Southwest Florida Astronomical Society
SWFAS

The Eyepiece
March 2014

Contents:

A MESSAGE FROM THE PRESIDENT

Boy am I glad February is over!
We had one of our busiest months! I do thank all that helped out at our events this past month! Things are really slowing down in March with only a few events happening mid month. We don't want to forget that April will bring Mars and a Lunar Eclipse! The meeting this month is about your equipment and any questions or issues you have. I plan to do a brief overview of some setup basics and different mounts, then break out to work with any equipment you have questions about. Our program next month is by Jack Berninger. He has brought us very interesting programs for the last several years!

Brian

In the Sky this Month

<u>Moon</u>: March – New 1st; 1st Quarter 8th; Full 16th; Last Quarter 23rd; New 30th.
April – 1st Quarter 7th; Full 15th; Last Quarter 22rd; New 29th.

<u>The planets</u>:
<u>Jupiter</u> is best viewed at nightfall since it passes the meridian this month still gorgeous at -2.3 magnitude.
<u>Mars</u> rises at 9:30 pm early in the month and brightens to -1.3 mag by end of month.
<u>Saturn</u> rises before midnight early in month with rings tilted at 22°; 0.4 mag.
<u>Venus</u> is low in the SE at dawn at -4.4 mag.
<u>Mercury</u> will be visible low in East at early dawn during first half of month.

<u>The International Space Station</u>: Nothing available for rest of March.

<u>Hubble Space Telescope</u>: Some evening views may be possible late in month.
Mar 5th at 7:30 pm from W to E; max alt 69°; for 7 minutes at 0.9 mag.
Mar 6th at 7:24 from W to E; max alt 73° for 6 minutes at 0.8 mag.
Mar 7th at 7:18 from W to E; max alt 81° for 7 minutes at 0.8 mag.
Mar 8th at 7:12 from W to ESE; max alt 88° for 7 minutes at 0.8 mag.
Mar 9th at 8:06 from W to SSW; max alt 74° for 8 minutes at 0.9 mag.
Mar 10th at 8:00 from W to SSW; max alt 59° for 8 minutes at 1.2 mag.
Mar 11th at 7:54 from W to SSW; max alt 46° for 8 minutes at 1.7 mag.
Extracted from http://www.heavens-above.com/

Future Events

Upcoming Meetings
Our March meeting will be held on Thursday March 6th at 7:30 pm at the Calusa Nature Center and Planetarium. Our meeting program is Equipment Assistance.

CRP Star Party Schedule
The remaining 2014 CRP Star parties are: Mar 29, May 3, May 31, June 28, July 26, Aug 23, Sept 27, Oct 25, Nov 22, and Dec 20. Please contact Bruce Dissette if you have any questions.

Date	Event	Location	Time	Info/Contact
Thurs Mar 6th	MonthlyMeeting Equipment (Bring any equipment you need help with)	Calusa Nature Center Planetarium	7:30 PM	Brian Risley
Sat Mar 15th 2014	Planetarium Observing	Calusa Nature Center & Planetarium	7:00 – 8:30 pm	Carol Stewart Program: Orion the Hunter

Sun Mar 16th	Hyatt Coconut Point	Concert Event	5:00pm - 10:00pm	Brian Risley
Fri Mar 28	Astronomy for amateurs	Hickey's Creek	Dusk	Kelly Flaherty
Sat Mar 29th	Star Party	CRP	Dusk	Bruce Dissette
Thurs April 3rd	MonthlyMeeting	Calusa Nature Center Planetarium	7:30 PM	Jack Berninger
May 3rd	Star Party	CRP	Dusk	Bruce Dissette
May 31st	Star Party	CRP	Dusk	Bruce Dissette

Minutes of SWFAS Meeting – February 6, 2014

The regular monthly meeting of the Southwest Florida Astronomical Society was called to order at 7:41pm by president Brian Risley in the Calusa Nature Center Planetarium.

Five visitors were introduced.

Past and upcoming events listed on the printed agenda were discussed. It was suggested that the March 1 star party at Caloosahatchee Regional Park will start with a barbeque at 1pm, motion by Bruce Dissette, second by Brian Shultis, the motion was passed by voice vote.

The International Dark Sky event at the Nature Center will be Saturday, April 19.

Brian Shultis spoke on the importance of safety concerns when using a laser pointer.

The cost of renewal of our web domain for ten years is $150. Brian Shultis made a motion to approve the expense, second by Bruce Dissette, motion was passed by voice vote.

A raffle was held to give away binoculars and a laser pointer.

Brian Shultis moved for acceptance of the January minutes contained in the newsletter, second by Bruce Dissette, motion passed on a voice vote.

Treasurer Tony Heiner reported a balance of $2428.13, a motion to accept was made by Brian Shultis, second by Susan Musick, motion passed on a voice vote. Bruce Dissette made a motion to reimburse Tony for the two printers purchased for the club, second by Brian Shultis, the motion passed on a voice vote.

Bruce Dissette thanked Librarian Maria Berni for the great job she did inventorying and organizing the club library.

A request was made for pictures for the club website.

A request was made for program ideas for the March and May meetings. A number of suggestions were shared.

It was reported that Robert Benedict donated a power pack for the CPC telescope.

The business meeting was adjourned at 8:40.

Bruce Dissette gave an entertaining power point presentation on observing in the southern hemisphere.

submitted by Don Palmer, secretary

Take a Moon Walk Tonight

by Alan MacRobert

The Moon's southern highlands are densely covered with overlapping craters. *Night Sky: Gary Seronik*

The Moon is one celestial object that never fails to impress when seen in a telescope. It's our nearest neighbor in space — big, bright, beautifully bleak, and just a quarter million miles away. That's fewer miles than you may have ridden in cars, and 100 times closer than our next nearest major astronomical neighbor (Venus) ever gets.

This makes the Moon a wonderful target for even the most humble astronomical instrument. You can spot and name at least a dozen of its surface features with the unaided eye. Binoculars show scores more, and a telescope can keep you busy on the Moon forever.

Of course, just looking and not knowing what you're seeing will grow old pretty fast. As in all of astronomy, the rewards come from recognizing and understanding what you find, and from planning neat things to seek out. Let's get started.

The Moon's Changing Phase

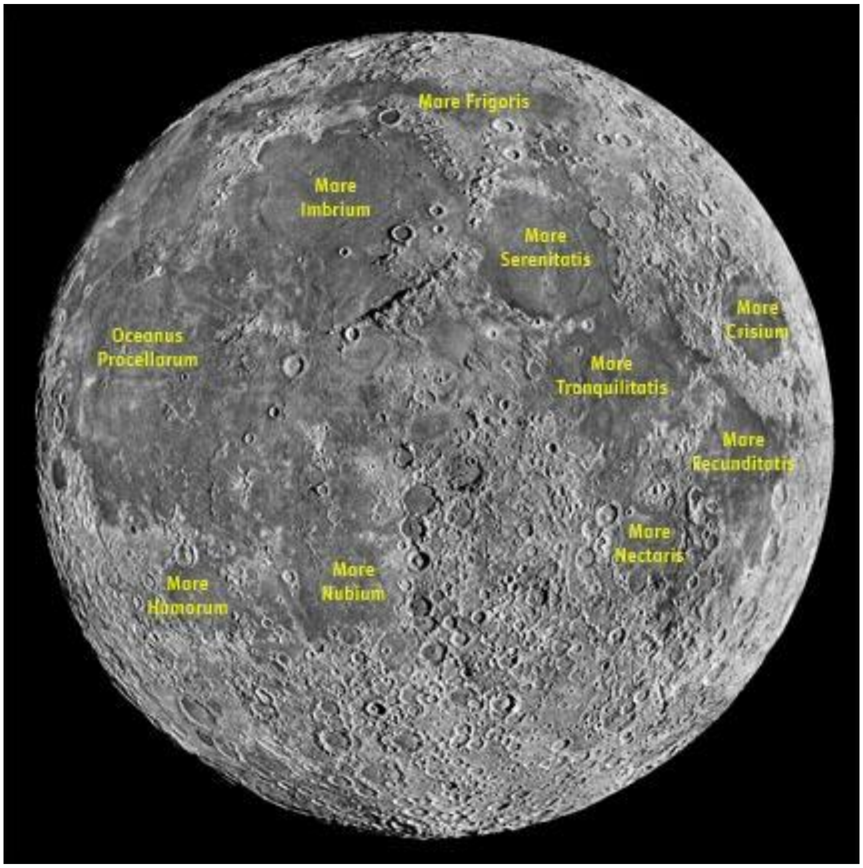
Night Sky: Tony Flanders

Each month as the Moon circles the Earth, we see it go through its cycle of phases. Starting from “new Moon,” when it is nearly in our line of sight to the Sun, the Moon grows, or waxes, to a crescent, then to first quarter (half lit), gibbous (somewhat football-shaped), and full. Then the Moon wanes back through gibbous, last-quarter, and crescent phases to new again. When waxing, the Moon is visible mostly in the evening. When waning, it’s best seen in the early morning hours.

In every phase except full Moon, the lunar globe is divided by the terminator, the line separating the Moon’s day and night portions. Along the terminator, the Sun is rising during the Moon ’s waxing phases, and setting when the Moon is on the wane.

Near the terminator, the lunar landscape stands out in stark relief. Mountains, craters and valleys here look especially steep and rugged,because the low Sun makes every low hill cast a long, dramatic shadow. As you look away from the terminator onto the Moon’s day side the surface appears smoother, because it’s lit by a higher Sun that casts few shadows.

Seas of Lava



Copyright 2004: Pablo Lonnie Pacheco Railey

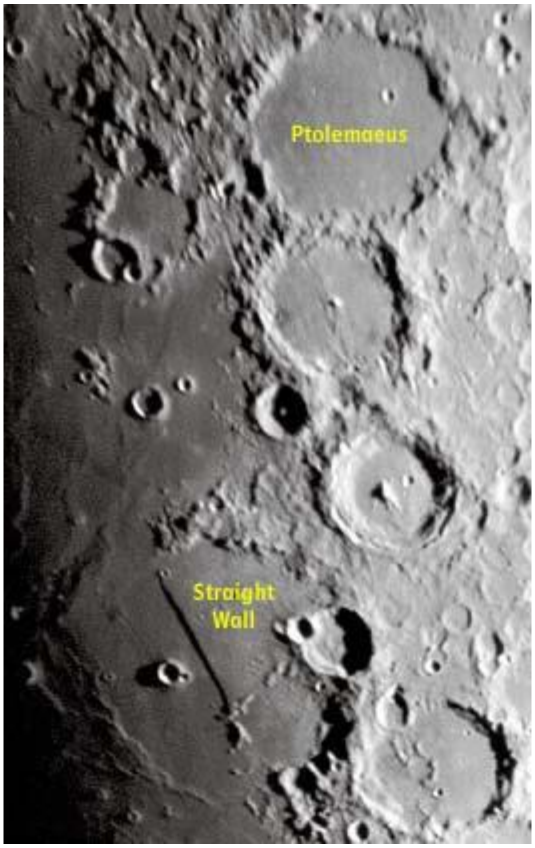
The Moon's biggest and most obvious features — visible even to the naked eye — are its large, flat, gray patches called *maria* (MAH-ree-a). This is the Latin plural of mare (MAH-ray), which means "sea." Early telescope users thought these markings might be similar to Earth's bodies of water. In 1651 the Italian astronomer Giambattista Riccioli gave them fanciful names such as Mare Tranquillitatis ("Sea of Tranquillity") and Oceanus Procellarum ("Ocean of Storms"), generally for the imagined astrological influences of the Moon's phases on the weather. Astronomers soon realized, however, that the Moon has no water — but the names stuck. In fact, the "seas" are ancient lava flows that flooded most of the Moon's lowlands between 3.8 and 3.1 billion years ago.

The Moon map here identifies the major maria. These are the Moon's most important geographical features, and even the smallest binoculars are enough for learning them. Make a point of memorizing a couple more of their names each night, and soon the geography of this new world will become as familiar as the continents of Earth.

This is especially easy to do because the Moon always shows us the same face. It does so because, long ago, the Moon's rotation period became locked to its orbital period around Earth. (Earth's gravity got hold of the Moon's most massive hemisphere and keeps it facing us all the time.) This "spin-orbit locking" is common among moons through-out the solar system.

The downside of this situation is that we never get to see the Moon's far side, unless we send spacecraft around back to look.

Impact Scars



One of the most spectacular crater chains stretches south from Ptolemaeus, near the center of the Moon. The Straight Wall is the Moon's most prominent fault. *Night Sky: Gary Seronik*

The Moon's most famous landforms, of course, are its *craters*. Practically all of these are the scars of titanic impacts by asteroids or comet heads. Most occurred more than 3.9 billion years ago during the "era of heavy bombardment" early in the solar system's history. Earth was bombarded just as heavily, but Earth's wind, water, and geologic activity have erased almost all trace of its early craters. The Moon, on the other hand, is geologically dead. We see on the Moon a record of what happened in the extremely ancient past, right there in stark view. The era of lava flooding that created the maria came later, so the maria bear fewer craters — only those caused by straggler asteroids and comets.

In fact, your telescope will show many places around the edges of the maria where the lava partially flooded preexisting craters. Sometimes the flooding was so nearly complete that only a "ghost crater" remains.

The Moon's large bright areas — the lunar highlands — are the oldest terrain, as you can see from the thick cratering still preserved here. Craters come in every possible size, from dozens or even hundreds of miles wide, down to tiny craterlets as small as your telescope can show, typically a mile or two across. You can often tell the sequence in which several craters formed by how they overlap.

A large crater often shows a central peak — a mountainous pile created when the surface rebounded after a giant impact. Other big craters, sometimes called *walled plains*, have very flat bottoms because they became flooded with lava, like small maria.

The youngest craters are surrounded by bright *rays* that extend far across the surrounding landscape. These are great splashes of rock ejected by the impacts. Unlike most lunar features, rays are best seen when they are illuminated by a high Sun far from the terminator. At full Moon, bright rays from the large, young crater Tycho (only about 110 million years old) can be seen extending far around the Moon's face.

Among the Moon's other features are mountain ranges and individual peaks. Canyonlike cracks, or *rilles*, are sometimes visible, especially around mare edges. Look carefully near the terminator and you'll see low *wrinkle ridges* winding across the maria.

How to Use a Moon Map

Every one of these features takes on its own individuality and meaning if you know its name. To do that, you'll need a Moon map and a flashlight to read it by. Many astronomy books include Moon maps, or you can buy one on our online store. But you'll need to know a trick or two to compare the map with what you see in the eyepiece — so read on.

Most maps show the Moon oriented more or less how you'll see it with the unaided eye or binoculars: with its north side up. But here's the tricky part. Many telescopes give an upside-down view, and many give a mirror-image view. Some telescopes do both. These two effects are entirely separate from each other, and you need to deal with them separately.

If you have a reflector telescope, or a refractor that you're viewing "straight through" (in a straight line from end to end), you'll see an ordinary, non-mirror image: a *correct* image. If you're using a telescope where the eyepiece fits into a right-angle attachment (a star diagonal), a *mirror image* is probably what you'll see.

To check, aim the telescope at a billboard or street sign during the daytime. Twist your head around so the sign appears more or less right-side up, and you'll see right away whether you're looking at correct writing or mirror writing.

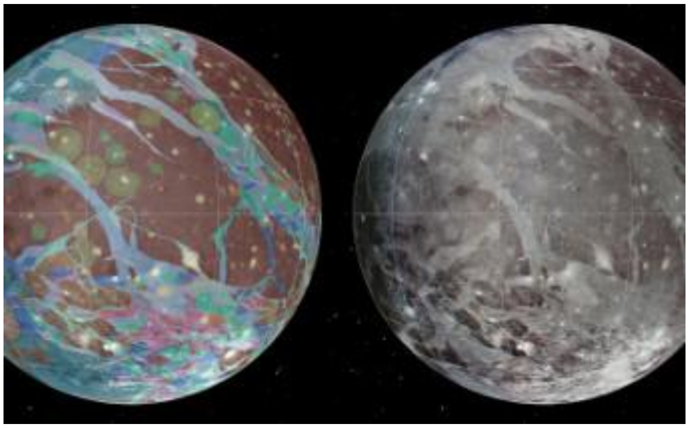
If you have a correct image, simply turn the Moon map around until its mare patterns match the patterns you see. (Never mind if the printing is upside down or at some weird angle.) You can now compare the map directly to the view in the telescope.

If you have a mirror image, you'll have to mentally flip the Moon in your eyepiece right-for-left to match the Moon on paper. Alternatively, you can buy a mirror-image Moon map. Small maps like these identify only a few of the thousands of lunar features revealed in an amateur telescope. The next step up is Antonín Rükl's larger *Field Map of the Moon* or — for true lunar enthusiasts — our highly detailed and beautiful moon globe, a three-dimensional representation of the moon built with 15,000 actual images from NASA's Lunar Reconnaissance Orbiter.

Unveiling Ganymede

Posted by Shannon Hall, February 14, 2014

Scientists have produced the first geologic map of Ganymede, the largest moon in our Solar System.



A geologic map of Ganymede provided by NASA's Voyager 1 and 2 spacecraft and NASA's Galileo spacecraft.

USGS Astrogeology Science Center / Wheaton / NASA / JPL-Caltech

If you ask me the highlight of Jupiter isn't its giant Red Spot, its windswept cloud layers, or even its sheer size, but instead its brilliant moons with their spewing volcanoes, pristine surfaces, and utter beauty.

For the first time, Ganymede, Jupiter's largest moon — and, in fact, the largest moon in the solar system (clocking in with a diameter of 3,280 miles, making it larger than the planet Mercury and almost as large as Mars) — has been fully charted.

The comprehensive map is the result of a project led by Geoffrey Collins (Wheaton College) with a little help from NASA's Voyager 1 and 2 spacecraft (flybys in 1979) and the Galileo orbiter (1995 to 2003). Although researchers had previously pieced together a global image mosaic, it fell to Collins and his team to organize the views into discrete terrain types.

The surface area of Ganymede is more than half of the land area on Earth, providing a wealth of diverse geologic features. Now planetary scientists can assess all of the incredibly varied terrain on Ganymede from an integrated perspective.

The colorful map provides detailed evidence for three periods in the colossal moon's history: an early phase where the icy crust was bombarded with meteorites, a phase dominated by great tectonic upheaval, and a late phase with a gradual drop in heat flow and further impact cratering.

You can easily see the two major terrain types: dark highly cratered regions and swaths of lighter, somewhat younger regions that crisscross 65% of the surface.

Even after decades of study, researchers can't decide whether the bright terrain, which typically is packed with long grooves and ridges, resulted from tectonic forces within the crust or from repeated outpourings of slushy ice flows from the interior. In 1996, the Galileo spacecraft discovered Ganymede's magnetic field, powered by a possible liquid iron core or a thin ocean beneath the icy crust. The latter may also lead to geologic change on the surface.

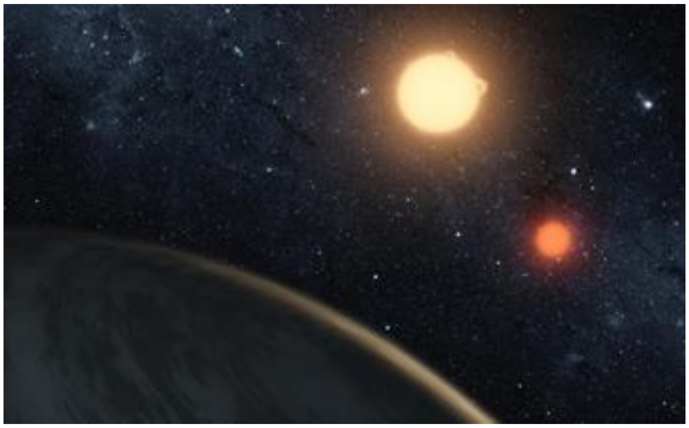
"This map illustrates the incredible variety of geological features on Ganymede and helps to make order from the apparent chaos of its complex surface," says team member Robert Pappalardo of NASA's Jet Propulsion Laboratory.

ESA’s upcoming Jupiter Icy Moons Explorer (JUICE) mission is slated to launch in 2022 and orbit Ganymede around 2032. This map will likely aid mission planning.
Ganymede is visible from Earth as one of the 4 Galilean moons seen alongside Jupiter (with Io, Europa, and Callisto). Jupiter is bright in tonight’s sky and is easy to spot with its 4 stunning moons in a decent pair of binoculars or a small telescope.
For more information read JPL’s press release or check out the detailed brochure provided by the U. S. Geological Survey.

Shedding Light on Circumbinary Systems

Posted by Shannon Hall, February 7, 2014

Astronomers are beginning to understand the unlikely formation and dangerous survival of exoplanets circling binary stars.



An artist's conception of a circumbinary exoplanet. *NASA / JPL-Caltech / T. Pyle*

Reality is catching up with science fiction. In 2011 astronomers detected a planet orbiting two stars and nicknamed it Tatooine after the fictional *Star Wars* planet. To date, six similar planets have joined the list of wacky circumbinary planets.
But even with a half dozen of these systems to study, astronomers are baffled. Binary star systems are downright dangerous. Powerful tidal forces from the two stars can easily grind a planet to dust, let alone prevent it from forming in the first place.
This week, however, two binary star systems are shedding twice the light on their circling exoplanets, providing promising clues to these exotic systems.

First case study: Kepler-34b

Research led by University of Bristol astronomers show that most circumbinary planets likely formed far away from their central stars and then migrated in at some point in their history.
Take as an example Kepler-34b. At a whopping distance of 4,900 light-years, this gaseous Saturn-like planet orbits its two Sun-like stars at 1.09 astronomical units every 289 days. The stars themselves orbit and eclipse each other every 28 days.
In order to better understand how this system formed and evolved, the team carried out two computer simulations representative of the Kepler-34 stellar system and a third of a single star system.
They began with a circumbinary protoplanetary disk: a dusty circling plane of small objects, or planetesimals,

where planets form. They then watched the disk's particles gravitationally interact with one another over time (in this case 150 years, or 2,000 binary orbits) in order to determine the likelihood that planets might form.

In all three simulations the authors included gravity between the planetesimals. Both simulations of the Kepler-34 system were identical except the first contained much larger planetesimals than the second. More massive planetesimals should be harder to disrupt.

The authors looked at three types of collisions, or "events." *Growth-enabling events* occur when two planetesimals collide and create one larger body. *Partial and catastrophic erosion events* occur when two planetesimals collide and grind each other down severely, even to dust. And *hit-and-run events* occur when two planetesimals collide and simply bounce off one another. Study coauthor Zoë Leinhardt (University of Bristol, UK) compares this event to a billiard ball hitting another billiard ball. There's minimal harm in that no mass is lost or exchanged, but there's also no growth.

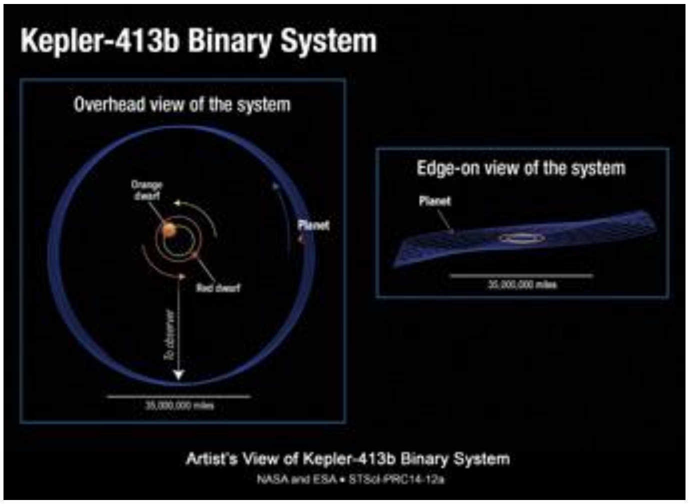
Around the single star, growth-enabling events account for 48% of the collisions, partial and catastrophic erosion events for 14% of the collisions, and hit-and-run events for 38% of the collisions.

In contrast, the collision outcomes in both simulated Kepler-34 systems vary dramatically by distance from the host stars. Super-catastrophic collisions dominate out to 1.1 a.u., leading to a hostile environment. But then partial and perfect mergers start taking over. And by 1.5 a.u., the collision occurrence rates begin converging toward that of a single star.

Given the harrowing formation environment that would have existed at Kepler-34b's current location, the planet likely formed beyond 1.5 a.u. and migrated inward. When the authors evaluated all known circumbinary planets, they found that only one planet, Kepler-47c, could have formed at its current location of 0.99 a.u.

While the research team was the first to include the self-gravity of the planetesimals and an accurate collision model, the next phase will be to include the gravitational influence of the gas in the protoplanetary disk (as opposed to only the solid planetesimals), says exoplanet researcher Hannah Jang-Condell (University of Wyoming). Leinhardt agrees this will be the next step.

Second case study: Kepler-413b



An illustration of the Kepler-413 binary system. View the original image here. *NASA / ESA / A.Feild*

A second circumbinary planet recently in the news is located a little closer to home at 2,300 light-years. Kepler-413b orbits an orange star and a red dwarf every 66 days.

But that doesn't mean this super-Neptune transits every 66 days like clockwork (most exoplanets we've detected do in fact transit consistently). Astronomers using data from NASA's Kepler mission found an unusual pattern in the transits: they saw three transits in the first 180 days, no transits throughout the next 800 days, and then five transits in a row. No visible transits should occur again for the next six years.

The main reason for this odd pattern is that the planet does not orbit the two stars in the same plane as the two stars travel in around each other. This misalignment leads to an *orbital precession* — the planet's point of closest approach to the stars slowly rotates around the system. This causes the orbit to oscillate well above and below the plane the two stars travel in around each other.

Because of this orbital precession, the incident stellar radiation on Kepler-413b varies from 0.9 times that of the Sun on the Earth to 2.7 times greater. When the exoplanet is closest to the binary star system it may be close to the primary star leading to a ton of incoming stellar radiation, or it may be close to the secondary star leading to little incoming stellar radiation, explains study coauthor Veselin Kostov (Johns Hopkins University and Space Telescope Science Institute).

This exoplanet will experience erratic changes in seasons due to drastic fluctuations in temperate from its host stars based on complex orbital dynamics.

Astronomers are still trying to explain why this planet is out of alignment with its stars. In our solar system, other planets exert gravitational influences on a single planet and cause it to precess. There could be other planets in this system, or the likely culprit could be a very powerful outside star.

References:

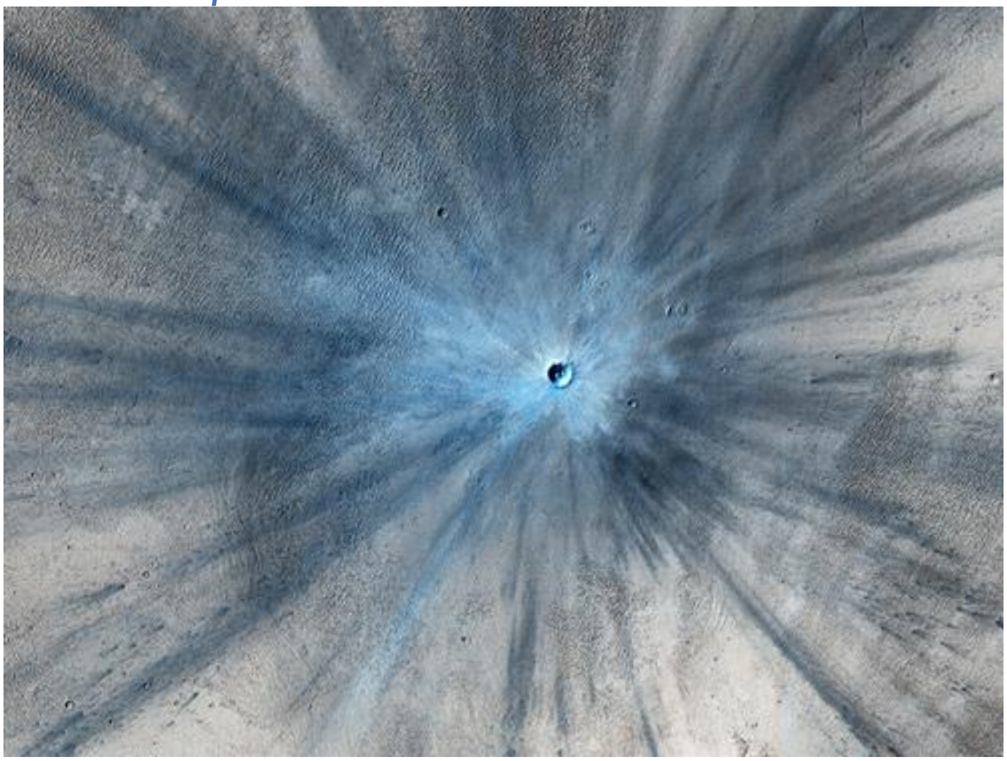
S. Lines et al. "Forming Circumbinary Planets: N-Body Simulations of Kepler-34." Astrophysical Journal Letters, 2014

V.B. Kostov et al. "Kepler-413b: a slightly misaligned, Neptune-size transiting circumbinary planet." Astrophysical Journal, 2014

New Splat on Mars

Posted by Emily Poore, February 11, 2014

NASA's Mars Reconnaissance Orbiter HiRISE camera captured this stunning image of a fresh impact on the Martian surface.



A fresh impact crater dominates this image taken by the HiRISE camera on NASA's Mars Reconnaissance Orbiter on Nov. 19, 2013. (Click image for larger version.) *NASA / JPL-Caltech / Univ. of Arizona*

Of the hundreds of space rocks that bombard the Red Planet every year, some make spectacular pockmarks in Martian soil. This new crater is no exception. Its stunning radial blast pattern was imaged on November 19, 2013 by NASA's Mars Reconnaissance Orbiter (MRO). The actual impact event occurred between July 2010 and May 2012, based on previous imaging of the area by MRO's Context Camera.

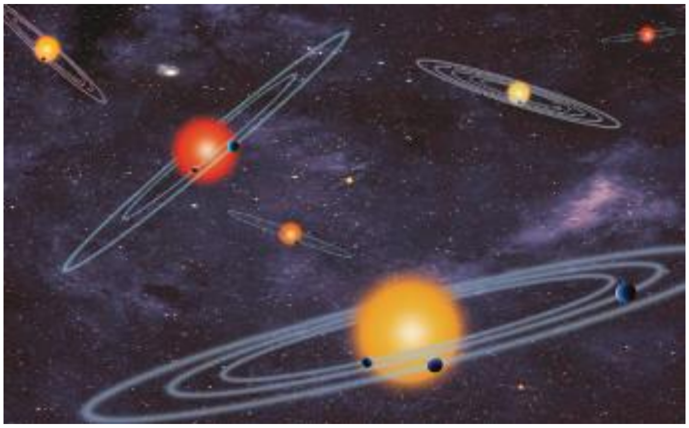
The impact site is located only 3.7° above the equator, west of the dark plain Syrtis Major. MRO used its HiRISE camera to image the area, producing the striking portrait above. The crater spans about 30 meters (100 feet), and its vibrant blast zone of bright and dark hues stretches out as far as 15 km (9.3 miles). The landscape appears blue in this enhanced-color image because the impact blew away much of Mars's reddish surface dust and blanketed the area in ejecta.

Read JPL's full press release here.

Kepler's Planets by the Hundreds

by Shannon Hall,

Old data from NASA's crippled Kepler space telescope has yielded a new windfall of confirmed exoplanets, nearly doubling the number tallied since 1992.



An artist's conception of multiple-transiting planet systems. *NASA*

NASA's Kepler space telescope is the world's most successful planet hunter and is often called one of NASA's greatest successes ever — despite the sudden end to its main mission last May. For nearly 4 years, Kepler continuously monitored 150,000 stars searching for tiny dips in their light when the silhouettes of planets crossed in front of them. Among Kepler's finds are some of the most extreme and uncanny worlds yet known. It has caught planets that nearly scrape their host star's surface, others that orbit a pair of suns, and multi-planet systems that are crammed into a space smaller than the orbit of Mercury.

Yesterday the Kepler science team broke another record by adding 715 newly confirmed exoplanets to its tally. "We have almost doubled, just today, the number of planets known to humanity," said Jack Lissauer (NASA's Ames Research Center) in a teleconference announcing the news.

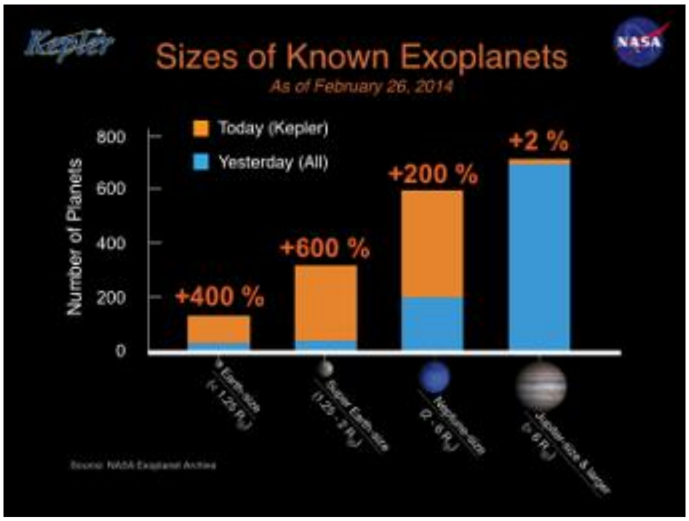
These newly verified worlds are all in multi-planet systems — dubbed "multis" — which is how they were confirmed. Most are relatively small; 95% rank as Neptunes, mini-Neptunes, super-Earths, and almost-Earths. Tantalizingly, even Kepler has a hard time detecting objects smaller than that. The new finds mark a big boost for the conclusion that small planets far outnumber giant planets, a trend that presumably holds true throughout the universe.

In a sense, however, none of the planets are new. They were all on Kepler's list of about 3,500 "planet candidates:" periodic transit-like signatures that likely indicate real worlds but may still be false alarms. In its nearly 4 years of operation Kepler recorded 30,000 seeming transits. But without additional evidence, these apparent planetary transits could only be claimed as planet "candidates."

The issue is this: there are other ways stars can produce the same slight clockwork dimmings. Binary star systems often eclipse each other. And sometimes, a normal eclipsing binary appears blended with the light of a brighter third star nearby. The result can look remarkably similar to the dimming created by a planet. In the past, confirmed planets trickled in slowly as verification usually required large ground-based telescopes to make slow, painstaking radial-velocity measurements of the star, in search for its signature gravitational wobble.

But the change came when the Kepler team verified that it could rely on a different kind of analysis. This has suddenly delivered more than 20 times as many planets as have ever previously been announced at once.

The key to this new technique, known as verification by multiplicity, is that systems in which 2 or more planet candidates transit a star are very unlikely to contain false positives. If more than 1 star were eclipsing Kepler's main target, orbital analysis shows the system would be in complete chaos and would have flung itself apart ages ago. In nearly all cases, these systems are simply too unstable to exist. Even if only 1 star were eclipsing Kepler's main target the system may be unstable.
But if more than 1 planet were eclipsing Kepler's main target, orbital analysis shows the system would be ordered and well-behaved. We know from our own Solar System that multi-planet systems can be incredibly stable.
For a multi-body (3 or more) system to remain stable there needs to be a large central mass (i.e. either 1 star or 2 closely bound binary stars) with all other masses relatively small. See animation. So the team is now confident that any Kepler-monitored star with multiple planet signatures is the real thing at about the 99% confidence level.



The histogram shows the number of planets by size for all known exoplanets. The gold bars on the histogram represent Kepler's newly-verified planets. *NASA Ames / W. Stenzel*

Not only did this free up a flood of "confirmed" exoplanets, it made it much easier to classify smaller planets as confirmed. The total number of known Earth-sized planets increased by 400%, super-Earths by 600%, and Neptunes by 200%
Excitingly, 4 of the new planets are less than 2.5 times the diameter of Earth *and* orbit in their star's habitable zones. If 4 sounds like a depressingly skimpy number compared to 715, that's because Kepler mainly finds broiling furnace worlds close to their suns. These simply have the greatest chance of causing transits from Earth's arbitrary viewpoint. Similarly large numbers likely orbit in the more clement zones a little farther out.
"Kepler has been able to showcase the diversity of planets present in our galaxy," said Sara Seager (Massachusetts Institute of Technology). It has reinforced the finding that planetary systems come in a huge variety, some drastically different from our own, and even called into question our understanding of multi-planet systems.
Nature has proven able to cram a surprising number of planets near each other in orbits smaller than Venus's or even Mercury's. The record-holder in the newly announced tally is Kepler 90: a Sun-like star with at least 7 transiting planets all circling the star within the Earth's orbit.
It's likely that planet migration played a role in the early history of these systems, or that protoplanetary disks denser than our solar system's initial disk are more common than previously thought. Massive disks not only

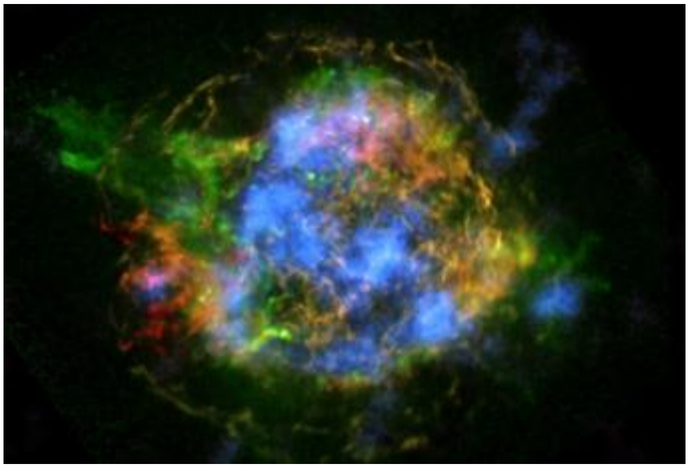
might spawn more globes, they should also make planet migration easier, since heavy disks will gravitationally interact with planets more strongly.
The 715 new confirmations were pulled only from Kepler's first 2 years of data. The next step will be to sift through the mission's entire database. Due to the longer time frame, the team expects to find hundreds more small worlds including a greater proportion in their systems' habitable zones. It naturally takes longer to catch at least 3 transits of Earth-like planets that circle their host stars once a year, compared to those that whip around their stars in just a few days.

References:
Jack J. Lissauer et al. "Validation of Kepler's Multiple Planet Candidates. II: Refined Statistical Framework and Descriptions of Systems of Special Interest" The Astrophysical Journal, in press
Jason F. Rowe et al. "Validation of Kepler's Multiple Planet Candidates. III: Light Curve Analysis & Announcement of Hundreds of New Multi-planet Systems" The Astrophysical Journal, in press

Mapping a Supernova's Radioactive Glow

Posted by Monica Young, February 21, 2014

A radioactive element produced near the heart of collapsing stars hints at the mechanism behind Cassiopeia A's supernova explosion.



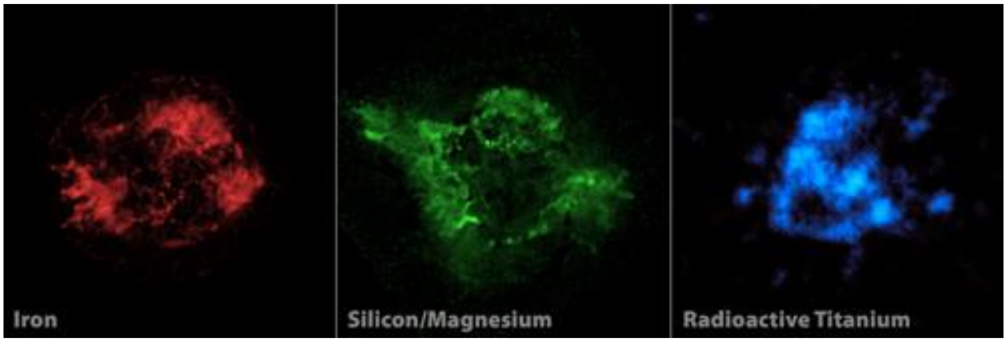
NuSTAR's observations of titanium-44's radioactive glow (blue) complement Chandra's previous X-ray observations of hot, shocked gas (red, yellow, and green). The titanium was born close to the collapsing star's core, so carries with it the echoes of the explosion's asymmetries. *NASA / JPL-Caltech / CXC / SAO*

Each massive star plays the leading role in its own tragedy. It tries desperately to stave off collapse by burning first hydrogen, then helium, then heavier elements arrayed in rainbow-like shells around a dead core. Yet the end remains inevitable: a spectacular demise as a supernova.
But unlike Shakespeare's plays, mystery shrouds this story's moment of truth. The star's core implodes in a matter of seconds, a crucial time that is nearly impossible to observe directly. So astronomers are grateful for the messy aftermath of discarded gas, which provides a window into the invisible seconds of collapse.
Now Brian Grefenstette (California Institute of Technology) and colleagues have published a brand new view

of the discarded gas nearest the core of a well-studied supernova remnant in the February 20 issue of *Nature*, observations that might hold the key for theoretical models trying to replicate reality.
"When we try to make stars explode in computer simulations, we tend to get duds," says Greffenstette. The shock wave that should rip a spherical star apart 'stalls out,' he explains, restrained by circumstellar material. Stars are generally pretty close to perfect spheres so if the shock wave is to break free, something must break the symmetry. But what?

Stellar Jet or Sloshing Star

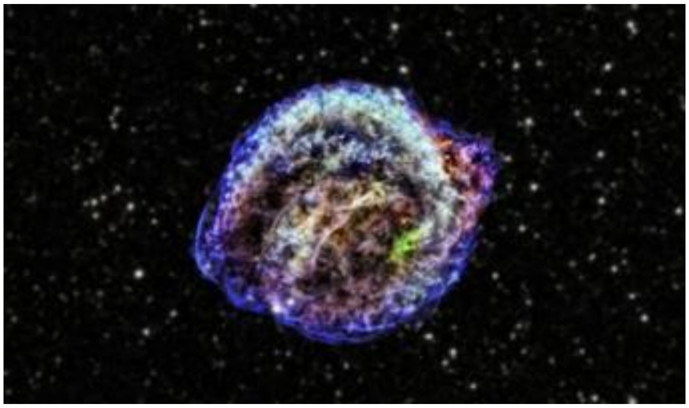
Cassiopeia A is a beautiful cascade of gases surrounding a neutron star that imploded some 300 years ago. Dozens of telescopes on the ground and in space have trained their eyes on this nearby remnant, imaging the hot, shocked gas that originated in the star's outer layers. These layers heated up as they shot outward through the material surrounding the star. But cooler gas originating closer to the star's collapsed core has so far remained invisible.
Fortunately, material doesn't have to be hot to glow. Radioactive titanium-44, which glows with high-energy X-rays, forms right at the boundary that divides the imploding stellar core from its exploding outer layers. Previous X-ray telescopes have seen this element, but haven't had the resolution to map its distribution.
Enter NuSTAR. This school-bus-size satellite stared at Cas A for 13.8 days straight to map out the faint glow of titanium-44. Grefenstette and colleagues found these X-rays radiate from clumps scattered unevenly around the remnant's center. And surprisingly, they don't align with a jet-like feature seen in previous optical and X-ray observations.



Surprisingly, the map of radioactive titanium-44 forged deep in the explosion (blue) doesn't align with the jet-like feature that appears in maps of silicon and magnesium (which are produced in the star's outer layers), nor does it align with the distribution of iron, which ought to be forged in the same place as titanium-44. *NASA / JPL-Caltech / CXC / SAO*

Some models had suggested that a jet might have ripped Cas A's star apart — a pretty good theory since evidence suggests jets are involved in more bombastic supernova explosions called long gamma-ray bursts. But if a jet emanated from the neutron star itself, titanium-44 should have clumped along the same axis.
Instead Grefenstette and colleagues argue that titanium's uneven distribution points to a subtler asymmetry: sloshing within the star itself. The star's explosion releases neutrinos, the by-products of fusion, and those tiny particles could reheat gas traveling behind the shock wave. If the star were sloshing before the explosion, that heating would be uneven, producing bubbles that poke through the material holding the shock wave back. Once the symmetry is broken, the shock wave breaks through, blowing the star apart.
And what about the jet? Grefenstette and colleagues argue that what looks like a jet is actually just holes in the material surrounding the star. The star's outer layers would have poked their way through these holes first,

producing a jet-like feature.
The team simulates two extremes to bolster their reasoning: the first models a bipolar collapse that sends a narrow jet ripping through the star, and the second models a roughly spherical collapse. Neither explains the observations, so the truth clearly lies somewhere in-between.
“One of the difficulties here is that the simulations in three dimensions are incredibly computer intensive, costing millions of hours of computer time,” Grefenstette notes. Though the sloshing-star model hasn’t been worked out for Cas A yet, simulations are underway.
“It is striking that they can make these sort of resolved measurements of the titanium-44 distribution,” says Stanley Woosley (University of California, Santa Cruz, and Lick Observatory), a supernova expert not involved in the current study. “We can expect to see a number of papers claiming to explain the result.”

Rethinking Supernova Physics
So far so good, but then the team compared NuSTAR’s titanium map with Chandra X-ray Observatory’s previous map of shocked iron. Surprisingly, the radioactive titanium and hot iron don’t align — even though standard theory says iron is produced in essentially the same location in the exploding star. Since Chandra’s exquisitely detailed map of iron in the remnant only sees those iron atoms shocked to temperatures high enough to emit X-rays, there might be more iron present that simply isn’t hot enough to be seen, but that explanation remains to be tested.


The remnant of the Type Ia supernova Johannes Kepler spotted in 1604.

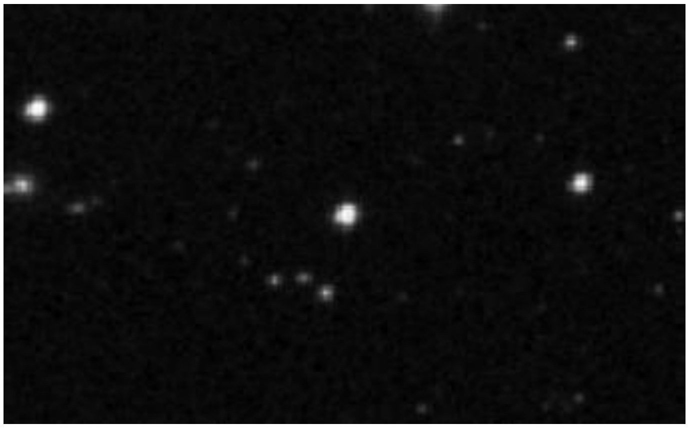
X-ray: NASA / CXC / NCSU / M.Burkey & others; Infrared: NASA / JPL-Caltech

As theorists continue to hack away at the problem with million-computer-hour simulations, the NuSTAR team is moving on to the next observations: mapping titanium in the Kepler, Tycho, and G1.9+0.3 supernova remnants, as well as the supernova recently spotted in nearby galaxy M82. These are all remains of Type Ia supernovae, where a white dwarf obliterated itself in a thermonuclear blast. Just as for the core-collapse supernova Cas A, mapping the titanium will trace the nature of these explosions.

The Purest Star Tells an Ancient Tale

Posted by Shannon Hall, February 20, 2014

Astronomers have discovered the purest star to date. Composed almost exclusively of hydrogen and helium — with 15 million times less iron than our Sun — it illuminates what happened among the first supernovae in the early universe.



SM0313 — the fuzzy blob in the center of this image — is located 6,000 light years away in the constellation Hydrus.

Digital Sky Survey

The young universe was virtually pure. Only hydrogen, helium, and a tiny trace of lithium emerged from the Big Bang nearly 13.8 billion years ago. And for hundreds of millions of years the universe was too hot to handle anything else.

But over time the universe cooled and giant clouds of the primordial elements collapsed to form the first stars. Without traces of heavier elements available to cool the gas clouds, the first "Population III" stars were extremely massive and bright, erupting as supernovae after relatively short lifetimes of just a few million years. These explosions, in turn, began seeding the young universe with heavier elements.

The cycle of star birth and death has steadily produced and dispersed more heavy elements throughout cosmic history, providing the substances necessary for rocky planets and intelligent life.

In astronomical circles we refer to all elements heavier than helium as "metals." The older a star is, the less contaminated it was at birth, and the fewer metals visible in its spectrum today.

The elements we see lacing a star's surface provide a key to understanding the supernovae (and other heavy-element factories) that preceded the star's birth. The Sun, for example, is metal-rich, with roughly 1.4% of its mass composed of elements beyond hydrogen and helium. Having formed only 4.6 billion years ago (two thirds of the way from the Big Bang to now) the Sun sprang from multiple generations of earlier stars which produced and blew off heavier elements.

But a few truly ancient stars remain: unassuming low-mass ones hidden among the millions of newer stars swarming the Milky Way. Their low metallicity betrays them, and astronomers have been patiently scanning the skies in search of them.

Now an international team of astronomers has discovered a record-breaking pure star — at least as measured by its low abundance of iron — located 6,000 light-years away in the southern constellation Hydrus. Its slightly odd colors flagged it among the 60 million other stars photographed by SkyMapper, a 1.35-meter sky-survey telescope in Australia, in its first year of operation. The team then took high-resolution spectra with the 6.5-meter Magellan Clay telescope in Chile.

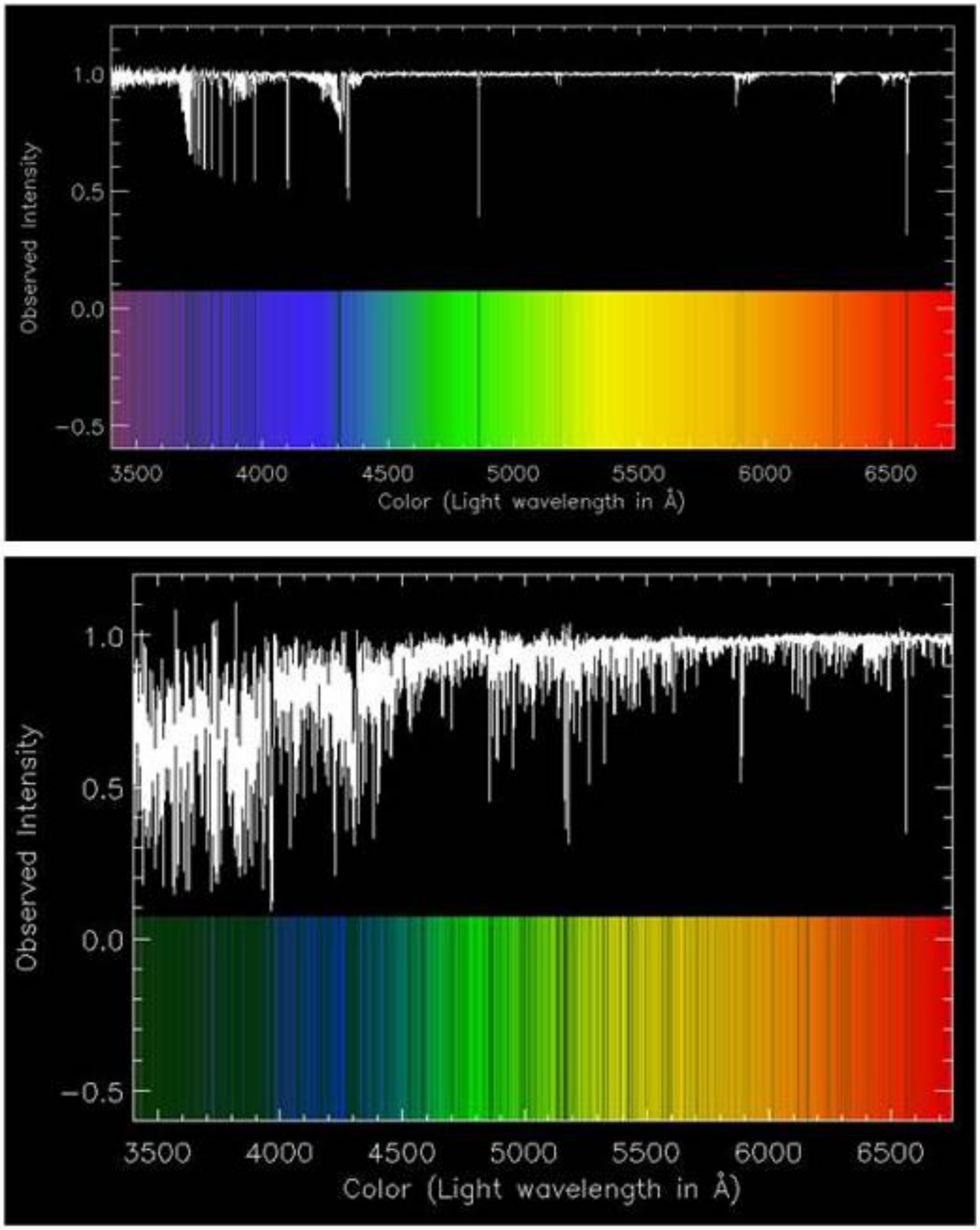
Chemically, this star — known as SMSS J031300.36-670839.3, or SM0313 for short — is the purest discovered to date, with 15 million times less iron than is in our Sun.

And that's just an upper limit. SM0313 is remarkable for the complete absence of detectable iron lines, writes lead author Stefan Keller (Australian National University). The star shows only four elements beyond hydrogen and helium: lithium, carbon, magnesium, and calcium, all of which are relatively light, and barely present in the star.

Astronomers use the Sun as a baseline for metallicity. So an iron/hydrogen ratio (denoted [Fe/H]) of zero is solar. Negative values are metal poor compared to the Sun; and positive values are metal-rich. To make it more complicated, they're expressed logarithmically.

The previous record holder had an iron abundance of [Fe/H] = –5.6, or 400,000 times less than the Sun's iron. SM0313 has an iron abundance of no more than [Fe/H] = –7.2, or 15,000,000 times less than the Sun's. That's almost 40 times lower than the most iron-starved star previously known.

Interestingly SM0313 has much more carbon, with a [C/Fe] of at least +4.5, or at least 30,000 times more carbon than iron as compared to the Sun. So SM0313 belongs to a class known as carbon-enhanced, metal-poor stars.



The upper spectrum is SM0313. The strong lines are from hydrogen (4861Å and 6560Å) and carbon (4300Å), as well as from the Earth's atmosphere (5800Å and 6300Å). The lower spectrum is a metal rich star for comparison with [Fe/H] = -0.85. The spectrum of the Sun would have even more absorption lines due to heavy elements.   *Courtesy of Anna Frebel*

Such drastically low iron and less-low carbon suggests this star was enriched by a single Population III supernova in the early universe. It is thus a second-generation star, nearly as old as the universe itself.
Prior to this discovery, astronomers believed the very first stars died in super-violent “hypernova” explosions that rapidly enriched huge volumes of space with iron. But SM0313 suggests that not all first generation supernovae were so extreme.
Computational models do show that the progenitor was likely a massive star, weighing 60 times the mass of our

Sun. After 3 million years it exploded and flung away the moderately light elements in the outer layers of its shell. The explosion, however, was not forceful enough to release the heavier contents of its inner layers, which collapsed into a black hole — trapping the expected iron.

This low-energy supernova would have exploded with the same energy as the famous SN 1987A in the Large Magellanic Cloud. But SN 1987A was only 18 times the mass of the Sun, so for a 60-solar-mass star, this energy would have been abnormally weak.

Its carbon-enhanced, iron-poor blast wave must have then helped SM0313 to coalesce quickly nearby, as there seem to be no contributions from other supernovae.

This was also unexpected. Typically we would expect star-forming sites to be huge and influenced by multiple supernovae, preventing the single-blast abundance pattern we see in SM0313.

While some have called SM0313 the *oldest* known star, we can't actually determine an exact age, says coauthor Anna Frebel (Massachusetts Institute of Technology). A record-breaking age is not the takeaway message here. Rather, the star provides a bold new look into the first supernova explosions that seeded surprisingly light elements into the young universe. "It's very exciting that we can establish SM0313 as a second-generation star," says Frebel.

The iron-starved star has started to expose a story nearly lost more than 13 billion years ago.

References:

S. C. Keller et al. "A single low-energy, iron-poor supernova as the source of metals in the star SMSS J 031300.36-670839.3" Nature, 2014

Seeing the Skies Through Galileo's Eyes

16 February 2014 12:30 pm

Dioptrice

Tool of the trade. A 1692 depiction of Galileo (*left*) and other astronomers, included in a new database of early refracting telescopes.

CHICAGO, ILLINOIS—When Galileo Galilei shook up the scientific community with evidence of a heliocentric world, he had a little tube fitted with two pieces of glass to thank. But just how this gadget evolved in the nascent days of astronomy is poorly known. That uncertainty has inspired a group of researchers to compile the most extensive database of early refracting telescopes to date, presented here yesterday during a poster session at the annual meeting of AAAS, which publishes *Science*. Now, the scientists plan to use modern optics to recreate what Galileo—and the naysaying observers of his time—experienced when they first peered through these tubes at the rings of Saturn, the moons of Jupiter, and the phases of Venus.

The database, called Dioptrice, went online earlier this month. It contains records of about 1300 telescopes—mostly physical artifacts from museums and private collections, but also descriptions in books and depictions in art—that date from 1610 to 1775. Those years marked a formative period for the telescope, explains Stephen

Case, a science historian and graduate student at the University of Notre Dame in Indiana who helped compile Dioptrice. For the last 2 and a half years, he has pored over books in attic of Chicago's Adler Planetarium and tracked down telescopes in museum catalogs from galleries around the world.

The first phase of the project involved documenting the origin and design of each telescope. Case and his colleagues concluded that most were used for military purposes, such as spotting distant ships or approaching troops, or were simply collected as status symbols, before they achieved widespread scientific use.

But phase two will look deeper at the optical abilities of the telescopes. Their designers weren't yet able to make perfectly curved class, so the lenses had jagged edges and a small field of view. And until the mass production of the achromatic lens around 1775, they couldn't correct for the fact that different wavelength of light refract at different angles and cause a blurry image at the focal point. Yet the crude setup inspired a string of eureka moments. "Galileo suddenly could see the phases of Venus," Case says. "He could see the moons orbiting around Jupiter. He suddenly had evidence for the heliocentric cosmology."

To precisely test how these devices transmitted distant light, the group will use adaptive optics—the technology behind today's large telescopes. These rely on a grid of deformable mirrors that tilt to adjust for the light-bending turbulence of the atmosphere. The researchers will essentially run that process in reverse, Case says, feeding a light source with a grid structure into the telescope and observing how that grid gets distorted when passing through 400-year-old glass. If the light source is an image of Saturn or Jupiter, Case explains, you can "get out on the other end what that telescope would have shown you."

Such tests could reveal whether a given telescope could conceivably show a separation between the rings of Saturn, for example. But Case points out that what a scientist perceived in these instruments also depended on his trained eye and his sense of what to look for. In other words, no adaptive optics system can account for a given stargazer's interpretation, or apply the Galileo filter.

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