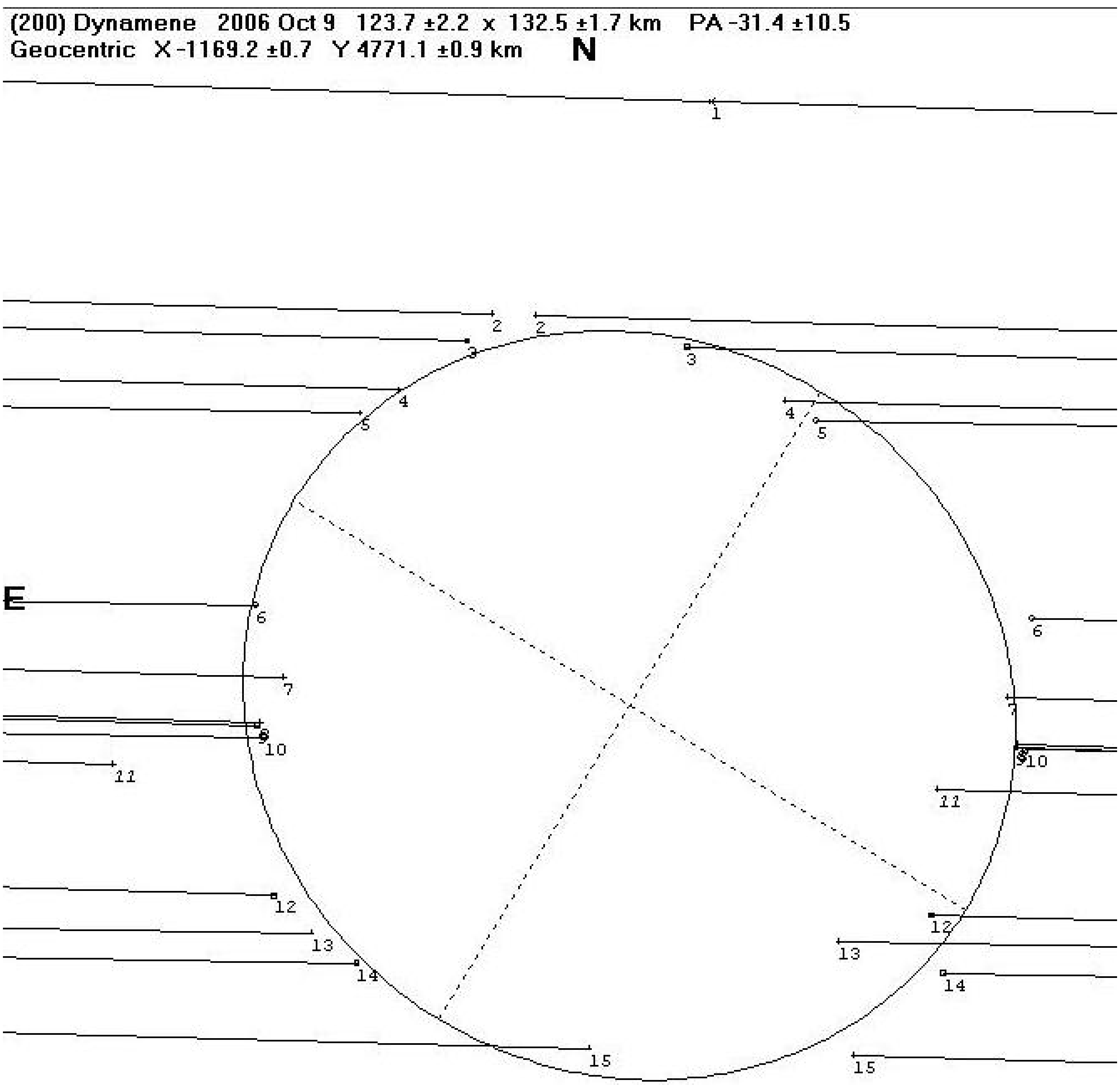
Occultation Newsletter

Volume 13, Number 2 | April 2006 | $5.00 North Am./$6.25 Other



Occultation of 11.3-mag. TYC 5230-01513-1 in Aquarius by the asteroid (200) Dynamene

In this Issue

Articles — *Page*

Resources — *Page*

ON THE COVER:

The cover shows the results of the trans-Atlantic occultation of 11.3-mag. TYC 5230-01513-1 in Aquarius by the asteroid (200) Dynamene. The plot shows the star's path for each observer as a solid line when it was visible. Steve Preston's prediction for the occultation path was quite accurate. The event shows that good results can be obtained even with relatively faint stars when enough observers try to observe an occultation. The event occurred not too late on a Sunday evening for observers in the populous northeastern U.S.A., which was fortunate enough to have mostly clear skies. And skies were also mostly clear in western Europe, where 5 more observers were able to time the occultation, in spite of rather low altitude. The occultation occurred about 24 minutes later in the U.S.A. than in Europe. Since Dynamene has a relatively long rotation period, about 19 hours, it rotated by less than 8 deg. while the shadow swept across the Atlantic Ocean, so combining the observations from both continents on one profile is reasonable. Perhaps most remarkable was Gerhard Dangl's observation at Nonndorf, Austria, where the altitude was only 7 deg. above the western horizon, in haze, at the time; Gerhard had to integrate several frames of his video recording, losing some time resolution, to show the star. Since the central duration was about 38 seconds, the lower time resolution gave acceptable results. The plot also show the superiority (better timing accuracy) of video over visual observations for stars this faint; the video observations are weighted 4 times that of the visual observations when fitting the ellipse to the observations. The observations were analyzed by Brad Timerson; the plot and the table of observers below are from his Web page of recent North American observed asteroidal occultations at http://www.asteroidoccultation.com/observations/NA/ .

```
 1(M) Brad Timerson, Newark, NY
 2    Alan MacRobert, Bedford, MA
 3    Bruce Thompson/ , Ithaca, NY
 4    Marek Kozubal, Brookline, MA
 5    Otto Farago, Stuttgart, Germany
 6    Gerald Rousseau, Clermont, France
 7    Craig Mailliard, Guys Mills, PA
 8    Rob Modic, Richmond Hts., OH
 9    David Dunham, Custards, PA
10    Gerhard Dangl, Nonndorf, Austria
11    Thomas Laskowski, South Bend, IN
12    Juan Arrieta-Camacho, Grove City, PA
13    Christian Gros, Besancon
14    Jean Lecacheux, Meudon, France
15    Frank Melillo, Holtsville, NY
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Publication Date for this issue: June 2007

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Europe--Roland Boninsegna; Rue de Mariembourg, 33; B-6381 DOURBES; Belgium or IOTA/ES (see inside back cover)
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All other areas-Jan Manek; (see address at left)

ON Publication Information

Occultation Newsletter (ISSN 0737-6766) is published quarterly by the International Occultation Timing Association, Inc. (IOTA), 5403 Bluebird Trail, Stillwater, OK 74074, USA. IOTA is a tax-exempt organization under sections 501(c)(3) and 509(a)(2) of the Internal Revenue Code USA, and is incorporated in the state of Texas. First class postage paid at Stillwater, OK, USA. Printing by Tony Murray of Georgetown, GA, USA. Circulation: 400

A False Occultation Caused By A Pixel Of Low Sensitivity

Roger Venable

Summary. During the video observation of an asteroidal occultation, a transient dimming of the occultation star was caused by a pixel of low sensitivity. The video record of the pixel event, the actual asteroidal event, and the brightness changes of nearby stars are here analyzed by use of the Limovie software. The false occultation event was characterized by gradual dimming and gradual brightening, in contrast to the asteroidal occultation, which was abrupt in both dimming and brightening. The two types of event are similar in that they last only a few seconds and they do not affect the brightness of nearby stars. As observers are using video recording increasingly in occultations, such pixel events can be expected to occasionally result in confusing data. In addition to demonstrating the occurrence and character of such misleading events, this report provides an example of the utility of the Limovie software in analyzing a video recording.

The occultation event. When asteroid 1687 Glarona occulted star TYC 1893-00303-1 on December 2, 2005, the event's visibility path crossed the southern United States from North Carolina to Arizona. The star is magnitude 11.1 and the asteroid was magnitude 14.3. The expected drop in brightness of 3.3 magnitudes was predicted to last a maximum of 4.7 seconds. For this event, the author operated two mobile observing stations in South Carolina. The altitude of the asteroid as seen from South Carolina was 60 degrees. The accuracy of the prediction of the location of the path of visibility was such that, were two observing sites each 0.45 pathwidths from the predicted centerline, one to the north and one to the south, the probability of observing an occultation from at least one site was estimated by Steve Preston at 53 percent. Because of this modest probability, the author decided to set up his two stations a full pathwidth apart, in an effort to obtain one video record of the event.

Equipment. At a site 0.5 pathwidth south of the predicted centerline, the author set up a Schmidt-Cassegrain telescope of 280-mm aperture, with a focal reducer yielding an actual focal ratio of *f*/3.7. A Watec 902K videocamera was used at prime focus to record analog video of the event. The video limiting magnitude of this system on this night was about 12.8. The telescope was used without a clock drive, pointed to the position in the sky at which the occultation would take place, and left in that position so that the asteroid drifted through the field of view at the time of the event. During the observation, time was inserted onto the video record using the Blackbox Camera Company's STV-Astro device and a Garmin 16 GPS unit. This set-up was left to function unattended.

At a site 0.5 pathwidth north of the predicted centerline, the author set up a Schmidt-Cassegrain telescope of 125-mm aperture, with a focal reducer yielding an actual focal ratio of about *f*/7. An image-intensified eyepiece and projection lens by Collins Electro-optics were used to focus the image onto the chip of a Supercircuits PC164C videocamera. The video limiting magnitude of this system on this night was about 13.0. The telescope's clock drive was used. During the observation, time was inserted onto the video record using the Blackbox Camera Company's STV-Astro device and a Garmin 16 GPS unit. This set-up was attended by the author during the event.

Conditions. Temperature was 8 degrees Celsius at both sites, and there was no wind. Dew was mild, and dew shields prevented the dewing of optics. No clouds were visible. The moon was not in the sky. There was no light pollution at the southern site, but mild light pollution at the northern site. Naked eye limiting magnitude was judged to be 6.0 at the southern site and 5.5 at the northern site. Slight upper-level haze was presumed to be present to account for the less-than-perfect limiting magnitude.

Data and analysis. At the northern, attended station, the author watched the video screen during the event, and noticed a dimming of the occultation star that lasted about 5 seconds. The other stars in the field of view did not appear to change in brightness during this dimming. At the time, it was thought likely to be a partial dimming due to the occultation of one component of a heretofore unrecognized double star, though it was peculiar in that the fading and rebrightening were both quite gradual. Its reality was confirmed by the review of the tape, though the explanation of the dimming was initially not clear.

After the event, the videotapes were reviewed visually in the usual way to extract the occultation data. This revealed a 3.8 second occultation recorded by the unattended southern station, with a very crisp blink-out and blink-on. The peculiar dimming at the northern station was found to have occurred some twenty-four seconds before the definite event that the southern station recorded. The crispness of the southern station's occultation ruled out the possibility of a double star.

The analog videotapes were captured on computer using a video capture card, and filed in Microsoft's avi format. The resulting files were analyzed for the brightness changes of stars, using the Limovie software written by Kazuhisa Miyashita.

The image-intensified eyepiece causes scintillations, consisting of bright spots of one-frame duration scattered about the field of view, and when one of these falls upon the measurement area of the Limovie program a spurious reading is obtained for the brightness of the star in that frame. To avoid this source of error, the brightness of the star in each frame was taken to be the median of the Limovie brightnesses of three frames: the index frame, the preceding frame, and the following frame. The automatic star tracking function of the Limovie program causes the location of the measured pixels to jump to the brightest nearby area of the field of view. This results in a spurious brightness reading when a scintillation-related bright pixel is nearby. To minimize this problem, the tracking radius was set to a low value of only 6 pixels. The combination of these two settings effectively eliminated the inaccuracy caused by the scintillations.

For consistency, the Limovie data from the south site, which did not use an image-intensified eyepiece, was also compiled as the median value of three frames. The Limovie settings of measurement aperture, background area, and star tracking radius were the same size for the data of both sites. Because the south site's video data showed the star drifting through the field of view, the location of the measurement aperture had to be changed repeatedly to keep the aperture over the star. A total of 20 such relocations were necessary, and the resulting 20 runs of data were strung end to end to make the time record that is graphed here. Limovie's star tracking function was unable to sense the asteroid during the southern station's occultation, so that tracking stopped during that interval. To initiate tracking as the star reappeared, the location of the reappearing star was noted and the measurement aperture was placed over it a few frames before reappearance. (An updated version of the Limovie software now allows the aperture to follow the star in a persistent way such that it is no longer necessary to repeatedly change the position of the measurement aperture in order to follow the star. The present measurement data were obtained before that function was available in Limovie.)

Results. In the graphs, the abscissa indicates seconds after 05:24 UT on December 2, 2005. The ordinate is separate for the data for each star.

Figure 1 shows the Limovie brightness data for the occultation recorded at the southern site. The actual occultation is plainly evident, occurring from about 41 to 45 seconds. The slightly lower brightness of the star on the left side of the graph indicates the presence of slight vignetting by the optical system, as the star was then at one side of the field of view and the occultation occurred when the star was in the center of the field.

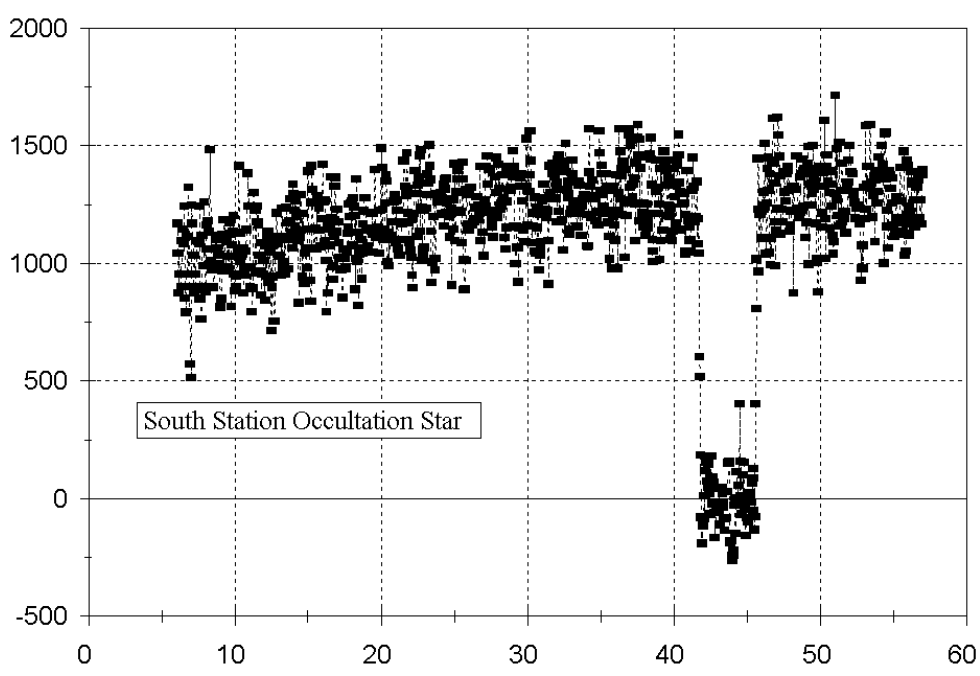

Figure 1. Limovie brightness data for the occultation star TYC 1893-00303-1 as seen from the south station.

Figure 2 is the data for the occultation star as recorded at the northern site. Notice the significant dimming centered about 24 seconds before the occultation that was recorded by the other site. This corresponds to the peculiar dimming noted on the video screen at the time of the event.

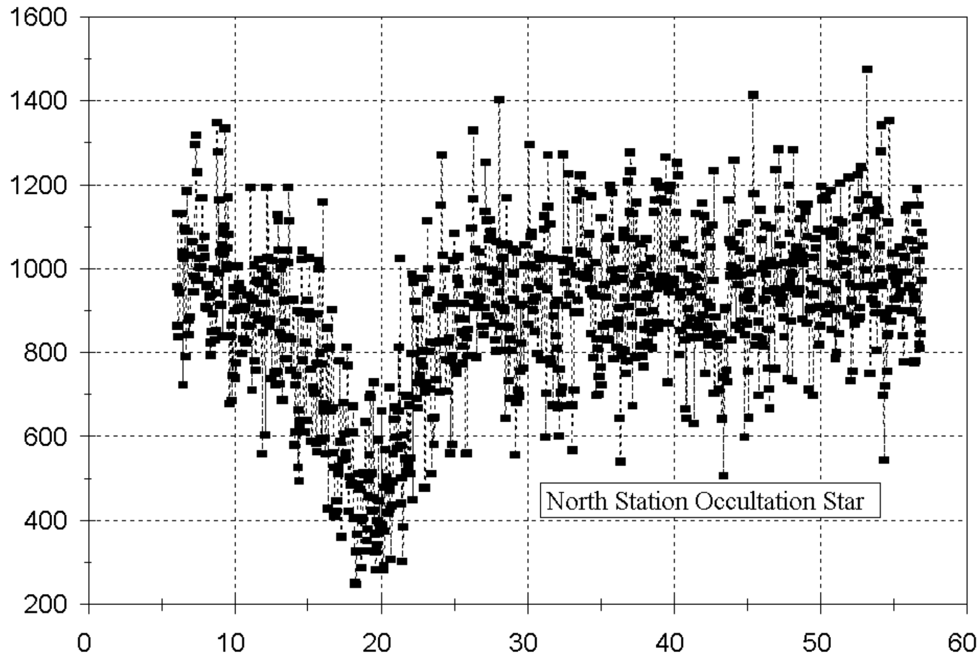

Figure 2. Limovie brightness data for the occultation of TYC 1893-00303-1 as seen from the north station.

The double star possibility. The 24-second discrepancy in timing is inconsistent with the dimming being the manifestation of the occultation of one component of a double star. Furthermore, the incompleteness of the disappearance does not fit the crisp total disappearance seen at the other site. The gradualness of the dimming and recovery are striking, and are different from the sharp changes in brightness that are commonly seen at occultations. These considerations rule out the possibility that the dimming at the North site could be due to an occultation of one component of a double star.

The cloud possibility. Considering that a cloud may have passed in front of the star as seen from the northern site, a Limovie analysis of nearby stars was made for comparison. The star field as seen in the video is represented well by Figure 3, which is a 42-minute wide by 30-minute high field showing stars to magnitude 13, created by the use of Guide 8.0 software by Project Pluto. The numbers under stars are the respective star's number in field 1893 of the Hubble Guide Star Catalog. The occultation star is thus 303. Comparison star 45 is of magnitude 11.0, at a distance of 7 arcminutes in position angle 20 degrees. Comparison star 99 is of magnitude 11.2, at a distance of 8 arcminutes in position angle 105 degrees. Comparison star 271 is of magnitude 11.4, at a distance of 4 arcminutes in position angle 233 degrees.

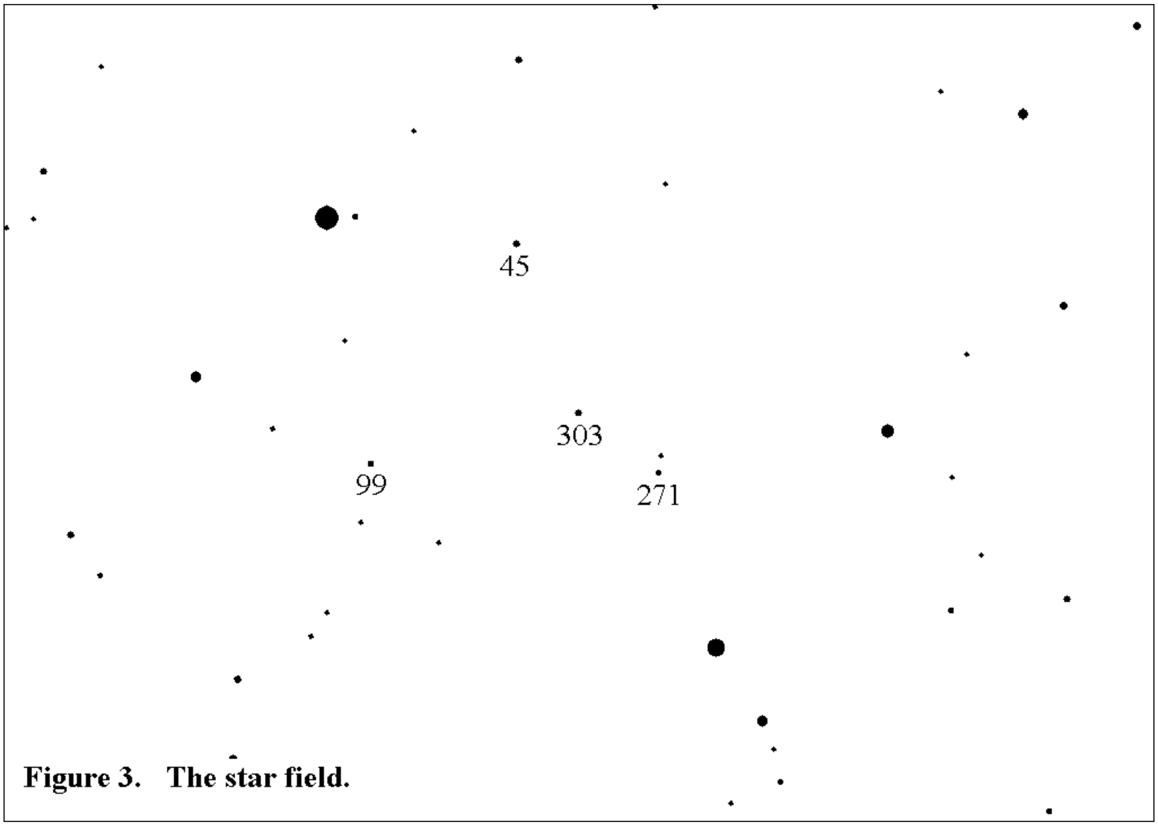

Figure 3. The star field.

Figure 4 shows the Limovie brightness analysis of these three comparison stars for the same time period, taken from the videotape made at the northern station that showed the peculiar dimming of star 303. Although there may be slight brightness variations associated with passing haze, no event comparable to the north station's dimming of the occultation star is seen. It is thus clear that no cloud passed through the video field of view, and some other phenomenon must be the explanation of the dimming of star 303.

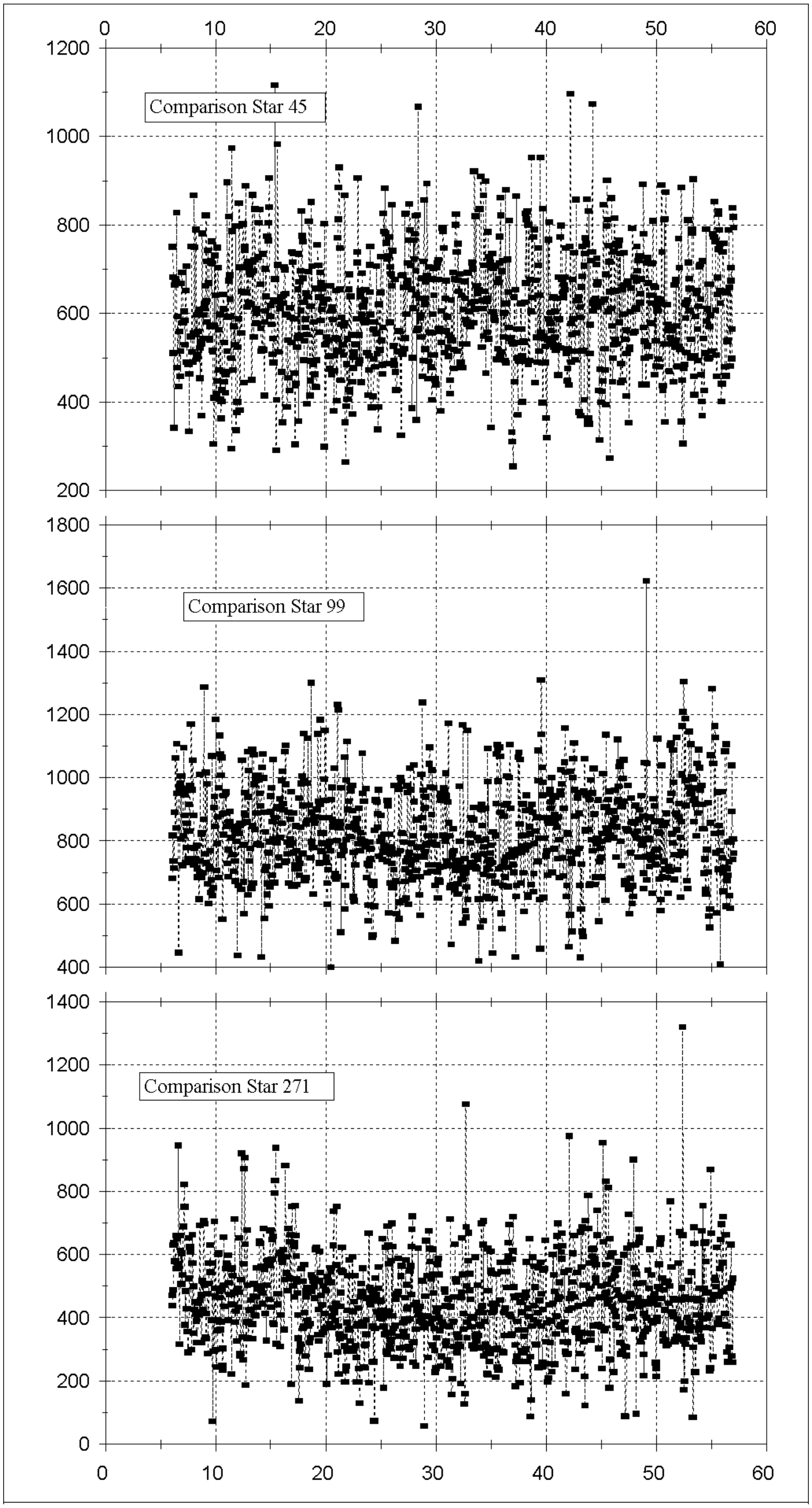

Figure 4. Limovie brightness data of the three comparison stars as seen from the north station.

The weak pixel possibility. The north station was nominally equatorially mounted but it was hastily aligned with the Earth's axis by using the "eyeball" method. Inaccurate polar alignment is manifested as drift in declination. During the period of the results displayed here, the occultation star drifted from pixel 319,230 to pixel 317,204. (These pixel numbers are respectively the horizontal and vertical coordinates of the center of the star's image on the 720- (horizontal) by 480- (vertical) pixel video screen as it was digitized by the video capture card.) This is a migration of 26 pixels in 51 seconds, or about 0.5 pixels per second. The camera was oriented at the eyepiece so that right ascension is horizontal and declination is vertical. Thus, the telescope drifted 13 times as far in declination as it did in right ascension during the observation. The dimming of the star was most pronounced when the star was centered at pixel 319,221. The light curve of the peculiar dimming of the occultation star seen at the north station (Figure 2) shows that the dimming lasted a total of about 16 seconds. Although the diameter of the aperture used in the Limovie software to measure the star's brightness was 14 pixels, the visible diameter of the star on the screen averaged 7 pixels. It thus appears that the star's image drifted across a less-sensitive spot on the detector, which influenced the brightness reading for a period corresponding to the time needed for the star to drift twice its apparent diameter.

Measurement of the sensitivity of the pixels involved has been a challenge, in part because of the irreproducibility of the exact pixel correspondence in follow-up assemblage of the video equipment; and by virtue of the fact that no calibration frames were obtained. To complicate this problem, the Limovie software proved itself, during this analysis, to be sensitive to field stars that are too faint to be visible on the video. Thus, a measurement of the Limovie brightness of a star or of a comparison dark area of the field can be polluted by unseen stars. When present in the aperture area, these will cause the brightness reading to be anomalously high, while if they are in the comparison area, they will cause the brightness reading to be anomalously low. To minimize this effect, the author printed a map of the area using *Guide* software, showing all Guide Star Catalog stars, and these stars were carefully avoided when positioning the measurement and comparison areas in order to make comparison readings. The use of the "meteor" comparison zone option afforded by the Limovie software aided in the avoidance of such faint stars.

With this technique, the author measured the brightness of small apertures along the drift path of the occultation star at times in the video record at which the star was not near these spots — that is, it had drifted away from the spot or had not yet reached it. Such measurements are comparable to field background measurements. The Limovie aperture was set at a radius of 5 pixels, while the background measurement area had an inner radius of 7 and an outer radius of 16. For each pixel, 60 consecutive frames were measured. The results of these measurements are shown in Figure 5, where the abscissa is the position on the Y-axis, and the ordinate is the measured brightness of the pixel at background brightness. From Figure 5 it is evident that the background brightness of the pixels along the drift path of the occultation star was least at the Y-coordinate of 221. This is exactly the location on the video field at which the star was noted to be at the nadir of its brightness in the false occultation.

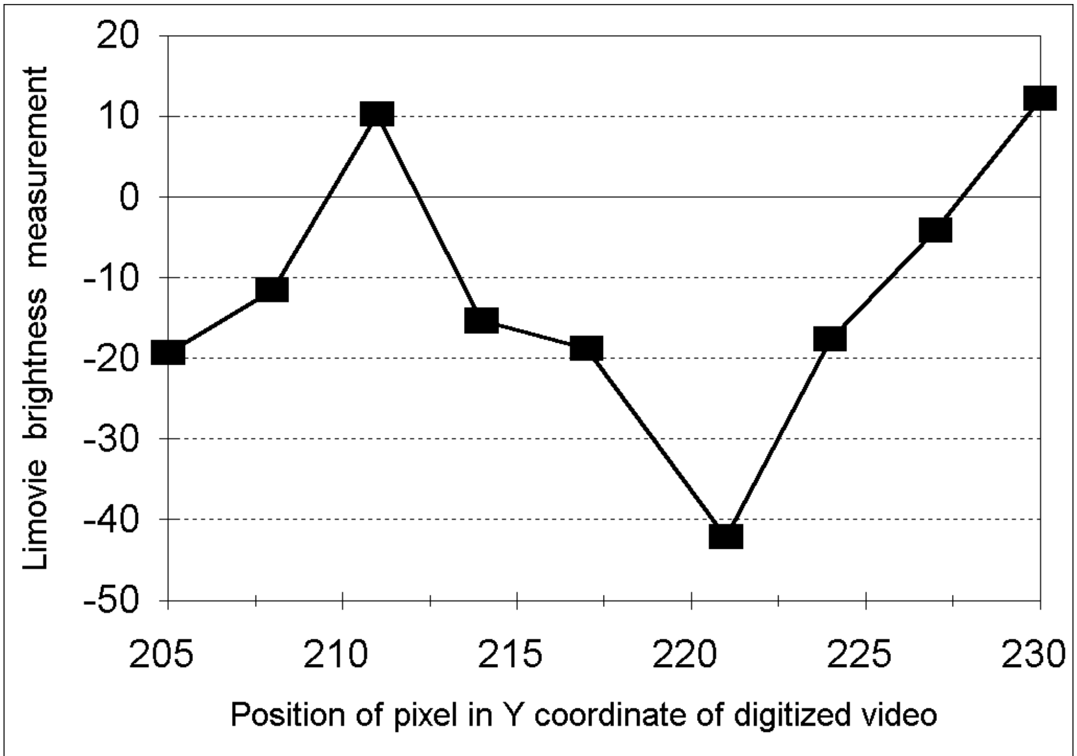

Figure 5

Finally, 19 pixels were chosen with care to avoid the locations in the field of the faint stars that were not directly visible on the video. The background brightnesses of each of these pixels was measured over 60 frames, using the same Limovie aperture and background measurement radii as were used in Figure 5. The range of brightness was found to be from -22.8 to +15, with a mean of -2.1 and a sample standard deviation of 10.7. These values are consistent with those plotted in Figure 5, and they confirm that the weak pixel plotted in Figure 5 is about three standard deviations below the mean in background sensitivity.

Comment. In view of the low likelihood of other explanations of the peculiar dimming of the star, and in view of the duration of the dimming event as compared to the rate of the star's drift in the field of view, together with the demonstration of the low background sensitivity of the pixel, it is clear that the dimming was due to a "weak pixel." This pattern of dimming probably is characteristic of the weak pixel phenomenon. Observers of occultations are likely to encounter it occasionally, so it is helpful to be acquainted with it in advance. To recognize it, particular notice should be made of, first, the shape of the brightness curve (Figure 2) as compared to that of the actual occultation (Figure 1), and second, the duration of the dimming as compared to the size of the measurement aperture and the rate of drift of the star.

The Limovie software proved itself invaluable in assessing these videotapes. This study demonstrated an important caveat concerning the software, for those who use it for photometric studies: It is sensitive to the light contributed by stars that are too faint to see on the streaming video. Deep images may be needed to avoid such stars in choosing the background-brightness measurements that one uses. ■

The Discovery and Confirmation of the Binary Star – Tau Scorpii

Hal Povenmire

In 1970, my graze team and I observed one total occultation on March 28 and one three station, 12 event grazing occultation on August 12 of Tau Scorpii. Significant dimming phenomena was observed and this star was reported as a likely binary to David Dunham. Because the star was very blue, the Moon gibbous and the altitude was low, the dimming effects were dismissed as likely fresnel or diffraction phenomena. On September 8, 1989, a spectacular graze of Tau Scorpii was observed by the same team from Golgonda, Illinois. This time the conditions were much more favorable and very well defined dimming and stair step events were recorded and again the star was reported to David Dunham, IOTA and ILOC as a probable binary.

On March 11, 2007, an extremely favorable graze of Tau Scorpii was predicted to go through Marianna, Florida and just to the east of Lake Wales, Florida. I had not planned to observe this graze, but when I realized this star was on my list of reported but unconfirmed binary stars, I made a special effort to observe it. The conditions were spectacular with a 58% sunlit waning Moon and Tau Scorpii grazing 13º on the dark, southern limb. Tau Scorpii is magnitude +2.82 and BO spectral class. It is the 12th brightest star that can be occulted by the Moon.

The graze was observed with 10 events from Marianna, Florida. Nearly all events showed dimming phenomena. One event lasted 4 seconds and another for more than one second. There were several times in which a probable companion was visible and it was about 25% the brightness of the primary and of the same color. It was also observed from east of Lake Wales from a 4 station with similar results. It was also videotaped by Tom Campbell. While the videotape was excellent for timing purposes, its position on the lunar limb and the method of reduction did not show much of the dimming phenomena. David Dunham also videotaped the R from Maryland.

Tau Scorpii is also known as SAO 184481, ZC 2383 and HIP 82166. It is magnitude +2.82 and BO in spectral class. These grazes reminded me a lot of grazes of Al Nath. Wayne Warren researched this star and found that it showed variable radial velocity. This would be consistent with a close companion. I expect that this observation and claim of duplicity will be challenged. This will be especially true of persons who did not observe it.

Most of this team were long term, very experienced graze observers. The total years of grazing occultation experience was approximately 180. Approximately 69 times were recorded. The observers were: Hal Povenmire, Tom Campbell, Chris Stephan, Rick and Jo Ann G. Armstrong. This report will be sent to David Dunham, the International Lunar Occultation Center (ILOC) in Tokyo, the International Occultation Timing Association (IOTA) and the U.S. Naval Observatory Interferometer (NPOI) at Lowell Observatory in Flagstaff, Arizona.

The conclusion of this observation and the two previous grazes and total occultations of Tau Scorpii along with the variable radial velocity is that Tau Scorpii is a previously reported close binary and the magnitude of the companion is approximately 25% of the primary. I consider this observation to be a confirmation.

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IOTA's Mission

The International Occultation Timing Association, Inc. was established to encourage and facilitate the observation of occultations and eclipses. It provides predictions for grazing occultations of stars by the Moon and predictions for occultations of stars by asteroids and planets, information on observing equipment and techniques, and reports to the members of observations made.

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IOTA Lunar Occultations, Eclipses, and Asteroidal and Planetary Occultations Site
http://www.lunar-occultations.com

This site contains information on lunar occultations, eclipses, and asteroidal and planetary occultations and the latest information on upcoming events. It also includes information explaining what occultations are and how to report them.