Section 2.8

Hipparcos Catalogue: Intermediate Astrometric Data

2.8. Hipparcos Catalogue: Intermediate Astrometric Data

2.8.1. Introduction

The Hipparcos Intermediate Astrometric Data are the one-dimensional coordinates (abscissae) on reference great circles, obtained by the FAST and NDAC Data Reduction Consortia. The relevance of the data is illustrated in Figure 2.8.1. Details of the data reduction procedures, and the merging of the results from the two consortia, are given in Volume 3.

Since each perigee passage of the satellite forced an interruption of at least a few hours in the observations, it was natural to divide the data into segments corresponding to the intervals between successive perigee passages. Each such interval is referred to as an 'orbit', and is identified by a unique sequential number.

For most orbits each consortium used a single reference great circle. This was always the case for NDAC but, for a few orbits, the FAST consortium split the data into two reference great circles. However, in order to merge the results from the two consortia, a one-to-one correspondence between the observations from each was necessary; in these few cases the FAST results for the two reference great circles in an orbit were averaged.

The data are provided in machine-readable form, in ASCII format, only (see Section 2.11 for further details of the corresponding formats). The first file contains the mid-epochs and poles, referred to ICRS, of the reference great circle adopted for each orbit, by each consortium. The second file gives, for each orbit, the residuals between the observed abscissae for each star and those calculated from the set of reference astrometric parameters which are given in the Hipparcos Catalogue Fields H8–13.

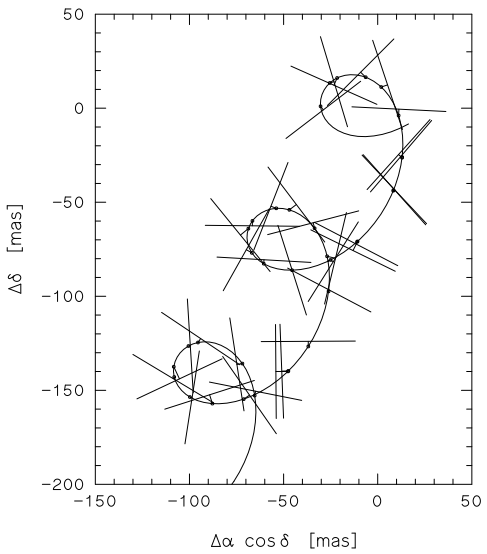

Figure 2.8.1. *The path on the sky of one of the Hipparcos Catalogue objects, over a period of three years. Each straight line indicates the observed position of the star at a particular epoch: because the measurement is one-dimensional, the precise location along this position line is undetermined by the observation. The curve is the modelled stellar path fitted to all the measurements. The inferred position at each epoch is indicated by a dot, and the residual by a short line joining the dot to the corresponding position line. The amplitude of the oscillatory motion gives the star's parallax, with the linear component representing the star's proper motion. The intermediate astrometric data allow the quality of the model fitting to be assessed, and possibly refined.*

2.8.2. Reference Great-Circle Data

This file (see Table 2.8.1) defines the mid-epoch, in years from the catalogue epoch J1991.25(TT) (see Section 1.2.6), for each great circle during the mission, together with the reference pole of these reference great circles. These data may be used for the computation of partial derivatives of abscissae with respect to the astrometric parameters.

The FAST and NDAC mid-epochs for a given orbit were always very close to each other. In some cases, an orbit used by one data reduction consortium was not used by the other one; in this case the relevant fields are blank.

The following formula allows the orbit number o to be derived, using an epoch t expressed in years relative to J1991.25(TT):

$$o = \mathrm{int}(1157.39 + 823.02t + 0.216t^2) \qquad [2.8.1]$$

Fields IR1–7: Reference Great Circle Data

Field IR1: Orbit number

Field IR2: FAST reference great-circle mid-epoch

The mid-epoch of the reference great circle is defined in years, relative to J1991.25(TT).

Field IR3–4: Equatorial position of the FAST reference great-circle pole

This gives the right ascension and declination (in degrees) within ICRS of the FAST reference great-circle pole.

Field IR5: NDAC reference great-circle mid-epoch

The mid-epoch of the reference great circle is defined in years, relative to J1991.25(TT).

Field IR6–7: Equatorial position of the NDAC reference great-circle pole

This gives the right ascension and declination (in degrees) within ICRS of the NDAC reference great-circle pole.

The statistics of the reference great circles are as follows:

Consortium	Number of circles	Minimum orbit number $o_{\min}$	(yr–1991.25)	Maximum orbit number $o_{\max}$	(yr–1991.25)
FAST	2262	48	−1.3478	2763	1.9505
NDAC	2326	1	−1.4049	2768	1.9565

2.8.3. Reference Great-Circle Abscissae

The data are ordered by increasing Hipparcos (HIP) number. For each star, a header record provides the reference astrometric parameters (Fields IH1–9, see Table 2.8.2), followed by a total of N_A individual abscissae records (Fields IA1–10, see Table 2.8.3) providing the results for each observation by each consortium, ordered by increasing orbit number.

Abscissae residuals are given for 118 204 entries. Compared to the main catalogue, 14 entries are missing: 10 entries without astrometry, and 4 double star component solutions obtained by NDAC only. Some entries have abscissae from one consortium only: 6594 entries have FAST data only, 44 entries have NDAC data only.

These discrepencies are due to the fact that the NDAC astrometric reduction of known double stars were not performed using the main NDAC reduction chain. For this reason, the NDAC great circles abscissae of certain double stars were not available for the astrometric merging procedure, and are therefore not available in the intermediate astrometric data file.

Fields IH1–7: Header Data

Field IH1: The Hipparcos Catalogue (HIP) identifier

Field IH2: Provisional *Hp* magnitude used for merging

This is the provisional *Hp* magnitude used for the astrometric data merging. It was not necessarily the final catalogue value derived for *Hp*, and may therefore differ from the final value published in the main Hipparcos Catalogue, Field H44 (such differences, however, having a marginal effect on the final astrometric parameters).

Fields IH3–7: Reference astrometric parameters

These are the Hipparcos astrometric parameters, the same as in Fields H8–9 and H11–13, to which the abscissae residuals refer, in the order position (α, δ), parallax (π), and proper motion ($\mu_{\alpha*}$, μ_δ) respectively.

The right ascension and declination are expressed in degrees, at epoch J1991.25(TT). The trigonometric parallax is given in milliarcsec. The proper motions in right ascension, $\mu_{\alpha*} = \mu_\alpha \cos\delta$, and declination, μ_δ, are expressed in milliarcsec per Julian year and refer to the epoch J1991.25(TT). Coordinates are given within the ICRS system.

A viable astrometric solution could not be found for some entries (flagged '–' in Field IH8). These have no astrometric parameters in Fields H8–13 of the main Hipparcos Catalogue; in these few cases, Fields 3–4 of the Hipparcos Catalogue provide an approximate position. This has been used as the reference position (Fields IH3–4), with Fields IH5–7 set to zero.

Fields IH8: Flag for the adopted astrometric solution

This flag indicates which astrometric solution was finally adopted:
5 : single star solution (5 astrometric parameters)
7 : acceleration solution (DMSA/G), 7 parameters
9 : acceleration solution (DMSA/G), 9 parameters
C : component solution (DMSA/C)
O : orbital solution (DMSA/O)
V : 'VIM' solution (DMSA/V)
X : stochastic solution (DMSA/X)
– : no astrometric solution

Fields IH9: Number of following abscissae records, N_A

Fields IA1–10: Abscissa Data

Field IA1: Orbit number

Field IA2: Source of abscissa

The field has the following meaning:
F : data from FAST;
f : data from FAST rejected in constructing the published astrometric solution;
N : data from NDAC;
n : data from NDAC rejected in constructing the published astrometric solution.

The rejection is indicated only in the case of solutions flagged '5', '7', '9' or 'X' in Field IH8.

Fields IA3–7: Partial derivatives

These are the partial derivatives, $\partial v/\partial a_i$, of the abscissa with respect to the five astrometric parameters $a_i = \alpha* \ (= \alpha \cos\delta)$, δ, π, $\mu_{\alpha*}$, μ_δ, for $i = 1, \ldots, 5$ respectively.

Other derivatives were needed in the case of non-single star solutions. The derivatives with respect to the right ascension and declination components of the second- and third-order motion of the photocentre (Field IH8 = '7' or '9', see Section 2.3.3 for details), may be computed as:

$$\frac{\partial v}{\partial g_i} = \tfrac{1}{2}(t^2 - 0.81)\frac{\partial v}{\partial a_i} \qquad [2.8.2]$$

and:

$$\frac{\partial v}{\partial \dot{g}_i} = \tfrac{1}{6}(t^2 - 1.69)\frac{\partial v}{\partial a_{i+3}} \qquad [2.8.3]$$

where $i = 1, 2$ for $\alpha*$, δ, and the mid-epoch t is given in Fields IR2 or IR5 for the FAST and NDAC data respectively.

The FAST and NDAC partial derivatives differ, partly because of the difference in orientation between the FAST and NDAC reference great circles and, to a lesser extent, because the FAST Consortium used the observation epoch of the star on the given reference great circle whereas the NDAC Consortium used the reference great-circle mid-epoch.

Field IA8: Abscissa residual Δv, in milliarcsec

This is the difference between the observed great-circle abscissa and the great-circle abscissa computed with the reference astrometric parameters. The star abscissa is the angle, as seen from the great-circle pole, from the ascending node of the great circle on the equator to the satellitocentric coordinate direction of the star at the great-circle epoch.

If corrections Δa_i are to be added to the reference astrometric parameters a_i, the abscissae residuals with respect to the new reference astrometric parameters $a_i' = a_i + \Delta a_i$ can be computed as:

$$\Delta v' = \Delta v - \sum_{i=1}^{5} \frac{\partial v}{\partial a_i} \Delta a_i \qquad [2.8.4]$$

The fact that the reference great-circle abscissae are determined modulo the grid period (1.2074 arcsec) means that certain abscissa residuals, in particular some of the residuals related to the entries without astrometric solution (flagged '–' in Field IH8), may be affected by grid-step errors of $\pm 1.2074n$ arcsec. Here n is a small integer, rarely greater than 2, which varies among the abscissa residuals of the entry. In order to enable a consistent astrometric solution, the affected abscissa residuals must be corrected by subtraction of the corresponding grid-step errors. The abscissa residuals of all entries with non-problematic single-star solutions should be free of grid-step errors ($n = 0$).

Field IA9: Standard error of the abscissa

This is the adopted *a priori* standard error of the abscissa measurement, in milliarcsec. Each consortium derived a relative weighting system for its own data reductions. These individual systems were transformed to the adopted self-consistent system during the merging process, as described in Volume 3. The adopted standard error given here does not include the 'cosmic' error added in the stochastic solutions (Field IH8 = 'X').

Field IA10: Correlation coefficient between abscissae

The correlation coefficients between the FAST and NDAC abscissae for a given great circle have been calibrated as a function of magnitude, standard error, and orbit number. Together with the standard error of the FAST and NDAC abscissae, these correlation coefficients provide the necessary information about the covariance matrix of the observations. If abscissa data on a given great circle were obtained by both FAST and NDAC, the correlation coefficient is repeated in the two records to which it refers; otherwise the field is blank.

In the case of stochastic solutions (Field IH8 = 'X'), the correlation coefficients which have been used were computed as a function of the quadratic sum of the abscissae standard errors and the 'cosmic error', and are thus different from those indicated in this field.

Table 2.8.1. Hipparcos Intermediate Astrometric Data: Reference Great Circle Data File

Field	Bytes	Format	Description
IR1	1-5	I4,X	Orbit number
IR2	6-13	F7.4,X	FAST orbit mean epoch (year relative to J1991.25)
IR3	14-26	F12.8,X	Right ascension of the FAST great-circle pole (deg)
IR4	27-39	F12.8,X	Declination of the FAST great-circle pole (deg)
IR5	40-47	F7.4,X	NDAC orbit mean epoch (year relative to J1991.25)
IR6	48-60	F12.8,X	Right ascension of the NDAC great-circle pole (deg)
IR7	61-72	F12.8	Declination of the NDAC great-circle pole (deg)

Table 2.8.2. Hipparcos Intermediate Astrometric Data: Observation File Header Record

Field	Bytes	Format	Description
IH1	1-7	I6,X	Hipparcos Catalogue (HIP) identifier
IH2	8-13	F5.2,X	Provisional Hp magnitude used for the merging (mag)
IH3	14-26	F12.8,X	Right ascension α (deg)
IH4	27-39	F12.8,X	Declination δ (deg)
IH5	40-46	F6.2,X	Trigonometric parallax π (mas)
IH6	47-55	F8.2,X	Proper motion in right ascension $\mu_{\alpha *}$ (mas/yr)
IH7	56-64	F8.2,X	Proper motion in declination μ_δ (mas/yr)
IH8	65-66	A1,X	Code for adopted solution (5, 7, 9, C, O, V, X, –)
IH9	67-69	I3	Number of following abscissae records, N_A

Table 2.8.3. Hipparcos Intermediate Astrometric Data: Observation File Abscissa Record

Field	Bytes	Format	Description
IA1	1-5	I4,X	Orbit number
IA2	6-7	A1,X	‘F’ or ‘f’ if FAST data; ‘N’ or ‘n’ if NDAC data
IA3	8-15	F7.4,X	Abscissa partial derivative with respect to $\alpha *$
IA4	16-23	F7.4,X	Abscissa partial derivative with respect to δ
IA5	24-31	F7.4,X	Abscissa partial derivative with respect to π
IA6	32-39	F7.4,X	Abscissa partial derivative with respect to $\mu_{\alpha *}$
IA7	40-47	F7.4,X	Abscissa partial derivative with respect to μ_δ
IA8	48-56	F8.2,X	Abscissa residual wrt reference astrometric parameters (mas)
IA9	57-64	F7.2,X	Standard error of the abscissa (mas)
IA10	65-69	F5.3	Correlation coefficient between FAST and NDAC abscissae