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Monitoring U Sco

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Introduction

U Sco is an 18th mag recurrent nova that erupts at approximately10-15 year intervals when it rises as many as 10 mag in brightness. In the past year, a prediction has been made that U Sco is nearing an eruption, with the result that AAVSO has begun a campaign to monitor its brightness (details at http://www.aavso.org/publications/specialnotice/141.shtml).

While the presence of an eruption can be identified by a rather simple observation (e.g., is U Sco greater than 14th mag?), there is also interest in its actual brightness, particularly variations that may precede the eruption. However, monitoring the brightness is difficult both because of its relative faintness (for amateurs) and the presence of a nearby field star. These notes identify some of the challenges for amateurs in making these measurements.

Measurements

Virtually all the measurements reported here were taken using an 18in. f3.9 (with coma corrector) Newtonian telescope in Maryland, USA with an ST402 small format camera. The image scale is almost exactly 1.00 a-s/pixel. In general, the object is only about 20deg above the Southern horizon and visible for only 1-3hours immediately after sunset in late summer. An evening's observations would normally consist of 30-90x60 sec. exposures through a clear filter. After calibration, the images are combined and the measurements made using MaximDL. Of the 20 nights of data reported here (every night offering at least some probability of useful data), only a few were of good quality. On all nights, the Reference star had a Signal/Noise ratio of at least 65, and usually well over 100. The S/N of U Sco ranged from about 6 to about 50.

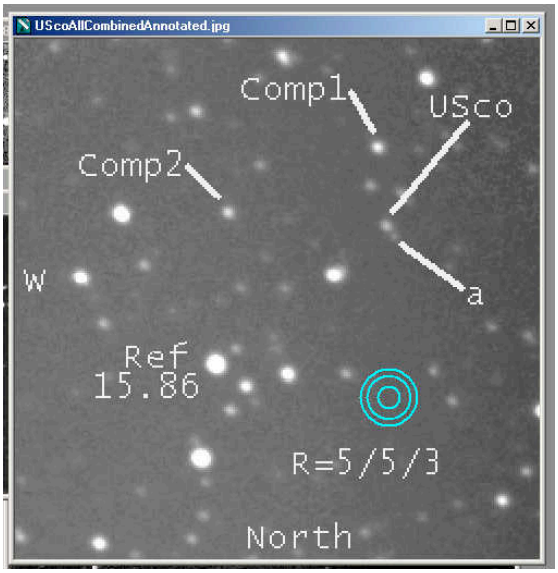


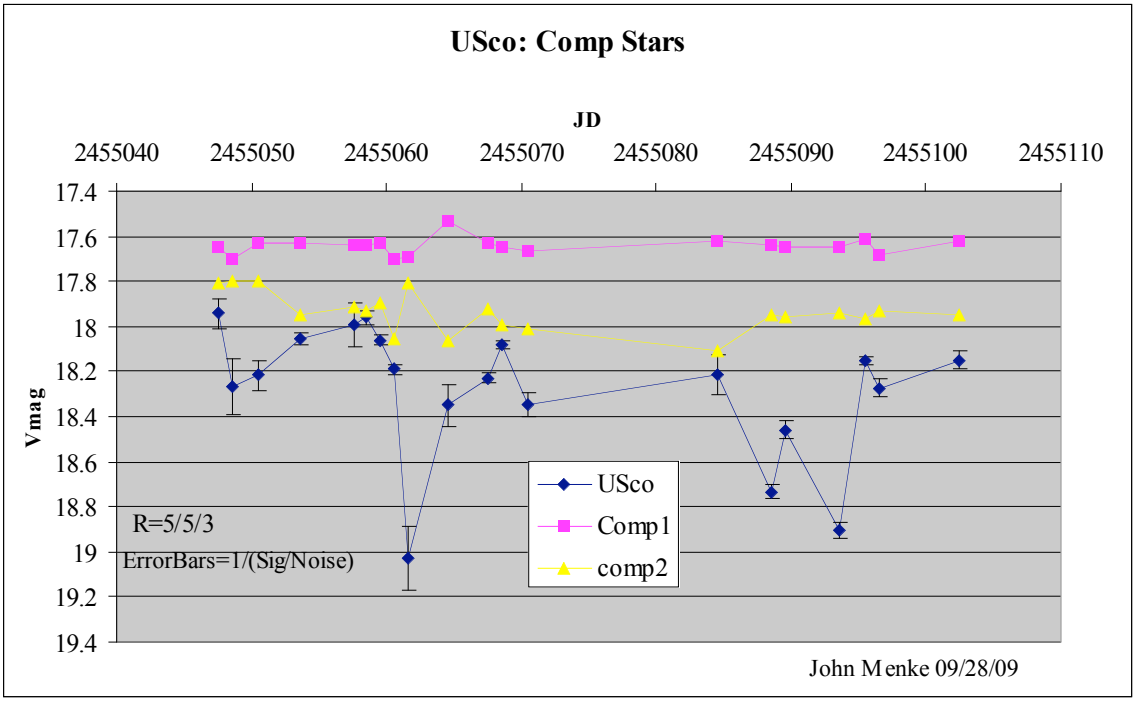
Figure 1 U Sco Field

Fig. 1 shows the field of about 3a-m square taken from a sum of nearly all the data images. The Reference star (set by AAVSO) has a V brightness of 15.86. Measurements using filters shows that the color index of the reference and U Sco are approximately equal. This is important because the air mass is high (often 2-4), varies greatly as the star sets, and the faintness of the target makes it desirable to use a clear filter whenever possible.

The comparison stars were chosen to be roughly as faint as the target, so as to get a better understanding of the normal variations in measurements at this faintness level.

As one can see, U Sco has a close field star "a". Whether the field star is in the measurement aperture or not, or in the background (outer) annulus or not, can change the measurement by as much as 0.5 mag. Using a measurement aperture of R=5pixels (as shown), a gap of 5, and a background annulus of 3pixels

gave the most consistent measurement results and was chosen to place the U Sco nearby star "a" inside the gap. These values do cause the nearby field star for the Reference to land in the background annulus; however, the error caused is only about 0.01mag and is ignored. Using this measurement aperture, the results of 20 days of data are shown in Fig. 2.



The two comp stars show variations having standard deviations of 0.04 and 0.09 mag respectively, with deviations in their mean of approximately 0.008 and 0.019 respectively. The error bars shown on the U Sco data are the reciprocals of the approximate signal to noise ratio of the U Sco measurement on each day. These are indicators of the data quality, and are not accurate determinations as a very slight change in aperture position may significantly change the S/N ratio. I do not for a moment believe that the measurements are as precise as the error bars would indicate.

I also investigated the sensitivity of the measurements to several parameter changes. Fig. 3 shows some of these results. These graphs show that removal of hot and cold pixels, or the minor variation of the measuring aperture, do not cause major changes in the results. The one point that changed was a day of very poor S/N.

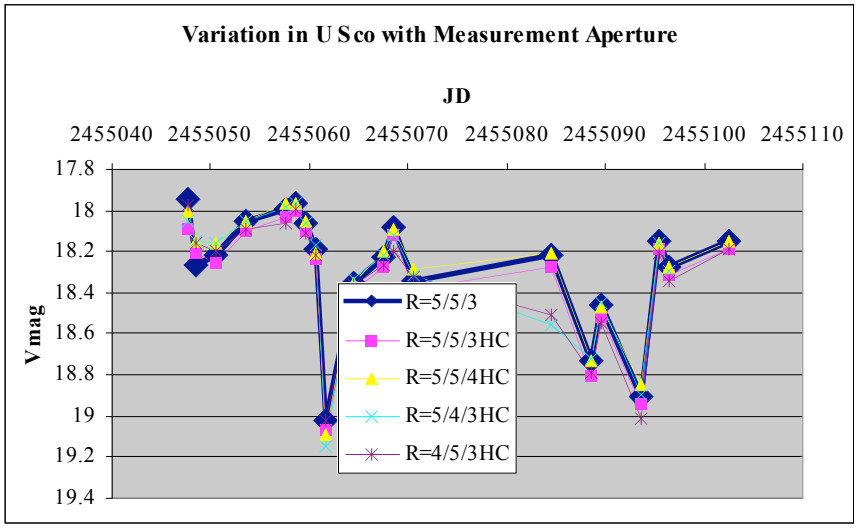


Figure 3 Variation in U Sco Results with Measurement Apertures

U Sco is also an eclipsing variable with a period of 1.23 days. Inserting the photometry data into Peranso (a period analyzing software) yields Fig. 4. The right hand side of Fig. 4 shows the period analysis using ALL the data, and shows clearly the 1.23-day period. Successive removal of the three faintest data points causes the 1.23day peak to weaken, and removal of all three yields the curve on the left in which the 1.23-day period has totally disappeared.

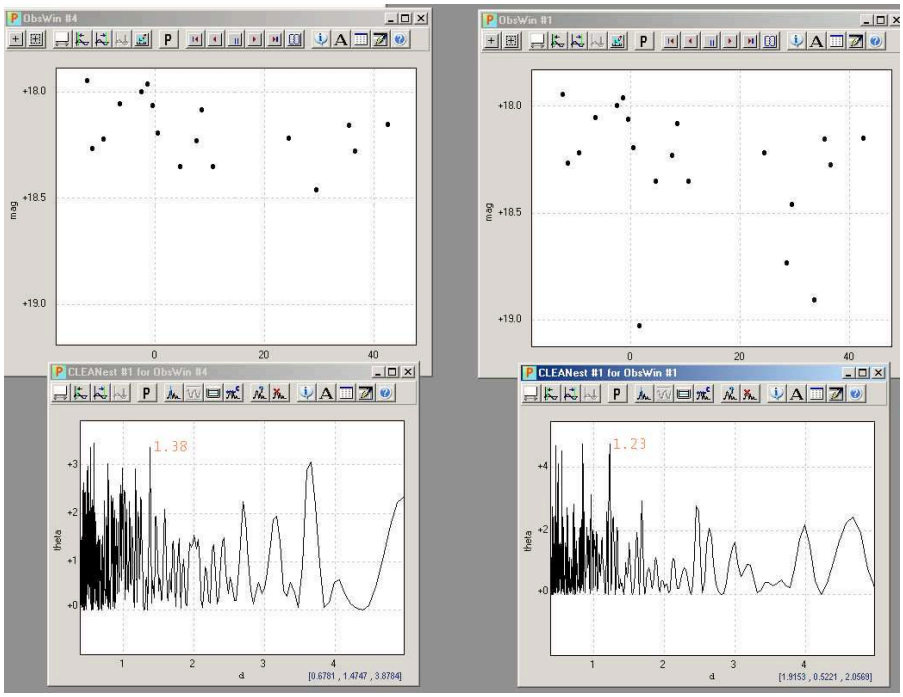


Figure 4 Peranso Results