Section 2.9

Hipparcos Catalogue: Transit Data

2.9. Hipparcos Catalogue: Transit Data

2.9.1. Introduction

The Hipparcos Transit Data file summarises intermediate astrometric and photometric information at the level of individual crossings of targets across the $0.^{\circ}9 \times 0.^{\circ}9$ main grid of the Hipparcos instrument. The data concern a total of 38 535 Hipparcos entries selected mainly on account of their known or suspected multiplicity, or as being parts of two- or three-pointing systems in which the detector signals of the different targets may be intermingled. The Hipparcos Transit Data file was derived from the 'Case History Files' constructed as part of the NDAC double star treatment (see Volume 3) and thus contains exclusively results of the NDAC processing: no merging of FAST and NDAC data at the transit level was deemed practicable in view of the very different approaches taken by the two consortia to the treatment of double stars.

For a specific double or multiple system, the Transit Data file provides a self-contained and globally calibrated compilation of the main detector signal parameters for practically all field transits of the system. For each transit, the five signal parameters (denoted b_1 to b_5 below) describe the detector signal as the sum of a constant component and two harmonics, without any constraints on the amplitudes and phases of the harmonics. Since this is a completely general model applicable to all kinds of objects (whether they are single, multiple, extended, variable, or in rapid orbital motion), the transit data can in principle be used to fit arbitrarily complex object models to the Hipparcos observations. For example, while the NDAC double star treatment was, for practical reasons, limited to the study of double and multiple systems with at most a linear relative motion of the components, the transit data could be used to derive the orbital elements of the resolved components of some short-period binaries with respect to their centre of mass, thus yielding mass ratios in addition to the relative orbits. The transit data may also be used to obtain astrometric results for some Hipparcos objects that were not successfully solved in time for inclusion in the catalogue, or for which the published results are affected by unresolved ambiguities.

The signal parameters given in the Transit Data file are fully calibrated in the sense that the amplitudes are corrected for sensitivity variations across the field of view and as a function of time and colour; similarly the phases are corrected for instrumental variations, and are referred to a specific reference direction in the global celestial reference frame defined by the Hipparcos Catalogue. The signal parameters thus corrected could more properly be called 'rectified', as they correspond to observations by a fictitious, ideal instrument with fixed and known sensitivity and response function. The rectified signal parameters can thus be modelled directly in terms of astrometric data in the ICRS system, and photometric data on the *Hp* magnitude scale, without regard to the actual variations of the instrument properties. Several thousand stars believed to be perfectly ordinary single stars ('*bona fide* singles') have been included in the Transit Data file in order to facilitate future checking of the rectification and for cross-validation of the reference frame and photometric system with respect to the Hipparcos Catalogue. These are not explicitly flagged here, but can be identified with reference to the main Hipparcos Catalogue (suspected) double star flags.

The Transit Data file also contains information on the pointing of the instantaneous field of view for each field transit. This information is essential for interpreting the attenuation effects of the detector's response profile (Table 1.4.1) especially for two- and three-pointing systems and cases where the pointing turned out to be significantly in error compared to the actual star. Note that the pointing data give the target position towards which the instantaneous field of view was aimed during observation. Due to the errors of the real-time satellite attitude determination, the actual pointing in a given transit may have differed by a few arcsec from this intended pointing. Such detailed pointing information, which in principle may be estimated from the difference between the real-time and *a posteriori* attitude determinations, is not contained in the Transit Data file.

In generating the Transit Data file, no screening of the data was applied in order to reject 'unreasonable' observations, e.g. with very small or very large signal strengths. This philosophy was adopted, firstly because it is very difficult to define acceptance limits in view of the variability of many objects, and secondly because the 'strange' values themselves could provide useful clues to some abnormal situation. The definition of a 'bad data point' is moreover a function of the fitted model and is therefore best left to the final user of the data. The user should however be aware that, in any analysis of the data, a few per cent of the transits may have to be rejected—and much more for some specific objects.

2.9.2. Basic Interpretation of the Transit Data

All transits of a particular Hipparcos entry are collected together in a set of consecutive records in the Transit Data file. This set begins with a header record, followed by a pointing record, and finally the transit records. A special index file contains a pointer from the HIP number to the relevant header record in the Transit Data file. For two- and three-pointing systems, data for the different pointings (each corresponding to a separate HIP number) are collected together, and the index file points to the same header record for the two or three different HIP numbers.

In the course of the Hipparcos mission the target positions for some objects (but not the proper motion or parallax of the reference point) were updated as a result of improved ground-based or preliminary space results; these are distinguished in the Transit Data file since the results are associated with the same HIP number but refer to different detector pointings. For simplicity, the set of HIP entries and target positions collected under the same header is here referred to as a 'system'. For most Hipparcos Catalogue entries only a single target position was used.

For a given system the Transit Data file specifies a reference point with astrometric parameters α_0, δ_0, π_0, $\mu_{\alpha*0}$, $\mu_{\delta 0}$ given in the header record. These parameters refer to the epoch J1991.25(TT) and the ICRS system, but they do not correspond to the parameters of any object contained in the Hipparcos Catalogue: usually they were constructed from the Hipparcos Input Catalogue parameters of the dominant target. The phase information in the subsequent transit data is defined relative to this reference point. Note that the reference point may have both a proper motion and a parallax, which must be added to the (relative) proper motion and parallax derived from the transit data in order to represent the absolute quantities on the sky.

The signal parameters b_1 to b_5 describe the fitted and rectified modulation light curve, expressed as photon counts per sample interval of 1/1200 s, according to the general second-order harmonic model:

$$I_k = b_1 + b_2 \cos p_k + b_3 \sin p_k + b_4 \cos 2p_k + b_5 \sin 2p_k \qquad [2.9.1]$$

where the phases p_k are taken relative to the reference point ($k = 1, 2, \ldots$ for successive samples of 1/1200 s). The actual photon counts N_k were modelled as an inhomogeneous Poisson process with a time-dependent expectation (intensity) described roughly as $(1+g)I_k + B$, where g represents the calibrated sensitivity variations over the field of view and over the mission, and B the similarly calibrated background count rate. The actual calibration and rectification process is much more complicated, involving also the modulation factors and relative phases of the two harmonics, all considered as functions of position in field, time, and colour of the object.

The rectification was made in such a way that the rectified signal expected for a point source of magnitude Hp at the reference point is:

$$I_k = 6200 \times 10^{-0.4Hp} \, [1 + \bar{M}_1 \cos p_k + \bar{M}_2 \cos 2p_k] \qquad [2.9.2]$$

where $\bar{M}_1 = 0.7100$ and $\bar{M}_2 = 0.2485$ are adopted reference values for the modulation coefficients of the first and second harmonics. An object consisting of n point-like sources is consequently expected to produce the rectified signal:

$$I_k = \sum_{j=1}^{n} K_j \, [1 + \bar{M}_1 \cos(p_k + \phi_j) + \bar{M}_2 \cos 2(p_k + \phi_j)] \qquad [2.9.3]$$

where $K_j = 6200 \times 10^{-0.4Hp_j}$ are the (instantaneous) intensities of the sources and ϕ_j their phase displacements in the current field transit relative to the reference point. The phase displacements are simply given by the linear expressions:

$$\phi_j = f_x \xi_j + f_y \eta_j + f_p \Delta\pi_j \qquad [2.9.4]$$

where ξ_j, η_j are the positional offsets from the reference point in the directions of $+\alpha$ and $+\delta$, respectively, at the epoch of the transit; $\Delta\pi_j$ is the offset in parallax with respect to the reference point. Numerical values for the factors f_x, f_y, f_p are provided for each transit of a system. They are expressed in radians of phase per radian of angular offset. The factors f_x and f_y are, in effect, the α and δ components of the fundamental spatial frequency of the grid, as projected on the sky for the transit in question. Note that ξ_j and η_j describe the time-dependent offset of the point source including both a difference in position at the reference epoch J1991.25 and its variation due to orbital and proper motion, but excluding the parallactic motion relative to the reference point, which is taken care of by the third term in Equation 2.9.4. ξ_j and η_j are in principle local plane coordinates, tangential to the celestial sphere at the reference point, as defined in Section 1.2.9. Stellar aberration of the reference point has been removed in the rectification process; differential stellar aberration produces a slight stretching or compression of the local apparent scale and has been included as such in the factors f_x, f_y and f_p. Thus stellar aberration does not enter the astrometric modelling of the rectified signal parameters.

The data given for each transit of a target consist of the epoch of the transit (t), the phase factors f_x, f_y, and f_p, and the signal parameters b_1 to b_5 with associated standard errors σ_1 to σ_5. The additional quantities s_1, s_2 and σ_{att} are explained in the next section.

The determination of the signal parameters for a composite object is derived by identifying the fitted I_k in Equation 2.9.1 with the modelled intensity in Equation 2.9.3. In terms of the (generally time-dependent) intensities and positional offsets, this results in the following equations of condition for each transit:

$$\begin{aligned} b_1 &= \sum_j K_j(t) \\ b_2 &= \bar{M}_1 \sum_j K_j(t) \cos[f_x \xi_j(t) + f_y \eta_j(t) + f_p \Delta\pi_j] \\ b_3 &= -\bar{M}_1 \sum_j K_j(t) \sin[f_x \xi_j(t) + f_y \eta_j(t) + f_p \Delta\pi_j] \\ b_4 &= \bar{M}_2 \sum_j K_j(t) \cos 2[f_x \xi_j(t) + f_y \eta_j(t) + f_p \Delta\pi_j] \\ b_5 &= -\bar{M}_2 \sum_j K_j(t) \sin 2[f_x \xi_j(t) + f_y \eta_j(t) + f_p \Delta\pi_j] \end{aligned} \qquad [2.9.5]$$

The modelisation is further complicated by possible signal attenuation from the instantaneous field of view profile, which could modify the K_j as a function of the positional offset of each component from the target position; additional corrections may be introduced as a function of the difference in colour index of each component with respect to the colour assumed in the calibrations (see below).

2.9.3. Additional Considerations for the Use of the Data

This section addresses several items that are not essential for a basic understanding of the transit data, but which must nevertheless be considered in order to make optimum use of the data. They concern in particular the interpretation of Fields JT16–19.

Colour effects: All calibrations, especially the photometric calibration of the detector as a function of time and position in the field of view, are colour-dependent, and a specific colour index $(V - I)_{\rm cal}$ had to be assumed for each HIP identifier in order to rectify the signal parameters. The assumed colour index is specified for each HIP identifier in the Transit Data file. (Nominally this colour index should be the same as given in Field H75 — but not necessarily the same as in Field H40; see further details under Field H40.) For double-pointing binaries, where separate colour indices were available for the components, this is fairly non-problematic (assuming the colours to be essentially correct), but for single-pointing doubles there are inevitable problems. The two components generally have different colours, and the (correct) mean of the calibrations is not necessarily equal to the (adopted) calibration for a mean colour. Where the individual colours and intensities are known, a re-derivation of improved transit data would in principle be possible, but the amount of work involved makes that wholly impractical. Also, for most of the close Hipparcos doubles, the individual colours are *not* known, and this 'differential colour problem' had to be left unsolved in the data reduction process.

Even if it were thus necessary to assume that the components have the same colour, two additional quantities s_1 and s_2 have been introduced in the transit records in order to permit the given signal parameters to be approximately corrected, should later observations prove the assumed colour index to be much in error. The corrected parameters are given by:

$$\begin{aligned} b'_1 &= b_1(1 + s_1 \Delta c) \\ b'_k &= b_k(1 + s_2 \Delta c), \quad k = 2, 3, 4, 5 \end{aligned} \qquad [2.9.6]$$

where $\Delta c = (V - I)_{\rm true} - (V - I)_{\rm cal}$ is the required correction to the colour index used in the calibration. The need for different corrections of the 'dc' (unmodulated, $k = 1$) and the 'ac' (modulated, $k > 1$) components of the signal reflects the slightly different effective wavelengths of the dc and ac photometric bands (see Section 1.3); that the same correction factor applies to the second harmonic ($k = 4, 5$) as to the first ($k = 2, 3$) is due to the fact that the ratio M_2/M_1 is rather insensitive to the colour.

If the colours of the individual components of a single-pointing system are known, the corrections in Equation 2.9.6 must use the effective colour of the system. An alternative procedure would be to incorporate the inverse correction factors $(1 + s_i \Delta c_j)^{-1}$ separately for each component (j) in the right-hand sides of Equation 2.9.5. This latter procedure seems preferable on theoretical grounds, but has not been tested in practice.

Attitude effects: The given standard errors of the signal parameters include (for σ_2 to σ_5) the uncertainty of the phases of the first and second harmonics. This uncertainty arises primarily from the photon noise of the raw counts, but in the rectification process a contribution from the attitude uncertainty has been added, as determined in the great-circle reductions. However, the attitude errors in successive transits, belonging to the same great-circle reduction, are strongly correlated. Moreover, the formal standard errors in the attitude derived in the great-circle reductions are usually slightly too small. Both effects tend to give an underestimation of the errors in any solution based on the combination of transit data. A satisfactory treatment of these effects is very difficult to achieve and no standard recipe can be given here. The procedure adopted for the NDAC double star treatment is briefly described in Volume 3.

Transits belonging to the same great-circle reduction can be identified as having the same 'orbit number' o calculated from the transit epoch t as in Section 2.8.2, and the expected correlation of the phase data among such transits should be assessed by statistical methods. A further quantity, σ_{att}, is provided with each transit record. This corresponds to the 'extra abscissa variance' that was added to the formal abscissae variances in the NDAC sphere solution in order to obtain abscissa residuals of unit weight. It is therefore *not* included in the given standard errors of the signal parameters, but should be added (wholly or partially) as phase noise fully correlated among transits sharing the same orbit number.

Pointing noise: A further noise source not included in the transit data standard errors is the photometric modulation caused by time-dependent errors in the piloting of the image dissector instantaneous field of view. This is small as long as a star is well centred in the instantaneous field of view, but may be very dominant for a stellar component at the edge of the response profile (some 15 to 25 arcsec from the centre). The modelling of this effect is quite complex, and may include both an enhancement of the photometric noise within a single transit (due to rapid variations in the actual pointing) and an apparent 'variability' of the component from one transit to the next.

Flagged transits: The standard errors σ_1 to σ_5 were normally computed by inversion of the 5×5 information matrix obtained by summing the information matrices of the individual observation frames (derived from the processing of the image detector tube photon counts), and taking into account the rectification of the frames by the relevant calibration data. For reasons not fully understood, in about 0.4 per cent of the transits, the computed information matrix turned out to be non-positive definite, and no standard errors could be computed as described above. In most of these transits the rectified signal parameters themselves appear to be valid, and it was decided to retain them in the transit data file with a suitable warning and a crude estimate of the standard errors. The affected transits are flagged in Field JT19, and the standard errors are set to the median values of the corresponding standard errors for the remaining transits of the same target position.

2.9.4. The Transit Data File

The Transit Data file contains data for 4 276 420 transits distributed over 37 368 different systems. For each system there is a header record (Table 2.9.1) followed by a pointing record (Table 2.9.2), and finally the transit records for the system (Table 2.9.3). All records are of the same length. The total number of records is 4 351 156.

The Header Record (Fields JH1–13)

Field JH1: The Hipparcos Catalogue (HIP) identifier for the first pointing in the system.

This field always contains an identifier (while Fields JH2–3 only give identifiers for two- or three-pointing systems). For two- and three-pointing systems the selection of the first pointing is to some extent arbitrary (usually it is the brighter component).

Fields JH2–3: Additional Hipparcos Catalogue (HIP) identifiers

These fields contain the additional HIP numbers of two- and three-pointing systems. Unused identifiers are set to zero. Thus, Fields JH2–3 are zero for single-pointing systems and Field JH3 is zero for two-pointing systems.

Field JH4: Number of different target positions in the system, N_P

This is the number of different target positions used to point the instantaneous field of view during observations. Note that a given HIP identifier may correspond to more than one target position, if the latter was updated in the course of the mission. N_P defines the number of significant fields in the subsequent pointing record and is also equal to the maximum pointing index I_P in the following transit records. N_P ranges from 1 to 7.

Field JH5: Number of following transit records, N_T

For 36 205 systems with a single HIP entry, N_T ranges from 6 to 357, with a mean value of 111 (only 25 systems have $N_T < 30$). For 1159 systems with two HIP entries, N_T ranges from 67 to 577 with a mean value of 223. For four systems with three HIP entries, N_T ranges from 259 to 583 with a mean value of 411.

Fields JH6–10: Astrometric parameters for the reference point

The phase information in subsequent transit records are given with respect to a reference point defined by the five astrometric parameters given in the order position (α_0, δ_0), parallax (π_0), and proper motion ($\mu_{\alpha*0}$, $\mu_{\delta 0}$).

The position is expressed in degrees, at epoch J1991.25(TT). The trigonometric parallax is given in milliarcsec (mas). The proper motions in right ascension, $\mu_{\alpha*0} = \mu_{\alpha 0} \cos \delta_0$, and declination, $\mu_{\delta 0}$, are expressed in milliarcsec per Julian year and refer to the epoch J1991.25(TT). Coordinates are given within the ICRS reference system.

Fields JH11–13: Colour indices $(V - I)$ assumed in the calibrations

These fields give the values $(V - I)_{\rm cal}$ used to rectify the signal parameters corresponding to the HIP identifiers in Fields JH1–3. Fields JH12–13 are set to zero when the corresponding Fields JH2–3 are zero.

The Pointing Record (Fields JP1–27)

Field JP1: Index (1 to 3) for the HIP identifier of target position 1

This indicates which HIP identifier (Fields JH1–3) and colour index (Fields JH11–13) apply to the transit records with $I_P = 1$ in Field JT1.

Fields JP2–3: Offset in α and δ for target position 1, in arcsec

This is the target position used to point the instantaneous field of view for subsequent transits with $I_P = 1$ in Field JT1. It is given as the offset coordinates in α and δ relative to the reference point defined in the header record (Fields JH6–10) and expressed in arcsec. The offset in α should be interpreted as $\Delta\alpha \cos\delta$.

Fields JP4–27: Information on other target positions

If $N_P > 1$, the corresponding data for target positions 2 to N_P are given in Fields JP4 to JP($3N_P$). Remaining fields in the pointing record are set to zero. The format allows up to nine different target positions, although the actual maximum N_P is seven.

The Transit Record (Fields JT1–19)

Field JT1: Target position index for this transit record, I_P

This index (in the range 1 to N_P) defines the target position of the instantaneous field of view for the observations collected in this transit record. The target position is given in Fields JP($3I_P - 1$) and JP($3I_P$) of the preceding pointing record, and the corresponding HIP identifier and colour index are given, respectively, in Fields JH(JP($3I_P - 2$)) and JH(10+JP($3I_P - 2$)) of the preceding header record.

Field JT2: Epoch of the transit, t, expressed in years from J1991.25(TT)

Fields JT3–5: Phase factors f_x, f_y and f_p

These quantities, defined through Equation 2.9.4, are the partial derivatives of the signal phase (of the fundamental harmonic) with respect to the positional coordinates and parallax, expressed in radians of signal phase per radian of angular displacement.

Field JT6: Signal parameter b_1, given as the natural logarithm $\ln b_1$

b_1 is the 'dc' (unmodulated) component of the detector signal and is always positive. Because of its large range, a logarithmic value is given to preserve space. b_1 is expressed in counts per sample interval of 1/1200 s, normalised to $b_1 = 6200$ at $Hp = 0$ mag.

Fields JT7–10: Normalised signal parameters b_2/b_1 to b_5/b_1

The unit for b_2 to b_5 is the same as for b_1, so the normalised quantities are dimensionless. In practice they range from -1 to $+1$.

Fields JT11–15: Standard errors σ_i of the signal parameters b_i, given as natural logarithms $\ln \sigma_i$ ($i = 1$ to 5)

The standard errors are expressed in the same unit as the signal parameters.

Fields JT16–17: Colour correction factors, s_1 and s_2

See Section 2.9.3 for an explanation of these quantities. They are expressed in mag^{-1}.

Field JT18: Additional attitude noise, σ_{att}

See Section 2.9.3 for an explanation of this quantity. It is expressed in milliarcsec.

Field JT19: Flag indicating computed (0) or assumed (1) standard errors

This flag is normally set to 0. In some cases when the standard errors in Fields JT11–15 could not be computed in the normal way, this flag is set to 1 and Fields JT11–15 give the median standard errors applicable to the target position. Flagged transits should be treated with caution (see Section 2.9.3).

Table 2.9.1. Hipparcos Transit Data: Header Record

Field	Bytes	Format	Description
JH1	1–7	I6,X	HIP identifier for the first pointing in the system
JH2	8–14	I6,X	Additional HIP identifier (set to 0 if not used)
JH3	15–21	I6,X	Additional HIP identifier (set to 0 if not used)
JH4	22–24	I2,X	Number of different target positions, N_P
JH5	25–28	I3,X	Number of following transit records, N_T
JH6	29–41	F12.8,X	Right ascension of reference point, α_0 (deg)
JH7	42–54	F12.8,X	Declination of reference point, δ_0 (deg)
JH8	55–61	F6.2,X	Parallax of reference point, π_0 (mas)
JH9	62–70	F8.2,X	Proper motion in α of reference point, $\mu_{\alpha*0}$ (mas/yr)
JH10	71–79	F8.2,X	Proper motion in δ of reference point, $\mu_{\delta 0}$ (mas/yr)
JH11	80–87	F7.3,X	Assumed $V - I$ for HIP identifier in Field JH1 (mag)
JH12	88–95	F7.3,X	Assumed $V - I$ for HIP identifier in Field JH2 (mag)
JH13	96–125	F7.3,23X	Assumed $V - I$ for HIP identifier in Field JH3 (mag)

Table 2.9.2. Hipparcos Transit Data: Pointing Record

Field	Bytes	Format	Description
JP1	1–2	I1,X	Index (1 to 3) for the HIP identifier of target position 1
JP2	3–6	I3,X	Offset in α for target position 1 (arcsec)
JP3	7–10	I3,X	Offset in δ for target position 1 (arcsec)
JP4	11–12	I1,X	Index (1 to 3) for the HIP identifier of target position 2
JP5	13–16	I3,X	Offset in α for target position 2 (arcsec)
JP6	17–20	I3,X	Offset in δ for target position 2 (arcsec)
JP7	21–22	I1,X	Index (1 to 3) for the HIP identifier of target position 3
JP8	23–26	I3,X	Offset in α for target position 3 (arcsec)
JP9	27–30	I3,X	Offset in δ for target position 3 (arcsec)
JP10	31–32	I1,X	Index (1 to 3) for the HIP identifier of target position 4
JP11	33–36	I3,X	Offset in α for target position 4 (arcsec)
JP12	37–40	I3,X	Offset in δ for target position 4 (arcsec)
JP13	41–42	I1,X	Index (1 to 3) for the HIP identifier of target position 5
JP14	43–46	I3,X	Offset in α for target position 5 (arcsec)
JP15	47–50	I3,X	Offset in δ for target position 5 (arcsec)
JP16	51–52	I1,X	Index (1 to 3) for the HIP identifier of target position 6
JP17	53–56	I3,X	Offset in α for target position 6 (arcsec)
JP18	57–60	I3,X	Offset in δ for target position 6 (arcsec)
JP19	61–62	I1,X	Index (1 to 3) for the HIP identifier of target position 7
JP20	63–66	I3,X	Offset in α for target position 7 (arcsec)
JP21	67–70	I3,X	Offset in δ for target position 7 (arcsec)
JP22	71–72	I1,X	Index (1 to 3) for the HIP identifier of target position 8
JP23	73–76	I3,X	Offset in α for target position 8 (arcsec)
JP24	77–80	I3,X	Offset in δ for target position 8 (arcsec)
JP25	81–82	I1,X	Index (1 to 3) for the HIP identifier of target position 9
JP26	83–86	I3,X	Offset in α for target position 9 (arcsec)
JP27	87–125	I3,36X	Offset in δ for target position 9 (arcsec)

Table 2.9.3. Hipparcos Transit Data: Transit Record

Field	Bytes	Format	Description
JT1	1–2	I1,X	Target position index (1 to N_P) for this record, I_P
JT2	3–13	F10.7,X	Epoch of the transit, t, in years from J1991.25(TT)
JT3	14–22	I8,X	Spatial frequency f_x (rad/rad)
JT4	23–31	I8,X	Spatial frequency f_y (rad/rad)
JT5	32–40	I8,X	Parallax phase factor f_p (rad/rad)
JT6	41–47	F6.3,X	Natural logarithm of b_1, $\ln b_1$
JT7	48–55	F7.4,X	Normalised signal parameter, b_2/b_1
JT8	56–63	F7.4,X	Normalised signal parameter, b_3/b_1
JT9	64–71	F7.4,X	Normalised signal parameter, b_4/b_1
JT10	72–79	F7.4,X	Normalised signal parameter, b_5/b_1
JT11	80–85	F5.2,X	Natural logarithm of σ_1, $\ln \sigma_1$
JT12	86–91	F5.2,X	Natural logarithm of σ_2, $\ln \sigma_2$
JT13	92–97	F5.2,X	Natural logarithm of σ_3, $\ln \sigma_3$
JT14	98–103	F5.2,X	Natural logarithm of σ_4, $\ln \sigma_4$
JT15	104–109	F5.2,X	Natural logarithm of σ_5, $\ln \sigma_5$
JT16	110–114	F4.2,X	Colour correction factor, s_1 (mag^{-1})
JT17	115–119	F4.2,X	Colour correction factor, s_2 (mag^{-1})
JT18	120–124	F4.1,X	Additional attitude noise, σ_{att} (mas)
JT19	125	I1	Flag for computed (0) or assumed (1) standard errors