

2017: A look ahead

As the Cassini and Dawn missions come to an end this year, JPL will prepare to embark on a first-time mission to Psyche, a metal asteroid. Meantime, back home, a critical follow-on mission to measure Earth's gravity field is being prepared for late in the year. JPL's suite of Earth-observing missions will continue their critical explorations, as will two rovers and two orbiters at Mars. Following are the major highlights for the Laboratory in the year to come.

PSYCHE: HEAVY METAL EXPLORATION

NASA's Discovery Program has given final approval to a JPL-managed mission to the main asteroid belt to encounter the largest metal asteroid ever identified. The mission is led by Principal Investigator Lindy Elkins-Tanton of Arizona State University. JPL will build the spacecraft with industry partner Space Systems Loral

of Palo Alto, Calif.

The asteroid, and mission, are both called Psyche. Launch is scheduled for 2023, with arrival at the asteroid in 2030, where it will spend 20 months in orbit. The spacecraft will use electric propulsion to reach and orbit the 157-mile-wide body.

Key JPL leadership includes Project Manager Henry Stone,

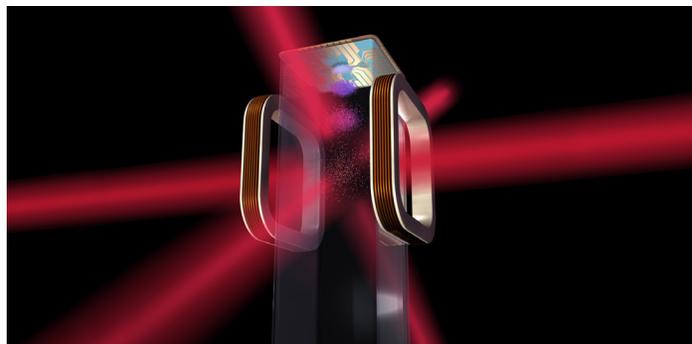
Continued on page 2



COLD ATOM LAB: INTO THE DEEP FREEZE

It's already chilly up at the International Space Station, but the JPL experiment "Cold Atom Laboratory" (CAL) will be the coolest place in the universe.

Scheduled for a summer 2017 launch, the mission's goal is to reach 100 pico-kelvin, less than a billionth of a degree above absolute zero, said Project Manager Anita Sengupta. "The whole purpose of the experiment is to get down to these temperatures so we are able to observe over a relatively long period of time, compared



to Earth-based laboratories, to better understand the physics of what happens when atoms interact at just above absolute zero," she said.

The experiment is configured

with a unique capability called atom interferometry that enables precise measurements of gravitation accelerations as well as inertial sensing.

"Ultimately, atom interferom-

etry is probably the 'killer application' of ultra-cold atoms in space, allowing scientists to address some of the most important questions remaining in physics, as well as having significant practical value," said Robert Thompson, CAL's project scientist.

"CAL will achieve these ultra-cold temperatures with innovative technologies that will be demonstrated in space for the first time," said Kamal Oudrhiri, the deputy project manager.

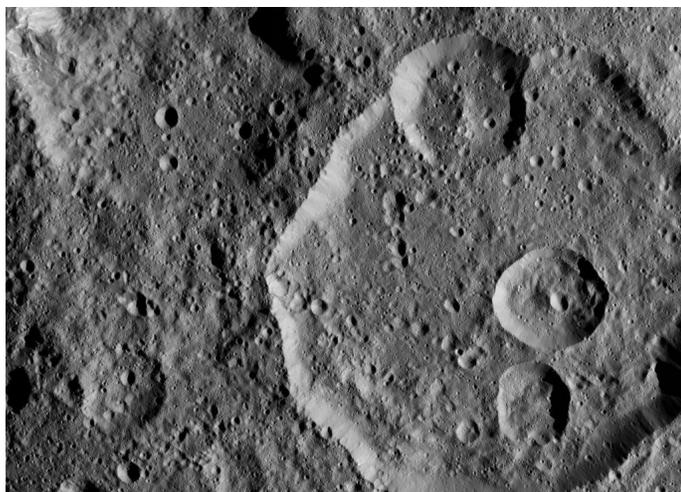
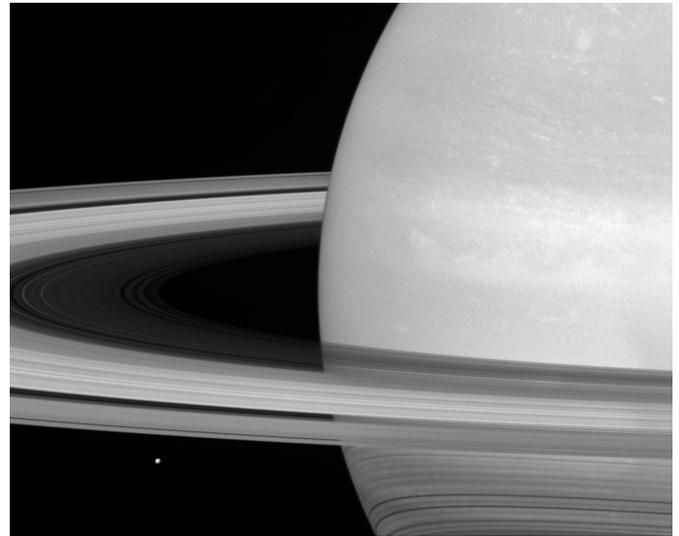
Continued on page 4

A LONG GOODBYE

All good things must come to an end, and for Cassini that time is September 2017. The venerable Saturn explorer is now executing a series of “ring-grazing” orbits, swooping down through the ring plane just outside Saturn’s F ring. These orbits will end with the spacecraft’s final close flyby of Titan in April, when Cassini begins a series of even more daring “grand finale” orbits.

Cassini will make the first of 22 plunges through the 1,500-mile-wide gap between Saturn and its innermost ring on April 26. The mission’s planned conclusion will be a final dive into Saturn’s atmosphere Sept. 15.

Saturn’s icy moon Mimas is dwarfed by the planet’s enormous rings in this 2016 image. Scientists think the rings are no more than a few times as massive as Mimas (246 miles wide) or perhaps just a fraction of Mimas’ mass.



This Oct. 26, 2016 view from Dawn shows Meanderi Crater on Ceres, seen at lower right. Meanderi hosts several medium-sized craters within its walls.

DAWN’S FAREWELL

Operating on an extended mission through June 30, 2017, Dawn’s exploration of the two largest objects in the main asteroid belt will come to an end at dwarf planet Ceres, which the spacecraft has been orbiting since 2015. Previously, Dawn revealed its first destination, Vesta, to be more closely related to the terrestrial planets (including Earth) than to typical asteroids. Dawn’s focus now at Ceres, the larger of the two, is to measure cosmic rays at high altitude in order to enhance measurements made during the eight-month phase at very low altitude. In January, Dawn began a new campaign of photography and visible spectroscopy.

The Dawn project, JPL and NASA will work together in the coming months to determine the best use of the spacecraft after it concludes its one-year extended mission.

PSYCHE *Continued from page 2*

Project Scientist Carol Polansky, Deputy Project Manager Bob Mase and Project Systems Engineer David Oh. The JPL proposal team included more than 75 people.

JPL co-investigators are Bruce Bills, Insoo Jun, Ryan Park, Carol Raymond and Daniel Wenkert.

Psyche is made almost entirely of nickel-iron metal and offers a unique look into violent collisions that created Earth and the other terrestrial planets. Scientists

will consider whether Psyche could be an exposed core of an early planet that could have been as large as Mars, but which lost its rocky outer layers due to a number of violent collisions billions of years ago.

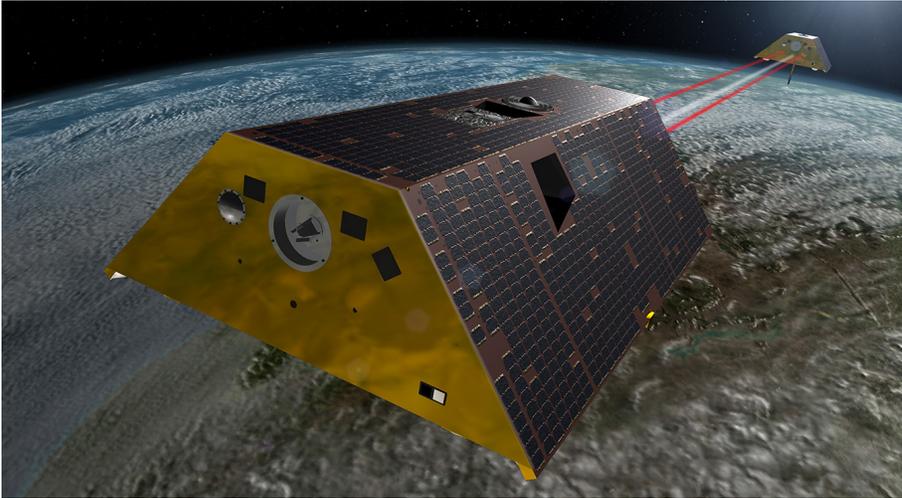
Psyche’s scientific goals are to understand the building blocks of planet formation. The mission team seeks to determine how old Psyche is, whether it formed in similar ways to the Earth’s core, and what its surface is like.

The Discovery Program also selected

Lucy, a robotic spacecraft scheduled to launch in October 2021 and slated to arrive at its first destination, a main belt asteroid, in 2025. Lucy will explore six Jupiter Trojan asteroids.

NASA also extended Discovery funding for the JPL-managed Near Earth Object Camera (NEOCam) project for an additional year. The infrared space telescope is designed to survey regions of space closest to Earth’s orbit, where potentially hazardous asteroids may be found.

GRACE FOLLOW-ON



Construction is complete on the first of the two satellites for JPL's Gravity Recovery and Climate Experiment Follow-On mission, planned for launch in the December 2017/January 2018 timeframe.

A partnership between NASA and the German Research Center for Geosciences, the five-year mission will continue the twin GRACE satellites' exploration of Earth's mass redistribution and monitoring

of changes in underground water storage, glaciers and sea level.

GRACE-FO will provide updated measurements of Earth's gravitational field every 30 days. Its satellites will also test an experimental instrument using lasers instead of microwaves, which promises to make the measurement of their separation distance at least 20 times more precise. Visit <http://gracefo.jpl.nasa.gov>.

EARTH AIR CAMPAIGN

JPL's suite of Earth-observing satellites and airborne campaigns will continue in earnest in 2017.

Among them are the Hyperspectral Infrared Imager mission, which will study ecosystems for critical information on natural disasters such as volcanoes, wildfires and drought. A campaign in Hawaii is planned for this year.

Also, a pair of different airborne missions—cubesats—will be prepared for launch in early 2018. Raincube (a technology demo to enable Ka-band precipitation radar technologies on a low-cost, quick-turnaround platform) and Tempest (cloud and precipitation processes) are scheduled for completion in September.

JPL is developing the global navigation satellite system for the Constellation Observing System for Meteorology, Ion-

sphere and Climate (COSMIC)-2 mission, which will launch six satellites into low-inclination orbits in 2017 to provide a revolutionary increase in atmospheric and ionospheric observations. The mission is led by the University Corporation for Atmospheric Research, a consortium of more than 70 universities.

JPL's delivery of the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (Ecostress) in July is a key milestone for NASA. Due for launch in April 2018, it will probe how the terrestrial biosphere responds to changes in water availability.

For more information, visit http://climate.nasa.gov/nasa_science/missions and https://airbornescience.nasa.gov/program/current_activities.

MORE AT MARS

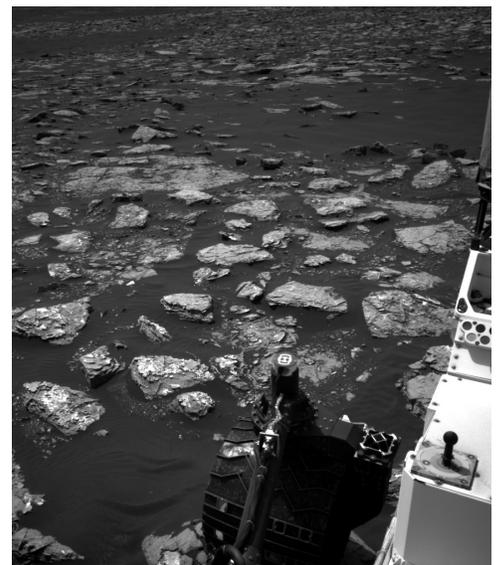
NASA's two Mars rovers and the two Mars orbiters managed by JPL all enter 2017 just three months into two-year extended missions approved after in-depth reviews during 2016.

Mars Odyssey, in orbit since 2001, is the longevity champion of all spacecraft ever sent to the Red Planet. During this two-year extension, it will be examining Mars in early-morning daylight for insights about fogs, clouds and frosts that form overnight in some regions. Odyssey will also continue providing data-relay service for robots on the surface of Mars.

A key destination for the Mars Exploration Rover Opportunity's current extended mission is to drive down a 200-yard-long gully carved long ago by a fluid that might have been water. No Mars mission has examined a fluid-carved gully close up. The Opportunity team hopes to determine whether the fluid was debris flow, with lots of rubble lubricated by water, or a flow of mostly just water.

In 2017, the Curiosity rover will continue climbing to higher and younger geological layers of Mount Sharp. Curiosity has

Continued on page 4



This December view from Curiosity's navigation camera shows rocky ground in view while the rover was working at an intended drilling site called "Precipice" on lower Mount Sharp.

JUNO



The Juno spacecraft, in orbit around Jupiter since July 4, 2016, will for the first time peer below the dense cover of clouds to answer questions about the gas giant and the origins of our solar system. The mission, now in a 53-day orbit, is scheduled for completion in early 2018.

The mission team is inviting amateur astronomers to upload their telescopic images and data of Jupiter. These uploads will help NASA successfully plan the future of the mission.

In addition, the public is invited to vote for their favorite images from JunoCam, which will provide close-up photos of Jupiter's poles for the first time. Voting for the next perijove (close approach) will begin Jan. 19.

Visit <https://www.missionjuno.swri.edu>.

COMING ATTRACTIONS

IN SIGHT: Preparations continue this year for the mission, due to launch in late 2018. InSight will place a lander on Mars that will drill beneath the surface to investigate the planet's interior structure. The lander will be equipped with a seismometer and a heat-flow probe.

MARS 2020: The 2020 rover is now in Phase C (building rover parts and the spacecraft). Also, the current list of its eight potential landing sites will be trimmed to three or four at a February workshop. There's also a critical design review next month as well. The rover is on schedule and budget for its planned launch in July or August 2020.

EUROPA: Scheduled for launch in the 2020s, JPL's planned Europa mission would conduct detailed reconnaissance of Jupiter's icy moon and investigate whether it could harbor conditions suitable for life. This year's milestones include preliminary design reviews in June and July for the propulsion subsystem, solar array, propulsion module electronics and propulsion module. A preliminary design review for the flight system (spacecraft and instruments combined) is planned for October. Also this fall

Another study, led by principal investigator Jason Williams of JPL, will explore interatomic interactions and interferometry of atomic matter waves with quantum gases at the extremely low-energy scales that can only be accessed in microgravity. "These studies will lead to an unprecedented level of control and accuracy in precision metrology with dual-species atom interferometers that is necessary, for example, for space-based tests of Einstein's Equivalence Principle," he said.

A JPL in-house build, CAL is currently in the final phase of assembly and test with delivery due in late April. "As the final pieces are integrated, it's remarkable to see such a highly complex system that typically fills an entire room come together into its consolidated form," said system test lead Dave Aveline.

There are 33 team members from 7X and divisions 33, 35 and 31, a unique mix of atomic physicists, laser-optical physicists and engineers. Launch via a SpaceX or Orbital rocket will occur no earlier than June 1.

The science team includes three Nobel Prize winners in physics: Eric Cornell, Wolfgang Ketterle and Bill Phillips. Once on-board the space station, the payload will be operated remotely from JPL.

MARS *Continued from page 3*

been examining evidence that, billions of years ago, the area was a lake bed with all the key ingredients for supporting microbial life. In the climb up lower Mount Sharp, the mission will continue investigating how the ancient environment evolved to harsher conditions more like modern Mars.

Studies by Mars Reconnaissance Orbiter of active processes that alter Mars' surface seasonally or on multi-year time scales will continue in 2017, with observations to learn more about processes such as downhill flows, crater-excavating impacts, dust storms and cycling of carbon dioxide between the atmosphere and seasonal sheets of "dry ice." The orbiter also supports other missions with data-relay service and evaluation of potential landing sites.

will be the completion of solar-array development tests for environmental survival and electrostatic discharge.

ASTEROID ROBOTIC MISSION: Due for launch in 2021, the unique mission will visit a large near-Earth asteroid, collect a multi-ton boulder from its surface, and use it in an enhanced gravity tractor asteroid deflection demonstration. The spacecraft will then redirect the boulder into a stable orbit around the moon, where astronauts will explore it and return with samples in the mid-2020s. Key dates this year include awarding a spacecraft contract in May. In June, NASA will announce the investigation team as well as hosted payloads for the mission.



Jessie Kawata

JPLer earns kudos from Art Center

JPL creative strategist and product designer Jessie Kawata has received the Art Center College of Design's Young Innovator Award for 2016.

Kawata graduated from the Pasadena college in 2011, earning a bachelor's of fine arts with honors in product design. A member of JPL's Advanced Design Engineering Group, she has been the lead product designer with the JPL Studio, co-investigator for a national climate assessment drought indicator project and lead product designer for the Office of Formulation's "A Team."

The Young Innovator Award recognizes a notable professional or creative innovation, bestowed on a recent alumnus of the past 10 years.

Kawata received the award Dec. 17 at the Pasadena Civic Auditorium.

Emerging Leader Award to van Houten

JPL systems engineer Tracy van Houten re-

cently received the Society of Women Engineers Emerging Leader Award for 2016. The award honors those actively engaged in an engineering or technology profession, and have demonstrated outstanding technical excellence as an individual resulting in significant accomplishments and has 10 to 15 years of engineering experience.

Van Houten is currently the flight system lead for the Mars 2020 project. She also heads JPL's new team to recruit women engineers to the Laboratory.

Van Houten earned bachelor's and master's degrees in aerospace engineering from Cal Poly San Luis Obispo and USC, respectively.



Tracy van Houten

Classifieds

Ads submitted Dec. 31 to Jan. 6.

For Sale

HOME GYM, Wilson cable type, good cond., \$100. Call/text Chris: 661-733-7020, cjbud@hotmail.com.

Vehicles / Accessories

'02 CANNONDALE Bad Boy Scalpel, older but essentially unused road bike built on mtn. frame w/ f/r suspension (Headshok Lefty ELO and Fox RL shock, both w/lock outs), burnished alum. frame w/carbon fiber chain stays, CX2 crank, 9-spd. Shimano XTR w/ Deore LX RapidFire shift levers, Magura Julie disc brakes, water bottle + air pump; currently mounts 26" Mavic Crosstrails w/26 x 1.6 Continental Sport-Contacts; also incl. set of 700 Mavic CXP21s w/700 x 23 Continental 3000s; clean bike, tires essentially new; believe sz. is Large, road setup easily converted to crosstrail/mtn., pics avail.; \$750. 310-322-5778, sohearn@csi.com.

'07 CHEVY Corvette custom Z06. <http://corvettestory.com/2007-corvette-z06-for-sale>.

'10 KIA Forte EX, 4-dr., 2.0L auto, 70.5K miles, no accidents, new brake pads, \$6,000. 213-393-9817.

Free

SLEEPER SOFA, red "bonded leather" with some cat scratch damage and wear, you haul (it's heavy), photos available. mroque4@gmail.com.

Wanted

SPACE INFO/memorabilia from U.S. & other countries, past & present, for personal use (see <http://www.youtube.com/watch?v=S7PvjGp7mCU>). mrayman@alumni.princeton.edu, 818-790-8523, Marc Rayman.

For Rent

ALTADENA (91001), furn. 2-bedrm., 2-bath home remodeled in 2012; ideal for roommates, bedrooms/baths at opposite ends of the house; refrigerator + microwave, plates, pots/pans, utensils, etc.; washer + dryer; gated parking in driveway + carport; nearest cross-st. Fair Oaks/Calaveras; long- or short-term lease avail.; renter pays utilities excl. trash; \$2,000/

mo., small pet OK for additional monthly fee. mpauken@gmx.com, 818-237-0645.

ALTADENA, furn. rm. w/awesome view for lease; non-smoker to share a 4-bedrm, 3-bath house across from community garden; close to local colleges + Pasadena schools, walk to JPL; utilities included, central air/heat, internet access, near bus stop, shopping, banking, entertainment and restaurants; \$800/month. 818-370-0601.

ALTADENA (91001), furnished loft for lease; non-smoker to share a beautiful 4-bedrm., 3-bath house across from community garden; walk to JPL; utilities incl., cent. air/heat, internet access; near bus, shopping, restaurants; \$740/mo. 818-370-0601.

PASADENA, large rm. w/attached full bath in a spacious furnished apt. in front of Caltech; living rm. + kitchen are shared; 1 garage spot and laundry privileges; 6 miles to JPL, close to public transport and Old Town; living space has TV, couch, piano; kitchen has utensils and dining table, view of campus from balcony; \$900 + \$900 deposit. 917-655-0068.

PASADENA, furn. rm. in 4-bd./2-bath house, big backyd, hardwd. floor, big closet, shared bathrm., kitchen/laundry; 2 miles/JPL, close to public transport; short- or long-term lease; must like dogs and be very clean; \$900 + \$900 deposit. 818-960-8654.

Vacation Rentals

MAMMOTH, Snowcreek, 2 bd., 2 ba. + loft, sleeps 6-8, fully equip'd kitchen incl. microwave, D/W, cable TV, VCR, phone, balcony w/mtn. vw., Jacz., sauna, streams, fishponds, close to Mammoth Creek, JPL discount, no pets. 626-798-9222, 626-840-3749 or valeriee@caltech.edu.

MAMMOTH, Snowcreek, beautiful updated condo, 2 bd., 2 ba. + loft (sleeps 6-8), great location by pond/meadow, new appliances, TVs, DVD, free wireless Internet and washer/dryer, no pets. 818-952-2696 or BigMtnPrettySky@gmail.com.

MAMMOTH, remodeled 2 bed/2 bath + loft, short walk to Canyon Lodge; Courchevel 6 features full kitchen, cable/Internet TV, DVD, Blu-Ray, wireless hi-speed Internet, 2-car garage, Jacuzzis, grill, pool; no pets. <http://Courchevel6.com>.

MEXICO (1 bedroom): Mayan Palace: Acapulco, Nuevo Vallarta, Riviera Maya, Puerto Vallarta; Sea Garden: Acapulco, Nuevo Vallarta, Mazatlan; Kauai, Hawaii (1 bedroom), Pacific Fantasy, Kapaa, HI; trades also available with II and RCI. 818-272-3262.



E-MAIL US AT
universe@jpl.nasa.gov