SIRIUS ASTRONOMER

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The Newsletter of the Orange County Astronomers

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OCA members staff a booth at the Southern California Astronomy Expo, held on July 12th at Oceanside Photo and Telescope. Special thanks to Barbara Toy, Alan Smallbone, Sheila Cassidy, Steve and Bonnie Short, and Greg Schedcik for their efforts in promoting our organization!

OCA CLUB MEETING

The free and open club meeting will be held August 8 at 7:30 PM in the Irvine Lecture Hall of the Hashinger Science Center at Chapman University in Orange. This month's speaker is Dr. Jocelyn Read of CSU Fullerton, speaking on 'Dense Matter and Gravitational Waves: Listening to the Symphony of Space-Time'

NEXT MEETINGS: Sept. 5, Oct. 3

STAR PARTIES

The Black Star Canyon site will open on August 23. The Anza site will be open on August 23. 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 August 1. The following class will be held September 12.

GOTO SIG: TBA
Astro-Imagers SIG: Aug. 12, Sept. 9
Remote Telescopes: TBA
Astrophysics SIG: Aug. 15, Sept. 19
Dark Sky Group: TBA

The Invisible Shield of our Sun

By Dr. Ethan Siegel

Whether you look at the planets within our solar system, the stars within our galaxy or the galaxies spread throughout the universe, it's striking how empty outer space truly is. Even though the largest concentrations of mass are separated by huge distances, interstellar space isn't empty: it's filled with dilute amounts of gas, dust, radiation and ionized plasma. Although we've long been able to detect these components remotely, it's only since 2012 that a manmade spacecraft -- Voyager 1 -- successfully entered and gave our first direct measurements of the interstellar medium (ISM).

What we found was an amazing confirmation of the idea that our Sun creates a humongous "shield" around our solar system, the heliosphere, where the outward flux of the solar wind crashes against the ISM. Over 100 AU in radius, the heliosphere prevents the ionized plasma from the ISM from nearing the planets, asteroids and Kuiper belt objects contained within it. How? In addition to various wavelengths of light, the Sun is also a tremendous source of fast-moving, charged particles (mostly protons) that move between 300 and 800 km/s, or nearly 0.3% the speed of light. To achieve these speeds, these particles originate from the Sun's superheated corona, with temperatures in excess of 1,000,000 Kelvin!

When Voyager 1 finally left the heliosphere, it found a 40-fold increase in the density of ionized plasma particles. In addition, traveling beyond the heliopause showed a tremendous rise in the flux of intermediate-to-high energy cosmic ray protons, proving that our Sun shields our solar system quite effectively. Finally, it showed that the outer edges of the heliosheath consist of two zones, where the solar wind slows and then stagnates, and disappears altogether when you pass beyond the heliopause.

Image credit: Hubble Heritage Team (AURA / STScI), C. R. O'Dell (Vanderbilt), and NASA, of the star LL Orionis and its heliosphere interacting with interstellar gas and plasma near the edge of the Orion Nebula (M42). Unlike our star, LL Orionis displays a bow shock, something our Sun will regain when the ISM next collides with us at a sufficiently large relative velocity.

Unprotected passage through interstellar space would be life-threatening, as young stars, nebulae, and other intense energy sources pass perilously close to our solar system on ten-to-hundred-million-year timescales. Yet those objects pose no major danger to terrestrial life, as our Sun's invisible shield protects us from all but the rarer, highest energy cosmic particles. Even if we pass through a region like the Orion Nebula, our heliosphere keeps the vast majority of those dangerous ionized particles from impacting us, shielding even the solar system's outer worlds quite effectively. NASA spacecraft like the Voyagers, IBEX and SOHO continue to teach us more about our great cosmic shield and the ISM's irregularities. We're not helpless as we hurtle through it; the heliosphere gives us all the protection we need!

Want to learn more about Voyager 1's trip into interstellar space? Check this out: http://www.jpl.nasa.gov/news/news.php?release=2013-278. Kids can test their knowledge about the Sun at NASA's Space place: http://spaceplace.nasa.gov/solar-tricktionary/.

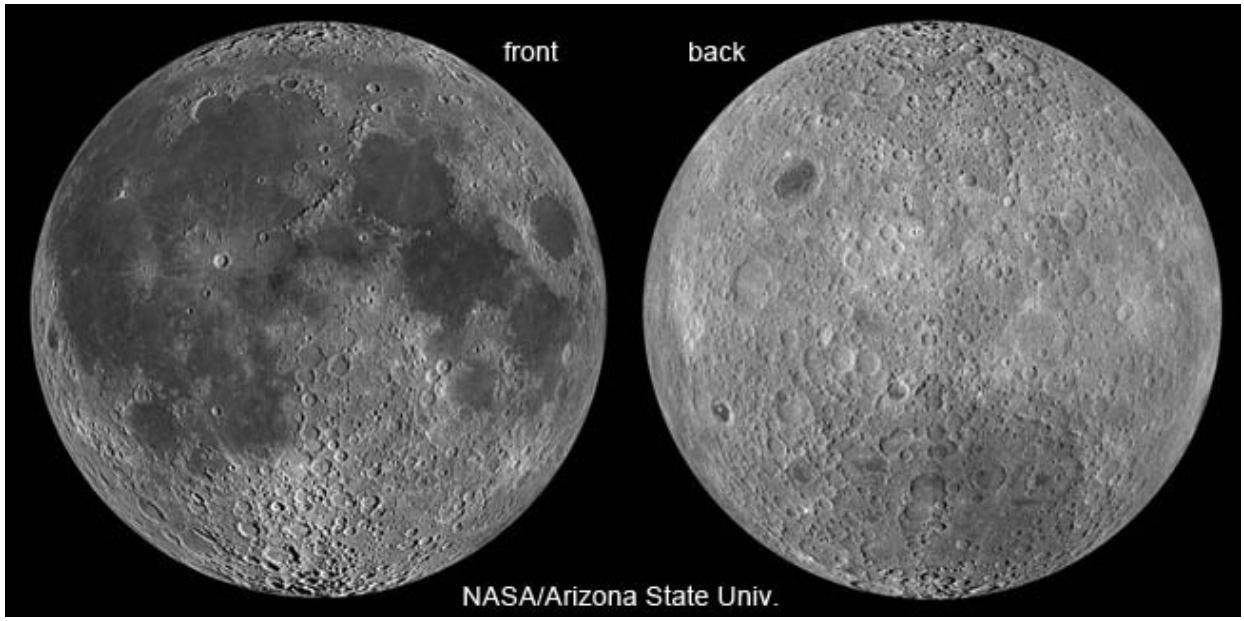
AstroSpace Update

August 2014

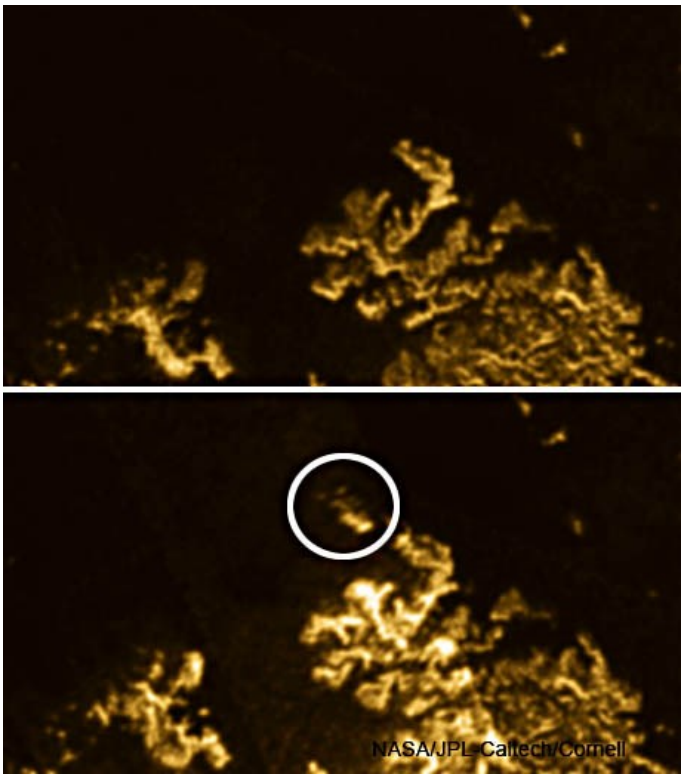
Gathered by Don Lynn from NASA and other sources

Moon's age – Just 3 months ago, a team of scientists announced a new determination of the age of the Moon, that is, when it was formed by an even larger object colliding with Earth and splashing material off that then coalesced into our satellite. The number was 95 million years after the Earth formed. That was supposed to settle arguments over the timing, since previous Moon dating methods had not agreed. A new method has now been used, depending on analysis of xenon trapped inside quartz-bearing Earth rocks that should have formed shortly after the Moon-forming collision. The new number is 40 million years after Earth. So the controversy is not over.

Moon's composition – The ratios of the various isotopes of oxygen have long been measured for both the Earth and the Moon. The fact that Earth and Moon were nearly the same was long accepted as some of the best proof that the Moon was indeed formed by a collision. But in recent years, the measurements showed it was exactly the same, yet the collision theory predicted it would differ a little because the object striking the Earth would likely have different ratios than Earth, and more of that object's material would show up in the Moon. So scientists measured Earth and Moon oxygen ratios again, with great precision, and finally found the slight difference expected.



Moon's back side – Since the 1st space probe to go behind the Moon in 1959, it has been known that the back side doesn't look anything like the front side. There are practically no "seas" (lava-filled basins) on the back side. This was finally explained in recent years when it was found that the crust of the Moon on the back side is much thicker than the front, so lava much more easily flowed through the thinner front (billions of years ago, when the seas formed). So the mystery moved from "why the seas are on only one side" to "why the crust is thicker on the back". A new study showed that shortly after the Moon formed, the Earth was still molten from the collision, and the heat radiated by the Earth kept the front side of the Moon too hot to form a crust until after it had formed on the back side. Hence the difference in crust thickness.

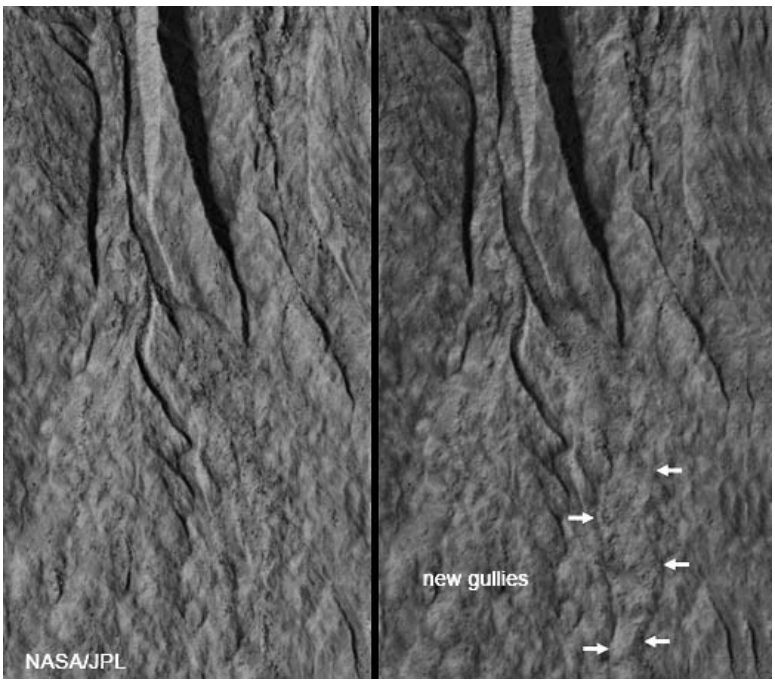


Titan's seas – Comparison of radar images of Titan's methane sea Ligeia Mare taken at different times shows an object appearing and then disappearing. It has been called a transient feature, but many astronomers are calling it the "Magic Island". Possible explanations include: winds forming a wave feature, surface bubbles from a gas release below, objects becoming buoyant with temperature change, suspended solids in the sea.

Titan's atmosphere – A study has found that the nitrogen in the atmosphere of Saturn's moon Titan originated in the conditions of the Oort Cloud comets, since the isotopes of nitrogen match that of those comets. The nitrogen does not match that which formed at Saturn's distance from the Sun, nor that of comets from the Kuiper Belt. It also does not match the Earth's nitrogen, so the nitrogen in the air we breathe did not come from the Oort Cloud.

Titan's ocean – Gravity data taken by Cassini during many flybys of Titan show that the ocean that must exist under the icy shell is very dense, and so must be extremely salty water, likely salts of sulfur, sodium and potassium. It would be as salty as the saltiest bodies of water on Earth, such as the Dead Sea. Other findings: the thickness of Titan's ice crust varies slightly from place to place. The best explanation of this is that the crust is growing as the ocean slowly freezes. The ice shell is quite rigid, which should prevent outgassing, except at scattered hot spots. Because Titan's atmosphere contains 5% methane, which is destroyed by sunlight, it is known that methane is replenished from some source, probably outgassing from inside the moon.

Martian gullies – Repeated high-resolution observations from the Mars Reconnaissance Orbiter (MRO) indicate that the newly forming gullies on the Red Planet show up in winter, when the temperature is quite low. This disproves the theory that the gullies are being formed by briny water seepage. The only explanations left that work at that temperature are ones involving dry ice, which should freeze thereabout. The 2 best theories are now: dry ice frost lubricates the hill sides, allowing dry material to flow downhill, carving the gullies; accumulated weight of frost buildup breaks loose and flows downhill. There remain other types of features than gullies that still have the possibility of being explained by surface water.



Vesta mineral – Researchers have identified for the 1st time a mineral component of the dark material seen on Vesta. It is serpentine. This discovery puts an end to the discussion about the origin of the dark material; impacts of primitive asteroids must have distributed the dark material on Vesta. Like any mineral, serpentine forms only under certain conditions of pressure and temperature. Serpentine would not have survived the heat Vesta had early in its history, nor the volcanism Vesta may have undergone. The asteroid impact explanation would require comparatively slow impact, in order not to have destroyed the serpentine.

Planetary molecule – Astronomers using the Herschel infrared space telescope have discovered the OH+ molecule in planetary nebulas. This molecule can be a step in producing water, H_2O. Planetary nebulas are cast off by dying Sun-like stars, and have nothing to do with planets, despite their name. 11 planetary nebulas were analyzed, finding OH+ in only 3 of them, the 3 containing the hottest stars. The OH+ was found in the areas where carbon monoxide was being broken down by strong ultraviolet radiation. Apparently the oxygen freed from the carbon monoxide is combining with hydrogen to make the OH+.

Star formation – New observations from the Hubble Space Telescope show that dwarf galaxies had much larger star-formation rates than large galaxies during the period from 3.5 to 6 billion years after the Big Bang, which is the time when most stars in the Universe formed. Thus the dwarf galaxies formed a larger proportion of stars than would be expected, given their numbers and masses. The result was found in a study of starburst galaxies, those forming stars at high rates. The dwarf starburst galaxies were forming stars so quickly that they doubled their mass of stars in 150 million years, while large starburst galaxies were taking 1-3 billion years to double. Another study, using computer simulations, found that at even earlier times, roughly 500 million years after the Big Bang, when the newly formed galaxies of the Universe were ionizing surrounding gas with their ultraviolet (UV) light from bright massive stars, dwarf galaxies contributed 30% of that UV. Again the dwarf galaxies contributed more than would be expected from their small numbers of stars. The reason was found to be that it is easier for UV to escape to surrounding gas from galaxies that are smaller.

Galaxies discovered – Astronomers using a new type of telescope, made by stitching together 8 telephoto lenses, discovered 7 dwarf galaxies while observing nearby spiral galaxy M101. The galaxies were previously overlooked because of their diffuse nature. The telephoto lenses have coatings that suppress internally scattered light, making them adept at detecting very diffuse, low surface brightness objects. The key question about the 7 galaxies is whether they orbit M101 or are just by chance in the same direction? The astronomers don't believe that they all orbit the spiral, in which case some of them are a new kind of object: isolated dwarf galaxies. Next step is to measure their distances. The team is also looking for debris from long-ago galaxy collisions, another type of low surface brightness object.

Red nuggets – Observations of galaxies in the early Universe have shown that dense massive galaxies, nicknamed "red nuggets", were common. But efforts to find red nuggets in the current Universe have been largely unsuccessful, until now. A new study found them hiding because they appeared as stars, but spectra taken in this study showed many (about 200) to be red nugget galaxies. The work was done with archived observations from earlier sky surveys. Comparing the red nuggets found to computer simulations showed that such objects begin their lives as very small galaxies, and during the next 10 billion years, some of them collide and merge, while some manage to avoid collisions and remain compact. The result is a variety of elliptical galaxies with different sizes and masses.

Gas stream – A team of astronomers, using data from several space telescopes, has discovered a stream of gas flowing rapidly outward from the center of galaxy NGC 5548. In just a few years the stream has moved so as to block 90% of the X-rays emitted near the supermassive black hole at the galaxy's center. Such galaxies expel large amounts of matter through powerful winds of ionized gas. This galaxy had been expelling wind at about 600 miles/sec (1000 km/s), but is now throwing out a wind 5 times as fast. It is believed that the X-rays limit the wind to slower speed, but the higher speed can be attained when X-rays are blocked by the new gas stream from reaching the location near the black hole that expels wind. The stronger wind may blow away material that that black hole would normally feed on.

M106 transitioning – Astronomers have released a composite image of galaxy M106 made from images of various wavelengths of light: X-rays, radio, visible light and infrared. It was already known that this galaxy has 2 normal spiral arms and 2 ghostly wisps of arms. Radio data shows that the supermassive black hole at the galaxy's center is producing powerful jets. The jets disrupt surrounding gas and generate shock waves, which are seen in infrared. The shock waves are heating the wispy arms to thousands of degrees. The X-ray data show that there are huge bubbles of hot gas above and below the plane of the galaxy, indicating that much of the gas originally in the disk was heated and ejected into the bubbles. Most of the original gas has been ejected, leaving little to form new stars. The rate of star formation is 10 times lower than that in our Milky Way. Astronomers estimated from the new data that all the remaining gas will be ejected within the next 300 million years. It will then have become a lenticular galaxy full of old, red stars, rather than a spiral.

Dust formation – A group of astronomers has followed the production of stardust during the aftermath oaf a supernova explosion. For the 1st time they showed that these cosmic dust factories make the grains in a 2-stage process, starting soon after the explosion, but continuing for years afterwards. The team used the Very Large Telescope in Chile to analyze the light (both visible and infrared) from supernova SN2010jl as it slowly faded. Astronomers know that supernovas may be the primary source of dust, especially in the early Universe, but it is still unclear how and where dust grains condense and grow. It is also unclear how they avoid destruction by the harsh environment. The team found that dust grains larger than 1/1000 mm formed rapidly in the dense material surrounding the star. Although tiny by human standards, this is large for cosmic dust grains, and the surprisingly large size makes them resistant to destructive processes. It is still not known what the process is that builds larger dust grains so fast. But the astronomers believe they know where the dust must have formed: in the material that the star shed into space before it exploded. In a 2nd stage, after several hundred days, an accelerated dust formation process occurs involving ejected material from the supernova. If the dust production in SN2010jl continues the observed trend, by 25 years the total mass of dust will be about half the mass of the Sun.

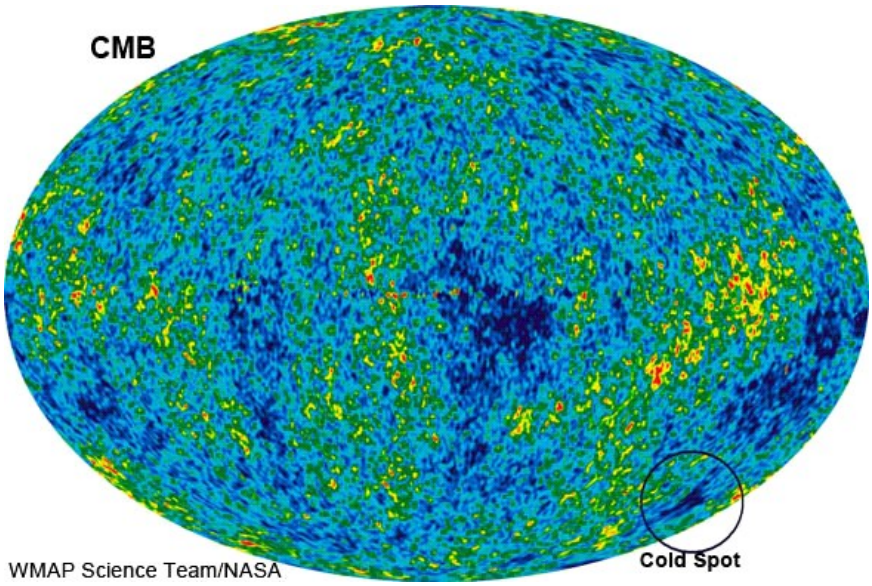
2 most distant stars in our Milky Way galaxy's halo have been discovered, at distances estimated to be 775,000 and 900,000 light-years away. That's 5 times the distance of the Large Magellanic Cloud, or 1/3 of the way to the Andromeda Galaxy. Some astronomers think that the halo is like a cloud of crumbs, the result of the Milky Way's merger with many smaller galaxies. So finding distant halo stars may help unravel our galaxy's history. The stars were found by looking for red giants in archived data from an infrared and a visible light survey. Red giants are relatively unusual, but are so bright they can be seen at great distances. They can usually be identified by their appearance through various filters, which were used in the surveys. Then 400 candidates were verified by taking spectra with the MMT Telescope in Arizona, and 2 of those were found to be very distant.

Gyrochronology – Sun-like stars are hard to define: astronomers would like them to match the Sun in temperature, mass, age, and spectral type, but age is difficult to measure. A new technique, called gyrochronology, has been developed. It is based on measuring a star's spin by means of the brightness changes caused by starspots passing by. The brightness change is very small, but Kepler, the planet-finding space telescope, excels at such measurements. Younger stars spin faster than older ones of the same type because stars slow down as they age. A demonstration of the technique measured the ages of 22 Sun-like stars. Although none of the 22 stars are known to have planets, this work is an important step in the hunt for Sun-like stars that could host Earth-like planets.

Protostar age – A new technique has been developed to measure the age of a protostar, that is, a star in the process of forming. It involves measuring its vibrations (sound waves). The technique was applied to 34 protostars in the cluster NGC 2264, all of which are less than 10 million years old. The youngest stars were found to vibrate slower. The vibrations are seen as tiny changes in brightness.

Fast radio bursts – Only the Parkes radiotelescope in Australia has seen what are called fast radio bursts. This led to doubt that they actually exist, rather than being noise in or near that telescope. Now fast radio bursts have been seen by the Arecibo radiotelescope. The bursts must occur thousands of times per day, but they last only a few thousandths of a second and occur in widely scattered localized points, which explains why they are so rarely seen. Arecibo managed to measure the plasma dispersion of the bursts, which is an effect where the radio waves arrive at slightly different times at different frequencies. The effect grows as the waves travel farther. This dispersion was 3 times stronger than any object in the Milky Way, and so the bursts must be traveling from farther away than our galaxy. Still no one knows the cause of the bursts. Possibilities include evaporating black holes, merging neutron stars and flares from magnetars. Plans are being made to try to observe the bursts with wide-angle radiotelescopes, which should see them more often. This may help identify what is emitting them.

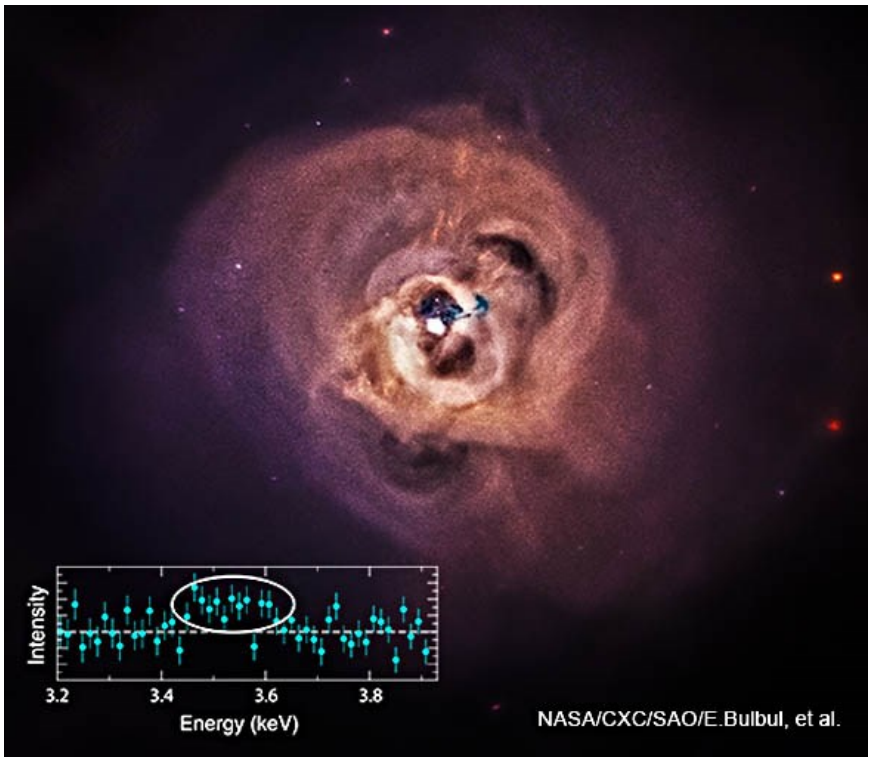
Cold white dwarf – A team of astronomers has announced the discovery of the coldest, faintest white dwarf star known. Or more precisely, they proved there exists an object that has to be cold or they would have seen it, and white dwarf is the only reasonable possibility of what it is. The object is orbiting a pulsar every 2.45 days, so they have a pretty good idea of its mass (1.05 times the Sun's). Its mass has been confirmed to warp space and therefore affect the pulsar's pulses in the expected amount. Not even the Keck Telescope in Hawaii could see it, which it would have if it were as warm as any of the cool white dwarfs known. It theoretically should consist largely of crystallized carbon, similar to a giant diamond. White dwarfs are composed mostly of carbon and oxygen, and represent the ashes left over when stars of roughly Sun's mass run out of fuel. They slowly cool and fade over billions of years. This white dwarf is likely about as old as the Milky Way in which it resides, or about 11 billion years. It is about 900 light-years away in Aquarius.



The Cold Spot is a place in the Cosmic Microwave Background (CMB) that is too cold and too large as compared to other temperature variations in the CMB. Cosmologists have proposed a number of explanations, including some pretty wild ones. A new study has found a supervoid, a gigantic hole in the Universe's web of galaxies, lying in the direction of the Cold Spot. A process known as the Integrated Sachs-Wolfe Effect is known to cool photons that pass through a huge void. The supervoid was found about 2.7 billion light-years away, spans about 900 million light-years, is roughly spherical, and may be the largest void known. However calculations show that it does not fully explain the depth of the Cold Spot.

Hotspot – A cosmic-ray observatory in Utah found a hotspot beneath the Big Dipper, where a disproportionately large number of the very highest energy cosmic rays originate. The study looked at only the highest energy ones because they should be deflected less by magnetic fields, and thus the direction in which they arrive should point back to their true origins. The hotspot is fairly large, so it is not clear what object or objects seen in light are the origin. It lies in the general direction of the Virgo supercluster of galaxies, and so may be related. What produces very high energy cosmic rays remains a mystery. Possibilities include active galactic nuclei and the most powerful of supernovas. Some lower energy cosmic rays are known to originate from our Sun, some types of stars, supernovas, and possibly radio galaxies, colliding galaxies or more exotic objects. Cosmic rays, discovered in 1912, are extremely fast-moving charged particles, not rays. It is known that the high-energy cosmic rays come from outside our Milky Way, but probably from within 300 million light-years, since reactions with the CMB should rob them of their energy after traveling that far. Very high energy cosmic rays are quite rare, and only 72 of them were detected in this study, over a period of 5 years. Scientists would like to build a larger and more sensitive observatory to catch more of the high-energy ones, which should pinpoint their origin better. There was already known a similar but weaker hotspot in the southern sky, discovered by the cosmic ray observatory in Argentina.

Possible dark matter – Using archived observations from the Chandra and XMM-Newton X-ray space telescopes, astronomers found an unidentified X-ray emission line in the spectra of 74 galaxy clusters. It is in the range of wavelength, or energy, predicted for the decay of the theoretical particle known as the sterile neutrino. That particle is one of the candidates to explain what dark matter is. Since no sterile neutrino has been discovered yet, and there are other possible explanations for the emission line, a lot more work must be done before this is considered evidence for dark matter. The next step in this study will be to look for the same X-ray emission line in a larger number of galaxy clusters, using more X-ray telescopes. Astro-H, an X-ray telescope to be launched next year, should help this search.



Earth-like planet – A team of astronomers discovered a new super-Earth orbiting a red dwarf named Gliese 832, 16 light-years away. This star is already known to harbor a cold Jupiter-like planet. The newly found planet, known as Gliese 832c was added to the Habitable Exoplanets Catalog, those where temperatures might allow liquid water to exist, bringing the

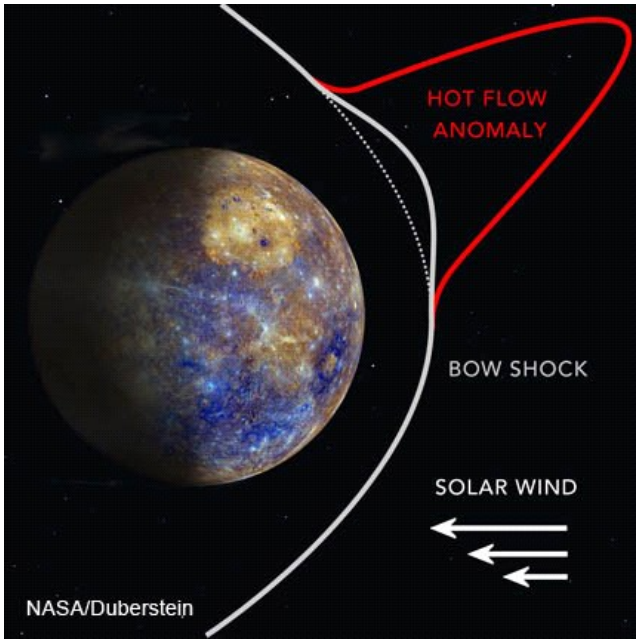
total in the Catalog to 23. 832c orbits in 36 Earth days, and has a mass about 5 times Earth's. Since it receives the same amount of light from its sun as Earth does from its, 832c may average about the same temperature as Earth. But it would vary widely with season because its orbit is fairly eccentric. The 2 known planets at this star make it look like a scaled down version of our Solar System, with its inner Earth-like and outer Jupiter-like planets.

Earth-like not a planet – What was thought to be a planet in the habitable zone of star Gliese 581 has been shown to be errors in the data caused by active regions (areas of starspots) on the star. These regions caused the spectrum of the star to appear to be wobbling as if a planet were orbiting and pulling gravitationally on the star. The original discovering astronomers had looked directly for such activity, and had found none. The new observations looked for the activity by an indirect means, looking for magnetic effects in the spectrum, which turned out to be more sensitive. Subtracting off the stellar activity seen magnetically made the evidence for planet Gliese 581d disappear. The new technique also confirmed a previous claim that another planet there, 581g, also did not exist. So out of the 6 planets there that have been announced over the past 9 years, this is the 3rd disproved, leaving only 3 real planets (Gliese 581b, c, and e). The new work also got a better number for the rotational period of the star (when magnetic effects rotated into view again) of 132 Earth days.

Asteroid Redirect Mission (ARM) – NASA is looking for asteroids for ARM to capture and park near Earth, for a later astronaut mission to visit. Candidates for ARM must be in orbits that could be deflected to the Earth's vicinity within the energy available with current rockets. In addition they have to either have a small enough mass and diameter to be captured and dragged, or have boulders on the surface that are small enough to be plucked and dragged toward Earth. Also, they can't be rotating too fast, as this would interfere with capturing them. Asteroid 2011 MD has just had its mass and diameter (roughly 20 feet = 6 m) measured, and it now qualifies, making the 3rd such candidate. 6 more are awaiting mass or size measurements. There are also 3 candidates that are too large, but are believed to have surface boulders that might qualify. We actually have pictures of the surface boulders on one (from the Hayabusa spacecraft), and will have pictures of the surface of another when OSIRIS-Rex mission arrives in 2018. 2011 MD's now known mass and diameter allowed its density to be calculated, and it is roughly the density of water. But it is known to be made of rock, not water, so should be 3 times denser. This implies it is either a rubble pile containing much empty space, or a small core surrounded by a halo of small particles. Launch of ARM is planned for 2019, so plenty of time remains to determine the target asteroid.

New Horizons (Pluto mission) – From before launch in 2006, it was planned to send the New Horizons spacecraft on to some other object in the Kuiper Belt after Pluto encounter. At launch, no object was known to be in the right direction. There is only a little surplus rocket fuel on board, so only a little change in the spacecraft's trajectory is possible, meaning the 2nd target has to be pretty much in the same direction as the spacecraft is moving when it leaves Pluto. But that didn't worry anybody, because Kuiper Belt objects were being found frequently, and there were many years to find such a target. Now with New Horizons only a year from its Pluto encounter, and still not a single suitable target known, astronomers are getting worried. They have stepped up programs to search the specific area with Earth-based telescopes, and still nothing. Now they got approved to use the Hubble Space Telescope (HST) to continue the search. HST will slowly drift in the direction of expect orbiting of such objects, which will make them stand out as dots among all other objects that are forming streaks. Also it will make the observations sensitive to dimmer Kuiper Belt objects, since their light will be concentrated in single spots.

Martian technology tested – NASA has completed the 1st test of Supersonic Inflatable Aerodynamic Decelerator (SIAD), a large doughnut-shaped deceleration technology, and of the Supersonic Disk Sail Parachute. These devices are designed to allow landing of very large payloads on Mars. They were tested by lifting them by balloon, then rocketing them higher still, to encounter Earth's atmosphere up where it is as thin as that of Mars. SIAD worked perfectly. The parachute did not deploy as expected, but data should allow engineers to make it work next test.



Instant AstroSpace Updates

MESSENGER (Mercury mission) has discovered a hot flow anomaly at Mercury, which is where hot solar wind is deflected by the planet's bow shock. Similar effects were already known at Earth, Venus, Saturn and Mars.

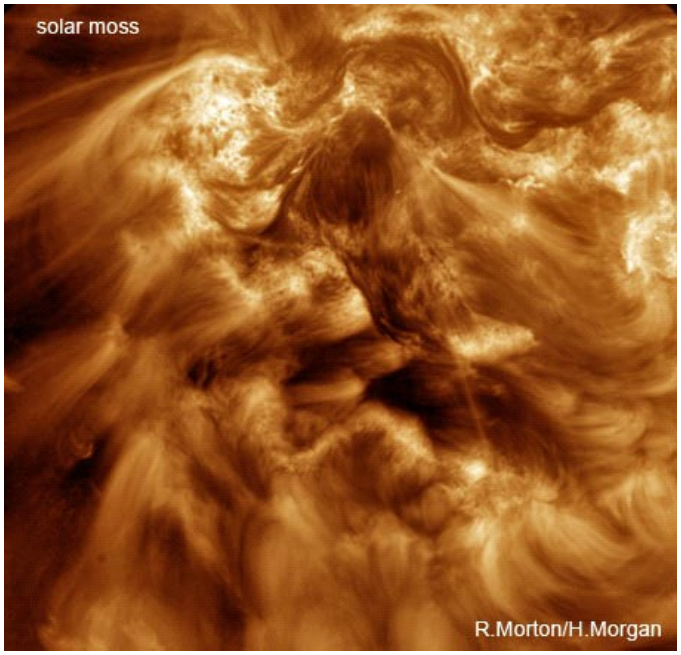
A recent study has shown that the intergalactic hydrogen is being lit by 4 times as much high-energy ultraviolet (UV) light as can be accounted for from all known emitters of such. Strangely this **UV source deficit** appears in the nearby Universe, but UV in the distant Universe matches known sources.

A new study shows that many of the **dwarf galaxies** accompanying the Milky Way and Andromeda had to have been pulled out from another galaxy which interacted with our local group, in order to explain the observations that show many of those dwarfs are found in the planes of the large galaxies, not distributed in all directions.

3 closely orbiting **supermassive black holes** have been found, during radiotelescope observations of galaxies thought to contain double black holes, in a galaxy more than 4 billion light-years away. They should be producing substantial gravity waves.

Gaia (star position-measuring space telescope) has been undergoing checkout and will soon begin collecting data. A problem with stray light is being investigated to determine its cause (possibly ice forming on the telescope) and develop a solution, but even without any solution, the mission can be completed with only a little deterioration of accuracy on the dimmest of stars.

A state-of-the-art ultraviolet camera launched on a sounding rocket in 5 minutes of flight above the atmosphere obtained exceptionally sharp images of "**solar moss**", bright features on the Sun forming in areas of strongest magnetic field that may hold the key to the mystery of how the Sun's corona is heated to millions of degrees. The moss was discovered to be violently oscillating at speeds up to 10,000 mph (16,000 km/h).



Beginning in early June, the **Rosetta** spacecraft has been observing water being given off by the target it is approaching, Comet 67P/ Churyumov-Gerasimenko, at a rate of about 2 glassfuls per second. As the comet approaches the Sun, the production rate will increase.

Mars rover **Curiosity** completed 1 Mars year (669 Martian days = 687 Earth days) on the Red Planet.

Report on the SAS 2014 Symposium

by Bob Buchheim

The 2014 Symposium was a "triple conjunction" joint meeting of the Society for Astronomical Sciences, the American Association of Variable Star Observers, and the Center for Backyard Astrophysics. The Symposium featured educational workshops and presentations of (mostly) small-telescope research activities and results. The subjects spanned a remarkable range of targets and methods. Various presenters showed the fruits of their Photometry, CCD astrometry, spectroscopy, speckle interferometry and polarimetry (and spectro-polarimetry!). The targets being studied included asteroids, variable stars, binary star systems, supernovae, classical novae, gamma-ray bursts and urban light pollution.

The Proceedings and videos of most of the technical paper presentations have been posted on the SAS website (www.SocAstroSci.org) at the "Publications" tab. Here are a few topics that particularly impressed and surprised this reporter...

Dr. Lance Benner presented recent radar observations of near-Earth asteroids showing wonderfully detailed three-dimensional pictures of these objects speeding past us. It seems that there are more "peanuts" and "muffins" in the NEA population than I would have guessed. Dr. Benner also noted the synergy between radar observations, small-telescope astrometry (which provides accurate pointing for the radar), and small-telescope photometry (which is used to determine the asteroid's rotation period and rotational phase during the radar observations).

Eric Craine's presentation of night-brightness measurements near Tucson illustrated the importance of gathering quantitative data, because light pollution is both complicated and in some ways counter-intuitive. Watch the video of his talk – you may be surprised!

Small-telescope research continues to probe into unexpected territory. Two such projects were described at the Symposium: supernova light echoes, and gamma-ray bursts. Dr. Doug Welch demonstrated that there are probably quite a few still-undiscovered supernova light echoes in the Milky Way, and that they can be found with diligent searches using amateur-scale telescopes. Once found, they provide the "pro's" with the opportunity to make detailed measurements on long-deceased supernovae. For example, Dr. Welch showed the spectrum of Tycho's supernova (1572), measured from its light echo.

Another foray into unexpected territory was described by Arto Oksanen, an amateur astronomer from Finland who has succeeded in discovering – and gathering photometry on – the optical glows from gamma-ray bursts. This is quite a challenging project, to observe very faint transient objects whose visible lifetime ranges from a few hours to a few days.

Supernovae showed up in several other discussions. Tim Puckett and Dr. Michael Richmond presented an educational workshop on "Supernova Discovery and Science". The 70 participants in this learned about the need for more participants in Puckett's extraordinarily successful supernova discovery program, and received a "short course" on the various types of supernovae and their distinguishing observa-

tional characteristics. Dr. John Martin presented a discussion of supernova lightcurves, the challenge of distinguishing between "real" supernovae and transient sources that are actually "imposters", and the significance of small-telescope and amateur contributions to his research. Finally, during an informal lunchtime "spectroscopy discussion group" (of about 40 people) it was pointed out that backyard-scale telescopes can be effectively used for supernova confirmation.

The annual SAS Symposium is a unique opportunity to experience the breadth and depth of small-telescope astronomical research. I imagine that all of the participants enjoyed connecting with old friends and meeting new ones, while collecting a list of projects to try during the coming year. The sponsors and vendors were well-prepared to provide everyone with any new gear that those projects may demand.

If you weren't able to attend the 2014 Symposium, some of the features of the Symposium are available to you. The Proceedings book is available for download from the SAS website; and videos of most of the technical presentations are also available for viewing. You'll find the links on the SAS website "Publications" tab. As in past years, both the Proceedings and the videos are made freely available as a service to the small-telescope research community.

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