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Editors:
Brian D. Warner
Jerry Foote
David A. Kenyon
Dale Mais

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An Amateur Astronomer's Growth into Science

Cindy Foote
Vermillion Cliffs Observatory – Venus Building
4175 E. Red Cliffs Drive, Kanab, UT 84741
cindyf@scopecraft.com

Abstract

This paper will discuss the change of interest and progression of a visual observer to a participant in astronomical science. It will talk about the move from using a borrowed telescope to buying a telescope, building an observatory, automating the telescope, and buying a CCD camera. The importance of having a mentor to expedite the learning process will be stressed. After more than a year's effort, the reward was a light curve showing the egress of HD209458b, which will be presented.

1. Introduction

As a visual observer for several years, my interest in astronomy took me to RTMC each spring to see and hear what was new, meet with old friends, and look through a variety of different telescopes. To this point, my contributions in astronomy had been sharing the night sky with the public outreach programs. At RTMC 2004, Tim Castellano (Castellano, 2004) gave a presentation that caught my attention. This discussion on detecting transiting exoplanets was something to get excited about. It was something I thought I could do and so make a contribution to science. Further reading (Castellano, 2004) (Laughlin et al. 2003) on the subject convinced me to move ahead.

The next course of action was to obtain a telescope, build an observatory, and automate the entire process.

With everything in place, the search for an exoplanet transit began. There were several nights of frustration, exasperation, and bad weather. However, the reward finally came in June 2005 when the telescope captured the egress of HD209458b.

2. Vermillion Cliffs Observatory – Venus Building

Desire to do research is one thing, but having the equipment to do the research is another. The current problem was that my husband, Jerry Foote, has one observatory (Vermillion Cliffs Observatory) on the property already. His observatory is focused on the measurement of Cataclysmic Variable stars in conjunction with the Center for Backyard Astrophysics. You can readily see that sharing his telescope was not an option. There was no dedicated telescope of my own to work with for the extended periods of time that it would be needed to capture a transit.

At the RTMC 2004 meeting, circumstance led me to a person with a new Meade 14" LX200GPS that he was interested in selling. Over the next few days we negotiated a price and it was loaded into the RV headed for Utah.

2. 1. Observatory

The next decision was where to build the new observatory. It was important that it didn't interfere with the current observatory but allow each telescope to observe the full sky available from this location. A sandstone bluff blocks the horizon to the northwest, so the ideal location was to the northwest of the main observatory, in the shadow of this bluff and construction began (Figure 1).

The observatory is a roll off roof design. The building is nine feet square. Six piers support the building and the roll off outriggers that are north of the building. The powered roll off roof is mounted on four V-rollers that ride on inverted angle iron tracks. The telescope sits on a pier isolated from the building. The upper portion of the south wall hinges down to allow access to the southern horizon. Since local light pollution is minimal, windows were installed to allow light during the day, and to provide ventilation during the hot summer nights. Power to the observatory is via underground conduit with a separate data cable conduit that connects the observatory computer to the house computers.

The observatory construction began July 10, 2004 and was completed in August (Figure 2). First light was 8/27/04 at ironically 8:27 PM MDT.

Figure 1. Placing the first floor support beam.

Figure 2. Completed Vermillion Cliffs Observatory – Venus Building with Vermillion Cliffs Observatory in the background.

2. 2. Telescope

The telescope is a Meade 14" LX200GPS (Figure 3). Tests after polar alignment showed tracking to be very poor. After repeated PEC trainings, it was found that the telescope still wouldn't track an object in RA throughout the night. Efforts to improve this included replacement of the nylon gears in both the RA and Dec drives with Petersen stainless steel gears and installation of Richard Seymour's patch to the Autostar control system. With these changes, an object could be tracked for a few hours but still not an entire night. At this time, the only way to track a program star throughout the night is to guide the telescope. There are multiple forums on the Internet dealing with LX200GPS telescope problems that are invaluable. With this said, the telescope is a good working instrument with reasonable optics for the money spent.

Figure 3. Meade 14" LX200GPS with SBIG ST-7E Camera attached.

2. 3. CCD Camera and Other Equipment

The CCD Camera is a previously owned SBIG ST-7E. This camera was purchased from an astronomy friend who wanted to have a larger camera. The focal reducer was another used item purchased from a local astronomy amateur. Recently, a SBIG CFW-8 filer wheel has been installed, again a used item that contains LRGB filters.

2. 4. Software

In order for the telescope to operate scripted, the Meade Autostar needs to be controlled by a separate computer. The software used to control the telescope and the camera is MPO Connections. This software has extensive scripting capabilities allowing very complex observing programs.

Rather than build a warm room next to the observatories, it was decided to run the computers by remote operation from the house. The software used is Remote Administrator which provides full screen, mouse and keyboard access of the observatory computer.

For data reduction of the many images collected each night, AIP4WIN (Berry et al., 2005) is used. The reduction process results in a text file that is imported into Microsoft Excel for final analysis.

2. 5. Time Calculator

One of my most valuable tools is a time calculator developed by Edwin Sheridan, Crescent Butte Observatory in Kanab, Utah (Figure 4). This calculator relates Universal Time, Local Time, and Local Sidereal Time. It has an overlay that shows the available range of RA that can be viewed at any particular local time.

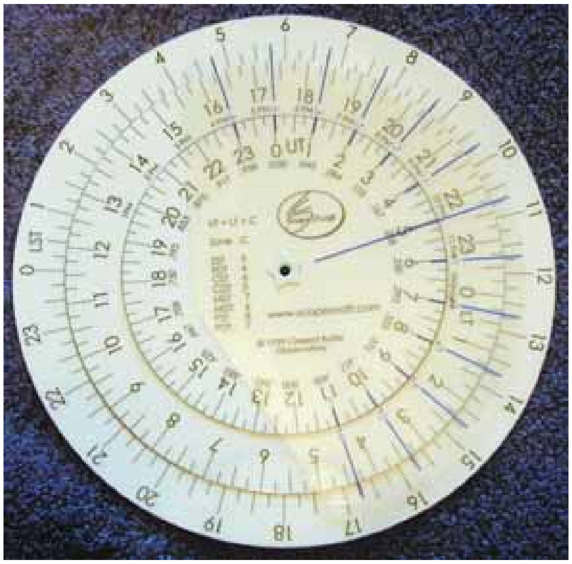

Figure 4. Time Calculator

3. HD 209458b

HD 209458 is a reasonably bright star located at RA 22:03:10.8 (J2000) Dec +18:53:04.0 (spectral class estimates F8V to G0V). It has a known Jupiter-mass planet that orbits every 3.52 days. The initial discovery was with spectroscopic radial velocity measurements. Later it was found by the STARE project that a photometric dip occurred at the expected time from the spectroscopic orbital parameters. This was confirmation of an exoplanet by photometric means (Transitsearch.org).

3. 1. Observations

A visit to the Transitsearch web site provided a list of possible times when HD 209458b would make a probable transit. The predicted central transit time was July 1, 2005, 05:29 UT, which was below the eastern horizon from this location. However, it was found that the egress would occur at 07:09 UT, making it possible to capture, but it would require making the initial measurements through a large air mass. The air mass range during the 500 observations was between 4.1 and 1.1.

Each observation was of five-second duration and was repeated with a 20-second delay between observations. With download time included, this resulted in a new observation every 32 seconds.

3. 2. Data Reduction

Previous to the night of observations, a master dark and a twilight master flat were created. The master dark is a median combination of 20 dark frames. The twilight master flat is the normalized median combination of 30 exposures with the telescope drive stopped.

AIP4WIN was used to reduce the data. Prior to the photometric measurement, each image was dark subtracted and flat fielded. The photometric process utilized an aperture of three times FWHM. A sky background measurement was made in an annulus around the star. Similar measurements were made of a comparison star and a check star in each image.

The differential photometric measurements from AIP4WIN were imported into a Microsoft Excel spreadsheet where the measurements could then be graphed.

3. 3. Results

There is considerable noise in the measurements due to the large air mass and scintillation from the short exposure times. However, it is clear that the egress was captured (Figure 5).

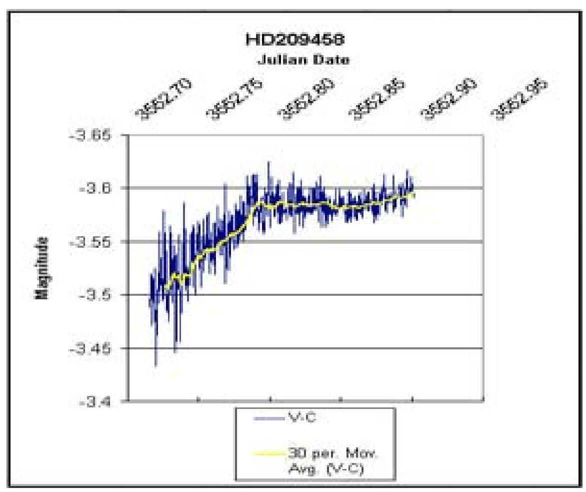

Figure 5. Light curve showing egress of HD209458b.

The trend line in Figure 5 is a moving average of 30 measurements. The general shape of the egress curve can be seen from this trend line. The predicted JD of egress was 3552.80 in close agreement with the light curve.

4. Importance of a Mentor

Enough cannot be said about having a mentor to expedite the learning process. Without one, the learning curve is great. Frustration sets in quickly and what you thought was going to be a satisfying progression into science contribution ends with failure.

A mentor provides a never-ending supply of knowledge about telescopes, software, observing techniques, data reduction, analysis, and terminology that a new astronomer gets lost in.

There are a number of mentors available in the SAS organization, both amateur and professional, to help you succeed. You just need to ask.

5. Conclusion

The intrigue of capturing an exoplanet transit was enough to lead me to find a telescope of my own and build an observatory that would facilitate the search. It involved learning a lot of new software and then finding an affordable camera and focal reducer. The learning curve was steep so a mentor was needed. Several other amateur astronomers as well as the SAS organization became valuable assets. Wanting to provide worthwhile contributions to astrophysics has been a journey of frustrations and successes, all worth the road traveled.

6. Acknowledgements

I would like to thank Ed Sheridan, Crescent Butte Observatory, for introducing me to the time calculation tool that helps me plan my observations and for his suggestions in the design of my observatory.

Thanks to Brian Warner, Palmer Divide Observatory, for his considerable help with MPO Connections (www.minorplanetobserver.com) and his dedication to continued improvements to this software.

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Last, definitely not least, many thanks to my husband Jerry Foote. His knowledge in this area is endless as well as his patience. I am grateful for his mentoring through all aspects mentioned in this paper and appreciate his continued commitment to my success.

7. References

Castellano, T., Presentation at RTMC Expo 2004.

Castellano, T., "Detecting Transiting Exoplanets", Sky and Telescope magazine, page 77, March 2004.

Laughlin, G., Castellano, T., "Join the Hunt", Astronomy magazine, page 54, January 2003.

Berry, R., Burnell, J., *The Handbook of Astronomical Image Processing*, Willmann-Bell, Inc., 2005.

Transitsearch website (2005), www.transitsearch.org.