http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 3, Vol. 2 November 2013–January 2014

PANOPTES—Aiming for Exoplanets With a Can(n)on?

by Bart Billard

Taking advantage of my recent retirement, I've signed up for a citizen scientist project that uses an exoplanet transit observation technique that has caught my interest in the past few years. I've learned that amateur equipment is capable of detecting the dimming of a star when caused by the transit of a large enough exoplanet. The Panoptic Astronomical Networked Optical observatory for Transiting Exoplanets Survey (PANOPTES) team aims to provide amateurs, clubs, schools, and citizen scientists with a cost-effective robotic telescope design that can serve as the basis for a network providing extensive time and sky coverage for detecting exoplanets and also doing other astronomical studies.

Image from PANOPTES prototype showing Comet Lovejoy and a Geminid (processing by Jon Talbot, an astroimager who joined the project)

Originally I was clued in by Don Clark's message last fall, passing along the announcement of a Night Sky Network (NSN) telecon on the project, given by PANOPTES team members Dr. Olivier Guyon and his colleagues Josh Walawender and Mike Butterfield. NSN has the presentation slides, a transcript, and audio recording of the telecon available for downloading at https://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=528. In addition, I made contact with a new Roanoke Valley Astronomical Society (RVAS) member, Dan Chrisman, who wrote an entertaining and informative article for the November RVAS newsletter. I especially liked the way he handled the discussion comparing "etendue" of different telescopes to illustrate the cost savings of the prototype design:

> …I encountered "etendue" in neither Sagan's "Cosmos" nor Astronomy merit badge, nor high school French class. The Web tells me that the "etendue" (or the collecting power) of a telescope is the multiplicative product of its collecting area times its field of view. So etendue serves as a useful parameter by which astronomers compare survey telescopes. And "etendue per dollar," similar to "bang for the buck," serves as a useful parameter by which accountants compare survey telescopes (and, if things get out of hand, start bar fights).

For 3 years, the PANOPTES team has operated three generations of prototypes on Mauna Loa Observatory in Hawaii. The basis for the telescope is a Canon digital single-lens reflex (DSLR) camera with an inexpensive 85-mm manual lens. Operation of the prototypes provided useful lessons learned, including information on the ability to withstand the weather without a dome, need to plan for power failures of 10 hours or more, and development of an algorithm to get precision photometry despite the hard-to-figure-out interaction of stellar images with DSLR color pixels. *(continued on page 8)*

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 $15 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 dark of the 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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Yahoo Group:
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Calendar of Upcoming Events

Club Meeting, Maury School	February 19
Star Party, Caledon	March 1
Club Meeting, Maury School	March 19
Star Party, Caledon	April 5
Club Meeting, Maury School	April 16

Recent Outreach Events Completed

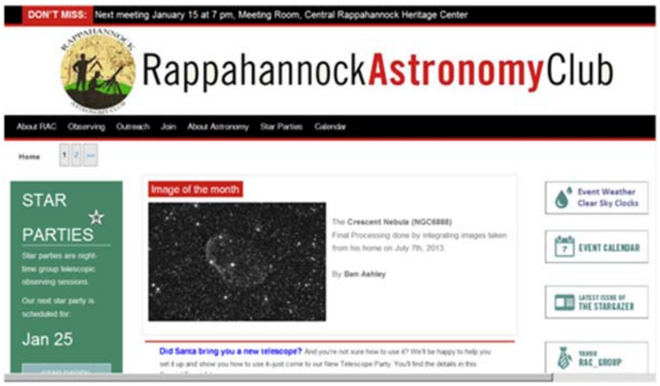
Astronomy Q&A, 4th Grade, Park Ridge Elementary	October 25
Star Party, Shiloh School, Northumberland County	November 9
Astronomy Presentation, Dumfries High School	November 18
Star Party, Caledon	November 30
Star Party, Caledon	December 28

President's Corner

Welcome to New RAClub Members (November–January)

- Jose Gomez
- Carol & Al Elkins
- Edwin Knighton
- Andrey Ruhkin

By the time you read this, the new Rappahannock Astronomy Club (raclub.org) website will be online and serving the needs of the membership and the public. The Communications Committee has worked long and hard on this project, which started almost a year ago. I want to thank all the members of the committee: Glenn Holliday, Terry Barker, Don Clark, Linda Billard, Scott Busby, and my daughter Rachel Konopa for their perseverance and dedication to getting it done right.



I know the membership will appreciate the cleaner interface and the brighter colors of the new website. I especially welcome the movement to a new hosting service and a new infrastructure (WordPress), which will make the maintenance of the site painless compared with the static site we had previously. Making the decision to move to the newest technology and away from the previous host was a large part of the discussion when we started this project last year.

This issue of the StarGazer is filled with our standard mix of articles and advice for beginners and experienced observers and astronomers alike. Over the past few months, I have come to the conclusion after talking to people in the industry and professionals that we are all just astronomers—whether we get paid to study the sky or not. There is nothing wrong with being called an amateur, but in today's environment, where paid and unpaid astronomers are working together with large and small telescopes to support each other, the word "amateur" becomes less of a differentiator. I, for one, am going to push this view whenever I go to events and am with other astronomers at star parties.

Thank you for your continued support of the Rappahannock Astronomy Club, and I look forward to seeing you at the monthly meetings and at star parties in the future.

Until next time, Clear Skies!—*Jerry Hubbell*

Astronomy Math by Scott Busby

Light travels at a speed of 300,000 km/sec. How long does it take light to travel:

a) To the Moon at a distance of 380,000 kilometers (km)?
b) To the Sun at a distance of 150 million km?
c) To Neptune at a distance of 4.5 billion km?
d) To the star Alpha Centauri at a distance of 41 trillion km?

Use this simple method to find the answer: Time = Distance/speed, so—

a) Moon: Time = 380,000 km/300,000 = 1.3 seconds.
b) Sun: Time = 150,000,000/300,000 = 500 seconds or 8 1/3 minutes.
c) Neptune: Time = 4,500,000,000 km/300,000 = 15,000 seconds or 4 1/6 hours.
d) Alpha Centauri: Time = 41,000,000,000,000 km/300,000 = 136,666,666 seconds or 4 1/3 years.

Using the Celestron Micro-Guide Eyepiece to Make Astronomical Measurements

By Glenn Faini

The Celestron Micro-Guide eyepiece is a modestly priced accessory that can transform nearly any telescope into an instrument for taking astronomical measurements.

My Celestron C80

In late 1997, I was given a used Celestron C80 refractor on a German equatorial mount. It was my first "real" telescope and a wonderful instrument; however, it was seriously handicapped by the stock eyepieces. The following year, I invested in a set of Celestron Ultima Series eyepieces and a matching Ultima Barlow. They were Celestron's top of the line eyepieces at the time and drastically improved image quality and eye relief. Although intrigued, I did not buy the Micro-Guide eyepiece because it was a bit pricey and I didn't have a need for it.

That changed in autumn 1999 when my son and I were discussing ideas for his science fair project. Viewing Jupiter and Saturn with their moons was always a rewarding experience, and we contemplated ways he might base a science project on them. I remembered the Micro-Guide eyepiece and suggested using it to measure something. He decided to measure the synodic orbital period of Saturn's moon Titan. Now able to justify the purchase, I ordered the Micro-Guide eyepiece.

Celestron Micro-Guide Eyepiece. Source: celestron.com/astronomy/celestron-micro-guide-eyepiece-1-25-in-12-5mm.html

The Micro-Guide is a 1.25-inch, multicoated, 12.5-mm Abbe (four-element) orthoscopic eyepiece with an apparent field of view of 42 degrees. It has a laser-etched reticle and a built-in battery-powered illuminator with adjustable brightness control. The reticle contains a linear scale, a semicircular position angle scale, concentric guiding circles, and a large circular scale.

Celestron's documentation states "Usage possibilities include: direct guiding on stars outside the center of the field of view; greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude; and measuring position angles and separation of double stars." I have yet to use it for any of these purposes. What I did do was measure the angular sizes of Jupiter and Saturn, and their angular separations from their largest moons, and I calculated the actual focal length of my C80 and magnification of my 2x Barlow.

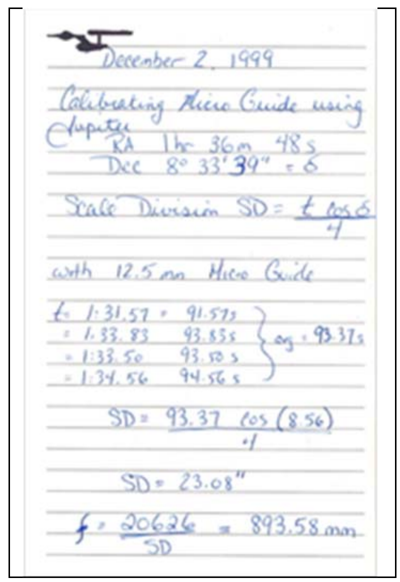
Before measuring angular distances with any specific telescope, you must calibrate the Micro-Guide's linear scale in arc seconds. The documentation included with the eyepiece is comprehensive and contains a lot of mathematics for advanced observers. I will provide some of the basic equations rather than discuss their derivations. Those of you interested in the mathematics can download a PDF of the 12-page documentation by Googling "Celestron Micro Guide Eyepiece 94171."

Micro Guide Reticle. Source: Google.com

The linear scale is exactly 6 mm long and has 60 divisions. Therefore, the distance between the division marks is 0.1 mm (100 µm). The distance between the scale divisions in arc seconds is related to the focal length of the telescope in mm by the equation:

$$SD = \frac{20626}{f}$$

Therefore, using my C80, which has a published focal length of 910 mm, each scale division is 22.7 arc seconds. However, because published focal lengths are only averages, more accurate calibration requires calculating the actual focal length. This is done by timing the passage of a star along the linear scale with the telescope's drive motors turned off.



Using a simple procedure explained in the documentation, I aligned the linear scale with the celestial equator and then recorded the time it took Jupiter to drift from 0 to 60 on the scale. To increase the accuracy of my calculation, I used a digital stopwatch, took three measurements, and averaged the drift times.

The distance between the scale divisions in arc seconds can be calculated by the following equation, where t is the star's drift time in seconds and δ is the star's declination in degrees.

$$SD = \frac{t * \cos\ \delta}{4}$$

At the time of my measurements, Jupiter's declination was 8.56 degrees. The average drift time was 93.37 seconds. Using the above equation, I calculated that SD = 23.1 arc seconds. Plugging this number into the first equation, I calculated that the focal length of my C80 is actually 893 mm, not 910 mm. Repeating this procedure with my Celestron Ultima 2x Barlow lens, I calculated that its magnification is actually 2.36x (3.56x when using my star diagonal between the Barlow and eyepiece).

Years later, I repeated this procedure with my new Celestron NexStar 102 SLT. I calculated the focal length to be 656 mm rather than the published 660 mm. That is a difference of only 0.6 percent and is probably insignificant.

Now that I have calibrated the linear scale, I can use my Micro-Guide to directly measure the size of sunspots or lunar features as well as the angular distances between stars or planets and their moons. I look forward to learning how to use the other three scales and sharing what I learn.

Congrats go to Jerry Hubbell on his appointment to the Association of Lunar and Planetary Observers (ALPO) staff. In its winter 2014 issue, the *Journal of the ALPO* (JALPO) announced his appointment as acting assistant coordinator for the Lunar Topographical Studies Selected Areas Program (that's a mouthful). He will be responsible for archiving observations received from members, support the assistant coordinator (Wayne Bailey), and help prepare "Focus On" articles for the *Lunar Observer* newsletter and JALPO. He will also be taking a lead role for either the Banded Craters or the Bright Lunar Rays sub-programs.

Comet ISON—R.I.P?

by Linda Billard

Comet C2012 S1, fondly referred to as ISON, appeared to disintegrate on Thanksgiving Day, hours prior to its predicted perihelion. To the disappointment of millions of fans, the "comet of the century" became what University of Arizona astronomer Carl Hergenrother described as a "turkey." However, the major campaign mounted by NASA to study the comet, supported by US spacecraft orbiting the Sun, Mars, and Mercury, was not a total bust.

On November 28, 2013, after a year of observations, scientists waited as ISON made its closest encounter with the Sun. Although remnants did make it around the Sun, NASA's solar observatories showed that they quickly dimmed and fizzled. This does not mean scientists were disappointed, however. The huge worldwide collaboration ensured that observatories around the globe and in space, as well as keen amateur astronomers, gathered one of the largest sets of comet observations of all time, providing fodder for years of study.

On December 10, at the 2013 Fall American Geophysical Union meeting in San Francisco, researchers presented scientific results from the comet's last days. They described how this unique comet lost mass in advance of reaching perihelion and most likely broke up during its closest approach. They also summarized what this means for determining the composition of the comet. "The comet's story begins with the very formation of the solar system," said Karl Battams, an astrophysicist at the Naval Research Laboratory in Washington, DC. "The dirty snowball that we came to call Comet ISON was created at the same time as the planets."

More recently, Russian scientists at the Vostok Antarctic station are to gather dust from ISON. They will take three attempts to harvest space dust—twice during the week of January 13 and again sometime in late January, as reported by Sergey Bulat of St. Petersburg Institute of Nuclear Physics, to RIA Novosti.

Bulat and his colleagues initially scheduled their dust hunt for December, when the comet was expected to pass Earth on its way back into outer space after grazing the Sun. But its destruction called for a change of plans. "We expected the comet to survive and hoped to gather some large particulates in December. Now if we get something, it would be particulates from the coma [the major part of the head of a comet] and tail left when it was approaching the sun," he explained.

Dust gathering is done in the Antarctic because the air over the polar continent is cleaner compared with more inhabited locations. The scientists will use five 150 m^2 pieces of polyethylene canvas as traps. Each trap will be spread out not far from the station in the hope that some comet particulates will fall on it. Any collected particles will be preserved in chemically inert argon gas and shipped to St. Petersburg for microscopic study, which will start in May. "We are most interested in particulates several micrometers in size, which didn't burn in the atmosphere and descended slowly. The fact that they did not experience heating is what makes them valuable," Bulat said.

Comet Lovejoy Over Monte Cristallo (Italy), 05:00 UT December 7. Source: Giogia Hofer (http://spaceweathergallery.com/indiv_upload.php?upload_id=90980)

So, although ISON disappointed some (mostly the media), scientists will be busy studying it for many years. In the meantime, Comet Lovejoy and several others will provide targets for anyone patient enough to look at the right time.

The 2013 Arizona Science and Astronomy Expo (ASAE)

By Jerry Hubbell

The 2013 Arizona Science and Astronomy Expo (ASAE) was held at the Tucson Convention Center November 16–17. I was fortunate to attend as an employee of Explore Scientific and help out Scott Roberts and the rest of our team in running our 53-foot trailer set up as a showroom to display all the cool instruments and eyepieces that Explore has to offer.

The ASAE is the brainchild of Alan Traino, the man formerly behind the NorthEast Astronomy Expo (NEAF). Alan has moved on to produce this show in the fall in Arizona—the astronomy capital of the world. This was the second annual show, and it is very much like NEAF in that most of the same vendors of astronomy equipment and other scientific instruments are represented at the ASAE.

I arrived the day before the show to help unpack and set up telescopes and do whatever was necessary to get the trailer ready for the show. Greg Bragg and Joe Napolitano were there, along with Scott Roberts to set up. Joe is the company's professional videographer, and producer for all of Explore's video presentations, and Greg is the Director of Sales for North America. Greg picked me up at the airport, and we had a few hours before we needed to get to the convention center so we ate lunch and then headed toward our hotel. On the way, we decided to visit the Pima County Air and Space Museum near Davis-Monthan Air Force Base. The museum includes the famous "Boneyard" where aircraft are moth-balled and stored for future use. We had a great time touring the museum.

Explore Scientific Portable Showroom

I was in for a treat that weekend because Scott had arranged for a couple of well-known people to be interviewed and talk about an upcoming event Scott is organizing for the Astronomy Outreach Network—namely David Levy of comet fame, and astronaut Story Musgrave who was involved with the first Hubble Space Telescope (HST) repair mission.


David Levy, Comet Hunter

David spent a few hours the first day of the show hanging around the Explore Scientific trailer greeting and talking with people. I was fortunate to be able to spend an hour or so talking with him about comets and his discovery, with the Shoemakers, of comet Shoemaker-Levy, which slammed into Jupiter in 1994. Later, Joe set up his cameras and studio equipment in front of the trailer to film David interviewing Story Musgrave. This was an excellent 40-minute interview; David asked questions ranging from amateur astronomy to comets, to the HST. David also asked Story about his thoughts on the state of space exploration and how amateurs can contribute to the astronomical community. It was an excellent interview, and watching it live was certainly a treat.

After the interview, I walked up to Musgrave and introduced myself... I said, "Hi, my name is Jerry Hubbell." It was really amusing to see the look on his face before he said anything. His eyes lit up, and he said, "I know another fellow named Hubble." It was really cool talking to him about being an astronaut and having him ask about my background. Although our conversation was perhaps only 5 minutes, at the end of our conversation, he reached into his briefcase, handed me one of his business cards, and asked me to contact him and keep in touch. All in all, a thoroughly memorable experience.

At the show, my book publisher, Springer, had conveniently set up their booth directly across from the Explore Scientific trailer. My editor, Nora Rawn, was staffing the booth, and I spent some time with her signing my book for customers. By the end of the day all the books I brought, and those that Springer brought, were sold.

I was able to spend a good amount of time talking and getting to know all the vendors better, and looking at all the equipment available to the astronomer today. It's a really good time to be an astronomer whether you get paid or not to study the sky. Even though the time went fast, it was still good to get everything wrapped up and packed away.

Story Musgrave, Astronaut

PANOPTES—Aiming for Exoplanets with a Can(n)on? (cont'd from page 1)

Phase 1 Prototype at Mauna Loa Observatory

Now the team is working on a baseline design with open-source software and public domain hardware design. This design will serve as a "well-documented common point of reference for all future evolution of PANOPTES." The team is seeking suggestions for modifications to improve the design, which they anticipate receiving from the core group of "expert" users (professionals and amateurs) who build the first units starting with the baseline design in the next phase of the project. That phase is planned to begin shortly and run roughly 9 months. In the telecon, Josh Walawender underscored simplicity as a design goal for the baseline unit with this quote from Antoine de Saint Exupery:

> Perfection is finally attained, not when there is no longer anything to add, but when there is no longer anything to take away.

Simple systems tend to be more reliable. Simple systems are easier for others to build, understand, and improve on.

The estimated cost of a PANOPTES system is about $3,400, a major share being the cost of an Orion Atlas mount (or equivalent). The camera and lens are $600 and $300, respectively, and there are also enclosures, a laptop, and electronics and sensors for monitoring weather conditions and running the mount and camera(s). Two cameras could fit in the box chosen for the baseline unit, and more could be supported with a larger box. The cameras will look through openings in the box, and the system will park with the openings pointed down in the daytime or when weather prevents operation.

I've been following the progress of phase 1 of PANOPTES and hope to complete a system in phase 2. Two components that look nearly ready to start on are the weather station and the control computer setup. When phase 3 starts, I am also interested in helping a local school participate. Whether I am a true "expert" user remains to be seen. I look forward to trying to learn to be an expert. I welcome suggestions if fellow RAClub members are interested in looking at the PANOPTES design and offering their ideas for improvements. The PANOPTES website provides more detail and explains how to join for those interested: http://www.projectPANOPTES.org/.

Recent RAClub Outreach Events—Shiloh and Local Schools

By Linda Billard with Ben Ashley and David Abbou

From Ben on the second annual Shiloh Schools star party in Kilmarnock—Kilmarnock, on the Eastern Shore, is a long way from here. However, the drive back in the early morning was long and peaceful enough to tire me out enough to sleep when I reached home. (I can never sleep after stimulating outreach events.) The location was breathtaking, and going there in November was rewarding for me personally. When we arrived at the old schoolhouses, Jane Towner greeted us enthusiastically. As the sun set, a group of about 60 people gathered. They had waited a year since our last visit and were glad to see us again. They wanted to learn everything we could teach.


Ben Setting Up at Shiloh Schools

A sizable group looked through our telescopes and encouraged us to talk about things that don't usually fit the "wow" bill of typical star party subjects. It seems a simple thing to show the constellations, but we forget that people who don't look at them often can be "wowed" when we point them out. Many have known about them since they were children, but few could even pick out Orion. It's exciting for so many just to be able to find the Big Dipper. Outlining a few of these with a green laser and peppering in phrases like "even with the fastest machines man has built, it would take more than 100 million years to reach that star" grabbed their attention. From there, we were allowed to explain the significance of what people are seeing. Visual astronomy is about appreciation. We look at faint stars and wispy blurs that can barely be discerned against the background sky and find it meaningful because, through learning, we have come to understand something of these wonders we see. You never know what audience you will have when you go to these outreach events. Sometimes you really feel you can share some of your passion…sometimes not. But it's always interesting. Hope to see you at the next event!

From David on his recent school presentations—I conducted an in-class astronomy presentation for Potomac Senior High School in Dumfries on November 18. This was for an astronomy class of junior and seniors totaling about 30 students. I gave an overview of astronomy today along with space program status using a PowerPoint presentation I created for high school students. I offered outreach materials provided by NASA, and the kids were very curious with many questions about all aspects of astronomy. I also informed them about RAClub and our outreach activities and events. Earlier, on October 25, I also held an astronomy Q&A for Park Ridge Elementary 4th graders where I answered all their pre-written questions about astronomy and the space program. There were LOTS of questions but I was able to answer all of them during the hour I was in the classroom.

Lucy in the Sky with Diamonds—A Diamond in a Class by Itself

By Linda Billard


Golden Jubilee Diamond (546 carats) Source: http://famousdiamonds.tripod.com/goldenjubileediamond.html

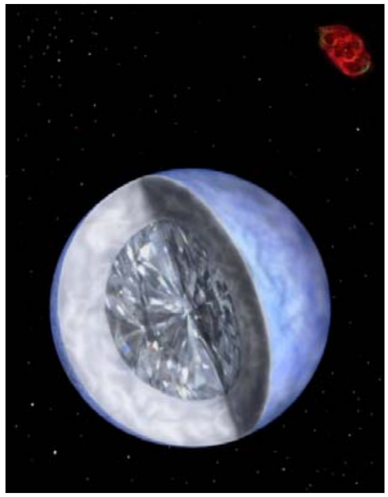
If you can…try to imagine a 10 billion, trillion, trillion carat diamond. This mega-diamond is the central core of a white dwarf star located in the Centaurus constellation, 50 light years from Earth. BPM 37093 (V886 Centauri) is the white dwarf's official name, but scientists also refer to it as "Lucy," referencing the Beatles' song, Lucy in the Sky with Diamonds.

Compared with the largest diamond ever found on Earth, Lucy is on a completely different scale. The largest diamond ever found here—755 carats—was mined in 1985. The "Golden Jubilee," is now part of the crown jewels of the Kingdom of Thailand. At 546 carats, it's big…but completely outclassed by Lucy, nearly 4,000 km in diameter.

Lucy Helps Astronomers Estimate the Ages of Stars

More than 50 years ago, astronomers predicted that the cores of the coolest white dwarf stars should eventually crystallize. Crystallization releases heat just as when water freezes to ice, causing a delay in cooling. The inability to accurately predict the timing of this crystallization effect was one of the greatest sources of uncertainty in modeling how white dwarfs cool, which in turn, is used to estimate the ages of stellar populations in both the Galactic disk and the halo.

In 2004, a team of astronomers led by Travis Metcalfe (Harvard Center for Astrophysics) used data gathered by the Whole Earth Telescope (WET) and the Hubble Space Telescope in a successful effort to improve the predictive capabilities of the models. A prime target was Lucy, a pulsating white dwarf. In the model of a typical mass white dwarf, crystallization does not begin until the surface temperature reaches 6,000–8,000 K. Metcalfe and his team used the observed pulsation periods of BPM 37093, the most massive white dwarf known, to probe the interior and determine the size of the crystallized core empirically. That initial exploration strongly suggested the presence of a solid core containing about 90 percent of the stellar mass, which was consistent with theoretical expectations.



Lucy in the Sky with Diamonds (BPM 37093) (artist's rendition). Source: http://www.cfa.harvard.edu/news/archive/pr0407image.html

The Creation of an Astronomical Diamond

So…how exactly does a star like Lucy come to have a diamond at its core? It's a process that happens to stars known as main sequence stars—our Sun is also a main sequence star.

Over time, these stars burn their hydrogen, helium, and other gases, expanding along the way. When the hydrogen in their core is gone, they transform into huge red giants whose fusion reactions create increasingly heavier elements. Eventually, these red giants lose their outer shell of gases, leaving a very hot core. This core begins to cool, and eventually, only oxygen and carbon are left. According to the theory, that's when crystallization occurs.

Although this cooling phase lasts billions of years, prior to 2004, scientists were never able to confirm the theory because they could not detect or study a crystallized dwarf star. And, although white dwarf stars pulsate during the start of the cooling phase, and these light and sound pulsations are detectable, they generally cease once crystallization has occurred.

However, BPM 37093 is unusual. It is so large that crystallization of the core has started while pulsations are still occurring. Scientists used this pulse data to analyze the interior of Lucy to determine that the core is already crystallized, and even measured this gigantic diamond. This type of analysis is called asteroseismology. In a press release at the time, Dr. Metcalfe explained: "By measuring those pulsations, we were able to study the hidden interior of the white dwarf, just like seismograph measurements of earthquakes allow geologists to study the interior of the Earth."

Our Sun, Forever Bright

So, what about our Sun? If you've wondered what will happen to it…now you know. In approximately 5 billion years, our Sun will die, becoming a white dwarf. It will take another 2 billion years to form a diamond core like BPM 37093. But eventually our Sun will also become a gigantic diamond at its core.

Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

December 2013—Status and Impact of Kepler and Amateur Transit Observation Opportunities

Kepler (Source: Spacechronology.com)

Bart Billard began his presentation by explaining Kepler's pointing problems, which began this year and prevented data collection since mid-May. The telescope needs three of its four "reaction wheels" to precisely align stars in its field of view on the same detectors over each 4-month period of data collection. One of the wheels failed in 2012, and this year, a second began showing signs of a possible bearing problem. Various efforts did not clear up the problem, and in May, the friction got too great for the wheel to properly control the telescope pointing. The mission team implemented a newly designed "point rest state" to maintain the telescope in a safe attitude with minimum fuel consumption while they searched for solutions to get one of the failed reaction wheels to work well enough for science operations. In addition, an effort began to find a follow-on mission for Kepler that was feasible with two reaction wheels.

Despite these problems, Kepler completed its nominal 3-1/2-year mission and 6 months of the extended mission. Three and a half years was the goal to allow a good chance of seeing enough transits to detect planets with orbital periods like Earth's, and the 4 years of data actually obtained increases that chance and allows for somewhat longer periods. In addition, a proposed follow-on mission is in the works. It would allow 83-day observing campaigns for target fields of view in the plane of the ecliptic. For periods of that length, two reaction wheels are sufficient for pointing precision because the telescope orientation could balance the light pressure from the Sun on the solar panels. Instead of monitoring a single field of view continually, this follow-on mission would switch targets to accomplish four and a half campaigns per year, changing before a target slipped behind the Sun. NASA management has approved this proposal to proceed to the 2014 Senior Review.

Meanwhile candidate and confirmed planet discovery counts grew; as of December, at least a year's worth of data from Kepler remains to be analyzed. The confirmed planet count reached 167 in November, compared with 67 in Bart's Kepler presentation a year ago. The increase in candidate planet and eclipsing binary star discoveries was substantial this time, and smaller sizes accounted for most of the increase. Earth-sized candidates increased from 246 to 674.

Scientific results reported this year included one that used Kepler data in a new way. Researchers used a combination of tiny effects of Kepler 76b on the system brightness to detect the planet, only later finding that it makes a grazing transit. The observed effects included brightness changes of the star resulting from the wobble caused by the gravitational pull of the planet. The motion causes light to "bunch up" and make the star brighter as it moves toward us. It also causes a little more of the light to "beam" in our direction, a subtle effect predicted by the theory of relativity.

The last part of the presentation covered opportunities for amateurs to participate in exoplanet transit observation. Amateurs can get started, even without equipment, by analyzing light curves. For example, the Planet Hunters citizen science project allows users to view and classify Kepler data. Harnessing human pattern-recognition capabilities and the strength of numbers has allowed the project to discover planet candidates missed by the automated analysis developed for the Kepler mission. A Lowell Observatory Amateur Research Initiative project active last year enlisted amateur volunteers to analyze Transatlantic Exoplanet Survey (TrES) light curves. In this case, volunteers used computer analysis tools for more in-depth analysis, allowing them to learn additional skills needed for exoplanet transit observations. Another step up in learning the skills could involve obtaining and processing image data to generate the light curves of transits. Bart found the Harvard Smithsonian Center for Astrophysics project "other worlds/other earths…" is a good resource. This project, designed for high school students to learn core scientific skills, is in field test version 2.0 with 12 teachers across the country. The project uses the free, online MicroObservatory robotic telescopes, and the website includes a curriculum outline, student and teacher guides, and other resources. Access to obtain enough new images to make a new transit observation may be limited to registered students and teachers, but archives of transit observation images are available for download by others.

For the amateur ready to do it all with his/her own equipment, Bruce Gary's book Exoplanet Observing for Amateurs is available as a PDF download or for purchase in Kindle format. It covers equipment choices and all aspects of planning observing sessions, obtaining calibration data and transit image data, processing images, and analyzing light curves. It also discusses scientific questions amateurs can help answer by making transit observations or other exoplanet observations. For example, "out of transit" observations could lead to discoveries of additional planets in systems with known exoplanets. A final resource for amateurs is the Panoptic Astronomical Networked Optical observatory for Transiting Exoplanets Survey (PANOPTES) project. (See lead article in this newsletter for more details about PANOPTES.)

January 2014—Show-and-Tell on New Equipment and Activities

This meeting's presentation period was devoted to a show-and-tell of new equipment or activities. *Jerry Hubbell* passed around his new QHY 5-II camera, which looked almost the same size as a 25-mm Ploessl eyepiece. It is a guide camera that he bought for its 75-percent quantum efficiency Sony chip. He said its efficiency made faint stars suitable for guiding, but he also planned to try it for planetary imaging. Also, it would fit in the focuser like an eyepiece and provide video via USB to a computer with a fast enough frame rate for convenience in focusing.

Myron Wasiuta brought in the Brandon telescope donated to the club, which he recently evaluated for the club. It is a 94-mm f/7 apochromatic refractor that Myron said was built likely 1987, 1988, or possibly 1989. (Earlier ones lacked blackening of the inside of the focuser that this one has.) This model was a first attempt at an affordable apochromat for amateurs, and the objective was made by Roland Christen, who later founded Astro-Physics. Myron showed us several features that he thought would be helpful for using the telescope. He pointed out that it appeared to have been intended for terrestrial use because it was equipped with an Amici prism for right-side-up images. He said that should not be used for astronomical viewing with 2-inch eyepieces because this restricted the field of view. He showed how to adjust the draw tube for proper focus without the prism. The tripod is difficult to handle for one person, and Myron recommended setting it up first without the optical tube assembly (OTA). When removing (or installing) the OTA, he said the altitude should first be set horizontal to prevent the OTA from slipping while the rings are loose. He noted the need for a good storage case for the OTA, replacement foot covers for the tripod legs, and eyepieces to match the quality of the telescope optics. Scott Busby said he thought Home Depot had suitable foot covers made for surveying tripods. Myron also observed that the tripod was a little unstable and should not be set up on a smooth surface. He set it up on a towel for his demonstration to avoid the tripod legs spreading out and collapsing the tripod. Finally, the telescope cannot go to the zenith position because the slow-motion controls, positioned for convenient access, are in the way. Myron described the tests he performed on the

Brandon Telescope (Source: telescopebluebook.com optics and said he had submitted a formal report we could read. He concluded that it is a fine instrument with significant historical value.

Ben Ashley showed us several recent images he had made. Of particular interest was one of the minor planets, Eris. He said he recently read Mike Brown's book, *How I Killed Pluto and Why It Had It Coming*. Brown was the astronomer who discovered Eris and may have set in motion the reclassification of Pluto by proposing, with justification, that Eris and similar objects likely to be out there should be designated as planets if Pluto is. Reading the book inspired Ben to see whether he could find Eris and image it. He showed us the picture he was able to take recently with his equipment. Eris was 18.7 magnitude and 14.5 billion kilometers away at the time. The final picture was the result of combining a 2-hour stack, and it showed no streaking of Eris, while an asteroid in the image did show streaking. Ben noted the 500-year orbit period of Eris made that possible. He also showed us an image where he succeeded in capturing Sedna at 22nd magnitude. That took 3 nights and about 7-1/2 hours of exposure. Myron observed that in the 1950s, that was about the magnitude limit of a 200-inch telescope using film.

Astrophotography for the Beginning Amateur Astronomer

by Jerry Hubbell

[This article is modified from one that appeared in the Fall 2013 issue of Sky's Up magazine.—ed.]

As a beginning amateur astronomer, you have lots of questions about how to start observing the sky, and if your goal is to start out in astrophotography, you will have questions about your equipment and how best to use it to take your first images. If you haven't done a lot of reading and studying on this subject, you probably "don't know what you don't know." It's best to understand the scope of the subject before diving in and spending valuable time studying things that may not apply to your interests.

Applying this approach to beginning astrophotography is fairly straightforward. Let's be clear here—I am talking about beginning deep sky astrophotography that involves imaging the stars and bright nebulae such as the Orion Nebula. This involves using a digital SLR camera that you may already have or are interested in buying. Your first time taking images through your telescope may have involved pointing your cellphone camera, or some other point-and-shoot camera, into the eyepiece of your telescope. This is great start for bright objects such as the Moon or planets but doesn't work well for "deep sky" imaging, which is your goal. In addition, there are limits on what you can expect from the typical beginner's equipment for deep sky imaging. Although such equipment is designed primarily for visual use, you can adapt it for astrophotography to produce results you will be proud of. It just takes a little study and practice. First, you need to match your expectations to your equipment; we're not using the Hubble Telescope here! As a novice, your skills and knowledge will not exceed the performance of your equipment until you have had some practice. We will begin by setting some boundaries on what your images will look like. Characteristics such as image field-of-view (FOV), exposure time, limiting magnitude will affect your results. Equipment choices and how well you set that equipment up in the field will also affect your results.


DSLR Camera Mounted Piggyback on Telescope

First, let's discuss mounting your camera on your telescope, piggyback fashion, to take advantage of the tracking ability of your telescope mount. The typical (equivalent) focal length (FL) of a DSLR camera is 50–100 mm, which generally provides a wide, 20–40 degree FOV of the sky. By mounting this camera on your scope, you can use your mount to track the sky, and instead of star trails, you should get sharp, round stars. Also, because you are tracking the sky, your image should include dimmer stars, even some dimmer than you can see with your naked eye. This characteristic is called limiting magnitude. It also allows you to get a good image of those nebulae previously mentioned. There are several ways to mount your camera to your telescope, and the various vendors and distributors, such as Orion Telescopes, Astronomics, and others, provide this mounting equipment—just search the Internet for "telescope piggy-back mount." This should provide you with several choices.

If you have yet to buy a telescope, and/or telescope mount, then there are several ways to approach that purchase. First, as a beginning astronomer, you are not only interested in astrophotography, but also in observing the sky, so starting out with an inexpensive visual system is perfectly okay. In fact, I recommend it because you are new to this whole field—there is no sense in spending a bunch of money on equipment that you may not use.

There are several choices in beginner equipment, but they boil down to choosing your mount and choosing your telescope. Vendors and distributors provide good combinations of different mounts and scope types. Telescope choices include long FL planetary refractors (>900 mm), short FL refractors (<700 mm), small Schmidt-Cassegrains, and Newtonian reflectors. Choices in mounts include manual German Equatorial mounts (GEM), motorized GEMs, computer-controlled Alt-Azimuth (ALTAZ) mounts, and Dobsonian mounts. If your goal is to do deep sky and planetary astrophotography, the Newtonian reflector on a Dobsonian mount is your least desirable choice. This type of telescope is designed primarily for deep sky visual observing with as large a mirror as you can get on a small budget. The most common choice for doing astrophotography has typically been the GEM type mount. Most astrophotographers prefer the GEM style mount because one axis, the Right Ascension Axis (RA), when aligned properly with the sky, tracks the stars without requiring any adjustment of the other axis, the Declination Axis (DEC). This simplifies the mechanics of driving the mount with a motor and makes controlling the mount simpler when doing astrophotography. A piggy-backed camera, mounted on a small refractor on a manual or a motorized GEM mount, would be the minimum requirement for doing deep sky astrophotography.

So, a good choice of starter equipment that will provide you multiple configurations for doing beginning astrophotography consists of—

1. Motorized GEM type mount (not necessarily a computer-controlled mount); alternatively, a manual GEM type mount
2. Short FL refractor (90 mm, 700 mm FL); alternatively, a longer FL scope (70 mm, >1,000 mm FL)
3. Piggy-back camera mount adapter
4. Camera capable of taking time exposures of at least 10 seconds up to 1 minute or more
5. Cross-hair eyepiece

This basic equipment allows you to start exploring the techniques for taking deep sky images. Once you have obtained your equipment, setting it up for doing piggy-back imaging involves a few steps. There are some requirements for the location and some things you want to study and practice before your first outing. I highly recommend adhering to a couple of rules, not only when doing this project, but also generally when obtaining new equipment. Before integrating any new accessories or replacement equipment into an existing system, assemble (as necessary) and check out the new parts. Make sure there are no issues, missing parts, or additional parts you need to integrate into your system. I suggest assembling your mount, attaching your telescope, and using it visually a few times before trying to integrate the camera onto your system. That way you will be familiar with your telescope and mount before you try to use your camera with it.

One important aspect of setting up your telescope and mount for astrophotography is properly aligning your mount to the Earth's polar axis. You will use this fundamental skill time and again with a portable telescope. Doing it properly makes the operation of the telescope and mount that much easier and enjoyable. Be sure to read and understand the specific instructions provided by your mount's manufacturer for doing a proper polar alignment. An important aspect of doing any alignment (or other adjustment on your system) is to understand and know what's "good enough"—how much leeway you have in making an adjustment and why you have that much leeway. Try to learn how much time you should spend aligning your mount, based not on doing it perfectly every time, but on your observing or astrophotography requirements. For *visual* use, getting the RA Axis pointed at Polaris within a few degrees is generally good enough. (Use a compass to help you locate Polaris in the sky.) For piggy-back astrophotography with a normal camera lens (50–100 mm equivalent) and exposures less than 1 minute, this same standard is fine. As you gain experience and skill, and start to do astrophotography with longer and longer FL lenses and telescopes, you will decrease the tolerance and increase the precision of your alignment, but you have plenty of time to work on those skills as you ramp up the FL over the next few months and years. For now, using a compass to align your mount is close enough.


DSLR Image of Orion

For barebones, basic, piggy-back imaging of the sky with a short FL camera lens, you will use the motor drive to track the sky or, with a manually adjusted mount, you will use the telescope and cross-hair eyepiece to track the sky manually. The technique is very simple. Just point your scope to the location in the sky you want to photograph—perhaps the Orion constellation—and then use the cross-hair eyepiece to focus on a bright star and center it on the cross-hair. Once you have the star located in the eyepiece, then start your camera exposure (set it to 1 minute) and while looking through the eyepiece, manually keep the star centered by turning and adjusting the RA axis control knob. I suggest practicing this before actually starting the camera exposure so you can gauge how much turning is required to keep the star centered. Once you have practiced this and taken some images, I know you will be pleased with the results. You should get similar results using a motorized mount.

One of the neat things about piggy-back imaging is that the camera does not have to be pointed at the same location in the sky as the telescope. You can point the telescope at any bright star and once you are aligned, point the camera anywhere to take an image. As long as you use the telescope and cross-hair eyepiece to guide your mount, or use the RA motor drive on motorized mounts, the camera will track the sky also. Practice pointing and guiding your telescope and take several images at the same location and also at different locations in the sky. you can further process your images and combine the data from several images to make astrophotographs that show dimmer and dimmer objects, that is, have a dimmer limiting magnitude.

One of the fundamental aspects of your images of the stars you will notice is that the brighter the star, the bigger the image of that star is on your astrophotograph. This is also how stars are depicted on a star chart. A fundamental science measurement that astronomers do with their images is to measure the relative brightness of stars. You can perform a simple science experiment with your images and a star chart to determine the dimmest star you can photograph and detect, given a specific camera system, lens, and exposure time. All you need to do is determine the location in the sky you have photographed, find the chart that depicts that location, and align your chart to the image. Once you have done that, you can compare and identify the stars in your image with those on the chart. Start with the brightest stars and work your way down to the dimmest stars. You may be surprised to find, depending on your chart, that you have stars on your images that are dimmer than those depicted in the chart. Search for other charts on the Internet to help identify dimmer stars. Use the search term “online star charts” in Google or Bing to find other charts with more stars.

To summarize, start with whatever equipment you have, practice your polar alignment, practice locating objects in the sky (use your compass to help!), practice guiding your scope manually if needed, and take lots of astrophotographs! It will become second nature before too long…have no fear, experiment, and have fun. Lastly, compare your images to star charts to start learning about how the camera images the sky, and also learn about the objects you have imaged.

Image of the Quarter

Bode's Galaxy M81 and the Cigar Galaxy M82, including the supernova SN 2014J, which was discovered on January 21, 2014, at the University College London. The apparent magnitude of SN 2014J was 10.8. Image taken by Ben Ashley from his home on January 26, 2014.