Chapter 1

Looking Up

Brandon Stroupe - BMAC Chair
Hello BMACers,

It is hard to believe, but we are already in the 2nd month of 2018. Welcome to February. This year is moving right along with all kinds of plans, events, and not to mention, crazy weather. I don’t know if I will ever get used to the temperatures in the 60’s one day and in the 20’s the next. I am not sure how you all feel, but I don’t really like it. I do have to admit, we have had a good number of clear nights so far this year. I do enjoy those. It is nice just to be able to go outside at night and just stare up into the night and just see so many beautiful stars. I could definitely get used to that. I’m sure you all could too.

At our meeting this month, we will be talking about eyepieces. There was some discussion about eyepieces at the annual dinner last month and it got me thinking that we have never really had a presentation about eyepieces. Well, February is going to be that month. We will talk about the various types of eyepieces and what objects in our night sky they are used for. A lot of us can be easily confused when looking at purchasing eyepieces because of their various strengths and weaknesses. We will talk about these as well. Please feel free to bring in your eyepieces to talk about or to show others. This presentation will be in an open format, meaning that it will be more of a discussion rather than formal presentation. These types of presentations have worked really well in the past and I would like to try it again. I hope to see everyone there and don’t forget your eyepieces!

For our January meeting we had our annual dinner. It was held at The Meadows Restaurant in the Meadowview Conference Center. We did not have a speaker for our dinner, but instead just sat and enjoyed the company of other fellow amateur astronomers and the wonderful food that was available at the restaurant. There was not really a business meeting at the dinner. We did talk briefly about the upcoming astronomy event taking place in Hickory, NC. The event is called the Annual Regional Gathering of Amateur Astronomers, also known as “BoBfest.” It is a free event on Saturday, February 3rd that is hosted by the Catawba Valley Astronomy Club. It will start at 8:30 a.m. and last until 4:30 p.m. We brought this event up because in the past, many BMACers have carpooled to the event. If you are able to read this before that date, we will be posting info for this event on the BMAC yahoo group in case anyone would like to carpool.
Camelopardalis

Camelopardalis the Giraffe
Image from Stellarium
Annotated by Adam Thanz
again. Thank you to everyone that was able to come out to the dinner and I really hope you enjoyed it.

For our constellation this month, we will be talking about Camelopardalis. Camelopardalis is translated to “giraffe.” This is the first constellation I have found that does not have an ancient myth associated with it. Possibly because it was created much more recently than other constellations. It was created in the 17th century. I honestly have never heard of Camelopardalis until now. Many of us may not have known about it because it does not have many bright stars. No stars in this constellation are brighter than 4th magnitude. This constellation does contain a pretty well-known asterism named Kemble’s Cascade. Camelopardalis also contains a few deep sky objects. They are NGC 1502, which is an open cluster, NGC 2403, which is a spiral galaxy, and NGC 1569, which is an irregular dwarf galaxy. If you would like to know more about what is in this constellation, check out Jason Dorfman’s article, “Celestial Happenings,” he will be adding a little more about it. As always, give Camelopardalis a look next time you are out.

That will be it for this month. Also, please remember that the StarWatches and the SunWatches will be starting back up in March. I hope everyone will be able to make plans to help with them when they start back. It is always fun to see a kid’s, and even some grown-up’s, reactions when looking through a telescope for the first time. Or seeing Saturn’s rings or Jupiter’s moons for the first time. It never gets old sparking an interest in astronomy to someone of any age. Until next month… Clear Skies.
Chapter 2

Celestial Happenings

Jason Dorfman
Planets
As the month begins, we once again find an evening sky devoid of bright planets. This has been our plight since Saturn plunged into the twilight glow of the setting Sun in mid-December. But the planetary doldrums are about to end. Last month, Venus crossed behind the Sun, moving from the morning to evening sky. Start looking for our sister planet at mid-month as it emerges from the bright evening twilight. By the evening of the 28th, Venus will be 12° east of the Sun and 5° above the horizon a half hour after sunset. At magnitude -3.9, it will be an easy target. This is also the day to look for the smallest planet in the Solar System, Mercury. Having made its trip behind the Sun on the 17th, it will then be just 2.3° to the lower right of Venus. However, at magnitude -1.4, you may need binoculars to counter the competing twilight and you’ll definitely need a clear view down to the horizon. Next month will bring us a much better opportunity to view Mercury as this swift planet moves towards its greatest elongation.

You can still look for Neptune in your scopes during the first week of the month, but it’s getting quite low in the west. Uranus is a bit higher and should be observable throughout the month. Look to my last two articles for more information on finding these ice giants. For the other planets in our Solar System, you’ll need to stay up late. Jupiter rises a little before 2 in the morning at the start of the month and just after midnight by month’s end. Though it will rise earlier and earlier in the coming months, the “King of the Planets” won’t be making an appearance for our StarWatch programs this Spring.

Jupiter will brighten slightly over the month, starting from magnitude -2 on the 1st to -2.2 on the 28th. The disk of this gas giant spans 37” at mid-month. As always, when viewing Jupiter, be sure to look for its four largest moons: Io, Europa, Ganymede and Callisto. Due to our nearly edge-on view to the plane of their orbits, the moons are seen in a line on either side of the planet. Also, because of their short periods, you’ll see a different arrangement from night to night. The innermost moon, Io, orbits in 1.8 days. The next furthest out, Europa, takes just 3.6 days and Ganymede, the largest moon, a bit longer at 7.2 days. The furthest out of the four is Callisto which orbits Jupiter every 16.7 days. If you took a second to consider those numbers, you might
have noticed something interesting with the inner three moons. Ganymede’s orbit of 7.2 days is twice as long as Europa’s 3.6 days, which is twice as long as Io’s 1.8 day orbit. This is not just an amazing coincidence, but a result of the gravitational interaction between the moons and Jupiter. It is known as an orbital resonance and is not unique. We find orbital resonances between pairs of Saturn’s moons and also with the planets, specifically Neptune and Pluto. For every two orbits that Pluto makes around the Sun, Neptune completes three orbits. This is noted as a 2:3 resonance.

Rising about an hour after Jupiter is the Red Planet, Mars. It starts out the month in the head of the scorpion and moves into Ophiuchus on the 8th. Be sure to take a look during the second week of February as Mars treks eastward above the brightest star in Scorpius, Antares, passing just 5° away on the 10th. This is a great chance to see how this star, with a similar color and magnitude, received it’s name, which translates to “Rival of Mars.” Earth is beginning to close the distance between us and Mars as we head towards opposition in July. We’ll see the Red Planet brighten over the month from magnitude 1.2 to 0.8.

The final planet on our list is Saturn. It was just beginning to peek through the early morning twilight at the end of last month and, though it will still be a bit low in the sky as the Sun brightens the eastern horizon, the view will improve through the month as it reaches about 20° above the horizon an hour before sunrise at month’s end.

**Luna**

On the 1st, look to the east for the nearly full Moon rising just before 8 p.m. On the evening of the 16th, just after sunset, find a clear view to the west and look carefully to pull out a thin crescent Moon from the early twilight. It will be just under 3° to the upper left of Venus.

In the second week of the month, in the early morning hours when you’re comparing Mars and Antares, the Moon will slide past Jupiter and Mars and then move on to Saturn. On the 8th, a fuller crescent will be between Mars and Jupiter and on the 9th it will be about 5° to the upper left of Mars, which will make a nice grouping with Antares just 5° below Mars. A few days later, on the 11th, a thin crescent will make a good pairing with Saturn in the pre-dawn hours.

**Constellation of the Month**

Camelopardalis is the constellation this month. This is definitely a more challenging pattern to find in the sky. The alpha and beta stars are about 4th magnitude. Looking northward in the evening, find Algenib in Perseus and Capella in Auriga and make a triangle with Polaris. The brighter stars of Camelopardalis are found within this triangle. The rest of the constellation boundary extends eastward towards the head of Ursa Major and down towards the cup of the Little Dipper. Camelopardalis is derived from the Greek
word for “giraffe,” which was really called a camel-leopard because it had a long neck like a camel and a spotted body like a leopard. However, the Greeks did not create this constellation as they considered this region of the sky empty. Camelopardalis was created by the Dutch astronomer Petrus Plancius and documented by the German astronomer Jakob Bartsch in 1624.

There are just over 20 galaxies located within this part of the sky. Most, however, are 11-13 magnitude. One of the brightest is NGC 2403 at about magnitude 8.8. It is a large spiral type galaxy with similar structure to the “Pinwheel” galaxy in Triangulum, M33.

That’s all for this month. Be sure to take advantage of those warms spells between the freezing cold temperatures to get out and do some observing. Clear Skies!
This month we celebrate the discovery of the most distant objects in the Universe. Our story begins in the late 1950’s when Allan Sandage and Thomas Matthews were performing surveys of the sky, searching for sources of radio radiation. Radio astronomy at this time largely involved an array of antennas that would sweep the sky as Earth rotated. When a signal was detected, its position in the sky was not very precise, so searching for where it was using optical telescopes was challenging. The first one to have an optical counterpart found was 3C 48, which looked like a faint blue star. Its spectrum was very odd-looking, and no one could identify the elements associated with the spectral lines.

Another of the radio sources, 3C 273 was going to be occulted by the Moon on five different occasions. That was the break needed to pinpoint its position in the sky. Cyril Hazard and John Bolton used the Parkes Radio Telescope in Australia to observe the occultations and were able to get a precise position. Armed with the coordinates, Caltech astronomer Maarten Schmidt used the 200-inch Hale Telescope at Mount Palomar in California to observe what looked like another faint star and to get its spectrum. The spectral lines again were very odd. On February 5, 1963, Maarten Schmidt realized that the spectral lines were actually those of the most common element in the Universe - hydrogen. So, why did they look so unusual? Because they were more red-shifted than anything previously observed, corresponding to the object moving away from Earth at a rate of 47,000 km/s, roughly 16% the speed of light. Armed with this new information, the first of these radio objects discovered, 3C 48, was found to be moving away at an even faster rate, 37% the speed of light! According to Hubble’s Law, how fast an object is moving away from us is related to its distance. Because these objects are moving faster than any other known objects, they must be farther than any known objects - billions of lightyears away. Hence these objects existed billions of years back in time. But if they are that far away, yet we can still see them optically, they must be insanely bright - brighter than hundreds of galaxies combined. Meanwhile, 3C 273 measured to be quite small - less than 1 lightyear across, compared to 100,000 lightyears across for our galaxy. How to explain that?
Hubble Probes the Heart of a Nearby Quasar.

Hubble images of quasar 3C 273. At right, a coronagraph is used to block the quasar’s light, making it easier to detect the surrounding host galaxy.

Image by Credit for WFPC2 image: NASA and J. Bahcall (IAS)
Credit for ACS image: NASA, A. Martel (JHU), H. Ford (JHU), M. Clampin (STScI), G. Hartig (STScI), G. Illingworth (UCO/Lick Observatory), the ACS Science
Meanwhile, we at least needed a name for these things. Because these objects looked like a star while giving off radio waves, they were dubbed “quasi-stellar radio sources.” American astrophysicist Hong-Yee Chiu, in a 1964 article in Physics Today came up with the shortened name, “quasar.” Because some were later found that did not give off strong radio signals, another name, “quasar-stellar object,” or QSO, was adopted.

But there still remained the concern that we are looking far away at something small, but insanely bright. Because of this apparent contradiction, many didn’t believe quasars were really that far away. Based on what was known in the 1960’s, there was no known way to explain that much energy production in such a small space. So, maybe they are really something less extreme, but much closer than thought. They came up with other explanations for the extreme red-shifting, including affects due to a strong gravitational force. Over time, however, more and more evidence helped confirm that quasars are really that far away, including: eventually being able to observe that they are inside of galaxies with the same red shift and being part of galaxy clusters with the same redshift.

So, how do they produce so much energy? Starting in the 1970’s and finalized in the 1980’s, astronomers began modeling what happens when material falls into a black hole. As material approaches a black hole, it spirals inward toward the event horizon, the boundary of a black hole beyond which there is no escape. If a lot of material falls toward a black hole, then it develops a disk of material outside of the event horizon, called the accretion disk. Within the disk, material is moving very rapidly, generating huge amounts of friction and energy. It was found that in an accretion disk, roughly 10% of the mass is converted to energy. In comparison, typical stars convert 0.7% of their mass into energy during the nuclear fusion process. Over time, the source of material falling into the black hole will get depleted. When that happens, the insane amount of energy production comes to a stop. So quasars are actually supermassive black holes in the centers of young galaxies. That’s why we only see quasars at huge distances, back when the Universe was young - they now no longer have the fuel falling into the black hole that is necessary to power their huge energy output. However, we do see that most, if not all, galaxies do have a supermassive black hole in their center. That’s what’s left of the quasar.

The discovery of quasars was also the last nail in the coffin for the Steady State theory, which proposed that the Universe has always existed, and has always looked about the same. Quasars are proof that the Universe looked very different in the past, implying that the Universe had a beginning as explained by the Big Bang Theory.

Today, there are hundred of thousands of known quasars, most much farther than 3C 273. The most distant known quasar, ULAS J1120+0641 is 28.85 billion lightyears away, roughly 10x farther
than 3C 273. [Ed.: This distance is derived from a co-moving perspective. It is also listed as 12.9 billion lightyears derived from a light travel perspective; a unit that is more commonly known.]

Maarten Schmidt's discovery of quasars changed the way we think about our Universe. The size of our Universe became an order of magnitude larger than previously known, not to mention much, much more energetic than ever imagined. Quasar 3C 273 can be found in the constellation of Virgo. With a large enough telescope, you can actually view it optically. So, find a friend with a monster scope and check out the first known of these insanely bizarre objects from our early Universe.

**References:**
Wikipedia - Quasar


Everyday Cosmology 1963 Maarten Schmidt Discovers Quasars

https://cosmology.carnegiescience.edu/timeline/1963

Today in Science: Quasar Mystery Solved by Deborah Byrd

http://earthsky.org/space/this-date-in-science-maartin-schmidt-discovers-first-known-quasar
Chapter 4

Space Place
Satellites are a part of our everyday life. We use global positioning system (GPS) satellites to help us find directions. Satellite television and telephones bring us entertainment, and they connect people all over the world. Weather satellites help us create forecasts, and if there’s a disaster—such as a hurricane or a large fire—they can help track what’s happening. Then, communication satellites can help us warn people in harm’s way.

There are many different types of satellites. Some are smaller than a shoebox, while others are bigger than a school bus. In all, there are more than 1,000 satellites orbiting Earth. With that many always around, it can be easy to take them for granted. However, we haven’t always had these helpful eyes in the sky.

The United States launched its first satellite on Jan. 31, 1958. It was called Explorer 1, and it weighed in at only about 30 pounds. This little satellite carried America’s first scientific instruments into space: temperature sensors, a microphone, radiation detectors and more.

Explorer 1 sent back data for four months, but remained in orbit for more than 10 years. This small, relatively simple satellite kicked off the American space age. Now, just 60 years later, we depend on satellites every day. Through these satellites, scientists have learned all sorts of things about our planet.

For example, we can now use satellites to measure the height of the land and sea with instruments called altimeters. Altimeters bounce a microwave or laser pulse off Earth and measure how long it takes to come back. Since the speed of light is known very accurately, scientists can use that measurement to calculate the height of a mountain, for example, or the changing levels of Earth’s seas.

Satellites also help us study Earth’s atmosphere. The atmosphere is made up of layers of gases that surround Earth. Before satellites, we had very little information about these layers. However, with a satellite’s view from space, NASA scientists can study how the atmosphere’s layers interact with light. This tells us which gases are in the air and how much of each gas can be found in the atmosphere. Satellites also help us learn about the clouds and small particles in the atmosphere, too.

When there’s an earthquake, we can use radar in satellites to figure out how much Earth has moved during a quake. In fact, satellites allow NASA scientists to observe all kinds of changes in Earth over months, years or even decades.
Satellites have also allowed us—for the first time in civilization—to have pictures of our home planet from space. Earth is big, so to take a picture of the whole thing, you need to be far away. Apollo 17 astronauts took the first photo of the whole Earth in 1972. Today, we’re able to capture new pictures of our planet many times every day.

Today, many satellites are buzzing around Earth, and each one plays an important part in how we understand our planet and live life here. These satellite explorers are possible because of what we learned from our first voyage into space with Explorer 1—and the decades of hard work and scientific advances since then.

To learn more about satellites, including where they go when they die, check out NASA Space Place: https://spaceplace.nasa.gov/spacecraft-graveyard.

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 5

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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<tbody>
<tr>
<td><strong>BMAC Meetings</strong></td>
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<tr>
<td>Friday, February 2, 2018</td>
<td>7 p.m.</td>
<td>Nature Center</td>
<td>Program: Learn all about eyepieces and how to use them in an open discussion forum. Bring your own eyepieces to share if you like.; Free.</td>
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<td>Discovery Theater</td>
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<td>Friday, March 2, 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, April 6, 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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<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>
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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>Saturday, April 21, 2018</td>
<td>1-4:30 p.m. 8:30-10 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 3-3:30 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.
Section 3

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.

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 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 theoreticsians 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 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. This photo shows the launch of Explorer 1 from Cape Canaveral, Fla., on Jan. 31, 1958. Explorer 1 is the small section on top of the large Jupiter-C rocket that blasted it into orbit. With the launch of Explorer 1, the United States officially entered the space age. Image credit: NASA