The Big Eye

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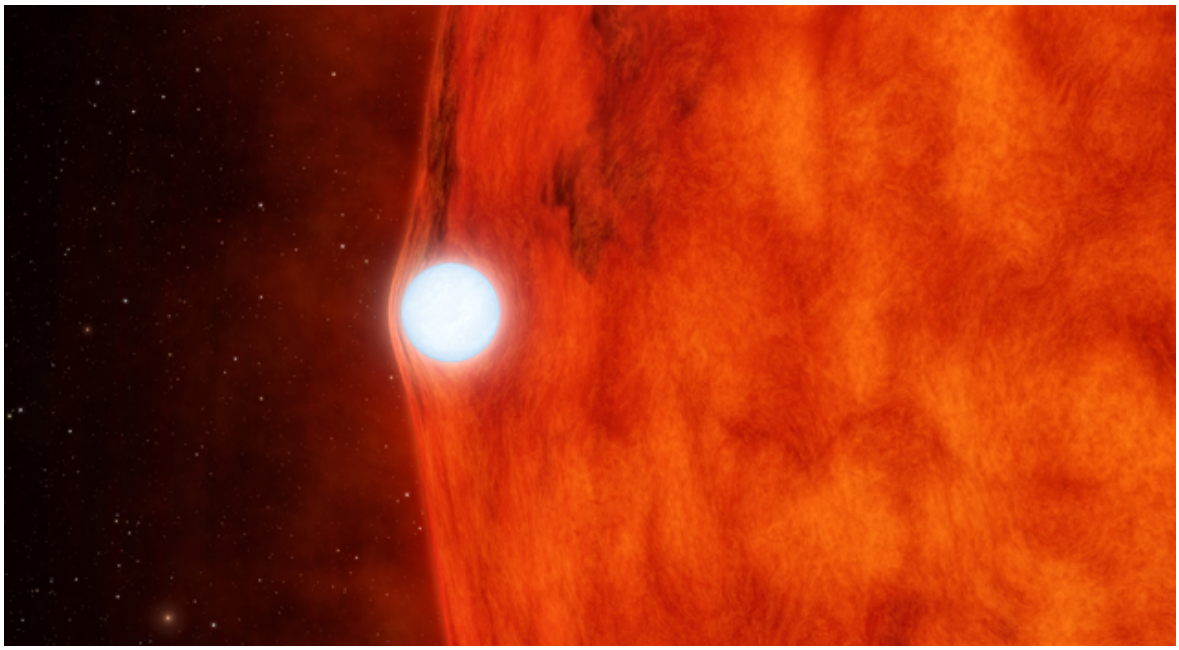
Gravity-Bending Find Leads to Kepler Meeting Einstein



This artist's concept depicts a dense, dead star called a white dwarf crossing in front of a small, red star. The white dwarf's gravity is so great it bends and magnifies light from the red star. Image credit: NASA/JPL-Caltech

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NASA's Kepler space telescope has witnessed the effects of a dead star bending the light of its companion star. The findings are among the first detections of this phenomenon -- a result of Einstein's general theory of relativity -- in binary, or double, star systems.

The dead star, called a white dwarf, is the burnt-out core of what used to be a star like our sun. It is locked in an orbiting dance with its partner, a small "red dwarf" star. While the tiny white dwarf is physically smaller than the red dwarf, it is more massive.

"This white dwarf is about the size of Earth but has the mass of the sun," said Phil Muirhead of the California Institute of Technology, Pasadena, lead author of the findings to be published April 20 in the Astrophysical Journal. "It's so hefty that the red dwarf, though larger in physical size, is circling around the white dwarf."

Kepler's primary job is to scan stars in search of orbiting planets. As the planets pass by, they block the starlight by miniscule amounts, which Kepler's sensitive detectors can see.

"The technique is equivalent to spotting a flea on a light bulb 3,000 miles away, roughly the distance from Los Angeles to New York City," said Avi Shporer, co-author of the study, also of Caltech.

Muirhead and his colleagues regularly use public Kepler data to search for and confirm planets around smaller stars, the red dwarfs, also known as M dwarfs. These stars are cooler and redder than our yellow sun. When the team first looked at the Kepler data for a target called KOI-256, they thought they were looking at a huge gas giant planet eclipsing the red dwarf.

"We saw what appeared to be huge dips in the light from the star, and suspected it was from a giant planet, roughly the size of Jupiter, passing in front," said Muirhead.

To learn more about the star system, Muirhead and his colleagues turned to the Hale Telescope at Palomar Observatory near San Diego. Using a technique called radial velocity, they discovered that the red dwarf was wobbling around like a spinning top. The wobble was far too big to be caused by the tug of a planet. That is when they knew they were looking at a massive white dwarf passing behind the red dwarf, rather than a gas giant passing in front.

The team also incorporated ultraviolet measurements of KOI-256 taken by the Galaxy Evolution Explorer (GALEX), a NASA space telescope now operated by the California Institute of Technology in Pasadena. The GALEX observations, led by Cornell University, Ithaca, N.Y., are part of an ongoing program to measure ultraviolet activity in all the stars in Kepler field of view, an indicator of potential habitability for planets in the systems. These data revealed the red dwarf is very active, consistent with being "spun-up" by the orbit of the more massive white dwarf.

The astronomers then went back to the Kepler data and were surprised by what they saw. When the white dwarf passed in front of its star, its gravity caused the starlight to bend and brighten by measurable effects.

"Only Kepler could detect this tiny, tiny effect," said Doug Hudgins, the Kepler program scientist at NASA Headquarters, Washington. "But with this detection, we are witnessing Einstein's general theory of relativity at play in a far-flung star system."

One of the consequences of Einstein's general theory of relativity is that gravity bends light. Astronomers regularly observe this phenomenon, often called gravitational lensing, in our galaxy and beyond. For example, the light from a distant galaxy can be bent and magnified by matter in front of it. This reveals new information about dark matter and dark energy, two mysterious ingredients in our universe.

Gravitational lensing has also been used to discover new planets and hunt for free-floating planets.

In the new Kepler study, scientists used the gravitational lensing to determine the mass of the white dwarf. By combining this information with all the data they acquired, the scientists were also able to measure accurately the mass of the red dwarf and the physical sizes of both stars. Kepler's data and Einstein's theory of relativity have together led to a better understanding of how binary stars evolve.

Other authors include Andrew Vanderburg of the University of California, Berkeley; Avi Shporer, Juliette Becker, Jonathan J. Swift, Sasha Hinkley, J. Sebastian Pineda, Michael Bottom, Christoph Baranec, Reed Riddle, Shriharsh P. Tendulkar, Khanh Bui, Richard Dekany and John Asher Johnson of Caltech; James P. Lloyd and Jim Fuller of Cornell University; Ming Zhao of The Pennsylvania State University, University Park; Andrew W. Howard of University of Hawaii, Hilo; Kaspar von Braun of the Max Planck Institute for Astronomy, Germany; Tabetha S. Boyajian of Yale University, New Haven, Conn.; Nicholas Law of the University of Toronto, Canada; A. N. Ramaprakash, Mahesh Burse, Pravin Chordia, Hillol Das and Sujit Punnadi of the Inter-University Centre for Astronomy & Astrophysics, India.

NASA Ames manages Kepler's ground system development, mission operations and science data analysis. NASA's Jet Propulsion Laboratory in Pasadena, Calif., managed Kepler mission development. Ball Aerospace and Technologies Corp. in Boulder, Colo., developed the Kepler flight system and supports mission operations with JPL at the Laboratory for Atmospheric and Space Physics at the University of Colorado in Boulder. The Space Telescope Science Institute in Baltimore archives, hosts and distributes the Kepler science data. Kepler is NASA's 10th Discovery Mission and is funded by NASA's Science Mission Directorate at the agency's headquarters. JPL is a division of Caltech. For more information about the Kepler mission, visit: http://www.nasa.gov/kepler .

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THE PALOMAR OBSERVATORY DOCENT CORNER

By Roger Weber

This year will be my fifth year as a Palomar Observatory docent. Thus, another year to learn more about the universe and meet more interesting people.

I grew up in Cleveland, in and surrounded by neighborhoods with tall maples and oaks that blocked most of highly illuminated night sky. Perhaps both explain why there was little interest in astronomy by my grade-school teachers and neighbors. But what kid doesn't at some time lie on the grass after sunset, even with small openings in the leafy canopies, and look at the stars, and wonder. I did. I remember some sky observations that caused me to have some early-life mysteries. Why didn't the sun rise earlier right after the winter solstice? Why the swing of daily moonrise positions on the horizon? What's the Harvest Moon all about? I remember that I thought the Pleiades was the Little Dipper. Later, I solved these mysteries, and began to understand comets, lunar eclipses, double and triple conjunctions, recognize star patterns, and enjoy naked-eye sky watching.

While working for the National Park Service in Arizona, my wife and I were fortunate to live just 70 air miles west of Kitt Peak, and witness the 1966 Leonid meteor shower
1,000 meteors per minute with trains lasting four to five seconds. (Yes, that's per minute, not per hour!) Months later, a friendly camper allowed us to look at Omega Centauri through his 10-inch telescope, and we attended a talk in Phoenix by an astronomer (Chick Capen) about sending laser beams from Caltech's Table Mountain Observatory, 25 air miles northeast of Mt. Wilson, near Wrightwood, that could be bounced off the moon and detected at the McDonald Observatory, 160 air miles southeast of El Paso, Texas. Wow. Still later, we would see the zodiacal light set behind the Panamint Mountains in Death Valley every moonless night, but never see the Gegenschein. In August, 1975, walking home from a neighbor's house, close to midnight, I gave the sky a quick glance and spotted a new star in Cygnus. First sighting of this nova had occurred hours earlier in Japan. I was not certain why I was so happy to see it. Yes, a naked-eye nova is rare, but it only took a second for me to recognize the star pattern in Cygnus was goofy. I guess I was thrilled to see it, and, at the same time, stunned that I had unknowingly memorized the star pattern and recognized an exception. Two years later I flew to Portland, Oregon to be in the shadow path of the 1977 solar eclipse. I watched televised eclipse coverage, with live images coming from an airplane well above the weather, while it poured cats and dogs outside the motel room.

Are you ready for two more of my wow moments? Viewing the impossibly dark sky from the hilltop parking lot the night before hiking down to Havasu Falls, and, on a quiet sunny morning, sitting on the front porch of the former Tucson home of A.E. Douglas (Mars Hill site selection and tree-ring dating) and thanking him for his discoveries.

A few years ago, after moving to the Temecula area, a newspaper story mentioned dark-sky ordinances in Riverside County. That prompted me to invite a speaker from the Palomar Observatory to have breakfast with my Rotary Club and talk about light pollution. Scott Kardel came down a week later, and spoke on this subject and the loss of Pluto's planet status from observations made at the Observatory. (Memo to author/astronomer Mike Brown: your book costs $25.00, but your daughter is priceless.) Scott made a lasting impression on all the club members. They still talk about his presentation, in an east-facing windowed room, with no window coverings to block the morning sun, while he projected his slides on a padre-brown colored wall. Not a disaster. On the contrary, we were enthralled.

His talk caused me to make a September visit to the Observatory where I discovered that one could take a behind-the-scenes look-see of the 200-inch building. I bought a ticket. My tour group's docents included Julie. Lagging behind the group, I spoke with her. She sensed my interest in astronomy and the telescope, and she urged me to become a docent, explaining that no special education was required, only a keen interest in astronomy and telescopes and people skills were needed. The next day, I sent Scott an application letter. Three months later, he promptly invited me to the Outreach Center to be interviewed, take a driving tour of the grounds, and do some paperwork. He did, we did, and I did. I was on my way to becoming a docent! It was five years ago, and I still express my appreciation to Julie for revealing this opportunity.

The first stop was an annual winter banquet where I met most of the other docents, all representing different career choices, ages, cities of residence, but all grateful to be Palomar docents. Scott introduced me to Susan Vergara and her husband, and several other Caltech on-site employees and their spouses, and I would grow to appreciate and respect and eventually near-worship all of them. Susan

now trains and coordinates the scheduling of the docents, arranges the star parties and astronomer talks, stocks the gift shop, and sees that the Outreach Center is supplied with Oreo cookies for docents.

During my first docenting weeks, I memorized a number of handouts, attended several Saturday half-day training sessions in the Outreach Center and 200-inch building, and accompanied dozens of tours to pick up the knowledge and confidence I would need to participate. While I would not suffer over confidence, I wanted to be as knowledgeable as the journeymen docents because of the responsibility I would have. It wasn't as if these visitors were being summoned to an IRS office and therefore having suspicious and guarded minds. I knew that most of the visitors I would be talking to were at the Observatory because they wanted to be. They were wide-open receptive to any astronomical or telescope fact and plain-talk explanations we docents could give. They would be open to new things and new concepts. They would want to learn and be able to get their questions answered so comfortably that they would not be reluctant to ask more. Questions that they might have harbored from the time they were kids and had lain in the grass and wondered. Anything we docents said would stick.

I learned that spending time in the visitor gallery with visitors not on the tours provides an equal but different satisfaction than from guiding a tour because of the ability to answer wide-ranging questions and listening to comments. I think I've heard it all. I am even now prepared to answer if Palomar astronomers have ever seen UFO's (Memo to self: don't dismiss UFOs entirely; after all, film star Demi Moore was born in Roswell and she is perfect.)

We docents are not cash compensated, but there is an amazing amount of psychic income. First, meeting people and helping them understand a little bit about the universe (science) and how astronomers observe proves to be a real joy. And to do this just west of Warner Valley where so many Native Americans lived and Kearney, Kit Carson, the Mormon Battalion and the gold rushers passed across and then along both sides of the Palomar Mountain (history). To be a few feet away from cutting edge spectrographs and adaptive optics (technology) while inhaling the scent of warm pine needles, listening to faint bird songs, and experiencing solitude (natural history) Bang! Sensory overload!

Second, being given an opportunity to be on the other side of the podium and see and hear things new to us. Last year was a good year for Palomar docents. In March, Site Superintendent Dan McKenna gave us an opportunity to see up close the 200-inch prime-focus tube, which, for maintenance reasons, had been lowered to the observing floor. This was the first time we docents were able to see, a few inches from our noses, all three secondary mirrors mounted just below prime focus. Dan even raised and lowered one to show us the movement.

In April, docent and Palomar College Astronomy Professor Mark Lane hosted our annual docent Banquet at the new Palomar College Planetarium, with two planetarium show packages for dessert.

In July, senior telescope operator Jean Mueller gave us a behind-the-scenes tour of the 48-inch Schmidt telescope and building, allowing us to see some comet discovery images, and hear some of her personal history of working on the second Palomar Observatory sky survey (POSS II).

During the year, Susan arranged for three lectures at the Outreach Center by astronomers that would be spending the night at the 200- or the 60-inch. In October, Caltech post-Doc Branimir Sesar spoke on galactic archeology. (This was first time I had seen those two words together.)

Also in October, Caltech's Observatory Director Shri Kulkarni and Deputy Director Andy Bowden invited all docents to a full-day Palomar research symposium and lunch at Caltech in Pasadena. We received mini-reports on asteroids, black holes, and everything in between, enhanced with power point slides, from scientists from Pasadena and several foreign countries. And we docents had an opportunity to visit with these world-class experts during lunch.

In late October, docent Jim Mettler and I had dinner with astronomer Branimir and his wife, and then the four of us spent the entire night in the 200-inch control room with Jean, chatting about the Milky Way's evolution and how the telescope is operated, while recording spectral data on some stars with uncommon motions that suggest the Milky Way is an aggregation of several smaller galaxies. Several times we went outside to check on the weather and cloud cover. (Memo to self: walking the dome's outside catwalk at night while looking up and wondering is like being a kid lying on the grass and wondering. It's just not as itchy.)

October was a mighty fine month!

During the first few months of 2013, the 18-inch Schmidt telescope will be de-mothballed and reassembled within the large room in the Addison Greenway Visitor Center. Docents have been invited to help with the assembly.

So, what's not to like being a Palomar docent? New stuff, new people, appreciation, beautiful physical setting, an association with Caltech and its astronomers, fresh Oreos! Bang! It just happened again.

I have never owned a telescope, probably because a telescope limits one's field of view to just a little bit of the sky, and I enjoy seeing all of the night sky all the time. Maybe I have spent too much time living where there are no street lights. Or maybe it's the National Park Service naturalness ethic in my DNA. Anyway, my interest remains with naked-eye viewing. Beginning with the moon landings, I have been particularly fascinated with the lunar theory and the back and forth motions of the moon's apsides and nodes. Or at least those irregularities that are naked eye. (Memo to I. Newton: yea, my head can hurt too.)

After a day of docenting at Palomar, I always experience a deep gratitude for the likes of Carnegie, Hooker, Rockefeller, Hale, Oschin, Mayer, and thousands of other lesser known philanthropists that gave and do give to support research and make the world a better place. I'm grateful for spending time with all the nice Palomar visitors that thank the docents for sharing our knowledge and hospitality. Maybe, just maybe, visitors and docents alike can cope with life a little better because of the day's experience. Maybe some school-age visitor will begin to lean toward a career in science.

Always, at the end of a docenting day, I deliberately drive from the Outreach Center to the Palomar Mountain Post Office as slowly as safety permits, along the curves and dips, with a pile of Oreos on the console screaming for attention, sensing the absence of any other cars, glancing at the high-country trees on both sides of the road….. Well, everything always seems so right with the world; everything is in its proper place. All is well with the universe. And I'm ready to spend another day at Palomar, maybe with people that have lain on itchy grass…..