University

Some of the newly discovered exoplanets orbit their stars so closely that one might think they would have vaporized long ago—especially the huge gas planets. Just what is holding them together at such close range to their parent suns?
—Mike Martinez
Eagan, Minnesota

It definitely seems puzzling that hot Jupiters—some only one tenth the distance to their star that Mercury is to our Sun—can maintain their atmospheres at all. The big-picture answer is that the hot Jupiters are massive (hundreds of times the mass of Earth), so that they are able to hold on to their massive atmospheres. Hot Jupiters are also not hot enough to lose all of their atmospheres. To be more specific, hot Jupiters' atmospheres can be reach temperatures up to 2,000 kelvins (about 1,700 degrees Celsius or 3,100 degrees Fahrenheit) or even higher. This temperature, though hot, is not hot enough for the atmosphere to evaporate away.

Alternatively, the extreme ultraviolet radiation from the host stars can heat the planets' uppermost atmosphere (called the *exosphere*) to temperatures of 10,000 kelvins (about 10,000 degrees Celsius or 18,000 degrees Fahrenheit). Even in cases such as these, hot Jupiters can still maintain their masses, possibly losing only a few percent of their atmospheres over billions of years. To lose its atmosphere, a planet would have to be much hotter or much smaller. For example, an Earth-mass planet at 2,500 kelvins (about 2,200 degrees Celsius or 4,000 degrees Fahrenheit) would have most certainly lost its atmosphere.

Space scientists have, however, speculated that some hot Neptune-mass exoplanets—or even hot super-Earths —may be remnant cores of more massive planets whose atmospheres or envelopes were completely lost.
—SARA SEAGER,
Massachusetts Institute of Technology

When did we first transmit a signal that could be received and recognized by a SETI (Search for Extraterrestrial Intelligence) program on a planet in another solar system?
—Richard Kroll
San Jose, California

From an extraterrestrial point of view, the best evidence for our presence on Earth consists of radio signals. Although there were experimental radio broadcasts before 1910, the first commercial stations went on the air in the early 1920s. These were AM broadcasts, and all were tuned to relatively low frequencies, typically around 1 megahertz (MHz). For example, the current AM radio dial runs from 520 to 1,610 kilohertz (kHz)—although lower frequencies are found in Europe. Despite the fact that this part of the radio spectrum is perfectly serviceable for terrestrial use, AM broadcasts would be invisible to alien SETI experiments because of Earth's ionosphere. Extending hundreds of miles above our planet's surface, the ionosphere consists of multiple layers of air in which the molecules are dissociated by ultraviolet light from the Sun. The UV strips electrons off atoms of air, producing a plasma of charged particles and free electrons. The layer of ions acts as a radio mirror, bouncing low-frequency signals back toward Earth.

Only emissions above 30–50 Mhz can pass unhindered through Earth's ionosphere. Therefore, the first human-made signals that could sail into space were from FM radio, television, and radar, all of which operate at frequencies of about 100 MHz or higher. The first real (not on a closed circuit) TV broadcast occurred in England in 1936, and FM radio began at approximately the same time. (The first FM station to broadcast in the United States was W1XOJ in Boston, which initiated service in 1937.)

During World War II, both FM radio and TV were joined by radar transmissions, which are today the strongest terrestrial radio signals leaking into space. Roughly speaking, we can say that Earth has been sending detectable signals into space for 70 years—signals that have washed over roughly 15,000 nearby star systems. If any extraterrestrials wished to detect these signals, they would need large antennas, typically the size of a city. Such antennas are certainly not out of the question.

—SETH SHOSTAK,
SETI Institute

Factinos

After seven months of observing more than 156,000 stars in a search for Earth-sized extrasolar planets, the *Kepler* spacecraft has discovered the first confirmed planetary system with more than one planet transiting (crossing in front of) the same star. *Kepler* scientists first saw transit signatures of two distinct planets in data for the Sun-like star designated Kepler-9.

They refined the estimates of the planets' masses using observations from the W. M. Keck Observatory in Hawaii. Their observations show that Kepler-9b is the larger of the two planets, and both have masses similar to but less than that of Saturn. Kepler-9b lies closer to the star, with an orbit of about 19 days, while Kepler-9c has an orbit of about 38 days.

In addition to the two confirmed giant planets, the researchers also have identified (but not confirmed) what appears to be a third, much smaller transit signature in the observations of Kepler-9. That signature is consistent with the transits of a super-Earth-sized planet about 1.5 times the radius of our planet in a scorching, near-sun orbit taking approximately1.6 days.

—from NASA

The* Kepler *spacecraft has discovered two Saturn-mass planets in orbit around the star designated Kepler-9. The spacecraft detected the giant planets by observing the slight perturbations they cause when crossing in front of (transiting) their star. *Illustration: NASA/Ames/JPL-Caltech*

A team of scientists using the European Southern Observatory (ESO) in Chile have discovered a planetary system containing at least five planets orbiting the Sun-like star HD 10180. They also have evidence that two other planets may be present, one of which would have the lowest mass of any exoplanet ever found. This would make the system similar to our own in terms of the number of planets (seven, as compared with our eight). The team also found evidence that the distances of the planets from their star follow a regular pattern—also seen in our solar system—known as Bode's Law.

"We have found what is most likely the system with the most planets yet discovered," says the Geneva Observatory's Christophe Lovis. "This remarkable discovery also highlights the fact that we are now entering a new era in exoplanet research: the study of complex planetary systems and not just of individual planets. Studies of planetary motions in the new system reveal complex gravitational interactions between the planets and give us insights into the long-term evolution of the system."

The team used the HARPS spectrograph, attached to ESO's 3.6-meter telescope at La Silla, for a six-year-long study of the Sun-like star HD 10180, located 127 light-years away in the southern constellation of Hydrus. In their 190 individual HARPS measurements, the scientists detected the tiny back-and-forth motions of the star caused by the complex gravitational attractions from five or more planets. The five strongest signals correspond to planets with Neptune-like masses—between 13 and 25 Earth masses—that orbit the star with periods ranging from about 6 to 600 days. These planets orbit around their central star at distances between 0.06 and 1.4 times the distance from Earth to our Sun.

"We also have good reasons to believe that two other planets are present," says Lovis. One would be a Saturn-like planet (with a minimum mass of 65 Earth masses) orbiting in 2,200 days. The other would be the least massive exoplanet ever discovered, with a mass of about 1.4 times that of Earth. It orbits very close to its host star, at just 2 percent of the Earth–Sun distance. One "year" on this planet would last only 1.18 Earth-days.

—from the European Southern Observatory

For more information on these discoveries, visit
http://planetary.org/news/2010/0827_From_the_Ground_and_from_Space_New.html

Members' Dialogue

Stay Focused

I have been a Planetary Society Member almost since the group's founding, and I find it painful to criticize what I have said is my favorite organization, but I must comment on two developments in the direction the Society has taken. Both involve the Society's de facto and, I believe, unwitting abandonment—certainly for decades to come—of manned spaceflight as a part of the exploration of the solar system.

The most recent development is the Society's embracing of the Obama administration's cancellation of the Constellation program and the reliance on private companies for future spacecraft. Private companies are interested in profits and don't want those profits realized only in the distant future. We need a greater vision than this for solar system exploration. Mars is my preferred goal, but for this we need a clearly stated mission and a budget. We don't have either. Arguing that Constellation was underfunded, so that it is good that it was canceled, is a strange justification. The Society's usual position is to support adequate funding when missions are underfunded.

Recently, the Society sent a letter to its members asking for donations to support the administration's budget. It referred to members of Congress who support the Constellation program (due to projects in their states) as "special interest groups." Is this a term that also applies to members of Congress who support planetary missions that the Society advocates? This is a dangerous road to travel.

The second issue is including the environmental protection of Earth as a major component of the Society's efforts. Environmental protection is of paramount importance, but whereas the country has many environmental groups, only the Planetary Society (and the smaller Mars Society) focuses on promoting solar system exploration. Diverting the Planetary Society's money and energy from promoting exploration of the other planets and moons weakens this cause.

The Society should stay focused on its original goals—robotic and manned missions. Will the Planetary Society eventually change its name to the Earth Society? It wouldn't be the first time an organization morphed into an organization of a different nature.

—ROBERT J. DOUGLAS,
Mill Valley, California

Knowing Where to Look

I believe that Tim MacAfee's response to Stephen Hawking's possible explanations for why we haven't heard from aliens (in your July/August 2010 issue) is correct. Advanced alien civilizations possibly have developed a more exotic communications technology. If an alien race is sending out a dedicated broadcast to alert other civilizations across interstellar space of its existence, however, it would not use some exotic form of communications but, rather, something that could easily be detected and deciphered by any civilization that has achieved basic communication technology. Using exotic media that only that race could understand would defeat the intent of the transmission.

It makes no difference what level of communication technology an alien civilization may possess; sending a strong signal into deep space, hundreds to thousands of light-years away, would require a highly directional antenna system that would produce a highly directional, narrow-beam signal. We would also need a similar antenna system with high gain and directional capability. Currently, our SETI systems have the capability that we need.

The problem is that if the alien system is pointed directly at us but we are looking in a different direction, we will not hear the signal. This condition would also arise with the new optical SETI system. Alignment is the key to detecting alien transmissions.

I believe that alien transmissions are streaming across the galaxy, but knowing where to look and when to obtain the precise alignment needed is a more difficult task than finding a needle in a dozen haystacks.

—DAVID M. ARMOUR,
Fitchburg, Wisconsin

Tim McAfee's letter on why alien transmissions still go undetected by us was, indeed, intriguing. To suggest that they might considerably surpass our archaic methods of communications technology may have hit the nail on the head. We may well be sitting in the midst of a cacophony of interstellar conversations, as the writer indicates, and be totally unaware of it.

Considering the vastness of the universe and the countless civilizations that must exist in it, there is but one conclusion: we are still just too dumb!

—WILLIAM R. LAMPA,
Embarrass, Minnesota

Erratum:

Bill Nye the Science Guy® was coined by Bill Nye's dear friend Ross Shafer. His name was left out of the article "Passing the Torch: The Planetary Society's New Executive Director," which appeared in the July/August 2010 issue of *The Planetary Report*.

Please send your letters to
Members' Dialogue
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Society News

Planetary Society Open House on YouTube

Perhaps it was an impossible dream: the staff wishing that all of our members and supporters could attend our Planetary Society Open House. If you didn't attend in person—or even if you did—we invite you to join us on a virtual tour, a video showcasing our new headquarters and some of our staff. Find it on our YouTube channel at *youtube.com/planetarysociety*.
—Lu Coffing, Financial Director

Victoria Robinson in the Volunteer Spotlight

Victoria Robinson, the 11-year-old daughter of longtime Planetary Society volunteer Willie Robinson, recently attended the New York event "Solar Sailing: Pathway to the Stars" with her father. There she met our current and exiting executive directors, Bill Nye and Lou Friedman, and was inspired to write her own essay about solar sailing and her father's volunteer work to promote the Planetary Society in his community.

Bill Nye with Victoria. Photo: The Planetary Society

You can read her essay and see more pictures at *planetary.org/participate/volunteer/*.
—Susan Lendroth, Manager of Events and Communications

Ray Bradbury's 90th Birthday Celebration

On August 20, two days before Ray Bradbury turned 90, the Planetary Society presented the acclaimed author with a giant birthday card at a city council meeting at Los Angeles' City Hall, during which the council approved a resolution proclaiming August 22–28, 2010 "Ray Bradbury Week." Louis Friedman testified on behalf of the resolution and personally gave Ray the card, filled with heartfelt wishes from our Members and other fans.

More than 1,600 people shared how much Bradbury's stories, novels, and plays have meant to them through the years.

Bradbury's extraordinary body of work includes *The Martian Chronicles*, *Fahrenheit 451*, and a vast collection of stories, poems, and plays. His famous collection of stories *The Martian Chronicles* traveled to the planet Mars aboard the *Phoenix* lander as part of a mini-DVD created by the Planetary Society, titled *Visions of Mars*. Ray Bradbury is also a longtime Planetary Society Advisory Council Member.
—SL

Become a Planetary Society Legacy Member

Would you like to make a gift to the future? You can, as a Planetary Society Legacy Member.

Your planned gift to the Planetary Society, whether it's cash, transfers of real estate, or naming the Society as the beneficiary of an insurance policy, makes a difference.

To become a Legacy Member, you must plan to benefit the Planetary Society after your lifetime—whether in the form of a bequest or another planned giving arrangement—and notify the Society of your plans. You don't need to tell us the financial details, although this information can be helpful in our long-term financial planning.

Your planned gift will help ensure that our projects, whether searching for life and other worlds, embarking on innovative missions like *LightSail*, or advocating for a strong and effective space program, will enjoy continued success.

To learn more about, or to join the Planetary Society Legacy Society, please contact Andrea Carroll, Director of Development, at *andrea.carroll@planetary.org* or (626) 793-5100, extension 214.

Thank you to all of you who have already named the Planetary Society in your will or estate plan.
—Andrea Carroll, Director of Development

You Can Invent Our Future

It goes without saying. As a Planetary Society Member, you are passionate about space exploration. You understand how important it is to extend our reach to other worlds and to seek life on other planets.

Thanks to you and your fellow Members around the world, we are shaping space exploration. And thank you to those of you who have taken your commitment even further as Members of the Planetary Society's New Millennium Committee.

New Millennium Committee Members give generously, from $500 to $30,000 in an unrestricted annual donation, to ensure that the Society can move swiftly and nimbly—whether it's to support a crucial mission or to rally for significant funding for NASA, or to partner on an innovative project that might otherwise wither.

To learn more about the New Millennium Committee or to join, please visit our website at *planetary.org/nmc* or contact Andrea Carroll, Director of Development, at *andrea.carroll@planetary.org* or (626) 793-5100, extension 214.

Cheers to all you New Millennium Committee Members—and a warm welcome to future Members!
—AC

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In *Venus Vulcanism*, Ron Miller depicts bright, molten lava spilling onto Venus' baked and desolate surface. Recent data from the Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) on *Venus Express* suggest that lava flows around several large volcanoes are no older than 2.5 million years and may be less than 250,000 years old—young enough to suggest that Venus might still be volcanically active. The discovery that Venus is still alive, and the study of how it has resurfaced over the past billion years, could give scientists greater insight into interior dynamics and climate change—there and here.

For more than 30 years, Ron Miller has been a freelance illustrator. His primary work today focuses on writing and illustrating astronomical, astronautical, and science fiction books. His *Worlds Beyond* series received the American Institute of Physics Award of Excellence, *The Art of Chesley Bonestell* received a Hugo Award, and the Astronomical Society of the Pacific has called *The Grand Tour* a "modern classic."