

Rappahannock Astronomy Club

Minutes, October 17, 2018, Meeting

In attendance:

Jean Benson
Bart and Linda Billard
Scott Busby
Don Clark
Glenn Faini
Glenn Holliday

Jerry Hubbell
Scott Lansdale
Dan Lien
Tim Plunkett
Ryan Rapoza
Matt Scott

The meeting began at about 7:05 p.m. Thirteen members were present.

Program

Jerry Hubbell presented “High Resolution Photometry for Exoplanet Observations.” He said his interest in the topic started with a paper he discovered in April. Amateurs began making analog measurements of stellar brightness in the 1970s, when they began using scintillation tubes. In the mid-1990s, professional CCD techniques began to be adapted by amateurs as software became available for analysis. Jerry said the original analysis technique was to measure the total intensity recorded within a circular area encompassing the star and then the sky background intensity nearby using the same aperture. A comparison star was measured in the same way to produce a differential magnitude. He said that when CCDs were adapted, an annulus around the star aperture could be used for the sky background. Image calibration was also added. Jerry showed some examples of CCD images illustrating the use of circular apertures and annuli. He noted they are applicable for measuring stars, exoplanet transits, and minor planets. One showed an example of a potential problem: another star fell within the annulus around the minor planet being measured.

Jerry talked briefly about equipment. He said it was best to use a thermoelectrically cooled camera with a monochrome CCD, as opposed to a color CCD with a Bayer color filter array. With a monochrome CCD, one can still use filters, for example, a V-band filter, which tries to match the response of the human eye.

Jerry said the long-held standard for amateur photometry measurements was ± 0.01 magnitudes (mag) (about a 1 percent error). His goal is less than half that error, or less than ± 0.005 mags. In response to a suggestion by Glenn Holliday, Jerry agreed that “high precision” was a better term than “high resolution.”

The main reason for high precision is to detect variations at the millimag (millimag) level. This precision is necessary for exoplanets, minor planets, and variable stars. Jerry said most exoplanets are in the 7–15 millimag range, and he thinks amateurs can observe in the 7–10 millimag range. The 1-percent precision can be good for Jupiter-class exoplanets. He would like to do more than just that precision.

Jerry showed an observation he made with Bart Billard of a transit of the exoplanet HAT-P-30/WASP-51b. These data were reduced on the Exoplanet Transit Database (ETD) website and are available there ([HAT-P-30/WASP-51b observation](#)). He said that he and Bart took a course on exoplanet transit observations in 2017, and this was the first observation we reported to ETD. Jerry pointed out the significant scatter in the data and said he would like to get that down. He discussed other ways amateurs could contribute to science with precision photometric observations. The Transiting Exoplanet Survey Satellite (TESS) recently began its science mission. Jerry showed a statement on the need for follow-up observations. For example, because the TESS instruments cover such large regions of the sky, many transiting signals detected could be from more than one star merged in the TESS photometric aperture for that target. Ground-based observations would be needed to sort out which star has transits, or whether one of the merged stars is actually an eclipsing binary system.

Jerry also explained how minor planet light curves allow 3-D shape modelling and rotation rate determination. He said higher-precision photometry of variable stars could reveal smaller changes. Star spots could be detected, helping to characterize lifecycles of stars.

Jerry discussed error sources, categorizing them as shot noise, residual calibration errors, and scintillation. Shot noise depends on the square root of the number of photons collected, meaning the more data the better the precision. Jerry said it was analogous to polling. For the precision goal he chose, it is desirable to collect about 10^7 photons or more in the aperture, which would provide a theoretical shot-noise precision of ± 0.3 millimag. Residual calibration errors can be determined by finding the variations over several flat calibration frames. The errors are smoothed out by averaging the calibration frames to make the master flat, but the remaining variations can cause errors as the star drifts to different pixel location during measurements of light curves. Scintillation is based on environmental factors. Jerry said it comes in short-term and long-term forms. Scintillation determines the lower limit on the errors affecting precision once shot noise is reduced.

Jerry described the use of diffusers for spreading light to obtain greater precision. With a diffuser, light from a star that would cover 20 pixels could be spread over an area of 450 pixels. He said he considers precision at two levels: sample precision from shot noise, short-term scintillation, and residual calibration errors; and the precision of a light-curve measurement involving many samples (for example an exoplanet transit depth measurement's precision). A diffuser can improve sample precision by allowing averaging over a large number of pixels (up to the point where too many dimmer comparison stars are lost). The diffuser method also mitigates the impact of tracking errors or a meridian flip on residual calibration errors.

Jerry said he was working on this diffuser project with Dennis Conti, who ran the exoplanet transit observing course he took with Bart last year and is also a designated NASA TESS Mission liaison to the amateur community and supports their exoplanet observation efforts. He showed some images and light curves he made for testing the diffuser performance. One was the minor planet (19) Fortuna, which produced a light curve with very little scatter.

Ryan Rapoza asked about detecting star spots and how one could tell the difference from transits. Jerry suggested one would see the depth change over time, or it might disappear completely. Bart suggested the star spots might have relatively long transits. Jerry said he planned to clean up his slides for posting on the club website.

Old Business

- Communications—Don Clark asked whether the club still wanted to consider moving from Yahoo groups to groups.io. Scott Busby said he had a month-to-month workaround for the calendar problem and was unsure about ownership—he is only an administrator. Someone suggested the owner might be Tom Pendergrass. Scott did not want to be the one making the transfer to a new host like groups.io. Don said he would provide information on the possibility of using the Google option we have. (This option appeared to be related to the email forwarding used for the club officers.)
- MSRO Update—Jerry said the training session held September 29 had Ryan Rapoza attending in person and two others attending online. He said MSRO was able to get the @remotetelescope Facebook name, which was where the training presentation could be viewed. The next session was scheduled for October 27 at the Wilderness branch library off Route 20. Jerry planned to propose to Myron Wasiuta that they repeat the introductory training session on October 27. He said he would let Linda know what to post about it. Ryan said he thought the session he attended was a good one.
- Completed events—the Caledon star party was held on October 6. Glenn Holliday said it was cloudy for the program but they discovered it had cleared up and they had about an hour for observing afterward. About 30 people came. Glenn Faini reported attending the VAAS meeting at Randolph Macon College (RMC). The meeting included four presentations and a tour of the telescope at RMC. He said he got to see Terry Barker, who coordinated the meeting. Glenn gave his notes to Linda Billard for the Newsletter. Scott Busby described his recent trip to the Yerkes Observatory, which he said is now closed. It was operated by the University of Chicago Department of Astronomy and Astrophysics. The closing was the result of the diminishing research value offered by the observatory because of light pollution. Scott said maybe a group could come in to operate it for outreach. A developer who wanted to buy the land, mothball the telescopes, and tear down the observatory recently lost the fight over that plan. The archive of observatory data is currently closed. Jerry said Explore Scientific has done outreach there.
- Treasurer's Report—Tim Plunkett's report showed no dues collected or expenditures for September, but he said he did get a payment earlier this month that he would credit for next

year's dues, not thinking it would be fair to credit just the 2 months left this year. He had forgotten to add Scott Busby to the list of members.

New Business

- Officer Nominations—Glenn Holliday read the duties listed in the club bylaws for the President and Vice President. He showed a proposed star party calendar for next year, mentioning the idea of moving the picnic to the October star party date. Scott Busby agreed his desire not to host the picnic in August did not rule out trying a different month. Jerry nominated Bart for Secretary with a second by Scott Lansdale. Linda nominated Glenn Holliday for Vice President or President (saying “his choice”). Glenn Faini asked how many hours were required for their duties. Glenn Holliday estimated he spent 10–20 hours a month and Scott Lansdale estimated 80 hours a year. Bart nominated Tim Plunkett as Treasurer and Linda seconded. There was interest in nominating Tom Watson for an officer position, but no one wanted to nominate him in absentia, and there was concern he might have health issues.
- Planned Events—Stratford Hall on November 10 was the next outreach planned. Joe and Sherry Francis had let Glenn Holliday know they might be able to attend. Glenn said he would not be able to go. Glenn Faini and Scott Lansdale said they did plan to attend. Linda and Bart thought they could attend.

Next Meeting

| The next meeting is on Wednesday, November 14, 2018, at **a place to be announced or** the Headquarters Library on Caroline Street, downtown Fredericksburg. We will be in room 2.