Nā Kilo Hōkū

THE ONES WHO LOOK TO THE STARS

No. 41 • 2011

A Newsletter from the Institute for Astronomy University of Hawai'i

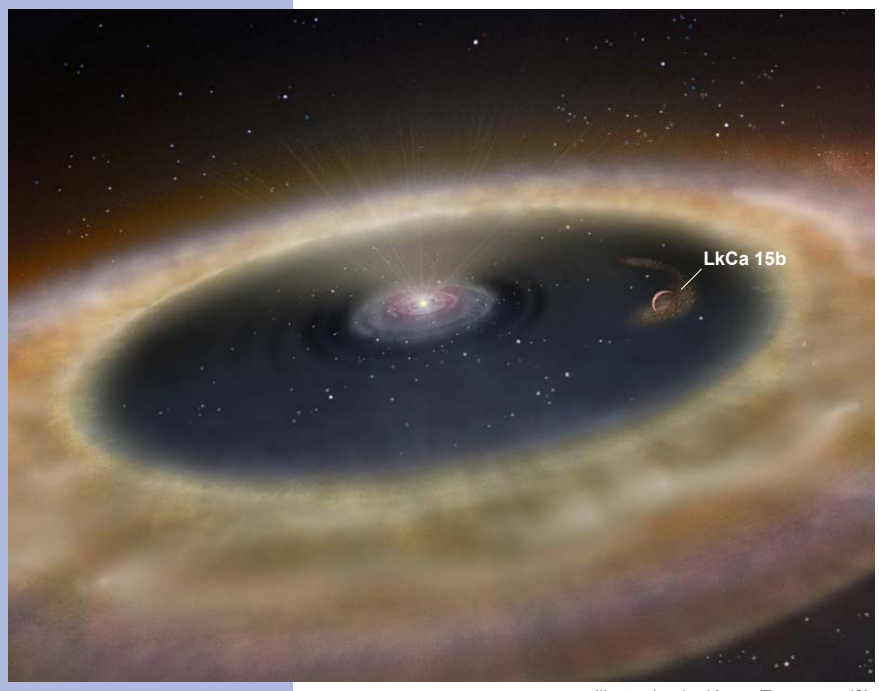


Illustration by Karen Teramura, IfA

Artist's conception of the forming planet LkCa 15 b orbiting its star. The young planet is surrounded by an outer disk of dust.

Kraus Finds Planet in the Process of Forming

IfA postdoctoral fellow Adam Kraus and Australian colleague Michael Ireland have taken the first direct image of a planet in the process of forming around its star. What astronomers are calling LkCa 15 b looks like a hot "protoplanet" surrounded by a swath of cooler dust and gas, which is falling into the still-forming planet. Images have revealed that the forming planet sits inside a wide gap between the young parent star and an outer disk of dust.

"LkCa 15 b is the youngest planet ever found, about five times younger than the previous record holder," said Kraus. "This young gas giant is being built out of the dust and gas. In the past, you couldn't measure this kind of phenomenon because it's happening so close to the star. But, for the first time, we've been able to directly measure the planet itself as well as the dusty matter around it."

Please see **Forming Planet, pg 2**

Join us for our upcoming public screening of "The City Dark" and discussion with filmmaker Ian Cheney and astronomer Richard Wainscoat on Wednesday, January 4, 2012. See page 7.

What's Inside

History: IfA's First Large CCD Mosaic Camera

by Louise Good

The previous issue (no. 40) of this newsletter stated that a camera designed and built at the IfA played a key role in the research that led to the 2011 Nobel Prize in physics. This camera, called the UH 8K CCD Mosaic Camera (UH8K for short) because it had 8192 x 8192 pixels (64 megapixels), contained the first of the new generation of large-format CCD mosaics.

The UH8K was designed and built to be used on the 3.6-meter Canada-France-Hawaii Telescope (CFHT) and occasionally at the UH 2.2-meter telescope, both on Mauna Kea. The camera was built at the IfA Detector Laboratory in Mānoa and saw first light at the CFHT in March 1995 and on the UH 2.2-meter telescope in August 1995.

The UH8K was built entirely by a team of only three people. Gerard Luppino, then an IfA astronomer who now heads GL Scientific, a Honolulu company that provides custom design and manufacturing services for scientific instruments, led the project as the principal investigator. He was also the designer, machinist, mechanical technician, and electronics technician. Postdoctoral fellow Mark Metzger wrote all the software. He left IfA to become a professor at Caltech and is now a senior research scientist at a hedge fund management company in New York.Visiting scientist Satoshi Miyazaki came from the National Astronomical Observatory of Japan. He subsequently built Suprime-Cam, *Please see* **CCDs pg 3**

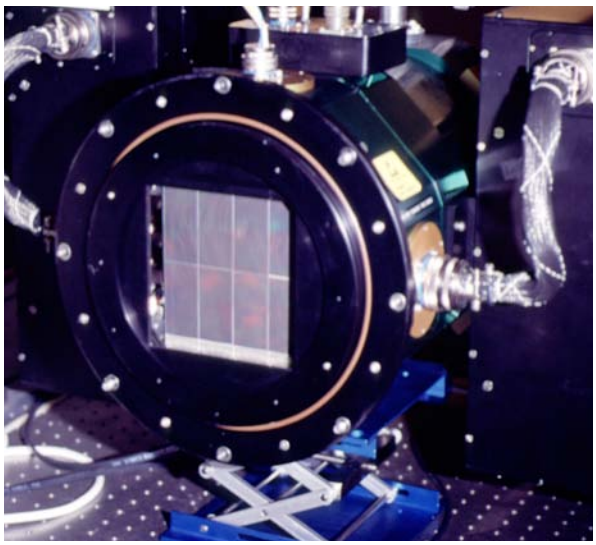
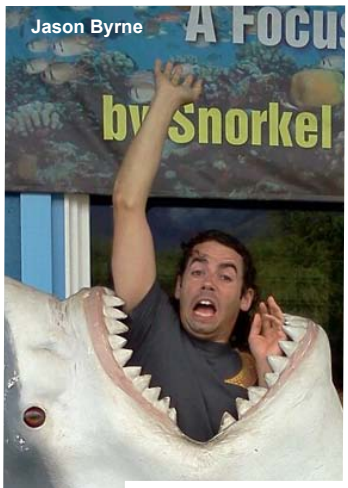


Photo by Richard Wainscoat, IfA

A team of only three people built the UH8K camera for less than $300,000 in only seven months At the time, it was the largest CCD camera in the world.

New Postdoctoral Researchers at the Institute for Astronomy



Each year, a new crop of postdoctoral researchers, many with freshly granted PhDs, arrives at IfA. Some bring national research grants, such as Hubble Fellowships. Others are supported by grants to IfA faculty.

Jason Byrne arrived in Hawai'i from Dublin, Ireland, in January 2011. In 2010 he received his PhD in physics from Trinity College Dublin, where he worked with NASA Goddard Space Flight Center and the Naval Research Laboratory in Washington, DC. His somewhat unwieldy title at IfA is "coronal mass ejection model and data analyst postdoctoral fellow." He is studying the Sun with Shadia Habbal.

Caitlin Casey (PhD, 2010, University of Cambridge, UK) is a Hubble Fellow. Casey studies ultraluminous infrared galaxies (ULIRGs), which have the highest rates of star formation in the Universe's history. She explains that while ULIRGs are rare now, "they were quite numerous about 10 billion years ago, when galaxy formation (and destruction) was much more common (and the Universe was a far more interesting place to be)."

Lydia Hallis (PhD, 2010, Open University, UK) is an Astrobiology Postdoctoral Fellow who studies water in the early solar system. Her main focus is the hydrogen isotope composition of the water in meteorites that come to Earth from Mars, and what this can tell us about the early history of Mars and the formation of the terrestrial planets.

Henry Hsieh received his PhD from UH in 2007, and after a stint as a postdoctoral fellow at the Queen's University Belfast in Northern Ireland, he has returned to IfA as a Hubble Fellow to pursue his studies of small solar *Please see* **New Postdocs pg 4**

Forming Exoplanet *from* **pg 1**

Hubble Fellow Adam Kraus

Kraus and Ireland observed LkCa 15 b with the Keck telescope on Mauna Kea. They combined the power of Keck's adaptive optics with a technique called aperture mask interferometry. Adaptive optics involves the use of a deformable mirror to rapidly correct for atmospheric distortions of starlight. Aperture mask interferometry involves placing a small mask with several holes in the path of the light collected and concentrated by a giant telescope. It allows the astronomers to cancel out the bright light of stars. They can then clearly see disks of dust around stars and the gaps in the dusty layers where protoplanets may be hiding.

"Interferometry has actually been around since the 1800s, but through the use of adaptive optics has only been able to reach nearby young suns for about the last 7 years." said Dr. Ireland. "Since then we've been trying to push the technique to its limits using the biggest telescopes in the world, especially Keck."

"LkCa 15 was only our second target, and we immediately knew we were seeing something new," said Kraus. "We could see a faint point source near the star, so thinking it might be a Jupiter-like planet we went back a year later to get more data."

In further investigations at varying wavelengths, the astronomers were intrigued to discover that the phenomenon was more complex than a single companion object.

"We realized we had uncovered a super Jupiter-sized gas planet, but that we could also measure the dust and gas surrounding it. We'd found a planet at its very beginning," said Kraus.

Kraus and Ireland plan to continue their observations of LkCa 15 and other nearby young stars in their efforts to construct a clearer picture of how planets and solar systems form. "Different theories of planet formation make very different predictions," Kraus explained. By continuing their study of young planets, they hope to make a significant contribution to figuring out how planets actually form. ■

CCDs *from* pg 1

the large camera on the Subaru Telescope and is now leading the effort to build an even bigger one for Subaru, the Hyper-Suprime-Cam.

The UH8K camera was built on a shoestring budget of less than $300,000. The funding for the hardware came from the Director's Discretionary Fund and Luppino's grant from the National Science Foundation (NSF), with the money for Metzger's salary coming from an NSF grant, "Wide Field Imaging of Solar System Objects," to IfA astronomer Karen Meech.

They built the UH8K very fast. Luppino explained, "Most instruments take years to develop and produce. We knew we had an opportunity to beat everyone else developing similar large cameras if we could get onto the sky quickly, so we departed from the usual several-year schedule. From the time we had CCD wafers with confirmed, working devices to first light was seven months! In this period, we designed the CCD packages, diced the wafers ourselves (at Loral Aerospace's Newport Beach foundry), did all the device packaging and wire bonding (in my lab at IfA), designed the dewar (a thermoslike container used to keep the camera cold) and built it in the IfA shop, designed and built a large shutter and filter slide, procured the controllers, wired up the system, and wrote all the software to run the CCDs and acquire the images. The CCDs were poor compared with the devices we have now. But they were big, and there were eight of them. For many programs, area trumped perfect detectors."

Luppino's reason for building the UH8K was to use it to study weak lensing in clusters of galaxies, work he was doing with Nick Kaiser (now heading the Pan-STARRS project at IfA), Lev Kofman (left IfA for the University of Toronto in 1998; died in 2009), and Isabella Gioia (still a frequent visitor to IfA). "For this work, the UH8K was ideal. It was also well suited for the supernovae searches that led to the Nobel prize," said Luppino.

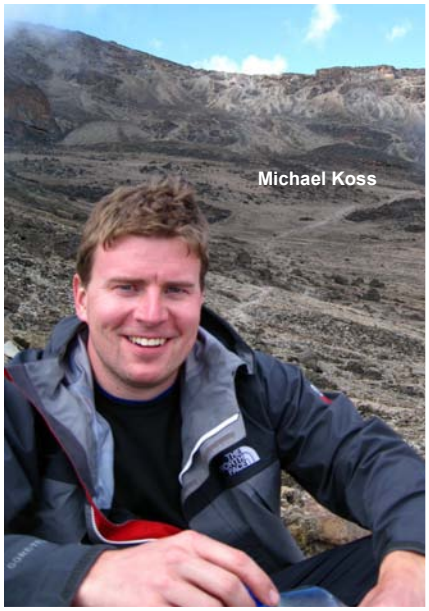
Meech's group used the camera for recovering comets. "The large area was important for comets whose orbital uncertainties were larger than the traditional CCD size. We also got some key observations of the really bright Comet Hale-Bopp, which had a huge tail," she said.

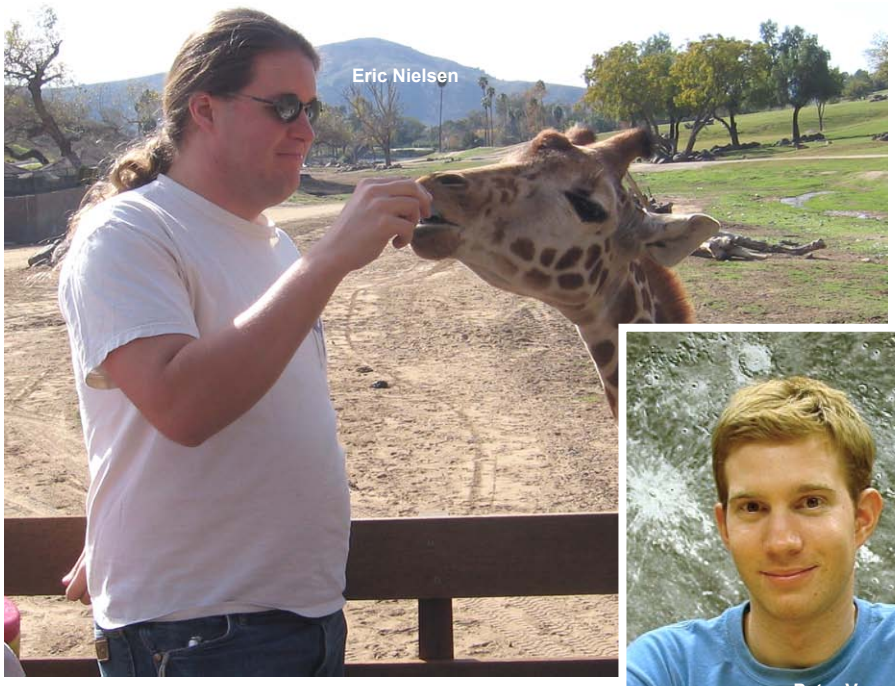
By 2000, the UH8K was replaced on the CFHT by the larger CFH12K (100 megapixels), which used better detectors. Later, the detectors on the UH8K were also upgraded, and it was fitted with improved optics, developed by IfA's Klaus Hodapp, so it could be used on the UH 2.2-meter telescope. It was employed on that telescope until 2005, when it was accidentally damaged. Since the repair would be costly and another camera is available for use on the 2.2-meter, it is likely that the UH8K will now be retired. ■

IfA Receives Patriot, Research Awards

On December 15, IfA Director Günther Hasinger accepted the Patriot Award on behalf of IfA for supporting programs that employ National Guard reservists, such as IfA employee **Chris Kaukali**, who was on active duty for four and a half years. From left to right, Command Sergeant Major Raymond Irie, Kaukali, Hasinger, US Army Reserve Ambassador P. Pasha Baker, and Lieutenant Colonel Carl Cruz. Irie and Cruz are with the 3303d Mobilization Support Battalion. ■

UH President M.R.C. Greenwood, Board of Regents Chair Eric Martinson, Lt. Governor Brian Schatz, and Congresswoman Colleen Hanabusa congratulate Regents' Medal for Excellence in Research awardee IfA astronomer **J. Patrick Henry**. IfA astronomer **Lisa Kewley** also received a Regents' Medal for Excellence in Research at the convocation ceremony in September. ■





New Postdocs *from* pg 2

system bodies, especially main-belt comets, which share properties of both comets and asteroids. (See "Comet or Asteroid?" in Nā Kilo Hōkū no. 12.)

Kaori Jogo (PhD, 2010, Kyushu University, Japan) is an Astrobiology Postdoctoral Fellow who studies water in asteroids. Her main focus is the oxygen isotopes in primitive meteorites (for example, carbonaceous and ordinary chondrites), and what they can tell us about the evolution process of the asteroids containing water.

National Science Foundation Postdoctoral Fellow, **Regina Jorgenson** (PhD, 2008, University of California, San Diego) studies galaxy formation and evolution. Prior to coming to Hawai'i, she was a postdoctoral fellow at the Institute of Astronomy at the University of Cambridge. Before attending graduate school, she traveled in Europe and Asia as a Thomas J. Watson Foundation Fellow for a project entitled "Women in Astronomy and the Effects of Culture on Science."

Michael Koss (PhD, 2011, University of Maryland) studies the host galaxies of active galactic nuclei, which contain huge black holes that radiate energy billions of times greater than that of the Sun. After graduating from Notre Dame with a degree in physics, Koss taught high school science for a year, and worked for three years on the Grand Challenge Robotic vehicles race. As a visiting graduate student at IfA, he mentored high school students and participated in the HI STAR program.

Jessica Lu (PhD, 2008, University of California, Los Angeles) is continuing her work on star formation in extreme environments, such as near the supermassive black hole at the center of our Milky Way Galaxy. She uses infrared images taken with the Laser Guide Star Adaptive Optics Systems on the Keck telescopes to measure the motion and brightness of these young stars, and compares them to those near the Sun to test whether stars form in a different manner under extreme conditions.

Eric Nielsen (PhD, 2011, University of Arizona) directly images and characterizes exoplanets and brown dwarfs. While a graduate student at the University of Arizona, he started working with IfA astronomer Michael Liu on the Gemini NICI Planet-Finding Campaign. NICI, the Near-Infrared Coronagraphic Imager installed on the Gemini South telescope in Chile, was designed specifically to image exoplanets.

Peter Veres (PhD, 2010, Comenius University, Slovakia) has succeeded Mikael Granvik as the Pan-STARRS PS1 Moving Object Processing System (MOPS) postdoctoral fellow. He studies populations of small near-Earth asteroids, meteors, and transiting exoplanets. Like several of the other new postdocs, Veres spent time at IfA while he was a student. ■

SEE-IT Hawaii Includes IfA

The IfA is one of 19 local companies and organizations participating in SEE-IT Hawaii (Science & Engineering Exposition – Innovative Technologies). It was launched at the Hawai'i Convention Center in November when the Asia-Pacific Economic Cooperation (APEC) meeting was held to show world leaders that Hawai'i is a place of dynamic science and cutting-edge technologies with global collaborations.

The purpose of the exhibit is to "motivate young people in Hawai'i to embrace technical careers," and to show them that it is possible to have such a career without leaving Hawai'i, according to Galen Ho, the president of SEE-IT.

The exhibition will remain on the convention center mezzanine for 16 months and then will be moved to a more permanent venue in 2013. It is open to school groups and the general public.

The IfA showcases two of its astronomy instrumentation marvels: the Pan-STARRS PS1 telescope on Haleakalā and the HAWAII family of infrared sensor arrays used at observatories throughout the world and in space. A display case highlights the Pan-STARRS Gigapixel Camera, the largest digital camera in the world, with actual camera components. Another display case houses infrared sensors that are going into instruments on new space telescopes and the Thirty Meter Telescope (TMT).

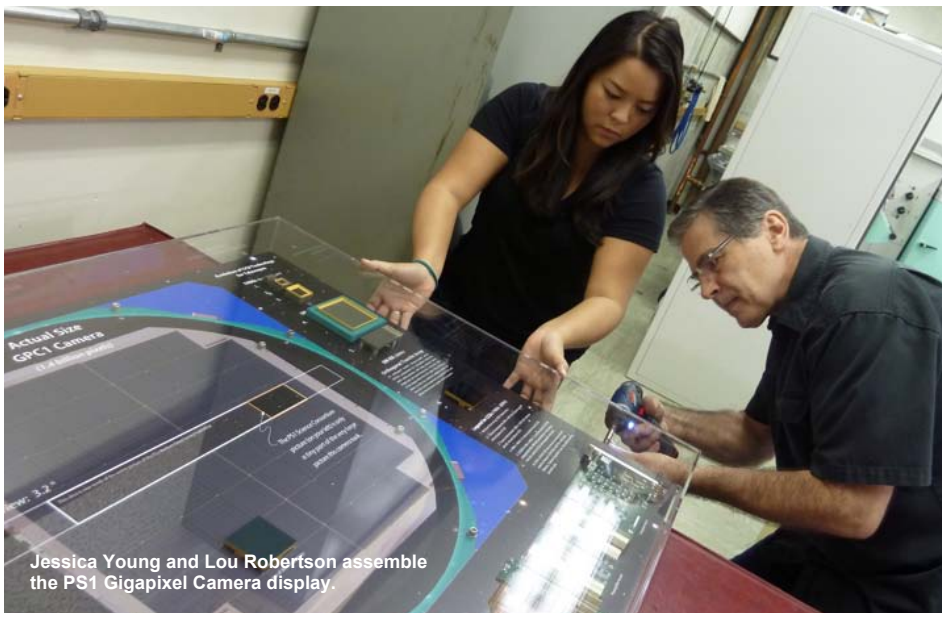
The IfA shares exhibit space with the TMT Corporation, which will build the world's largest optical/infrared telescope on Mauna Kea, pending final approvals. The TMT exhibit features a scale model of the huge telescope and a poster showing the actual size of one of the 492 segments that will make up its 30-meter-diameter mirror.

Exhibit participants include local companies working in science, engineering, homeland security, biomedical science and health care, virtual reality, robotics, cybersecurity, global defense, and clean energy (solar, wind, wave, and tidal). Space exploration exhibitors also include the W. M. Keck Observatory, which has the twin 10-meter telescopes on Mauna Kea, and the Pacific International Space Center for Exploration Systems (PISCES), which seeks to develop a technology park in Hilo. Exhibitor sitesare online at http://see-it-hawaii.com/exhibitors/.

Kudos go to Roy Gal for getting IfA into SEE-IT and coordinating this undertaking; Karen Teramura for exhibit concept, design, art, photography, web pages, and installation; Louise Good for editing text; Don Hall, Gerry Luppino, and Teledyne for supplying the infrared content, hardware, and photography; Peter Onaka for obtaining Gigapixel Camera hardware; Jessica Young, Lou Robertson, and the IfA Machine Shop for mounting hardware to the display; Bill Unruh, and Roy and Christine Gal for installation assistance; and the Friends of the IfA for providing some of the exhibit production funds. ■

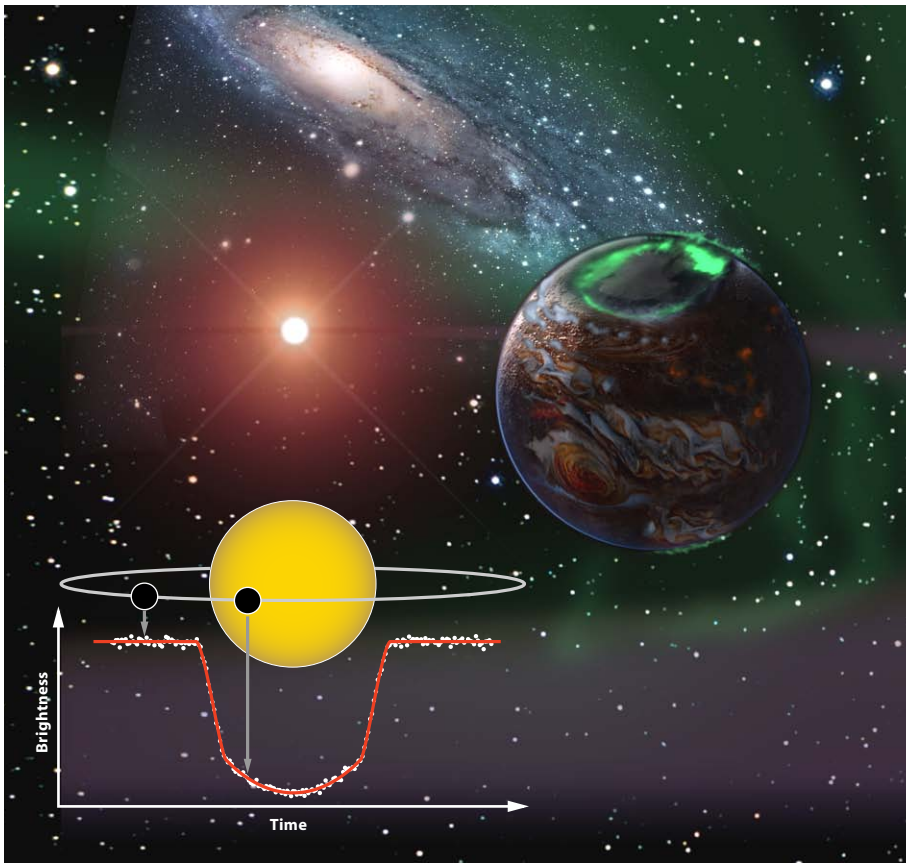
Karen Teramura in front of IfA's area of the SEE-IT Hawaii Exhibition.

Günther Hasinger, IfA director, explains the HAWAII family of infrared sensors to Gov. Neil Abercrombie.



Jessica Young and Lou Robertson assemble the PS1 Gigapixel Camera display.

http://ifa.hawaii.edu/see-it/ (SEE-IT Hawaii mobile phone site for the IfA)



Finding Exoplanets. Art by Karen Teramura

You Can Participate in Astronomy Research Projects *by Louise Good*

The illustration above includes a graph that shows how the light we see from a star decreases slightly when one of its planets crosses the star's disk. Planet hunters sometimes use this transit technique to find exoplanets.

You can become a planet hunter using data from the Kepler space telescope by going to planethunters.org. The website has tutorials to teach you how to participate in this research project.

You don't have to be a professional astronomer, or even own a telescope, to participate in astronomy research projects. These days, a computer and an Internet connection are all you need.

There are three astrophysics volunteer distributed-computing projects that use the Berkeley Open Infrastructure for Network Computing. The oldest and most famous is **SETI@home** (setiathome.berkeley.edu). It began in 1999 and proved that the "volunteer computing" concept —which uses unused operating power on ordinary home and office computers—is both viable and practical. SETI@home enables you to participate in the search for extraterrestrial intelligence (SETI) by running a free program that you download. It analyzes radio telescope data in an attempt to detect radio signals that may originate from intelligent beings beyond Earth by weeding out noise from natural celestial sources and the receiver's electronics. The two other BOINC projects are **Einstein@home**, which searches for pulsars, and **MilkyWay@home**, which aims to generate an accurate three-dimensional model of the Milky Way galaxy.

Those who want to take a more active role than just lending their computer to a project should check out the **Zooniverse** (zooniverse.org), which claims it is the Internet's "largest, most popular and most successful citizen science project." It began in July 2007 with a single project called the **Galaxy Zoo**, a dataset of a million galaxies from the Sloan Digital Sky Survey (SDSS). Scientists were hoping that members of the public would help them sort and classify the galaxies according to their shapes, a task at which the human brain is better than even the most advanced computer, though you still need a computer with an Internet connection to participate. They expected the project to take at least two years, but the response of citizen scientists was overwhelming. More than 50 million classifications from almost 150,000 people were received during the first year. With data from the SDSS galaxies sorted out, participants are now working on hundreds of thousands of galaxy images from NASA's Hubble Space Telescope archive.

The enthusiastic response to the Galaxy Zoo has led to the addition of other Zooniverse projects. The **Milky Way Project** aims to sort and measure our galaxy. Volunteers are asked to find bubbles in infrared data from the Spitzer Space Telescope. These bubbles are part of the life cycle of stars. The scientists involved in this project hope to learn more about how stars form and how our galaxy changes and evolves with time.

Another Zooniverse project is **Planet Hunters** (planethunters.org). Since being launched in December 2010, 40,000 users from around the world have been helping professional astronomers analyze the light from 150,000 stars in the hopes of discovering Earth-like planets orbiting around them. They analyze real scientific data collected by NASA's Kepler mission, which has been searching for exoplanets (planets beyond our own solar system) since its launch in March 2009.

The Planet Hunters team is a collaboration between astronomers at Yale, the University of Oxford, and the Adler Planetarium in Chicago. In September, astronomers at Yale announced the discovery of the first two potential exoplanets discovered by Planet Hunters. The Kepler team had discarded the two found by Planet Hunters for various technical reasons that led them to believe they weren't promising candidates. "These [planet] candidates might have gone undetected without Planet Hunters and its citizen scientists," said Meg Schwamb, a Yale researcher and Planet Hunters co-founder. "Obviously Planet Hunters doesn't replace the analysis being done by the Kepler team. But it has proven itself to be a valuable tool in the search for other worlds." ■

Friends of the IfA may pick up 2012 IfA poster calendars (17 inches by 22 inches) at the IfA offices on Maui, in Hilo, and in Mānoa. The calendar picture was taken with the Pan-STARRS PS1 telescope Gigapixel Camera.

In his talk about black holes, Günther Hasinger described the galaxy NGC 6240, which consists of two smaller galaxies in the process of merging. Each galaxy is home to its own supermassive black hole, which will eventually merge and become one. It is the first such double black hole ever discovered.

Black Holes and the Fate of the Universe

In his inaugural public lecture since becoming director of the IfA, Günther Hasinger took the audience gathered in the Art Auditorium on November 16 for the Frontiers of Astronomy Community Lecture on a journey from the beginning of the Universe until its end by focusing on its 10 billion black holes.

A black hole is an object that is so dense that even light cannot escape from it, in accordance with Einstein's general theory of relativity. If the Sun were squeezed down to the size of Honolulu, it would be a black hole, Hasinger said. The first, relatively small, black holes came into being in the early Universe when the first generation of massive stars in the middle of the early Universe's primal collapsing hydrogen cloud used up their fuel and collapsed at the end of their lives. As the hydrogen cloud continued to collapse, the black holes grew larger and larger until the cloud became galaxies with supermassive black holes at the center. The most distant objects in the Universe, and therefore the oldest, that astronomers have seen are likely gamma-ray bursts resulting from the creation of these early black holes.

There is a black hole with a mass of 300 million times that of our Sun in center of the Milky Way. Astronomers see flares in the vicinity of the galactic center almost daily. These flares happen because the black hole is "snacking" on comets and asteroids. Angular momentum—the momentum a body has because of its rotation—prevents stars orbiting the black hole from being easily sucked into it. But every hundred thousand years or so, a star is captured by the black hole. This means that the black hole "eats" about 10 percent of the star. The rest of the star's matter is belched back out into the galaxy, where it may become part of new stars. There are galaxies that are much more active than our Milky Way. Their black holes consume stars at a much higher rate.

The other way black holes grow is through galaxy mergers. When galaxies merge, they produce binary black holes. When the binary black holes merge, they produce the very bright and powerful quasars. These quasars are powerful enough to blow out all the gas from their galaxies. What remains are elliptical galaxies with no spiral arms and no gas with which to form new stars. They are "red and dead," as Hasinger put it. But then, after a long time, these galaxies start to grow a new disk, get spiral arms again, and the cycle starts over. This is the cycle of black hole evolution.

Astronomers who have studied black holes with a succession of X-ray satellites—ROSAT, XMM Newton, and Chandra—have concluded that the most massive and brightest black holes lived when the Universe was still rather young, but that most black holes have grown relatively recently.

As dark energy accelerates the expansion of the Universe, the largest black holes will continue to grow to hundreds of billions of solar masses and live as long as 10^{100} years. They will outlive all other forms of matter in the Universe until they too return to the "nothingness" with which the Universe began. ■

If you missed this talk, it will eventually be on our website: www.ifa.hawaii.edu/videos/

Upcoming Events

Please check with the sponsoring organization to confirm times and locations for all events.

O'ahu Events: call (808) 956-8566
www.ifa.hawaii.edu/specialevents/

Wednesday, January 4, "The City Dark," a feature documentary about light pollution and the disappearing night sky, 7:00 p.m., UH Mānoa Art Building Auditorium (Rm 132). Free.
www.thecitydark.com

Sunday, April 29, 2012, 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.
www.ifa.hawaii.edu/haleakalanew/outreach/

Hawai'i Island Events:
(808) 932-2328 or fujihara@ifa.hawaii.edu

Saturday, January 28, Onizuka Science Day, UH Hilo, 8:00 a.m.–3:15 p.m.
www.spacegrant.hawaii.edu/OnizukaDay/

March 1–9, Journey through the Universe (for educators & families)
www.gemini.edu/journey/

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, see
www.ifa.hawaii.edu/info/vis/visiting-mauna-kea/summit-tours.html

Dear Friends of the Institute for Astronomy,

I was so pleased to see a large turnout at the Frontiers of Astronomy Community Lecture that I gave in November. I hope that many of you will also attend our next presentation, "The City Dark," a feature-length documentary film about light pollution and the disappearing night sky. The film will have its Hawai'i premier on January 4 at 7 p.m. in the UH Mānoa Art Building Auditorium. The filmmaker, Ian Cheney, and our own resident expert on light pollution, astronomer Richard Wainscoat, will participate in a discussion after the screening of the 84-minute film. Admission will be free.

Cheney grew up in rural Maine, received bachelor's and master's degrees from Yale, and then moved to New York City, where the light pollution is extreme. In this film, he asks, "Do we need the dark?" And, "What will it be like for a generation of kids to grow up without a glimpse of the Universe above?" The film features astronomy in Hawai'i, stunning astrophotography, and a diverse group of scientists (including IfA's Jeff Kuhn), philosophers, historians, and lighting designers. It premiered in competition at the 2011 South by Southwest Film Festival, where it won the Jury Prize for Best Score/Music.

Unfortunately, light pollution affects those of us living in Honolulu. If you go out on a moonless, cloud-free night in Honolulu and look up, chances are you will be able to see only about 20 stars. If you live in the suburbs, you may be able to see about 200. Only those lucky enough to live far from the city lights, such as in the rural areas of Hawai'i Island, are able to see the 2,000 or more stars visible to the naked eye.

So please join us on January 4 for the film and the discussion, which will include possible solutions to the problem of light pollution.

Best holiday wishes and a happy new year,

Günther Hasinger

Director, Institute for Astronomy

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