http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 4, Vol. 5 February 2017–April 2017

Star Party Weekend at Stratford Hall

On Saturday and Sunday, May 6–7, RAC will participate in a 2-day astronomy event on the Oval at Stratford Hall in Westmoreland County. Saturday's events (weather permitting and free to the public) will begin at 6 p.m. and go until 11 p.m. Observing with members of the club will start at approximately 8 p.m. using a variety of telescopes set up on the Oval (in front of the main house).

On Sunday, opportunities for solar observing will be provided by RAC members in the same location from 9:30 a.m. until noon. Sunday will also feature Dean Howarth—actor, educator, and historical interpreter—portraying the 18th century astronomer David Rittenhouse. The 18th century saw the discovery of new planets, advances in navigation, and the mapping of the solar system by notable scientists such as Herschel, Harrison, and Rittenhouse. Rittenhouse was known for his observations of the transit of Venus across the Sun in 1769, which helped measure the size of the solar system. There is an admission fee for the public for Sunday's events.

For directions and additional details, view the event flyer and/or the Stratford Hall website.

How to Join RAClub

RAClub is a non-profit organization located in the Fredericksburg, Virginia, area. The club is dedicated to the advancement of public interest in, and knowledge of, the science of astronomy. Members share a common interest in astronomy and related fields as well as a love of observing the night sky.

Membership is open to anyone interested in astronomy, regardless of his/her level of knowledge. Owning a telescope is not a requirement. All you need is a desire to expand your knowledge of astronomy. RAClub members are primarily from the Fredericksburg area, including, but not limited to, the City of Fredericksburg and the counties of Stafford, Spotsylvania, King George, and Orange.

RAClub annual membership is $20 per family. Student membership is $7.50. Click here for a printable PDF application form.

The RAClub offers you a great opportunity to learn more about the stars, get advice on equipment purchases, and participate in community events. We meet once a month and hold regular star parties each month on the Saturday closest to the new Moon. Our website, www.raclub.org is the best source of information on our events.

We also have an active Yahoo group that you can join to communicate with the group as a whole. Just click the link, then the blue Join this Group! button, and follow the instructions to sign up.

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Website: www.raclub.org
Yahoo Group:
http://tech.groups.yahoo.com/group/rac_group/

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Jerry Hubbell, Astrophotography
Myron Wasiuta Mark Slade Remote Observatory (MSRO)

Calendar of Upcoming Events

Star Party, Stratford Hall	May 6–7
Star Party, Caledon State Park	May 27
Star Party, Caledon State Park	July 22

Recent Outreach Events Completed

After School Program (outreach), Mt. View HS	Feb. 7
Virginia Governor's School presentation, River Bend HS	Feb. 17
Star Party & Outreach, Marine Corps Museum	March 11
Kate Waller Elementary School presentations	March 30
Star Party, Caledon State Park	April 29

President's Corner

Welcome to New RAClub Members (February–April)

- Michael & Cheyanne Pratt
- Logan Palmer
- David Hiles
- Geri & Mark Rodman

The winter that never was is over, and we are in full springtime bloom just in time for some great opportunities for star parties and other outreach events.

As you can read on the front page of this newsletter, the big event for the spring is our **2-day event at Stratford Hall in Westmoreland County on May 6 and 7**. This should be a great opportunity for astronomy and history lovers to come out and enjoy dark skies out on the Northern Neck. We are crossing our fingers for clear skies because this is our first go at such an ambitious outreach event. Other events include our regular Caledon star parties and other outreach events still in the planning phases. Please check our calendar for updates.

In this issue, you will find some great reviews, including a lens (from our past president Ron Henke), as well as tracking mounts and books. Also included is an update from the Mark Slade Remote Observatory (MSRO), a Focus On article on the smaller details of the Moon, and highlights from recent club programs. For such a small group, the amount of information and details provided are remarkable, and another thanks goes to our amazing editor Linda. Please check out the details and join us at one of our events or club meetings.

Clear Skies, Scott Lansdale

Astronomy Math: Calculating the Force of Gravity by Scott Busby

To use the absolute method to calculate the force of gravity, you enter the values (in this case, the masses m_1 and m_2 in kilograms (kg) and the distance in meters (m)) and constants (here only G) in appropriate units. If the values of any of the variables are in different units, you'll have to convert to the required units. Then perform the necessary math operations to arrive at an "absolute" answer—that is, an answer that represents a value with appropriate units rather than a relative answer. So, let's calculate the force of gravity between the Sun and Uranus:

Begin by writing down exactly what you're given, what you're trying to find, and what relationship connects them. In this case, you're given the names of two objects (the Sun and Uranus), and you're asked to find the force of gravity between them. Newton's Law of Gravity can be used to find the force of gravity between any two objects, as long as the mass of each object and the distance between them is known. Because you don't have the masses the Sun or Uranus, you'll have to look them up.

You should find that the mass of the Sun is about 2×10^{30} kg, the mass of Uranus is about 8.7×10^{25} kg, and Uranus' distance from the Sun varies from 2.74×10^{9} to 3.01×10^{9} km. Because we don't know at what point in Uranus' orbit you should find the force of gravity, you're free to use any distance in that range. We'll use the middle of the range (2.87×10^{9} km). You now have all the quantities to find the force of gravity. However, before you can start plugging values into Newton's Law of Gravity, it's essential to convert the distance into the required units of meters:

$$R = 2.87 \times 10^{9} \times \left(\frac{1{,}000\ \text{m}}{1\ \text{km}}\right) = 2.87 \times 10^{12}\ \text{m}$$

Now you can plug in the values for the masses and the distance:

$$F_g = \frac{Gm_1m_2}{R^2} = \left(6.67 \times 10^{-11}\frac{\text{Nm}^2}{\text{kg}^2}\right)\left[\frac{(2 \times 10^{30}\text{kg})(8.7 \times 10^{25}\text{kg})}{(2.87\,x\,10^{12}\text{m})^2}\right]$$

$$= \left(6.67 \times 10^{-11}\frac{\text{N}\cancel{\text{m}^2}}{\cancel{\text{kg}^2}}\right)\left(2.11 \times 10^{31}\frac{\cancel{\text{kg}^2}}{\cancel{\text{m}^2}}\right) = 1.4 \times 10^{21}\text{N}$$

Product Review: HyperStar Lens

By Ron Henke

When I lived in Virginia, I had a Celestron NexStar 8 SE telescope. It was great. I loved it. It was portable and easy to align. However, as our move to Tucson drew nearer, I got the itch to try something new. I decided that I wanted another single-arm alt/az telescope, and I was determined to get the Celestron Evolution. As a plus, all new Celestron SCTs are Fastar/HyperStar compatible. What more could I want…easy alignment with deep sky imaging potential with an alt/az mount!

When we got to Tucson, I began looking for my next telescope. As a bonus, I discovered that the Starizona astronomy store, which makes the HyperStar lens, is less than 4 miles away. When I visited the store, the guys at Starizona asked the inevitable key question: What do you want to do? Well, I wanted ease of use and the ability to do deep sky imaging, probably with HyperStar. I had myself convinced that I would buy a Celestron Evolution. Well, Dean, the owner of Starizona, talked me into a Celestron Advanced VX mount with a C8 OTA, and I'm glad he did. I am quite happy with it. It is incredibly accurate.

Fast forward to a couple of months ago. I finally bought a HyperStar lens…and a bunch of other stuff to make it work. The total equipment list was:

- HyperStar Lens
- Camera, in this case, an Atik 460EX one-shot color, 6MP CCD
- Feather Touch Micro Focuser by Starlight Instruments
- Micro Touch Controller by Starizona*
- Maxim DL, Pro version

*Controls the Feather Touch through a software interface, so focusing is done automatically. This setup works very well with Maxim DL.

The first important thing to note with a HyperStar lens is that it is only compatible with a SCT OTA. Also, if you are planning to buy a HyperStar lens, check with Starizona to ensure there is a lens or an adapter for the lens that fits your camera.

Shown above is my Celestron Advanced VX mount with a standard C8 tube. It is important to note that the secondary mirror must be labeled "Fastar" if it is to readily accept a HyperStar lens. There is an adapter that can be purchased to make SCTs HyperStar compatible. Again, check with Starizona first to ensure your tube is compatible.

The picture at right shows the HyperStar lens itself (left) and the Atik 460EX, one-shot color, 6-megapixel camera (right). This lens is made specifically for a Celestron 8-inch SCT tube. The lenses and tube are manufacturer-specific. The EX line of Atik cameras is made especially for use with a HyperStar lens. The camera body has the same diameter as the lens. I bought the 6-megapixel camera because it has a full-size chip—not the same pixel density as the 9- or 12-megapixel versions—but it costs less.

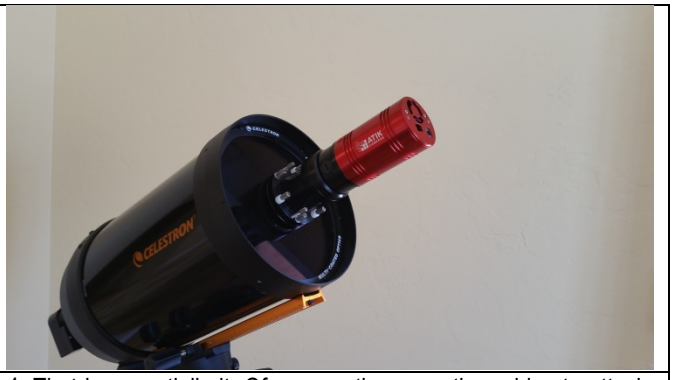
The picture on the right shows a Starizona lithium ion battery (left) and one-half of the Micro-Touch focus controller (right). While the battery is not on the equipment list above, I use it to power my mount. It's great. It's about the size of a brick and weighs about a pound. It's much better than the lead acid battery I was using in Virginia. It has about 10 hours of battery life. (In fact, Bart Billard bought one when he was here visiting.) The other half of the focus controller is a motor that connects to a Feather Touch 10:1 manual two-speed focuser. This is all controlled by a program called Focus Max. In fact, I get to Maxim DL by launching Focus Max first. It works well. With this setup, I will typically get a FWHM of between 2 and 3.

To go from visual viewing to HyperStar imaging is surprisingly simple, as shown in the steps below:

1. Remove the secondary mirror by loosening and removing the retention ring and then the mirror.

2. Put the secondary mirror in the lens cap that comes with the HyperStar and secure it with the retention ring. Note there is a notch on the receiver for the secondary mirror on the OTA that ensures that the mirror is reattached perfectly so the mirror does not get out of alignment.

3. Next, screw the camera into the receptacle at the end of the HyperStar lens, and attach the lens with the camera to the telescope where the secondary was. Yes, the corrector plate is dusty.



4. That is essentially it. Of course, there are the cables to attach, but that's really all. One more word about cables: There are a lot of cables with this setup and cable management becomes a priority. The HyperStar I bought was perfectly collimated right out of the box.

Pros and cons of using HyperStar:

Pros:	Cons:
❖ Very fast; F2.2 with HyperStar versus F10 without HyperStar ❖ Simple to set up and use ❖ Good for one-shot color cameras because of its speed ❖ Guide scope and camera not required, thanks to the wide field ❖ Can take a picture in a fraction of the time compared with conventional imaging ❖ A good way to get into deep sky astrophotography with an alt/az mount	❖ May not save any money ❖ Because of such a wide field, targets may be very small ❖ Because of the wide field, a camera with a high pixel density is best

After having the HyperStar and camera setup for several months now, I'm glad I bought it and would do it again. Its main advantage is the speed. I remember doing a shot of the Hickson Compact Group 44 with Jerry Hubbell. It took an hour to do (20 sub-frames of 3 minutes each). With HyperStar, I could do the same thing in 15 minutes (30 sub-frames of 30 seconds each), although the objects would be smaller.

I have included a small sample of some HyperStar images I have taken. All these pictures were taken with a HyperStar lens, Atik 6 MP 460 EX one-shot color camera, Celestron Advanced VX mount, standard Celestron C8 OTA, and each is 30 sub-frames of 30 seconds each.

Editor's Note: Another one of Ron's recent HyperStar photos is shown at the end of this newsletter as the Image of the Quarter.

M42

M81 and M82

M45

M31

Product Review: iOptron CubePro Alt-Azimuth Mount

By Tom Watson

Astronomy and astrophotography are hobbies deeply entangled in the tradeoff between investment and result. A common problem, especially with astrophotography, is the need to balance a budget while providing a stable and accurate tracking platform for photos, as well as the ability to readily find and remain centered on targets in the night sky. To this end, I purchased an iOptron CubePro Alt-Azimuth mount. My goal was a go-to mount for wide-angle astrophotography and visual observation and ease of use—for a reasonable price tag.

Perhaps the most useful feature of the CubePro is its go-to capability. You can calibrate against a single star and immediately begin using the go-to capability. While the unit has a 32-channel GPS that provides a relatively good understanding of its location, calibrating against a second or third star increases its accuracy. This allows easy location of harder-to-find objects using the CubePro's computer and built-in directory of 130,000 items. If any items are missing from this database, the user can program up to 256 additional items to track.

The unit is lightweight and portable and requires minimal setup and takedown time, making it very useful for star parties or merely taking to a friend's house to enjoy the stars. With a battery compartment holding AA batteries, the unit can provide a full night of observation with tracking without the need for an external power source, although it can accept an external power source.

While the go-to capability is the most useful feature of the CubePro, it also leads to its greatest weakness. The unit tends to become uncalibrated or has trouble finding items in its database very easily. Keeping the unit calibrated becomes burdensome during extended use. In general, I found myself using classical star location techniques instead of the go-to after becoming frustrated with the unit losing its calibration.

The CubePro is sometimes suggested as an effective astrophotography platform, but this is not realistic. While wide-angle photography is easily achievable using the CubePro, with focal lengths of more than 300 mm you will begin to notice star drift in as little as 10–20 seconds of exposure. This makes the CubePro undesirable for long exposure astrophotography, unguided. Importantly, an auto guider can be attached to the CubePro potentially reducing the impact of this problem.

Something important to keep in mind when using a telescope with either a large eyepiece or a camera attached is the CubePro's rotation. The unit will sometimes rotate in an unexpected direction while slewing to a target. This can cause exposed eyepieces and cameras to impact the tripod legs causing the unit to skip gears and potentially harm itself. Moreover, the power cable, if external power is used, can become detached easily as the unit swivels to slew to a target. Careful attention is necessary to prevent this from happening.

Pros and cons:

Pros	Cons
❖ Easy transportation. ❖ Simple use and quick calibration. ❖ Large celestial database. ❖ 4. Can accept an auto guider. ❖ 5. Useful for wide angle photography. ❖ 6. A full night of use from batteries. ❖ 7. Under $500.	❖ Difficulty taking astro photos. ❖ 2. Easy misalignment and loses alignment. ❖ 3. The unit can damage itself if you are not careful.

In conclusion, the iOptron CubePro Alt-Azimuth go-to mount is a reasonably priced mount for observational astronomy or wide-angle photography. It is not desirable for long exposure photography. Its motorized capability makes it useful when slowly hunting for deep sky objects, while its go-to capability provides an easy method for finding hard-to-find objects, so long as extra care has been taken to ensure its calibration is solid.

Product Review: Sky Watcher Star Adventurer Tracking Mount

By Tom Watson

Motorized tracking mounts are one of the most valuable tools for astronomy and astrophotography. The primary downside is the cost (typically thousands of dollars) and their complexity of use. While hunting for a mount for astrophotography that was both accurate and cost effective, I contacted Sky Watcher with a series of product questions about their Star Adventurer mount. It was not long before they made me the offer to send a free tracking mount for my evaluation. I received the Star Adventurer tracking mount at no cost in hopes that I would review it.

The first thing I noticed was that the mount appeared to have been designed by people who gave much thought to how it would be used in the field. Several times, it occurred to me that a particular feature would make the mount better, only to realize that it had that feature already. For example, the motor locking mechanism, which allows free rotation of the angle of right ascension when unlocked and engages the movement by the motor drive when locked, is quite large and easy to use in the dark without even looking. The entire mount is easy to operate without the need to look for anything, which is crucial on a dark night.

Perhaps the most important feature is the accuracy of the tracking. Using a 400 mm focal length telescope, I was able to readily hold a star "locked" in place long enough to photograph with exposures of 60 seconds or more, unguided. Most mounts cannot exceed 30 seconds, unguided, for under a thousand dollars, without noticeable movement of the stars. I was able to reproduce this level of precision over and over by merely ensuring a good Polaris calibration and a reasonably level mount. Such precision allows faint, deep sky objects, such as galaxies, to be photographed.

Sirius, Canon Rebel T5, 75mm(75-300mm), f/4 (14s x 86 Frames = 1204s) IS800

Besides its more obvious benefits, the mount also provides the capability to use an external auto guider or go-to apparatus, which can connect into an auxiliary port. For panoramic photography, the mount provides several prebuilt auto panoramic swivel operations and is capable of controlling the camera through a camera shutter port.

While the mount is easy to use and has superb tracking accuracy, it does suffer from a few design flaws. The most obvious are two plastic parts: the lens caps for the Polaris finder scope. While they are not required for the operation of the mount, losing them would be troublesome because the finder scope would become dirty and require continuous cleaning. They are lightweight and easily fall off. The Polaris finder scope, itself of absolutely superb quality, also suffers because its internal illumination battery fails almost immediately after use. I could not find a way to shut the light off readily. Although this may have been user error, it breaks with the mold of intuitive use that the rest of the mount excels in.

The other major problem is the accessories not included with the unit that are essentially required to use the unit to its maximum capability. A photographic ball mount is advertised as an effective means of reaching a proper Polaris alignment. In reality, the angled wedge, sold separately, is much sturdier than a ball mount and can handle the full load of the unit, unlike most ball mounts. This fact makes the angled wedge nearly a requirement. Moreover, the counterweight and L-bar for attaching telescopes and cameras are also practically a requirement. I list these needed accessories as negatives because they do not come with the unit but must be purchased separately.

Pros and cons of using the Star Adventurer:

Pros:	Cons:
❖ Light-weight, easy setup ❖ VERY accurate unguided star tracking! ❖ Metal construction. ❖ Long battery life. ❖ Polaris finder scope. ❖ Lots of great knobs and parts designed to simplify use. ❖ Intuitive design. ❖ Can perform per-programmed panoramic photography motions. ❖ Typically under $500. ❖ Supports external auto guider.	❖ Some plastic parts (not needed for operation). ❖ Needs angled wedge and counter weight to be useful. ❖ Limited payload weight. ❖ Polaris finder scope light failed very quickly.

In conclusion, the Sky Watcher Star Adventurer is a durable and extremely cost-effective tracking mount for the astrophotographer and astronomer trying to balance budget and quality. I find myself reaching for the Star Adventurer over my other mounts because it is easy to carry with one hand, provides almost guaranteed results, and gives me the longest exposure times of any of my tracking mounts. It is a well-balanced and well-constructed device made with astrophotography in mind.

MSRO Director and Assistant Director Give Talk to Commonwealth Governors School Students

By Myron Wasiuta

On Friday, February 17, Jerry Hubbell and I gave a talk to approximately 120 11th graders enrolled in the Commonwealth Governors School (CGS). We gave our presentations at the Riverbend High School location but were telecast into classrooms at the Stafford, Spotsylvania, and King George CGS locations as well.

I led off with a talk on the lifecycles of both stellar and high mass stars. Incorporated into my talk were actual images taken using the Mark Slade Remote Observatory (MSRO) telescope of stars at various stages in their evolution—from protostars, to main sequence stars, and finally white dwarfs, planetary nebulae, and even supernova remnants. I also briefly touched on the concept of nucleosynthesis and the roles stars play in this process.

After my talk, Jerry gave an informative presentation on the MSRO itself, with emphasis on its equipment and capabilities. He illustrated the various software capabilities and gave multiple examples of appropriate research projects that could be effectively carried out using MSRO. He then connected remotely to the observatory and, as the students watched, opened the shutter and rotated the dome.

After the talks, students engaged us in a question and answer session. Overall, there seemed to be much interest and enthusiasm from the students of the CGS, and we made a formal invitation for the students to use MSRO for their Culminating project.

Caledon Observing Report (January 28, 2017)

By Scott Lansdale

The weather was unusually nice for a January evening although it did get chilly as the night drew on. It was a moonless night which made observing deep-sky objects the focus of the night. There were several club members in attendance and perhaps 20 visitors, which was a great turnout. For the night's observing, I set up the club's Sky View Pro Mount combined with my 8-inch Orion RC reflector.

Before getting started on the "faint-fuzzies," we observed Venus and Mars. Mars did not reveal much detail other than a ruddy small disk, even under higher power. Venus, however, was a true pleasure. As a crescent, Venus put on more of a show than normal, and under high power, it looked much like the Moon minus the craters. I could almost imagine being able to see details in the clouds if that was possible.

Next, we moved on to other objects including the Orion Nebula (M42), the Andromeda Galaxy (M31), and the Pleiades. We were also able to observe a few star clusters including M37, M41, and M44. Another object we

observed was the double star Castor, which, with the naked eye, appears to be a single star but under high power actually reveals two stars.

The seeing was particularly good this evening, so when twilight had completely faded, we went back to observe M42. This time, we attempted to take some photographs instead of observing directly. We used two different cameras—both were Sony Mirrorless DSLRs. This type of camera has a removable lens, which allows insertion of an adaptor into the lens holder of the telescope. The camera's CCD chip then functions much like your eye but is able to soak up much more light over time. The results were quite amazing (see photo at right), and we were able to take 30-second exposures with only slight star trailing. The telescope mount had only been polar-aligned by eyeball so this was very fortunate—the best I had ever experienced with this telescope mount.

From the good turnout, weather, and observing, the night was a great success, and I hope we have many more like it.

Book Review: Hidden Figures

By Payel Patel

Margot Lee Shetterly's book, *Hidden Figures*, aims to commemorate the challenges and achievements of three mathematicians who contributed to the American space exploration. With diligence and perseverance, Dorothy Vaugh, Mary Jackson, and Katherine Johnson, among various other female African-American mathematicians, provided crucial calculations that helped protect our astronauts and the integrity of our space program. This book, so successfully meeting its objective to highlight these hidden figures of our history, was indeed a worthwhile read. Not only did I learn about the meticulous measures that were taken to ensure the safety and efficiency of our aircraft and spacecraft, but I also learned that these "human computers" had overcome obstacles that you and I couldn't have even imagined if we were living in the 1960s. Every story presented by Shetterly unveiled the sentiments these women faced as they displayed the value of their inherent gifts—not only to their superiors and peers at work—but also to their families and to themselves. These women stood on the shoulders of other high-achieving women who came before them, and now, they themselves are the giants upon whose shoulders we stand.

I was especially impressed with the humility of Katherine Johnson. The brilliant women in this book did not appear to seek recognition. They deserve it, yet they never demanded it. Ms. Johnson, in particular, claimed that it was due to her luck that she was chosen to be the "girl." That "girl" was a reference to the human computer who double-checked the numbers to see whether the computer-generated trajectory was accurate before John Glenn boarded the mission to orbit the Earth, providing him the assurance he needed for his safety. On the contrary, I would say that it was the steps taken by Ms. Johnson, as crafted by her will and her attitude, her natural talent, and the support of her mentors such as Schiefflin Claytor, that placed her in a position to make these vital calculations.

At times, the book felt detail heavy. It also struggles with the vast number of characters whose stories are briefly touched upon. Overall, however, these are minor setbacks, and the message that the author seeks to convey was

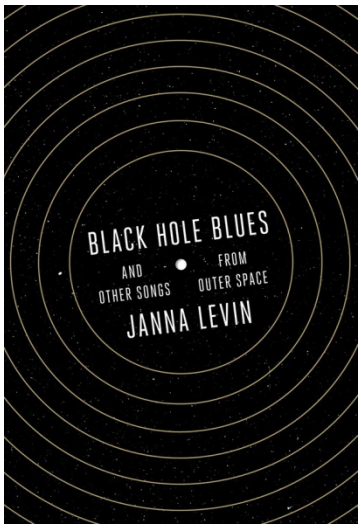
received clearly. These women chose not to be victims of discrimination and bad behavior; instead, they were opportunists who focused on their career goals, using each chance that came their way and ignoring the sneers, occasionally even with cognitive dissonance. From the human computers crammed in the West Wing of Langley Research Center, to the current-day physicists and engineers of NASA, these women are role models to the ambitious.

I am looking forward to meeting this skillful author in Fredericksburg at University of Mary Washington on March 4.

Editor's note: Payel met Linda and Bart Billard at Dodd Auditorium for the lecture presentation by Ms. Shetterly. The auditorium was packed, and the University had to get Fire Marshal approval so that people could stand along the walls. As good an author as she is, Ms. Shetterly's an even better speaker. After the lecture, Payel was 1 of some 500 who waited patiently to get a signature on their copy of the book.

Book Review: Black Hole Blues and Other Songs from Outer Space

By Bart Billard



The story of the development of the Laser Interferometer Gravitational-Wave Observatory (LIGO) covers a campaign of 50 years involving hundreds of scientists and engineers. LIGO is, to date, the National Science Foundation's most expensive undertaking. Janna Levin tackles this story in *Black Hole Blues*, starting in the 1960s and taking it to the preparations for the first observation run of Advanced LIGO in 2015. This was the 4-month run that detected two black hole mergers and another signal too weak to be confirmed with the required confidence, as described in the epilogue. Levin is a professor of astrophysics at Barnard College of Columbia University. She also wrote *How the Universe Got Its Spots* and a novel, *A Madman Dreams of Turing Machines*.

Much of *Black Hole Blues* focuses on the personalities of some of the people involved through most of the long project. For example, as a kid, Rainer Weiss (Rai) was interested in high fidelity. In 1947, he built his own equipment using speakers salvaged and lugged home by subway from the Brooklyn Paramount Theater after a fire there led the owners to get rid of them. Weiss was one of the earliest scientists to dream up a device to record the sound-like waves of spacetime predicted by Einstein's general theory of relativity. In 2005, he achieved the august title of professor emeritus at MIT (retired but still active). He retired essentially so he could be like a student again, walking the 4-kilometer cement tunnels containing the interferometer arms, checking for vacuum leaks, measuring seismic vibrations, and occasionally dealing with wasp nests or other critter invasions. Two of the other main figures described are Kip Thorne, a Caltech astrophysicist, and Ron Drever, an experimental physicist from Scotland.

The book also offers a good taste of the nitty-gritty nature of experimental science. The hard vacuum in the interferometer arms is essential to minimize the presence of air molecules that could slow down the light enough to mask the tiny changes in the length of the arms caused by gravitational waves. Levin describes this as "a change in distance less than a human hair relative to 100 billion times the circumference of the world." It would take several years to get the vacuum back down to the desired level if an arm were exposed to atmospheric pressure. To help measure such small changes in the length of the interferometer arms, the light is recycled many times down each arm and back, and the circulating laser power builds up to near a megawatt. When the interferometer is locked, a detector registers no power unless small disturbances or gravitational waves disturb the match between the lengths of the two arms. These register as a tiny fraction of the megawatt circulating in the arms. On one occasion, the

detector was fried when the machine dropped out of lock. Stainless steel shutters were added, designed to quickly close and protect the detector. Even the metal got smoked in another incident.

A *Sky & Telescope* review said, "….Levin gives her readers a satisfying look at how big science starts, develops, and—in the end—succeeds." I pretty much agree with this characterization. If you read the first two or three chapters and find it tells an interesting story, I doubt you will be disappointed by the book.

FOCUS ON: Schiller-Zucchius Basin

By Jerry Hubbell

(Note from the author: A version of this article was published in the November 2016 ALPO The Lunar Observer *as the Focus On bi-monthly article. Part of my role as the Assistant Coordinator (Lunar Topographical Studies) is to write articles periodically on research done by ALPO contributors. To see full-size versions of the photos, go to http://moon.scopesandscapes.com/tlo.pdf)*

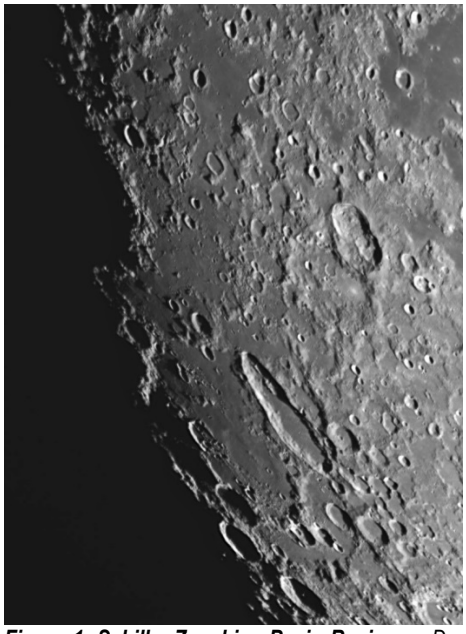


Figure 1. Schiller-Zucchius Basin Region *– David Teske—Starkville, MS, October 13 2016 0134UT, North/Up, East/Right, Seeing 4/10, Celestron 9.25" Edge SCT and Mallincam GMTm Camera. Crater Zucchius and Segner shown in deep shadow. The full relief of the basin is revealed in this image.*

Figure 2. Schiller-Zucchius Basin Region—*Jay Albert—Lake Worth, FL, August 8 2016 0157UT, North/Up, East/Left, Celestron NexStar 6" SCT and Celestron Neximage 5 Solar System Camera.*

Continuing our studies of small regions of the Moon, the Schiller-Zucchius Basin is another very interesting area. Spanning more than 200 miles (335 km) in diameter and centered at selenographic coordinates 56.0°S, 45.0°W, the basin is named after the odd, elongated crater Schiller to the north and younger crater Zucchius to the southeast. The basin was formed in the pre-nectarian period 4.0–4.5 billion years ago (lower portion Figure 1). The basin is a flooded impact zone that also contains the flooded crater Segner immediately northwest of Zucchius, and other flooded craters formed billions of years ago. The recent favorable lunar librations provide an excellent view as shown in figures 1 and 2.

Figure 3 shows sunrise over the crater Zucchius and provides the lighting necessary to reveal the basin in excellent relief. The image shows a very shallow, sunken area within the basin with a low range of mountains in the center. This is most likely a flooded crater that was a result of the original impact. This is not evident in other views of the region where the Sun is higher up in the sky.

Crater Schiller, located at selenographic coordinates 51.8°S, 40.0°W, provides a fascinating object to study with its terraced crater walls and central mountain chain to the north. The overhead, aerial view shown in Figure 4 reveals the true shape of the basin, crater Schiller, 113x45 miles (179x71 km), and crater Zucchius, 40 miles (64 km).

The Figure 4 view shows the basin as a generally circular area with crater Segner located northwest of Zucchius. There are several craters in the 5- to 20-mile (8- to 32-km) range located in the basin interior. This region is worthy of further study, especially during low-light angles as shown in Figure 3. The various mountain ranges in the area are ripe for measurement using the Lunar Terminator Visualization Tool (LTVT).

Overall, smaller impact basins < 500 km in diameter on the Moon are worth our time and effort to study the topography of the region and will lead us to discover features that would not

be obvious in our general photographic surveys of these regions. Keeping this in mind when planning our observations can lead to discovering new, subtle features that enhance our understanding of the formations and history of the lunar surface. Using software tools enhances our ability to study these topographical features and keep us excited about observing the Moon.

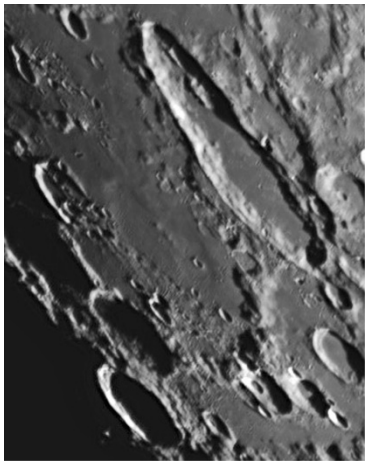


Figure 3. Schiller-Zucchius Basin Region (crop of Figure 1.)—*David Teske – Starkville, MS, October 13 2016 0134UT, North/Up, East/Right, Seeing 4/10, Celestron 9.25" Edge SCT and Mallincam GMTm Camera.*

Figure 4. Schiller-Zucchius Basin*—Jerry Hubbell, Locust Grove, VA, January 16, 2012 0141UT, North/Up, East/Right, 127mm APO refractor, DMK 21AU04.AS CCD video camera. This image was processed in LTVT and shows an aerial overhead view of the basin.*

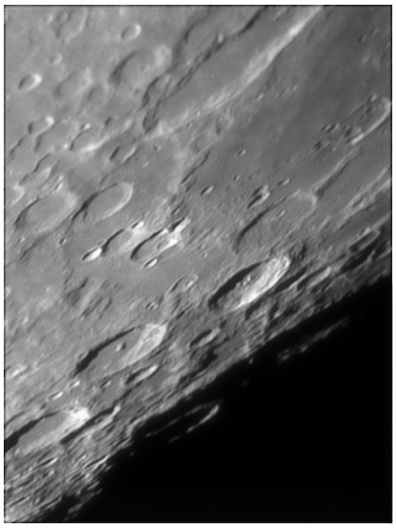


Figure 5. Schiller-Zucchius Basin *– Jerry Hubbell, Locust Grove, VA, January 16, 2012 0145UT, North/Up, East/Left, 127mm APO refractor, DMK 21AU04.AS CCD video camera. This image highlights the crater Zucchius near the center of the frame. Segner is well presented to the northwest of Zucchius.*

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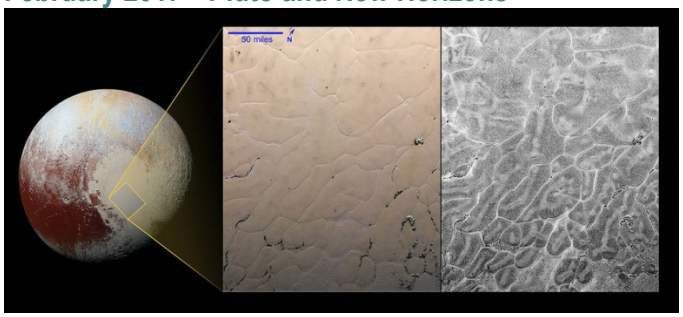
Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

February 2017—Pluto and New Horizons



Intricate Surface Patterns Revealed on Pluto's Sputnik Planum. Source: https://www.nasa.gov/mission_pages/newhorizons/images/index.html

Scott Lansdale's presentation included the following topics: Pluto's discovery, "What is a planet?" the New Horizons mission, facts about the Pluto system, the unexpected, and what's next for the New Horizons mission. He began by explaining Clyde Tombaugh's use of blinking images to discover Pluto in 1930. Scott asked Jerry Hubbell whether this technique could be used with the Mark Slade Remote Observatory (MSRO). Jerry confirmed it works with MSRO and that we have done it for asteroids; however, the images only have to be 45 minutes apart to see asteroid movement, not days apart like the Pluto images. Tombaugh also discovered a number of asteroids. He was working at Lowell's observatory at the time. Scott said Tombaugh was searching in the area Lowell had predicted based on anomalies of the orbits of Uranus and Neptune. However, he said Lowell had used an incorrect mass for Neptune, and consequently finding Pluto may have just been a lucky coincidence.

Scott said the International Astronomical Union (IAU) revised the definition of a planet in August 2006. The new answer to "What is a planet?" lists three requirements: (1) It orbits the Sun, (2) it has enough mass for a nearly spherical shape, and (3) its influence has cleared the neighborhood around its orbit. This definition demoted Pluto to a minor planet because it is part of the Kuiper Belt and has not cleared its neighborhood. Glenn Holliday commented that while preparing for a historical astronomy talk some time back, he came across some old books that listed a few of the major asteroids as planets.

Scott's next topic was the New Horizons mission. He said New Horizons launched in January 2006 to visit the last planet yet to be probed (7 months before the IAU made it a minor planet). New Horizons made a fast flyby of the Pluto system, so it was programmed to just gather data, storing it to begin transmitting after completion of the flyby. It made a flyby of Jupiter in February 2007 and began observing in fall 2014, about 200 days before the Pluto flyby.

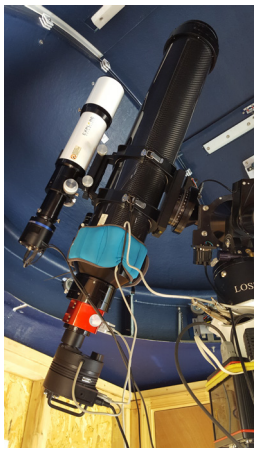
Pluto is smaller than the Moon and several other satellites, such as Ganymede, Titan, and Triton. Scott showed a comparison of Pluto with Mercury and several satellites, three of which are greater than twice Pluto's size. Pluto orbits up to 49 astronomical units away from the Sun and is part of the Kuiper Belt. Pluto has a retrograde rotation and is about two-thirds rock and one-third ice, with nitrogen ice at the surface. Pluto and Charon, its largest moon (1,207 km diameter), orbit each other more like a binary system would, and they are both tidally locked. Like our own Moon, Charon may have formed from a collision of something with Pluto.

Pluto is not the cold-dead Kuiper Belt world it was thought to be. Scott's highlights of the unexpected included cryovolcanoes, active geology, and mountains up to 11,000 feet. Pluto's surface is younger than expected. The heart-shaped region named Sputnik Planum has red deposits from the UV breakdown of hydrocarbons that generates tholins.

Scott told us the next target for New Horizons is Kuiper Belt object 2014 M69. He said New Horizons had recently completed a course adjustment, and the flyby was expected New Year's Day 2019. (It is a billion miles farther away than Pluto.) Jerry noted 2014 M69 was discovered about the same time as the Pluto flyby. Bart Billard said he recently saw a call for observations of possible occultations involving it that were predicted for this year.

Scott ended with a few videos about Pluto from a series, "Pluto in a Minute," and one made from images taken during New Horizons' approach to Pluto.

March 2017—MSRO Demonstration



After the business meeting, it was dark enough for Jerry Hubbell to demonstrate MSRO. He projected the MSRO computer desktop (viewed remotely via TeamViewer). First, he showed the ASCOM POTH (Plain Old Telescope Handset) and Maxim DL, two of the programs for controlling the telescope and observatory. A webcam view showed the refractor mounted in the dome. Jerry explained he had to add weight to the back of the refractor so that it would balance in the center instead of nearer the heavy objective end. The telescope was only a foot shorter than the dome diameter, and the balancing was necessary to have clearance from the dome at the back of the telescope as well as the front.

Jerry said MSRO was using the refractor to support an Explore Scientific remote observing "Experience" that would provide a fund-raising opportunity. He said the refractor was getting finer focus, which somewhat made up for the aperture difference. It could get 18th magnitude with 1-minute exposures. Jerry said there were already two customers for the remote observing experience with MSRO.

Jerry next showed the Cartes du Ciel program for navigating the sky. Using the program's display, he centered on the star Procyon and selected "slew to cursor" to command the telescope to go there. The webcam display showed the movement of the telescope (in blurred glimpses every 3 seconds, because the webcam needed a long exposure in the low light). Next, Jerry used the observatory control in Maxim DL to slave the dome to the telescope. When the dome caught up with the telescope, Jerry started the Maxim DL camera control window and took an image. The exposure caught a satellite. Don Clark asked about the size of the Procyon image. Jerry said it looked wider than fainter stars because more of the bell-shaped curve of the light distribution shows up in the range of intensities displayed.

Jerry noted that the mount had centered the star well, so that it was unnecessary to calibrate its position with a "plate solve" of the image. He simply confirmed to the Cartes du Ciel program that the telescope was centered on the star. Next he tried moving to M42, which involved a "pier flip" for the German equatorial mount to cross the meridian. The M42 image did not come out well, which Jerry concluded was because it was too close to a tree that blocks some of the western horizon at MSRO location. Instead of trying to get a better image of M42, Jerry selected —M67, taking the telescope back east of the meridian. Ryan Rapoza asked whether anyone had tried variable stars. Jerry said not a lot yet. Bart said he and Jerry planned to try some eclipsing binaries as preparation for trying to observe exoplanet transits.

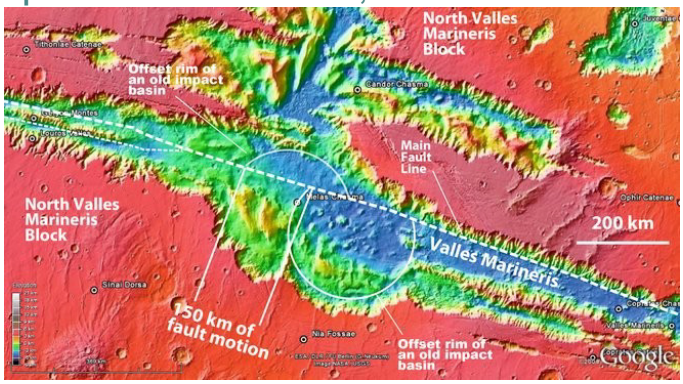
Don asked whether MSRO could be automated with a schedule setup. Jerry said it was more oriented toward teaching with hands-on experience involvement. He got an image of M67, and then made a longer exposure,—3 minutes instead of 30 seconds—and the stars were pretty round. Ryan asked about weather apps, and Jerry showed Weatherninja.net, an Internet weather resource, as an example of what's set up on the MSRO computer. The Davis weather station for the observatory was currently not communicating well.

Don asked about how scheduling was handled if more than one person wanted to be on. Jerry said more than one person can be connected at the same time, or the schedule can be based on what they want to observe.

Jerry's next object was M44. He slewed to its coordinates and then slewed a second time. He said he does that to make up for his controller software not yet fully handling the sky movement that occurs during the slew. We looked at the image Jerry then took and tried to match the star patterns with the display in Cartes du Ciel. Ryan eventually

worked it out and showed Jerry on his phone. Jerry finished the tour with a visit to a pair of galaxies in Leo. He found three in the image. When it was time to shut down, Jerry demonstrated parking the dome and telescope, turning off the camera cooler, and then disconnecting the camera in the camera control window, followed by the other items in the observatory control window.

April 2017—Your Next Home, Your Next Planet—Mars



Glenn Holliday began by saying he would describe some comparisons between Mars and Earth, saying each difference contributes to the challenge of going to Mars (both arriving and living there). Mars has a radius half of Earth's, one-tenth the mass, and a third of the surface gravity. Glenn gave a temperature range of -200 F to 100 F (rounded) and noted temperatures are mostly on the cold end. Mars started out hot like Earth and also differentiated like Earth, with heaviest metals in the core and lighter rocks in the mantel and crust. Because of its size, it cooled faster than Earth, leading to a thicker crust. However, there is good evidence the core is still at least partially liquid. Mars' geology could still be alive. Valles Marineris, with a length one-fifth the planet's circumference the longest valley on Mars, might be a boundary between two tectonic plates. Straight lines of volcanoes and shearing of an old crater basin rim suggest these plates have moved past each other on a fault line.

Glenn said Mars has two moons and described how odd they are. Phobos (11 km radius) and Deimos (6.2 km radius) are both too small to be round. Their gravity is very low from our perspective. Multiple theories of their origin remain in contention. He listed three: formed from the protoplanetary disk, captured asteroids, or results of debris from an impact on Mars. Glenn went into some detail on the strangeness of Phobos. It orbits across the Martian sky 47 degrees in an hour, three times faster than stars move across our sky. The result is Phobos is seen to rise in the west and set in the east. Glenn said its orbit decays 2 cm per year, and tidal forces will eventually break it up into a ring. Theoretically it could then eventually re-form into a smaller moon. In fact, its composition is essentially a pile of rubble, suggesting it may have been through a ring phase before.

Although a lot of evidence indicates ancient Mars had flowing rivers, lakes, and seas, the atmospheric pressure now is only 6 millibars, compared with 1,013 millibars on Earth. Surface water can no longer exist on Mars because it evaporates as soon as it is exposed to the low pressure. Glenn said the atmosphere once must have been much thicker, and evidence from rocks found on Mars indicates it had more oxygen and less carbon dioxide when they formed compared with today's mostly carbon dioxide atmosphere. He said now the atmosphere is cold, and when winter comes to either polar region, 16 percent of the atmosphere falls there as carbon dioxide snow. Long ago, the thicker atmosphere with more oxygen could have been habitable to humans. He asked, "Why do we need space suits there today?"

Glenn discussed the possibility it is because of the lack of a magnetic field like Earth's. The magnetic field surrounding Earth deflects the solar wind, protecting us from radiation. He said it may also protect our atmosphere by reducing the heating of upper air molecules by the solar wind. These air molecules only need a small amount of energy to reach escape velocity. The effect of the magnetic field deflecting the solar wind could mean fewer air molecules leak out into space. Glenn noted some researchers question the importance of this mechanism. One critic suggests the oxygen loss from Earth, Venus, and Mars is not very different, and proposes the explanation of Earth's oxygen level is its replenishment by life.

Maybe life formed on Mars around the time it did on Earth. Glenn discussed what evidence we have. In 1976, the Viking lander looked for chemistry that life could cause. It found something, but the cause was ambiguous. Glenn discovered results of a recent experiment using samples of soil from Antarctica and deserts. Although the samples definitely contained life, the Viking test did not detect it. In 1996, NASA scientists studying a meteorite identified as originating from Mars reported finding features that could be fossils of Martian bacteria. Following the report, other explanations were proposed, and most scientists do not accept the interpretation of the features as remains of life. Glenn said Mars satellites and rovers periodically find spikes of methane and formaldehyde, both of which, on Earth, are most commonly caused by life. On the other hand, he said, both might have other non-living causes.

The next topics were getting to Mars and how to survive there. Glenn said he found more competitors than you might think, each with a different plan to get there. NASA has had more than one plan. An early 2000s plan to return to the Moon on the way to Mars with a $500 billion budget died and was succeeded by a more recent plan mandated by Congress to use Apollo-style rockets. Its budget is reduced to $450 billion, and the first arrival would be in the 2030s. Elon Musk and SpaceX have proposed colonizing Mars to "…be more than a single-planet species." The plan would involve a spacecraft capable of carrying 100 people per flight. A $10 billion budget appears to be supplemented by a possibility of a $100,000 ticket price. Blue Origin has plans to build a rocket that can reach the Moon and beyond, with a goal of commercializing space. The budget is $1 billion a year. The plan of the United Arab Emirates makes the SpaceX 10-year plan and NASA 20-year plan look optimistic. Their plan is to establish a colony on Mars in 100 years, and Glenn said, "They have the money." He also talked about the status of the Mars One plan, which got a lot of attention by accepting applicants worldwide to be one-way colonists to Mars, with first arrival in 2032. A reality TV show was supposed to finance it, but TV sponsorship has ended. Mars One recently started letting applicants purchase a higher priority of being chosen. Announcement of final crews and crew training is behind schedule. On colonists surviving, Glenn said challenges include life support, radiation protection, and living with 1/3 gravity. We will have to build a home that can make its own air, water, and food and not need a maintenance call. NASA's twin astronaut study of Mark and Scott Kelly showed unexpected changes in the brain and DNA. All the colony proposals call for putting the living space underground because of radiation. We know of harmful effects on human bodies of living long term in microgravity, but much less about long-term effects of gravity 1/3 of Earth's. Glenn noted that colonies would mean the likelihood of a first human being born on Mars, but we don't know whether human pregnancy and childbirth will work out in 1/3 gravity.

Glenn last topic was possibilities of terraforming Mars and the ethical questions raised by terraforming. One approach suggested by NASA would provide Mars with a protective magnetic field using a 2-Tesla magnetic field generator orbiting at Mars' L1 point. It would provide radiation protection and might reduce the erosion of Mars' atmosphere by solar wind. If Mars could then hold its atmosphere, the atmosphere would thicken and warm enough in 40 years to begin returning carbon dioxide frozen in the polar caps back to the atmosphere and create further warming. Elon Musk has separately proposed melting the poles to try to warm the planet using the greenhouse effect. Glenn said it might require first warming the entire planet above the freezing point of carbon dioxide to keep it in the atmosphere long enough for the greenhouse effect to really change the climate.

Another suggestion is colonizing Mars with microbes. Glenn said it would require a large habitat to support the diversity of an entire ecosystem. We live with thousands of other life forms. Although one NASA project proposes building Earth's entire biome on Mars from the ground up, current research is only addressing what microorganisms could survive on Mars if we introduced them now.

Radically terraforming Mars could destroy any native Martian life that might exist. Almost universally, people would consider that unethical, and we might lose the feature of Mars we are most interested in. Some suggest terraforming Mars would be like destroying our national parks. On the other hand, making Mars habitable might be the only option for a Plan B if Earth should be destroyed.

Glenn's summary asked, "Why go?" He listed adventure, exploration, new knowledge, Earth 2, "because we can," commercialization of Martian resources, and "add your reasons here…" Don Clark asked whether any other countries were interested. Glenn was not aware of any others, but said several countries such as China are interested in the Moon. He thought there might be interest in an international project. Glenn said the pdf of his presentation included a bibliography and is available on the club website.

Image of the Quarter

Hickson Compact Group 44 by Ron Henke

Ron says: One of the projects I worked on with Jerry Hubbell using the MSRO was an image of a Hickson Compact Group in Leo. I don't know if was 44 or not. The image was 20 three-minute subframes and was guided. It was taken using a 12-inch SCT at F10. The above image of Hickson Compact Group 44 (I like galaxies) was taken April 16. It is centered on NGC 3190, and was done with a HyperStar lens. The image has been cropped and expanded to near pixilation. The image was taken on my 8-inch SCT using the HyperStar (at F2.2) and is 30 subframes of 30 seconds each, unguided. The targets are between 60 and 100 million light years away and are the most distant objects I have imaged. *Editor's note: See Ron's product review of the HyperStar lens earlier in this newsletter.*