THE
LOWELL OBSERVER

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THE QUARTERLY NEWSLETTER OF LOWELL OBSERVATORY

CELEBRATING 125 YEARS

COVID-19 STATUS

As of December 2020, Lowell Observatory is in Phase 1B of reopening, offering Premium Access to small groups with reservations. For updates see **lowell.edu/welcomeback** or follow us on social media.

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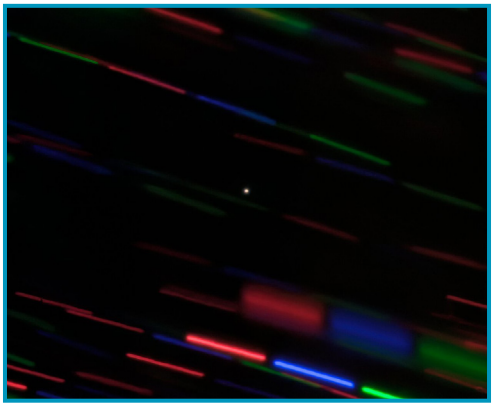

Cool, Pulsating Yellow Supergiants Found in the Large Magellanic Cloud

By Kathryn Neugent, Research Associate

Massive stars spend the majority of their lives as incredibly hot (up to 50,000 K) and luminous (up to a million times the luminosity of the Sun) stars burning through their hydrogen on the main sequence. After their hydrogen is depleted, they transition to burning what's left, which is mainly helium. During this phase they cool down dramatically and briefly become yellow supergiants (YSGs) before living out the rest of their lives as cool (4000 K) red supergiants. Once they've burned through their supply of heavy elements, they end their lives as spectacular supernovae. That's at least the story for most massive stars. But, a combination of observations and theory now suggests that some of the most massive stars actually pass through the yellow supergiant phase a second time! After cooling down and becoming red supergiants, they experience enough eruptive mass-loss that they heat up again and turn back into yellow supergiants before exploding as supernovae.

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Lowell Scientists Help Characterize 2nd Known Minimoon

By Kevin Schindler, Historian

Astronomers using data collected with the Lowell Discovery Telescope (LDT) have helped to characterize only the second known minimoon of Earth, a newly discovered asteroid with the designation 2020 CD3, or CD3 for short. The LDT observations helped to clarify both the rotation rate and the orbit of this diminutive body, the latter of which helped prove that CD3 is a natural body and not some relic piece of human-made space junk.

Minimoons are small asteroids temporarily captured into orbit around Earth. Within about a year, they are flung back into

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DIRECTOR'S UPDATE

By Jeffrey Hall

A few weeks ago, I spotted a comment scrolling by on one of the social media feeds from a visitor to Flagstaff. He was very glad he didn't live in our city: there were restrictions downtown due to the pandemic, and you even had to get a reservation to come to Lowell Observatory.

That comment made me glad I do live in Flagstaff and work at Lowell Observatory. By and large, our city and its residents have done a good and responsible job dealing with a situation where the decisions available in response are bad, even worse, and terrible. Likewise, the Lowell team has done a similarly fine job moving forward under the most adverse and unexpected circumstances.

Through it all, we've tried to follow the science and take a reasonable course. Willy-nilly mingling and ignoring the overwhelming data regarding modes of viral transmission is not the answer. But absolute, unrelenting shutdown is its own treacherous slope. We've done the best we can to find that fine line and keep our research, telescopes, and outreach up and running while being as careful as we can with the health and safety of our staff and visitors.

Science is the way out of this, and our science-savvy team has kept Lowell going admirably, while taking all prudent steps for slowing the spread. Now, with vaccines being deployed, there is light at the end of the proverbial tunnel—as we reach the winter solstice and the days likewise begin to brighten.

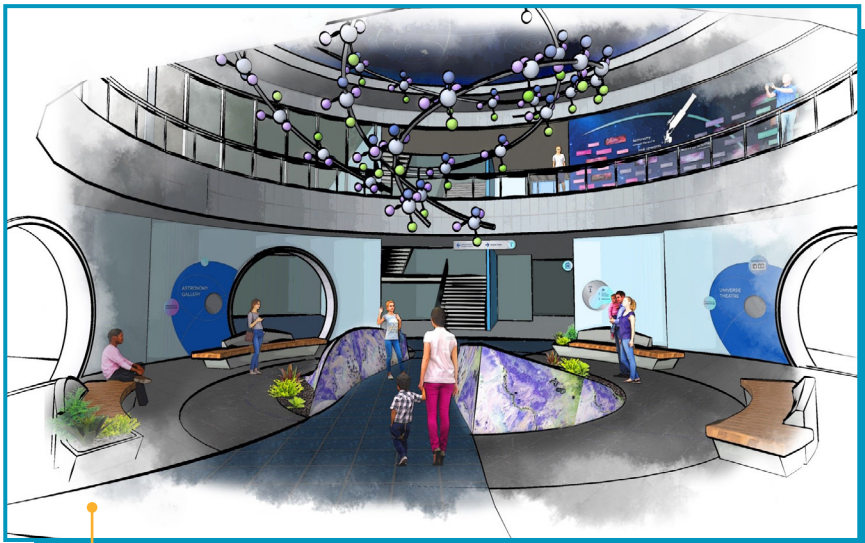
May many more brighter days lie ahead in 2021 for all of our team and all of our loyal supporters. Thanks so much for sticking with us through this extraordinary time.

TRUSTEE'S UPDATE

By W. Lowell Putnam

I have been unable to be on Mars Hill since mid-March and it does bother me. Video calls and emails are not the same as being there. And I know from conversations and correspondence that I am not alone in feeling the way I do. But I remember the old adage, "When you have lemons, make lemonade."

As I look at the work that the staff are doing, even through quarantines and social distance, I am impressed with how they are taking this situation and creating opportunities. When we all do get back onto Mars Hill, and that is looking more and more like mid-2021, you will see how much work has been done to improve the campus. As you read this issue, you can also see how are science staff are continuing their research and growing our knowledge of the universe and our place in it. My thanks to all of them and all of you whose support makes this possible. And now I will go have some lemonade...

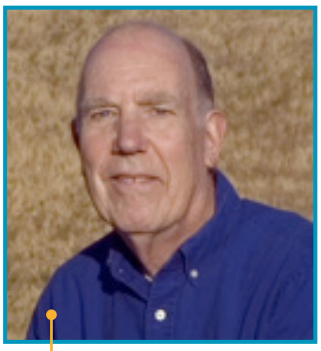


Rendering of the Origins Gallery, the central hub of the Astronomy Discovery Center. | Credit: Kei Space Design Ltd.

Mars Hill Campus Expansion Update

By Dave Sawyer, Technical Project Manager

We are in a very exciting phase for campus expansion activities as we prepare for the groundbreaking of the Astronomy Discovery Center (ADC) and the start of construction in early 2021! On the architectural front we are finalizing engineering and detail design activities and developing construction documents for the building itself, as well as developing plans for the site infrastructure outside of the ADC including the north plaza that connects the ADC to the Giovale Open Deck Observatory (GODO), pedways, lighting, and access roads. In concert with the architectural design, we are also moving into the schematic design phase for the interpretive elements. A well-planned interpretive theme that tells the story of the Universe—from the Big Bang to life today—has been developed. This theme is now being turned into actual exhibits and interpretive elements that will be implemented throughout the ADC to provide a memorable and educational journey for visitors of all ages.



Longtime Lowell Observatory supporter Robert Ayers.

Robert Martin Ayers, 1941-2020

By Lisa Actor, Deputy Director for Development

We gratefully recognize Robert "Bob" Ayers' long commitment to Lowell Observatory and feel an immense loss at his passing in November.

Bob became interested in astronomy as a teenager. Through family connections, he landed an internship at Lowell Observatory in the summer of 1960. Bob graduated from Harvard with a degree in Astronomy in 1962 and enjoyed a long and distinguished career in computer science. He returned to Lowell as a member of the Advisory Board in 2010.

"Bob had a dry sense of humor, but his insights were always spot on," said Observatory Sole Trustee W. Lowell Putnam. "His help and advice to me personally and the observatory have been substantial."

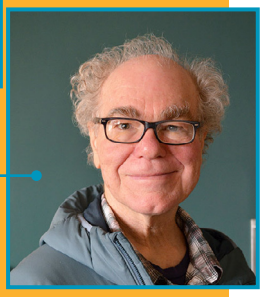
The Giovale Open Deck Observatory is one of the options for a Premium Access experience. Credit: Sarah Gilbert

New Fund for Premium Access Experiences

By Stephen Riggs, Development Manager

Thanks to an initial lead gift from supporters Nikii and Mark Johnston, a new fund was created to help families participate in the observatory's new Premium Access experiences. The fund, called Community Stars Fund, will provide free, intense telescope viewing experiences at the Dyer and GODO telescopes to help encourage those with an interest in astronomy, but who could not otherwise afford the additional fees for Premium Access tours. Participating families will be selected with the help of Flagstaff area non-profits. It is hoped that the fund will grow over the years to help many others. Those wishing to contribute to this new endeavor can contact the Development Office at (928) 268-2924.

Dr. Nick Moskovitz



Dr. Phil Massey

Research Funding

Dr. Nick Moskovitz's *Mission Accessible Near-Earth Objects Survey (MANOS)* project was selected for funding by NASA's new Yearly Opportunities for Research in Planetary Defense program. The three-year, $855,000 grant will support the ongoing MANOS survey of Near Earth Objects, allowing tools and methods to be developed for the rush of new discoveries expected from LSST.

Dr. Phil Massey was awarded a $45,000 grant from NASA's Space Telescope Science Institute in support of his Hubble Space Telescope project *The Nature of a Newly Discovered Wolf-Rayet Binary: Archetype of Stripping?*

Pluto occultation observing teams, past and present, at Lowell Observatory, in front of the Pluto dome, 2015. Standing (left to right): Ralph Nye (Lowell), Bob Millis (Lowell), Luke Weisenbach (MIT), Peter Collins (Lowell), Amanda Bosh (MIT/Lowell), Hugh Harris (NOFS), Carlos Zuluaga (MIT), Stephen Levine (Lowell), and Ted Dunham (Lowell). Kneeling (left to right): Thanawuth (Atom) Thanathibodee (MIT) and Steph Sallum (Steward Observatory).

New Operations Manager Amanda Bosh

By Kevin Schindler, Historian

Dr. Amanda Bosh, Lowell Observatory's recently named observatory operations manager, may be new to the position but her roots at the observatory run deep. Dating back to 1986 she has participated in a variety of research and outreach efforts at Lowell and her resume bulges with achievements that include co-discovering Pluto's atmosphere and co-founding the Native American Astronomy Outreach Program. Not bad for someone who thought about going into social work when she was young.

Bosh grew up in Norton, Massachusetts, not far from another longtime Lowell scientist, Dr. Nat White. Unlike so many space scientists whose careers were inspired at an early age by the Apollo space program or provocative scientists such as Carl Sagan, Bosh had her sights set elsewhere. She laughs, "I'm not one of those people who always wanted to be an astronomer." When she enrolled at MIT for college, she still didn't want to be an astronomer but rather an engineer.

Her outlook began to change as she took an astronomy class, and then another, and then another. She soon realized she didn't really like engineering as much as astronomy, so she veered in this direction and never looked back. This decision was cemented one afternoon during her sophomore year (1984-85) when her telephone rang. The caller was Dr. Jim Elliot, a leading planetary astronomer who helped pioneer the technique of stellar occultations. Bosh had earlier contacted Elliot while searching for a research program to join, and his phone call that afternoon resulted in her joining his team, under the direction of future Lowell scientist Dr. Ted Dunham.

At MIT, Bosh shared an office with other undergraduates, including future Lowell scientist (as well as her future husband) Stephen Levine. In 1986, Bosh participated in an astronomy field camp at Lowell Observatory. She says, "With that first visit I knew I wanted to work at Lowell. I fell in love with the place, the area, the people."

Bosh finished her undergraduate work in 1987 and then jumped right into MIT's graduate program. In 1988 she rode aboard the Kuiper Airborne Observatory—predecessor of the Stratospheric Observatory for Infrared Astronomy (SOFIA)—and was part of the team that included scientists from Lowell, MIT, and elsewhere that discovered Pluto's atmosphere.

Upon earning her PhD in 1994, her dream of working at Lowell started to become a reality as she was awarded a postdoctoral fellowship. She held this position until 1997 and after a one-year stint in the Department of Physics at Hofstra University, returned to Lowell as an assistant research scientist. Throughout these years at Lowell she participated in a number of outreach activities. Seeing an opportunity to take astronomy to underserved Native American communities, Bosh teamed with Dr. Deidre Hunter in 1996 to found the program known today as the Lowell Observatory Native American Astronomy Outreach Program.

In 2002 Bosh accepted a position with Boston University as a senior research associate at Lowell, a position she held until 2009. She then took on the role of lecturer and, later, senior lecturer, at MIT, maintaining an adjunct position with Lowell. During this time, she continued working on occultations of Pluto, pinpointing observing locations that were crucial to SOFIA observations, as well as the New Horizons flyby of Pluto.

This past August she returned to Lowell fulltime as the operations manager. Bosh says, "I feel like I'm in the middle of an amazing carnival of science at Lowell, with so many fun things in any direction you look. It's a great place to be, and I'll not only get to help Lowell achieve its goals in my role as operations manager, but I'll also get to do some of my own science. I couldn't be happier."

The MIT team, who flew on the Kuiper Airborne Observatory in 1988: (left to right) Amanda Bosh, Stephen Slivan, Leslie Young, Ted Dunham, and Jim Elliot.

Robert Burnham at the Lawrence Lowell (Pluto Discovery) Telescope.

Robert Burnham and his Celestial Handbook

By Kevin Schindler, Historian

"The appeal of astronomy is both intellectual and aesthetic; it combines the thrill of exploration and discovery, the fun of sight-seeing, and the sheer pleasure of firsthand acquaintance with incredibly wonderful and beautiful things."

So wrote longtime Lowell observer Robert Burnham, Jr., the author of one of the most prized astronomy books of our time. Burnham's story is one of passion, persistence, and, ultimately, tragedy.

Robert Burnham, Jr. was born in Chicago on June 16, 1931. His family moved to Arizona in 1940, settling in Prescott. At an early age Robert began a lifelong pursuit of studying the universe, collecting rare coins, amassing bookshelves full of rocks and minerals, and peering at the sky through telescopes—all while reading as much as he could on each subject.

Robert Burnham, Jr. stands in his Air Force uniform with his parents at their Prescott home. One of Robert's telescopes sits behind his father. Ca 1951. Credit: Donna Courtney.

He graduated from Prescott High School in 1949 and two years later enlisted in the Air Force. After his four-year-tour finished, he returned home to Prescott and eventually took a job as a shipping clerk, though he continued his passion of studying the universe. It was at about this time that he began thinking about compiling an astronomy book like no other, one that comprehensively covered the science and mythology of all 88 constellations.

And so went Burnham's life for several years—uninspiring job during the day, probing the depths of nature from Earth to outer space at night. And then one night in 1957 his life took a decided turn when he spotted a fuzzy patch of light through his telescope. This was a comet, and up to this day no one else had ever seen it before. He was not alone in detecting it, as two other observers independently discovered this new celestial nomad. News traveled fast and Burnham soon became a celebrity of sorts, lauded as the self-trained amateur astronomer from Prescott. None other than Senator Barry Goldwater visited Burnham and even gave the young man a family telescope that dated back to the 1800s.

Not long after, Burnham found himself in conversation with Astronomer Henry Giclas of Lowell Observatory. Giclas had begun a program to study the movement of stars over time, a so-called proper motion survey, and hired Burnham to work on it. Soon he also moved into a cabin onsite. Burnham would spend the next 21 years living in that same cabin at Lowell Observatory, a short stroll from telescopes he could only dream of as a kid. No longer would he have to spend many of his waking hours at a hum drum job; he could now devote virtually all his waking hours to studying the universe. When not fulfilling his regular job duties of photographing the night sky and examining the resulting images, he jumped headfirst into his long-planned "Celestial Handbook".

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DISPATCHES FROM THE UNIVERSE

The Universe from One to Ten

By Michael West, Deputy Director for Science

1 "I never imagined that I would become an astrophysicist," says Marie Korsaga. With few opportunities in her home country of Burkina Faso, she went to South Africa and earned her Ph.D. there in 2019. Today, she's an expert on galaxies. As West Africa's first female astrophysicist, she hopes to inspire young people in her homeland and beyond.

2 Mars has two small moons, Phobos and Deimos. The Anglo-Irish writer Jonathan Swift foretold their existence in 1726, more than a century before their discovery. In his satirical novel, *Gulliver's Travels*, Swift told how astronomers on the flying island of Laputa had "discovered two lesser stars, or satellites, which revolve about Mars."

3 Only three people have died in space, though many more have perished trying to reach it. In 1971, Georgy Dobrovolsky, Vladislav Volkov, and Viktor Patsayev spent several weeks aboard the world's first space station, Salyut 1. Sadly, all three cosmonauts died when their capsule depressurized during its return to Earth. Three craters on the Moon and a group of hills on Pluto are named in their honor.

4 Thomas Jefferson Jackson See was an American astronomer whose ego far outshone his accomplishments. In 1913, using a pseudonym, he published a book titled *Brief Biography and Popular Account of the Unparalleled Discoveries of T. J. J. See*. The word 'genius' appears 35 times in the book. The word 'humble' appears only four times.

5 In a single year—1905—Albert Einstein published five scientific papers that transformed physics. One described his special theory of relativity. Another introduced his famous $E = mc^2$ equation. A third paper that year, which suggested that light is a stream of particles called photons, earned him the 1921 Nobel Prize in Physics.

6 Everything we see—planets, stars, galaxies, people—is made of atoms. But atoms are made of even tinier pieces called quarks, which come in six varieties. Theoretical physicist Murray Gell-Mann predicted the existence of quarks in the 1960s. He took their name from a whimsical line in James Joyce's book, *Finnegan's Wake*, which mentions "three quarks for Muster Mark."

7 A week has seven days, but it wasn't always that way. The ancient Egyptians and Chinese divided a month into three weeks of ten days. The Romans used an eight-day week until A.D. 321, when Emperor Constantine decreed that it should be changed to seven days. And the traditional calendar of the Akan people of western Africa was based on a six-day week.

8 Charlene Heisler's doctor advised her not to become an astronomer. The young Canadian had cystic fibrosis, an incurable disease that slowly robs the lungs of oxygen. But she refused to give up. After earning her Ph.D. in astronomy from Yale University in 1991, she continued to explore the universe until the disease took her life eight years later, at the age of 37. Her courage inspired many.

9 Long before Pluto's discovery, the 19th-century French astronomer Urbain Le Verrier predicted a different ninth planet. A gifted mathematician, Le Verrier's calculations led to the discovery of Neptune in 1846. He named his other hypothesized planet Vulcan and believed it would be found inside Mercury's orbit, hidden by the Sun's glare. This time, he was wrong.

10 Vincent van Gogh's most famous painting, *The Starry Night*, was long thought to be an imaginary nightscape. But in 1985, art historian Albert Boime showed that it's actually a faithful depiction of the sky visible from the asylum where the Dutch artist was confined after his mental breakdown. The painting shows ten stars plus Venus and the Moon as they appeared before dawn on June 19, 1889—the day van Gogh finished his painting. P

Deputy Director for Science Dr. Michael West

While carrying out his duties overseeing care of the grounds, Dave Shuck's constant companion is Lucky (left).

STAFF HIGHLIGHT

Dave Shuck & Lucky

By Madison Mooney,
Content Marketing Specialist

Dave Shuck has been Lowell Observatory's Facilities, Grounds, and Maintenance Manager for 10 years, a milestone he reached in October of this year. Friendly, boisterous, and always smiling, Dave is on call 24/7 to lend a hand wherever it's needed, and he lives on campus to ensure that he's always close by. His daily responsibilities include performing repairs and keeping our campus looking its best. He and his team work tirelessly to keep the paths on Mars Hill clear of ice, snow, leaves, and other hazards. On especially snowy days, Dave's maintenance team and snow removal volunteers are up before the Sun to clear the roads so everyone can get to the observatory safely.

Wherever Dave goes, he is accompanied by his loyal Shepherd-Heeler mix Lucky. Lucky can typically be found chasing after Dave's maintenance cart or lounging in a patch of shade. Dave adopted Lucky when he was just six months old, and the two have been inseparable ever since. Lucky turned nine years old in November—almost as old as Dave's career at Lowell!

When asked what he enjoys most about his job, Dave replies that he loves being able to do so many different things, and the fact that he gets to help out and interact with everyone on campus. "It's the best job I've ever had," he says, "I can't imagine working anywhere else."

Tax Benefits in the CARES Act

By Stephen Riggs, Development Manager

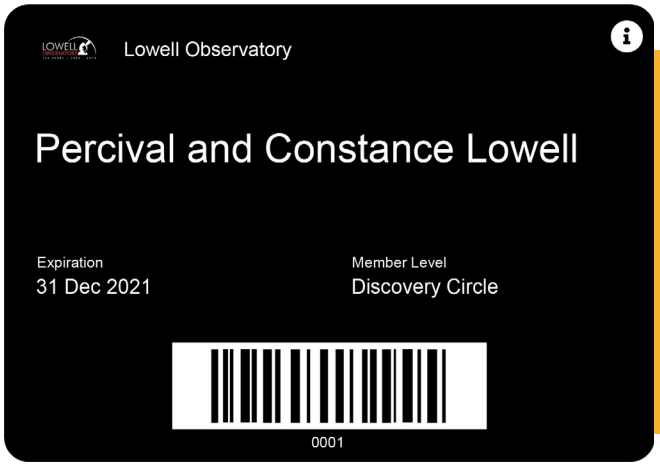
The CARES Act was signed into law earlier this year. In it are some items that could have a significant impact on your 2020 charitable giving. Three items are of particular note:

1. Individuals who do not itemize can take an additional deduction on top of the standard deduction for charitable gifts made in cash of up to $300.

2. Individuals who do itemize can now elect to deduct up to 100 percent of your Adjusted Gross Income (AGI) for charitable cash gifts.

3. Own a business? The AGI limit for cash contributions was also increased to 25 percent of taxable income for corporate donors.

Please check with your tax professional to see how you may benefit from the CARES Act this year.



Introducing Digital Membership Cards

We are thrilled to offer our new digital membership cards, which can be downloaded and saved to your smartphone. Going digital means that you never have to worry about forgetting your membership card at home, in addition to being more environmentally friendly! Physical cards will still be available by request.

Left: Nadine Barlow holds a globe of her favorite planet, Mars. | Credit Bonnie Stevens

Right: During Lowell Observatory's 40th anniversary of the discovery of Charon in 2018, Paul Shankland (left) poses with Charon discoverer Jim Christy, Lowell Director Jeff Hall, Sole Trustee W. Lowell Putnam, and Charlene Christy, for whom Jim named Charon. | Credit: Dave Eicher

In Memoriam

By Kevin Schindler, Historian

We are sorry to say goodbye to two valued friends and leaders of the Flagstaff astronomy community—Dr. Nadine Barlow and Dr. Paul Shankland. Nadine died on August 17 after a two-year bout with cancer. An astronomer specializing in impact cratering process, especially on the planet Mars, she spent the last 18 years of her life as an astronomer at Northern Arizona University (NAU). In recent years she served as chair of the Astronomy and Planetary Science Department at NAU. She was also director of the NAU/NASA Space Grant Program and associate director of the Arizona Space Grant Consortium.

Paul died on October 20, also from cancer. An aviator in the U.S. Navy, he piloted 22 aircraft types and accumulated 3800 hours of flying time during his 25-year tour of active duty. He retired from uniformed service with the rank of Commander. He also earned his PhD in astronomy, focusing his research on the dynamical properties of Earth-like planets and Kuiper belt objects around M-dwarf stars. In 2008, he was named sixth Director of the Naval Observatory Flagstaff Station and served in that role for more than a decade.

Nadine and Paul both promoted interaction between the astronomical organizations of northern Arizona and we will miss them professionally and personally.

Lowell Wins EcoTourism Award

By Kevin Schindler, Historian

On October 14, Discover Flagstaff announced winners of the Second Annual City of Flagstaff Eco Awards, and Lowell Observatory took home the prize in the "attraction" category. These awards are sponsored by Discover Flagstaff and the City of Flagstaff's Sustainability Section and celebrate Flagstaff's growing commitment to destination stewardship—the concept of celebrating culture in an environmentally responsible manner. Lowell was recognized for its critical leadership in dark skies protection, both in policy and practice, that benefits Flagstaff in a variety of cultural and economic ways.

New Case for Blink Comparator

During the observatory's inaugural I Heart Pluto event in November, staff and supporters rededicated the blink comparator that Clyde Tombaugh used to discover Pluto in 1930. This came on the heels of the machine returning to Lowell after five years of being displayed at the Smithsonian National Air and Space Museum. In November, the observatory received a new case for the comparator. It comes courtesy of the Air and Space Museum and was designed to publicly display this important artifact while properly preserving it.

The new case for the blink comparator is here shown nearly ready for display.

ROBERT BURNHAM

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With the patience of Job, Burnham marched through the constellations and self-published his magnum opus in loose-leaf folders that the kids of Lowell staffers helped assemble. Eventually, with the vision of substantial royalty payments in mind, Burnham sold the rights to Dover. Little did he know that his life had reached its apex and soon would begin to spiral downward.

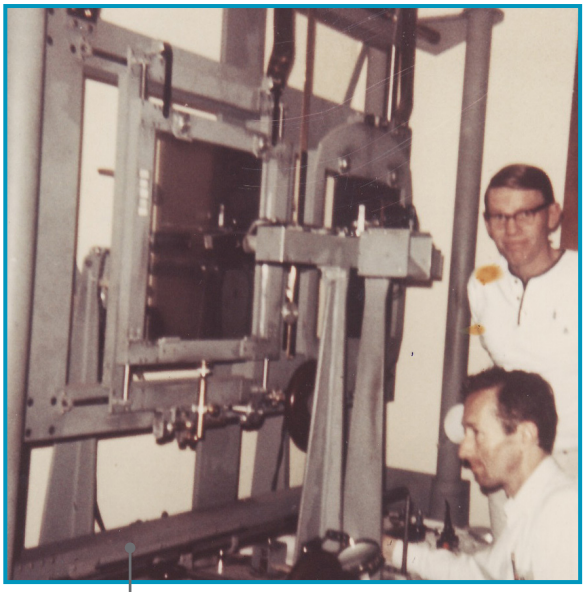
The proper motion survey ended in 1979 and Burnham was out of a job. After 21 years, he no longer enjoyed regular access to research telescopes, no longer had a home, no longer had a regular income. To many people this would have been a challenge but one they could conquer. To Burnham, this was almost a death sentence. As eloquent as Burnham was on paper, he was equally awkward in person. Exceptionally introverted—former Lowell Observatory Director Bob Millis calls Burnham the shyest person he ever met—Burnham was not one to go out into the world and start over. Without the regularity of his beloved work and the stability of his adopted lifestyle, he was lost.

Burnham lived with his sister for a short time and then disappeared, with neither family nor friends knowing his whereabouts. A few years later, the son of one of Burnham's closest Lowell colleagues was walking through Balboa Park in San Diego when he noticed a skinny, bearded man. As he drew near, he realized the man was Burnham. He learned that Burnham lived in bleak housing nearby, having never seen the riches he expected from the handbook royalties and making a minimal living by selling paintings of cats in the park.

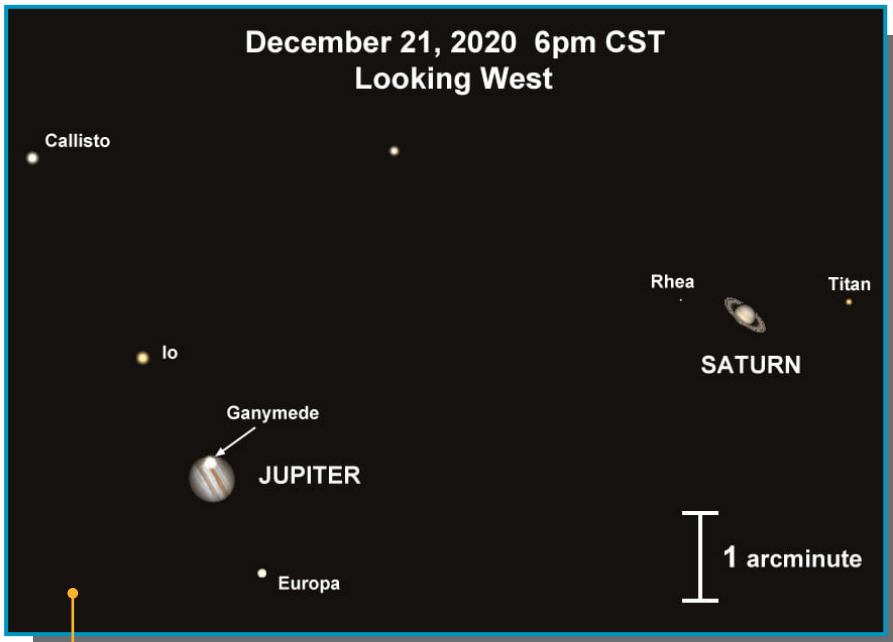
In 1993, at the age of 61 and after suffering from a heart attack and other health maladies, Burnham died. His remains went to Fort Rosecrans National Cemetery's columbarium in San Diego. Burnham was a loner to the end: his name was misspelled on his grave marker and his family didn't even find out he died until two years later.

While Burnham's tragic life ended in obscurity, his beloved handbook lives on and is a staple in the library of thousands of astronomers, professional and amateur alike. Burnham chronicler Tony Ortega has called Burnham's 2,138-page handbook a real-life Hitchhiker's Guide—"part travel guide, part history text, part encyclopedia, it's like a handheld natural-history museum of the universe."

In recent years, efforts have been made to honor Robert Burnham. Amateur astronomers in Phoenix led an effort to create a plaque honoring Burnham, and Lowell Observatory is now developing a new display highlighting his life and work. In September, as part of National Astronomy Day, the observatory hosted a virtual discussion about the triumph and tragedy of Burnham. Ortega, Burnham's niece Donna Courtney, and Lowell's Brian Skiff and Kevin Schindler participated. Also, the Lowell archives houses several artifacts and documents related to Burnham.



Burnham and colleague Norm Thomas at the blink comparator they used while working on the Lowell Observatory Proper Motion Survey. December 1964.



The Great Conjunction of 2020

By Kevin Schindler, Historian

Contrary to the social distancing going on around Earth these days, Jupiter and Saturn recently drew near each as seen from our perspective on Earth. They were closest on December 21—the same day as the winter solstice this year—when they appeared 0.1 degrees apart, which is only 1/5th the diameter of the full Moon. Such a close approach of the two largest planets in our solar system is called a great conjunction, and they occur about every 20 years. This year's is special because it marked the closest great conjunction since 1623, and the closest easily observable one since 1226.

View of the 2020 Great Conjunction on December 21, 2020, as seen through a small to moderately sized telescope. Jupiter, Saturn, and some of their moons were visible in the same field of view. Credit Rice University, using graphics from Stellarium.

Looking Back: Stars Aligned for the Lowell Observatory Foundation

By Lisa Actor,
Deputy Director for Development

After nearly six years of leading the Lowell Observatory Foundation as Founding Board Chair, W. David Connell, passed the gavel to Donna Weistrop in June. Connell recruited the initial board, drafted the founding policies, and worked with the foundation trustees to approve them.

Since its founding in September of 2014, the Lowell Observatory Foundation's endowed funds have grown from $2 to $8.5 million toward an initial goal of $20 million.

Michael Beckage, Chair of the Lowell Observatory Advisory Board Executive Committee, remembers working with Lowell Putnam to create the foundation. "There was a contingent of supporters who felt that the observatory's governance, not having a traditional Board of Trustees, could be an impediment to endowment giving," said Beckage. "That's why we created the foundation. David Connell was the perfect person to launch the organization."

When asked to lead the foundation board, Connell didn't hesitate. "This initiative aligned with my professional background, so it was particularly satisfying to assist in building momentum for the creation of the foundation and to help get it up and running," said Connell. He added, "I believed at the time—and still do—that the creation of a supporting organization was critical to securing future funding for the observatory from individuals and private foundations."

Incoming Board Chair Donna Weistrop offered praise for Connell's efforts. "As the founding chair of the Lowell Observatory Foundation Board, David Connell has done an outstanding job establishing the foundation. In addition to growing the endowment to $8.5 million during his tenure, Connell put in place many of the protocols and guidelines that will carry the foundation into the future," she said. "We are truly fortunate to have had David as the first chair of the foundation."

Connell believes the time was right for the foundation's success. "We had the right trustee, the right director and, immediately thereafter, the right Deputy Director for Development was hired," he said. "We had a steady and growing economy, the financial markets were performing well and then, I am convinced, the observatory developed the right vision for its future. I guess we can rightly say 'the stars aligned'."

New Lowell Observatory Foundation Board Chair Dr. Donna Weistrop

Lowell Observatory Foundation Founding Board Chair W. David Connell

Supporter Feedback

Compiled by Heather Craig, Marketing Specialist

"Great job! Good mix of objects, lots of good information for beginners too. Thanks!"

About Interactive Stargazing on YouTube

About Premium Access

"We had a magical time. The staff was excellent, informative and accommodating."

"Our private stargazing experience on the Giovale Open Deck Observatory at Lowell Observatory was amazing from start to finish."

About Premium Access

About Sagas in the Sky on YouTube

"I love these lessons you guys give."

Recent Publication

Steckloff, Jordan K.; Soderblom, Jason M.; Farnsworth, Kendra K.; Chevrier, Vincent F.; **Hanley, Jennifer**; Soto, Alejandro; Groven, Jessica J.; **Grundy, William M.**; Pearce, Logan A.; Tegler, Stephen C.; **Engle, Anna**. Stratification Dynamics of Titan's Lakes via Methane Evaporation. *The Planetary Science Journal*, Volume 1, Issue 2, id.26, 7 pp.

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YELLOW SUPERGIANTS

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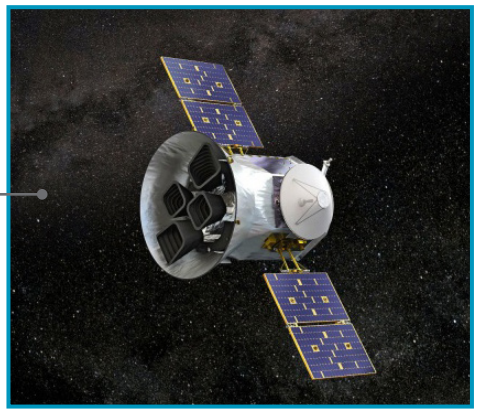
So, how then do you tell if a yellow supergiant is cooling down on its way to becoming a red supergiant (as is normal), or if it has already gone through the red supergiant phase (as is rare) and is slowly getting warmer? It appears the answer could be in how it pulsates.

Recent work by a team of astronomers found that a subset of yellow supergiants pulsate with periods faster than one day and have named them Fast Yellow Pulsating Supergiants (FYPS). This work was led by University of Washington (UW) PhD Candidate Trevor Dorn-Wallenstein, who was assisted in the study by me (I'm a Lowell Observatory Research Associate and UW PhD Candidate), along with our thesis advisor Dr. Emily Levesque, a (very) former past Lowell REU student who is now a UW faculty member. Dorn-Wallenstein and the team used high-cadence data from the Transiting Exoplanet Survey Satellite (TESS) to measure how the brightness of a sample of 76 YSGs located in the nearby galaxy—the Large Magellanic Cloud—varied. We found that five of these stars were unlike the others and showed regular pulsations.

So, why do these stars pulsate? As massive stars burn through their various heavier elements, they change drastically in temperature, but not much in luminosity. However, during the red supergiant phase, these stars lose up to half of their mass during eruptive events and FYPS lose even more! While they're still just as luminous as before, their masses are now too low to remain stable and thus they begin to pulsate in strange ways. It is these pulsations that Dorn-Wallenstein and team measured. While it is possible these pulsations are caused by a different evolutionary mechanism, these stars are certainly unlike any other YSGs previously discovered. Further work is planned to find more such pulsating stars and better understand where they fit into massive star evolution.

FRONT COVER IMAGE: The FYPS were found in the Large Magellanic Cloud, a dwarf irregular galaxy located 180,000 light years away and clearly visible in the Southern Hemisphere under clear, dark skies. While we expect to find FYPS in other galaxies (such as our own), we do not yet have the necessary data from TESS to identify such fast pulsations. | Credit: Yuri Beletsky (ESO).



The Transiting Exoplanet Survey Satellite's (TESS) primary objective is to find exoplanets transiting stars by detecting small changes in the star's brightness as a planet passes in front. However, astronomers like Dorn-Wallenstein have used this publicly-available data to study a host of astronomical phenomena such as the massive stars discussed here. | Credit: NASA Goddard

MINIMOON

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interplanetary space. The first known minimoon, 2006 RH120, was detected 14 years ago.

CD3 was discovered on February 15, 2020 by Kacper Wierzchos and Teddy Pruyne via the Catalina Sky Survey, operating out of the University of Arizona's Lunar and Planetary Laboratory. Due to the rarity of minimoons, a global effort led by postdoctoral research fellow Grigori Fedorets of Queen's University Belfast was quickly launched to study this object. Twenty-three researchers from 14 academic institutions in seven countries participated, using several telescopes including the LDT. The team made observations through mid-May 2020 and published their results this fall.

Lowell Observatory astronomer Dr. Nick Moskovitz and former Lowell postdoctoral fellow/current Arecibo Observatory scientist Dr. Maxime Devogele participated in the effort, assisted in observing on the LDT by the University of Maryland's Quanzhi Ye. By measuring CD3's changing brightness over time (i.e. its light curve) with the Large Monolithic Imager (LMI) on the LDT, they established its rotation rate to be about three minutes. Fedorets said, "The rotation rate was probably the largest unanswered question of this research. The Lowell team showed that it rotates slower than anticipated for objects of this size range."

Moskovitz and his Lowell colleagues also used the LMI/LDT combination to precisely measure CD3's position to refine its orbit. This information, combined with CD3's physical characteristics—such as an inferred silicate composition—indicate this is certainly a natural object. This distinguishes it from another recently discovered object, 2020 SO, which scientists believe may be the upper stage of NASA's Surveyor 2 spacecraft.

The study estimates CD3 is approximately 1-1.5 meters in diameter—about the size of a small car— and that it came within about 13,000 kilometers (8,100 miles) of Earth at closest approach. Observing objects this small is challenging and requires a telescope big enough to see them. In addition, their transient nature means the window of time to observe them can close quickly. Enter the 4.3-meter LDT, Lowell Observatory's flagship telescope. Its large size and ready availability make it optimized for such studies. Moskovitz said, "This object wasn't bright enough to study for very long. The fact that we have this telescope in our backyard and were able to rapidly respond really made a difference."

The global response to CD3 may very well serve as a template for future minimoon studies, which scientists anticipate to happen soon. According to Fedorets, "Minimoons are expected to be discovered in high numbers in the following decade, with the opening of the Vera C. Rubin Observatory expected in 2023." This facility is now being built in Chile and features an 8.4-meter telescope that will allow astronomers to detect many more small bodies such as minimoons.

Scientists are interested in learning more about these bodies for several reasons. Because minimoons are close to Earth, they are potentially accessible targets for robotic or human exploration. Such efforts will be scientifically valuable to understand the origin of these objects and their relationship to other asteroid and comet populations in the solar system. These objects could also someday be commercially important as targets for in-space resource mining.

FRONT COVER IMAGE: International Gemini Observatory image of 2020 CD3 (center, point source) obtained with the 8-meter Gemini North Telescope on Hawaii's Maunakea. The image combines three images each obtained using different filters to produce this color composite. 2020 CD3 remains stationary in the image since it was being tracked by the telescope as it appears to move relative to the background stars, which appear trailed due to the object's motion.
Credit: International Gemini Observatory/ NOIRLab/NSF/AURA/G. Fedorets.

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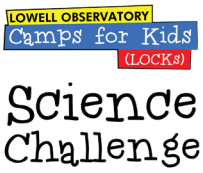

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