CALIBRATION AND CHARACTERISTICS OF THE HIPPARCOS PAYLOAD

HANS SCHRIJVER
SRON Space Research Utrecht
Sorbonnelaan 2
3584 CA Utrecht
The Netherlands

ABSTRACT. The Hipparcos geometrical calibrations directly linked with the astrometrical precision are shortly described, and their accuracies given. An example for the basic angle shows the very high stability of the instrument.

1. Introduction

The high astrometric precision to be obtained from the Hipparcos measurements requires that the geometrical properties of the instrument are known with a very high precision. These properties include the basic angle of the beam combiner,and the distortions by the telescope imaging, the position detection on the grid (Perryman and Vaghi 1989).

The most important part of this calibration is constituted by the determination of the basic angle and the computation of the large-scale imaging distortions. These quantities can be determined as a part of the solution on the great circle in which the one-dimensional positions of the stars as obtained on the main grid are combined to a set of abscissae on a reference great circle (van der Marel et al. 1989).

As a part of its processing scheme, the FAST data reduction consortium has implemented a so-called first-look facility at SRON Space Research Utrecht. One of the functions of this system is the regular following of the evolution of instrumental parameters, in particular the ones mentioned before (Schrijver 1989). Once a week, a set of observations with a duration of about 6.5 hours is processed. The main features of this processing are presented here together with an example of the results. Full details can be found elsewhere (Schrijver 1991, 1992).

2. Calibrations

2.1. Principles

In the reduction on a reference great circle each measurement of a star position on the main grid leads to an observation equation relating the measurement result to a one-dimensional position on the sky (abscissae on the great circle), the transformation from the field system to the grid system (the distortions), and the basic angle (van der Marel et al. 1989). If G is the coordinate measured on the grid, x the coordinate in the field in the direction of the scanning motion, and y the field coordinate perpendicular to x, then the transformation

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TABLE 1. Accuracies of geometrical parameters obtained in a typical reduction in milliarcseconds at the edge of the 0.9×0.9 degree field of view.

Basic angle	0.3	(relative acc. $1.5\,10^{-9}$)
g_{100} (scale factor)	0.5	(relative acc. $3\,10^{-7}$)
g_{010} (rotation)	0.7	($\equiv 0.09''$)
g_{200}, g_{110}	0.3	
g_{020}	0.4	
$g_{300}, g_{210}, g_{120}$	0.6	
g_{030}	0.8	
g_{101}	0.3	
g_{011}	0.4	

can be expressed like

$$G = f \cdot \Big(g_{100}x + g_{010}y + g_{200}x^2 + g_{110}xy + g_{020}y^2 + g_{300}x^3 + g_{210}x^2y + g_{120}xy^2 + g_{030}y^3 + g_{101}cx + g_{011}cy \Big)$$

where f is the telescope focal length and $c = B - V - 0.5$, and independent expressions are used for the preceding and following field of view. The scale factor g_{100} is close to 1, the other g_{ijk} are 0 for the nominal instrument, except for g_{300} and g_{120} that include the nominal transformation from the spherical field system to the flat grid system.

The basic angle is described as a constant term, a term linear in c, and terms linear and quadratic in time:

$$\gamma = \gamma_{00} + \gamma_{01}c + \gamma_{10}(t - t_0) + \gamma_{20}(t - t_0)^2$$

For the determination of the geometrical parameters we use a so-called active-star solution. Here only a selection of stars contribute. The selection is made both on the basis of a priori criteria (single stars) and on the basis of the observations. In a typical reduction this leads to about 35 000 equations with 1100 star abscissa unknowns, 10 000 attitude unknowns, and 24 instrumental unknowns.

2.2. Results

The first-look system has succesfully processed about 75 observation sets until July 1991. For a typical reduction the obtained accuracies for the basic angle and the other geometrical parameters are given in Table 1. Deviations sometimes occur mainly for the terms depending only on y (g_{0i0}) when the length of the observation is shorter than 2 complete 2.1333-hour great-circle scans.

As an example, in Figure 1 the values obtained for the basic angle are presented. It is clear that, within the computed accuracies (as indicated by the error bars), the results are well reproducible from one set to another. The evolution of the basic angle appears to be very smooth, with a few rather abrupt changes. These have all been connected with periods where the thermal control system was out of order for some time, so that the payload temperature changed by several degrees (normal stabilization is within 0.1 degree).

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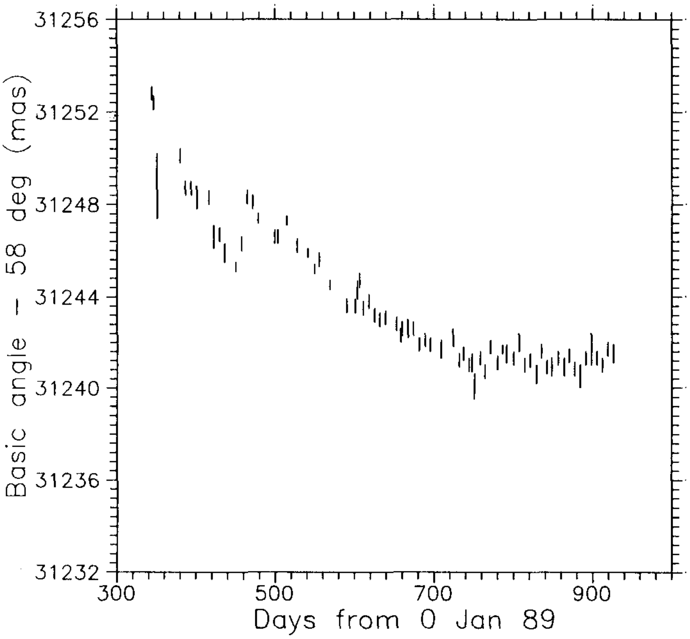

Figure 1. Evolution of the Hipparcos basic angle between December 1989 and July 1991 expressed as offset from the nominal value of 58°. Error bars are 2σ.

In agreement with this very stable evolution is the fact that the time dependent terms γ_{10} and γ_{20} do not reach significant values.

Similar results have been obtained for the other geometrical parameters. Details can be found elsewhere (Schrijver 1991, 1992). As for the basic angle, results for the geometrical parameters are well reproducible and exhibit very slow secular changes. Figure 2 presents the evolution of a few third-order terms.

Most features of this geometrical model have been explained in terms of an optical model of the telescope-grid system by Lindegren et al. (1992). They show that the observed secular changes correspond to minute movements in the payload with amplitudes of a few μm.

3. Conclusion

The calibration results have established that the long-term behaviour of the geometrical properties of the Hipparcos instrument is very stable. As the basic-angle results show, perturbations of the thermal control have little permanent effect on the parameters.

Based on these results, one may expect that this very stable instrument is qualified to meet the high requirements on the final accuracies of its results.

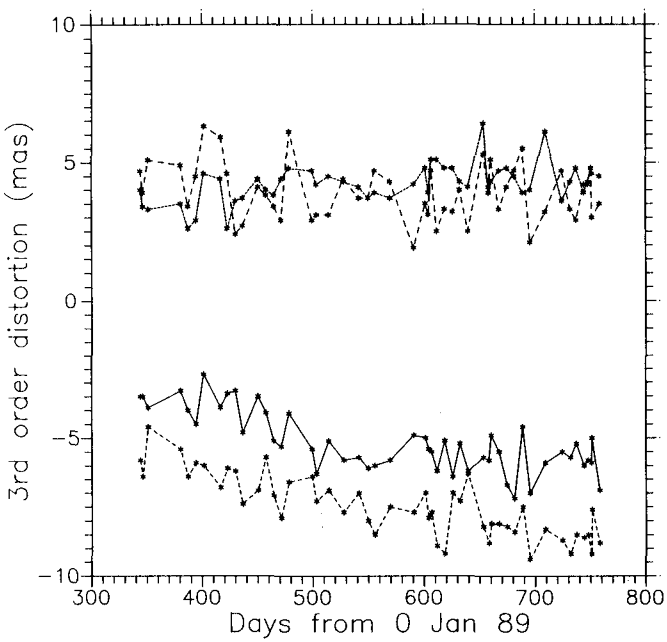

Figure 2. Evolution of some Hipparcos third-order distortions during 1990 (expressed in milli-arcseconds at the edge of the 0.9 × 0.9 field of view).

4. Acknowledgements

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