TITLE
*ASP Conference Series, Vol. **VOLUME**, **PUBLICATION YEAR***
EDITORS

Calibrating the astrometric fluctuations in the CMT CCD Drift-Scan Survey

D. W. Evans

Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, UK

Abstract. The Carlsberg Meridian Telescope (CMT) has recently undergone a major upgrade. A 2k×2k CCD camera has been installed with a Sloan r' filter operating in a drift-scan mode. With the new system, the effective exposure time is about 90s, the magnitude limit is $r' = 17$ and the initial positional accuracy is in the range 50–100 mas. A method is presented that can improve the positional accuracy for a *single* observation to the range 30–50 mas.

1. Introduction

The main task of the CMT is to map the sky in the declination range -3° to $+30^\circ$ with the aim of providing an astrometric, and photometric, catalogue that can accurately transfer the Hipparcos reference frame to Schmidt plates. Projects similar to the CMT, which include the Southern sky, will also be able to provide astrometric calibration for VISTA and other deep wide-field surveys.

One of the main problems with drift-scan surveys is the astrometric fluctuations, caused by atmospheric seeing effects (Høg 1968; Benevides-Soares et al. 1993), which have a wavelength of a couple of minutes and a typical peak-to-peak amplitude of a few tenths of an arc second. These cause systematic errors in RA and declination as a function of RA. Even with the Tycho 2 catalogue, not enough standards are present to calibrate these fluctuations directly.

2. Other methods

The main method used by other groups so far has been to use a subcatalogue of positions *eg.* Bordeaux (Viateau et al. 1999). Each area is observed on a number of nights and, after a simple fit to Tycho 2 is applied, the positions are added to a subcatalogue. Any nights that seem to be much worse then any others are rejected. For each star an average position is formed which should reduce the effect of the nightly fluctuations. This makes the reasonable assumption that the fluctuations are not correlated from one night to the next. If a position is required for a particular night, *eg.* for a planet, the subcatalogue is used to calibrate the fluctuations and produce a position for that night. The problem with this technique is that it considerably increases the amount of time required to cover the sky. Also, even with a large number (N) of observations, the reduction in the amount of fluctuations left in the subcatalogue will only be by a factor $\sqrt{N}$.

3. Transfer Functions

The technique used by the CMT is to use the Tycho 2 stars to calibrate out the fluctuations and get around the problem of sparsity of standards by using overlapping frames.

Observations of the survey are carried out on a declination grid of 15 arc minutes. Observations taken on different nights at adjacent declinations will have an overlap of about 36%. This is sufficient to define a transfer function (using all the stars in the frame) which characterizes the difference in the fluctuations between two nights. By applying these differences to the positions in the second frame the fluctuations of the secondary night are effectively transformed into those of the primary.

The transformed positions from the secondary nights are then added to those from the primary night. Further frames that overlap this "new" extended frame are searched for and added in a similar way. This process is carried on until there are a sufficient number of standards in the frame.

After building up a large frame, Tycho 2 stars are matched and the fluctuations mapped using a calibration function. This calibration function characterizes the difference between the primary night fluctuations and the Tycho 2 positions. This is then applied to the positions of the primary night to produce a calibrated output file.

3.1. Calculating the transfer function

The transfer function is simply a set of cubic splines. The initial set of knots are placed at intervals of 1000 pixels ($\equiv$ 45 seconds of time). If a smaller interval was used, then the transfer function would map out a higher frequency than would be valid. This is determined by the highest frequency of fluctuations observed, which is in turn determined by the effective exposure time ($\equiv$ 2000 pixels $\equiv$ 90s).

After the initial placement of knots has been made, the data is checked to see if there are enough points present to define the splines reliably. If this is not the case, then the number of knots is reduced iteratively.

A similar procedure is carried out to calculate the calibration function. A density of higher that 1 Tycho 2 star per 200 pixels is needed in order to obtain a reliable final calibration function.

3.2. An example calibration

Figure 1 shows an example of the final Tycho 2 calibration function for 5 generations of overlapping frames. This frame was chosen as an example since it was from a particularly bad night and has very large fluctuations. Note that the rightmost trough of the upper plot does not have enough primary standards to define it adequately, but the addition of the standards from the overlapping frames provides enough information to calibrate the trough correctly.

3.3. Comparisons: internal and external

After applying this calibration method to two overlapping frames a comparison was carried out. The results are shown in the lower 2 plots of Figure 1. The two frames are from the nights of the 28th May and 2nd June of 1999. Most of the

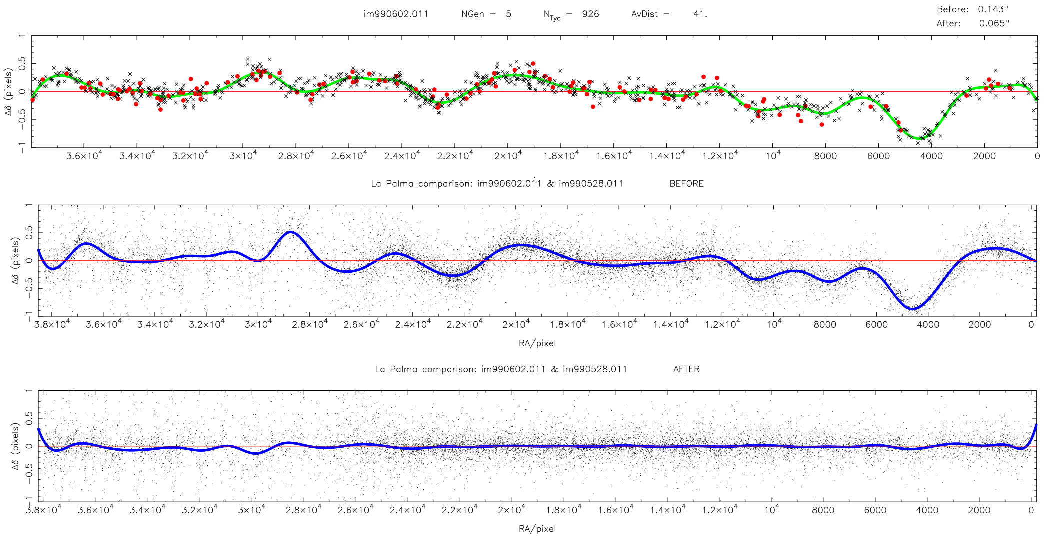

Figure 1. The upper plot shows an example of a Tycho 2 calibration function for a particular frame. The filled circles are the residuals in declination from the primary frame. The open circles show the data from the overlapping frames. The line is the derived final calibration function. The units of the residuals (CMT − Tycho 2) are in pixels ($\sim 0.7''$). The lower 2 plots show an example of a night-to-night comparison for declination. The middle plot is BEFORE the calibrations have been applied and the bottom one AFTER.

differences seen stem from the fluctuations on the 2nd June (see upper plot). As can be seen in the AFTER plot, most of the fluctuations have been removed.

External comparisons with FASTT (Stone, Pier & Monet, 1999) and UCAC (Zacharias et al. 2000) show that the external errors for a *single* CMT observation is in the range 30–50 mas. This is probably a function of the density of standards available and thus of Galactic latitude.

4. Conclusions

The results shown here indicate that using transfer functions enable us to calibrate the fluctuations using just the Tycho 2 stars. This is a more efficient method than using a subcatalogue since multiple measurements are not required.

References

Benevides-Soares P., Teixeira R. & Réquième Y. 1993, A&A, 278, 293
Høg E. 1968, ZAp, 69, 313
Stone R.C., Pier J.R. & Monet D.G. 1993, AJ, 118, 2488
Viateau B. et al. 1999, A&AS, 134, 173
Zacharias N. et al. 2000, AJ(in press)