Rappahannock Astronomy Club

Minutes, October 11, 2017, Meeting

In attendance:

Jean Benson
Bart & Linda Billard
Joe and Sherry Francis
David Hiles
Jerry Hubbell
Venita Johnson
April Peterson
Tim Plunkett
Matt Scott
Tom Watson

The meeting began shortly after 7:00 p.m. Ten members and 2 visitors were present. One of the visitors joined during the meeting. With Scott Lansdale and Glenn Holliday both absent, Bart Billard and Tim Plunkett asked Jerry Hubbell to run the meeting.

Program

The program for the evening was Bart Billard's "How to Detect What Stars Are Made of." He said he had had an idea for using an instrument he once worked with in the lab as the basis of an instrument amateurs could build to reveal information about stars and other objects in the sky. With help from Matt Scott and Lauren Lennon and advice from Myron Wasiuta and Jerry Hubbell, Bart was nearly ready to test it on a telescope.

As background, Bart described the story of the application of spectroscopy to the stars. Isaac Newton contributed to the understanding of how white light is a mixture of colors, comprising its "spectrum" with experiments in 1665 that are described in George Johnson's *The Ten Most Beautiful Experiments*. Newton passed sunlight from a hole in the shutter of his darkened room through a prism to produce the rainbow effect on the far wall. He noted the oblong shape of the beam—much longer than it was wide. Newton then tried different parts of the prism, changed the hole size, and even put the prism outside the window and found no effect on the oblong shape. He found that he could pass the colors through a lens and make them recombine, leaving a circle of white light on the wall. Newton concluded the colors were not added by the prism but were a part of the light from the Sun. This was verified when he tried another prism on individual colors selected with a hole in another screen between the first prism and the wall. He found that each color, starting at the red end bent a little more than the last in the second prism. He concluded each color represented a component of light with a characteristic amount of "refrangibility," the degree to which it bends (refracts) in a prism or lens. White light was a mixture of these different kinds of rays.

Spectroscopy of astronomical objects began in the mid-1800s, not long after the death of Auguste Comte, a philosopher/scientist who concluded, based on distances being found for the planets and some nearby stars, that "…we can never know anything of [the planets'] chemical or mineralogical structure…" (let alone the stars). Physicists Joseph Fraunhoffer, Gustov Kirchoff, and Robert Bunsen pioneered spectroscopic techniques. Fraunhoffer discovered dark lines in the Sun's spectrum. Kirchoff and Bunsen showed that these lines were related to bright lines produced by chemical elements in a laboratory flame. Taken together, they showed evidence for sodium in the Sun's spectrum.

Soon other elements were identified, and in 1868, French astronomer Jules Janssen and English astronomer Norman Lockyer had found the first evidence of the element helium. It was a yellow line in the Sun's spectrum that Lockyer concluded was an element in the Sun unknown on Earth. He and English chemist Edward Frankland derived the name from the Greek word for the Sun. Bart said the story of Comte and the early work with the Sun's spectrum is told on Michael Richmond's website "How do we know the composition of the stars?" (Michael Richmond is a professor of astrophysics at the Rochester Institute of Technology.) There you can also read about Cecilia Payne-Gaposchkin's work to put spectroscopy on a more quantifiable basis, which led to the discovery that hydrogen is the most common element in the Sun and typical stars, followed by some helium.

Bart next talked about interference patterns and how they can be related to spectroscopy. He showed examples, such as water waves in a "ripple tank," iridescence of a soap bubble film, and Newton's rings

formed from the layer of air between a convex lens and a flat glass plate in contact with the lens. Bart explained we see the effects when light from one source reaches our eye via different paths. For example some could reflect off the outside surface of the soap bubble film, and some could reflect off the inside surface between the film and the air inside the bubble. This light travels some distance farther, depending on the angle of its path through the film and the thickness of the part of the film it goes through. Like the waves in the surface of a ripple tank, light consists of waves with peaks and troughs. They can be aligned peak-to-peak and trough-to-trough and reinforce each other (constructive interference) or peak-to-trough and cancel each other (destructive interference). How they align depends on the distanced between one peak and the next, called the wavelength, as well as the difference in the length of the paths travelled. Different wavelengths correspond to different colors. The result is parts of the soap film can have some colors enhanced and others suppressed in a way that varies across the bubble and produces the iridescence effect.

Bart illustrated with a diagram of a two-slit interference experiment. He showed how the distance from one slit would vary compared with that from the other. A point directly opposite the midpoint between the two slits would be the same distance from each slit, and light of any wavelength would align for constructive interference and be the location of a bright fringe. A point at an angle to one side of this first point would be closer to the slit on that side. The extra distance to the slit on the other side, measured in wavelengths, tells how many fringes at that wavelength would be found between the two points. Another shorter wavelength might be found to fit one extra wavelength in that same extra distance. Its pattern would have one extra fringe between the two points. That tells us we could distinguish these two wavelengths by counting fringes. It turns out patterns corresponding to a combination of wavelengths with varying intensities can be analyzed to reveal the relative contributions of all the wavelengths and thus reproduce the spectrum.

Bart next showed the Michaelson interferometer used by professional astronomers. It includes a "beamsplitter," which reflects part of the light and transmits part to split it into two paths, and two mirrors which reflect the light back to the beamsplitter the way it came. The beamsplitter recombines the returning light and reflects some of it to a detector. One of the mirrors can be moved closer or farther from the beamsplitter by a motor to vary the distance for the corresponding path and produce an interference pattern at the detector. This interferometer can produce up to 100,000 fringes just by moving the motorized mirror a centimeter, allowing it to distinguish light wavelengths extremely close together. On the other hand, it is very sensitive to vibrations, tricky to align, and requires expensive precision moving parts. Bart compared it with a common-path interferometer that is the basis for his instrument. It uses a lens and CCD camera instead of the detector, and the two mirrors are fixed and turned to send the light from the beamsplitter from one mirror to the other and back to the beamsplitter in nearly identical clockwise and counterclockwise paths. The camera sees two images of the source side by side a fixed distance apart. A person or camera looking into the Michaelson interferometer would see one source in line with the other, a variable distance in front or behind as the motor moves the mirror. The side-by-side images in the common-path interferometer produce their interference pattern like a two-slit interferometer. The fringes are spread out across the camera as a function of the angle of the light from the source. The common path makes it easier to align and insensitive to vibrations, and there are no moving parts. Bart said he first became enthusiastic about the idea when he realized he could let stars drift through the field of view of his Dobsonian telescope, and they would record the interference pattern on the CCD camera in their trails. The telescope does not need to track the sky.

Bart concluded by showing his interferometer. He said he had had the good fortune some time ago to encounter Matt Scott and Jean Benson downtown early in his work on the interferometer. He realized Matt's mechanical engineering background would be very helpful and told them about the project. Also during the early phase, he discussed the idea with Myron, Jerry, and Lauren at MSRO Commission meetings, and Lauren mentioned she was getting trained to use the 3-D printers at the Library. Matt designed a yoke to hold the beamsplitter, and it was ready for Lauren to print when she was finished her 3-D printer training. Since then, Bart has visited Matt and Jean several times to work on a layout on the original breadboard that can be enclosed in a box holding a collimating lens to direct the light from a telescope source and Bart's DSLR camera and lens to record the interference pattern. The walls of the box with adapters for the lenses were ready during the last week, and Bart was able to record interference patterns indoors and included one in the talk. The next step is to make the lid for the box and decide on a bracket for stabilizing the package when mounted to the MSRO2 telescope. A copy of Bart's presentation is available on the RAC website club programs page.

Old Business

- Treasurer's Report for September 30, 2017—Tim Plunkett said he had no changes to report for September. Two of the visitors last month expressed interest in signing up but had not sent in the application by the end of the month. Tim said one of them had just paid at this meeting, so that payment will be reported next month. The number of members for 2017 remained 34 as of September 30.
- Communications—Tom Watson and Linda Billard were the only committee members present. Tom said he had not done much. He mentioned limited free time and his spectroscopy work as reasons for lack of activity on communications. Linda said she was in the final stages of preparing the next newsletter. She still needed a few outstanding submissions. She was expecting eclipse reports from Jerry and Ron Henke. She and Tom talked about him doing one on his spectroscopy experiment, which she told him she needed soon, because the newsletter goes out on November 1.
- MSRO—Jerry said he had done some camera testing and some rearrangements of the instruments. He said the new 80-mm refractor was f/6 and had about a 1.6-degree by 1.2-degree field of view with the one-shot color camera. The camera was significantly more sensitive than the older SBIG camera and provided 75-percent quantum efficiency. Tom asked about maximum exposure times. Jerry said the TDM was good for 5-minute exposures that could be stacked for total exposure times of several hours.
- Recent Events—Jerry asked Bart to talk about the Triton occultation event he had attempted to time with Jerry and Myron Wasiuta at MSRO on October 5. Bart said he had seen the event using the "Occult Watcher" application available for people interested to find out about events predicted to occur nearby their preferred observing location. It also allows them to announce a station for attempting to observe events. Bart realized Triton was the moon of Neptune, its orbit predicted to pass between Earth and a star, and that many observers were announcing stations for such an unusual event. Because he announced MSRO as a station, he received an email about the predicted event and learned it would be scientifically interesting because observations of the occultation could provide information about Triton's atmosphere. Observers in the center of the predicted shadow path would likely record a "central flash" because Triton's atmosphere would refract starlight around the moon to the center of its shadow on Earth. Bart said he had two successful practice days with Myron on October 1 and with Myron and Jerry on October 4. Unfortunately, on the day of the event, they had to contend with clouds. Neptune was visible when it was dark enough, but the clouds moved in as the event approached, and Neptune was partially obscured near the predicted event time. Bart said he was hoping there might still be good enough signal-to-noise in some of the data they recorded for him to find either the star disappearance or reappearance with more analysis.

New Business

- Nominations for club officers—Jerry said the October meeting was designated for holding nominations for club officers ahead of the November election meeting. He started it off by nominating Scott Lansdale as president, and Linda seconded the nomination. Linda then nominated Glenn Holliday for vice president and was seconded by Tom. Jerry nominated Bart Billard for secretary and Jean Benson seconded. Bart nominated Tim Plunkett for treasurer and was seconded by Tom. Jerry noted that we would have an opportunity for more nominations from the floor before the voting during the November meeting.
- Upcoming Events—Jerry mentioned that the next event would be the dedication ceremony and picnic for MSRO on October 21. He explained the announcement could be found in the news section of the club website home page and said club members were invited. Jerry said members should follow the instructions to reply to Myron Wasiuta at the email address in the announcement, telling him how many family members would attend. Myron would provide directions to get there. There would be a chance to see how the MSRO telescopes work and viewing if weather permits. The date of the next Caledon star party was November 11, and the November election meeting was the following Wednesday, November 15. There would be no program, but pizza would be served. The topic planned for the December 20 meeting was exoplanet observing by Jerry and Bart.

- 2018 Caledon Star Party Schedule—Jerry showed the tentative schedule on the screen. We thought it was the list of dates Glenn had suggested in an email recently, and that Glenn might still need confirmation for some dates on whether other members would be available to cover them. Tom said he thought he would make it to most of the ones shown and also thought Ryan Rapoza might be a regular as well. Some of us though Scott Lansdale had been attending regularly as well.
- Additional Program Ideas for 2017—Tom said he would be available for a program on his spectroscopy and that January would be ok. He said he had caught a coronal mass ejection.
- Stargazer Update—Linda had already discussed the topic during the Communications Committee report earlier in the meeting. She added that she would at least like a report from Tom on what happened at Caledon during the eclipse. Tim noted that he should send something about his experience viewing the eclipse in Tennessee. Jerry suggested members should try to send Linda brief email reports about any successful astronomy activity such as seeing meteors or an interesting night viewing with binoculars.

Next Meeting

The next meeting is the club officer election meeting on Wednesday, November 15, 2017, at the Headquarters Library on Caroline Street, downtown Fredericksburg. We will be in room 2, and pizza will be provided.