Nā Kilo Hōkū
THE ONES WHO LOOK TO THE STARS
A Newsletter from the Institute for Astronomy, University of Hawai`i
No. 42 - 2012

From the Director

Dear Friends of the Institute for Astronomy,

It was only a few years ago that many professional astronomers considered extragalactic astronomy—the study of the Universe outside our Milky Way galaxy—the hot topic, and planetary research not so interesting. But that has changed with the discovery of what are called extrasolar planets, that is, planets orbiting stars other than our Sun. In addition to the hundreds of extrasolar planets found by ground-based astronomers, the Kepler spacecraft has found over 2,300 planet candidates and so far confirmed 61 of them, so this field is growing at an explosive rate.

IfA already has several faculty members who work on planetary science, including studies of our own solar system (see the articles "Earth's Other Moons" and "Potentially Habitable Planet Found Orbiting Nearby Star" in this issue). Now many up-and-coming astronomers are choosing to study planetary bodies in our solar system and beyond.

We recently advertised two junior faculty positions and were overwhelmed by the number (almost 250) of excellent applications we received. It is clear that astronomers see the IfA as an attractive place to work. We invited and interviewed nine top candidates. Several of them were interested in extrasolar planets, and we have made offers to two of these. We are convinced that the results of this recruitment will give the IfA a chance to excel in this area of astronomy even more than we already do.

Aloha!
Günther Hasinger
Director, Institute for Astronomy

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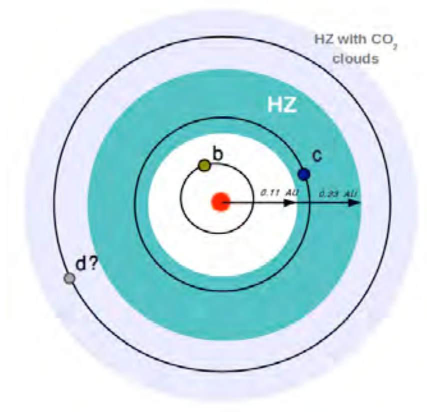
Potentially Habitable Planet Found Orbiting Nearby Star

IfA astronomer Nader Haghighipour is a member of an international team of scientists that has discovered a potentially habitable orbiting a nearby star. The planet is categorized as a super-Earth planet, which means it is two to ten times more massive than Earth. This discovery demonstrates that habitable planets could form in a greater variety of environments than previously believed.



GJ 667C planetary system showing the orbits of the planets b, c (the potentially habitable one), and d (not yet confirmed). The habitable zone (HZ) in which liquid water could exist is shown in blue. The outer gray circle could be an extended HZ if a planet's atmosphere contains a large amount of warming carbon dioxide (CO_2). An astronomical unit (AU) is the distance between Earth and the Sun. Credit: G. Anglada-Escudé.

The M-class dwarf star called GJ 667C, which is 22 light-years away from Earth, had previously been observed to have a super-Earth (called GJ 667Cb) that orbited the star in only 7.2 days, making it too close to the star, and thus too hot, to support life. The study started with the aim of learning more about the orbit of GJ 667Cb. But the research team found a clear signal of a new planet (GJ 667Cc) with an orbital period of 28.15 days and a minimum mass of 4.5 times that of Earth. The new planet receives 90 percent of the light that Earth receives. However, because most of its incoming light is heat (infrared light), a higher percentage of this incoming energy should be absorbed by the planet. When both these effects are taken into account, GJ 667Cc should absorb about the same amount of energy from its star that Earth absorbs from the Sun. This would allow surface temperatures similar to Earth and perhaps liquid water, but this cannot be confirmed without further information on the planet's atmosphere.

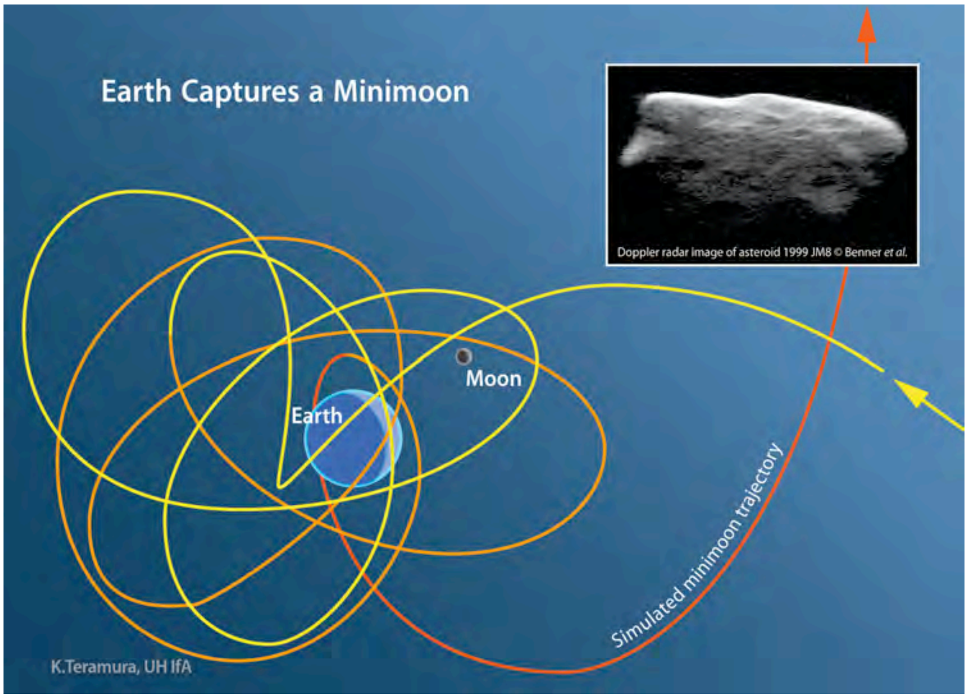
"This planet is the new best candidate to support liquid water and, perhaps, life as we know it," team leader Guillem Anglada-Escudé said. "The detection of this planet is strong evidence that our strategy in choosing M stars as potential hosts for habitable planet is correct and has been successful," said Haghighipour, who is a member of the UH NASA Astrobiology Institute. M stars are smaller than our Sun.

The team used public data from the European Southern Observatory and analyzed it with a novel data analysis method. They also incorporated new measurements from the Keck Observatory's High Resolution Echelle Spectrograph in Hawai'i and the new Carnegie Planet Finder Spectrograph at the Magellan II Telescope in Chile. They used the planet-finding technique that involves measuring the small wobbles in a star's orbit in response to a planet's gravity.

GJ 667C is a member of a triple-star system and has less metallic elements (those heavier than hydrogen and helium) than our Sun. The other two stars in the triple system (GJ 667AB) also have a small concentration of heavy elements. Since such elements are the building blocks of terrestrial planets like Earth, the team thought it was unusual for a metal-depleted star system to have an abundance of low-mass planets.

Haghighipour recently received a Humboldt Research Fellowship for Experienced Researchers to work on planets in binary star systems. As part of that award, he will spend 2013 in Germany at the Max Planck Institute for Astronomy in Heidelberg and the University of Tübingen. Haghighipour has edited a book entitled *Planets in Binary Star Systems*, and he is a member of the planet-binary working group of the Kepler Space Telescope, which is searching for habitable planets.

Earth's Other Moons



Earth captures a minimoon. The path of a simulated minimoon that is temporarily captured by Earth. The object approaches Earth from the right along the yellow line and continues on its trajectory along the orange path and finally escapes capture along the red path to the upper right. The size of Earth and the Moon are not to scale but the size of the minimoon's path is to scale in the Earth-Moon system. Inset: Radar image of near-Earth asteroid 1999 JM8 made with NASA's Goldstone Solar System Radar in California and the Arecibo Observatory in Puerto Rico. This two-mile-diameter asteroid is more than a thousand times larger than the biggest minimoons, but it shows the irregular shape and pockmarked surface expected on the much smaller minimoons.

Earth usually has more than one moon, according to a team of astronomers from the University of Helsinki, the Paris Observatory, and the IfA.

Our 2,000-mile-diameter Moon, so beloved by poets, artists, and romantics, has been orbiting Earth for over 4 billion years. Its much smaller cousins, dubbed "minimoons," are only a few feet across and usually orbit our planet for less than a year before resuming their previous lives as asteroids orbiting the Sun.

Mikael Granvik (formerly at IfA and now at Helsinki), Jeremie Vaubaillon (Paris Observatory), and Robert Jedicke (IfA) calculated the probability that at any given time Earth has more than one moon. They used a supercomputer to simulate the passage of 10 million asteroids past Earth. They then tracked the trajectories of the 18,000 objects that were captured by Earth's gravity.

They concluded that at any given time there should be at least one asteroid with a diameter of at least one meter orbiting Earth. Of course, there may also be many smaller objects orbiting Earth, too.

According to the simulation, most asteroids that are captured by Earth's gravity would not orbit Earth in neat circles. Instead, they would follow complicated, twisting paths. This is because a minimoon would not be tightly held by Earth's gravity, so it would be tugged into a crazy path by the combined gravity of Earth, the Moon, and the Sun. A minimoon would remain captured by

Earth until one of those tugs breaks the pull of Earth’s gravity, and the Sun once again takes control of the object’s trajectory. While the typical minimoon would orbit Earth for about nine months, some of them could orbit our planet for decades.

"This was one of the largest and longest computations I've ever done,” said Vaubaillon. "If you were to try to do this on your home computer, it would take about six years.”

In 2006, the University of Arizona’s Catalina Sky Survey discovered a minimoon about the size of a car. Known by the unimaginative designation 2006 RH120, it orbited Earth for less than a year after its discovery, then resumed orbiting the Sun.

"Minimoons are scientifically extremely interesting,” said Jedicke. "A minimoon could someday be brought back to Earth, giving us a low-cost way to examine a sample of material that has not changed much since the beginning of our solar system over 4.6 billion years ago.”

The team’s paper, "The population of natural Earth satellites,” appears in the March issue of the journal *Icarus*.

The team used the Jade supercomputer at the National Computer Center for Higher Education (Centre Informatique National de l'Enseignement Supérieur, or CINES) at Montpelier, France.

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A Day in the Life of IfA's Maui Laboratories

The Advanced Technology Research Center.

The laboratories at IfA's Advanced Technology Research Center (ATRC) on Maui are one of IfA's best-kept secrets. Opened in September 2007, the ATRC (also called Maikalani) is a unique Hawai'i facility for the design and construction of advanced instrumentation for remote sensing (the study of objects or phenomena from a distance using light).

Located in Pukalani, less than an hour from the summit of Haleakalā, the ATRC was designed to fulfill both the needs of the IfA, which anticipated that the Advanced Technology Solar Telescope (ATST) would be built on Maui and would need instruments, and of the local high-tech community, which helps the Air Force develop new instruments for its telescopes on Haleakalā. The State of Hawai'i provided funding for the construction, and competitive grants from the Air Force provided several million dollars that were matched with state capital funding for the sophisticated laboratory equipment. The goal was to provide a powerful resource for advanced microfabrication (the miniaturization of technical components), metrology (the scientific study of measurement), and optical testing. These laboratories are used by the local Maui technology community, and have been important for attracting several millions of dollars in other instrument projects to the IfA.

A group of four laboratory workspaces are linked to an outdoor coelostat, a device with a computer-controlled mirror that directs solar, stellar, or other light into these labs. Each of these is equipped with optical tables and mounts, as well as a variety of other complex tools for developing scientific instrumentation.

In the first workroom, which houses the detector lab and a precision laser cutting machine, IfA astronomer Haosheng Lin is developing a spectrograph for the National Solar Observatory at Sacramento Peak, while Masato Kagitani (a scientist from Tohoku University, Japan, here on a year-long visit) is using the laser system to build fiber bundle arrays for imaging spectroscopy and polarimetry. He is developing instrumentation for the PLANETS project (a new telescope that will search for planets outside our solar system) and SOLARC (a prototype telescope for ATST) on the summit of Haleakalā.

In the second workroom, IfA postdoctoral researcher David Harrington and IfA astronomer Jeff Kuhn are working on a novel precision polarimeter using fast liquid crystals and charge-shifting

Graduate student Ryan Swindle calibrating the all-sky polarimeter at the ATRC.

detectors. Harrington competes for lab space with IfA scientist Joe Ritter, who is using a different kind of liquid crystal to control futuristic membrane mirror shapes. This lab also houses the optics for a nighttime telescope made of ultrathin glass that Stan Truitt (IfA adjunct optical scientist) and Ritter have been optically testing, and that will soon move to an existing observatory on the Haleakalā summit.

In lab 3, graduate student Ryan Swindle is building a precise all-sky polarimeter for use with several telescopes on the summit of Haleakalā. Here he is also characterizing an infrared camera that is set up in this lab for eventual spectropolarimetry experiments with SOLARC. Swindle and Kagitani (with Kuhn) are also preparing their detectors and fiber-bundle imaging experiments for the upcoming transit of Venus.

In lab 4, graduate student Dani Atkinson is using the coelostat for her novel polarimetry experiment that will make ultrasensitive planetary polarization observations. She competes with three other experiments for coelostat time: Jon Valliant (UH Maui College engineering student) is working on a daylight imaging project, an attempt to image satellites during the day. Its purpose is to keep track of satellites and "space junk" that may harm our satellites or the International Space Station, or come crashing down to Earth. IfA astronomer Stuart Jefferies is debugging a novel solar oscillation instrument designed to solve the mystery of the temperature structure of our star. Kuhn is measuring sunlight at far-infrared wavelengths using the Fourier transform spectrometer, an instrument used for high-resolution spectroscopy, located in lab 3, to find ways of seeing cold molecular solar "dark matter."

These are just some of the novel optical technology developments that are ongoing at the ATRC, and in future issues of this newsletter, we hope to explain some of them in more detail.

Glossary:

Spectroscopy: The branch of science concerned with measuring spectra produced when matter interacts with or emits electromagnetic radiation. For more information, see issue no. 37 of this newsletter.

Spectrograph: A device for dispersing light into a spectrum so that the intensity of each wavelength can be recorded.

Polarimeter: An instrument for measuring the polarization of light (polarimetry), which is the phenomenon in which light waves vibrate in a preferred plane or planes, or the process of confining the vibrations to certain planes.

Imaging spectroscopy and spectropolarimetry: The use of sensitive measurements of both the spectroscopic and polarization properties of light to reveal properties of the light's source or point of last scattering. An imaging system combines these measurements with an instrument that can distinguish the properties of distinct image points.

The editor wishes to thank Jeff Kuhn and all the other IfA staff members at the ATRC who contributed to this article.

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Stockton, Shih Aided Significant Supernova Study

Observing a "once-in-a-generation" supernova visible for just 10 minutes became the challenge for IfA astronomers Alan Stockton and Hsin-Yi Shih in August 2011. On the morning of August 25, Stockton received an urgent email from UC Berkeley scientist Peter Nugent. Would Stockton, who was working at the Keck II Telescope on Mauna Kea that night, observe "a new nearby supernova" discovered the previous night by a telescope in California?

Stockton and Shih would have only 10 minutes to make the observations between the time when it grew dark enough to see the supernova and the time when it moved out of range of the Keck. Waiting until the next night meant it would be visible for an even shorter time.

At 21 million light-years from Earth, the supernova (SN 2011fe) is considered very close by cosmic standards. The exploding star was also discovered very early, just after its light first reached Earth, giving astronomers an exceptional opportunity to observe the evolution of its brightness and the spectra of its energy emitted over time. Stockton and Shih fulfilled the request, and in return became co-authors on papers using the data, one of which is published in the December 15 issue of the journal *Nature*.

"I am glad we were able to assist in a discovery of this magnitude," Stockton said. "It was clearly an opportunity that does not come along very often, and it was not a major imposition on our own program." Shih, a graduate student, added, "It was a thrill to participate in such a momentous study this early in my career."

The discovery enables scientists for the first time to exclude red giant stars as the companion of the white dwarf star that explodes as a Type Ia supernova, and gives a better idea of how these supernova explosions occur.

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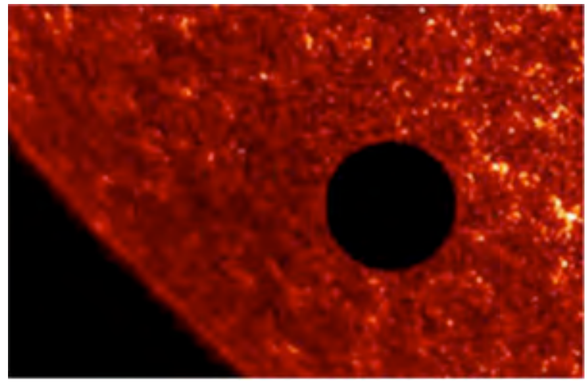
Join IfA for a Rare Transit of Venus on June 5



The 2004 transit of Venus as taken by NASA's Sun-observing TRACE spacecraft. Image credit: NASA/LMSAL

On the afternoon and evening of June 5, people in Hawaiʻi will have the rare opportunity to view the planet Venus cross the disk of the Sun. This is the last time this will happen in our lifetimes: The next transit of Venus will occur in 2117.

The IfA will set up telescopes equipped with special solar filters for public viewing on Waikīkī Beach near Kapahulu Avenue, near the Pacific Aviation Museum on Ford Island, and at Ko Olina near Lagoon 4. In Waikīkī, we hope to follow the viewing with entertainment and a Sunset on the Beach movie with an astronomy theme. We plan to distribute free “eclipse shades” that will allow individuals to look at the Sun safely at all three locations, as well as at our Mānoa Open House on April 29. For updates on activities related to the transit, see our transit web page (www.ifa.hawaii.edu/transit/).

On Hawaiʻi Island, there will be telescope viewing at the Mauna Kea Visitor Information Station (tinyurl.com/72z7wd3). ʻImiloa Astronomy Center in Hilo is also planning some activities related to the transit, including having NASA webcast of the transit playing in their lobby and telescope viewing on their lawn (weather permitting) free of charge. Go to their website (imiloahawaii.org) for the full schedule and the latest updates.

The NASA webcast of the transit (www.nasa.gov/multimedia/podcasting/nasaedge/) will originate from the summit of Mauna Kea.

Venus will appear as a small dark spot moving across the Sun. **Never look directly at the Sun without proper eye protection.** Sunglasses do **not** provide enough protection. More safety information is available at transitofvenus.org/june2012/eye-safety.

In Hawaiʻi, this event has a special historical significance, for it echoes a transit of Venus that occurred during the reign of King David Kalākaua. On December 8, 1874, a British expedition made the first scientific astronomical observations in Hawaiʻi by observing the transit from a site near the corner of Punchbowl and Queen Streets in Honolulu, as well as from locations in Waimea on Kauaʻi and Kailua-Kona on Hawaiʻi. They observed the transit to gather data that would be used to determine the precise distance between Earth and the Sun, and thereby, to measure the size of the solar system. For more information about the 1874 transit expedition in Hawaiʻi, see an illustrated lecture given by science historian Michael Chauvin at the Smithsonian Institution in 2004 (transitofvenus.org/history/1874-1882/278-between-captain-cook-and-mauna-kea).

Hawaiʻi and Alaska are the only places in the United States where this event can be viewed in its entirety. In the contiguous 48 states, the Sun will set before the transit is over. In Honolulu, the transit will begin at 12:10 p.m. and end at 6:45 p.m. Because Hawaiʻi is one of the best places to view this happening, it is attracting many visitors to our state.

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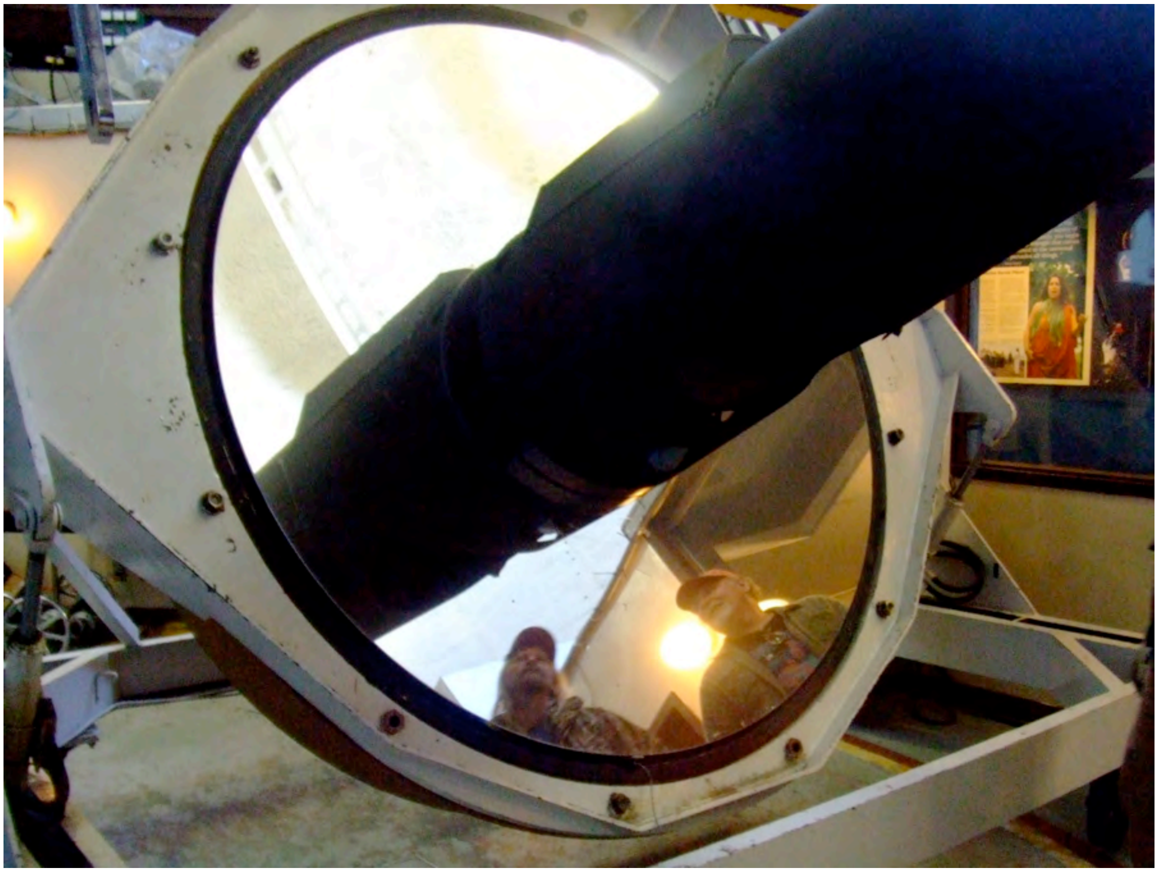
UH Telescope Upgrades Delayed by Drive Problem

by Colin Aspin



The mirror of the UH 2.2-meter telescope shows the reflections of Greg Osterman (right) and Colin Aspin.

The University of Hawai‘i 2.2-meter telescope has been located on the volcanic peak of Mauna Kea on the Big Island of Hawai‘i for over 40 years. It was the first large telescope on the mountain and has produced many exciting discoveries, including the detection of the first outer solar system Kuiper Belt object. During the last two decades, however, it has been overshadowed by the newer, larger telescopes on Mauna Kea. But even over this period, the UH88, as it is colloquially called (it was originally named the UH 88-inch telescope), has remained the workhorse for astronomical research for the faculty and graduate students at the Institute for Astronomy. For while IfA astronomers have access to all the larger telescopes on Mauna Kea, the 2.2-meter telescope is the only professional telescope on Mauna Kea that is totally controlled by UH. Now, however, its age has become increasingly detrimental to the efficiency and productivity of the astronomers using it.

In the mid-2000s, IfA developed a plan to replace the UH88 with either a modern survey telescope (such as Pan-STARRS) or a larger telescope. However, for many reasons, including the economic downturn of the late 2000s, these plans have not yet become a reality, so we are continuing our efforts keep the UH88 operational and scientifically productive for at least another five years. This is proving to be a rather challenging task requiring significant effort and ingenuity from the small, dedicated team of engineers and scientists working on it. We have started around

20 upgrade projects aimed at improving the reliability and efficiency of the telescope and instrumentation.

Unfortunately, these upgrades are now on hold while we solve a more serious problem—a fault with the telescope hour angle drive, which enables the telescope to track astronomical objects as they rise and set. Recently, this drive has begun to fail to complete movements and to stop while following astronomical objects. The components of the drive are all over 40 years old, and our engineering team has been studying their design and operation while attempting to track down the source of the failure.

The detective work involved in tracking down the cause of this problem has so far involved checking five different systems. First, we looked at the high-level computer programming to understand what event triggers the error that stops the telescope motion. Next, we examined the motion control electronics, that is, the signals between the telescope control computer and the telescope itself. The third system checked was the mechanics. We confirmed that the gears, shafts, bearings, and brakes forming the hour angle drive operate correctly. Fourthly, we checked the hydraulic pump and pressure lines to make sure they are working and leak-free. Having ruled out problems with those systems, we finally examined the oil viscosity.

The telescope has a hydrostatic oil bearing that is supposed to have a thickness of 8 thousandths of one inch for reliable operation. The oil used has to possess very specific viscosity characteristics over the operating temperature of the oil, which is 32° to 68° F (0° to 20° C). The oil originally used in the hydrostatic bearing was called Mobil “Flying Horse" oil, but unfortunately the company terminated production around 15 years ago. A replacement oil was installed around five years ago, and this was deemed the best possible substitute then available. However, after much investigation, it is seeming more and more likely that either the viscosity characteristics of that oil are not close enough to those of the original oil, or that the oil has become contaminated over time. After an in-house study of oil characteristics, 150 gallons (nearly 600 liters) of a more modern synthetic oil have been ordered, and we hope that this will solve our current dilemma.

Once the problem with the hour angle drive is resolved, and normal observing has been resumed, we will again turn our attention to our upgrade projects. More on those in the next issue of this newsletter.

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Support the IfA through Planned Giving

by Donna Bebber

IfA salutes Mark and Jo Ann Schindler (center) for including IfA in their will. These two UH alumni devoted their careers to teaching astronomy and physics, library services, and community work for our state. Their bequest will benefit our community by supporting IfA's outreach programs for generations to come. Also pictured (left to right) UH Mānoa Chancellor Virginia Hinshaw; IfA Director Günther Hasinger; Chip Fletcher, associate dean, School of Ocean and Earth Science and Technology; and Greg Willems, vice president for development, UH Foundation.

Planned giving helps you meet your personal, financial, and estate planning goals by making a lifetime or testamentary charitable gift. Here are some examples of how you can plan your estate to best suit the needs of yourself, family, and the IfA and other charities that you want to support.

A charitable bequest is one of the easiest ways you can leave a lasting impact on the IfA. A bequest may be made in your will or trust by directing a gift to the IfA through the University of Hawaiʻi Foundation (UHF).

If you are looking for a secure source of fixed income, now or in future, and are tired of living at the mercy of the fluctuating stock and real estate markets, a charitable gift annuity may be the right solution for you.

You may be concerned about the high cost of the capital gains tax upon the sale of your appreciated property. Or perhaps you recently sold property and are looking for a way to save on taxes this year and plan for retirement. In that case, a charitable remainder unitrust or a charitable annuity trust might be right for you. A charitable remainder unitrust may be especially useful if your appreciated assets (such as stock, bonds or real estate) are producing little or no income.

There are two other ways your property may benefit the IfA. In a bargain sale, the UHF would purchase your property for less than fair market value. You receive the cash and a charitable deduction for the difference between the market value and purchase price. A life estate reserve may be the right solution if you desire to leave your home or farm to the UHF at your death, but would like to receive a current charitable tax deduction.

If you are looking for a way to pass on some of your assets to your family while reducing or eliminating gift or estate taxes, a charitable lead trust is an excellent option. Another alternative is the give it twice trust, which allows you to transfer your IRA at death to a term of years unitrust. The unitrust will pay income to your family for a number of years and then distribute the balance to the UHF.

The information above was taken from the University of Hawaii Foundation website. Please go to uhflegacygift.org or contact Donna Bebber at bebber@ifa.hawaii.edu for additional information.

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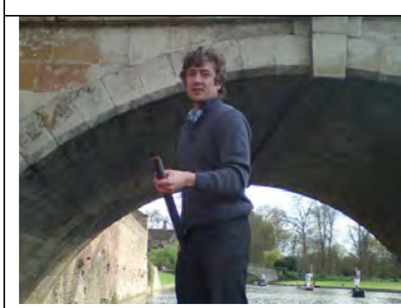
More Postdocs

We just didn't have room for all of the new postdoctoral fellows in the last issue, so here are a few more.

	**Hsin-Fang Chiang** (PhD, 2011, University of Illinois at Urbana-Champaign) is an experienced optical, submillimeter, and radio astronomy observer. She is based in Hilo and is working with faculty member Bo Reipurth in the area of star formation.
	**Brendan Hermalyn** (PhD, 2011, Brown University), an astrobiology postdoctoral fellow, studies hypervelocity impact physics and cratering problems through computational simulations and high-speed experimental measurements at the NASA Ames Vertical Gun Range facility. He has been involved with the Deep Impact, LCROSS, DIXI, and Stardust-NExT space missions. He is interested in solar system cratering processes, including volatile retention and excavation, aerodynamics, and the development of spaceborne instrumentation.
	**Eric Hilton** (PhD, 2011, University of Washington) studies low-mass stars and the planets around them. He works both at IfA and the Department of Geology and Geophysics, since his advisor is Eric Gaidos, a professor in the latter. He is very interested in communicating science to the general public and encouraging diversity in science. Prior to attending astronomy graduate school, he was a Peace Corps volunteer in Guyana, South America, where he taught science in a secondary school.
	**James Stephenson** (PhD 2011, University of Cambridge, UK) is a biologist who wrote his dissertation on the 3D structure of RNA in HIV. As an Astrobiology Postdoctoral Fellow, he studies the 20 amino acids, out of thousands, that encode life. He holds an undergraduate degree in genetics, a master's in bioinformatics, a second master's in mathematical biology, and PhD in medicine.

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Upcoming Events

O'ahu Events: call (808) 956-8566 www.ifa.hawaii.edu/specialevents/
Sunday, April 29, Annual IfA Mānoa Open House, 11 a.m.–4 p.m.

Maui Events: call (808) 573-9516
Maui Maikalani Community Lectures usually occur on the second Friday of the month.

Hawai'i Island Events: (808) 932-2328 or fujihara@ifa.hawaii.edu
Saturday, May 5, AstroDay Festival, Prince Kūhiō Plaza, Hilo, 10 a.m. to 4 p.m.

All Islands: Tuesday, June 5, Transit of Venus, approximately 12:10 p.m. to 6:45 p.m.
www.ifa.hawaii.edu/transit/

VISITING MAUNA KEA
The Onizuka Center for International Astronomy Visitor Information Station (VIS) at Hale Pōhaku (9,300-foot level of Mauna Kea) is open daily, 9:00 a.m. to 10:00 p.m.
"The Universe Tonight" features recent discoveries, 6:00 p.m., first Saturday of every month.
Lecture on the cultural aspects of Mauna Kea, 6:00 p.m., third Saturday of every month.
Public stargazing nightly from 6:00 to 10:00 p.m.
Escorted summit tours begin at the VIS at 1:00 p.m. on Saturday and Sunday. For essential information, www.ifa.hawaii.edu/info/vis/visiting-mauna-kea/summit-tours.html

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