SIRIUS ASTRONOMER

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The Newsletter of the Orange County Astronomers

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Rick Hull created this image of the eastern Veil Nebula at our Anza site in August of this year. This image represents 4 hours of data. Rick used an SV 110ED at f/7 on an AP400 mount and an STF – 8300C imager to create the image.

OCA CLUB MEETING

The free and open club meeting will be held October 3 at 7:30 PM in the Irvine Lecture Hall of the Hashinger Science Center at Chapman University in Orange. This month's speaker is Michelle Evans, who will discuss her new book *The X-15 Rocket Plane: Flying the First Wings Into Space*.

NEXT MEETINGS: Nov. 14, Dec. 12

STAR PARTIES

The Black Star Canyon site will open on October 18. The Anza site will be open on October 25. Members are encouraged to check the website calendar for the latest updates on star parties and other events.

Please check the website calendar for the outreach events this month! Volunteers are always welcome!

You are also reminded to check the web site frequently for updates to the calendar of events and other club news.

COMING UP

The next session of the Beginners Class will be held at the Heritage Museum of Orange County at 3101 West Harvard Street in Santa Ana on October 10. The following class will be held November 7.

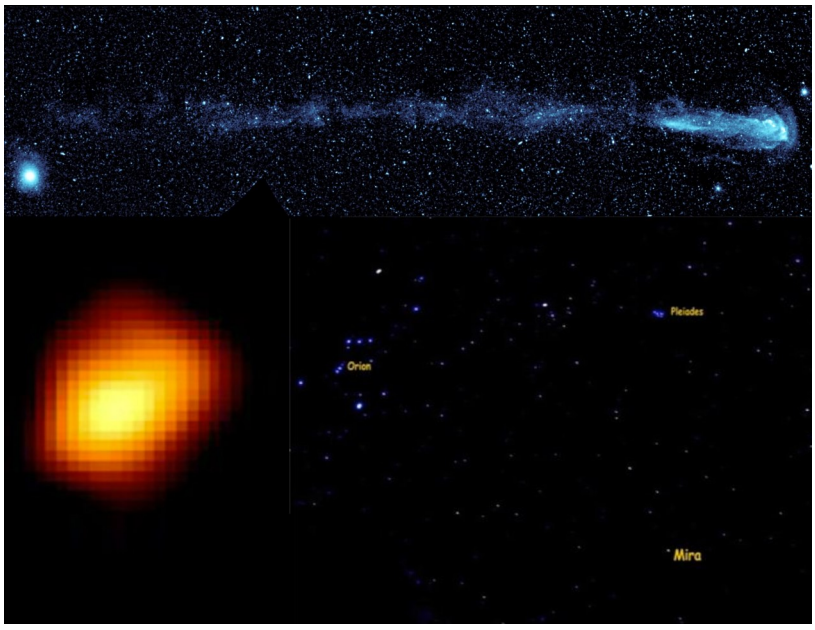
GOTO SIG: TBA
Astro-Imagers SIG: Oct. 14, Nov. 11
Remote Telescopes: TBA
Astrophysics SIG: Oct. 17, Nov. 21
Dark Sky Group: TBA

Twinkle, twinkle, variable star

By Dr. Ethan Siegel

As bright and steady as they appear, the stars in our sky won't shine forever. The steady brilliance of these sources of light is powered by a tumultuous interior, where nuclear processes fuse light elements and isotopes into heavier ones. Because the heavier nuclei up to iron (Fe), have a greater binding energies-per-nucleon, each reaction results in a slight reduction of the star's mass, converting it into energy via Einstein's famous equation relating changes in mass and energy output, $E = mc^2$. Over timescales of tens of thousands of years, that energy migrates to the star's photosphere, where it's emitted out into the universe as starlight.

There's only a finite amount of fuel in there, and when stars run out, the interior contracts and heats up, often enabling heavier elements to burn at even higher temperatures, and causing sun-like stars to grow into red giants. Even though the cores of both hydrogen-burning and helium-burning stars have consistent, steady energy outputs, our sun's overall brightness varies by just ~0.1%, while red giants can have their brightness's vary by factors of thousands or more over the course of a single year! In fact, the first periodic or pulsating variable star ever discovered—Mira (omicron Ceti)—behaves exactly in this way.



Images credit: NASA's Galaxy Evolution Explorer (GALEX) spacecraft, of Mira and its tail in UV light (top); Margarita Karovska (Harvard-Smithsonian CfA) / NASA's Hubble Space Telescope image of Mira, with the distortions revealing the presence of a binary companion (lower left); public domain image of Orion, the Pleiades and Mira (near maximum brightness) by Brocken Inaglory of Wikimedia Commons under CC-BY-SA-3.0 (lower right).

There are many types of variable stars, including Cepheids, RR Lyrae, cataclysmic variables and more, but it's the Mira -type variables that give us a glimpse into our Sun's likely future. In general, the cores of stars burn through their fuel in a very consistent fashion, but in the case of pulsating variable stars the outer layers of stellar atmospheres vary. Initially heating up and expanding, they overshoot equilibrium, reach a maximum size, cool, then often forming neutral molecules that behave as light-blocking dust, with the dust then falling back to the star, ionizing and starting the whole process over again. This temporarily neutral dust absorbs the visible light from the star and re-emits it, but as infrared radiation, which is invisible to our eyes. In the case of Mira (and many red giants), it's Titanium Monoxide (TiO) that causes it to dim so severely, from a maximum magnitude of +2 or +3 (clearly visible to the naked eye) to a minimum of +9 or +10, requiring a telescope (and an experienced observer) to find!

Visible in the constellation of Cetus during the fall-and-winter from the Northern Hemisphere, Mira is presently at magnitude +7 and headed towards its minimum, but will reach its maximum brightness again in May of next year and every 332 days thereafter. Shockingly, Mira contains a huge, 13 light-year-long tail -- visible only in the UV -- that it leaves as it rockets through the interstellar medium at 130 km/sec! Look for it in your skies all winter long, and contribute your results to the AAVSO (American Association of Variable Star Observers) International Database to help study its long-term behavior!

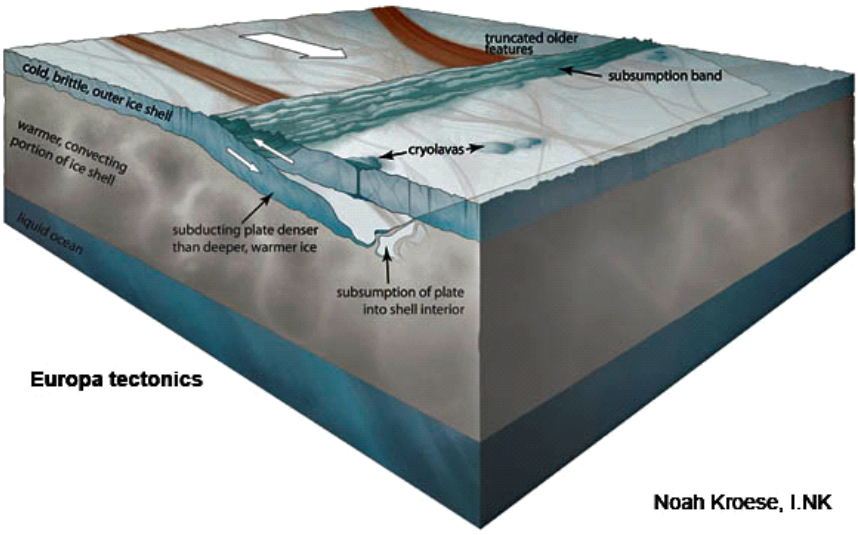
Check out some cool images and simulated animations of Mira here: http://www.nasa.gov/mission_pages/galex/20070815/v.html

Kids can learn all about Mira at NASA's Space Place: http://spaceplace.nasa.gov/mira/en/

AstroSpace Update

October 2014

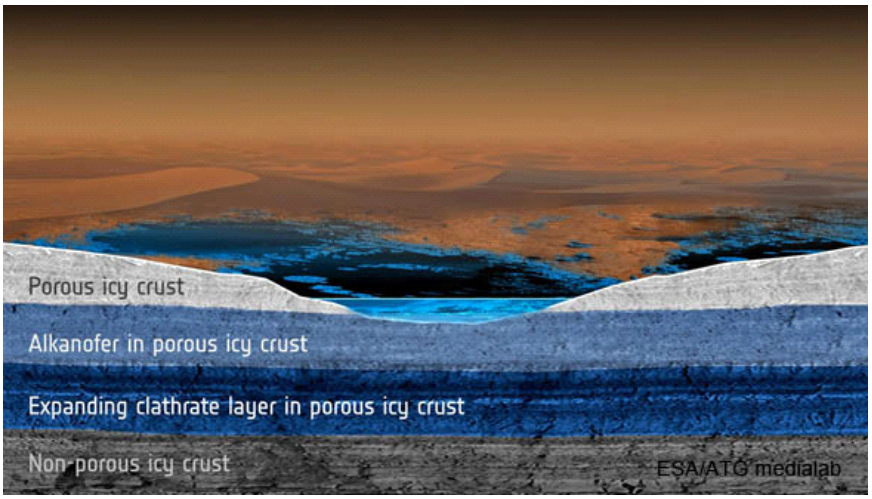
Gathered by Don Lynn from NASA and other sources



Europa tectonics – Scientists have found evidence of plate tectonics on Jupiter's moon Europa. This is the 1st indication of tectonics on a world other than Earth. Researchers have for some time found evidence of new crust formation, but until now could not find how space was made for this new crust. New study of images taken by the Galileo spacecraft showed that the surface pieces that had to have existed before the new crust formation were now missing parts that must have been subducted (forced under other pieces). Thousands of square miles (thousands of km^2) have apparently been subducted in the far north.

Ring clumps – A recent study compared the narrow F-ring around Saturn between images taken by the Cassini spacecraft and by the Voyager mission 30 years earlier. The study team found that, while the overall number of clumps in the F ring remained the same, the number of exceptionally bright clumps of material drastically reduced during those 30 years. The researchers hypothesize that the brightest clumps are caused by repeated impacts into the ring's core by small moonlets up to about 3 miles (5 km) wide, whose paths around Saturn lie close to the ring and cross into it every orbit. They propose that the diminishing number of bright clumps results from a drop in the number of these little moonlets between the Voyager and Cassini eras. The team has a suspect for what caused the moonlets to become scarce: the moon Prometheus. The F ring is near the Roche limit, the place where tidal forces from the planet's gravity tear apart smaller bodies. Prometheus orbits just inside the F ring and stirs up the ring particles, sometimes leading to moonlet creation and sometimes to their destruction. Every 17 years, the orbit of Prometheus aligns with the orbit of the F ring in such a way that its influence is particularly strong. The study team thinks this periodic alignment might spur the creation of many new moonlets. The moonlets would then crash repeatedly through the F ring, creating bright clumps. But as time goes by, the moonlets themselves are eventually destroyed by crashes. If the theory is true, another period of bright clumps should happen in the next couple of years, so Cassini will keep watching.

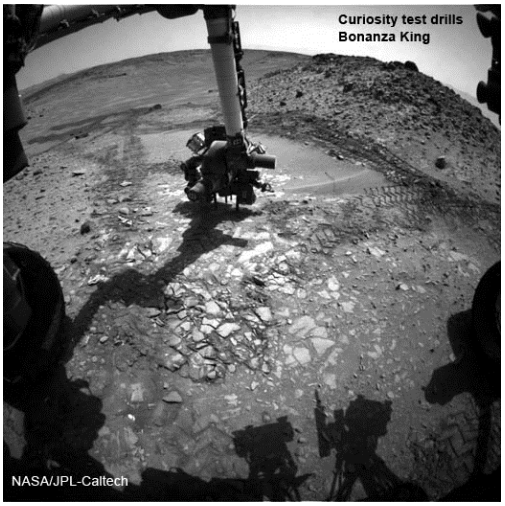
Titan lakes – Cassini (Saturn mission) has revealed hundreds of lakes and seas spread across the north polar region of Saturn's moon Titan. These lakes are filled with hydrocarbons, including methane, which is thought to be replenished by methane rain. A recent computer simulation examined how Titan's methane rainfall would interact with icy materials within underground reservoirs. They found that materials called clathrates formed and changed the chemical composition of the rainfall runoff by a process called fractionation. The clathrates change methane into propane and ethane. So liquid coming from the underground reservoirs should have a different composition than the rainfall. Future observations should be looking for areas of higher concentration of propane and ethane to help understand how the surface lakes interact with the underground reservoirs.



Opportunity (Mars rover), which has been roaming the red planet for more than 10 Earth years, has developed problems with its flash memory. Resets due to these problems have increased in frequency, preventing science operations until each is commanded to recover. So the flash memory is being reformatted, which identifies bad cells and flags them to be avoided. Reformatting was successfully done on the twin rover Spirit 5 years ago.

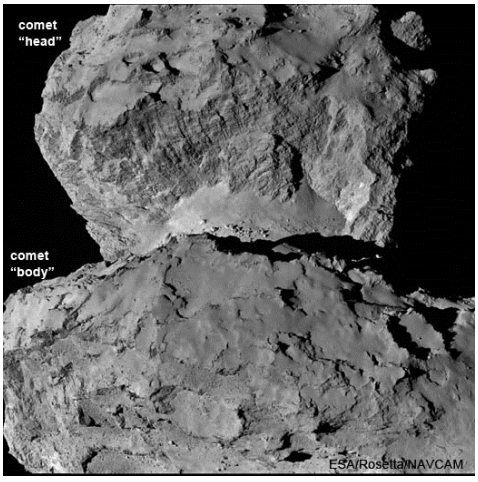
Curiosity (Mars rover) - Controllers moved Curiosity out of Hidden Valley, which had been the preferred route to reach the base of Mt. Sharp, because the valley was found to hold dunes too soft and deep to negotiate. An alternate path was found, though it requires dodging the worst sharp rocks, since such have damaged the rover's wheels in past roving. Days later Curiosity reached the base of Mt. Sharp, which has been the rover's long-term destination. This is marked by the geological boundary where the base layer of the mountain meets crater-floor deposits. Further examination of images taken from orbit prompted the rover science team to choose a new route over the mountain base, where more vertical exposures of geological layers are exposed.

Curiosity found an interesting rock dubbed "Bonanza King", which was actually uncovered by driving over it. The rock possessed thin, white cross-cutting mineral veins, which could indicate that liquid water flowed here in the distant past. It was decided to do a test drill of the rock. But during the drilling, software on the rover detected that the rock moved, creating an unsafe condition, and drilling was automatically stopped. Controllers decided to skip any further investigation of Bonanza King, and moved on to other work. Perhaps the controllers were remembering that a flying rock during Curiosity's landing apparently damaged the meteorological instrument.



Rosetta (European comet mission) – The 1st ultraviolet data of comet 67P/Churyumov-Gerasimenko have been returned from Rosetta. The comet is unusually dark in ultraviolet, darker than charcoal. Hydrogen and oxygen have been found in the comet's coma, or atmosphere. Water ice was not found on the surface, though it had been expected because it is too far away from the Sun in its orbit to have yet vaporized ice. Visible-light images show parallel linear features that may be cliffs on the smaller lump of the nucleus (being referred to as the head), and multivariable terrain with peaks and valleys and both smooth and rough features on the larger lump (the body).

The **Rosetta** mission has chosen 5 candidate landing sites on the comet nucleus for its Philae lander. The landing is planned for mid-November. It will be the 1st ever soft landing on a comet. Landing sites are evaluated for maintaining communications with Rosetta, absence of surface hazards, sufficient illumination for scientific operations and solar power, and other factors. Originally 10 sites were chosen, lettered from A to J, and then the best 5 were chosen. Sites A & C are on the "body" and B, I & J are on the "head". As Rosetta gets closer, more detail will be seen, which will influence the final decision.



Planet formation – Theories of planet formation predict that a planet-forming disk should start out with dust the size of soot or sand grains. How these grow to larger objects, eventually planets, is not completely understood. Observations in recent years have found such disks with millimeter-size to pebble-size grains. New observations with the Green Bank radiotelescope of the Orion Molecular Cloud Complex have found that it contains long-dust-rich filaments, which are dotted with many dense cores. Theoretically large dust grains should spiral in toward their star. But since planets do actually form, somehow the larger dust is protected from such a fate. There are several theories to explain this: 1) dust traps (high density regions) herd the particles, 2) the filaments (such as seen in Orion) have low temperatures, high densities, and low relative velocities, speeding grain growth, and 3) larger particles escaped from other disks or cores and seeded grain growth. Further observations are needed to determine which theory holds.

Close exoplanet – A super-Earth (planet larger than Earth, but smaller than Neptune) has been discovered orbiting star Gliese 15A, only 11.7 light-years away. This is the closest known super-Earth, and one of the closest exoplanets. It was discovered by the radial velocity technique. The star is one of a binary, composed of 2 red dwarf stars. The planet is 5.35 times the Earth's mass and orbits its star in only 11.44 days, making it so close to its star that it is quite hot.

Binary-star exoplanets – How many exoplanets orbit binary stars? A new study has found that to be 40 to 50%. This is just about the fraction of all stars that reside in binary systems. The implication is that a companion star does not substantially interfere with the process of forming planets. The new result was obtained by using speckle imaging of a number of stars believed to have planets. The speckle imaging technique consists of obtaining digital images 15 to 25 times per second and processing them with software, yielding a final picture with resolution better than .05 arcseconds. The results were extrapolated to account for stars at different distances than that for which speckle imaging works and to account for chance alignment of background stars. This study was not able to determine if each planet orbits one or both of the binary pair, but other observations have found examples of both cases.

Stripped exoplanets – Though hot Jupiters (exoplanets roughly the size of Jupiter, but orbiting very close to their stars) have been known for a long time, more recent discoveries have found hot super-Earths. A new study suggests that hot super-Earths are actually hot Jupiters that have had their hydrogen atmospheres stripped off by tidal forces from their stars. Computer simulations of the stripping process seem to fit what is observed, particularly in orbital periods and masses. However there appear to be too many hot super-Earths for this theory, which may just mean that we haven't been thorough in looking for hot Jupiters.

Exoasteroids – The Spitzer (infrared) Space Telescope has spotted an eruption of dust around a young star, possibly the result of a collision between large asteroids. Scientists had been regularly tracking the star when it surged with a huge amount of fresh dust between August 2012 and January 2013. While dusty aftermaths of suspected asteroid collisions have been observed before, this is the 1st time scientists have collected date before and after the smashup. The star is about 35 million years old and lies 1200 light-years away in Vela. Previous observations had already shown small variations in the amount of dust around the star, so small collisions are likely common. The collision apparently occurred while the star was behind the Sun and unobservable. Observations now continue as the cloud destroys itself by grinding its grains down.

More planet formation – A team of scientists has discovered new evidence that planets are forming around a star about 335 light-years from us. The team found carbon-monoxide emission that strongly suggests a planet is orbiting a relatively young star known as HD 100546. The candidate planet is the 2nd that astronomers have discovered orbiting that star. This is one of the 1st times astronomers have been able to observe planet formation happening. The star is about 2.5 times as large and 30 times brighter than the Sun. The new planet is a gas giant at least 3 times the size of Jupiter. Its distance from its star is about that of Saturn from our Sun. The favored hypothesis is that the emission comes from a circumplanetary disk of gas orbiting a giant planet. Such a disk is where moons form about a new planet. More work is needed to eliminate other possible explanations for the gas observed, such as a wake from tidal interactions.

Ice clouds – A team of scientists has discovered the 1st evidence of water ice clouds on an object outside our Solar System. Water ice clouds exist on our own gas giant planets (and Earth). But the new evidence is for ice clouds on a brown dwarf, a star with insufficient mass to maintain nuclear fusion. A near-infrared camera was used, and it found the coldest known brown dwarf. It is the 4th nearest system to us, and is known as W0855. Clouds of frozen sulfide were also detected.

Pleiades distance – Until the 1990s, traditional methods of distance determination said that the Pleiades (or Seven Sisters or M45) are about 430 light-years from Earth. That was too far to allow measuring the distance by parallax, until the highly precise Hipparcos satellite was launched in 1989. Hipparcos gave a result of 390 light-years. Believing this new figure would require massive revision of how stars form and evolve, as well as revision of other distance determination methods. So many astronomers refused to believe this particular distance from Hipparcos. Now using an array of radiotelescopes spread across the Earth, astronomers have measured the parallax of the Pleiades, and the measurement should be accurate to 1%. The result is 443 light-years. So Hipparcos was wrong on this measurement. Yet essentially all its measurements to other objects were consistent with other distance measures. This is going

to take a lot of explaining. Gaia, which is the follow-on to Hipparcos, and should be far more accurate, has already been launched. It will be interesting to see how far Gaia says the Pleiades are.

Supernova companion – Using the Hubble Space Telescope, astronomers have finally identified the blue helium-burning companion star predicted to accompany the star that blew up as a rare Type IIb supernova in 1993 in galaxy M81. This type of supernova contains much less hydrogen than is typical. Astronomers believe that a companion star gravitationally pulled off most of the hydrogen before the explosion. Observations of the companion were difficult because it is so faint relative to the supernova. The discovery team combined visible light with ultraviolet light images.

Almost first-generation star – Astronomers have long been looking for a first-generation star, that is, one that formed out of the hydrogen and helium left by the Big Bang, without any heavier elements. All the massive first-generation stars have long since burned out, and no low mass stars have been found with no heavier elements. But the next best thing has now been found. Theory shows that the very massive first-generation stars (over 100 times the Sun's mass) should at the end of their lives explode in a supernova (the so called pair instability type of supernova) that blasts away essentially no lighter heavy elements (such as carbon and magnesium), but a bit of the heavier heavies (such as iron and nickel), and nothing heavier than iron. The newly found star contains exactly the amounts of elements that should have been given off by the explosion of an extremely massive first-generation star, so the newly found star must have formed right after a first-generation very massive star exploded near it. 500 stars known to have low amounts of heavy elements were examined, and only this one had this makeup.

Midsize black hole – Astronomers have identified an unusual midsize black hole, dubbed M82 X-1. This was accomplished by finding rhythmic pulsations in archival data from the RXTE X-ray space telescope. The black hole has about 400 times the mass of our Sun. Almost all black holes either have the mass of a heavy star or else millions of times the mass of a star, with very few black holes in the midsize. M82 X-1 has been suspected of being midsize for about a decade, but compelling evidence of its mass eluded astronomers until now. As gas falls toward a black hole, it heats up and emits X-rays. Rapid fluctuations in the X-rays happen near the black hole's event horizon, the point beyond which nothing, not even light, can escape. The fastest fluctuations come in pairs with a 3:2 frequency ratio, which is the signature of material near the event horizon. The particular frequency depends on the mass of the black hole. Analysis of the RXTE date found a pair of fluctuations with the 3:2 ratio, and the frequency yielded the mass of 400 solar masses.

Triple or double? – Last month I reported here that a triple black hole had been found (the 4th ever). Another group of astronomers had been observing this same galaxy with a different array of radiotelescopes, and their data showed that the closest 2 of the 3 black holes were actually the ends of jets from a single black hole. So it appears the triple is actually a double black hole.

Galaxy formation – A new survey of faint galaxies billions of light-years away by the Spitzer Space Telescope has already yielded surprises. Building on previous evidence showing that the Universe's earliest galaxies are more massive than expected, the new work has turned up hundreds of hefty galaxies more massive than our Milky Way, dating back to a time when our Universe was less than 1 billion years old. Galaxies assembled even faster than the previous evidence was showing. Current theories hold that the very first galaxies collided and merged to make larger galaxies, but that should have taken too long to have accomplished much in the 1st billion years. This may mean that galaxies grew by other means than collision, such as extended massive star formation.

More galaxy formation – Astronomers have for the 1st time caught a glimpse of the earliest stages of massive galaxy construction. The site is a dense galactic core blazing with the light of millions of newborn stars that are forming at a ferocious rate. Because the core is so far away, the light we observed was created 11 billion years ago, just about 3 billion years after the Big Bang. Although only a fraction of the size of the Milky Way, the tiny core already contains about twice as many stars as our galaxy, all crammed into a region only 6% the diameter of the Milky Way. Previous observations have not seen galaxy formation this dense in stars. The astronomers suspect that this core-formation process occurred only in the early Universe before it had expanded so much. The core was forming stars about 30 times as fast as our Milky Way does now. Astronomers theorize that this frenzied star birth was sparked by a torrent of gas flowing into the galaxy's core. Observations indicate that the galaxy had been furiously making stars for more than a

billion years. This kind of star formation may have not been seen before because it occurs in thick gas and dust, which hides it. But the new observations were made in infrared light, which better penetrates such.

Our supercluster – Galaxy superclusters are composed of clusters and groups of galaxies that are interconnected in a web of filaments, but the boundaries are poorly defined. To better refine this, researchers are proposing a new way to evaluated superclusters by examining their impact on the motions of galaxies. Using this way and observations by radiotelescopes, astronomers have mapped out the supercluster that we live in. They have dubbed it Laniakea, which is Hawaiian for "immense heaven". Laniakea is 500 million light-years across and contains the mass of 100 quadrillion Suns spread across 100,000 galaxies. Within its boundaries, galaxy motions are directed inward. The Great Attractor, a region that seems to be pulling in galaxies in our neighborhood, is like a gravitational valley, where everything around is falling down into it.

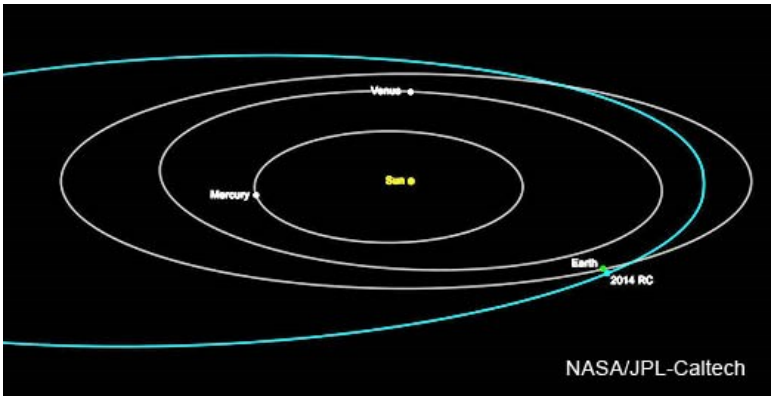
Dark matter – A new theory has been proposed to explain why there are not as many dwarf galaxies orbiting our Milky Way galaxy as expected from computer simulations of galaxy formation. The new theory suggests that dark matter particles experience a slight interaction with photons and neutrinos, instead of absolutely no such interaction, as currently theorized. Computer simulations of galaxy formation with this slight interaction show the dark matter particles scattering somewhat, reducing the pockets that trap ordinary matter into forming dwarf galaxies. There are other theories to explain the scarcity of dwarf galaxies, so more work needs to be done before the new theory can be accepted.

Adaptive optics (AO) combat the atmosphere's blur by continuously monitoring the ever-changing turbulence and then deforming their mirrors to compensate. The overall utility of AO has been limited principally because AO images are generally quite small, usually only a few tens of arcseconds on a side. Recently, a team of astronomers installed a Multi-Object AO system (MOAO) called Raven on the 8-meter Subaru Telescope in Hawaii. Raven uses measurements from multiple stars of changes in the atmosphere. It has 3 sensors for tracking natural guide stars and a 4th to work with a laser guide star. Raven delivers images with roughly 0.15 arcsecond resolution (not diffraction-limited) over a larger field than previous systems. It is a technology demonstrator; future MOAO instruments might have 8 laser guide star sensors.

International Space Station (ISS) – Science experiments being sent on a Falcon 9 rocket to ISS (among 255 investigations) include the ISS-Rapid Scatterometer to monitor ocean surface wind speed and direction; new biomedical hardware that will help facilitate prolonged biological studies of rodents in microgravity; a study of a small flowering plant that allows scientists to study plant growth and adaptations in space; SpinSat, to test how a small satellite moves and positions itself in space using new thruster technology; and the 3-D Printing In Zero-G Technology Demonstration, the first 3-D printer in space.

Instant AstroSpace Updates

Earth-approaching asteroid 2014 RC, about 60 feet (20 m) wide, zipped past Earth on September 7 and left after Earth's gravity bent its orbit. It passed less than 1/10 the distance of the Moon, but is not expected to come close enough to hit the Earth in the next century.



Using the most sensitive neutrino detector, the Borexino beneath Italy's Apennine Mountains, scientists have for the 1st time detected the type of **neutrinos** emitted by the proton-proton nuclear reaction in the Sun. Borexino uses in its detector a benzene-like liquid derived from really old petroleum, from which essentially all carbon-14 has decayed, since carbon decay hides neutrino detections.

Using various radiotelescopes, astronomers have looked through a gravitational lens to get the best view yet of **colliding galaxies** when the Universe was only half its current age. The collision looks surprisingly like the nearby colliding galaxies, the Antennae.

Grand Canyon River Trip: An Astronomical Perspective

By Tim Hogle

Background:

By way of context, this past May I had the opportunity to take a raft trip through the Grand Canyon. It was a private trip, which means that the eight of us were responsible for sharing all the work, without a paid crew to do such things as guide, row and cook. My brother Mark and I were the seniors. His three grown offspring – Luke, Abe and Megan – and three of their friends Kate, Paul, and Jeff rounded out the group.

Rowing 280 miles on the Colorado is not for the faint of heart, but there was plenty of energy between the millennials to make up for the limited baby boomer stamina. Luke had done the trip twice before, so he was our de-facto guide. Between us we had three 16- to 18-foot rafts, rotating rowing duties and the rest along for the ride, and a "mini" 12-foot paddle raft in tow for those wanting to explore areas needing additional maneuverability or desirous of a heightened rush in the rapids. Boats, all gear except personal items, and preplanned and packed gourmet meals were provided by an outfitter in Flagstaff who also delivered us to the Lee's Ferry river entry and picked us up at Lake Mead, 16 days later.

The many rapids were exciting indeed. Quite a few were technically challenging. We were usually able to stop and plan a route through them (assess currents, avoid rocks and big holes). Each of us was knocked into the river by rough rapids at some point during the trip in spite of planning and holding on tight, but no boats except the "mini" actually capsized. It was especially interesting when the person rowing was the one who was knocked out of the boat! But with air temperatures in the 80's to 90's during the day and about 60 at night, and water in the 50's at the start to about 60 by the end, an unexpected dip was not too shocking. And it became comfortable to just jump off the boat anytime the heat become oppressive.

The geology was, of course, beyond superlatives. The changing morphology of the Grand Canyon continually exposed new layers of rock from further back in time. More and more of the Earth's history unfolded before us every day. It was literally a religious experience. Even with a chart showing the defined layers, it was hard to keep track of which layers were visible, with the exception of the ever-present and obvious Redwall Limestone after the second day. We had four medical professionals and three engineers between us; what we needed was a geologist to interpret what we were seeing.

Camps were on sandy beaches by the river, and we slept under the stars almost exclusively (no noticeable rain, bugs, hostile animals; majestic vistas of the canyon walls by day continued into the night sky). We were on the move from dawn with coffee started by the first person up until the final dishes were washed, typically by flashlight, with day hikes and side trips nearly every day. In spite of an estimated 29,000 people making this trip every year, careful following of environmental rules resulted in virtually no trace of other people at the camps except footprints in the sand.

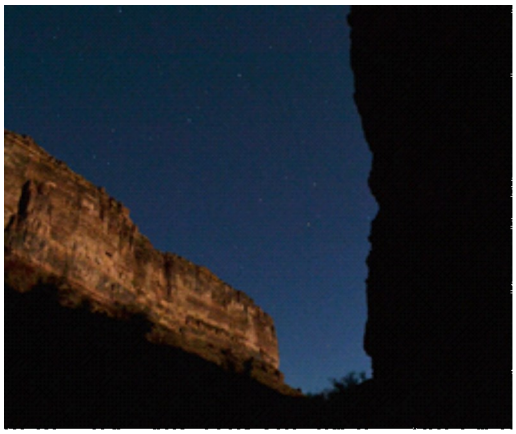
Astronomy:

But this is to be an astronomy account – one that might be useful to other amateurs contemplating such a trip. Before the trip, I was encouraged to bring a telescope along. It was said there was to be plenty of room on the boats and no restrictions on personal gear. I have a five-inch Schmidt Cass and a pre-GoTo ETX-90; either would be easy to carry and to protect against jarring and water entry.

I'm really glad I resisted the temptation. With a dawn to dusk adventure schedule, I had very little interest in setting up a scope in the evening, and there was little interest on the part of the rest of the group in doing more than watching me point out planets and constellations from the comfort of a folding chair with Gatorade or beer in hand. The beaches would have been problematic for telescope pointing stability, and the fine, clingy sand would have been of more danger to the instrument than water or physical abuse. I did bring a pair of Celestron 7x40 waterproof binoculars, which were nice, but of more use for looking at condors or bighorn sheep during the day than for stargazing. But even that was really more than necessary and needed to be protected during the day from being battered around on the boats, which

limited their usefulness. If I were to do it again, I would just bring a pair of cheap mini binoculars and keep them strapped to myself or the boat (as was necessary for every item that wasn't packed away to avoid sudden loss). They would get more use.

While the canyon is dark at night, the sky background was visually brighter than I expected. We started just before full moon, so for the first week or so the brightness was understandable. The high canyon walls and the moonlight made for some interesting night sky photography. Unfortunately, I didn't do any since I and my non-waterproof camera went overboard on the second day. The camera filled with water; fortunately, I did not. After two days of leaving the camera open to dry, I was contemplating trying to turn it on again when a raven raided my camp during breakfast and pecked open the automatic lens cover and tossed the open camera off into the sand (as well as opening up every single zipper (!!), plastic bag and pocket in my gear and stealing everything edible).



Although I had anticipated some great naked eye viewing under the stars, the steep canyon walls allowed limited visibility of the skies. Sometimes all we could see would be a 30 to 40 by 150 degree swath of sky. Every night the orientation was completely different due to the severe meandering of the river. On nights with a good N-S orientation, I could get my astronomical bearings from the Big Dipper, but other times it took several minutes to recognize the constellations. Mars was the constant; high in the sky and just barely coming off of opposition. It was truly the beacon of the evening sky. But any night I might awaken at 2AM, the summer triangle was overhead, making it easy to relate to familiar patterns. I neglected to bring my Pocket Sky Atlas; it would have helped in orienting myself to the limited horizons as well as determining limiting magnitudes.

I couldn't evaluate the seeing conditions beyond star twinkling, but that did not seem a significant effect. Transparency was another matter. Many nights were cloudy (no stars) or with high haze/cirrus (3rd magnitude limit). Those nights that were clear, especially when the moon was swinging around through new, the sky was visually satisfying, and several attempts at tripod-mounted DSLR star photography were quite successful. A 3000 foot elevation at the bottom of a veritable hole was not quite the same as being on a mountain top. But for sure there was no sign of city lights!

Our last night on the river was to be an astronomy night. With 40 miles to go and no more rapids, we lashed the boats together to float down the river and everyone slept on deck (we were reasonably chummy by that time). We rotated a watch at the oars through the night to be sure we didn't get stuck in an eddy or bump into canyon walls. Pulling out of the canyon, we expected the sky to open up. I was set to introduce the stars and constellations to the group with a green laser pointer. But it was cloudy, so the discussion turned to recitations of Robert Service poetry by Mark and myself, and musings on the vastness of the universe, our place in it, the fine tuning of processes that are required for us to exist, and the implications for a Creator versus purely natural processes that might have allowed all this to happen.

It was a very good trip; memories for a lifetime. Although I would take a mountain top to the bottom of a canyon for astronomy any day, the wonderful thing about our hobby is the ability to enjoy it and share it with others anywhere we go.

Photo Credits: Daytime - Jeff Olden, Night - Paul Chen

Observing from Kearney Mesa, California, Pat Knoll used a Meade 10-inch LX200 Classic to capture this image of the Trifid Nebula (M20) on August 30, 2014. M20 is a combination of four objects: an open cluster; an emission nebula; a reflection nebula; and a dark nebula.

For Sale: Losmandy G11 German Equatorial Mount. This mount is the digital drive (non-Gemini GOTO) version. It has encoders, a Robin Casady dovetail saddle, and many extras. It has a payload capacity of 60 pounds, plus counterweights. If interested, contact John Fisanotti at jfisanotti@sbcglobal.net or 818-957-2605 and he will send you an eight-page brochure with further details and many more photos. Asking $2400 and will deliver to a local (within Southern California) buyer.

FOR SALE: 2 Meade Maksutovs. Take your choice or buy both - excellent optics, rarely used.

ETX-125 5" $575

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Contact Rick Hull email hull3@cox.net

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