SIRIUS ASTRONOMER
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Even professionals have trouble imaging objects low on the horizon! An early attempt to capture a comet via photographic plate instead caught a nearby church steeple and a group of trees. The plate is seen here compared to a modern image of the same field of view in daylight (this is the same church and the same trees). This is one of over 500,000 photographic plates produced by Harvard University during the late 19th and early 20th centuries. For more about this image, and the plates generally, read Bob Buchheim's article about this fascinating piece of astronomical history! (page 8).

OCA CLUB MEETING

The free and open club meeting will be held May 10 at 7:30 PM in the Irvine Lecture Hall of the Hashinger Science Center at Chapman University in Orange. This month, Dr. Marc Rayman from JPL will discuss NASA's Dawn mission to the Asteroid Belt.

NEXT MEETINGS: June 14, July 12

STAR PARTIES

The Black Star Canyon site will open on May 4. The Anza site will be open on May 11. 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 May 3. The following class will be held June 7.

GOTO SIG: TBA
Astro-Imagers SIG: May 21, June 18
Remote Telescopes: TBA
Astrophysics SIG: May 17, June 21
Dark Sky Group: TBA

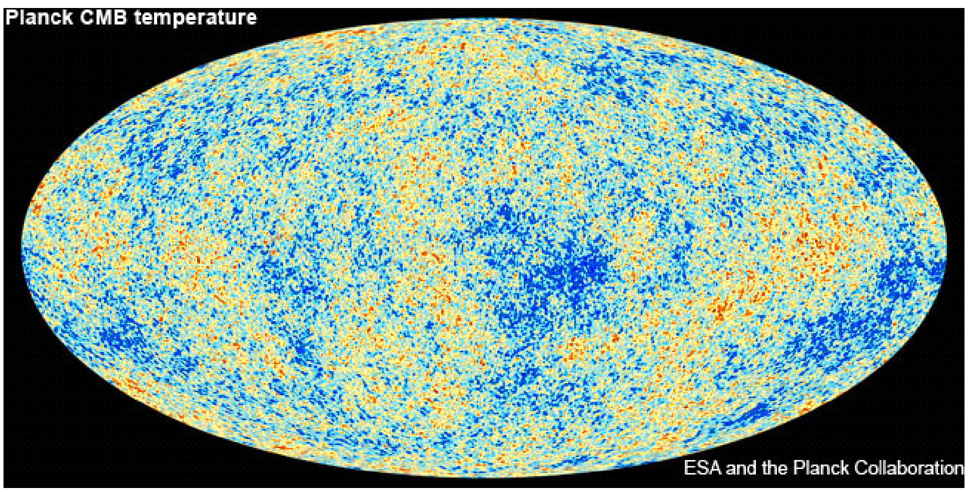
AstroSpace Update

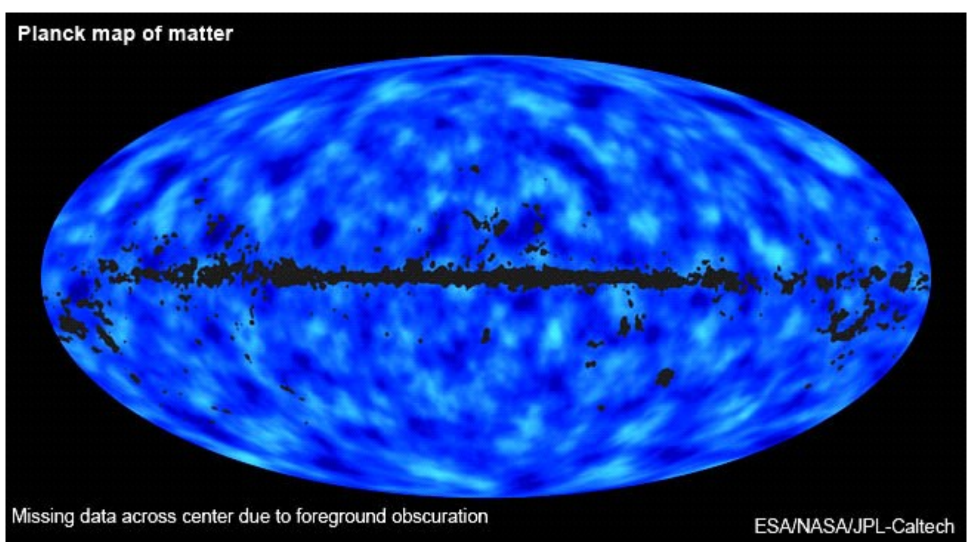
May 2013

Gathered by Don Lynn from NASA and other sources

Dark matter may have been detected by the AMS cosmic ray detector that is attached to the outside of the International Space Station, but we will have to wait months or a couple of years to be certain. AMS has detected 25 billion cosmic rays so far, of which 400,000 are positrons (anti-matter electrons) in the energy range of 0.5 to 350 Gev. Theorists predict that dark matter particles should on rare occasions collide with each other and annihilate into an electron/positron pair in this same energy range. The frequency/energy spectrum that AMS observed exactly matches the theoretical predictions of dark energy annihilation. But neutron stars also produce positrons, and could have a similar frequency/energy spectrum, so scientists were careful to state that dark energy had not definitively been detected. Theory says that at higher energies, the frequency of positrons from dark matter should differ from those produced by neutron stars. AMS does measure positrons at higher energies, but they are rare, so not many have been detected. But AMS will continue to take data for years, and it should be able to distinguish if dark matter has actually been detected in a matter of months or years. The positrons measured so far seem to be distributed randomly about the sky, and neutron stars are not distributed randomly, so that favors the dark matter explanation. The positrons have showed no variation over time. The excess of positrons at certain energy levels has been known for a couple of decades, but AMS is counting the positrons with far greater precision than before. Other scientists are searching for signs of dark matter in experiments at the Large Hadron Collider and a number of experiments installed deep underground. All previous evidence for dark matter relies on its gravitational effects. Zwicky and others in the 1930s first saw dark matter gravitational effects, so scientists have been trying to find what it is for 80 years.

Planck (cosmic microwave background [CMB] space telescope) results have been announced, and while they generally agree with the previous CMB results from the WMAP spacecraft and other measures, the numbers were a bit different. Changes since WMAP: the Universe is 13.80 billion years old, up from 13.77; dark matter is 26.8% of the Universe, up from 24%; dark energy fell to 68.3% from 71%; normal matter is up to 4.9% from 4.6%; the Hubble constant (expansion rate of the Universe) is 67.15 (±1.2), down from 74.3 (±2.1). Planck's resolution in measuring the CMB is 2.5 times better than WMAP. A new map of the temperature of the CMB was presented, in which the finer resolution from WMAP was obvious. Planck was able to measure the gravitational bending of light from the CMB, and thus allowed creation of a 2-dimensional map of all matter in the observable Universe. The results were based on about 15 months of data, which consisted of a trillion measurements of a billion points in the sky. The supercomputers are still digesting further data, so more results are expected in 2014. Previous CMB work had hinted that one direction in the Universe was a little hotter than the other, a hard thing to explain theoretically, and the Planck data just made the problem worse. The half is not just hotter, but has more variation in temperature, which is even harder to explain. There are also some anomalies from theory in the temperature fluctuations with the largest areas. This will keep theorists working for years.





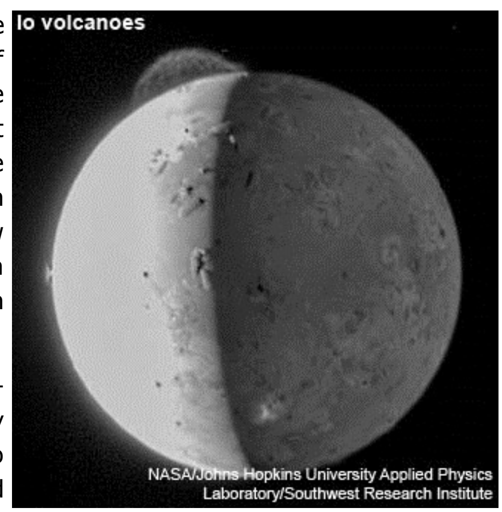
Mars rover Curiosity has performed an analysis of the atmosphere and determined the ratios of various components to high precision. In particular the ratio of the isotopes of Argon, when compared to that ratio in the Sun and Jupiter, shows that Mars has lost much atmosphere to a process that loses lighter isotopes. That process is quite likely loss to space due to Mars' comparatively low gravity. Argon isotopes at Mars were measured as far back as 1976 by the Viking spacecraft, but Curiosity's new measurement is far more accurate.

Curiosity has been measuring the weather on Mars, and has found the daily air temperature to be climbing steadily (with seasons) and that it does not vary much from place to place. But the humidity does vary significantly with location. Trails left by dust devils have not been seen anywhere in Gale Crater, where the rover is, but Curiosity's weather instruments have detected many whirlwinds, though not as frequently as previous Mars rovers (in other locations). Mars is going behind the Sun (conjunction), as seen from Earth, which disrupts radio communication from early April to early May, so the rover was given a series of commands to perform science (but no driving) on its own until it hears from us again.

Recently the **Curiosity** rover team announced that analysis of the drilled powder indicates past warm and wet conditions over long periods. New infrared and neutron measurements found more hydrated minerals near the drill site than at locations the rover visited earlier. Elevated hydration was found in narrow veins cutting across many of the rocks in the area. Those hydrated minerals are different from the clay in the drill sample. The drill sample matched basalt, the most common rock type on Mars. It is igneous, but it is also thought to be the parent material for sedimentary rocks that Curiosity has examined.

Early Martian volcanoes – A new study of how magma is erupted as lava under low-oxygen conditions, such as Mars has, concluded that carbon in the magma will release as methane and carbon monoxide gases into the atmosphere. Earthly conditions cause the carbon to be released as carbon dioxide instead. Both methane and carbon monoxide, particularly the former, act as greenhouse gases, warming the planet. The new study calculated that enough methane could have been released in Mars's early volcanic activity to have warmed the planet to the point that liquid water could exist. Much evidence already exists that liquid water flowed on Mars billions of years ago, and this new work may help explain how.

Io – New computer simulations of tidal-stress heating of Jupiter's moon Io show that the resulting volcanoes are in the wrong place, about 30 to 60 degrees longitude east of where they should be. The scientists involved propose that this discrepancy could be explained by an interior structure permitting magma to travel significant distances before erupting, or tides in an underground magma ocean, or other factors not included in the computer simulation. If the explanation is a magma ocean, then it would have to behave like a sopping sponge, with a matrix of harder rock filled with the liquid magma.



Europa – A new paper shows that hydrogen peroxide is abundant across much of the surface of Jupiter's moon Europa. That chemical had been found in a limited region of Europa by the Galileo mission more than a decade ago. But recent observations with the Keck Telescope in Hawaii show that hydrogen peroxide is found over most of that moon, with highest concentrations on the leading side (as it orbits) and lowest on the trailing side. Even the high concentration is about 20 times more dilute than hydrogen peroxide available at your drug store. If surface material mixes into the ocean below Europa's frozen surface, then it would constitute a source of energy for microbial life in the ocean, if such developed. The peroxide is created by Jupiter's radiation reacting with surface ice.

Titan – A laboratory experiment simulating the atmosphere of Saturn's moon Titan suggests that complex organic chemistry extends lower in the atmosphere than previously thought. It was known that the gases in the upper atmosphere react due to sunlight to form such chemistry, but the new experiment showed that the liquids and solids found lower in the atmosphere also react similarly. So the volume of Titan's atmosphere that is creating complex organic chemistry is much larger than thought.

Old rings – New analysis of visual and infrared data from Cassini (Saturn mission) apparently answered the long-asked question of whether Saturn's rings formed at about the same time as the planet or are newer. The rings were found to contain such large quantities of ice that they likely formed when the planet formed, though the rings are tinted with more recent pollution which was found to be only skin-deep. The color on the ring particles and moons roughly corresponds to their location. Inner ring particles and moons have been whitewashed (with ice) from the geysers on Enceladus. Farther out, the surfaces of moons generally were redder the farther their orbits. Phoebe, an outer moon thought to have been captured from the Kuiper Belt, seems to be shedding reddish dust that eventually coats the surfaces of nearby moons, such as Hyperion and Iapetus. A rain of meteoroids from outside the system appears to have turned the Bring a subtle reddish hue. The color may be rust or polycyclic aromatic hydrocarbons. One surprise was that the moon Prometheus, next to the rings, and nearby ring particles are reddish, while ring particles not so near are white. The explanation may be that Prometheus formed from nearby ring particles.

Ring rain – A new study using infrared observations from the Keck Observatory in Hawaii has tracked the "rain" of charged water particles into the atmosphere of Saturn. The main effect of ring rain is that it reduces the electron densities in the ionosphere where it falls. This explains why for decades observations have shown electron densities to be unusually low at certain latitudes on Saturn. The ring particles affect what kind of particles are in this area and where it is warm or cool. The ionosphere is where charged particles are produced when the otherwise neutral atmosphere is exposed to a flow of energetic particles or solar radiation. The charged water particles from the planet's rings are being drawn towards the planet along Saturn's magnetic field lines and are neutralizing the glowing hydrogen ions, leaving "shadows" in the otherwise planet-wide infrared glow. These shadows cover 30-43% of the planet's upper atmosphere from around 25 to 55 degrees latitude. Cassini will examine these phenomena.

Enceladus geysers – A new paper says that the geyser jets on Saturn's moon Enceladus likely reach all the way down to a subsurface salty liquid sea thought to lie about 6 miles (10 km) beneath the icy surface. The amount of tidal-stress heating was calculated not to be sufficient near the surface to result in the temperatures measured along the "tiger stripes", or cracks, in the surface of Enceladus. Thus the heated water has to be coming from deeper. This would result in the temperatures observed. 98 individual jets have now been observed on Enceladus.

Vesta – Scientists discovered that the asteroid Vesta was hit by a bombardment of high-speed projectiles about 4 billion years ago that was similar to that determined long ago to have hit our Moon. This answers the question of whether the lunar bombardment was widespread in the Solar System, since Vesta orbits relatively distantly from the Moon. The findings support the theory that the gas giant planets repositioned their orbits early in the life of the Solar System, destabilizing portions of the asteroid belt and triggering a system-wide bombardment of asteroids.

Lunar Reconnaissance Orbiter (LRO) observed the intentional crash of the twin GRAIL spacecraft last December, and results were just announced. Ultraviolet observations identified mercury and atomic hydrogen in the plumes raised, consistent with that seen when LCROSS crashed into the Moon in 2009. Both craters were fairly small, perhaps 13-20 feet (4-6 m) across, and both have faint dark ejecta patterns. Dark is unusual, as most crater ejecta is light. The dark color may be due to spacecraft material being mixed with the ejecta. The impact craters about 7200 feet (2200 m) apart. GRAIL B (Flow) impacted about 30 seconds after GRAIL A (Ebb). Heating from the impact was measured as relatively small, within the expected range.

Impact melt – Astronomers had assumed that impacts, such as those that made lunar craters, would stir up the melted rock into an indistinguishable mass. But new analysis of observations of Copernicus Crater on the Moon show a sinuous feature that contains minerals differing from those elsewhere in the crater. The feature is 18 miles (29 km) long and is rich in magnesium pyroxene minerals, while other parts of the crater do not have these, but instead iron and calcium pyroxenes. The observations were made in visible and infrared light by India's Chandrayaan-1 lunar orbiter about 4 years ago.

Kepler (exoplanet finding space telescope) has observed gravity bending light (as Relativity says it should) when it passes near the surface of a white dwarf star. Surface gravity of white dwarfs is quite high because they pack so much material (about the same as the Sun) into so small a volume (about the same as Earth). When Kepler 1st observed the variation in light of this particular star, astronomers thought that it was caused by a gas giant planet eclipsing part of the light of the star. But radial velocity measurements by the Palomar Observatory determined that the eclipsing object was far too massive to be a planet. Further ultraviolet (UV) observations showed that the star orbiting the white dwarf is a very active red dwarf star. The UV observations were made with the GALEX UV space telescope, which is observing all possible planets discovered by Kepler. After it was known that the star was a binary white/red dwarf pair, further study of the light variation from Kepler showed that light from the red dwarf was being bent and magnified as it passed by the white dwarf. From all the data, the masses and diameters of the 2 stars were calculated.

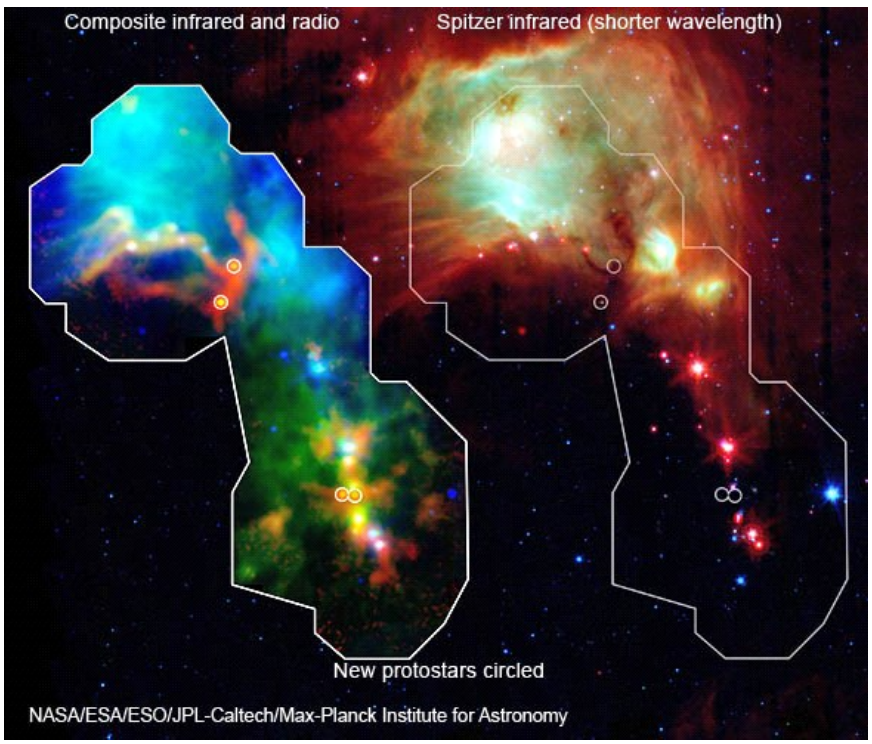
Herschel (infrared space telescope) has studied 2 massive star-forming regions and found numerous very massive stars forming. Astronomers have long wondered why the strong radiation and powerful stellar winds that young massive stars are known to emit do not blow away star-forming material and stunt the growth of stars before they become this massive. The new observations point to a solution. In these very dense star-forming regions, there appears to be a continuous process by which the raw material is moved around, compressed and confined. This apparently keeps the material from blowing away, and thus allows the stars to continue to grow.

Herschel has found some of the youngest stars, or protostars, ever seen. Their dense envelopes of gas and dust made finding them difficult. Herschel operates in longer wavelengths of infrared than previous telescopes, so those wavelengths penetrate obscuring material better. Follow-up observations were made with other telescopes at other wavelengths of light to confirm. 15 protostars turned up in a survey of a star-forming region in Orion. This is the largest group of such young stars found in a single region. Of the

15, 11 are very red, meaning their light is from cooler areas. This implies they are quite young. The youngest stars spend perhaps only 25,000 years in this phase.

Integral (X-ray space telescope) was observing a galaxy when another galaxy in the field of view (NGC 4845) flared up. Follow-up observations with other X-ray telescopes, including MAXI mounted on the International Space Station, found that the flare reached maximum brightness, 1000 times what it had been for decades, in January 2011, then faded over the course of a year. Analysis showed that the black hole at the center of the galaxy tore apart and swallowed an object that was probably in the range of 14-30 times the mass of Jupiter, so was a gas giant planet or brown dwarf. The black hole likes to play with its food: there was a 2-3 month delay between the object being torn apart and the resulting matter being heated to glowing on its way into the black hole.

Ultraviolet – Observations of 6 of the Green Pea galaxies, a galaxy type discovered by volunteer citizen scientists in 2007, have shown that the ultraviolet light (UV) generated by the star-forming activity within them exceeds the UV that is absorbed by matter within them. This implies that substantial UV is escaping from the Green Pea galaxies. This may solve a mystery about the early Universe. It is known that most of the hydrogen in the Universe was ionized by UV in the first couple of billion years. But astronomers have yet to measure substantial UV escaping from any galaxy until now. Astronomers are hoping that whatever mechanism allows UV to escape the Green Peas also acted on the 1st galaxies that formed in the early Universe. Green Pea galaxies are small, round and green-colored (from oxygen emission) in images taken by the Sloan Digital Sky Survey; hence the name. The 6 studied are between 1 and 5 billion light-years away, and thus are not galaxies in the early Universe, but may share characteristics with them.



Giant galaxy – A team of astronomers has discovered a previously unknown gigantic radio galaxy using initial images from a new ongoing all-sky radio survey, using the LOFAR radiotelescope array. The new radio source is the size of the full Moon. It was found to be associated with material ejected from 1 member of an interacting galaxy triplet 10s to 100s of millions of years ago. The extent of the material is much larger than the galaxy system itself, extending millions of light-years across. The galaxy triplet is known as UGC 09555, and the central galaxy is 750 million light-years away. The central radio source was already known, but the larger source from the ejected material was overlooked because it emits at lower radio frequencies, which LOFAR is tuned to. Since LOFAR is observing a new part of the radio spectrum, many new discoveries are expected.

Spiral galaxies – A new more-precise computer simulation of material within galaxies has shown that giant molecular clouds (star-forming regions) perturb motions within galaxies so as to form spiral structure, and further that the spiral structure is self-sustaining after the cloud perturbations are gone. The debate over how spiral structures form and perpetuate has been going on for a very long time, and this new simulation may help end the debate. The simulation dealt with stand-alone galaxies, so work is still to be done on those with close companions or collisions.

Star formation at the galactic center – Astronomers using ALMA (radiotelescope array in Chile) have discovered signs of star formation perilously close to the supermassive black hole at the center of our Milky Way galaxy. If confirmed, this would be the 1st time that star formation was observed so close to the galactic center. Near any supermassive black hole is a turbulent region of space that is thought to be wracked by such extreme tidal forces that any star-forming clouds would be ripped apart. Yet ALMA spotted jets of material bursting out of what appear to be dense clouds of gas and dust. Such jets normally indicate the formation of a young star. The astronomers speculate that these molecular clouds have become so massive and dense, possibly by colliding, that their internal gravity can overcome the tidal forces trying to tear them apart. Rapid rotation and magnetic effects of a forming star accelerate some material and shoot it out from the poles as jets. Astronomers were able to detect these jets by tracing silicon monoxide, which has a strong spectral line in short radio wavelengths.

Herschel (infrared space telescope) has provided the 1st images of a dust belt, which is produced by colliding comets or asteroids, orbiting a subgiant star, Kappa Coronae Borealis. After a Sun-like star has completed nuclear burning (fusing) of hydrogen during its normal lifetime, it swells to become a subgiant star, and later a red giant. Previous ground-based observations show that Kappa has a planet or possibly 2. So the planetary system and dust disk have apparently survived the entire normal (main sequence) life of this star. Kappa is 1.5 times the Sun's mass, is about 2.5 billion years old, and lies roughly 100 light-years away. More work is needed to see if other subgiant stars also have planets and dust disks.

New supernova type has been identified: Type Iax. It has been described as a mini supernova, since it is about 100 times fainter than Type Ia, though it also comes from exploding white dwarf stars. The team identified 25 examples of the new type. None of them appeared in elliptical galaxies, which are filled with old stars. This suggests that Iax comes from young star systems. Based on a variety of data, the team concluded that Iax comes from a binary star system containing a white dwarf and a companion star that has lost its outer hydrogen, leaving helium dominant. The white dwarf collects helium from the other star until it explodes. The exact mechanism of exploding is not known yet. It appears that in many cases the white dwarf survives the explosion, unlike Type Ia. It was calculated that Iax are about 1/3 as common as Ia. So few Iax have been found because they are so faint.

Chandra (X-ray space telescope) has observed the remnant of the Type Ia supernova seen by Johannes Kepler in 1604 and deduced that the supernova was triggered by a red giant star dumping material onto a white dwarf. Recent evidence from other Type Ia supernovas has implied that they were caused by 2 white dwarf stars merging, not from another type of star dumping material on a white dwarf. The new observation therefore supports that both causes happen. A disk-shaped structure was seen (in X-rays) near the center of the remnant. The researchers interpret this to be caused by the collision between supernova debris and disk-shaped material that the red giant expelled before the explosion. A substantial amount of magnesium (an element not produced in great amounts by a Type Ia) was found in the Kepler remnant. This suggests that the magnesium came from a red giant. The disk seen resembles in shape and location one observed by the Spitzer Space Telescope, and these type of disks are thought to be dusty bands expelled by star with stellar wind, such as a red giant. The researchers found much more iron on 1 side of the remnant than the other. The scientists speculate that the cause is that the companion star blocked the ejection of iron by the supernova in one direction. The remaining challenge is to find the damaged leftover of the red giant.

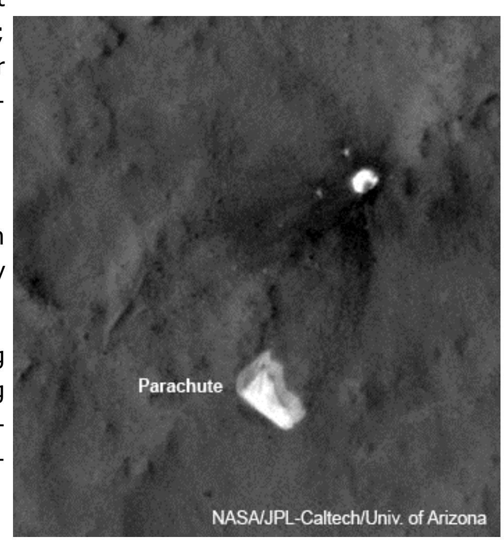
Hubble Space Telescope has once again found the farthest Type Ia supernova known, the type used for distance measures. This one exploded over 10 billion years ago, and its light is just now arriving to us due to its great distance. Very distant Type Ia supernovas are important because they tell us how far they are, and how expansion of the Universe and other properties have changed since the light left them. The discovery was part of a 3-year program begun in 2010 to find distant Type Ia supernovas. The program has so far found more than 100 very distant supernovas, of which 8 are Type Ias more distant than 9 billion light-years.

Asteroid mission – The budget proposal for NASA for next year contains allocation to begin a new mission: astronauts to an asteroid. A new twist, however, is that the mission is mostly to bring the asteroid to the astronauts rather than vice versa. The proposal is to attach a robotic spacecraft to a rather small asteroid (25 feet=7 m across) and, using ion engines, divert its motion into a parking orbit near the Moon in 2019. Then send astronauts to the asteroid in 2021, using the Orion spacecraft and SLS rocket now under development. This was determined to be faster and cheaper than the originally proposed asteroid mission that would have sent astronauts to rendezvous with an asteroid that happened to pass near Earth. The 1st money allocated to the new mission is to find an asteroid near enough and small enough to be diverted. Statistically there should be some.

Explorer – NASA has selected 2 missions for launch in 2017, as part of its astrophysics Explorer program of low-cost missions: TESS to look for exoplanets transiting their stars, much as the current Kepler mission, but searching the entire sky instead of a small portion, using an array of space telescopes; NICER to measure the variability of X-ray sources, in particular neutron stars, to better understand the surface and interior of them. A heliophysics Explorer has also been approved for 2017 launch: ICON, which will probe the variability of the Earth's ionosphere.

Instant AstroSpace Updates

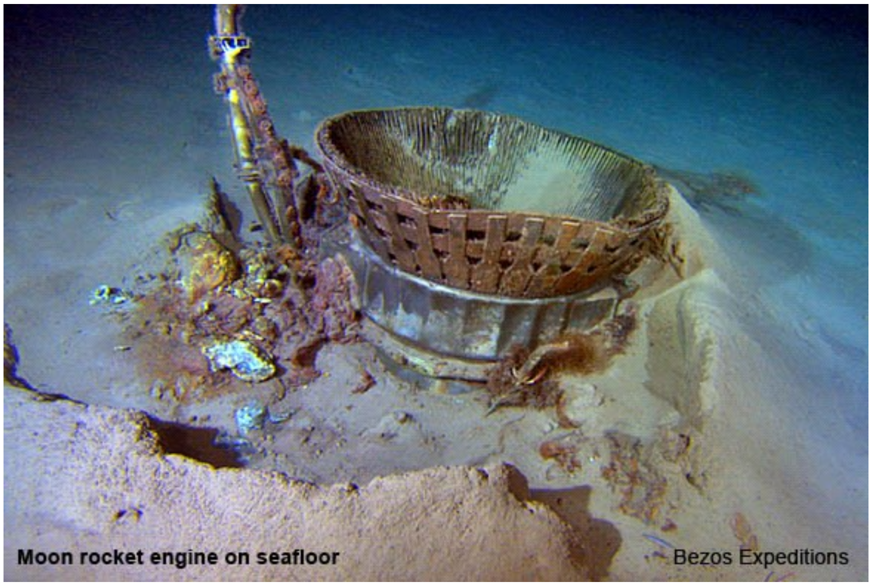
Mars Reconnaissance Orbiter has taken several images of the parachute dropped when the **rover Curiosity** landed, and it has moved, showing that Martian winds occasionally flap the chute about.



XMM-Newton (X-ray space telescope) has identified a star and a black hole orbiting each other at a distance of only about 600,000 miles (1 million km) at the dizzying speed of once every 2.4 hours, the fastest known. Swift space telescope actually discovered them, but it took XMM-Newton observations to determine the nature of the objects.

9 new names for craters on Mercury have been accepted by the IAU, conforming to the convention to honor deceased writers, artists and musicians, which include Lovecraft, L'Engle, and Pahinui (Hawaiian guitarist). Most are in the south polar area, the last to be mapped by **Messenger** (Mercury orbiter).

An ice cloud is building up over the south pole of **Titan**, as the existing similar cloud over the north is fading, as a result of the changing seasons (southern winter approaching). The type of ice is unknown, and appears to be complex chemically.



Moon rocket engine on seafloor

Jeff Bezos, the billionaire founder of Amazon, has **salvaged Saturn V** rocket engines from 3 miles deep in the ocean where they fell on the way to the Moon. His team plans to restore the engines and make them available for public display.

Mars Reconnaissance Orbiter (MRO) has imaged the steep slope of a crater twice in 5 years and found new markings of bright lines and spots, apparently caused by **boulders** bouncing and rolling down in the time between pictures, punching through the dark surface coating to show lighter rock. Source of the boulders has not been determined.

MRO has imaged objects that match what is expected in size, shape and arrangement for the **Mars 3** lander, parachute, retro rocket and heat shield. The 1971 Soviet mission was the 1st soft landing on Mars, though it operated only 15 seconds after landing. The objects were found by Russian citizens searching public MRO images.

FOR SALE

88-pound meteorite fragment from Campo del Cielo meteorite in Argentina—extra consideration will be given to universities and museums. Contact Mark at 949-49591700

Meade ETX-125EC with UHTC coatings and accessories. - Maksutov-Cassegrain Telescope in original box with tripod (tote bag), autostar GOTO controller, original manual & instructional DVD, 26mm Meade lens and extra misc. accessories: AC power cord, Telegizmo solar scope cover, Meade table tripod and Meade dew shield.   Original owner - all in excellent shape or never used for $650.00. Contact Caroline Torres at 949/697-9718 or cytorres@yahoo.com

Meade LXD75 German Equatorial Mount with tripod and Autostar controller. - Also included: Meade USB to RS-232 Bridge Cable and cords for Autostar updates. Mount only used once $550.00 Contact Caroline Torres at 949/697-9718 or cytorres@yahoo.com

Losmandy Universal Dovetail Plate V Series 14.0".   Only used once $55.00   Contact Caroline Torres at 949/697-9718 or cytorres@yahoo.com

Skywatcher 100ED f/9 Refractor with Celestron CG-4 mount. Scope comes with a hard case, 8x50mm finder; 2 LET eyepieces, 2-inch dielectric diagonal; Baader solar filter. CG-4 mount has motor drives on both equatorial and declination axes. All in excellent shape for $650 or best offer. Celestron Sky Prodigy 90mm Maksutov with all attachments, $375. Vixen Porta II Altazimuth Mount, $100; Telrad finder, $25. Contact Val Akins (949) 382-1869

Meade Model ETX-90EC Maksutov-Cassegrain with AutoStar; 90mm objective, f/13.9 with 8X25 right-angle viewfinder, Rigel Quik Finder, electric focuser, 26mm eyepiece, 2X Barlow, and Meade rigid carry case. $300. Contact Don at (714) 996-5138 or dgrconsult@roadrunner.com

INTES 66 6-inch Maksutov-Cassegrain on a Celestron 6/8-inch NexStar GoTo mount/tripod with 2-inch star diagonal, dovetail, 50mm finderscope, full aperture solar filter, AC/DC power adapter, PC cable, and soft telescope case. Paid $1800; will sell for $850 OBO. Equatorial mount/tripod with manual hand controls and cables suitable for scopes up to 15 lbs. $35 OBO. Contact Dave at (949) 492-5342

A Visit to the Plate Collection at Harvard College Observatory

by Bob Buchheim

I have been curious about what an astronomical "plate collection" looks like and how it is organized. Ms. Alison Doane, the Curator of the Plate Collection at Harvard College Observatory, generously offered to give me a tour of the collection. The plate collection is not open to the public since it is an irreplaceable and fragile asset, of special value to both researchers and historians.

The majority of the Harvard plates are 8X10 inch negatives (black stars on clear background), as shown in **Figure 1**. The plates are a bit less than 1/8 inch thick. Each plate has an identifying number that is used as the primary ID of the plate. The routine in the old days was to expose the plate (many are 90 minutes or more, hand-guided), and record essential information in the astronomer's log book – instrument, observer, date, plate ID, RA/Dec, start and end times of exposure, etc. A typical page from a log book is shown in **Figure 2**. The plates were (and still are) stored in envelopes, marked with the plate number and some identifying information that prevents mis-filing. There are a variety of risks when maintaining a collection of hundred-year-old glass plates. The photographic emulsion is (like a front-surface mirror) delicate and it can easily be scratched or marred. A careful routine is followed in handling the plates. The edge of the envelope is pressed gently, so that it bows open before the plate is removed; this way, the face of the plate doesn't touch the envelope as it slides out. The envelopes (like any "manila envelope") are made from folded and glued paper; but the outgassing from the adhesive can have a subtle effect on the image; therefore, plates are always put in the envelopes with the image-side away from the adhesive. The manipulation puts the plate emulsion-side-down onto the light table, so you don't slide the plate once it's there!

Figure 1: 8x10 inch plate negative

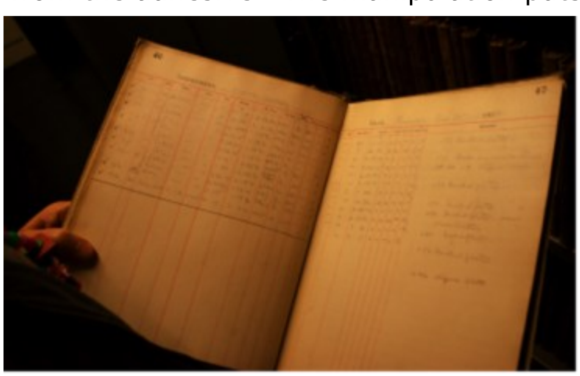


Figure 2: Logbook

The "back side" of the plate was a convenient location for the observer to mark objects of interest. On most plates, there will be one or two delicate ink circles or lines marking a star or object of interest, and a hand-written code that identifies the object. These written notes are very fine and delicate: I guess about 8 point fonts, with a clear legible hand in a very tiny pen. Once the business of astronomical photographic photometry became a "production-line" operation (under Dr. Pickering's guidance), the need for standard photometric sequences resulted in plates that were densely cluttered with these notes, such as the example shown in **Figure 3** (right).

I viewed several plates under a jeweler's loupe, and was impressed with the quality of the images. The stars are pin-points (from a 90-

minute hand-guided image), there is very clear detail in nebulae, and many spiral galaxies show up as miniscule whirls or spindles. Most of the plates cover a huge field of view. **Figure 4** shows a typical AAVSO finder chart (1-degree scale), and the location of that field on the corresponding plate.

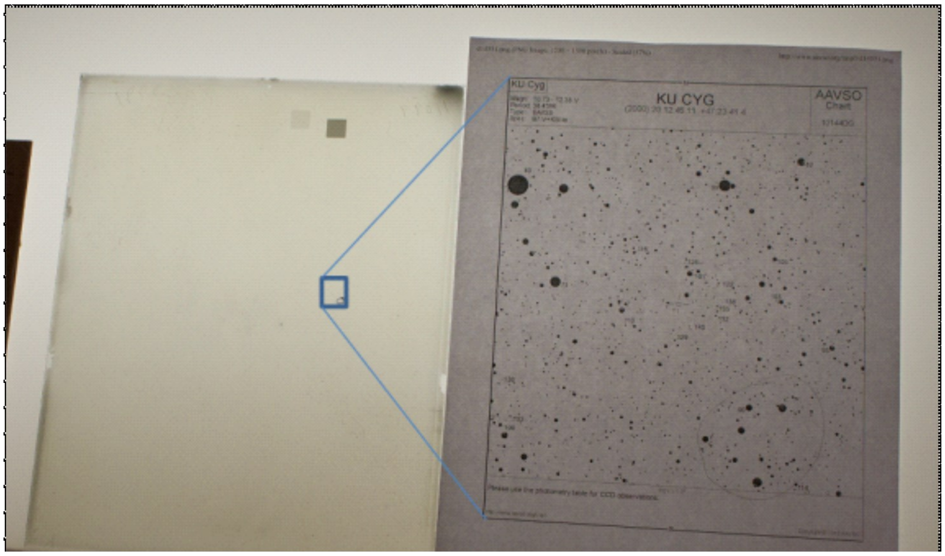
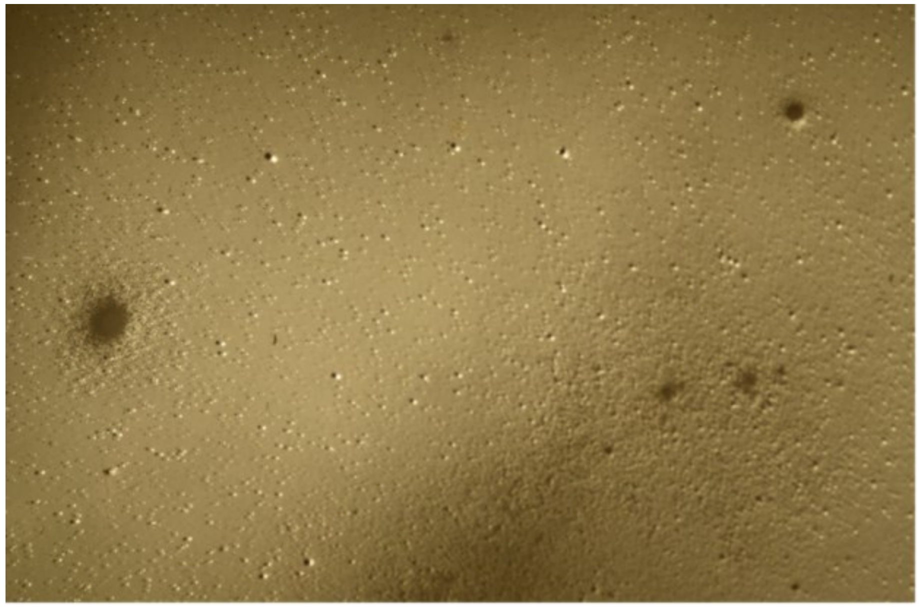


Figure 4: Comparison of AAVSO Finder Chart to corresponding area on Harvard photographic plate.

Measuring stellar brightness on these plates was a very tricky and time-consuming affair. The best indicator of the star's brightness is the diameter of the star's "dot" on the image, but the relationship between "diameter" and "magnitude" is non-linear, and there is no guarantee that two plates would have exactly the same sensitivity. So one standard approach was to make an exposure of your target field of view and then move the telescope to the field of the "north polar sequence" (well-characterized stars of known brightness), and make a second exposure on the same plate. That way, there is no difference in plate sensitivity between your "science image" and the "calibrated star image".

The negative plates could be turned into "positive" images (white stars on a black sky) by making a "contact plate" -- a fresh plate is exposed through the negative plate, An example of a contact plate is shown in **Figure 5** (right; note the missing corner: this is one of the plates that has suffered an accident somewhere during its history).

Searching such a plate to discover variable stars is a daunting challenge. The typical plate contains tens of thousands of star images, each a miniscule dot that must be examined under a jeweler's loupe. In order to detect stellar variability, each star must be examined on two plates, taken at different epochs. One of the most successful approaches made use of a negative plate from one epoch, and a positive contact plate from a later epoch. When the two are stacked on the light box, it gives a wonderfully eerie three-D effect. Once the two plates are perfectly registered, the observer can search for star-dots whose size has changed. As Ms. Doane pointed out, this is a clever mechanism to compare magnitudes, but it still required an astounding visual acuity to recognize that the white ring around one black star was thicker or thinner than all of the other white rings around other stars (the two exposures would have produced different star-dot diameters just due to trailing/exposure length/weather, etc.) If a star's image is a different size on the two images, its brightness has changed between the two epochs and thus it is a candidate variable star. As simple as this sounds, imagine the meticulous care and diligence that is required to check every one of the thousands of stars on an image such as the one shown in **Figure 6 (above)**.



The Harvard College Observatory plate collection totals 525,000 plates. That's three entire floors of cabinets containing envelopes of plates! A tiny portion of the collection is shown in **Figure 7 (below)**. In addition to the glass plates as described above, there are some interesting historical items, including a couple of very early daguerreotypes of the Moon.

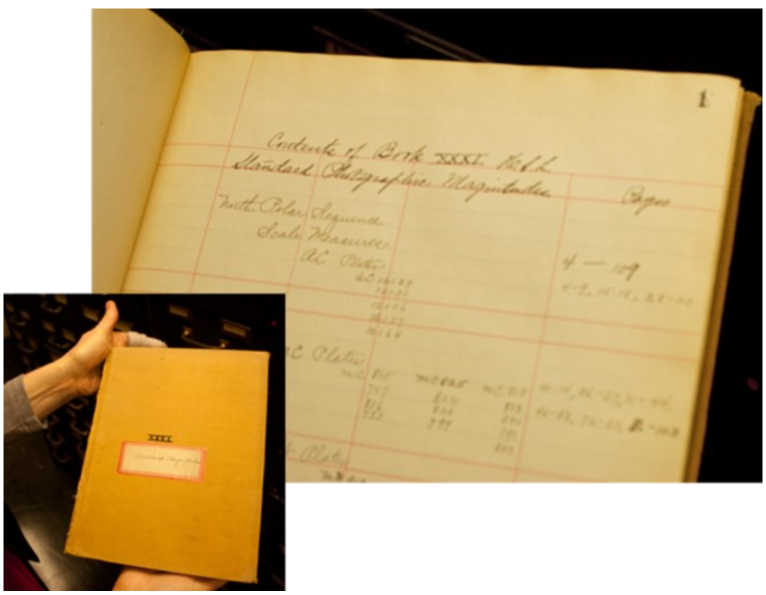
There are (at least) two threats to a collection like this. First, there is the very real risk of accidental loss. Imagine what a small earthquake or the heat of a fire could do to these delicate plates. And every time a plate is handled, there is the potential for a human mistake. Some plates (such as the one shown in Figure 5) have suffered handling damage; and a few have been dropped and shattered over the years. Second, perhaps the greater challenge is that the human skill at reading the plates to derive stellar brightness (photometry) and precise locations (astrometry) is rapidly disappearing ... indeed, is mostly already gone. In order to deal with this challenge, and make this record of astronomical observations more accessible to researchers, a project has begun to scan, digitize, and conduct photometric and astrometric reduction of the plates. This DASCH project ("Digital Access to a Sky

Century at Harvard") has developed the hardware for precision scanning and the software to translate the star images into brightness values (roughly ±0.1 mag accuracy) and astrometric positions. As with any other handling of the plates, it entails a well-crafted procedure to ensure careful handling, cleanliness of the plate and the equipment, and double-checking of quality and inventory management (don't put that plate into the wrong envelope!).

A careful look at the "files" of envelopes/plates shows that some of the envelopes have a small red mark on their visible edges, indicating that that plate has been scanned. The progress has been impressive, but when you have half a million of anything to do, it's going to take quite a while to complete the task. The first data release, of the region around the north celestial pole, is scheduled to "go live" in a few months.

The approach currently being used for scanning and data reduction is a giant step toward preservation and easy access to the plates that display star images. However, there is a whole other class that will need additional development work: the plates that record stellar spectra taken with an objective prism. The current algorithms can't deal with those.

How do you pay for the maintenance of such a collection? The DASCH project is funded in part by NSF grants and a donation from the Cornel and Cynthia K. Sarosdy Fund for DASCH. Ongoing costs for curating the collection are provided by private donors, the most significant being a bequest that was established in the 1880's by the widow of Henry Draper (Anna Mary Palmer).



The story of Harvard College Observatory, Dr. Pickering, Ms. Henrietta Leavitt and the other female assistants, is familiar to anyone who has studied the history of variable star investigations. Ms. Leavitt – by virtue of years of careful study of these glass plates and the various types of variable stars they displayed – was the discoverer of the "period-luminosity relation" of the Cepheid variables. This is the fundamental basis of almost all cosmological distance measurements. In **Figure 8**, the curator, Ms. Doane, is holding one of Ms. Leavitt's notebooks.

Finally, here's an item that struck me as fun, and which may resonate with any astro-imager who has tried to image something just above the horizon. The plate shown in **Figure 9** was an attempt to photograph a comet as it was rising in the twilight (the comet is, indeed, visible on the plate with the aid of a jeweler's loupe, but you can't see it in my photo). The jagged pattern on the lower right of the plate is the steeple of a church across the street. The church – and the trees that frame it on the old plate – is still there, visible through one of the windows in the room that houses the plate collection.

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