TRACKING ERRORS OF TWO 2 M CARL ZEISS TELESCOPES

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Abstract

Image motions during the integration time can cause photometric errors and frustrate exact position measurements with manually operated telescopes. Errors in drive rate were measured on the two 2 m Carl Zeiss Ritchey-Chretien telescopes located at the Rozhen Observatory in Bulgaria and on Mount Terskol Observatory in North Caucasus. The instruments being used are high-speed photon counting photometers. The actual procedure for detecting drive rate errors envolved intensity variation measurements of a star image covering about 50 % in the diaphragm edge area. Oscillations with period of about 5, 20 and 40 s and amplitudes of tenths of an arc second were seen in both telescopes. If all these harmonics are superimposed this may cause several arc seconds of image motion. This type of error can not be completely removed even with the automatic telescopes emploing CCD centering devices within the typical accuracy of about 0.2 arc second.

1 Introduction

The millimagnitude precision of ground-based stellar photometry and the milliarcsecond accuracy in coordinate of position measurements seemed distant summits for most practitioners. For a complete discussion of the factors limiting the precision of stellar photometry and the consequent recommendations we refer to Young's et al. (1991) review. The authors gave 15 practical advices, by implements of which, it appears possible to reach an overall precision of 0.001 mag. However, a practice for over last decade showed that 1 millimag accuracy had not been achieved. Even time resolved CCD photometry of an ensemble of stars in open clusters in attempt to improve photometric precision had demonstrated a practical barrier of 2 millimag (Gilliland et al. 1991). No doubt, the only possibility to improve the precision consists in exploration the area behind measurement errors.

Image motions may be a major limitation on photometric accuracy at the millimagnitude level and a major source of errors in position measurements. The main goal of this work was to detect variability of a target star caused, as supposed, by the effect of image motions due to errors in tracking devices of telescopes. Note that such errors amounting to a few tenth of arc second may be only marginally detected in the trivial round measurements.

2 Methods and Results

The observations presented here were obtained on the Rozhen 2 m telescope and on the 2 m telescope on Mount Terskol. Observations were made on Mount Terskol in seeing of $\sim 2''$ on 2000 October 28. The field star PPM119406 (F2, $9.^m16$ in B) was monitored with a sampling time of 0.1 s. Corresponding observations were

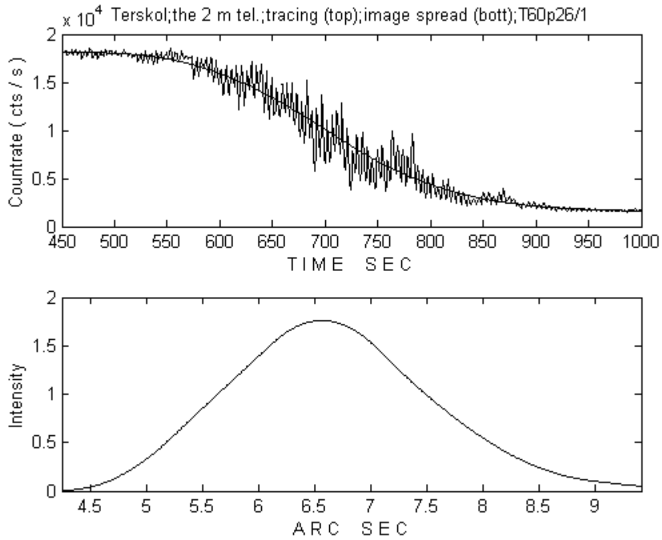

Figure 1: The Terskol 2 m telescope. An image tracing by a diaphragm-edge (upper) ; star's image spread (lower, arbitrary units)

carried out at Rozhen on 2000 October 23. The Terskol data were collected by tracing a bright star across the diaphragm. The Rozhen object was recorded in configuration when a star image was covering a range about of 50% in the edge diaphragm area. In both cases the data show evidence of a periodic modulation. The most striking feature in the Terskol data is the 5 s harmonic that extends $\sim$ 2 arc seconds in the neighborhood of the diaphragm edge (Figure 1). This harmonic can also be recognized on the preceding part of the light curve. Other obvious harmonics can be identified as well, with periods near 20 and 40 seconds.

Figure 1 presents also the tracing light curve smoothed by spline with the 100-point boxcar to average the short scale oscillations. The star image spread shown lower was determined by numerical differentiation of the tracing light curve. As can be seen the star has a FWHM about of 2 arc seconds. The intensity drops to about 1% at a circle of 4-arcsec diameter. From this image motion in amplitude may be evaluated as large as of the order $\sim$ 0.2 arc second. Modulation with similar

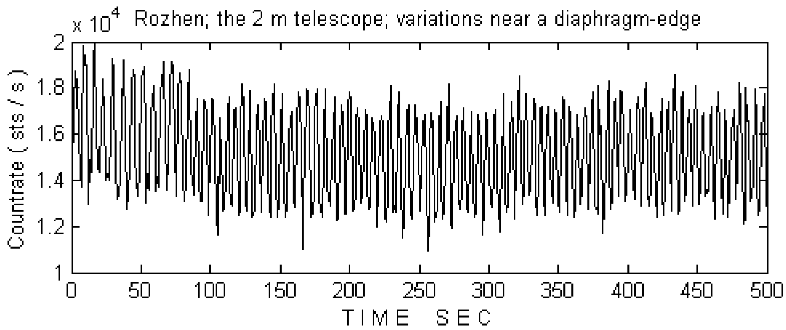

Figure 2: The Rozhen 2 m telescope. Variations near a diaphragm-edge

spectacular properties reveals the Rozhen 2 m telescope (Figure 2). Oscillations in image motion with a period in the range from 5 to 7 s are visible throughout the recording time of about 6 min. The modulation amplitude appeared to be constant and is equal to about 20%.

Figures 3 and 4 demonstrate dynamic spectra of the observations obtained with two 2 m telescopes. Intensity is represented in gray scale. Each pixel corresponds to 10 seconds of time and 0.004 Hz of frequency. Black-to-white corresponds to an increase of about 100 times.

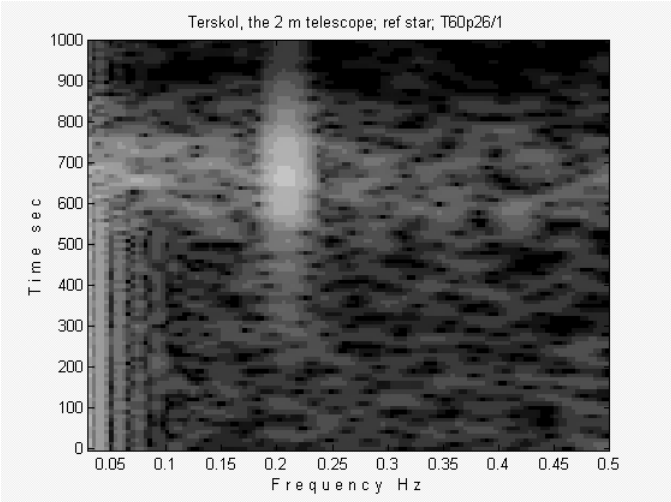

Figure 3: The Terskol 2m telescope. Image motion dynamic spectrum

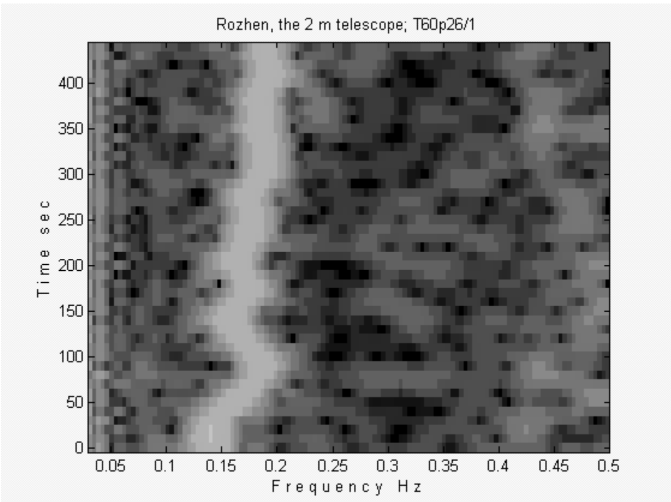

Figure 4: The Rozhen 2m telescope. Image motion dynamic spectrum

The modulation frequency at 0.21 Hz remains constant for a series of measurements with the Terskol 2 m telescope. For the Rozhen 2 m telescope oscillations on a quasi-period of 5 - 7 s show positive frequency drift on a running time of 6 min. Both spectra show clearly the oscillation trains in the low-frequency range anf flashes of oscillations with a length of zug of tens of second, grouped at 0.33, 0.44 and 0.47 Hz. All the data were processed with programs from the package MATLAB (©1984-2000, The MathWorks, Inc.).

In search of possible longer periodicities in the data, we removed modulations corresponding to a period in the range 5 - 7 s using the bandstop filter in the frequency band from 0.13 to 0.22 Hz. After preliminary filtering the readings were rebinned to 0.4 s to avoid aliasing errors. The power spectra in Figure 5 indicate clearly that a low-frequency modulation feature has a place in both telescopes. It is significant that the power spectra closely resemble, showing the same periodicities about of 40 and 23 and 12 sec.

3 Conclusion

Our observations indicate that star image in the focal plane of two 2 m Carl Zeiss RCC telescopes reveals periodic motions. Modulation visible near the diaphragm-edge area indicate periodicities of about 40, 20 and 7 - 5 seconds.

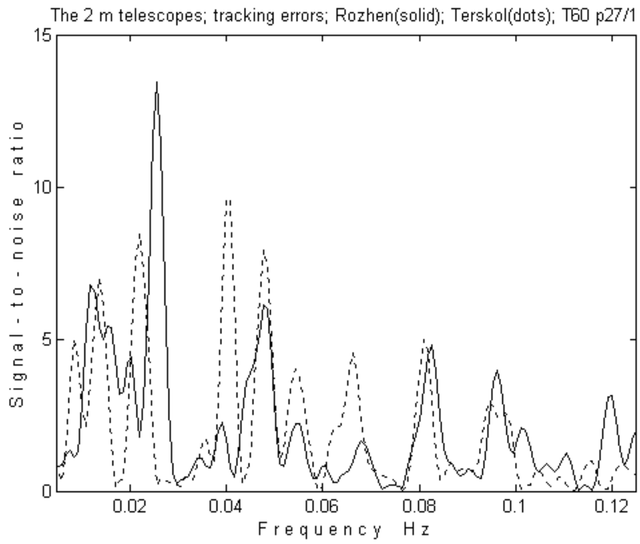

Figure 5: Tracking errors; Rozhen (solid), Terskol (dots)

An amplitude of image motions may amount to about of 0.2 arc seconds. We have found also that the modulation patterns of both telescopes show strong resemblance. This effect may be caused by errors in drive rate of telescopes. Such a type of centering error may cause several seconds of telescope displacement during photometric or exact coordinate of position measurements. One can think that employing CCD centering and guiding devices with the typical accuracy of about 0.2 arc second can not fully restrain the effect caused by image motions. Note that our findings provide information needed for accurate data reduction and a means of removing such errors, toward achievement higher precision in photometric and coordinate of position measurements.

References

[1] Gilliland R.L., Brown T.M., Duncan D.K. et al., 1991, AJ, 101, No 2, p. 541

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