The Monthly Newsletter of the Bays Mountain Astronomy Club

Edited by Adam Thanz

April 2017
Chapter 1

Looking Up

Brandon Stroupe - BMAC Chair
Hello BMACers,

It is now April and the year is just zooming right along. We are more than a quarter into the year and one step closer to warmer weather. We are also getting ever so closer to the year’s biggest celestial event. Of course, I am talking about the Total Solar Eclipse coming up on August 21st. Whether you are accompanying Bays Mountain on their excursion or taking a trip of your own, most of us plan on spending that day staring at our very own star. Of course, we are all going to do it the safe way, right? I sure hope so. [Ed.: If you don’t have your solar glasses for safe, cool viewing, then come by the gift shop. We have them for $2 each.] I know I am looking forward to this event. I have never seen a Total Solar Eclipse before and hopefully the weather will cooperate so I can experience it with everyone else. Keep your fingers crossed and try to summon good, clear weather. I know I will.

At our March meeting, we featured our very own Robin Byrne. Her presentation was entitled, “A Trip Through Poland’s Scientific History.” A conference in Warsaw gave Robin and Adam the opportunity to explore Poland and visit many sites commemorating Polish scientists. Although Copernicus dominated, there were others waiting to be discovered, as well. Robin showed a lot of pictures reflecting the astronomy background of the people during that time. She also shared the experience, the history, and several major players in the development of astronomy as we know today. It was a very interesting program. Robin is an Associate Professor of Astronomy in the Science Department at Northeast State Community College in Blountville, TN. She has been a member of the Bays Mountain Astronomy Club since 1992 and has been chairperson of the club as well. She also writes an ongoing science column in this very newsletter every month. Robin always gives a very entertaining and knowledge-filled presentation and this time was no different. If you were unable to attend, be sure to check out one of her presentations in the future.

At our meeting this month, we will be in the planetarium for a special showing of “Comets & Discovery” and a constellation shootout to get everyone primed for StarWatch viewings.
Ursa Major, the Big Bear
Image from Stellarium
Layout by Adam Thanz
For our constellation this month, we will be talking about Ursa Major. This is probably the most well-known constellation other than Orion. Ursa Major is translated as the Greater Bear. Most of us call it the Big Dipper even though the stars of the Big Dipper make up only part of the whole constellation. There are a lot of different myths about Ursa Major. One of the more interesting ones I have found is one of Roman mythology. According to Roman mythology, Jupiter lusted after a young woman named Callisto and Juno, who is Jupiter’s jealous wife. She discovers that Callisto has a son named Arcas and she believes that Jupiter is the father. So, Juno then transforms Callisto into a bear so Jupiter will no longer find her attractive. Callisto, while in bear form, later encounters her son Arcas and he almost shoots the bear. So, Jupiter turns Arcas into a bear too so this would not happen again. He placed them both in the sky forming Ursa Major and Ursa Minor. I found this to be a very interesting myth. As for the deep sky objects that Ursa Major has within it, there are plenty to choose from. There are about 9 galaxies the lie within this constellation. Some of the more notable ones are M81 and M82, which are sometimes referred to as Bode’s Galaxy and the Cigar Galaxy. Another well-known galaxy is M101, which is known as the Pinwheel Galaxy. Finally, there is also a really cool planetary nebula located within Ursa Major. It is M97, the Owl Nebula. Needless to say, there is plenty to look at when looking at this constellation. Be sure to get out there and look at Ursa Major just a little bit closer.

That will be it for this month. Just a reminder that the StarWatches are in full swing now. The SunWatches are as well. We do encourage volunteers to come up and help run the scopes and talk to the visitors about our night sky. If you come up, please arrive about 30 minutes before dusk to help setup. We look forward to these public events so we can show everyone how awesome our night sky is. Please do not forget that Astronomy Day is coming up on April 29. We are still trying to finalize the complete plan for the displays we will be showing the public. And as always, we will have the observatories open to the public that night as well. If you have any ideas on how we can share our wonderful hobby with the public or you would like to volunteer to work one the tables, please contact me, William Troxel, Adam Thanz, or Jason Dorfman. I look forward to seeing you all there. Until next month… Clear Skies.
Chapter 2

BMAC Notes
BMAC Youtube!
The BMAC has a YouTube channel. Click here to see what's on!

(https://www.youtube.com/channel/UCwIQM6nUs9qxJtDQe4AaAWQ)

There are now four entries in our channel. Check them out!

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Chapter 3

Celestial Happenings

Jason Dorfman
Greetings fellow sky watchers! First, I’d like to start with a big “Thank You!” to Adam Thanz for filling in for me with last month’s article. February turned into a fairly hectic month for me and I appreciate Adam helping me out. Also, as a side-note, we have finished production on our new program called “Totality!” It will be our main show in the planetarium starting this month on April 18th. We feel that it is one of our best shows yet, so be sure to check it out.

With April, Spring is officially here. Though, as I write this, it is 24°F outside! I think Spring and Winter have been battling for supremacy since January and apparently we don’t have a clear winner, yet. Hopefully, the month of April will bring some more consistent and pleasant weather. Looking to the skies above, April does hold some good planet observations, a comet, a meteor shower and the beginnings of a rich field of galaxies for observation.

Planets

The month of April opens with a great opportunity to observe the planet Mercury. This swift and somewhat elusive world reaches its greatest eastern elongation on the 1st when it will appear 19° from the Sun. It will be 12° above the horizon about a half hour after sunset. At magnitude -0.1, it should be easy to find, as long as the weather cooperates. Though Mercury will be visible for just over a week, don’t wait too long to take a look. By the 8th, its magnitude will fade to +1.6 and it will be a bit lower in the sky as it begins its swift trek back towards the bright glare of the setting Sun. Looking through a telescope on the 1st, you can see the 8” diameter disk at about 40% illumination. By the 8th, the disk diameter will increase slightly to 9” but the illumination will drop to just 16%. Mercury will reach inferior conjunction, the point in its orbit when it is between the Sun and Earth, on the 20th.

The red planet, Mars, continues to shine in the west after sunset. Mars will move from Aries into Taurus on the 12th. It remains about magnitude +1.5 for most of the month and is just a small blob in a telescope. The highlight for Mars observations this month will be the 20th-22nd when it passes just 3° from the Pleiades star cluster. By month’s end, it will be passing between the Pleiades and Hyades clusters in Taurus. On the 27th and
28th, there will also be a thin crescent Moon making it’s way through Taurus. This should make for a nice pairing.

The planetary spotlight shines brightest on Jupiter this month. Jupiter reaches opposition on the 7th, the position in it’s orbit when it is directly opposite the Sun from the Earth. At opposition, it will be just 414 million miles from Earth. This opposition, however, occurs close to Jupiter being at aphelion, it’s furthest distance from the Sun. The disk of Jupiter spans about 44” along the equator, which is only slightly less than the roughly 50” seen when Jupiter is at perihelion, so we’ll still have some spectacular views. There are many interesting features to notice when observing the “king of the planets.” Jupiter is a gas giant made mostly of hydrogen and helium, so what we observe is it’s enormous atmosphere. Jupiter has a fast rotation of just under 10 hours. This has created a very turbulent atmosphere consisting of colorful bands and many circular storms. The bands are split into bright areas called zones and dark areas called belts and are the easiest features to notice even in poor seeing conditions. For a more challenging observation, try to notice the Great Red Spot, Jupiter’s largest storm system that has been churning in its southern hemisphere for at least hundreds of years. Don’t worry if you don’t see it at first, it may be on the far side of the planet but, with Jupiter’s fast rotation, should be visible within a few hours. Another feature to notice which is also due to Jupiter’s fast rotation, is that the planet appears to be squashed. The polar diameter is smaller than the equatorial diameter.

Jupiter has many, many moons. 67 at last count, of which only 53 have been officially named. Most are captured asteroids. The four largest are known as the Galilean moons in honor of Galileo, who first observed and deduced that these points of light were indeed satellites of Jupiter. They are Io, Europa, Ganymede and Callisto, in order of distance from Jupiter. See if you can notice all four. To determine which moon is which, refer to one of the helpful diagrams found in either Astronomy or Sky & Telescope magazines. Because we are looking edge on to the orbital planes of the moons, we can often see the inner 3 casting shadows onto the surface of Jupiter. The moons orbit rather quickly, so you’re guaranteed a different sight from night to night. Also, don’t forget that the Juno spacecraft is currently in orbit about Jupiter. Check out the mission website for some new close up views of Jupiter: missionjuno.swri.edu.

If you’re an early riser, check out Saturn and Venus. Saturn rises about 1:30 a.m. at the start of the month and is located in Sagittarius. It will be highest in the south during the pre-dawn hours. Venus rises an hour before sunrise and will be exhibiting the reverse of what we saw in the evening sky in February. It begins the month at magnitude -4.2 and is quite close with a 58” diameter disk, but it only shows 3% illumination. By month’s end, it will reach peak brightness at magnitude -4.7. Though the disk diameter will have shrunk to 38”, the illuminated portion will have increased to 26%. Venus will dominate the morning skies for the
next few months as it journeys on to its greatest western elongation in June.

Luna

As the month of April opens, we find a thin crescent Moon in the west just above and left of Aldebaran. On the evening of the 6th/7th, a waxing gibbous Moon will make a nice pairing with Regulus in Leo. Full moon is on the 10th and occurs when the Moon is just 3° from Jupiter. The Moon makes another close pairing with a planet on the morning of the 16th when you'll see a waning gibbous about 4-5° to the upper right of Saturn.

Comet 41P/Tuttle-Giacobini-Kresak

I think some of you have already been paying attention to this comet. It is currently about 10th magnitude, but will be peaking this month and could become quite spectacular. Comet 41P will pass closest to Earth on the 1st and closest to the Sun on the 13th. Look for it in Draco, the dragon, in the North. It will be passing near α Draco (alpha) between the handle of the Big Dipper and the cup stars of the Little Dipper. Conservative estimates have it brightening to 8th magnitude but optimistic predictions see it potentially reaching 5th magnitude, which would make it naked-eye visible under dark skies. Obviously, comets are very unpredictable, so it could go either way. This comet has had outbursts in the past, however, so we could be in for a real show. In 1973, the surface of the comet cracked and released large amounts of gas and dust for a couple of weeks resulting in outbursts of 10 magnitudes!

Lyrids Meteor Shower

Though it's not often considered a prominent annual shower, “the Lyrids will be the major active meteor shower!” (IMO.net) for Spring and Summer this year. The Lyrids are best observed on the three nights around the peak, which is on the evening of the 22nd/23rd when the Moon will be a thin waning crescent. The radiant is in the constellation of Lyra, the harp, which will be highest in the pre-dawn hours after 2 a.m. The predicted rate or ZHR (zenithal hourly rate) is 18 per hour. Lyrids normally lack persistent tails but can produce some fireballs. With a bright gibbous Moon once again getting in the way during the peak for the Perseids in August, this may be the shower worth making the trip outside.

Well, this has turned into quite the long article. Hopefully, I’ve provided you with enough goodies to look at to keep you busy for the month. Wishing you all clear skies!
Chapter 4

The Queen Speaks

Robin Byrne
This month we celebrate the life of a man who helped us to better understand our galaxy and the formation of stars, and who enjoyed sharing his discoveries with all the people. Bartholomeus Jan Bok was born April 28, 1906 in Hoorn, Holland. His interest in astronomy began at an early age, and by the time he was 13, he knew he would be an astronomer. While in high school, Bart was active in an astronomy club and wrote an astronomy article for The Hague’s newspaper.

In 1924, Bart Bok entered the Sterrewacht in Leiden to study astronomy. Among his teachers were Ejnar Hertzsprung and Jan Oort. In 1927, he began his graduate work in Groningen. The following year, Bok attended the Third General Assembly of the International Astronomical Union, where he met two people who would change his life. First, he met Harlow Shapley, whom Bok had admired since childhood. Shapley invited Bok to come to Harvard to continue his graduate work, which he did the next year. Second, Bart met Priscilla Fairfield, an American astronomer. After much persuasion on Bok’s part, they married on September 9, 1929, only two days after Bok arrived in the United States. Bok completed his PhD in July of 1932.

Bart Bok stayed on at Harvard for the next 25 years. While there, his research concentrated on the structure of the Milky Way. He and Priscilla worked together as a team on such areas as the structure and evolution of star clusters and mapping the spiral arms of the Milky Way. His study of interstellar gas and dust led to studying star formation. In particular, Bok was interested in small dark nebulae where star formation occurs. These dark regions are now known as Bok globules. While at Harvard, Bok initiated a program in radio astronomy, which he also promoted elsewhere. Bok helped to establish the National Radio Astronomy Observatory program.

Bok enjoyed teaching both undergraduate and graduate courses. He especially enjoyed the introductory level courses, where his enthusiastic teaching style grabbed the attention of several students who went on to major in astronomy. Bok felt it was important to popularize astronomy and make it accessible to everyone. In 1941, Bart and Priscilla published their book, “The Milky Way.”

In 1955, Bart and Priscilla moved to Australia, where Bok was given the position of director of the Mount Stromlo Observatory.
Here, he encouraged work in both the radio and optical wavelengths and oversaw the establishment of the Anglo-Australian Observatory at Siding Springs. Bok also established the Graduate School of Astronomy at the university. Bok's presence attracted a number of American scientists to do their research in Australia, including Walter Baade, Harlow Shapley, Paul Hodge, and a former professor of mine and Adam’s, Frank Bradshaw Wood, who was known to start a story with the immortal line, “I remember, back in Australia…”

In 1966, Bart and Priscilla returned to the United States, where Bok took the position of director of the Steward Observatory at the University of Arizona. Here he continued working on regions of star formation. After Priscilla’s death in 1975, Bok cut back on many of his activities. He was finally brought back into action as he became involved with the development of what was then called the NASA Large Space Telescope, but which we now know as the Hubble Space Telescope. This was Bok’s last big project. Bart Bok died August 5, 1983 at the age of 77, although he was very active and continued to be involved with research up to the very end.

When I was in graduate school, “Bok and Bok” was synonymous with all there was to know about galaxies, and their writings were considered required reading for any respectable galaxy course. Although Bart and Priscilla brought so much new knowledge about our Milky Way to the scientific community, like so many successful scientists, Bok felt that an equally important part of his career involved bringing astronomy to all the people, not just the academics. In many ways his last project, the Hubble Space Telescope, embodies Bok’s philosophy and life. HST has brought about a tremendous amount of scientific understanding about our own galaxy, as well as others. But the images from Hubble have also made astronomy accessible to the general public by sharing the beauty of our Universe and the mysteries that make astronomy so enjoyable. I think Bart Bok would be very pleased.

References:
Bright Sparcs-The 1997 Australian Science Festival Important Scientists Web Page
http://www.asap.unimelb.edu.au/bsparcs/other/asf_scientists.htm#bart
http://books.nap.edu/books/0309049784/html/72.html#pagetop
Chapter 5

Space Place
With seven Earth-sized planets that could harbor liquid water on their rocky, solid surfaces, the TRAPPIST-1 planetary system might feel familiar. Yet the system, recently studied by NASA’s Spitzer Space Telescope, is unmistakably alien: compact enough to fit inside Mercury’s orbit, and surrounds an ultra-cool dwarf star—not much bigger than Jupiter and much cooler than the Sun.

If you stood on one of these worlds, the sky overhead would look quite different from our own. Depending on which planet you’re on, the star would appear several times bigger than the Sun. You would feel its warmth, but because it shines stronger in the infrared, it would appear disproportionately dim.

“It would be a sort of an orangish-salmon color—basically close to the color of a low-wattage light bulb,” says Robert Hurt, a visualization scientist for Caltech/IPAC, a NASA partner. Due to the lack of blue light from the star, the sky would be bathed in a pastel, orange hue.

But that’s only if you’re on the light side of the planet. Because the worlds are so close to their star, they’re tidally locked so that the same side faces the star at all times, like how the Man on the Moon pattern always faces Earth. If you’re on the planet’s dark side, you’d be enveloped in perpetual darkness—maybe a good thing if you’re an avid stargazer.

If you’re on some of the farther planets, though, the dark side might be too cold to survive. But on some of the inner planets, the dark side may be the only comfortable place, as the light side might be inhospitably hot.

On any of the middle planets, the light side would offer a dramatic view of the inner planets as crescents, appearing even bigger than the moon on closest approach. The planets only take a few days to orbit TRAPPIST-1, so from most planets, you can enjoy eclipses multiple times a week (they’d be more like transits, though, since they wouldn’t cover the whole star).

Looking away from the star on the dark side, you would see the outer-most planets in their full illuminated glory. They would be so close—only a few times the Earth-Moon distance—that you could see continents, clouds, and other surface features.

The constellations in the background would appear as if someone had bumped into them, jostling the stars—a perspective skewed by the 40-light-years between TRAPPIST-1 and Earth. Orion’s belt is no longer aligned. One of his shoulders
would be lowered.

And, with the help of binoculars, you might even spot the Sun as an inconspicuous yellow star: far, faint, but familiar.

Want to teach kids about exoplanets? Go to the NASA Space Place and see our video called, “Searching for Other Planets Like Ours:” https://spaceplace.nasa.gov/exoplanet-snap/

This article is provided by NASA Space Place. With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit spaceplace.nasa.gov to explore space and Earth science!
Chapter 6

BMAC
Calendar
and more

More on this image. See FN7
## BMAC Calendar and more

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<th>Date</th>
<th>Time</th>
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<th>Notes</th>
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<tbody>
<tr>
<td><strong>BMAC Meetings</strong></td>
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<tr>
<td>Friday, April 7, 2017</td>
<td>7 p.m.</td>
<td>Planetarium</td>
<td>Program: Join us in the planetarium for a special showing of “Comets &amp; Discovery” and a constellation shootout.; Free.</td>
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<tr>
<td>Friday, May 5, 2017</td>
<td>7 p.m.</td>
<td>Nature Center Discovery Theater</td>
<td>Program: Topic TBA; Free.</td>
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<tr>
<td>Friday, June 2, 2017</td>
<td>7 p.m.</td>
<td>Nature Center Discovery Theater</td>
<td>Program: Topic TBA; Free.</td>
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<tr>
<td><strong>SunWatch</strong></td>
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<td>Every Saturday &amp; Sunday March - October</td>
<td>3-3:30 p.m. if clear</td>
<td>At the dam</td>
<td>View the Sun safely with a white-light view if clear.; Free.</td>
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<tr>
<td><strong>StarWatch</strong></td>
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<tr>
<td>Mar. 4, 11, 2017</td>
<td>7:00 p.m.</td>
<td>Observatory</td>
<td>View the night sky with large telescopes. If poor weather, an alternate live tour of the night sky will be held in the planetarium theater.; Free.</td>
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<tr>
<td>Mar. 18, 25, 2017</td>
<td>8:00 p.m.</td>
<td>Observatoy</td>
<td>View the night sky with large telescopes. If poor weather, an alternate live tour of the night sky will be held in the planetarium theater.; Free.</td>
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<tr>
<td>Apr. 1, 8, 15, 22, 29, 2017</td>
<td>8:30 p.m.</td>
<td>Observatory</td>
<td>View the night sky with large telescopes. If poor weather, an alternate live tour of the night sky will be held in the planetarium theater.; Free.</td>
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<tr>
<td><strong>Special Events</strong></td>
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<tr>
<td>Saturday, April 29, 2017</td>
<td>1-4:30 p.m.</td>
<td>Nature Center &amp; Observatory</td>
<td>Annual Astronomy Day - Displays et al. on the walkway leading to the Nature Center, 1-4:30 p.m.; Solar viewing 3-4 p.m. at the dam; Night viewing 8:30-10 p.m. at the observatory. All non-planetarium astronomy activities are free.</td>
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Annual Dues:

Dues are supplemented by the Bays Mountain Park Association and volunteerism by the club. As such, our dues can be kept at a very low cost.

$16 /person/year

$6 /additional family member

Note: if you are a Park Association member (which incurs an additional fee), then a 50% reduction in BMAC dues are applied.

The club’s website can be found here:

www.baysmountain.com/astronomy/astronomy-club/

Regular Contributors:

Brandon Stroupe

Brandon is the current chair of the club. He is a photographer for his home business, Broader Horizons Photography and an avid astrophotographer. He has been a member since 2007.

Robin Byrne

Robin has been writing the science history column since 1992 and was chair in 1997. She is an Associate Professor of Astronomy & Physics at Northeast State Community College (NSCC).

Jason Dorfman

Jason works as a planetarium creative and technical genius at Bays Mountain Park. He has been a member since 2006.

Adam Thanz

Adam has been the Editor for all but a number of months since 1992. He is the Planetarium Director at Bays Mountain Park as well as an astronomy adjunct for NSCC.
The novel illumination geometry that accompanies equinox lowers the sun's angle to the ring plane, significantly darkens the rings, and causes out-of-plane structures to look anomalously bright and to cast shadows across the rings. These scenes are possible only during the few months before and after Saturn's equinox which occurs only once in about 15 Earth years. Before and after equinox, Cassini's cameras have spotted not only the predictable shadows of some of Saturn's moons (see PIA11657), but also the shadows of newly revealed vertical structures in the rings themselves (see PIA11665).

Also at equinox, the shadows of the planet's expansive rings are compressed into a single, narrow band cast onto the planet as seen in this mosaic. (For an earlier view of the rings' wide shadows draped high on the northern hemisphere, see PIA09793.)

The images comprising the mosaic, taken over about eight hours, were extensively processed before being joined together. First, each was re-projected into the same viewing geometry and then digitally processed to make the image “joints” seamless and to remove lens flares, radially extended bright artifacts resulting from light being scattered within the camera optics.

At this time so close to equinox, illumination of the rings by sunlight reflected off the planet vastly dominates any meager sunlight falling on the rings. Hence, the half of the rings on the left illuminated by planetshine is, before processing, much brighter than the half of the rings on the right. On the right, it is only the vertically extended parts of the rings that catch any substantial sunlight.

With no enhancement, the rings would be essentially invisible in this mosaic. To improve their visibility, the dark (right) half of the rings has been brightened relative to the brighter (left) half by a factor of three, and then the whole ring system has been brightened by a factor of 20 relative to the planet. So the dark half of the rings is 60 times brighter, and the bright half 20 times brighter, than they would have appeared if the entire system, planet included, could have been captured in a single image.

The moon Janus (179 kilometers, 111 miles across) is on the lower left of this image. Epimetheus (113 kilometers, 70 miles across) appears near the middle bottom. Pandora (81 kilometers, 50 miles across) orbits outside the rings on the right of the image. The small moon Atlas (30 kilometers, 19 miles across) orbits inside the thin F ring on the right of the image. The brightnesses of all the moons, relative to the planet, have been enhanced between 30 and 60 times to make them more easily visible. Other bright specks are background stars. Spokes -- ghostly radial markings on the B ring -- are visible on the right of the image.

This view looks toward the northern side of the rings from about 20 degrees above the ring plane. The images were taken on Aug. 12, 2009, beginning about 1.25 days after exact equinox, using the red, green and blue spectral filters of the wide angle camera and were combined to create this natural color view. The images were obtained at a distance of approximately 847,000 kilometers (526,000 miles) from Saturn and at a Sun-Saturn-spacecraft, or phase, angle of 74 degrees. Image scale is 50 kilometers (31 miles) per pixel.

The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA’s Science Mission Directorate, Washington, D.C. The Cassini orbiter and its two onboard cameras were designed, developed and assembled at JPL. The imaging operations center is based at the Space Science Institute in Boulder, Colo.


Image Credit: NASA/JPL/Space Science Institute

2. Duke on the Craters Edge

Astronaut Charles M. Duke Jr., Lunar Module pilot of the Apollo 16 mission, is photographed collecting lunar samples at Station no. 1 during the first Apollo 16 extravehicular activity at the Descartes landing site. This picture, looking eastward, was taken by Astronaut John W. Young, commander. Duke is standing at the rim of Plum crater, which is 40 meters in diameter and 10 meters deep. The parked Lunar Roving Vehicle can be seen in the left background.

Image AS16-114-18423

Creator/Photographer: NASA John W. Young

3. The Cat’s Eye Nebula, one of the first planetary nebulae discovered, also has one of the most complex forms known to this kind of nebula. Eleven rings, or shells, of gas make up the Cat’s Eye. Credit: NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA)

Acknowledgment: R. Corradi (Isaac Newton Group of Telescopes, Spain) and Z. Tsvetanov (NASA)

4. Jupiter & Ganymede

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Footnotes:

1. The Rite of Spring

Of the countless equinoxes Saturn has seen since the birth of the solar system, this one, captured here in a mosaic of light and dark, is the first witnessed up close by an emissary from Earth … none other than our faithful robotic explorer, Cassini.

See from our planet, the view of Saturn's rings during equinox is extremely foreshortened and limited. But in orbit around Saturn, Cassini had no such problems. From 20 degrees above the ring plane, Cassini’s wide angle camera shot 75 exposures in succession for this mosaic showing Saturn, its rings, and a few of its moons a day and a half after exact Saturn equinox, when the sun’s disk was exactly overhead at the planet’s equator.

The moon Janus (179 kilometers, 111 miles across) appears near the middle bottom. Pandora (81 kilometers, 50 miles across) orbits outside the rings on the right of the image. The small moon Atlas (30 kilometers, 19 miles across) orbits inside the thin F ring on the right of the image. The brightnesses of all the moons, relative to the planet, have been enhanced between 30 and 60 times to make them more easily visible. Other bright specks are background stars. Spokes -- ghostly radial markings on the B ring -- are visible on the right of the image.

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Image Credit: NASA/JPL/Space Science Institute
NASA’s Hubble Space Telescope has caught Jupiter’s moon Ganymede playing a game of "peek-a-boo." In this crisp Hubble image, Ganymede is shown just before it ducks behind the giant planet.

Ganymede completes an orbit around Jupiter every seven days. Because Ganymede’s orbit is tilted nearly edge-on to Earth, it routinely can be seen passing in front of and disappearing behind its giant host, only to reemerge later.

Composed of rock and ice, Ganymede is the largest moon in our solar system. It is even larger than the planet Mercury. But Ganymede looks like a dirty snowball next to Jupiter, the largest planet in our solar system. Jupiter is so big that only part of its Southern Hemisphere can be seen in this image.

Hubble’s view is so sharp that astronomers can see features on Ganymede’s surface, most notably the white impact crater, Tros, and its system of rays, bright streaks of material blasted from the crater. Tros and its ray system are roughly the width of Arizona.

The image also shows Jupiter’s Great Red Spot, the large eye-shaped feature at upper left. A storm the size of two Earths, the Great Red Spot has been raging for more than 300 years. Hubble’s sharp view of the gas giant planet also reveals the texture of the clouds in the Jovian atmosphere as well as various other storms and vortices.

Astronomers use these images to study Jupiter’s upper atmosphere. As Ganymede passes behind the giant planet, it reflects sunlight, which then passes through Jupiter’s atmosphere. Imprinted on that light is information about the gas giant’s atmosphere, which yields clues about the properties of Jupiter’s high-altitude haze above the cloud tops.

This color image was made from three images taken on April 9, 2007, with the Wide Field Planetary Camera 2 in red, green, and blue filters. The image shows Jupiter and Ganymede in close to natural colors.

Credit: NASA, ESA, and E. Karkoschka (University of Arizona)

5. 47 Tucanae

In the first attempt to systematically search for “extrasolar” planets far beyond our local stellar neighborhood, astronomers probed the heart of a distant globular star cluster and were surprised to come up with a score of “zero”.

To the fascination and puzzlement of planet-searching astronomers, the results offer a sobering counterpoint to the flurry of planet discoveries announced over the previous months. *“This could be the first tantalizing evidence that conditions for planet formation and evolution may be fundamentally different elsewhere in the galaxy,” says Mario Livio of the Space Telescope Science Institute (STScI) in Baltimore, MD.*

The bold and innovative observation pushed NASA Hubble Space Telescope’s capabilities to its limits, simultaneously scanning for small changes in the light from 35,000 stars in the globular star cluster 47 Tucanae, located 15,000 light-years (4 kiloparsecs) away in the southern constellation Tucana.

Hubble researchers caution that the finding must be tempered by the fact that some astronomers always considered the ancient globular cluster an unlikely abode for planets for a variety of reasons. Specifically, the cluster has a deficiency of heavier elements that may be needed for building planets. If this is the case, then planets may have formed later in the universe’s evolution, when stars were richer in heavier elements. Correspondingly, life as we know it may have appeared later rather than sooner in the universe.

Another caveat is that Hubble searched for a specific type of planet called a “hot Jupiter,” which is considered an oddball among some planet experts. The results do not rule out the possibility that 47 Tucanae could contain normal solar systems like ours, which Hubble could not have detected.

But even if that’s the case, the “null” result implies there is still something fundamentally different between the way planets are made in our own neighborhood and how they are made in the cluster. Hubble couldn’t directly view the planets, but instead employed a powerful search technique where the telescope measures the slight dimming of a star due to the passage of a planet in front of it, an event called a transit. The planet would have to be a bit larger than Jupiter to block enough light — about one percent — to be measurable by Hubble; Earth-like planets are too small. However, an outside observer would have to watch our Sun for as long as 12 years before ever having a chance of seeing Jupiter briefly transit the Sun’s face. The Hubble observation was capable of only catching those planetary transits that happen every few days. This would happen if the planet were in an orbit less than 1/20 Earth’s distance from the Sun, placing it even closer to the star than the scorched planet Mercury — hence the name “hot Jupiter.”

Why expect to find such a weird planet in the first place?

Based on radial-velocity surveys from ground-based telescopes, which measure the slight wobble in a star due to the small tug of an unseen companion, astronomers have found nine hot Jupiters in our local stellar neighborhood. Statistically this means one percent of all stars should have such planets. It’s estimated that the orbits of 10 percent of these planets are tilted edge-on to Earth and so transit the face of their stars.

In 1999, the first observation of a transiting planet was made by ground-based telescopes. The planet, with a 3.5-day period, had previously been detected by radial-velocity surveys, but this was a unique, independent confirmation. In a separate program to study a planet in these revealing circumstances, Ron Gilliland (STScI) and lead investigator Tim Brown (National Center for Atmospheric Research, Boulder, CO) demonstrated Hubble’s exquisite ability to do precise photometry — the measurement of brightness and brightness changes in a star’s light — by also looking at the planet. The Hubble data were so good, they could look for evidence of rings or Earth-sized moons, if they existed.

But to discover new planets by transits, Gilliland had to crowd a lot of stars into Hubble’s narrow field of view. The ideal target was the magnificent southern globular star cluster 47 Tucanae, one of the closest clusters to Earth. Within a single Hubble picture Gilliland could observe 35,000 stars at once. Like making a time-lapse movie, he had to take sequential snapshots of the cluster, looking for a telltale dimming of a star and recording any light curve that would be the true signature of a planet.

Based on statistics from a sampling of planets in our local stellar neighborhood, Gilliland and his co-investigators reasoned that 1 out of 1,000 stars in the globular cluster should have planets that transit once every few days. They predicted that Hubble should discover 17 hot Jupiter-class planets.

To catch a planet in a several-day orbit, Gilliland had Hubble’s “eagle eye” trained on the cluster for eight consecutive days. The result was the most data-intensive observation ever done by Hubble. STScI archived over 1,300 exposures during the observation. Gilliland and Brown sifted through the results and came up with 100 variable stars, some of them eclipsing binaries where the companion is a star and not a planet. But none of them had the characteristic light curve that would be the signature of an extrasolar planet.

There are a variety of reasons the globular cluster environment may inhibit planet formation. 47 Tucanae is old and so is deficient in the heavier elements, which were formed later in the universe through the nucleosynthesis of heavier elements in the cores of first-generation stars. Planet surveys show that within 100 light-years of the Sun, heavy-element-rich stars are far more likely to harbor a hot Jupiter than heavy-element-poor stars. However, this is a chicken and egg puzzle because some theoreticians say that the heavy-element composition of a star may be enhanced after it makes Jupiter-like planets and then swallows them as the planet orbit spirals into the star.
The stars are so tightly compacted in the core of the cluster – being separated by 1/100th the distance between our Sun and the next nearest star — that gravitational tidal effects may strip nascent planets from their parent stars. Also, the high stellar density could disturb the subsequent migration of the planet inward, which parks the hot Jupiters close to the star.

Another possibility is that a torrent of ultraviolet light from the earliest and biggest stars, which formed in the cluster billions of years ago may have boiled away fragile embryonic dust disks out of which planets would have formed.

These results will be published in The Astrophysical Journal Letters in December. Follow-up observations are needed to determine whether it is the initial conditions associated with planet birth or subsequent influences on evolution in this heavy-element-poor, crowded environment that led to an absence of planets.

Credits for Hubble image: NASA and Ron Gilliland (Space Telescope Science Institute)

6. Space Place is a fantastic source of scientific educational materials for children of all ages. Visit them at:

http://spaceplace.nasa.gov

7. NGC 3982

Though the universe is chock full of spiral-shaped galaxies, no two look exactly the same. This face-on spiral galaxy, called NGC 3982, is striking for its rich tapestry of star birth, along with its winding arms. The arms are lined with pink star-forming regions of glowing hydrogen, newborn blue star clusters, and obscuring dust lanes that provide the raw material for future generations of stars. The bright nucleus is home to an older population of stars, which grow ever more densely packed toward the center.

NGC 3982 is located about 68 million light-years away in the constellation Ursa Major. The galaxy spans about 30,000 light-years, one-third of the size of our Milky Way galaxy. This color image is composed of exposures taken by the Hubble Space Telescope’s Wide Field Planetary Camera 2 (WFPC2), the Advanced Camera for Surveys (ACS), and the Wide Field Camera 3 (WFC3). The observations were taken between April 2000 and August 2009. The rich color range comes from the fact that the galaxy was photographed invisible and near-infrared light. Also used was a filter that isolates hydrogen emission that emanates from bright star-forming regions dotting the spiral arms.

Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

Acknowledgment: A. Riess (STScI)

8. This artist’s concept allows us to imagine what it would be like to stand on the surface of the exoplanet TRAPPIST-1f, located in the TRAPPIST-1 system in the constellation Aquarius. Credit: NASA/JPL-Caltech/T. Pyle (IPAC)