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# Tests of Video Cameras in Asteroid Occultation Applications

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## Introduction

While new, more sensitive video cameras would appear to allow occultation measurements with stars of lower brightness, some cameras may have artifacts of operation such as increased noise or poorly shaped images. These artifacts raise questions as to whether the claimed increased sensitivity can in fact be utilized.

## Experiment

I compared four cameras in six tests, using setups and software that are very similar to that used by many occultation researchers. The cameras included the new PC164EX2, an EX190-SH, a Mintron, and a Watec 902H Supreme. The test target field was a star cluster immediately to the west of M67. I used an 18inch f3.5 Newtonian (AP mount), with a Parracor that yields approximately f3.9 fields roughly 7x10a-m, depending on chip size.

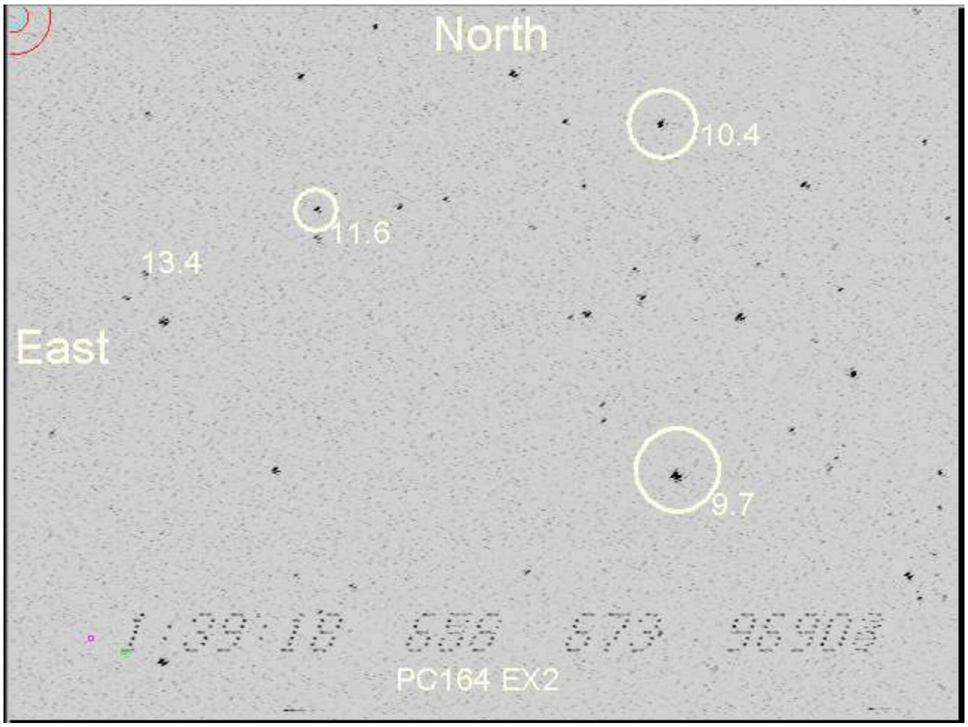
The cameras were manually focused (with RoboFocus) using the screen of the camcorder. The video from the camera fed through a Kiwi OSD (on screen display) time encoder, thence to a Sony TRV66 Hi8 Camcorder. For most tests, approximately 30 sec of recording was made with sharp focus, then the focus was manually degraded and another 30 sec recorded.

The camcorder was played back through a Kworld frame grabber that fed USB video into the PC (running XP). The incoming video was captured by VirtualDub software to produce the *.avi file. The file was then run through LiMovie for analysis. LiMovie is used by occultation researchers to analyze video, and can measure the integrated brightness relative to background of up to three stars. The output is in a *.csv text file which can be imported into Excel. LiMovie also produces a graph of the integrated intensities vs. time, which I copied using the pc print/screen function (these are shown below).

When choosing the stars to be analyzed, I picked three stars covering a fair range of intensity -- about 4:1. All three stars were visible in all cameras, to a greater or lesser degree. The stars were the following (TheSky V5):
Star1: GSC 814:1515 Mag. 9.7 (K3)
Star2: GSC 814:1147 Mag 10.4
Star3: GSC 814:1007 Mag 11.6

The tests were run within about an hour in the order shown on a fairly clear night (probably about 0.5 mag of extinction from high cloud). At the end, camera test "A" was repeated, yielding close to the original results.

I also estimated lower limit of detection for each camera. This is a qualitative estimate from comparing the recorded video compared to the star charts.



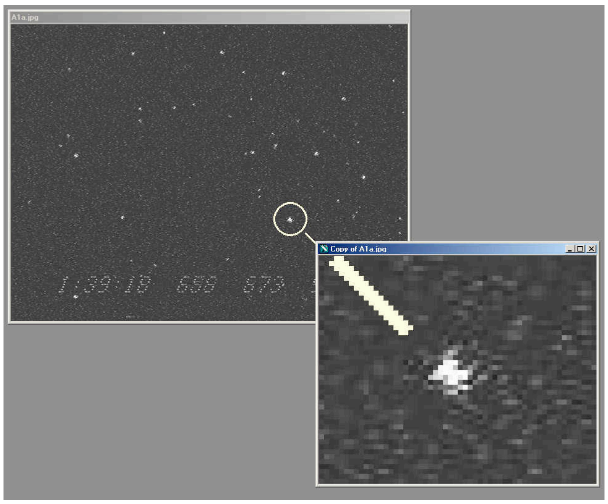

**Results**

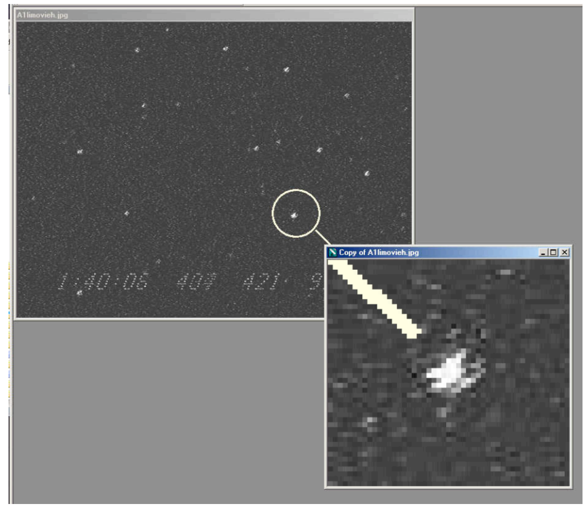
As expected, there was substantial variation in the sensitivity of the cameras. Using data from the LiMovie graphs, the integrated intensities are summarized in the table below. As discussed below, in certain circumstances, star images were saturated, thus causing errors in the measurements. The intensities given in the table are corrected approximately for this effect, using the out of focus and other data as guides.

| # | Camera | Star1 | Star3 | Ratio | Limit |
|---|---|---|---|---|---|
| A | PC164EX2 | 10000 | 2500 | 4.0 | 14.0 |
| B | EX190-SH | 2500 | 300 | 8.3 | 12.9 |
| C | Mintron x1 | 1500 | 400 | 3.8 | 11.2 |
| D | Mintron x6 | 6000 | 1300 | 4.6 | 14.7 |
| E | Watec Sup lo | 4000 | 700 | 5.7 | 13.5 |
| F | Watec Sup hi | 9000 | 2500 | 3.6 | 11.5 (snow) |
| | | | | | |

Notes:

- Test A: PC164EX2 is new camera from Super Circuits. Very sensitive, but at overall low light levels the star image quality degrades so that star images are very poorly formed making focus difficult and the aesthetics displeasing. The pictures below show the in focus (left) and out of focus (right) images. The left picture has the sharper star image, still poorly formed, and with many saturated pixels.




- Test B: EX190-SH high resolution is a bullet style camera from Super Circuits that supposedly is similar to the old, plain, PC164. Image quality on this and all other cameras is excellent.
- Tests C,D: Mintron is a true integrating camera that can integrate from 1-128 frames. A manual on screen menu allows selection of operation. Integration increases sensitivity, but for occultation work introduces a delay offset in the time of occultation as well as an increase in the time uncertainty of the occultation. The Mintron was tested with two integration settings.
- Tests E,F: Watec 902H Supreme camera (not the Watec Ultima) is a non-integrating camera. It has an internal hi/lo sensitivity switch. The external controls include an EL switch and a "Level" setting control. These external controls had virtually no effect when using the internal Lo setting, and little effect on the internal Hi setting (when I did set them for best signal to noise ratio). The internal Hi setting does produce a very high apparent noise level in the video; however, the signal to noise level measured in LiMovie is not much different from other settings or other cameras. The Watec was tested with the two different internal sensitivity settings.

**Discussion**

**Saturation**. As seen in the LiMovie graphs (below), saturation effects were immediately obvious in several of the cameras, in which the bright Star1 showed an increase in brightness when out of focus, as compared to the less bright Star3. I verified this by checking the pixel values in the star images. For Star1 with the 164EX2 camera, the change when defocusing was approximately 50% while the Mintron at x6 was about

100%.  If the camera were operating heavily saturated, an occultation would result in a substantially smaller drop in measured brightness than is really the case.

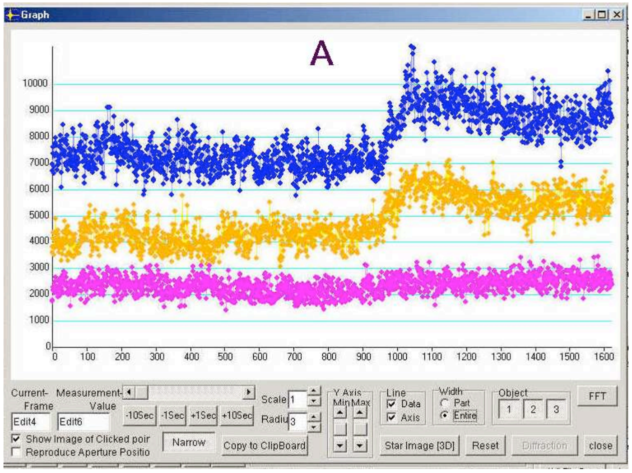
Clearly, for maximum signal to noise ratio, when using the more sensitive cameras on bright stars, one should defocus the camera.  How do you know when to do this?  One way is to use the value in the table (for an 18in f3.9 telescope) as a guide.  Another is to feed the live video into the computer and perform a frame grab, using some form of imaging software.  Then examine the pixel values to be sure the star image is not seriously saturated.

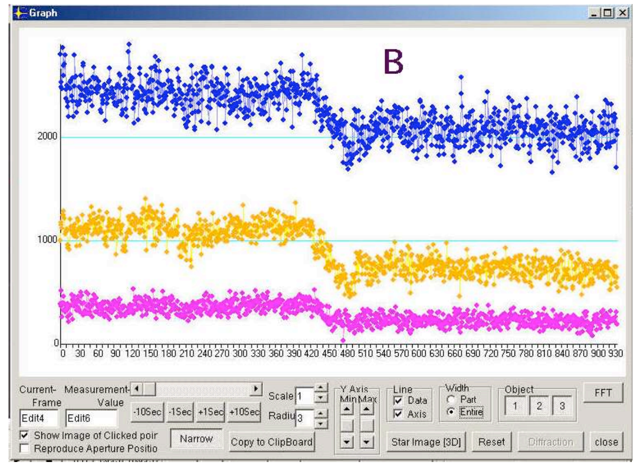
**Small Signal Errors**.  Examining the table, one sees that the smaller signals (fainter star, less sensitive camera) suffered a loss (i.e., were smaller than expected) when measured in LiMovie.  That is, the ratio of bright Star1 intensity to faint Star3 intensity was too high (e.g., the EX190-SH).  I do not know whether this is intrinsic to LiMovie, or resulted from an error in setup.  In any case, an occultation of such a star would be detected; however, because the signal is lower than it "should be", noise or scintillation would make the occultation harder to observe.  In addition, out of focus faint stars tended to lose integrated brightness, thus further increasing the faint star "penalty" when using a relatively insensitive camera.

**Watec 902H2 Supreme .**  This camera with the internal sensitivity set to Lo is a good camera, though not as sensitive as the 164EX2.  At the Hi setting, the noise appears as a very objectionable snow in the video.  However, LiMovie does a good job of filtering that out in its measurement, resulting in a sensitivity as good as the 164EX2.  However, while this is true for stars in this measurement range (i.e., fairly well above the minimum detection limit), stars fainter than Star3 are extremely hard to see for the snow.  It would appear that the 164EX2 would do better on very faint stars (the 164EX2 can go deeper than 13.5 with this telescope).  In the LiMovie graph, you can also see the slow progression of video bands up the image causing the slow variation of the Star1 readings.

**164EX2.**  The ugly star images from this camera do not appear to adversely affect asteroid occultation applications: LiMovie does an excellent job of integrating the image.  Indeed, given its high sensitivity, stars brighter than about 11 mag (18in f3.5) should be defocused (and  a larger measuring aperture used in LiMovie).

**Reference Data**.  Below are the LiMovie graphs for the three stars for each camera run.  Graphs A,B,C,D,E show both in-focus (first part) then out-of-focus (second part) readings, while Graph F was only taken in focus.


Graph
A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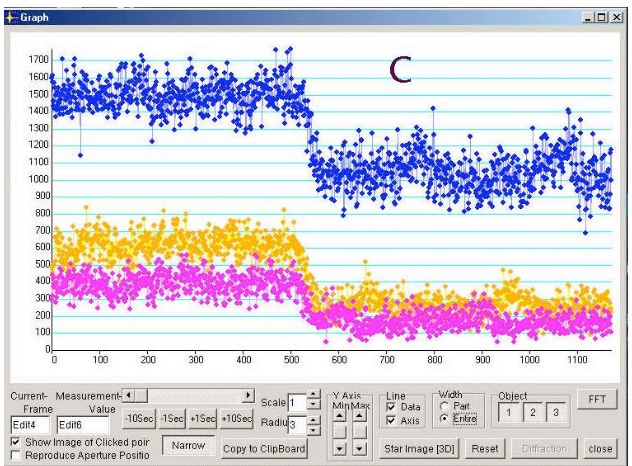
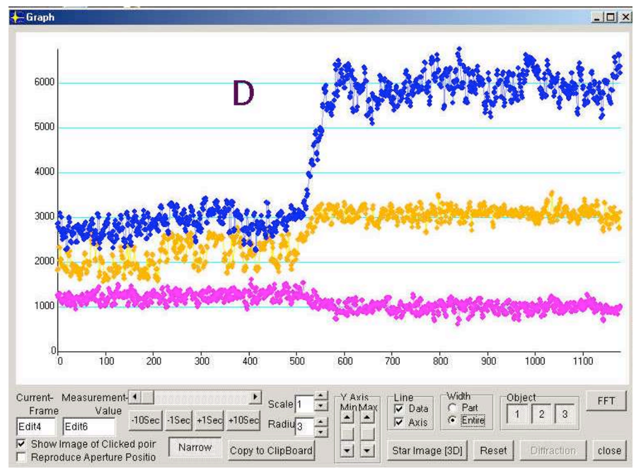
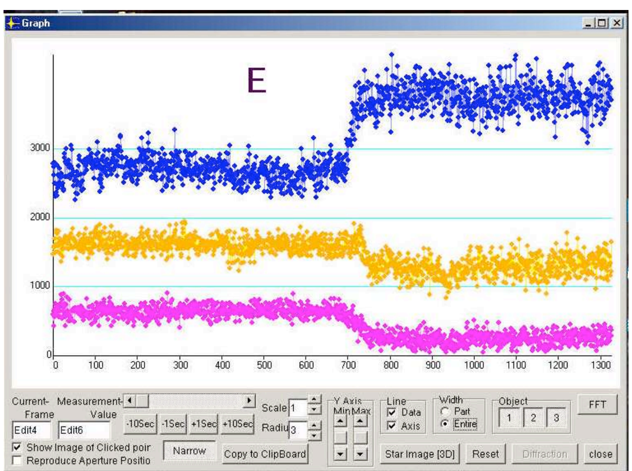
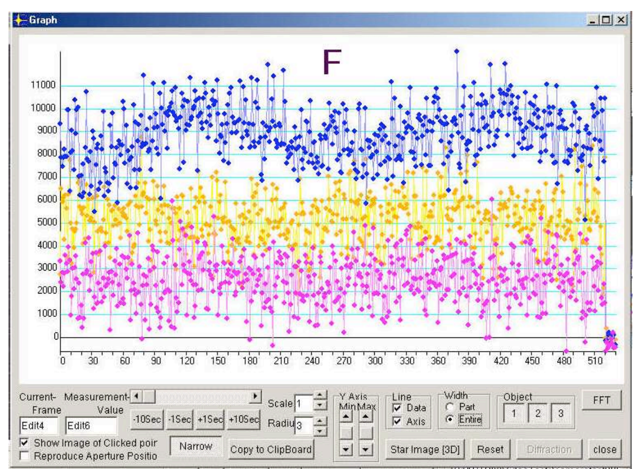

Graph
C


Graph
D


Graph
E


Graph
F