The Monthly Newsletter of the Bays Mountain Astronomy Club

Edited by Adam Thanz

December 2019
Chapter 1

Cosmic Reflections

William Troxel - BMAC Chair
Greetings fellow BMACers!

December is here, it seems like it was just the other day we were getting ready for StarFest!

December is the last month, of course, of the calendar year, and the big holiday for me is Christmas. It has been a wonderful year which I will talk a little about later.

I wanted to thank you for your part in the November’s meeting. I know it was a little different then what we normally do. I hoped the different approach showed you that you do know a lot about our hobby and it is easy and fun to share your knowledge. I will be using this style of meeting in the upcoming months again. Thank you again for letting me introduce a little different type of meeting format.

We had a few questions and the feedback that was shared with me seemed real positive. I hope you felt that also. Guest and member feedback is important as it gives me support about the effectiveness of applying my ideas to the club meetings.

2019 has been a year of trying new and a little different things for the club meetings. I feel that we have had some ideas that were major hits and some others that were OK. I am going into 2020 with the same motivation. Change is not easy, however it is something that we all must do. Clubs need to continually seek new, different ways to keep its’ member’s interest. I want to invite you to share your ideas with me, as you can see some things have worked and some have not. I want to encourage you to use your creativity to come up with ideas to present concepts that you think will be fun for everyone. Let’s make the club meetings a place where we can work as a group to encourage everyone to have fun with astronomy, not just one night a month, but every day. I want to focus the 2020 new year on as many of the aspects of astronomy as I can that you have an interest. In order for that to happen, I need to know what you are interested in as well. We have had a quite a few new members join us this year and I want to remind you to help me help welcome them. If you are a visitor reading this article and have not joined us, please feel free to ask any questions and I hope you will consider ending 2019 by joining the club. The dues are only $16 per year. Additional family members are $6 each. If your are a Park
Association member, then those fees are cut in half ($8 & $3). Should you have any questions, please feel free to ask. Remember, this is your club.

I want to encourage you to come out for the December meeting as we will welcome our guest speaker Davis Gentry from PARI (Pisgah Astronomical Research Institute). His topic is “PARI: A Facility of the Past Preparing for the Future.” Davis Gentry was an intern at PARI last summer teaching and helped campers understand basic astronomy and astrophysics. He is currently a graduate student at Appalachian State University in their Engineering Physics program. He enjoys observational astronomy.

I hope to see each of you at the meeting on December 6th, 2019 starting at 7 p.m. in the Discovery Theater classroom on the lower level of the Nature Center. Until next time, this is your chairman....

Clear Skies.
ALCON 2020

All BMAC members are also members of the Astronomical League. As such, you should receive a quarterly newsletter from them. You also have access to the multitude of astronomy programs they offer. They are designed to help you become better observers and to learn more about astronomy.

The League has an annual conference. The next one will be held in Albuquerque, NM on July 16-18, 2020. The details are still being worked out, including the keynote speakers, but, you can book your hotel rooms. If you do go, I recommend staying a number of extra days as that part of the US is amazing with lots to see.
The transit of Mercury at 3rd contact. 2:28 p.m., November 11, 2019. Meade ETX90 telescope.

Image by Jim Williams
BMAC meeting Nov. 6, 2019. Both teams were working out a presentation about the upcoming Mercury Transit from provided materials.

The team on the left was working out how to safely view the transit.

Image by William Troxel.
BMAC meeting
Nov. 6, 2019.
This team was working out a presentation about the specifics of the upcoming Mercury Transit from provided materials.

Image by Robin Byrne.
Chapter 3

Celestial Happenings

Jason Dorfman
Understanding the Magnitude Scale

As amateur astronomers, we use and talk about magnitudes a lot. Therefore, it’s important to understand exactly what the magnitude scale is and what it is measuring. On the surface, it’s simply a measure of how bright an object appears to be. But, how did the current magnitude scale come into use and what is it actually measuring?

Historical Beginnings

In 129 B.C, Hipparchus of Rhodes, a Greek astronomer and mathematician, created the first star catalogue, which listed the celestial latitude and longitude of about 850 stars with greater accuracy than ever before. To account for the different brightnesses of the stars, Hipparchus created the magnitude scale. He grouped the naked-eye stars into six different levels. The brightest stars he assigned to magnitude one (m = 1) and the faintest that he could see with his eyes were magnitude six (m = 6). Almost three centuries later, Ptolemy refined the measurements made by Hipparchus, incorporating much of Hipparchus' work into his own.

In the 17th century, when Galileo began observing the sky with his telescope, he added a 7th magnitude level to the magnitude scale to account for the fainter stars that he was now able to observe. As the telescope improved and apertures grew larger, additional magnitude levels continued to be added.

By the 1800’s, with so much data and no standard to quantify the brightness of an object, the magnitude system was becoming a bit confusing. A mathematical definition for the magnitude system was greatly needed to provide agreement between two different astronomers for exactly how bright a star was. In 1856, Oxford astronomer Norman Robert Pogson proposed the system presently in use. He suggested that a star’s magnitude should be defined in terms of the star’s radiant flux. Using the finding of William Herschel that a 1st magnitude star is 100 times brighter than a 6th magnitude star, Pogson proposed that this logarithmic scale be used to standardize the separation between the different magnitude levels. From this relation, it follows that a magnitude 1 star is 2.5 times brighter than a magnitude 2 star.
To standardize the scale, the zero point was defined by giving Polaris a magnitude of exactly 2. At this point, the level for magnitude 1 was found to contain too great a range of luminosities and negative magnitudes were introduced to spread the range. Sirius, the brightest star in the night sky, has a magnitude of -1.4, the Full Moon is about magnitude -12.5 and the Sun is magnitude -26.7. It was later discovered that the brightness of Polaris varies slightly. Vega was then chosen to be the standard reference star as its magnitude was very near zero. Today, the magnitude scale extends to well beyond Hipparchus’ 6th level to include very faint celestial objects that have been observed with the Hubble Space Telescope.

**Modern Use of Magnitudes**

There are several terms worth knowing that are related to magnitude and also several factors that affect the magnitude of an object. When we are talking about magnitudes or referencing the magnitude in a star chart, we are dealing with apparent magnitude (m) - how bright an object appears to an observer from Earth. For amateur astronomers, this is the only magnitude value that we will usually work with. One factor that affects the magnitude of a celestial object is how distant the object is. The farther away - the dimmer it will appear. Another factor is extinction. The light that reaches the Earth’s surface from distant celestial objects has passed through many filters before it reaches us: intergalactic and interstellar media (i.e., dust), the Earth’s atmosphere, and always the telescope and detection system. These filters extinguish or lessen the amount of light we receive.

A related term that is useful for amateurs is the limiting magnitude. This refers to the faintest apparent magnitude of a celestial body that is detectable or detected by a given instrument. Our eye is a detector and the limiting magnitude for naked eye visibility is dependent upon several factors. For most people, the faintest stars that can be seen with the unaided eye near the zenith on a clear moonless night will be about 6th magnitude. The amount of light pollution and humidity level in a given area will affect this. From remote desert or high altitude areas, some amateur astronomers can see nearly as faint as 8th magnitude. For a telescope, the limiting magnitude increases as the aperture increases. To get a rough estimate of the limiting magnitude of your telescope, we can calculate the gain in magnitudes for a given scope with diameter $D_1$ for the primary mirror or lens compared to your dark adapted eye, $D_0$ (typically 6-7mm), using the formula:

$$Gain = 5 \log_{10} \left( \frac{D_1}{D_0} \right)$$

For a 10-inch scope ($D_1=254\text{mm}$), the gain works out to be about 8 magnitudes. So, if you were at a location where you could observe 5th magnitude stars with the naked eye, your telescope
would increase your limiting magnitude to 13th magnitude, in a perfect world.

Historically, the magnitude for an object was its visual magnitude, that seen by the human eye, which is more sensitive to yellow and red light. The introduction of photographic film, which is more sensitive to blue light, resulted in different values for visual magnitude and photographic magnitude. Today, we observe over the entire electromagnetic spectrum with various types of detectors. Astronomers have created lists of standard stars for which the magnitudes over various wavelengths have been determined. These are used to calibrate the detector used for the observation in order to determine accurate magnitudes.

The other main type of magnitude used by astronomers is absolute magnitude (M) - how bright a star would appear if placed at a distance of 10 parsecs (32.6 ly). A parsec is derived from the term parallax arcsecond. One parsec is the distance to an object whose parallax angle is one arcsecond. This distance is 3.26 light years. The absolute magnitude gives us a better idea of a star’s actual luminosity. It removes the distance factor and any extinction effects allowing us to compare the luminosities of different objects. For example, the Sun’s absolute magnitude is +4.83 while the absolute magnitude for Sirius is +1.4. Other examples are Rigel (-7.0), Deneb (-7.2), and Betelgeuse (-5.6). From this, we can see that some of the bright stars that we observe in the night sky are truly much more luminous than our Sun.

That’s all for this month. Wishing you all a happy holiday season and a Happy New Year!

References:
http://abyss.uoregon.edu/~js/glossary/hipparchus.html (November 21, 2019)
Chapter 4

The Queen Speaks

Robin Byrne
The Keynote speaker at this year’s Southeastern Planetarium Association conference was Astronaut Clayton C. Anderson. A bookstore was on hand selling his books, which he would then sign. So, naturally, I bought one of his books, The Ordinary Spaceman: From Boyhood Dreams to Astronaut.

The book, much like Clayton’s keynote address, was lively and entertaining. Not strictly presented in chronological order, the book covers snippets of his life from childhood to adulthood. Naturally, the bulk of the stories are about his time at NASA. Clayton talks about growing up in Nebraska during the Apollo era and wanting to go to space. He methodically worked toward that goal, majoring in engineering in college. A NASA internship got his foot in the door, leading to a job at NASA as an engineer after graduation.

Clayton calls himself an “ordinary” spaceman, in part, due to how much trouble he actually had being chosen for the job. He applied a total of 15 times before finally making the cut. Each time, Clayton learned a little more about what to do to make himself stand out. Finally, all the pieces were in place.

Throughout the book, Clayton describes his experiences as a new astronaut. The excitement of being fitted for his spacesuit, learning to fly a jet, and survival training with his fellow astronaut class members. When his name came up for a stay on the International Space Station, learning Russian was added to his duties, with frequent trips to Russia to learn their system, as well. He also spent time aboard the underwater habitat, NEEMO, to get experience working with a group of people in an isolated environment.

Prior to actual spaceflight, he took on many roles within the astronaut corps. One such duty was being assigned as a family escort, which meant accompanying the family of an astronaut on launch and landing days, to help them navigate the NASA system, and to be in the right place at the right time. Little did Clayton know that his responsibilities in that role would go well beyond the ordinary. He was assigned to escort the family of one of the astronauts on, what would become, the last flight of the Columbia Space Shuttle. When Columbia broke up during reentry, due to heat shield damage, Clayton comforted the wife and the children, and continued to accompany them throughout
NASA astronaut
Clayton C. Anderson,
mission specialist.
Image from 11/3/2009,
NASA.
NASA astronaut Clayton Anderson floating in the Destiny laboratory of the International Space Station during Expedition 15. Image from 7/28/2007 NASA.
The STS-117 crew patch symbolizes the continued construction of the International Space Station (ISS) and our ongoing human presence in space. The ISS is shown orbiting high above the Earth. Gold is used to highlight the portion of the ISS that will be installed by the STS-117 crew. It consists of the second starboard truss section, S3/S4, and a set of solar arrays. The names of the STS-117 crew are located above and below the orbiting outpost. The two gold astronaut office symbols, emanating from the ‘117’ at the bottom of the patch, represent the concerted efforts of the shuttle and station programs toward the completion of the station. The orbiter and unfurled banner of red, white and blue represent our Nation’s renewed patriotism as we continue to explore the universe. NASA.
Robin Byrne with Astronaut Clayton Anderson 6/7/19, Columbia, SC. Image by Adam Thanz.
the horrible days following the tragedy, including the funeral.

Once Clayton’s time in space arrived, he describes many details about his day-to-day life in ISS, including the ever popular topic of how to go to the bathroom in space. During his stay, Clayton got to perform multiple spacewalks. From his descriptions, it’s clear that he relished walking and working in space. After nearly half a year living in weightlessness, Clayton clearly describes the difficulty of adjusting to gravity. Nausea and total weakness of his body were the most obvious initial reactions. An adjustment to being around other people and no longer being in a special environment also took time.

While many biographies of astronauts emphasize the glamorous part of being an astronaut, Clayton made a concerted effort to show both the good and the bad. Not just the bad side of living in space, but also his own bad side. He was frankly honest about times that he overstepped his bounds and upset other people. Clayton had a tendency to want to take matters into his own hands, and circumvented the NASA hierarchy in the process. Needless to say, he pissed off many people that way. Clayton stepped on enough toes that, after his flight, he was told that he would not fly in space again.

I thoroughly enjoyed reading The Ordinary Spaceman, and I cherish having had the opportunity to meet Clayton and spend time talking with him. That said, there were a few moments in the book that made me cringe. Presented as amusing anecdotes, in the age of #metoo, some of the stories were particularly uncomfortable to read. A tale of an important individual from Johnson Space Center who insisted on passionately kissing all the women at a party, whether they wanted to be kissed or not. An episode with his fellow astronaut classmates during Mardi Gras, when a female member of their group was encouraged to show her breasts in order to gain entrance to a nightclub. And a description of a female Russian interpreter wearing a sheer dress, with far too much detail about what she had on underneath. I would have been quite happy to have skipped reading about any of those incidents.

Those few stories aside, I’m glad I read The Ordinary Spaceman by Clayton Anderson, and I would recommend this book enthusiastically.

**References:**
The Ordinary Spaceman: From Boyhood Dreams to Astronaut by Clayton C. Anderson; University of Nebraska Press, 2015.
Chapter 5

Space Place

See FN6
Winter begins in December for observers in the Northern Hemisphere, bringing cold nights and the return of one of the most famous constellations to our early evening skies: Orion the Hunter!

Orion is a striking pattern of stars and is one of the few constellations whose pattern is repeated almost unchanged in the star stories of cultures around the world. Below the three bright stars of Orion’s Belt lies his sword, where you can find the famous Orion Nebula, also known as M42. The nebula is visible to our unaided eyes in even moderately light-polluted skies as a fuzzy “star” in the middle of Orion’s Sword. M42 is about 20 light years across, which helps with its visibility since it’s roughly 1,344 light years away! Baby stars, including the famous “Trapezium” cluster, are found inside the nebula’s whirling gas clouds. These gas clouds also hide “protostars” from view: objects in the process of becoming stars, but that have not yet achieved fusion at their core.

The Orion Nebula is a small window into a vastly larger area of star formation centered around the constellation of Orion itself. NASA’s Great Observatories, space telescopes like Hubble, Spitzer, Compton, and Chandra, studied this area in wavelengths we can’t see with our earthbound eyes, revealing the entire constellation alight with star birth, not just the comparatively tiny area of the nebula. Why then can we only see the nebula? M42 contains hot young stars whose stellar winds blew away their cocoons of gas after their “birth,” the moment when they begin to fuse hydrogen into helium. Those gas clouds, which block visible light, were cleared away just enough to give us a peek inside at these young stars. The rest of the complex remains hidden to human eyes, but not to advanced space-based telescopes.

We put telescopes in orbit to get above the interference of our atmosphere, which absorbs many wavelengths of light. Infrared space telescopes, such as Spitzer and the upcoming James Webb Space Telescope, detect longer wavelengths of light that allow them to see through the dust clouds in Orion, revealing hidden stars and cloud structures. It’s similar to the infrared goggles firefighters wear to see through smoke from burning buildings and wildfires.

Learn more about how astronomers combine observations made at different wavelengths with the Night Sky Network activity, “The Universe in a Different Light,” downloadable from bit.ly/different-
light-nsn. You can find more stunning science and images from NASA's Great Observatories at nasa.gov.

This article is distributed by NASA Night Sky Network. The Night Sky Network program supports astronomy clubs across the USA dedicated to astronomy outreach. Visit nightsky.jpl.nasa.org to find local clubs, events, and more!
Chapter 6

BMAC
Calendar
and more
### BMAC Meetings

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<tr>
<td>Friday, December 6, 2019</td>
<td>7 p.m.</td>
<td>Nature Center</td>
<td>Program: Davis Gentry from PARI (Pisgah Astronomical Research Institute) will speak. The title of his talk is “PARI: A Facility of the Past Preparing for the Future.” Davis Gentry was an intern at PARI last summer teaching and helped campers understand basic astronomy and astrophysics. He is currently a graduate student at Appalachian State University in their Engineering Physics program. He enjoys observational astronomy.; Free.</td>
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<td>Discovery Theater</td>
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<tr>
<td>Friday, February 7, 2020</td>
<td>7 p.m.</td>
<td>Nature Center</td>
<td>Program: TBA; Free.</td>
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<td>Discovery Theater</td>
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<tr>
<td>Friday, March 6, 2020</td>
<td>7 p.m.</td>
<td>Nature Center</td>
<td>Program: TBA; Free.</td>
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<td>Discovery Theater</td>
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### SunWatch

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<tbody>
<tr>
<td>Every Saturday &amp; Sunday</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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<td>March - October</td>
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### StarWatch

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<tr>
<td>Oct. 19, 26, Nov. 2, 2019</td>
<td>7 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>Nov. 9, 16, 23, 30, 2019</td>
<td>6 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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### Special Events

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<tr>
<td>January ?, 2020</td>
<td>5 p.m.</td>
<td>TBA</td>
<td>Annual BMAC Dinner. <em>The Saturday a week later is the snow date.</em></td>
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<tr>
<td>Saturday, May 2, 2020</td>
<td>1-4:30 p.m.; 8:30-9:30 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 3-3:30 p.m. at the dam; Night viewing 8:30-9:30 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:

https://www.baysmountain.com/astronomy/astronomy-club/#newsletters

Regular Contributors:

William Troxel

William is the current chair of the club. He enjoys everything to do with astronomy, including sharing this exciting and interesting hobby with anyone that will listen! He has been a member since 2010.

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.
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.

Without 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. Leo Rising

A sky filled with stars and a thin veil of clouds.

Image by Adam Thanz

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 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 December 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 image from NASA's Spitzer missions shows Orion in a different light – quite literally! Note the small outline of the Orion Nebula region in the visible light image on the left, versus the massive amount of activity shown in the infrared image of the same region on the right. Image Credit: NASA/JPL-Caltech/IRAS /H. McCallon. From bit.ly/SpitzerOrion