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The StarGazer

Newsletter of the Rappahannock Astronomy Club

No. 2, Vol. 3 August 2014–October 2014

It's a Zoo Out There—Using the Galaxy Zoo System to Aid in the Search for S0 Galaxies

by Lauren Nicholson

The Sloan Digital Sky Survey (SDSS) is the largest color image of the sky ever completed. When I was working with the SDSS team, they were doing the third survey and had more than 500 million objects in the field—and 3 million of those already have high-resolution spectra. Their current data run began this year, and all previous data are available to anyone through their website: sdss.org. Before SDSS, *too much* data was never an issue—astronomers could get through it all in a reasonable time because surveys were done on a much smaller scale. However, there aren't enough graduate students in the world to tackle 500 million objects!

Enter Galaxy Zoo (GZ): a “citizen scientist” initiative aimed at taking advantage of all the people wasting time on the Internet at any given time. GZ hosts SDSS images, and anyone can register on the site to take the tutorial and classify the objects. Many users classify each object based on their answers to a series of questions, resulting in a correct classification the majority of the time. While a computer program would be faster and more reliable for some of the empirical data, for galaxy morphology, the human eye is vastly superior in identifying small structures and patterns. Within the first year of going live, GZ had more than 50 million classifications. On its third version, the data and results of classifications were made available to SDSS members.

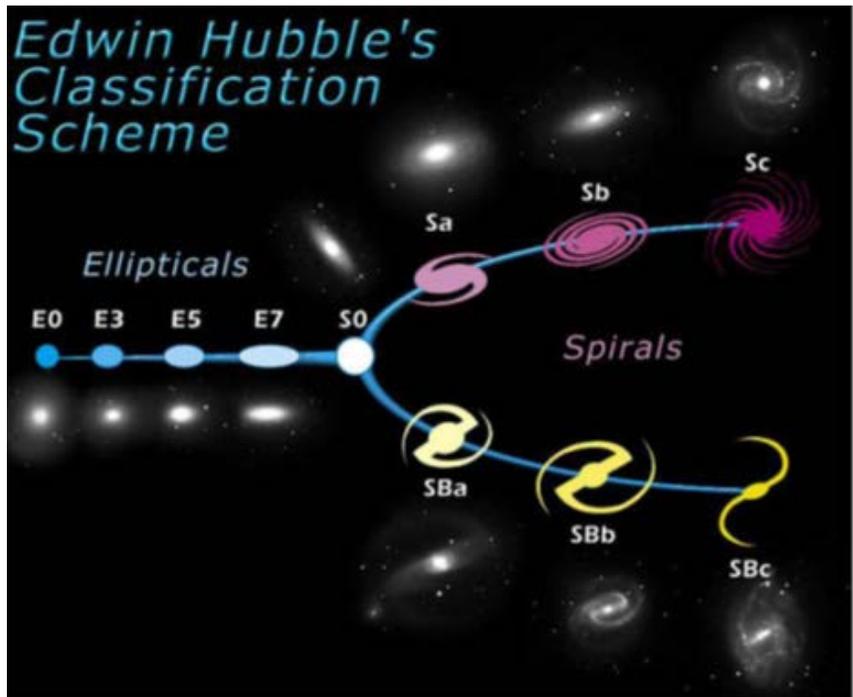


Figure 1: The accepted galaxy classification scheme, developed by Edwin Hubble and fondly called the “tuning fork.” Image: <http://www.spacetelescope.org/images/heic9902o/>

Working with Idit Zehavi (CWRU Department of Astronomy), I decided to tackle a group of galaxies that her team had noticed while working with SDSS Data Release 7. These dim red galaxies exhibit enhanced clustering on a small scale that seemed very different from other galaxy classes. Previous work suggested that these are satellites clustering in the outer, massive halos of galaxy clusters, but there were several obvious discrepancies when compared with normal (elliptical) cluster galaxies. Photometrically, they behave differently from the typical bright red and faint blue galaxies (typical galaxies, see Figure 1). (continued [here](#))

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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[Editor: Linda Billard](#)

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[Reference: <http://www.copyright.gov/fls/fl102.html>, June 2012]

Website: www.raclub.org

Yahoo Group:

http://tech.groups.yahoo.com/group/rac_group/

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Calendar of Upcoming Events

Star Party, Shiloh Schools, Northumberland County	November 15
Club Meeting, Maury School	November 19
Star Party, Caledon	November 22
Club Meeting, Maury School	December 17
Star Party, Caledon	December 27
Star Party, Caledon	January 17*
Club Meeting, Maury School	January 21

Recent Outreach Events Completed

Observe the Moon, Porter Library, Stafford	September 6
Club Meeting, Maury School	September 17
Star Party, Caledon	September 27
Observe the Moon, Wilderness Elementary	September 30
Club Meeting, Maury School	October 15
Star Party, Caledon	October 25

*Tentative. Please check website closer to the date

President's Corner

Welcome to New RAClub Members (August–October)

❖ Adam Zwieko

Well, this issue of the StarGazer is somewhat special to me because it contains my final contribution as president of the RAC. I have enjoyed providing comments about each issue of the StarGazer via the President's Corner but my 3-year tenure as president is about up. It's been a very good experience for me, and I will cherish the time I have spent. I am most proud of the work that the club membership has done in revamping the website and also restarting this excellent newsletter. I commend the work of Glenn Holliday, Linda Billard, Terry Barker, and Don Clark over the last 2 years in making this happen. I still plan on making regular contributions to the newsletter. (Linda is holding me to that!)

This issue of the StarGazer has excellent articles by two of our members who are professionally trained astronomers: Lauren Nicholson and Scott Lansdale. We also have two reports on Observe the Moon month events and an equipment report by Terry Barker. Ron Henke has written an excellent article on astronomy classes and apps on the Internet that I am sure you will find most useful in your astronomical pursuits.

Please continue to report your observations and any other astronomical activities to the club membership. We all enjoy hearing about what everyone is doing out there. Our next meeting is November 19 and is the club election meeting—there is no presentation. I look forward to seeing all of you then. Thanks for all your support over the past 3 years—I very much appreciate it.

Clear Skies!—*Jerry Hubbell*

Astronomy Math by Scott Busby

Inverse Square Law

The brightness of an object decreases dramatically as you move farther from the source. The result is due to a larger "sphere of influence." Light from a source such as a star shines in all directions, so the area of illumination increases with increasing distance and the total brightness thins out.

This is called the Inverse Square Law:

$$b = \frac{L}{4\pi d^2}$$

Where: b = apparent brightness in W/m^2
 L = luminosity in W
 d = distance in meters

Solar Flares—Radio Astronomy Observation Notes for the Second Week September 2014

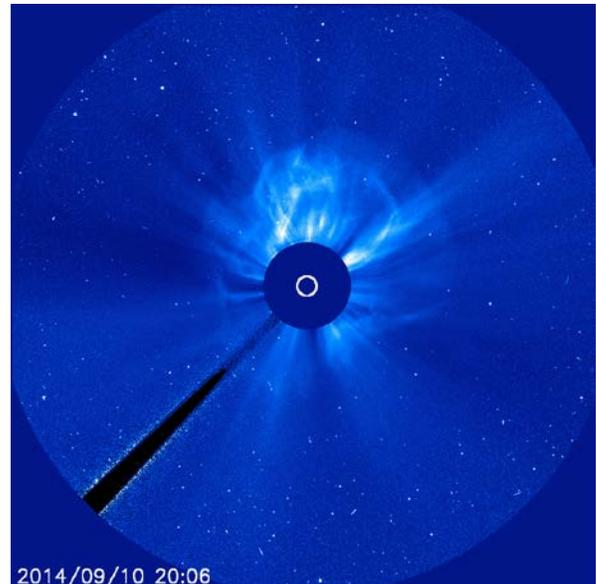
By Scott Lansdale

Several large solar eruptions occurred during the week of September 8, including M4- and X1.6-class solar flares from sunspot AR2158. The class—smallest to largest C, M, and X—is determined by the brightness of the X-rays emitted. Also known as a Coronal Mass Ejection (CME), the event on September 10 sparked particular interest because the sunspot and eruption were facing Earth, and eruptions of this size can disrupt radio transmissions and affect satellites in orbit. More often than not, a CME is not directly facing Earth and so the effects are minimal.

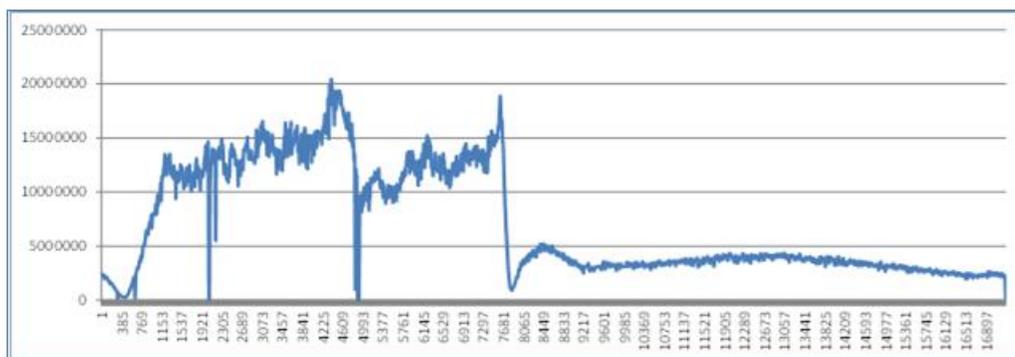
NASA continually monitors the Sun with satellites such as the Solar and Heliospheric Observatory (SOHO), Solar TERrestrial RELations Observatory (STEREO), and Geostationary weather Satellites (GOES). However, we can also observe these events at home with a Sudden Ionospheric Disturbance (SID) monitor. The system I use is simply the monitor connected to a PC, which gathers input from a small loop antenna and records it in a file each day.

The antenna works by collecting signal strength data from Very Low Frequency (VLF) stations. Very simply, the signal path of the radio waves changes when the X-rays from the Sun collide with the ionosphere. This change to the ionosphere allows the signal to propagate without as much attenuation, generating the spike in data. When the event subsides, the ionosphere returns to its previous state. The results can be plotted in a line graph that shows relative signal strength versus time. My SID monitor was tuned to station NAA (24 KHz) based in Cutler, Maine. The following charts show the data collected at my home observatory.

The first data plot, recorded on September 9, shows what a typical daytime pattern looks like with no events. This is a particularly clean plot with no noise or other interruptions. To the left of the small bump in center is the nighttime radio signal only. The drop in noise followed by the small bump is sunrise and the start to the normal ionization of the atmosphere for the day.

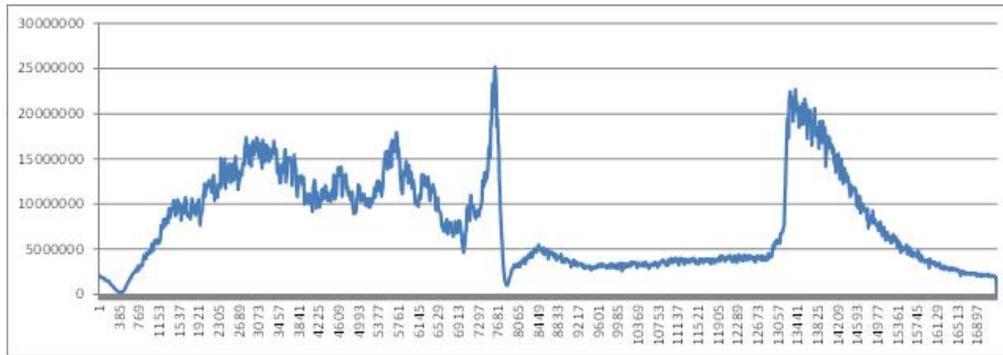


The CME associated with a Sept. 10, 2014, X1.6 flare is visible in this image from the joint European Space Agency and NASA's Solar and Heliospheric Observatory. Image Credit: ESA&NASA/SOHO



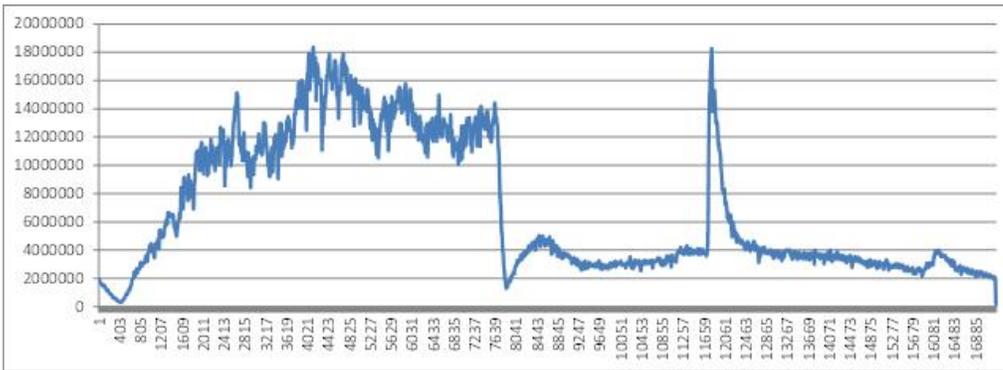
September 9: Typical Pattern

The following day was a completely different story. This plot shows the scale of the X1.6 class solar flare. Both the relative intensity and the breadth of time are considerable compared with "typical" flares.



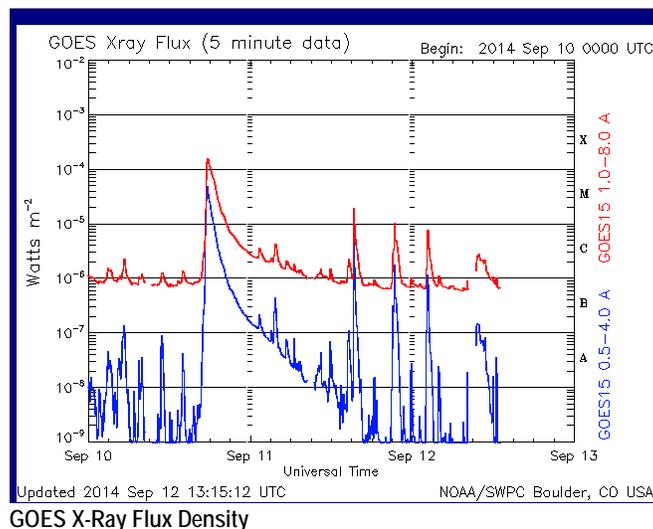
September 10: X1.6 solar flare

Again, on the next day, September 11, there was another solar flare. This was also intense but did not last nearly as long. On the far right there is another small bump indicating another even smaller flare.



September 11: M4 Solar Flare

These three charts can now be compared with the NASA X-ray flux density data collected by the GOES. You can see that early on September 10, the activity was relatively quiet before the large solar flare. The data I have for September 11 are the next two spikes. The ones following those shown in the GOES data occurred during the night (on September 12) when I cannot collect data.



Learning About Astronomy on the Web—My Favorite Resources

By Ron Henke

As you are certainly aware, there's a lot of scientific content on the web, in addition to astronomy content. As with anything on the web, some is very good and some is very bad. The trick is being able to tell the difference. In addition, there are many different ways to obtain that content. Most are free, and some are worth paying for. At the end of the article, I share some of the content sources I have found most interesting and useful. Hopefully, this will serve as short guide and lead you to some information you were unaware of.

There is an amazing amount of free content on the web. That same content is usually available on both Apple and Android platforms, especially using YouTube. But there is a difference. First I discuss the Apple iPhone and iPad, and then the Android.

iPad/iPhone

If you have an iPad or iPhone you are in luck. The apps on these platforms are outstanding. There is an app that comes with the iPhone and iPad called **Podcasts**. It is very visual, which makes it easy to use. From there you can search for what you are looking for. Just put in a topic, such as "astronomy." Dozens of suggestions will pop up. There's everything from traditional podcasts to the audio of college lectures, including courses from Yale, Ohio State, and Stanford (on quantum mechanics). One of the best podcasts for astronomy beginners is Backyard Astronomy (Search: "Back Yard Astronomy"). It has all sorts of interesting topics, including what you can see in the night's sky by month and how to keep an observing log.



Source: Metro.co.uk

The greatest thing about Apple is **iTunes U(niversity)**. It is filled with all kinds of great subjects, not just astronomy. iTunes U has much of the same material as mentioned above but in a visual format. If you are so inclined, you can actually "take" a course. There are 18 different courses available, from an eighth grade course titled "Formation of the Universe" to courses from major universities. For example, Yale offers a course on iTunes U called ASTR160: Astronomy: Frontiers and Controversies (Search: "ASTR160"). Everything you will find in a normal university level course is there: video of the lectures, lecture notes, transcripts of the lectures, pertinent web links, problem sets, the solutions for the problem sets, midterm test preparation, a sample midterm, the answers for the sample midterm, the midterm itself, the answers for the midterm, all the same material for the second midterm. And the list goes on. There are lectures that last 30 minutes, and, as mentioned above, there are also lectures that go on for hours.

Android

The availability of the same material on my Android phone is not as rich. While I can find the audio of the same information, I cannot find an app that offers as much as iTunes U. The podcast app that I use on my phone is **Pod Cast HD**, which provides quite a large selection of audio podcasts (Search: "Astronomy" and pick from the choices—there will be many).

YouTube

Another source of information that is very good is **YouTube**. Much of the video content mentioned above that is on iTunes U is also on YouTube but without the other course content. So, if you just want to watch a lecture, YouTube is a very good way to go.

Other than lectures, there is a huge amount of astronomy-related information on YouTube. Everything from full episodes of documentaries (Search: "The Universe the history channel", to the new episodes of The Cosmos

(Search: Cosmos with Neil deGrasse Tyson). When I first decided I wanted to get into amateur astronomy, I used YouTube to learn about the different types of telescopes and how to choose a telescope (Search: “choosing your first telescope”). I have also used YouTube to find out how to use the telescope I eventually purchased (Celestron Nexstar 8 SE). My only caution with YouTube is that some of the information and productions are better than others. On this, you will have to make your own decisions.

Favorites

Of all the content I have found on the web, my two favorites are **Astronomy Cast** and the **Silicon Valley Astronomy Lecture Series**.

Astronomy Cast is available in both audio and video form. It is hosted by Fraser Cain, the publisher of *Universe Today* and Dr. Pamela Gay, an astronomy professor at Southern Illinois University, Edwardsville. Their weekly podcasts aren't too long, usually about 30 minutes. What's neat is that they are very informative. As Fraser Cain says at the start of each show, “We not only tell you what we know, but how we know what we know.” And they do. The podcast is presented in layman's language, and they don't shy away from difficult or controversial subjects. Their podcasts are available on any podcast software, but their website, astronomycast.com also includes transcripts of the podcasts and cites the documentation backing the facts they use for each podcast. This is a great source of information. Astronomy Cast is now up to episode 353, so there's a lot to choose from.



Founded in 1999 (but podcasted since 2004), the Silicon Valley Astronomy Lectures are presented six times each academic year at Foothill College. Speakers have included a wide range of noted scientists explaining astronomical developments in everyday language. The series is organized and moderated by Foothill's astronomy instructor Andrew Fraknoi and jointly sponsored by the Foothill College Astronomy Department, NASA's Ames Research Center, the SETI Institute, and the Astronomical Society of the Pacific. While the audio of these lectures is good, the video is great. The best way to access these series of lectures is directly through Foothill College's website (<http://www.foothill.edu/ast/>), although they can also be

found on podcast apps and on YouTube. While this is the information I have found most useful and interesting, it just scratches the surface. The more you look...the more you will find.

EZ Binoc Mount

By Terry Barker

Binoculars have a huge advantage over telescopes—they let you use both eyes, which is much more natural for your perception of an object. And you can't beat the setup time. So, I've always been a big fan. Unfortunately, those of us bit by the astronomy bug are never satisfied with a small aperture but the bigger the binoculars, the harder it is to hold them. No matter how light they seem when you first pick them up, they start to weigh down your arms after only a few minutes.

I bought 12 x 80 binoculars at NEAF about 4 years ago (for the unbelievable price of \$40), and they give me beautiful views of the sky...for about 30 seconds...then I have to put them down.

I thought I had solved my problem with a \$130 parallelogram type mount that attaches to a camera tripod. It sort of worked, but it was too finicky and did not let me get close enough to the eyepieces to feel comfortable.

I finally solved the problem 2 years ago, also at NEAF, by buying this wonderful invention called the EZ Binoc Mount from Peterson Engineering. It's quite a bit larger than my last gadget, but it works quite well. Once I sat down and tried out a display unit at NEAF, I was sold.



EZ Binoc Mount in Action.

It's a kit made of pieces of pipe custom-made for this device. In addition, you have to purchase additional pieces of pipe to make up the whole contraption. As you can see from the photo, it can support a massive pair of binoculars. It uses a counterweight, made up of barbell weights, to balance the binocs, so it's extremely easy to move around.

It allows movement in all three directions by virtue of the pipe rotating in the fitting that it's attached to. Ingenious. You do have to apply a bit of muscle to make this happen, though. During the initial assembly, you must apply joint compound to every single joint, and then you have to muscle the pipe into the joint further than it was designed to go. This is so you end up with more threads engaged, and also so the pipe turns very smoothly if it's a joint that's meant to rotate.

This is not something you're going to put together in a day. Not only because of the number of pipes, but also because you'll want to rest your muscles in between sessions. Also, because the pipe is shipped with a preservative to keep it from rusting on the shelf, you have to strip that stuff off, and it's very greasy. But, as long as you have a little patience, it's pretty

foolproof to build. Then, once you paint it, you're good to go for many years—even if you let it sit outside permanently (so the directions say). I keep mine in my van, so it's protected, and always available on short notice.

It's a lot more portable than it looks—I only have to remove the three bottom legs, and the rest of the unit can be twisted via rotating different joints, so that it becomes essentially one long piece of pipe.

The cost was \$95 for the kit, and another \$80 to \$90 for the extra pipe. The kit includes joint compound and various hardware to hold the rotating joints in position (like large wing nuts) and hardware to mount your binoculars.

I'm very happy with it, and I look forward to using it at public skywatches. And hope nobody walks into one of the weights. For more information visit [Mr. Peterson's site](#).

It's a Zoo Out There—Using the Galaxy Zoo System to Aid in the Search for S0 Galaxies (continued from page 1)

These faint red galaxies are especially disky compared with similarly colored ellipticals, consistently displaying characteristics that fall between traditional red elliptical and blue spiral galaxies. They are believed to be a morphological transition phase known broadly as "S0" (*Figure 2*) or "Fuzzy Red Blob."

An S0 galaxy falls in the middle of the galaxy classification scheme, and is exceptionally difficult to find. At first glance, it looks like an elliptical—"red and dead"—because its stellar population have aged to the later red giant phases and there is no ongoing formation of new (bright and blue) stars and normally no features beyond a bulge. However, upon visual inspection, you will find formations that are only found in spirals. Their characteristics place them in the middle of what you would find for spirals and ellipticals. They are presumed to be caused by a spiral



Figure 2: Examples of standard galaxies as seen in SDSS. These are used in the training tutorial for GZ. Left: a “grand design” spiral—bright blue star formation, a central bulge, and spiral arms of increased star and gas density. Right: an elliptical—“red and dead”; no ongoing star formation and a smooth, spherical distribution of stars that decreases exponentially with radius. Center: an S0—a spiral where star formation has stopped; the morphological features of a spiral remain, but there is no ongoing star formation, and the stellar population has aged to the point of being red like a typical elliptical.

being disrupted (by a partner or within a whole cluster) and having its stellar formation shut down by that interaction with the outside force. Current models don’t predict their formation, and the mechanism for formation is strongly debated at almost every astronomical conference when galaxies are discussed. Papers have depended on samples of only a handful of classified S0 galaxies, so to find a method to identify the large number of S0s that statistically should be in the SDSS data would be exciting. Because their identification hinges on visual inspection, GZ offered a prime opportunity to put many more eyes to work on the search. Now for the best part! For a large sample of galaxies containing all classifications, there is normally a strong relationship between increased clustering and increased luminosity. But in SDSS Release 7, that wasn’t the end of it—galaxies with magnitudes between -17 and -19 had higher-than-predicted clustering; these dim red galaxies are more clustered than their brighter counterparts on small scales. Because S0 galaxies occur most often in massive galaxy cluster halos, that trend would be expected for a sample of S0s.

The GZ users gave me morphological classifications for the galaxy (they were also specifically instructed not to base their classification on color), and SDSS gave me magnitudes in the u, g, r, i, and z bandpasses that would be used to classify the color (g minus r, for example) of each galaxy. In the end, I had the color, chance of being a spiral or elliptical, apparent bulge size, calculated bulge-to-disk ratio, Sersic index (a mathematical function describing how the intensity of a galaxy varies with distance from its center), clustering information, number of spiral arms, estimate of the dark matter halo, and assorted other properties for the population most likely to be S0s. From there, statistics and cool graphing programs do the rest of the work!

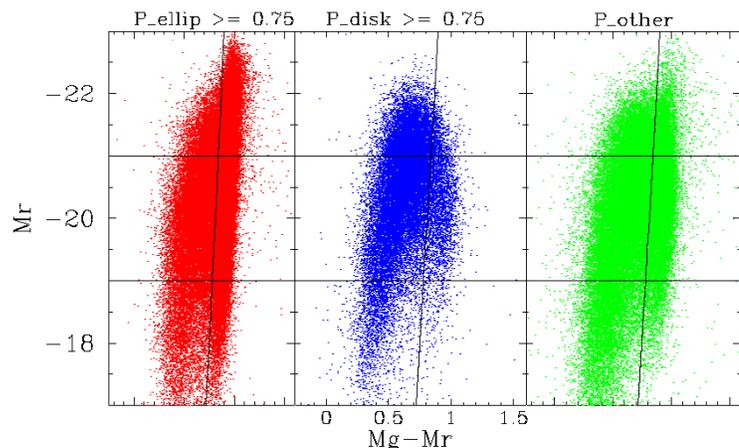


Figure 3: Morphology distribution for the galaxies in common between GZ and the LSS survey within the SDSS data. P_{ellip} indicates that at least 75 percent of GZ users classified that galaxy as a smooth elliptical; likewise, P_{disk} means at least 75-percent agreement that the galaxy is a disk, and P_{other} means that there was no agreement. Credit: Lauren Nicholson

Galaxies were separated into three groups (see Figure 3): (1) the ones that 75 percent or more GZ users said were featureless ellipticals, (2) those that 75 percent or more said were disky spirals, and (3) those for which no consensus was reached. Using previously developed criteria for the division between “red” and “blue,” the black

lines divide each of the groups into red (right side of the line) and blue (left side of the line). As expected, most disk galaxies are found on the “blue” side, while the smooth elliptical and inconclusive galaxies are spread evenly across all magnitudes and colors. When we sorted the galaxies into histograms of two characteristics—surface brightness as a function of radius and the radii ratio at which 50 and 90 percent of the galaxy’s light is contained (a small ratio means a more abrupt decrease in brightness from the center to edge)—we saw the same pattern—the dim red galaxies fall between the red and blue classifications. We also sorted into histograms of GZ users’ agreement on classifications of “smooth and featureless” (likely to be elliptical) and “odd.” The “odd” question was one of the last asked, allowing users to flag that galaxy if they were having trouble answering a question or were just unsure of how to properly classify it. The results were inconclusive. While some of the dim reds were flagged as unusual or as disks, the majority were tossed into the elliptical category even if the GZ users were more uncertain about classifying them. When asked whether there was anything odd about a galaxy, they actually classified the dim reds with the highest certainty of any of the three groups—the majority of GZ users saw nothing odd about the galaxy, but did classify many of the faint blues of similar brightness as having odd features.

Considering that there’s an order of magnitude difference for each ± 1 value of astronomical magnitude, the dim reds are on the order of 100 to 10,000 times fainter than the bright reds. When imaging such faint objects, even when they are relatively nearby, features tend to get missed by the untrained eye or simply averaged out by pixilation, depending on the resolution of the image that was shown. While users were instructed to ignore color and make selections solely on observed features, there still might have been a tendency to put all red-appearing objects into the elliptical category. That is the burden of a sample limited by the amount of light collected—the bright red galaxies are typically found in clusters very far away from our Local Group, and although the dim reds and dim blues are expected to appear at a similar volume density at all redshifts, we can only see them when they’re relatively nearby (Figure 4).

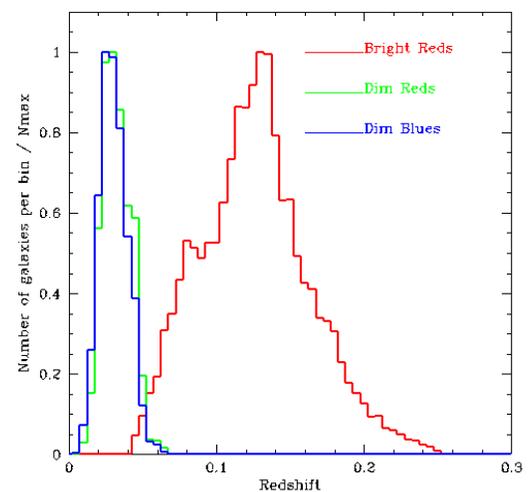


Figure 4: Redshift distribution of the galaxies in the sample.

So, can we use GZ data to help us search for these galaxies? The brightness and resolution of the screen image may be a permanent limitation on using GZ data to supplement SDSS, as evidenced by so many galaxies being incorrectly classified simply because of their faintness. It may be that the intrinsically fainter objects, regardless of distance, will not yield good results with the current setup. The images of these faint, fuzzy objects are scaled down to a website image only a few square inches in size, which might completely erase all traces of already-hard-to-see features.

The untrained eyes of the “citizen scientists” might also just fail to notice any small traces that remain. To determine whether there are actually features there, future work would need to include a “re-do” of these dim galaxies in which both ordinary people and scientists were presented with higher-quality images of the same galaxies and asked to answer the same questions. If the results are the same, it means these galaxies are just too small and faint to be classified by eye reliably. If the results are different, however, then other options must be considered in future work.

Observe the Moon Events at Porter Library (Stafford) and Wilderness Elementary School (Spotsylvania)

By David Abbou and Ron Henke

In September, David Abbou and Ron Henke participated in separate local Observe the Moon events. Below are their reports.

*David said...*For the second consecutive year, I partnered with the Porter Library in Stafford on Saturday, September 6, to conduct the Meet the Moon event for International Observe the Moon Night. Despite the cloudy weather again this year, we had roughly 150 people attend who were treated to presentations, hands-on activities, and discussion about the Moon, astronomy, and the space program. NASA LRO, New Horizons, JWST, and RAC outreach materials were distributed to the attendees. Several educators also attended and commented how much they enjoyed the evening's activities. We did get a few quick views of the Moon through my telescope when the clouds finally cleared for a few minutes toward the end of the event. Photo shows participants waiting for views through the telescope.



*Ron said...*On Tuesday, September 30, I had the pleasure of representing RAClub at Wilderness Elementary School's Observe the Moon Night. They had seven stations set up to teach the students about different aspects of the Moon. One of these stations was "Gaze at the Moon," which gave students and parents the opportunity to look through a telescope. Luckily, there were four other telescopes and a set of astronomical binoculars. The event was scheduled to last from 6:30 to 8:30 pm, and the weather couldn't have cooperated any better. I arrived a little after 6:00 and started setting up. Others were already there setting up their telescopes. As with other events I have attended, as soon as I had the Moon in the field of view there was a line, along with all the "wows" and "amazings." I estimate that in the 1 hour and 45 minutes I was set up, I gave more than 100 views. It was a fun evening, and I thoroughly enjoyed myself. If these event opportunities come up again please do not hesitate to call on me to participate.

Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

Note: There was no presentation in August because the picnic was held instead of a regular meeting. No presentation occurred at the October meeting because of a scheduling mix-up.

September 2014—Prehistory and Cryptozoology of the Telescope

Glenn Holliday presented a program on the origins of the telescope. He had participated in a club outreach at this year's Renaissance Faire and became interested in the state of astronomy in Elizabethan (1540s) England while doing research for the event. The Elizabethan period represented at the Faire was about 60 years before the invention of the telescope, but Glenn found several people were aware of the possibility and actively trying to develop one. People had been making lenses for many years. The earliest lens that has been found is the Nimrud lens from Assyria, about 2,700 years old. Eyeglasses were being used from the 1280s. In addition, hints of the possibility of the telescope include Roger Bacon writing in the 1200s that a magnifying lens made new stars appear

where the sky seems empty to the naked eye, and Leonardo writing in the 1400s that a lens made features on the Moon appear larger. Glenn said both were probably using a convex lens in a way that is now used in high school science experiments and noted that young eyes are needed to focus this kind of image.



Another development contributing to the eventual invention of the telescope was the camera obscura, in which a pinhole or lens in an opening to a room projects an image onto the opposite wall. One was first built by al-Haytham circa 1000. It was widely adapted by artists in the Renaissance for assisted drawing in the new perspective style.

Under the topic of "cryptozoology," Glenn discussed references he found to "mystery beasts that never were (or were they?)." For example, European writers in the Middle Ages claimed a giant mirror in the harbor of Alexandria magnified distant ships and enabled the inspector to examine them as they approached the port. There were also claims of such mirrors at other harbors. Glenn said that the people who built the mirror at Alexandria never claimed it had such powers. Accurate curvature on such a scale was beyond the capabilities of the time. (It would have required a center of curvature more distant than the ships, and thus a mirror many meters tall.) The mirror behind the myth was added by the Romans to the Lighthouse at Alexandria to reflect the sunlight by day and firelight at night. The lighthouse was one of the seven wonders of the ancient world.

Leonard Digges, a prominent architect, surveyor, and landed gentleman of the reign of Henry VIII, built a portable camera obscura, a "perspective trunk," for surveying use. It projected an image onto a parchment screen so that the image could be observed from outside the trunk. In 1571, Leonard's son, Thomas Digges, wrote that he could magnify that image and read a broadside posted 2 miles away, saying he would write a paper on this subject. Glenn said that "Thomas Digges became England's first modern astronomer, the first to promote the Copernican model in England, and tried to develop a telescope."



Later in the 1570s, Thomas Digges sent his patron, Lord Burghley, a telescope design using an objective lens and mirror focuser. Glenn learned that Burghley sent this design to Royal Navy cannon inventor William Bourne. Bourne then proposed switching the elements to have a primary mirror and a lens for magnifying and focusing, and in 1580, he proposed a new design with two lenses. Glenn said that after the defeat of the Spanish Armada, Queen Elizabeth awarded Thomas Digges land and money for unspecified services to the Crown, suggesting a possibility the Royal Navy had a Digges telescope that helped in that defeat. However, although researchers have built the Digges design with modern technology, the technology of the day was not sufficient to do so. Digges calculated that he needed a 12- to 16-inch lens and mirror, and the largest usable lens at the time was 2 inches. Glenn concludes Digges probably demonstrated the perspective trunk at a Royal Navy lookout post.

The period preceding and during the early development of the astronomical telescope saw a great deal of activity, as Glenn illustrated in his talk. Among the events he talked about were Fracastoro's 1538 account written in Italy of using two lenses to make objects appear larger and closer, John Dee in England writing about the military uses of the perspective glass in 1570, Italian Della Porta placing a mirror and lens in a camera obscura to enlarge the image, and Kepler's publication of *Optics* in 1604. When Hans Lipperhey demonstrated the first telescope in Holland in 1608, the result of all this activity was very rapid development. In the same year, a telescope was offered for sale at the Frankfurt Book Fair, and in 1609, telescopes were on sale in Paris. On August 2, 1609, Thomas Harriott in England observed the Moon through a Dutch telescope, publishing sketches of the Moon before Galileo. He also developed the first theory of refraction, which was lacking in both Bacon's and Kepler's *Optics*. In July to

August 1609, Galileo made a copy of a Dutch telescope. He quickly improved the design, and in March 1610, he published his first observations. In his second telescope, he used the aperture stop that Lipperhey had introduced to use the central part of the lens where lens-making techniques of the time produced the best optical quality. By the end of his career, Galileo had advanced his telescope-making skills from 10 mm to 60 mm apertures, and his lenses were the best available at the time.

Scott Gingrich noted that the Frankfurt Book Fair mentioned in Glenn's talk apparently is a longstanding tradition still going on today. Adam Zwierko wondered about the selection of 2009 for the 400th anniversary of the telescope with all that Glenn related to us going on before and after 1609. Glenn thought it could be attributed to Galileo's name and all that he accomplished. A copy of Glenn's presentation is posted on the club website on the [monthly programs page](#).

Image of the Quarter



Partial Solar Eclipse and Sunspots taken by David Abbou. "I took the sunspot photo with my Celestron 8 telescope and digital camera. The partial solar eclipse photo was taken with my Canon digital camera (and solar filter) on a tripod. You can see the same giant sunspot group in the eclipse photo. All photos were taken from Stafford."

