Chapter 1

Looking Up

Brandon Stroupe - BMAC Chair
Hello BMACers,

I know it is hard to believe, but it is already May. The years just seem to fly by anymore. That’s my opinion anyway. I’m sure some of you agree and some of you do not. May is a good month for many because it marks the end of the school year. Some may be just out for this school year and some may be graduating. I know a few of you are teachers or professors and I know you are happy for the end of the school year. To all of those who are graduating or if you are getting ready to start a new year in the fall, I want to congratulate you and wish you look on your future endeavors. To the rest, keep on pushing, it will be worth it in the end.

At our meeting this month, we will be welcoming Tom Rutherford and his students. In the past few years, May has been reserved for Tom and his students to show us what projects they have been working on this year. Tom has been a long-time member of our astronomy club and a science teacher at Sullivan South High School in Kingsport. Many of Tom’s students are chosen to give their presentations at local and regional science fairs. Some even make it to the national level. The topics of the presentations for May’s meeting include: “Bacteria in Commercial Ice,” “Bacteria in Packaged Meat,” “Growing Plants Under the Light of Other Stars,” and “The Age and Distance to the Open Cluster NGC 559.” These presentations are always a joy to see. It is great to see all these young minds work this hard and really like what they are researching. I hope that everyone will be able to come out and see these presentations.

At our April meeting, we once again welcomed Steve Conard. Steve has given numerous presentations to our club in the past and once again, his presentation was awesome. Steve is an optical systems engineer for John Hopkins Applied Physics Laboratory. He has had a 35-year career building spaceflight optical instruments for astrophysics and planetary science missions. As a hobby, he measures the size and shape of asteroids for the International Occultation Timing Association. His presentation focused on the New Horizons spacecraft and the Kuiper Belt Object 2014MU69. The New Horizons spacecraft is planning to perform a flyby of the small Kuiper Belt Object, 2014MU69, on January 1, 2019. Until the summer of 2017, very little was known about this object. Its size was estimated to be
Steve Conard at the April 6, 2018 BMAC meeting. He’s pointing out the potential of a possible moon orbiting the next New Horizons flyby target, 2014MU69. This information was gleaned from an asteroid occultation observation event. Image by Jason Dorfman
Hydra the Water Serpent

Image from Stellarium

annotations by Adam Thanz
between 10 and 40 km in diameter. Knowing the size of the object would make the pre-planned observations during the New Horizons flyby much more effective and lower risk. Steve described two different expeditions to Argentina, where a diverse team used off-the-shelf amateur astronomy equipment to both measure the size and shape of this body. The results obtained revealed an unusually shaped body that has further raised scientific expectations for next year's encounter on January 1, 2019. Steve said he would love to come back and share the results with us when they come in. Steve has become a great friend to the club and we should be grateful that he takes the time out of his busy schedule to come give us talks. Thank you, Steve, for all that you do!

For our constellation this month, we will be talking about Hydra. Hydra translates to “The Water Serpent.” In Greek mythology, Hydra was a beast with the body of a hound and 100 serpentine heads. Hydra also had poisonous breath that was so bad that it caused most people to die of fear from simply seeing it. Hercules was tasked to kill Hydra and when he started to fight it, he discovered that every time he cut off one of the heads, three grew back in place of it. To prevent this from happening anymore, Hercules had his charioteer, Iolus, burn the stump after each time he cut off a head, which prevented the regeneration of heads. The last head was immortal, however, so after cutting it off, they trapped it under a rock. Hydra contains quite a few deep-sky objects; three of them are Messier objects. They are M83, also known as the Southern Pinwheel Galaxy, M68, which is a globular cluster near M83, and M48, which is an open star cluster. Hydra also has a planetary nebula called NGC 3242. It was discovered by William Herschel and he nicknamed it the "Ghost of Jupiter" because of its resemblance to the giant planet. Hydra has many other deep-sky objects in it and they are worth looking at next time you are out. If you would like to know more, check out Jason Dorfman's article, “Celestial Happenings.”

That will be it for this month, but I want to leave you with an update on how Astronomy Day on April 21. It was a very good turnout of public visitors to the Park and by our tables. There were well about 250 visitors during the daytime Astronomy Day event and about 250 visitors to the StarWatch that night. Unfortunately, we only had a few club members show up to help. I really wish we could have had more of you there to help inform and show the public our wonderful hobby. In order for our club to succeed and prosper, we need our members to help and show everyone how great the field of astronomy is. Thank you to those members that came out and helped. It was a wonderful day. Also, please remember that the StarWatches are finished for the first part of the year. They will start up again in October. The SunWatches are still in full swing every Saturday and Sunday from 3-3:30 p.m. We always need volunteers for that as well. Until next month… Clear Skies.
Chapter 2

BMAC

Notes
Reminder
Please turn in or mail to Adam Thanz your completely filled out volunteer forms (the ones I sent recently) if you would like to be able to volunteer for any of our public programs. It will take a short while to get the forms processed and for you to come and attend an orientation meeting. After the end of May, I must have the process complete for you if you want to volunteer for any program.

Astronomy Day 2018
Another Astronomy Day has come and gone with the result of hundreds of visitors enjoying a beautiful day and learning a lot about astronomy. There were about seven tables set up with astrophotography, giveaways, telescope types, charts and books, solar and night viewing, and kid make-and-take activities.

Thank you to the BMACers who came and helped out: Wayne Manly, Wayne Davis, William Troxel, Robin Byrne, Brandon Stroupe, and BMP planetarium staff.

We Intrepid Three
by Ray and Kate O’Connor & Wayne Davis

Plagued by clouds and poor seeing, the astronomy gods laughed, granting us a scant 3 hours of viewing.

We arrived early and set up our telescopes under clear skies, toasting our endeavor with hot chocolate as the sun set. The start of our Messier Marathon gave us a fixed band of clouds just above the horizon, blocking the first six items. We were able to come back for M31 later, but thin clouds were moving in and we could not see the satellite galaxies (M32, M110).

The park had some volunteers staying for the week and they came up for a visit, red flashlights in hand. Ray explained what we were doing and they looked at some things with us. Sadly, the telescope was bumped, badly skewing the finder scope. We missed 2 more items while re-sighting it.

We did have a cloud-free sky for most of the items we saw, but after seeing all three M objects in Puppis, the next two constellations were occluded. We hurried on to Cancer and saw M44 before the clouds covered that area. We tried to go to Leo,
BMACer William Troxel is seen here explaining the difference between telescope types during Astronomy Day.

Image by Robin Byrne
BMACer Wayne Manly and planetarium intern Kaytlyn Jones is seen here showing the Sun during Astronomy Day.

Image by Robin Byrne
Some pix of Astronomy Day.

Images by William Troxel
but the clouds were quicker. A hop to Ursa Major for M81 got us there in time to see clouds wafting through the eyepiece. We ended our evening just after midnight with 18 items viewed.

Was it worth it? Yes! Was it fun? Yes! Would we do it again? YES!!

What We Learned
Preparation is the key. In the months prior to your marathon, view as many M objects as possible. For practice, find 3 - 5 objects, then try to locate them again in the same order.

We brought a card table and quickly realized that it was almost as important as the telescope. Bring star charts with lots of detail. We marked the M objects with small, thin arrows cut from post-it notes. Wayne found a search list with photos of each object next to the M numbers. This is very useful if you are unfamiliar with the objects in question.

We didn’t make it to the realm of the galaxies, but we did have several maps of the Virgo cluster showing a lot of detail. Not every galaxy is a Messier object and they seem to be close together. We want to spend time exploring this area before another Marathon.

It is a challenge, but if you want to try a Messier Marathon, go for it. There is a small window each year. You’ll need a moonless night, dark skies and good horizons. Even though we didn’t complete the marathon, we realized that we were in good company. Few people do finish with all objects viewed.

The most important thing we learned… enjoy yourself!
This month, the opportunity to observe planets continues to improve as Jupiter and Saturn appear earlier. Jupiter also reaches opposition early this month, so you’ll want to be sure to put it on your list of observation targets. Mars, though still visible in the early morning hours, also improves remarkably as we head towards it’s late July opposition. The Moon will make a few appearances close to the planets throughout the month, as well.

**Planets**

As I mentioned in last month’s article, the prominent figure in our early evening skies this month will be Venus. Shining brightly at magnitude -3.9, Venus begins the month just 5° North of the Hyades cluster. It will make its trek eastward through the horns of Taurus and cross into Gemini on the 19th. Venus is still coming around from the far side of the Sun in its orbit and will not change much over the month. It’s magnitude will only brighten slightly and through a telescope you will see the illuminated portion of the planet wane slightly from 88% to 80%. Look just north of west an hour after sunset and you’ll find Venus about 15° above the horizon.

The real planetary highlight for May is Jupiter, the “King of the Planets.” As the Sun is setting on the 1st, Jupiter is already rising in the east. It is amongst the stars of Libra and is moving in retrograde this month. Jupiter reaches opposition on the 8th, which also coincides with its closest approach to Earth. This will result in some wonderful observations of Jupiter, despite its low altitude. Around the date of opposition, look south after 1 a.m. and you’ll find Jupiter at its highest in the sky - around 35°. By month’s end, Jupiter will climb just a bit higher and reach this altitude just before midnight. The appearance of Jupiter will remain fairly constant throughout the month. The disk will span between 44" and 45" and the planet will shine brightly at magnitude -2.5. Be sure to take this opportunity to look for the Great Red Spot and shadow crossings from it’s four largest moons.

Next up is the other gas giant, Saturn. As Jupiter is reaching it’s highest altitude, look for Saturn low in the southeast. Like Jupiter, the appearance of Saturn will not change much during the month. It’s magnitude will brighten slightly from +0.3 to +0.2. In a scope at mid-month, you’ll see the disk measuring 18" and
A way to understand scale when looking through a telescope. The Moon is 30’, Jupiter at opposition is 45”, and Mars at opposition this summer is 24.3”.

the rings spanning 40\" with a tilt of 26°. With a 29 year orbit, Saturn’s slow motion will keep it in Sagittarius throughout the month, just north of the Teapot. It’s also still close to the 5th-magnitude globular cluster M22, moving from 1.7° north to 1.8° northwest of the cluster.

Mars rises shortly after Saturn at the beginning of the month, just before 1:30 a.m. The appearance of Mars will change quite a bit this month as we head towards a late July opposition. Its brightness will double, going from magnitude -0.4 to -1.2. The angular diameter of Mars will increase from 11" to 15". Unlike Jupiter and Saturn, Mars continues to move swiftly eastward. It starts out the month in the eastern part of Sagittarius, just northeast of the Teapot. On the 15th, it crosses into Capricorn, where it will remain until late August. Your best views will come just before dawn when Mars has risen almost 30° in altitude towards the south.

**Luna**

May begins with a nearly full waning gibbous Moon. New Moon occurs on the 15th and Full Moon on the 29th. In the early morning hours on the 4th, look to the southeast to catch the waning gibbous Moon just 1.7° north of Saturn. Two days later it will be 3° north of Mars. In the evening skies of the 17th, look to the west for a very thin crescent 5° south of Venus. On the 27th, you will find a nearly full Moon about 4° northeast of Jupiter. The Moon will complete its orbit around the Earth and once again come within 2° of Saturn on the 31st.

**Constellation of the Month**

Hydra is the constellation for the month of May. It is a more difficult one to find as it is long and thin, stretching across the southern horizon. The head of the serpent can be found just below Cancer. It then extends down below Sextans running in a southeast direction. As it reaches the constellation of Crater, it then continues due east below Crater, Corvus and Virgo and ends just below the western half of Libra.

Because of its large extent across the sky, we find several interesting deep sky targets within it. The first to look for is M48 or NGC 2548. It is located on the western edge of Hydra about 14° to the southeast of Procyon. It is an open star cluster of about magnitude 5.5 that contains about 50 stars of magnitude 9 to 13. The cluster spans about 40' making it a good binocular target. Look for it early in the month when it will be about 30° high in the southwest an hour and a half after sunset.

Further east, below the stars of Corvus, is the 8th-magnitude globular cluster M68. And even further east we find M83, an 8th-magnitude spiral galaxy nicknamed the Southern Pinwheel galaxy. It is located about 18° below Spica along the southern border of Hydra with the constellation Centaurus. With a declination of nearly -30°, you’ll want to view this Messier object when it reaches its highest altitude due south, which will be just
after midnight at the start of May and two hours earlier by month’s end.

The final object of interest is the "Ghost of Jupiter," a 9th-magnitude planetary nebula. It is located a little westward of the middle of Hydra, about 1.8° below the star μ Hydra. It appears as a pale bluish glowing disk, like a "ghost" of Jupiter, measuring about 40" x 35". The fainter central white dwarf that is energizing the surrounding gas is about magnitude 11.4.

That’s all for this month. Clear Skies!
This month we celebrate the anniversary of an important milestone in space flight and honor the passengers on that flight.

The use of animals for testing the viability of sending humans into space began as early as 1935. Dr. Harry Armstrong used animals in ground-based altitude and acceleration experiments. This led to the first sub-orbital animal flight in 1949. However, it wasn’t until 1952 that the animals on board returned alive.

As the space race heated up, it became even more important to send a human safely into space. Vital to that goal was the development of the Jupiter rocket. The development of rockets began as a military priority with the development of the Redstone rocket during a project led by Werner Von Braun from 1952 - 1955. The Redstone was then lengthened and mated with solid fuel upper stages to become the Jupiter rocket.

In December 1958, the first Bioflight mission carried a squirrel monkey named Gordo using a Jupiter rocket. During the flight, his heart rate, heart sounds, body temperature, blood pressure and radiation exposure were monitored. However, he did not survive the flight.

On May 28, 1959, Bioflight 2 was launched from Launch Complex 26, again using a 60 foot tall Jupiter rocket. Housed in a 250 pound nosecone was an all-female crew. Abel was a reddish-brown, 7 pound rhesus monkey who was born in Kansas. Baker was a one pound, long-tailed squirrel monkey born in the Peruvian jungle and brought to the United States when she was very young. The names Abel and Baker were taken from an outdated international code. If the person who had named them had been up-to-date, they would have been named Alpha and Bravo.

These two monkeys were chosen from an elite group of candidates. They were picked for their ability to endure hours of confinement and the stresses of acceleration, deceleration, and weightlessness. During the flight, their biomedical conditions were monitored by the Army Medical Service and Army Ballistic Missile Agency, Army Ordnance Missile Command, with the cooperation of the USN School of Aviation Medicine, and the USAF School of Aviation Medicine. Also during the flight, Abel was trained to tap a switch when a red light flashed, so data was gathered on how well she could perform simple tasks while in
Able being suited up. Image from NASA.
Display of Able and her couch at the National Air and Space Museum. Image from RadioFan with full permission.
flight. They reached an altitude of 300 miles, traveling at speeds up to 10,000 miles per hour. They withstood up to 38 g’s, and were weightless for about 9 minutes.

The entire flight lasted about 15 minutes. Splashdown was in the Atlantic Ocean, about 1500 miles downrange. For the first time, the animal astronaut crew returned alive. After the mission, Abel was taken by the Army to Fort Knox, Kentucky. On June 1, Abel was being operated on to remove the electrode instrumentation that had been implanted for the flight. She reacted to the anesthesia and died. Her body is now on display at the Smithsonian’s Air and Space Museum in Washington, DC.

Baker’s fate was a happier one. She was taken by the Navy to Pensacola, Florida, where she took up a husband. In 1971, the couple moved to the Alabama Space and Rocket Center in Huntsville, Alabama, where she was a favorite attraction for the many visitors. She died in 1984 at the age of 27. She was the longest-lived squirrel monkey known. Her grave stone maker is inscribed, “First U.S. animal to fly in space and return alive.”

This flight was an important step toward putting a man in space. If it had not been for the things we learned from these animal flights, we may not have been willing to ever send a human. We owe a great debt of thanks to all of the animal astronaut pioneers, and especially to Abel and Baker.

References:

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www.nal.usda.gov/awic/newsletters/v6n2/6n2borko.htm#living

“Space Flight Encyclopedia” by Nicholas Roes & William Kennedy

US Biomedical Space Research Timeline Web Page
www.shuttle.nasa.gov/history/shuttle-mir/science/history/ustime.htm

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Animal Astronauts - Abel and Baker Web Page
ham.spa.umn.edu/kris/able.html
Mars is Earth’s neighbor in the Solar System. NASA’s robotic explorers have visited our neighbor quite a few times. By orbiting, landing and roving on the Red Planet, we’ve learned so much about Martian canyons, volcanoes, rocks and soil. However, we still don’t know exactly what Mars is like on the inside. This information could give scientists some really important clues about how Mars and the rest of our Solar System formed.

This spring, NASA is launching a new mission to study the inside of Mars. It’s called Mars InSight. InSight—short for Interior Exploration using Seismic Investigations, Geodesy and Heat Transport—is a lander. When InSight lands on Mars later this year, it won’t drive around on the surface of Mars like a rover does. Instead, InSight will land, place instruments on the ground nearby and begin collecting information.

Just like a doctor uses instruments to understand what’s going on inside your body, InSight will use three science instruments to figure out what’s going on inside Mars.

One of these instruments is called a seismometer. On Earth, scientists use seismometers to study the vibrations that happen during earthquakes. InSight’s seismometer will measure the vibrations of earthquakes on Mars—known as marsquakes. We know that on Earth, different materials vibrate in different ways. By studying the vibrations from marsquakes, scientists hope to figure out what materials are found inside Mars.

InSight will also carry a heat probe that will take the temperature on Mars. The heat probe will dig almost 16 feet below Mars’ surface. After it burrows into the ground, the heat probe will measure the heat coming from the interior of Mars. These measurements can also help us understand where Mars’ heat comes from in the first place. This information will help scientists figure out how Mars formed and if it’s made from the same stuff as Earth and the Moon.

Scientists know that the very center of Mars, called the core, is made of iron. But what else is in there? InSight has an instrument called the Rotation and Interior Structure Experiment, or RISE, that will hopefully help us to find out.

Although the InSight lander stays in one spot on Mars, Mars wobbles around as it orbits the Sun. RISE will keep track of InSight’s location so that scientists will have a way to measure these wobbles. This information will help determine what materials are in Mars’ core and whether the core is liquid or solid.
InSight will collect tons of information about what Mars is like under the surface. One day, these new details from InSight will help us understand more about how planets like Mars—and our home, Earth—came to be.

For more information about earthquakes and marsquakes, visit: https://spaceplace.nasa.gov/earthquakes. 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
## BMAC Calendar and more

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<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>Notes</th>
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<tr>
<td><strong>BMAC Meetings</strong></td>
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<tr>
<td>Friday, May 4, 2018</td>
<td>7 p.m.</td>
<td>Nature Center</td>
<td>Program: Sullivan South High School educator Tom Rutherford will bring their research. Topics include: “Bacteria in Commercial Ice,” “Bacteria in Packaged Meat,” “Growing Plants Under the Light of Other Stars,” and “The Age and Distance to the Open Cluster NGC 559.”; Free.</td>
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<td>Discovery Theater</td>
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<tr>
<td>Friday, June 1, 2018</td>
<td>7 p.m.</td>
<td>Nature Center</td>
<td>Program: Topic TBA; Free.</td>
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<td>Discovery Theater</td>
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<tr>
<td>Friday, August 3, 2018</td>
<td>7 p.m.</td>
<td>Nature Center</td>
<td>Program: Topic TBA; Free.</td>
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<td>Discovery Theater</td>
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<tr>
<td><strong>SunWatch</strong></td>
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<tr>
<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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<td>Mar. 3, 10, 2018</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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<td>Mar. 17, 24, 2018</td>
<td>8:00 p.m.</td>
<td>Observatory</td>
<td></td>
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<tr>
<td>Apr. 7, 14, 21, 28, 2018</td>
<td>8:30 p.m.</td>
<td>Observatory</td>
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<td><strong>Special Events</strong></td>
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<tr>
<td>July ?, 2018</td>
<td>6 p.m.</td>
<td>?</td>
<td>Annual club picnic. BMACers and their families are most welcome to enjoy the evening along with a potluck dinner. Please bring a dish to share. You’ll need to bring your own chair and telescope to share the night sky.</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/
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. Seen 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 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

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 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 measured 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 star.

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 if 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 March 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. An artist’s illustration showing a possible inner structure of Mars. Image credit: NASA/JPL-Caltech