Stroboscopic Method for Precise Ground-Based Stellar Photometry

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Precise is rarely better than 0.001-0.005 of a magnitude with ground-based telescopes. At the same time a potential achived accuracy limit defined by a Poisson statistics would run close to 0.0001 mag for bright stars. A precision of 0.002 mag was achieved with newest robotic telescopes (Young et al. 1991). But its value is inadequate for solving many astrophysical problems which are usually related to the microvariability.

We found that main limiting factor is due to short-term variations of the stellar intensity. Stecklum (1985) had first discovered flashes in scintillation power with a duration of some ten seconds. This view is supported by Dravins et al. (1997). Using a 120-s integration time they found that the temporal structure of scintillation is seen to change on time scale of tens of minutes. Our findings (Zhilyaev et al., 1998) are consistent with these deductions on very short time scales down to 1 s. We may conclude that the actual stellar intensity is not only a stochastic process, but an unsteady one on different time scales. In this connection there does not exist the rigorous in the mathematical sense notion of what "the brightness of star" means. It must be redefined in more comprehensive statistical sense. Shown in Figs 1,2 exhibit the sample error in relation to the running time for two narby stars observed simultaneously with a high-speed two-channel photometer. Observations were carried out at Peak Terskol (North Caucasus, 3100 m a.s.l.) with the 60 cm telescope in the U band with 0.1 s integration time. The stars are R CrB in quiescence and its reference one distanced at 20 arcmin. The value of error has been derived from the equation presented in our papers (see Zhilyaev et al., 1994 and in this volume). Shown in Fig 1 as open circles gives some typical example for a run time up to 20 s. The same shown in Fig 2 points clearly to the presence of a nonstationarity. That wave-shaped structure is not damped out on a great time scale.

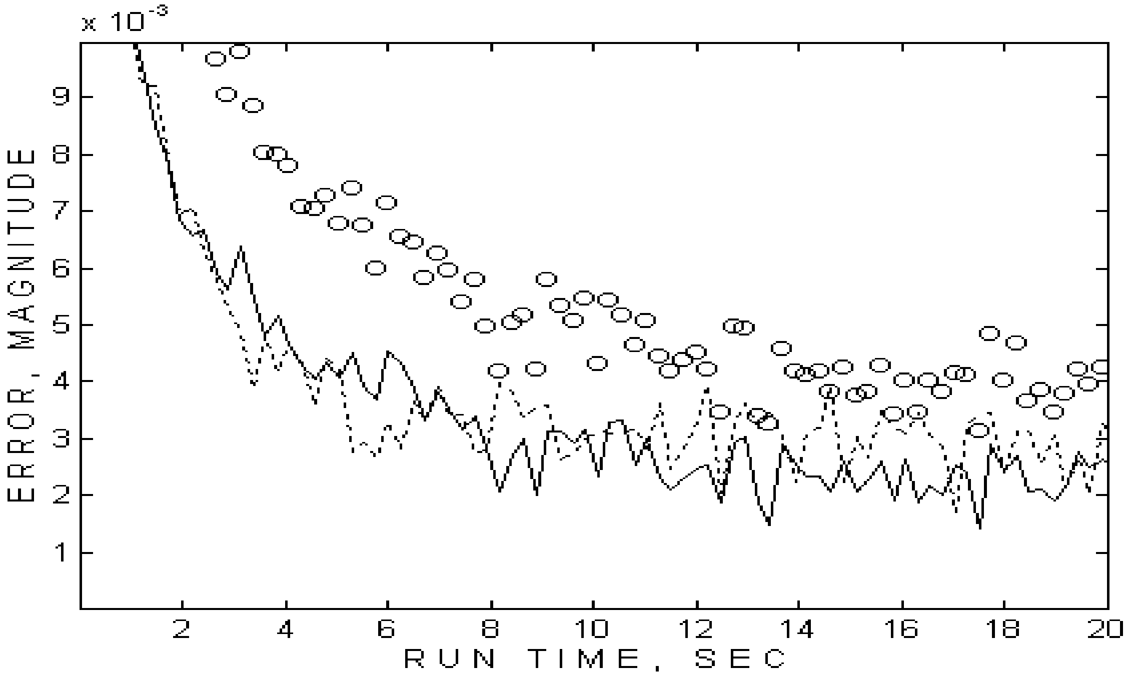

Figure 1: The 60 cm telescope, Peak Terskol, U band. July 21, 1995, 20:16 UT. Open circles - raw photometric data for R CrB. Stright and dotted curves - censoring data for R CrB and refernce star respectively.

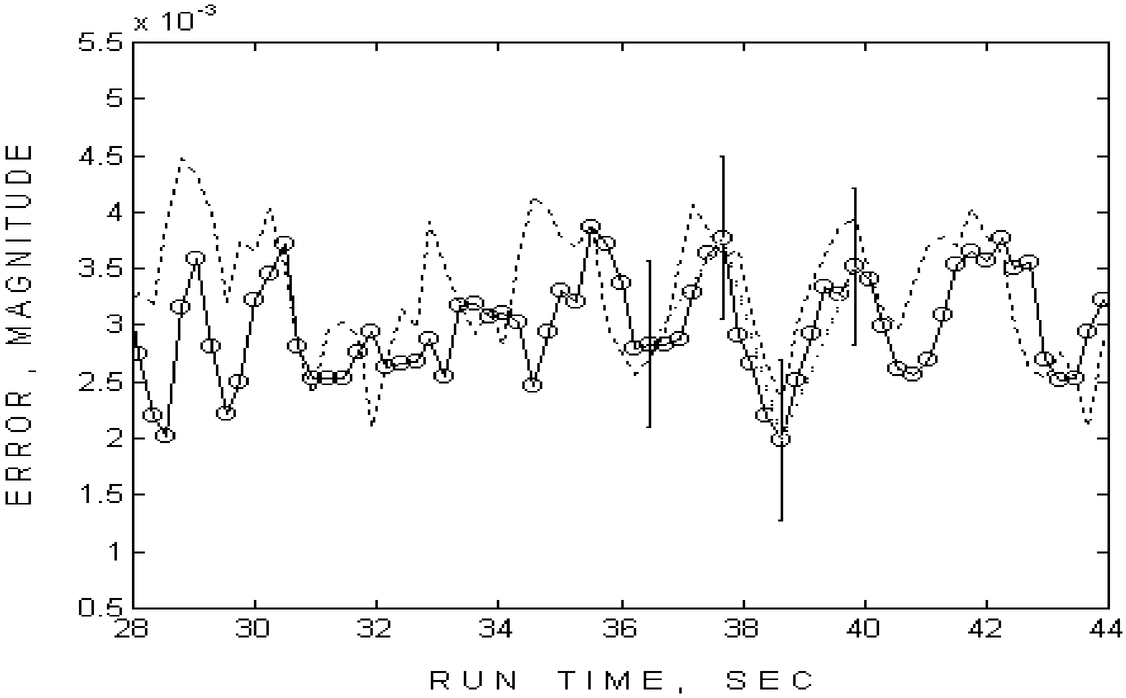

Figure 2: The same as in Fig 1. Raw photometric data for R CrB (stright line) and reference star (dotted line). The bars indicate the theoretical deviation for the Poisson statistics.

The method proposed to increase further the precision is based on some censoring procedure applied to the time series obtained with a pulse-counting photometer. The algorithm picks out the segments with "good" count statistics. It operates like a stroboscope and converts the unsteady-state light curve into clipped one with stationary distribution. Comparing the stright and circles curves in Fig 1 belonging to one and the same star (both pre- and post-censoring operation) we can see the advantage of the method proposed. In this instance the pulse- amplitude clipper was used with clipping level of $\pm 2\sigma$. One would expect the method proposed opens the way to provide a photometric precision close to the Poisson accuracy limit.

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References

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