Featured Stories

Looking Back On A Year That Looked Forward

The past year was less a story of major launches than of major progress.

Mars 2020 came together in the high bay, Psyche leapt off the drawing board, Europa Clipper moved into final design, and the Lab's next generation of flight projects advanced to the starting line.

Mars InSight started studying marsquakes, and interactive coverage of the probe's landing in 2018 won an Emmy for the mission team and their communications colleagues. More than 20,000 space fans toured the Lab during Explore JPL, and nearly 11 million added their names to chips that, if all goes well, will leave Earth on Mars 2020 and land in Jezero Crater.

The **Astronomy and Physics** directorate cheered NASA's selection of SPHEREx, a mission to survey the universe that promises to return a wealth of data far out of proportion to its modest cost. By mapping the sky in the optical and near-infrared spectra, SPHEREx will glean clues to the origins of the universe and to the prevalence of water, organic molecules and other ingredients for life in our Milky Way galaxy.

"I'm really excited about this new mission," said NASA Administrator Jim Bridenstine. "Not only does it expand the United States' powerful fleet of space-based missions dedicated to uncovering the mysteries of the universe, it is a critical part of a balanced science program that includes missions of various sizes."

The past year also saw the successful launch and commissioning of the Deep Space Atomic Clock, a technology demonstration of a small and extremely stable atomic timekeeper. The clock is 50 times more accurate than its predecessors, which can enable more precise navigation and data collection for future missions.

The directorate delivered all promised NASA hardware to the European Space Agency's Euclid project for integration and testing in the Near-Infrared Spectrometer and Photometer instrument; conducted a successful preliminary design review for the coronagraph instrument on WFIRST; and launched a new science module to the International Space Station for installation on Cold Atom Lab, enabling atom interferometry research in space.

The **Earth Science and Technology** directorate made news with startling data from a two-year survey of methane emissions in California. In a collaboration with Cal State researchers, the California Air Resources Board and the California Energy Commission, JPL flew a plane equipped with methane leak detectors over nearly 300,000 sites, including oil and gas fields, large dairies and landfills. The team documented more than 550 sources emitting plumes of highly concentrated methane, with 10 percent contributing the majority of emissions.

In another collaboration, but this time of complementary instruments, the orbiting GRACE-FO mission measured a deceleration and then a rapid increase in melting from the Greenland Ice Sheet, while the airborne Oceans Melting Greenland mission accounted for the fluctuation: water underneath the ice had remained cold for a brief period, slowing glacial melt, but then warmed enough to drive another rapid melting phase.

The Orbiting Carbon Observatory-3 (OCO-3), NASA's newest spaceborne carbon dioxide-measuring mission, launched to the ISS in May and has begun collecting data, with more results expected in early 2020. OCO-3 measurements will complement the science from an adjacent JPL instrument called ECOSTRESS, which is measuring the health of vegetation. ECOSTRESS engineers successfully overcame the loss of its mass storage units by devising an ingenious fix that allowed the mission to continue collecting data. The relatively inexpensive ECOSTRESS mission demonstrated that high quality science data can be acquired from the space station.

In July 2019, the **Interplanetary Network Directorate** marked the 50th anniversary of the Apollo moon landings, supported by the Deep Space Network, and looked forward to the return of DSN-enabling human spaceflight missions to the Moon with the planned launch of Artemis I late in 2020. JPL also took the leading role in the international Lunar Communications Architecture final report, which will be used by the Artemis program for human lunar exploration.

The DSN also enabled key mission events around the world, including the SpaceIL and Chandrayaan-2 Israeli and Indian lunar missions, the Japanese Hayabusa2 asteroid sample-return mission, and the New Horizons encounter with a Kuiper Belt object.

The DSN's Aperture Enhancement Project progressed toward delivery of two new antennas at the Madrid deep space center complex, including the completion of both pedestals, delivery of panels, mirrors and sub-reflector for both antennas, and significant advances in antenna fabrication and assembly.

In the **Mars Exploration** directorate, 2019 rolled inexorably towards 2020. The Mars 2020 mission achieved integration of the cruise stage, descent stage and rover, with successful system and environment testing. As the year was counted down, the rover's time at JPL – and on this planet – also neared its end.

In one of its last challenges on Lab, the rover passed its driving test. JPL engineers maneuvered the rover around a clean room and pronounced it ready to wander the Martian surface. Strapped to the rover's marsupial belly: Mars Helicopter, a high-risk, high-reward technology demonstration.

Mars 2020 will join its older cousin, the Curiosity rover, which passed the seven-year mark on a high note with the discovery of clay deposits in Gale Crater, suggesting the basin once held a significant amount of water. But Mars 2020 will arrive too late for Opportunity, whose roving mission came to an official end last year after a gigantic dust storm in 2018 cut off communications and solar power. Opportunity rests in Perseverance Valley after a record 15 years of Martian roving.

Mars Reconnaissance Orbiter also passed a milestone with its 60,000th orbit in 2019. After 13 years, the orbiter's instruments have returned nearly 380,000 images and relayed vast amounts of data to Earth from NASA's rovers and landers.

The **Solar System Exploration** directorate celebrated NASA's approval to start bending metal for Psyche, the first mission to explore the exposed metal heart of a planetary body.

The Psyche team saw years of planning and formulation start to bear fruit in 2019, as the first pieces of flight hardware were unveiled for the spacecraft's solar-electric propulsion chassis. The mission will carry an imager, magnetometer, and gamma-ray spectrometer, to help scientists understand whether the asteroid is the core of an early planet, when it was formed, what types of terrain and materials characterize its surface, and whether it formed in similar ways to Earth's core. Launch is targeted for August 2022.

The Europa Clipper mission to Jupiter's icy moon received its own good news as NASA approved completion of final design, followed by spacecraft and science payload construction and testing.

"We are all excited about the decision that moves the Europa Clipper mission one key step closer to unlocking the mysteries of this ocean world," said Thomas Zurbuchen, associate administrator for the Science Mission Directorate at NASA Headquarters in Washington. "We are building upon the scientific insights received from the flagship Galileo and Cassini spacecraft and working to advance our understanding of our cosmic origin, and even life elsewhere."

The directorate in 2019 also delivered key instruments to the Mars 2020 mission: SHERLOC, to search for organics and minerals altered by watery environments; MOXIE, a demonstration technology to produce oxygen from the Martian atmosphere; and PIXL, to search for signs of past microbial life.

A different pioneer, the Caltech-led Lunar Trailblazer mission, was one of three finalists selected by NASA in 2019 as a potential future expedition to orbit Earth's moon in order to detect and map water on the lunar surface.

As approved flight projects march towards launch, the **JPL Next** investment program aims to develop emerging systems into radically new types of missions. The first system funded by JPL Next, Ocean Worlds Life Surveyor, successfully detected and verified ocean-based life using its full instrument suite during field tests in 2019. The OWLS team plans to move into the next stage of development in early 2020.

The Mars 2020 rover and descent stage in the Spacecraft Assembly Facility Image Credit: PhotoLab

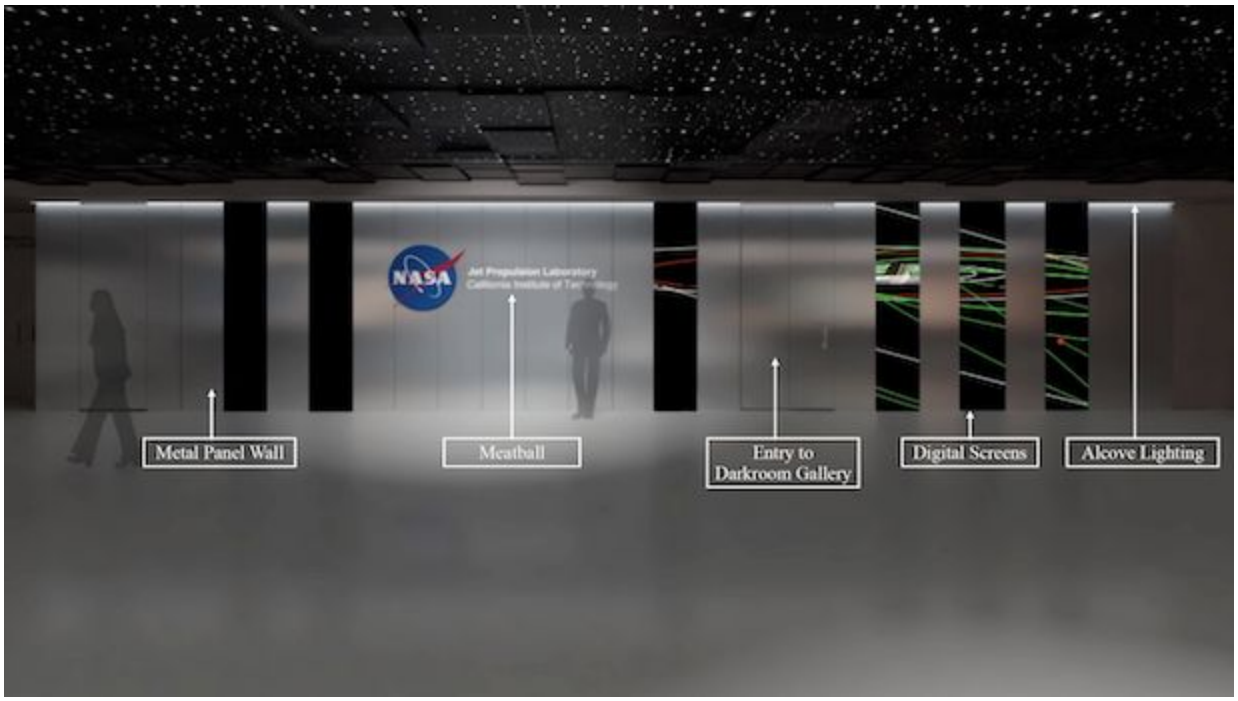
A Look Ahead At 2020

The ushering in of a new decade at JPL marks the sendoff of the Mars 2020 rover inhabiting High Bay 1, as the car-sized spacecraft prepares for transport to Cape Canaveral in February.

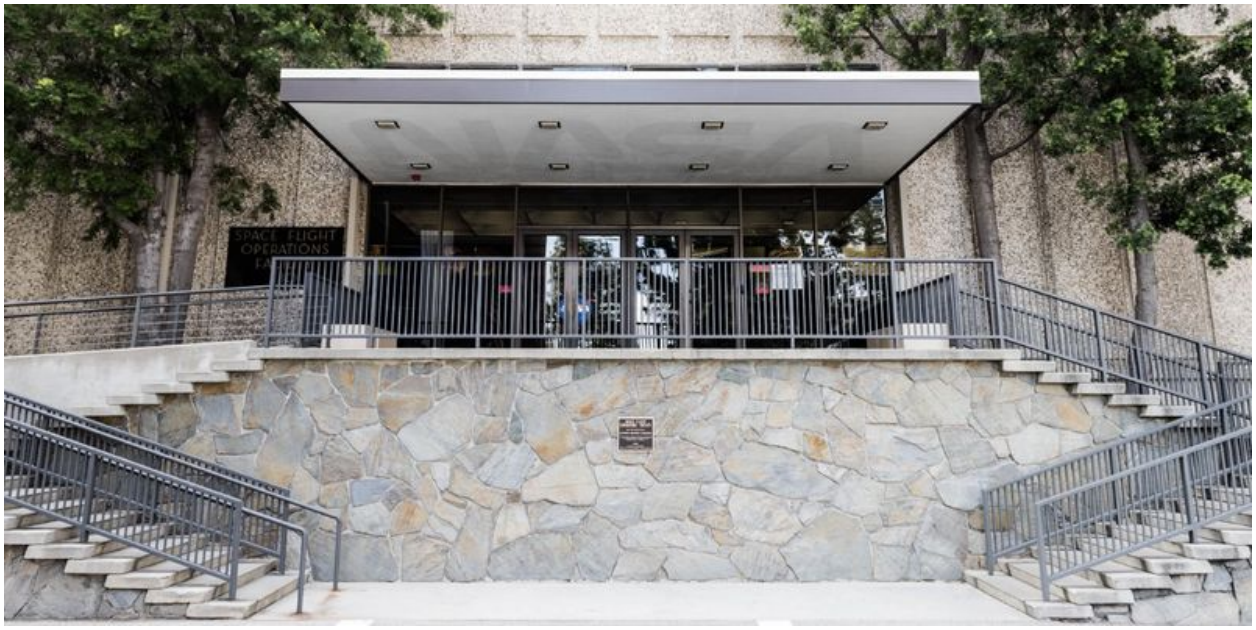
The launch of the most advanced Mars mission to date headlines a new year of momentous steps for the Lab, including assembly of two Earth-observing satellites in High Bays 1 and 2, breaking ground on a new 34-meter antenna at Goldstone Deep Space Communications Complex, and a bittersweet send-off for the first telescope to capture the reflected light of a planet outside our solar system.

Around Lab, JPLers will see improvements to the Mall and Mission Control over the course of 2020. Plans call for the defunct fountain to be removed in February and replaced with a wooden deck that will act as a transition between the plaza to the lawn, and allow for additional seating and umbrellas. Building 230 is getting a facelift, as visitors to the historic facility will now enter an updated lobby with five floor-to-ceiling screens that will work as one large display, a fiber optic star-filled ceiling, and a renovated viewing gallery with updated furniture.

An artist's rendering shows the plans for improvements to JPL's Mall area.



Plans for the lobby of Building 230 call for an updated look with digital screens.



The entrance to Building 230 will soon have a NASA worm logo.

Earth Science

Following the successful 2019 launch of the Orbiting Carbon Observatory-3 and its mission to continue gathering carbon dioxide measurements of the planet, the Earth Science and Technology directorate turns to the ocean in 2020, with the launch of the Jason Continuity of Service (Jason-CS) mission on the Sentinel-6 spacecraft. The mission—a partnership between NASA, ESA and others—includes two identical satellites scheduled to launch in November 2020 and 2025 that will monitor sea level rise continuously throughout the next decade.

This summer, visitors will be able to view the assembly of the NASA-ISRO SAR Mission (NISAR) in High Bay 1, and the beginnings of the Surface Water and Ocean Topography mission assembly in High Bay 2.

In preparation for the NISAR mission--which will use dual-frequency synthetic aperture radar to study hazards and global environmental change--the Indian Space Research Organization and JPL collaborated to test airborne synthetic aperture radar (SAR) in L- and S-band that is similar to the space-borne dual frequency SAR planned for the 2022 launch. The airborne research is key to testing the new hardware systems of NISAR and verifying the frequencies are synchronized and the data is optimized--paving the way for unprecedented and detailed measurements of the planet's complex ecosystem disturbances including ice-sheet collapse and natural hazards such as earthquakes, tsunamis, volcanoes and landslides.

NASA-ISRO Synthetic Aperture Radar

Mars Exploration

For Mars, the new year ramps up to the planned July 17 to Aug. 5 launch window of the Mars 2020 rover.

The past year saw the nearly complete integration of the cruise stage, descent stage and rover, with successful system and environment testing completed along the way. Now, the team moves toward packing the rover into a specially-designed container and sending it off to Cape Canaveral, where the spacecraft will undergo final processing and testing before launch.

Six months later, around Feb. 18, 2021, the Mars 2020 team will be hoping anxiously for another round of high-fives, memorable handshakes and celebrations in Mission Control, as the car-sized rover embarks from Mars' Jezero Crater to search for signs of past life, characterize the planet's climate and geology, and collect samples for future return to Earth missions.

Make that "near future." The directorate plans to move the Mars Sample Return mission to Phase A in the July/August 2020 timeframe, and further develop a mission concept to bring back rock and dust samples from another planet for the first time in history.

Interplanetary Network

With multiple launches, landings, and even a return to Earth in 2020, the Interplanetary Network Directorate will have its hands full providing Deep Space Network communication services to space missions managed around the world, including; the Mars 2020 launch, the European Space Agency's ExoMars Launch, the Osiris-Rex Touch and Go from Bennu asteroid, the United Arab Emirates Hope Mars Mission launch, the launch of the Artemis-1 Moon mission, and Japan's Hayabusa2 return to Earth.

To meet the demand, the Deep Space Network will complete development and deployment of its "Three Links per Operator" capability, enabling full automation of tracking passes and improving operational efficiencies.

On the ground, new antennas are slated for Madrid's Deep Space Center Complex, with development and operation of DSS-56 expected to begin this year. And at Goldstone, construction will start Feb. 11 on a new 34-meter radio frequency/optical hybrid antenna.

Astronomy and Physics

While work continues in the Astronomy and Physics Directorate's quest to better understand our universe, 2020 will also be a time of reflection and celebration, as the 16-year-long mission of the Spitzer Space Telescope comes to an end.

Spitzer was the last of NASA's four original Great Observatories to launch, joining Hubble, the Compton Gamma-Ray Observatory, and the Chandra X-ray Observatory. Designed for a five-year mission, Spitzer launched on August 2003 aboard a Delta 2 rocket from Cape Canaveral. It was the first telescope to see light from a planet outside our solar system, and it also made important discoveries about comets, stars, exoplanets and distant galaxies.

Looking forward, the directorate aims to complete the critical design review (CDR) of the coronagraph instrument to fly aboard the Wide Field Infrared Survey Telescope, and will start work on CASE—an infrared spectrometer that will study what exoplanets are made of—and SunRISE—a constellation of CubeSats that will operate as a synthetic aperture radio telescope and provide an entirely new view on particle acceleration and transport in the sun's inner heliosphere.

Illustration of the Spitzer Space Telescope

Solar System

For the Solar System Exploration Directorate, instruments aboard the Mars 2020 rover will accelerate our understanding of the Red Planet's ancient past, and potential human exploration efforts in the future. SHERLOC and PIXL—instruments that use spectrometers, lasers and high-resolution imagers and cameras—will search for organic compounds and identify chemical elements at a tiny scale, which could point to signs of past microbial life on the Red Planet. MOXIE—an instrument designed to turn Mars'

carbon dioxide into oxygen—is also aboard the Mars 2020 rover with the goal of creating for fueling rockets and breathable air for future human-led missions to Mars.

And attached to the belly of the rover resides Mars helicopter—a technology demonstration that has space fans buzzing about its potential for future planetary exploration and scientific research capabilities.

With a year under its belt, InSight remains hard at work at Elysium Planitia, with its seismometer detecting more than 300 marsquakes to date.

Rocket Style: Kayla Andersen

If you're lucky, you might spot Kayla Andersen outside of her usual clean-room bunny suit and in one of her bright, patterned dresses (like we did, while she was walking across Lab one day). Andersen works as an engineer on the seal dispenser mechanism on Mars 2020, doing assembly, testing and troubleshooting for the rover. We sat down with her to discuss her funky, "proudly nerdy" style—when she's not in the clean room, of course.

How would you describe your style?

Hindered by the clean room (laughs). On average, for most of the past year, I've been in a bunny suit four to five days a week, all day. More recently, it's been about two days a week because we're almost done. I also have to wear a sterile smock and goggles.

Let's talk about your style *outside* of the clean room, then!

If there's a day I know I'm not going to be in the clean room, I make sure that's when I wear one of the fun outfits I have. I like to have at least one part of my attire that's nerdy. Sometimes it's an obnoxious skirt with light sabers on it, or sometimes it's just a pair of shoes with physics equations or gravity wells with planets. Back in college, I had shoes with a periodic table pattern on them—I wore those into the ground.

Tell us more about the clean room rules. How did you adjust?

It takes about five to seven minutes to put on a bunny suit. Shoes have to be covered too. We can't wear makeup, perfume or any hair products. You have to shower with non-scented soap and shampoo, and use unscented deodorant. [JPL provides us with a list of approved products.] I never wear makeup, and my hair is normally up, so it wasn't too big of a change for me. I do dye my hair, though. I asked the contamination control engineer and she said, 'As long as you don't dye it in my clean room, it's fine!' I always dye it several days beforehand because the scent can be strong, so I'll dye it on a Friday or Saturday afternoon and then I'll be ready to go in on Monday.

How does your style reflect your personality?

I'm a very nerdy person and I have been my whole life. I think it reflects that side of my personality. I'm really into Star Trek and sci-fi, and I love math and science. I'm also the sort of person who will calculate height by dropping a quarter and measuring the time; my friend and I were on a trip to Scotland, and we climbed a tree and picked our heaviest coin to drop. I'm a nerd in all regards.

Tell us about your cool blue hair.

I started off dyeing it blue, and it's been that way for about a year and a half. Blue suits me; it's my favorite color and I thought a dark blue would be almost passable for black. I might dye it dark purple later. I love that color, too.

Tell us about your dresses.

I have eight dresses that I bought online. A couple of them I bought at Disney World. One of them has a big Millennium Falcon on it; another has a giant Enterprise going through a star field at the bottom. It's floor length with pockets, and it's made of T-shirt material—I've worn it to the orchestra! A few of them are homemade—there's a musical notes skirt that I made and a Star Trek comics skirt that my sister made. I taught myself how to sew. I'm working on a quilt right now from a bunch of old T-shirts.

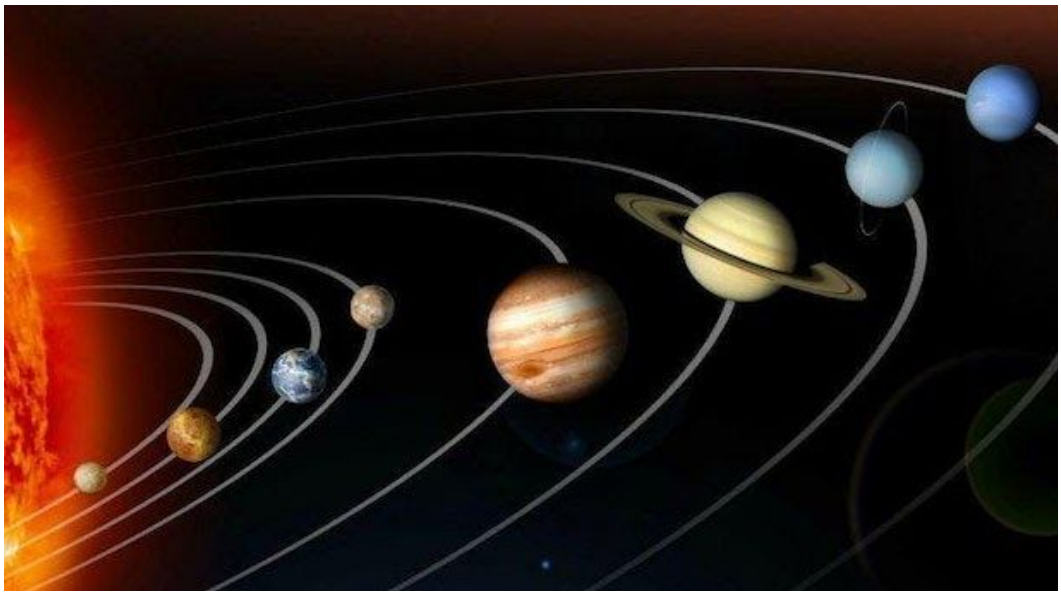
Musical notes skirt? Do you play any instruments?

I'm also a musician. I play trumpet and I sing. I'm in the JPL Jazz Propulsion Band.

Overall, why do you want to express your personality through your clothes?

I find it helps me connect with people who have similar interests. I really like wearing a "May the force be with you" shirt with the force equation. I would wear that to an amusement park, and people would come up to me and say hi. It can be a crowd deterrent and a crowd attractor—it helps me know who wants to hang out. I'm a nerd and wear it proudly.

Events



Planetary Decadal Survey Town Hall

Monday, Jan. 13
3 to 4 p.m.
Building 180-101

The upcoming planetary decadal survey will determine the science interests and technology needs for the period of 2023-2032. This decadal survey will drive what we will be doing here at JPL. The planetary science community can play an active role and influence the future by writing white papers that will be considered by the Decadal Survey committee. In this town hall, we will answer any questions one may have on how to participate. A brief presentation will outline the ongoing pre-decadal studies and summarize some key facts.

Participants who can answer your questions include:

-Bonnie Buratti: Planetary science section manager (322) and SBAG (Small Bodies Assessment Group) chair
-**Tony Freeman:** Manager Solar System Exploration Directorate (4x) mission formulation office
-**Joe Lazio:** Interplanetary Network Directorate (9x) Chief Scientist
-**Rosaly Lopes:** Member of the NAS Space Studies Board
-**Christophe Sotin:** Solar System Exploration Directorate (4x) Chief Scientist
-**Rich Zurek:** Mars Exploration Program Chief Scientist

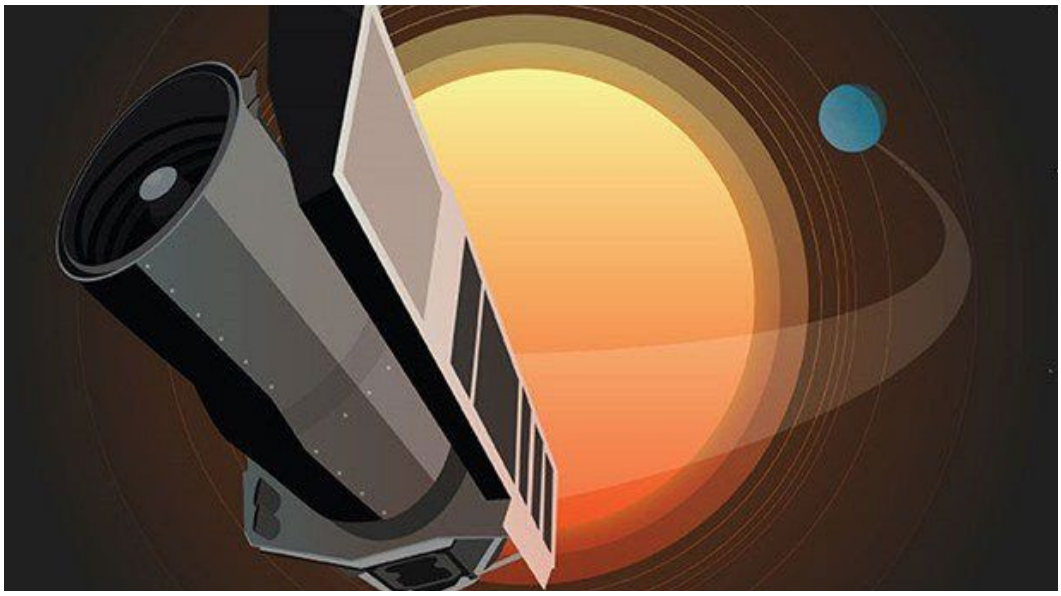
Sparking Creativity By Embracing Change

Tuesday, Jan. 14
Noon to 1 p.m.
321 - Pickering Auditorium

How can we be our creative best when change is happening all around us? Context, culture and relationships propel creativity during times of high-speed change. Hear Aithan Shapira, internationally acclaimed artist, share his insights, pulled from leading researchers and experts — in arts, human development, cognitive science, anthropology, systems thinking, machine learning and AI — on empowering personal creativity through embracing change.

Aithan Shapira is a lecturer at MIT Sloan, Harvard iLab and Stanford d.school. He is the founder of Making to Think, a pedagogy for change that is enabling global organizations,

governments, and Fortune 100 leaders to create conditions for enduring cultures of innovation.



Von Karman Lecture Series - Spitzer: Final Voyage

Thursday, Jan. 23
7 p.m.
Von Karman Auditorium

Friday, Jan. 24
7 p.m.
Caltech's Beckman Auditorium

The Spitzer Space Telescope has been observing the universe in infrared light for over 16 years. As the mission comes to a close, we'll take a look at some of the amazing highlights and the lasting legacy of this incredible observatory.

Host: Brian White

Speakers:
Varoujan Gorjian, Spitzer Research Scientist, JPL
Robert Hurt, Spitzer Visualization Scientist, Caltech/IPAC
Suzanne Dodd, Former Spitzer Project Manager (2010-2016), JPL
Joseph Hunt, Spitzer Project Manager (Current), JPL

JPL Family News

Retirees

The following JPL employees recently announced their retirements:

Sarah H. Head-Sperber, Section 1190, 13 years
William M. Owen, Section 3920, 40 years
Joseph I. Statman, Section 9110, 40 years

Passings

Won-Kyu Rhim died on Nov. 23, 2019 at the age of 82. He was employed at JPL for 28 years. His most recent organization was at Caltech as a senior research associate/staff scientist. Rhim retired in 2004.

At JPL, he was a senior scientist, technical staff, and a technical Group Leader in areas of technology development for containerless science, undercooling-nucleation experiments, containerless protein crystal growth experiments, drop dynamics experiments, and the technology development for solid state NMR experiments

Rhim was instrumental in developing the High Temperature Electrostatic Levitator (HTESL). This device uses controlled electrostatic forces to isolate a molten sample in high vacuum condition allowing the melt to deeply undercool and its thermo-physical properties and solidification phenomena are investigated. In addition to Temperature-Time-Transformation (TTT) curves, the HTESL can measure the specific volume, thermal expansion coefficient, the surface tension, the viscosity, the ratio of specific heat and total hemispherical emissivity, and the electric resistivity of undercooled liquids.

In collaboration with Eugene Trinh of JPL, an electrostatic-acoustic hybrid levitator was developed. Charged liquid drops were suspended in air by controlled electrostatic forces, and their resonant oscillations and rotations were induced by applying an appropriate acoustic pressure. An extensive experimental investigation of dynamics of freely suspended liquid drops was conducted. Through this experiment, the theoretical results on the shape evolution of rotating drops were confirmed.

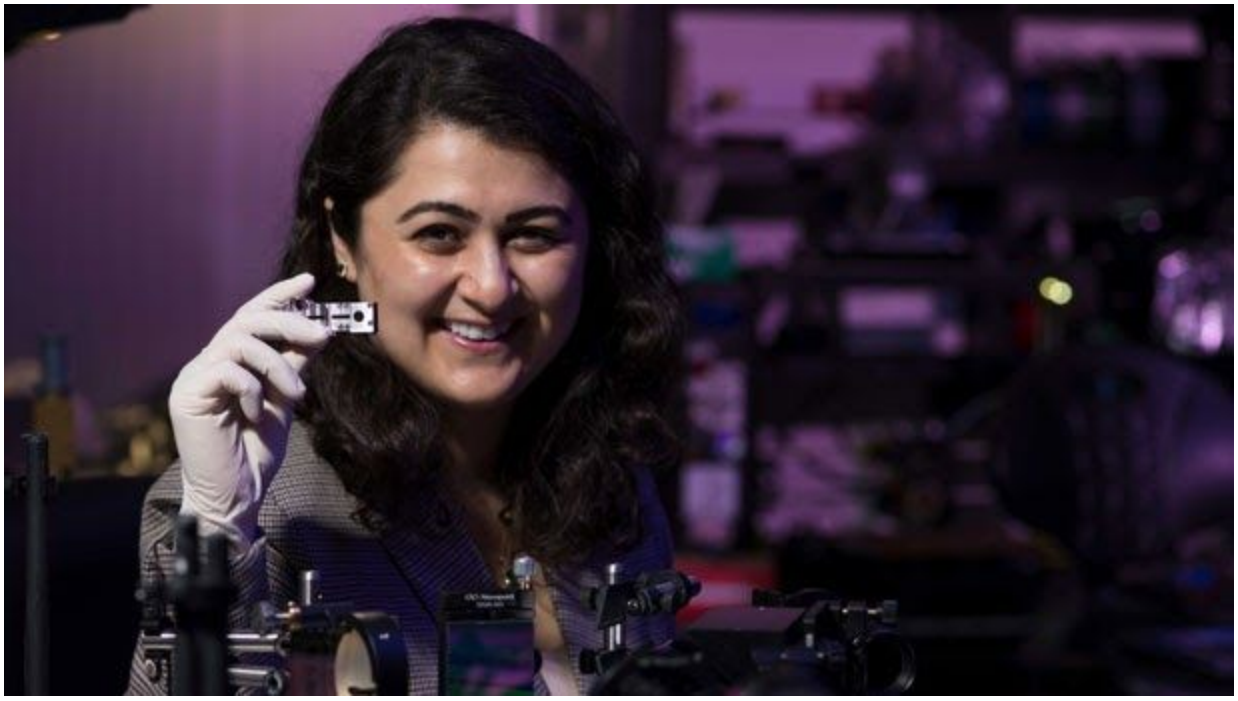
A new method of mass-producing monodisperse polymeric microspheres was invented, and a U.S. patent was obtained. Monodisperse monomer droplets produced by a specially designed nozzle were captured by a liquid nitrogen bath and vitrified. Monodisperse polymeric microspheres were obtained upon slow thawing of the frozen particles after g-ray irradiation.

In cooperation with Melvin Saffren and Daniel Elleman, both theoretical and experimental studies of dynamics of simple and compound drops were conducted. Compound drops made out of water and silicon oil were produced in a neutral buoyancy tank, and the theoretical results were successfully verified.

Rhim was instrumental in the development of dipolar line-narrowing techniques for the high-resolution solid state NMR: The line-narrowing pulse sequences known as the Rhim-Elleman-Vaughn 8-Pulse Sequence (REV-8), and the Burum-Rhim 24-Pulse Sequence (BR-24) are being used in the solid state NMR spectroscopy. Using these techniques, the strong dipolar interactions in solid phase can be selectively removed while preserving more interesting interactions such as the anisotropic chemical shifts or the exchange interactions.

Rhim is survived by four children: Sung-Hee Lee, Jean Rhim, Eugene Rhim and Paul Rhim, and seven grandchildren.

Awards



Sona Hosseini Receives 2020 SPIE Early Career Achievement Award

Research and instrument scientist Sona Hosseini has received the 2020 Early Career Achievement award from the International Society for Optics and Photonics (SPIE) for her innovative optical design work on ultra-miniature spatial heterodyne spectrometers (SHS).

SHS technique is an ultra-compact, high-sensitivity spectrometer that can obtain key measurements in far-UV to IR wavelengths such as spectral line profile and isotopic ratios. Hosseini has pioneered the mathematical concept for the cyclical SHS, which enables developing the SHS instrument for shorter wavelengths down to far-UV wavelength regions. And she has designed and developed various SHS construction methods to make the SHS instrument robust for space missions. Hosseini’s recent work with JPL’s lunar PUFFER rover led her to develop a new generation of 100-gram, ultra-miniature high spectral resolution SHS spectrometer for detecting OD and OH in the water on the lunar surface. Depending on science objectives, SHS instruments are scalable: they can be made as a relatively large instrument (mini-refrigerator size) for a large mission or as an ultra-compact instrument (snickers fun size) for SmallSats. Most robotic platforms have a small payload capacity; therefore, the 100-gram SHS instrument enables a new ultra-compact, ultra-sensitive science payload for key future robotic planetary missions as well as CubeSats and SmallSats.

Hosseini's SHS instrument concepts are used in multiple NASA mission concept studies and robotic platforms. She leads and works with a team of more than 30 scientists, engineers, software developers, and students building miniature spatial heterodyne spectrometers for NASA's planetary and lunar missions. Her instruments are an enabling technology for future Earth, Planetary, and Astrophysics missions to measure the fundamental spectral signatures such as the deuterium-to-hydrogen (D/H) ratio (308nm) for the Solar System, moons, and comets to discover the origins of water on Earth.

The SPIE Early Career Achievement Award – Government/Industry focus is given to an early career professional in recognition of significant and innovative technical contributions to any of the engineering or scientific fields of interest to the international optics community and SPIE.

For Hosseini's Early Career SPIE award press release, click here.