National Aeronautics and Space Administration

NASA's New Worlds News

The EXOPLANET EXPLORATION PROGRAM *Newsletter*

Issue 12 - October 2013

HEADLINES

Genius Granted

Sara Seager (MIT) has been named one of the 2013 MacArthur Fellows, a prestigious award popularly known as the "genius grant". For more information visit the PlanetQuest at http://www.macfound.org/fellows/903/

1. Program Manager's Update

By Gary Blackwood, Manager, Exoplanet Exploration Program Office

What's happening with the coronagraph for the Astrophysics Focused Telescope Assets (AFTA)? The AFTA Coronagraph Working Group is in full swing. Weâ€™ve held two workshops with leading representatives from the field, and plan two more prior to December. The purpose is to choose a primary and backup coronagraph architecture to focus technology and design investments prior to a possible new mission start at the beginning of fiscal year 2017. The AFTA Science Definition Team has developed preliminary science requirements, and the working group has developed analysis tools to describe instrument performance and science yield of six different options (and their combinations). Recommendation criteria will be science, technical, programmatic, and risk, and these were described at ExoPAG-8 in Denver on October 5 and 6. A joint recommendation will be made by the Exoplanet Exploration Program Office Manager and the AFTA Study Office Manager, and the Astrophysics Director will make the final decision.

How are technology priorities being set? Technology priorities have been established by the program office for both the starshade and the coronagraph (both on-axis for AFTA, and for off-axis). The purpose is to maximize the technology readiness, typically to TRL 5 at new mission start and to TRL 6 at the start of the implementation phase. Those dates are notionally at the start of fiscal year 2017 and 2019, respectively, for both AFTA or any exoplanet probes alternatives. The AFTA coronagraph priorities are being used by the AFTA Study Office to focus directed funds on the gaps of highest priority and urgency. For non-AFTA coronagraph and starshade technologies, the program office will work with the community to plan near- and medium-term work on those priorities starting from the top of the list. Recently, the two probe-scale Science and Technology Definition Teams (one for starshade, one for coronagraph) have independently

For information on any of the stories or events below, please visit: http://exep.jpl.nasa.gov/newslettersarchivelist/

EXOPLANETS IN THE NEWS

October 1, 2013
Mapping Distant Clouds
BBC, **Time**

August 19, 2013
A year in 8 hours or less
The Los Angeles Times, **National Geographic**, **Fox News**

August 16, 2013
Kepler's New Mission
Time, **The New York Times**

August 8, 2013
Hot Pink Planet
National Geographic, **Huffington Post**

July 11, 2013
Glass rain may give planet blue hue
BBC, **Time**

EVENTS

GSA's 125th Annual Meeting - October 27-30
Location: Denver, Colorado

Second Kepler Science Conference - November 4-8
Location: NASA Ames Research Center, Moffett Field, CA

XIV Latin American Regional IAU Meeting - November 24-29

produced technology priority lists, and these will now inform what the program carries. Itâ€™s our hope that, despite limits on funding, significant work can be accomplished on the most important and urgent tasks, and we will be able to show that mission concept reports are technically viable in addition to being scientifically compelling.

What are you looking forward to as Program Manager? Exozodiacal dust measurements, at the level needed for future Earth-characterizer missions, will become available as soon as the Large Binocular Telescope Interferometer (LBTI) enters its final season of commissioning. We eagerly anticipate the outcome of the Kepler two-wheel evaluation, given the strong community interest and response. I especially look forward to engaging the exoplanet community at the ExoPAG-9 in Washington, DC, just prior to the January AAS meeting.

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2. Message from NASA Astrophysics Division Director

By Paul Hertz, Director, NASA Astrophysics Division

Since fall 2012, NASA has been studying potential uses of the 2.4-meter telescope assets that were made available to the Agency by the National Reconnaissance Office (NRO) in mid-2012. The Astrophysics Focused Telescope Assets (AFTA) study showed that for approximately the same costs, the telescope assets would enable a Wide-Field Infrared Survey Telescope (WFIRST) mission with significantly improved science capabilities relative to the design described in the Astrophysics Decadal Survey. Use of the telescope assets would also enable the addition of an exoplanet imaging instrument to WFIRST that would enable imaging and characterization of planets around nearby stars up to a decade earlier than contemplated in the Decadal Survey. The results of the studies were presented to the NASA Administrator and other senior officials across the Agency on May 30, 2013. The Administrator directed the Science Mission Directorate to continue pre-formulation activities for a mission using the 2.4-meter telescope assets to prepare for a later decision as to whether a WFIRST mission would be undertaken with these optics. No decision on a future wide-field infrared survey mission is expected until early 2016. The study report by the AFTA Science Definition Team is available at http://wfirst.gsfc.nasa.gov/science/.

Although this remains a time of opportunity for NASA Astrophysics, the budgetary future remains uncertain. The FY13 rescission and sequestration has an impact. The rescission (~1.8%), sequestration (~5%), and other budget adjustments have resulted in an FY13 Astrophysics budget significantly lower than planned: $592M, which is $44M (7%) lower than the planning budget. The President's FY14 Budget Request announced in April 2013 supports several NASA decisions that have been previously announced, including a new Explorer mission (TESS; http://web.mit.edu/newsoffice/2013/nasa-selects-tess-for-mission-0405.html) and a new Explorer Mission of Opportunity (NICER; http://heasarc.gsfc.nasa.gov/docs/nicer/) downselected for development leading to flight, a new Euclid project to fund hardware procurement and a US science team for our partnership with the European Space Agency (ESA), and mission extensions for Spitzer, Planck, Chandra, Fermi, XMM, Kepler, Swift, and Suzaku per the recommendation of the 2012 Senior Review. The FY14 Budget Request also requires efficiencies in Fermi mission operations to be implemented in FY14, ahead of schedule and resulting in a significant reduction of operating costs, and it does not support selections for the 2012 Astrophysics Explorer Mission of Opportunity AO. Impacts of these revised budget planning numbers also include lowered research and analysis (R&A) selection rates in 2013 (for FY14 funding), delays in future Explorer AOs, and other reductions in FY14 where funding requirements were deferred from FY13. The constrained budget request for FY14 and constrained planning budget for FY15-FY18 means priorities must be set and choices must be made.

Within these budgetary constraints, NASA will continue to be guided by the goals of the 2010 Astrophysics Decadal Survey; we have developed an implementation plan to do so, and it is available at http://science.nasa.gov/astrophysics/documents/. Per the implementation plan, we have initiated science and technology definition teams for probe-class missions addressing exoplanet and x-ray astrophysics priorities in the decadal survey. A task force of the Astrophysics Subcommittee (APS), led by Chryssa Kouveliotou, is developing an Astrophysics Roadmap to create a compelling, 30-year vision for Astrophysics at NASA. The team has received community input through abstracts on science and technology challenges, as well as through invited talks

Location: Florianópolis/SC, Brazil

What Asteroseismology has to offer to Astrophysics - December 2-4
Location: Brussels, Belgium

Exoplanets and Disks: Their Formation and Diversity - December 8-12
Location: The Big Island of Hawaii

Astrotomography II - Imaging at the micro-arcsecond scale - December 10-13
Location: Santiago, Chile

ExoPAG 9 - Washington, DC, January 4-5, 2014
Location: Washington, D.C.

AAS 223rd Meeting - January 5-9
Location: National Harbor, MD

PROGRAM WEBSITES

Exoplanet Exploration Program (ExEP)

http://exep.jpl.nasa.gov/

PlanetQuest - Public Outreach Website

http://planetquest.jpl.nasa.gov/

NASA Exoplanet Science Institute (NExScI)

http://nexsci.caltech.edu/

NASA Science Astrophysics

http://science.nasa.gov/astrophysics/

NASA Cosmic Origins Program (COR)

http://cor.gsfc.nasa.gov/

NASA Physics of the Cosmos Program (PCOS)

http://science.nasa.gov/astrophysics/

from experts. The Roadmap team is maintaining communication with the astrophysics community through their webpage at http://science.nasa.gov/science-committee/subcommittees/nac-astrophysics-subcommittee/astrophysics-roadmap/.

NASA is compelled to make the short-term sacrifices necessary to meet this vision. The impacts of a reduced budget include a change in the pace of the Explorer program and putting on hold selections from the 2012 Announcement of Opportunity for Explorer Missions of Opportunity; lowered R&A selection rates in 2013 (for FY14 funding); and other reductions in FY14 where funding requirements have been deferred, such as funding of accepted Cycle 7 proposals to the Fermi Guest Observers program, which will be deferred until early FY15. We continue to look for scientists who would like to join the NASA staff for a few years and bring their talent and ideas to influence the nation's space Astrophysics program.

My entire Town Hall Presentation from the June AAS meeting in Indianapolis is available at http://science.nasa.gov/astrophysics/documents/.

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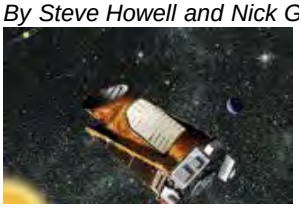
3. New Vision for Kepler

By Steve Howell and Nick Gautier



In May 2013, the Kepler spacecraft suffered its second failure of a momentum wheel. Kepler uses momentum wheels to point itself accurately and stably to obtain the extremely precise brightness measurements of stars that have allowed the spacecraft to detect small planets around the target stars in its exoplanet survey. Kepler started its mission with four operational momentum wheels and requires three operational wheels to maintain stable pointing. With the failure of a second wheel on Kepler, the existing pointing-system software can no longer control the spacecraft as before, thus ending the ability to search for Earth-size planets orbiting Sun-like stars. For now, science data collection has stopped and the Kepler spacecraft has been placed in a fuel-efficient safe mode while we decide what to do next.

All of the science data taken before the second wheel failure have been sent back to Earth, giving a full four years of exoplanet survey data. The first three years of survey data have been thoroughly analyzed and searched for planets. Analysis is in progress of the fourth year of data and comprehensive analysis of all four years together continues. We expect to discover many new planets in these data, perhaps even a few Earth-analogs -- Earth-size planets in the habitable zones of stars like the Sun.

While the existing pointing-control software cannot control the Kepler spacecraft with only two momentum wheels, it has become clear that modest modifications to the software will allow control of the spacecraft pointing with two wheels. The pointing stability with two wheels, as well as a number of other factors, is not expected to provide sufficient photometric precision and high-impact science benefit to continue to pursue the original exoplanet survey. However, the stability is expected to be good enough to continue to do important and exciting scientific observations. The Kepler Project, Ball Aerospace (which operates the spacecraft), and NASA are actively working on planning an exciting science mission that can be enabled by a two-wheel repurposed Kepler mission. Our plans for a two-wheel science mission will be submitted to NASA review in early 2014. If this initial review by NASA is satisfactory, Kepler will submit a formal proposal for a 2 wheel mission to the Senior Review Panel for Operating Missions asking for funding and approval to execute the mission.

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4. Direct Detection of Exoplanets: Mission Studies Are Underway

By Steve Unwin

In May 2013, NASA chartered two Science and Technology Definition Teams (STDTs) to develop probe-scale mission concepts for direct detection and spectroscopy of exoplanets. Karl Stapelfeldt's team is studying a mission based on a telescope with an internal coronagraph; Sara Seager's team is looking at blocking out the interfering starlight using an external occulter (starshade) that

flies in formation with a telescope.

The teams are now well into their studies, and have met in person twice so far, opting to hold meetings at the team leaders' home institutions -- at GSFC on July 1-2, and at MIT on September 11-12. At the first meeting, the teams were introduced to the Design Team, staffed through the Exoplanet Exploration Program's Study Office and led by Keith Warfield (JPL). The program presented an overview of the task ahead, which culminates in early 2015 with the delivery of Concept Study Reports (one from each team) to NASA HQ. To be fully responsive to the STDT charter, a mission concept must have certain attributes -- most notably a cost target. These reports will become a key part of the Astrophysics Division's presentation to the NRC Committee on Astronomy and Astrophysics, which is chartered to review NASA's progress in implementing the recommendations of the 2010 Astronomy and Astrophysics Decadal Survey.

At the meetings so far, the teams have discussed topics in common in joint session. These include the high-level science requirements and related considerations, like the expected state of knowledge in the exoplanet field from ground- and space-based observations prior to the nominal flight date of a probe-scale mission (early 2020s). By then, the next generation of large ground-based telescopes will be coming online (Thirty Meter Telescope, Giant Magellan Telescope, and European Extremely Large Telescope); each is developing high-contrast imaging instruments, though their projected performance is very uncertain at this early stage in their development.

Each team has the task of narrowing down possible instrument architectures during fall 2013, with selection in January 2014 of a single concept to develop in detail for the final year of the studies. There was a lively discussion at the first meeting on what constitutes science "musts," which would be used to guide that process. At both meetings so far, the teams split into parallel sessions to work on the specific design and performance issues that feed into the architecture trade. Both teams, assisted by the Design Team, have made rapid progress; the existence of a number of relevant previous concept studies has helped, even though they were developed under different sets of constraints. The teams have already provided the program with a preliminary list of key technologies for their concepts to aid in technology planning.

In parallel, the Study Office has been laying the groundwork for developing cost estimates for the two concepts to be selected in January. The charter calls for a Cost Analysis and Technical Evaluation (CATE) to be conducted by an independent contractor. Members of the Aerospace Corporation CATE team met with program staff on September 3 to discuss their process. This was very informative, and will help the STDTs and Design Team to develop good cost estimates by allowing enough time for interaction with the CATE team to understand the details of each concept.

There will be status updates at ExoPAG-8 (http://exep.jpl.nasa.gov/exopag/exopag8/) in Denver October 5-6; at ExoPAG-9 (http://exep.jpl.nasa.gov/exopag/exopag9/, at the Washington, DC, AAS meeting (January 4-5), and also at an evening session there.

Web pages devoted to the STDTs on the ExEP website are at http://exep.jpl.nasa.gov/stdt/, where you can find the team membership lists and the charter that governs their work. As the studies progress, we will add updates and news. Public versions of the final reports should be available in mid-2015.

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5. August Was a Month of "Discovery" for Starshade Technology

By Mark Thomson, Doug Lisman, and David Webb

On Tuesday, August 27, the Discovery Channel filmed the initial deployments of the world's first prototype deployable Starshade, a huge deployable structure for the direct imaging of extrasolar planets, or exoplanets. The video sequences, filmed by a crew from Pioneer TV of

the UK, are for an exoplanet-themed segment of "How the Universe Works," scheduled to air in 2014.

The starshade concept is comprised of an external occulter, or Starshade, flown in formation with a companion telescope, capable of launching jointly on a single launch vehicle. The Starshade is compactly stowed for launch and deploys to a very large structure of approximately 34 meters in diameter. Resembling a sunflower in shape, the Starshade consists of an opaque inner disk with flower-like petals around the circumference, shaped to control the diffraction of starlight.

Accurately controlling the deployed starshade petal positions is a key performance parameter and the focus of a "Technology Development for Exoplanet Mission," or TDEM. This effort by JPL and Astro Aerospace, a business unit of Northrop Grumman Aerospace Systems (NGAS), is led by Professor Jeremy Kasdin of Princeton University. The Starshade prototype, conceived and designed at JPL, includes an existing 12-meter-diameter AstroMesh antenna truss, modified by Astro to form the inner disk of the starshade, complimented with 4.3 meter petals, assembled at JPL by summer interns from Princeton and MIT.

The fully integrated Starshade prototype has been deployed over 10 times as of September 23, 2013 at Astro's facilities in Goleta, Ca. After each deployment, metrology data were collected and analyzed to determine the 3-D position of the hundreds of measurement targets spread across the Starshade to an accuracy of approximately 100 microns, or .004 inches. Preliminary results indicate that the truss nodes, which locate pairs of interface points at the root of each petal, deploy repeatedly over the 12-meter truss to within a radius of better than 250 microns (0.010 inches) relative to nominal. This level of structural repeatability is two times better than the requirement, which is based on achieving a worst-case minimum of 109 starlight suppression in a flight system. Final results will be published after aligning the petal interface points relative to the design circle and repeating ten more deployments with metrology.

To learn more about starshade technology, read the following abstracts:

- STARSHADES FOR EXOPLANET IMAGING AND CHARACTERIZATION: KEY TECHNOLOGY DEVELOPMENT can be found at: http://exep.jpl.nasa.gov/technology/2009tdemabstractKasdin/
- VERIFYING DEPLOYMENT TOLERANCES OF AN EXTERNAL OCCULTER FOR STARLIGHT SUPPRESSION can be found at: http://exep.jpl.nasa.gov/technology/2010tdemabstractkasdin/

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6. X-Ray Observations of Exoplanet Atmospheres

By Katja Poppenhager, Sagan Fellow, Harvard-Smithsonian Center for Astrophysics

Many exoplanets are different from the planets in our solar system: they often orbit their host stars at very close distances, with a full orbit lasting only a couple of days. The atmospheres of such planets are strongly heated by the stellar irradiation, and we can observe those atmospheres through transits of the planet in front of the stellar disk. In my work as a Sagan Fellow, I use x-ray observations to study the outermost layers of exoplanetary atmospheres. These observations are challenging because stars are much fainter in x-rays than they are in optical light. However, the combined signal from several x-ray transits allows us to peek into atmosphere layers that cannot be observed at other wavelengths. My goal is to use these observations to understand how the atmospheres of exoplanets evolve over time. To learn more, please visit http://hea-www.harvard.edu/~kpoppen/.

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7. Finding Nearby Habitable Zone Exoplanets, Inexpensively

By Cullen Blake, Nancy Grace Roman Fellow, University of Pennsylvania

Thanks to Kepler, today we know that small stars commonly host Earth-size planets. Approximately half of all stars are low-mass M dwarfs, and at least half of these may have an Earth-size companion, making it likely that there are Earth-like planets within just a few parsecs of the Sun. Given the cool temperature, low mass, and feeble luminosity of an M dwarf, the Doppler signal induced by an Earth-mass companion in the Habitable Zone (HZ) is

significantly larger than the Sun's wobble caused by Earth. The hunt for these nearby planets is on.

As a Nancy Grace Roman Fellow, I am developing an instrument to conduct a census of planets in the HZs of our nearest stellar neighbors. The Small Red Spectrometer (SRS) is a Doppler spectrometer designed specifically for telescopes of modest aperture. A small telescope permits the use of a compact instrument that is stable, inexpensive, and easy to replicate. SRS is optimized for red optical wavelengths, where modern CCDs are very sensitive and an M dwarf is near peak brightness. SRS will be adaptable for observations from new platforms, such as high-altitude balloons, and new observing modes, including a "Beowulf Telescope" mode in which it accepts light from several telescopes simultaneously.

Designed exclusively for precise Doppler measurements of the brightest low-mass stars, SRS can play a key role in the discovery and characterization of the nearest Earth-like planets to the Sun and provide crucial follow-up observations of planet candidates from the upcoming Transiting Exoplanet Survey Satellite (TESS) mission.

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8. LBTI-The Monsoon Season Is Finally Over!

By Rafael Millan-Gabet

Following an icing accident in April 2013, the right-side adaptive optics (AO) secondary was replaced by a spare unit that has now been mounted and tested at the telescope. The spare AO secondary unit is currently undergoing calibrations on the sky in order to be operational when observing resumes, following the monsoon season summer shutdown. During the shutdown, the Large Binocular Telescope Interferometer (LBTI) team (P.I. Phil Hinz, University of Arizona) has been busy characterizing the instrument's photometric sensitivity and implementing sequencer software, which has greatly improved the observing efficiency. NASA commissioning nights that could not be used in spring 2013 due to the adaptive secondary failure have been rescheduled to fall 2013, and commissioning is now expected to be completed during three observing runs of two nights each in October, November, and December 2013.

On a related note, the LMIRCam 3-5 micron high-contrast imager (funded by NSF but also housed by the LBTI instrument) had a very productive spring 2013 observing season for the LBTI Exozodi-Exoplanet Common Hunt (LEECH) project (P.I. Andrew Skemer, University of Arizona): 36 objects were observed during 14 nights (all non-NASA thus far). No new exoplanets have been discovered yet, but a number of very interesting discoveries on a variety of topics (e.g., brown-dwarf companions and debris disks) have been made along the way, and the observations have served to validate the instrument's capabilities for direct detection and spectroscopic characterization of Jupiter-mass exoplanets as close to their parent star as 0.75 arcsec.

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9. Science Update

By Wes Traub and Steve Unwin

The "snow line" is an almost poetical term that tells us where it gets cold enough in a protoplanetary disk for gas molecules to freeze out as "snow." In a recent Atacama Large Millimeter/submillimeter Array (ALMA) observation, the snow line for CO was found by the indirect trick of imaging N2H+, and noticing that in the frozen phase of CO the N2H+ remains as a gas, whereas in the gas phase of CO there is very little N2H+ because the species react, depleting the latter. Thus, the observed ring of N2H+ is a marker for frozen CO. See http://www.sciencemag.org/content/341/6146/630.full.pdf for the paper by Qi et al.

A crescent of millimeter-size grains was found around IRS 48 at a radius of about 55 AU, even though the gas and micron-size dust appear in full ring-type structures. The authors explain this peculiar clumping of large particles by positing a 10-Jupiter-mass planet at about 20 AU. The paper, by van der Marel et al., with these ALMA observations and a model of the system, is at http://www.sciencemag.org/content/340/6137/1199.full.pdf.

On the other hand, Lyra and Kuchner http://www.nature.com/nature/journal/v499/n7457/full/nature12281.html show that it is possible to form "sharp eccentric rings in debris disks with gas but without planets." This mechanism provides a counterexample to the common model of a planet shepherding disk material into a ring-like structure, and makes it all the more challenging for observers to interpret their data.

We continue to like the science fiction articles in the back of Nature every week. Here is another, by Gregory Benford, that the planet-characterization types among us might enjoy: http://www.nature.com/nature/journal/v499/n7458/full/499374a.html.

Finally, to show that exoplanets are still high on the list of topics that the greater public cares about, we are encouraged by an article in The Economist that briefly looks at the radial velocity and transit techniques, and even mentions direct imaging as being one of the "clever tricks" we can use -- all very encouraging for future users of Wide-Field Infrared Survey Telescope-Astrophysics Focused Telescope Assets (WFIRST-AFTA). Seehttp://www.economist.com/blogs/economist-explains/2013/06/economist-explains-8 for the article.

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10. Technology Update

By Peter Lawson

Exoplanet technology is in a period of transition right now. Back in May, Paul Hertz received the go-ahead from the NASA Administrator to continue studying how the Astrophysics Focused Telescope Assets (AFTA) 2.4-meter telescope could be used to implement Wide-Field Infrared Survey Telescope (WFIRST) science. With that approval, the AFTA coronagraph went from being a "proxy for an instrument" to an integral part of the ongoing study plans. However, for a coronagraph to be part of AFTA, it must demonstrate that it is ready -- and convincingly so by January 2015. That is when NASA Astrophysics will decide on its future path and begin pre-formulation activities for its next big mission.

The Exoplanet Exploration Program is also studying mission concepts for coronagraphs and starshades for a cost cap of $1B, as there is no knowing if a presumably more expensive AFTA mission will in fact be funded.

It's getting so that you need a decoder ring to keep track of all the meetings of the different study groups. There is an AFTA Science Definition Team (SDT), an AFTA Coronagraph Working Group, a Probe Coronagraph Science and Technology Definition Team (STDT), and a Probe Starshade STDT. We of course have the NASA Exoplanet Exploration Program Analysis Group (ExoPAG) and its Science Analysis Groups (SAGs). All of these groups are keenly interested in the program's plans for technology.

To be ready by 2015, the program must make some hard choices and narrow down the technologies that are funded so as to make more rapid progress in very specific areas. For the AFTA coronagraph, we are on a track to recommend a primary and backup instrument concept by January 2015 -- out of the current pool of six existing concepts -- and then start to manufacture and test these designs in the lab. The probe coronagraph and starshade studies are also in the process of narrowing their options so as to arrive at their respective baseline designs for a recommended path forward.

At the time of writing, the dust has yet to settle. Most of the decisions will be made before the end of 2013. The trades are being formulated based on the known technology gaps, the estimated technology development times, and the available funds. It all has to come together, and quickly. Stay tuned.

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11. Sagan Fellowship Call Goes Out

The NASA Exoplanet Science Institute (NExSCI) solicits applications for Sagan Postdoctoral Fellowships to begin in the fall of 2014. The deadline for

applications and letters of reference and endorsement is Thursday, November 7, 2013 at 4 pm PST.

The Sagan Fellowships support outstanding recent postdoctoral scientists to conduct independent research that is broadly related to the science goals of NASA's Exoplanet Exploration program. The primary goal of missions within this program is to discover and characterize planetary systems and Earth-like planets around nearby stars.

Jared Males will work at the University of Arizona, Tucson, to investigate exoplanetary habitability by perfecting instrumentation to image Jupiter- and Saturn-sized planets in the liquid water habitable zone of nearby stars.

More information: http://nexsci.caltech.edu/sagan/fellowship.shtml

Questions: saganfellowship@ipac.caltech.edu

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12. Bringing Strange New Worlds to Your Desktop

By Randal Jackson

The ExEP Program's new "Eyes on Exoplanets" visualization tool provides a visually stunning, fully rendered 3D universe of the 900-plus "exoplanet" discoveries in our galactic neighborhood. With the click of a mouse, users can now visit all types of newly discovered worlds, including gas giants, terrestrials, super-Earths, and more.

Powered by NASA's Exoplanet Archive and available at http://eyes.jpl.nasa.gov/exoplanets/index.html, "Eyes" is JPL's most advanced interactive visualization product to date, according to Kevin Hussey, manager of visualization technology at JPL. "This program turns raw numbers and statistical data into a stunning, immersive environment, and is able to keep pace with the onslaught of new discoveries," Hussey said.

Visitors to "Eyes on Exoplanets" can instantly find out the time it would take to travel to each planetary system by car, jet plane, bullet train, or starship; use an overlay to compare the orbits of planets in our solar system with those around other stars; view the night sky and see visible stars where exoplanets have been discovered; and access a variety of other interactive features.

ACKNOWLEDGEMENTS

NASA's Exoplanet Exploration Program Office
