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High-energy focus on black holes coming up

NuSTAR prepares for launch in March

By Mark Whalen

Top: NuSTAR has a 10-meter mast that deploys after launch to separate the optics modules (right) from the detectors in the focal plane (left).

Middle: A Goddard Space Flight Center technician works on concentric cells that comprise the optics on NuSTAR.

Bottom: NuStar will launch from a Pegasus XL rocket.

Black holes—rips in the fabric of space-time from which even light cannot escape—have intrigued astronomers for decades. Amazingly, these exotic objects lurk in the heart of every galaxy, and astronomers believe they are central to understanding how galaxies and structures form.

However, finding them can be tough, because they often live in regions filled with dust and gas, hiding them from the view of many telescopes.

The upcoming JPL-managed Nuclear Spectroscopic Telescope Array, or NuSTAR, mission offers the technological breakthroughs to provide scientists with easier access to hidden black holes and other mysteries of deep space, from which much can be learned about the most energetic and exotic phenomena in the universe.

NuSTAR, now at Vandenberg Air Force Base in Santa Barbara County preparing to be integrated onto the rocket that in March will launch it from a plane in the South Pacific, will be the first telescope that can focus high-energy X-rays, making it 100 times more sensitive and able to make images 10 times sharper than any previous telescope operating in this part of the electromagnetic spectrum.

NuSTAR is led by Principal Investigator Fiona Harrison of Caltech. From the time she came to Caltech in 1993, Harrison dreamed of making a highly sensitive, high-energy X-ray telescope, but the technologies to achieve this didn't exist. This led her to assemble a team to develop a balloon experiment, the High Energy Focusing Telescope, that was critical for demonstrating these key technologies.

"It has been a long road," said Harrison. "When we started we really had no idea how to find the very smooth, thin substrates needed for the optics, nor what material we should use for the imaging detectors that must be capable of stopping penetrating X-rays." Over the course of a decade, she said, the team solved the problems. The 2005 balloon flight demonstration was central to the successful proposal to NASA's Small Explorer Program to build the NuSTAR mission.

Also essential for the NuSTAR telescope is achieving a long, 10-meter focal length, or distance between the optics and detectors. To launch on the Pegasus rocket available to Small Explorer missions, the school bus–length structure that holds the optics and detectors at the requisite separation has to be carefully folded up inside a meter-tall canister for launch, and deployed after the observatory is on-orbit.

Enter JPL. "I realized that JPL was the perfect partner," said Harrison, "since they had been responsible for a 60-meter extending structure used on the Shuttle Radar Topography Mission that was similar to what NuSTAR needed."

NuSTAR's project manager is Yunjin Kim, a 23-year JPL veteran who previously managed the Radar Science and Engineering Section and the Focused Physical Oceanography and Solid Earth Program Office.

Kim said JPL also provides project systems engineering as well as safety and mission assurance. The Lab oversaw the design, build and testing of the 10-meter mast, and designed the metrology system required to measure the distortions of the structure on-orbit. The instrument was also integrated and tested at JPL, and about 20 JPL employees are working on NuSTAR through launch.

Focusing X-rays is quite different from focusing optical light. While visible light reflects off a mirror at any angle, X-rays only glance off a reflective surface at an angle nearly parallel to it, like stones might skip off the surface of a pond. For NuSTAR to gather this "glancing" reflection requires shells of very thin glass, stacked one inside the other. Each shell intercepts a portion of the incoming X-ray beam, and together they form a focused image. The challenge of building a high-energy X-ray focusing optic is that the higher the X-ray energy, the more glancing the reflecting angles. This requires a large number of shells made of very thin glass.

Each NuSTAR optics module consists of 133 concentric reflecting shells, each only 0.2 millimeters thick. In contrast, NASA's Chandra Observatory, which images the sky in the low-energy X-ray band, employs four shells, each more than 1 centimeter thick. A key challenge for the detectors was developing a custom, very low-noise readout chip that can register not only the position of the X-ray in the focal plane, but accurately measure its energy.

The mast consists of 56 bays, each of which has 16 components that are put together by hand, noted JPL's Jason Willis, the project systems engineer. The deployment, which takes about 26 minutes, will take place on the seventh day after launch.

NuSTAR will launch into a low-Earth orbit from the Kwajalein Atoll, which lies midway between Australia and Hawaii. Orbital Sciences Corp. built the rocket, which will be released at about 12,000 meters (40,000 feet) from an L-1011 aircraft.

"As cool as it is to be air-launched on the Pegasus, it adds an extra layer of complexity to an already complex event," said Willis, who noted the additional structural load cases and unique environmental and contamination-control issues not seen on traditional vertical launches. Ultimately, he said, for NuSTAR it is worth the extra effort. "The flexibility the air launch provides will allow us to get to an almost equatorial orbit that increases our observing efficiency by minimizing the time we spend passing through the South Atlantic Anomaly," he added, referring to an area where Earth's inner Van Allen radiation belt comes closest to the planet, exposing satellites to higher-than-usual levels of radiation.

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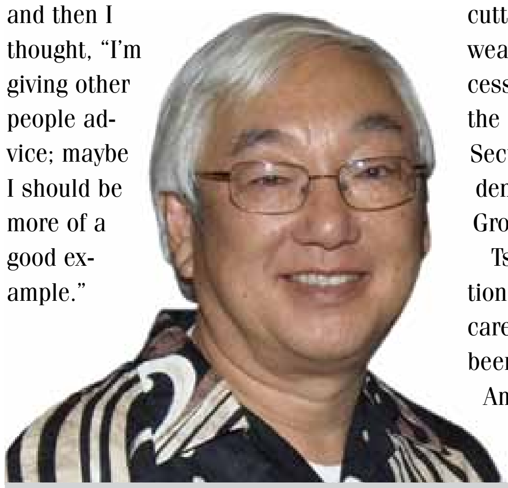
Tsurutani decides to give back

Now in his 40th year at JPL, senior research scientist Bruce Tsurutani thought that he ought to take advantage of a unique opportunity to give back to the science community in which he has served for so many years.

"I still enjoy working half-time, I have pretty much everything I need, and my family are well provided for," he said. "I was talking to some friends who are wealthy and I was telling them they ought to give some of their money away, and then I thought, "I'm giving other people advice; maybe I should be more of a good example."



Bruce Tsurutani

Tsurutani, a member of the Space and Astrophysical Plasmas Group (3263), along with his wife, Olga Verkhoglyadova of the Ionospheric and Atmospheric Remote Sensing Group (335G), have provided a financial contribution for a new award for members of the American Geophysical Union that includes a $10,000 cash prize to be bestowed every two years.

The Space Weather and Nonlinear Waves and Processes Prize will recognize cutting-edge work in the fields of "space weather" and "nonlinear waves and processes." The award will be presented by the union's Space Physics and Aeronomy Section (Tsurutani is the former president) and Nonlinear Geophysics Focus Group.

Tsurutani has made major contributions to the two fields throughout his career at JPL. Although he has recently been recognized by being awarded the American Geophysical Union Fleming Medal for "original research and technical leadership in geomagnetism, atmospheric electricity, aeronomy, space physics and related sciences," specific mention of the topics of the new prize are not mentioned.

Tsurutani said a plaque and medal will accompany the cash award, which he intends to fund based on investments with an expected solid accumulation of interest. "I want to set up a fund that will allow the award to be eternal," he said.

"The vital research being done in the areas of space weather and nonlinear waves and processes has all too often gone unrecognized and unrewarded by the scientific community," said Tsurutani. "I have been an AGU member for nearly 50 years, and I'm honored to be able to give back to the union that has served me throughout my career."

The two focus areas of the American Geophysical Union prize will alternate for each presentation of the award. The inaugural award will recognize a scientist for his or her work in space weather, and will be first presented at the union's 2013 fall meeting. The award presented in 2015 will recognize a scientist for work in nonlinear waves and processes.

The topic of space weather made a rare but significant appearance in the public eye in January with solar storms providing not only an astonishing light show in the north but also bombarding Earth with radiation—the largest such radiation storm since 2005. Also, Tsurutani authored a recent study on an intense magnetic storm in 1859 that, if repeated today, would probably disable power grids. "It's a national concern, and there's quite a lot of effort being dedicated to this right now," he said. "People are now understanding much more about the effects of space weather.

"My hope for this award is that by calling attention to the work of these dedicated researchers, their contributions can serve as an inspiration for future generations."

NUSTAR *Continued from page 1*

ATK-Goleta and Magna Corp. delivered the mast and its structure, Caltech provided the electronics and detectors, UC Berkeley designed the focal plane mechanical system and mast deployment motor, and Columbia University, Danish Technical University and NASA Goddard delivered the optics. Still to come at Vandenberg are electrical interface verification tests and integration with the launch vehicle as well as flight simulations to verify launch and all operations, Kim said.

"The high-energy community around the world is extremely excited about NuSTAR," said JPL's Daniel Stern, the mission's project scientist. "Models predict that two out of three black holes are deeply buried in dust. Optical and low-energy X-ray emissions are unable to see these hidden black holes, but NuSTAR will do very well at finding these buried black holes, thereby mapping the cosmic history of black hole formation. NuSTAR will allow us to probe the important role these black holes play in how galaxies evolve."

Joining Stern on the science team from JPL's Evolution of Galaxies Group are supervisor David Meier and postdoc Roberto Assef. Overall, Stern said, about 100 co-investigators worldwide will contribute.

"For me there's a nice synergy between NuSTAR and previous JPL missions I've worked on," said Stern. "When a black hole is heavily buried, it disappears in both visible light and in the low-energy X-rays. However, the obscuring material gets heated up and emits in the thermal mid-infrared. The dominant population of black holes is best studied in the mid-infrared and in the high-energy X-rays. When I first came to JPL I was on the Spitzer science team and I'm now on the WISE science team—a lot of my science at JPL has been on these buried black holes."

In addition to finding black holes, NuSTAR has a diverse science program that includes surveying the region of the Milky Way galaxy surrounding its central black hole to find neutron stars and white dwarfs—the densest celestial objects known—and mapping the remnants of recently exploded stars, still glowing in radioactivity, in order to understand both the explosion process and how elements like calcium are formed.

"We even plan to look at our own sun," said Harrison, "not something we planned when we designed the telescope, but given a brand-new capability, astronomers will find inventive ways to use it."

For more information, visit *www.nustar.caltech.edu.*

Clockwise from top: the JPL NuSTAR team; the NuSTAR spacecraft being lowered into its shipping container at Orbital Sciences Corp. in Dulles, Va. in January; engineers in the final stages of assembling the satellite at Orbital Sciences.


FOUNDRY RESPONDS TO COMPETITION

Lab's mission formulation gets a boost from increased emphasis on front-end activities

By Mark Whalen

It's a whole new world in the future of space exploration.

Tight federal spending leading to lean NASA budgets means scarce opportunities for flagship missions. Meanwhile, competitive large and medium-class missions, such as New Frontiers and Discovery, are up for grabs as never before. Almost half of the Lab's business is won competitively.

Also, principal investigators are shopping their bold proposals to find the best partnerships to help fulfill their dream missions. But why would they choose any place other than JPL?

With the Lab's well-earned track record of dozens of history-making missions, the answer might not be as clear-cut as it seems. The Lab's decades of success exploring the solar system and beyond are no longer enough.

To help obtain the best future mission opportunities and maintain its leadership role in exploration, JPL chartered the JPL Innovation Foundry, which integrates all tools and methods associated with formulating new missions.

"The Foundry is a response to our awareness that we are in a more competitive environment, and that we believe we can do better in formulating our missions, both competed and assigned," said Daniel McCleese, JPL's chief scientist and director of the Foundry.

In response to more competitors, more complex mission ideas and tougher standards of technical evaluation, the Foundry provides JPL program offices, their principal-investigator partners, and their proposal teams, with standout JPL subject matter experts, both technical and programmatic, who offer expertise at every step from the spark of an idea through concept development, said Brent Sherwood, manager of the Foundry.

Sherwood noted that about 27 percent of the JPL population touches proposals in some way. Today, he said, 45 percent of the Lab's future business is up for competition.

The Foundry's capabilities are supported by best-practice methods and by facilities such as the Project Design Center, the Proposal Center, and new places for idea exploration including a room in Building 301 known as "Left Field" that is based on innovation methods pioneered by companies in Silicon Valley.

Historically, JPL's approach to formulation has had two parts. "In the case of a competed proposal, a program office might develop a concept with a principal investigator who might be at JPL or from an outside institution," said McCleese. "Later that concept is amplified in the Team X environment, which provides concurrent engineering to help teams rapidly develop it, determine its technical feasibility, and its cost."

The second step has been the Proposal Center, where ideas are worked intensively for many months, sometimes a year, said McCleese, before a proposal is fit to submit in response to NASA announcements of opportunity.

Recent activities have retooled JPL's formulation lifecycle activities to better support principal investigators, teams and program offices.

Team X and the proposal center have worked quite well, but sometimes, said McCleese, ideas are not quite ready for the Team X environment.

"Rather, what's needed is something before that: a concept development phase, in which there's broader exploration, a stretching of ideas to find different implementation strategies, or even different ways of going about getting the science," he added.

That's where the "A-Team" has come in to add a critical capability to the front end of the formulation process. The small team provides ideation, feasibility analysis, and trade-space exploration early in the concept lifecycle to toughen a proposed scientific approach and ready it for more detailed concept engineering.

The A-Team approach builds on some of JPL's success stories. Juno, launched last August to explore Jupiter's origin and evolution, is a prime example. Some concepts initially called for sending a probe into the Jovian atmosphere to do the necessary measurements. But by working through alternatives, the team found that remote sensing with microwaves could do a substantial amount of what the probe was going to do. "So that idea is the one that was developed and eventually taken to Team X to engineer and cost, and then they developed this proposal and it was selected by NASA," McCleese said. "All teams might have done it this way, but Juno chose to push the boundaries of the concepts before they went to Team X, and it proved to be invaluable."

The Foundry is a response to our awareness that we are in a more competitive environment, and that we believe we can do better in formulating our missions, both competed and assigned.

Daniel McCleese

The A-Team has been focused on about a dozen strategic ideas so far, some of which are already heading into JPL's competitive portfolios.

McCleese noted the effectiveness of pilot studies conducted since last summer. "There are a lot of lessons learned that we will use in how we train individuals to help teams, to facilitate and guide," he said. "Some of these studies have really shown the value of this front end by identifying concept elements that were new, things that hadn't been thought about by the team prior to going through the pilot.

"One such example is in the coming New Frontiers opportunity, which we're getting ready for in the planetary program," McCleese added. "But there have been many. We've done at least one pilot study for each of the directorates."

Sherwood said JPL needs more of this front-end action in concept development to "uncover alternatives and to disassemble assumptions," to find the right balance of scope and cost before the proposal phase begins. "A project will never again have as much flexibility as it does at this early stage, so we owe it to the principal investigator to exploit that unique opportunity."

With so much at stake, for JPL to win its future, the Lab will, as always, count on its best asset, said Sherwood. "Ultimately, it comes down to the quality of the people we have."

News Briefs

Gerard Holzmann

Holzmann honored with fellow designation

Gerard Holzmann, chief scientist of the Laboratory for Reliable Software and a JPL fellow, has been selected into the 2011 class of fellows of the Association for Computing Machinery.

The organization recognizes 2011 Fellows for their "contributions to computing that have provided fundamental knowledge to the computing field and generated multiple technology advances in industry, commerce, healthcare, entertainment and education."

Holzmann, a faculty associate at Caltech in the Department of Computing and Mathematical Sciences, has been with JPL since 2005.

The association will formally recognize the 2011 fellows at its annual awards banquet in June 16 in San Francisco.

Earth science proposals selected

Two JPL researchers have been awarded funding for their proposals to NASA's Advancing Collaborative Connections for Earth System Science program.

Hook Hua of the High Capability Computing And Modeling Group will lead a study outlining Collaborative Climate Model and Observational Data Services, a system that will address data access and interoperability issues that often exist in NASA Earth Science's distributed and heterogeneous data and information systems.

The system will also simplify voluminous data transfer by automating observation and model data assembly, merging and analysis on the server side. The new capabilities address specific science gaps in the model evaluation process.

Meemong Lee of the Space and Astrophysical Plasmas Group will lead Multi Mission Observation Operator, whose goal is to create a streamlined interface mechanism between atmospheric chemistry model developers and atmospheric sounding mission data providers by infusing mission-generic observation integration technologies developed under the Advanced Information System Technology program.

This will address a major challenge in utilizing the space-based observations within the atmospheric chemistry modeling and assimilation community. The team will work with model analysis communities to use Earth science observational data and improve users' ability to mine useful information from distributed, large volumes of heterogeneous data.

Honoring Dr. King

Thom Wynne / JPL Photo Lab

A poem by JPLer Tiffany Snow and an inspirational tribute to Dr. Martin Luther King Jr. highlighted JPL's celebration of the civil-rights leader's legacy Jan. 12.

Snow (top), a five-year JPL employee who works in the University Relations and Staffing Operations Group, recently won the NAACP Best Supporting Actress Award for her role as the Lady in Green in the play "For Colored Girls."

Actor and inspirational speaker Gerald Rivers (bottom), a longtime voice of King in numerous events for schools, colleges and community organizations, delivered a tribute. In August, he spoke the words of King for the Martin Luther King Jr. Memorial dedication in Washington, D.C.

GRAIL twins get names

Fourth-grade students at Emily Dickinson School in Bozeman, Mont., along with their teacher, Nina DiMauro, celebrate their winning entry in a contest to name the Gravity Recovery and Interior Laboratory (GRAIL) satellites. Ebb and Flow was chosen from more than 11,000 student entries. The JPL-managed mission to Earth's moon launched Sept. 10, 2011 and entered orbit in January. Ebb and Flow will start science data collection in March.

Passings

Gerrit Bodt

Retiree **Gerrit Bodt**, 93, died Jan. 22.

Bodt joined the Lab in 1968 and retired in 1983. He worked in the Nucleonics Division, testing nuclear generators from NASA's Nuclear Auxiliary Program.

He is survived by daughter Patricia and son Albert, as well as five grandchildren and two great grandchildren.

Jack Taylor

Retired metallurgical research engineer **Jack L. Taylor,** 94, died Jan. 25.

Taylor worked in the Materials Research and Science Instrument sections at JPL from 1946 to 1982. During his career, he contributed to numerous planetary missions including Mariner, Viking and Voyager flight instruments.

He is survived by his wife, Maude Ann; son Brian, his wife Susan and grandchildren Justin and Lauren; daughter Jacqueline, her husband Chuck Badeau and grandson Taylor.

A memorial celebration of Taylor's life will be held Saturday, Feb. 18 at 1:30 p.m., 645 Fairview Ave., Sierra Madre.

Letters

I would like to thank my fellow coworkers for your kind words of comfort and the ERC for the beautiful plant you sent in remembrance of the passing of my father.

Mike Sucy

I would like to thank everyone who provided contributions to the American Heart Association and sent their kind thoughts and notes of sympathy on the passing of my mom. She was just shy of her 98th birthday. She often told me that for me to work at JPL for as many years as I have, I must be in the company of a lot of great people and close friends. She was right. Thank you all, again.

Wayne Zimmerman

My family and I would like to thank our friends and colleagues at JPL family for the kind words of support after the recent passing of my mother. Thanks also to JPL for the beautiful plant in remembrance of her. Your e-mails and kind words have been most comforting to us. Thank you so much.

David E. Brinza, Ph.D.

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