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Mining in the Hipparcos raw data⋆

J.L. Falin and F. Mignard

Observatoire de la Côte d'Azur, CERGA, UMR CNRS 6527, Av. N. Copernic, F-06130 Grasse, France

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Abstract. The Hipparcos solutions flagged as unreliable after the completion of the standard data processing have been systematically revisited in the light of additional information, primarily related to their multiplicity. In many cases improved solutions have been obtained, yielding at the same time an Hipparcos based separation and position angle and a better astrometric solution for the system. The principles applied in this reprocessing are explained and more than a hundred new solutions with absolute and relative astrometry are presented and discussed.

Key words: stars: fundamental parameters — binaries: general — astrometry — stars: distances

1. Introduction

The processing of the Hipparcos observations culminated in June 1997 with the official publication of the astrometric solutions of nearly 118 000 stars included in the Hipparcos Catalogue (ESA 1997). The average astrometric precision for the bulk of the Catalogue is about 1 mas in each of the five astrometric parameters: position, parallax and the two components of the proper motion. However, due to time constraints, it was known at the time of publication that the solutions for about one thousand stars were not fully satisfactory and for 263 entries no solutions at all were found acceptable from the data.

The raw data have been archived by each of the two consortia and intermediate data have been published with the other Hipparcos products. Relieved from the pressure of the publication schedule we have revisited the solutions not considered as final in the Hipparcos Catalogue, taking advantage of updated information regarding their multiplicity status. The criteria used to identify the *doubtful* Hipparcos solutions are given below in Sect. 3, but by itself this flagging was not a sufficient condition to start a new processing.

First, new information not used in the mass processing had to be available, otherwise there were no chances to get something really different. Secondly, as a result of the organisation of the file storage in the FAST consortium, there were only about 20 000 stars detected as non-single for which a new double star treatment was feasible. Thus all the stars re-examined for duplicity problems were in this set. The vast majority of the improved solutions belong to this category.

Unlike the results available in the Hipparcos Catalogue, the solutions presented in this paper do not follow from a cross-check between the two consortia and are entirely based on the software developed by teams of the FAST consortium and published under the sole scientific responsability of the authors.

2. The Hipparcos processing

Before proceeding with the new solutions it is worth recalling the various categories of astrometric solutions published in the Hipparcos Catalogue. The Hipparcos Catalogue is the primary result of the observations and reductions of the satellite data acquired over 37 months between November 1989 and March 1993. The Catalogue comprises 118 218 entries with median astrometric positions of the order of 1 milliarcsec and specific results (separation, magnitude difference) for double and multiple systems. For single stars the standard astrometric model yields the five astrometric parameters (position, parallax and the two components of the proper motion) together with their full covariance matrix.

Many catalogue entries were known to be, or found to be, components of a double or multiple system. The final astrometric solution for these complex entries, given either for the photocenter of the system or for the brighter component, is fully independent of the relative position of the

Send offprint requests to: F. Mignard, mignard@obs-azur.fr

⋆ Tables 1 to 7 are also available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html two components. In cases of detected duplicity the observation model had to be extended to account for resolved systems or for systems exhibiting a significant motion on the sky over the mission. One major difficulty in the double star processing was the consequence of the large variety of categories of systems and the difficulty to solve simultaneously for the relative and absolute astrometry.

It was clear when the time came to publish the results that several hundred problem stars were left and their solution could not be given with the same level of reliability as for the bulk of the Catalogue. The main problems were primarily linked to the double and multiple star solutions and much more time would have been required to clear the remaining difficulties for a subset no larger than a thousand stars. The main sources of problems were:

- Due to the presence of a periodic modulation grid, the relative position between the two components of a double system may be wrong by an integral number of grid periods, of about 1.2 arcsec. Should this happen, for particular elementary observations and provided it remained undetected, no reliable astrometric solution can be obtained in the subsequent processing.
- The double star processing may provide numerous spurious solutions and in some instances the final choice was based on the fact that a solution was found in close agreement with the ground based configuration. If the latter was not correct, because of a misidentification or because of the relative motion since the measurement epoch, the error was propagated in the Hipparcos solution.
- Finally the data processing by FAST and NDAC may have led to different solutions for the parameters of a binary and a choice was made at the end. Either one solution was retained or the entry was classified as suspect binary and processed as single. In such a case the final fit was usually of poor quality and published with a warning or with large standard errors.

3. The doubtful solutions

The observations reinvestigated during this work are limited to the Hipparcos entries for which a problem has been detected in the routine processing. This does not mean that all such solutions are spurious, in fact most of them are correct, but the proportion of unreliable solutions is larger in this group than in the rest of the Catalogue.

The final statistics published in the Catalogue documentation (ESA 1997, Vol. 1) give an order of magnitude of the number of entries to be reinvestigated on a case by case basis. In addition the different categories help understand what kind of problem may be expected in the reprocessing and provide hints to orient the search for new information.

1. There were 263 entries with no astrometric solution published. Only 10 were not observed because of large errors in the Input Catalogue positions, while 253 solutions were finally rejected as inadequate.
2. The solutions with a time dependent proper motion (solutions flagged G in the Catalogue) refer probably to astrometric binaries with periods above about 10 years. There are 2622 such solutions.
3. The stochastic solutions (flagged X in the Catalogue) that is to say published solutions for which it was not possible to find an acceptable single or multiple star solution in reasonable agreement with the random error of the abscissas. While a significant fraction might be short period astrometric binaries, many others could be true double stars with inadequate relative astrometry.

In addition to these broad categories, there are two other indications that can be used to pinpoint questionable solutions:

1. Under field H29 one finds the percentage of data that has been rejected in order to converge to an acceptable fit. In general this number is below 10% and a larger value is an indication that the solution should be taken with care as a significant number of outliers has been discarded.
2. The field H30 attempts to quantify the quality of the final fit, when the outliers have been removed. Values larger than 3 or 4 indicate a bad fit to the data.

4. Sources of new data

Most of the new solutions given in the following sections were made possible because of the availability of several pieces of information that were not used during the data processing for lack of time, or simply because the information did not exist at that time or was overlooked. Essentially, the new data consists of updated values for the relative astrometry and/or photometry of double stars.

As mentioned above the grid step error could be avoided if a good a priori separation and position angle could be secured to select the most likely solutions among the two or three possible. It is worth emphasising that for the vast majority of the double stars solved from the Hipparcos data, the processing was self-sufficient and did not need to rely on a good starting point. Only when the double star signal was too weak or the observation equations poorly conditioned was the starting value more crucial. This concerned only a small fraction of the Hipparcos double stars, but a large fraction of the subset reinvestigated in this paper.

Several sources were used to reprocess the Hipparcos observations of the selected doubtful solutions:

- The Tycho Catalogue includes components of wide binaries ($\rho \geq 3$ arcsec) observed as two independent entries provides they are brighter than $V = 10.5$. From the individual astrometric solutions it was easy

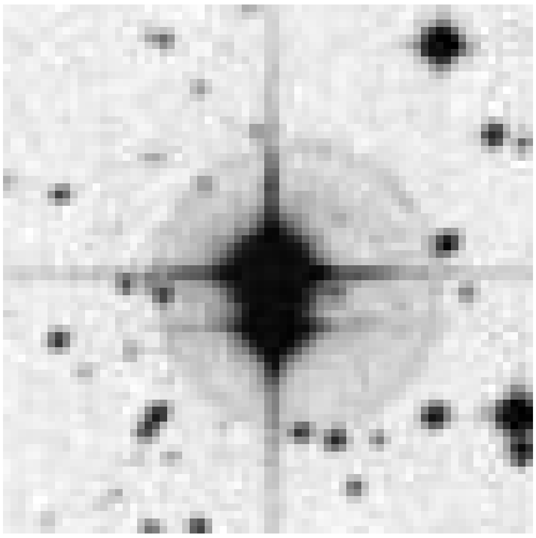

Fig. 1. Example of a binary system (HIP 34707) measured over a field of 120×120 arcsec from the STScI Digitized Sky Survey (1st epoch) and showing well detached components. A crude measurement in the image gave $\rho = 12''.0$ and $\theta = 180$ deg. From the Hipparcos observations one gets respectively $12''.14$ and 183.8 deg

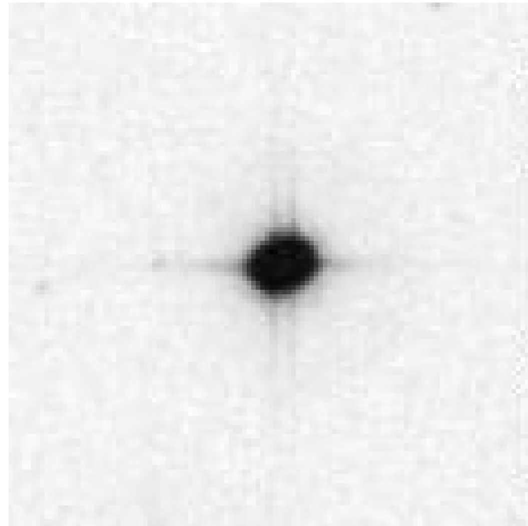

Fig. 2. Example of a binary system (HIP 21000) measured over a field of 120×120 arcsec from the STScI Digitized Sky Survey (2nd epoch) near the lower limit of resolution. A crude measurement in the image gave $\rho = 4''.3$ and $\theta = 290$ deg. From the Hipparcos observations one gets respectively $4''.37$ and 289 deg

to derive the separation and position angle of the two components.
- For each of the suspected binaries not solved from the Hipparcos data, we have systematically extracted a field from the Digitized Sky Survey, either from the first or second epoch. When the separation between the two components is larger than about 5 arcsec this was easily detected as an elongated image or two well-defined stellar images. A rough measurement was sufficient to provide a reliable input for ρ and θ which was then used for the starting value in the Hipparcos double star software. Figures 1-2 show two examples taken respectively from the the first and second epoch of the Digitized Sky Survey.
- In some cases the Input Catalogue provided valuable information not fully exploited during the automatic data processing essentially because of the complexity of sorting out the components of the multiple systems, a practical problem which did not fit easily within a mass processing with stringent time constraints.
- Finally recent CCD observations of visual double stars yielded updated or new astrometric parameters for several systems (Cuypers et al. 1998; Lampens et al. 1998; Oblak 1998).

5. The solutions

The new solutions are presented in Tables 1-7 with a layout close to that of the Hipparcos Catalogue for the relevant columns. For each Hipparcos entry there are one line (Table 1) or two lines (all the other tables). In the latter case the first line reproduces the Hipparcos solution as it appears in the Catalogue, while the second line gives the corresponding values from the new processing. Only the second line appears in Table 1.

The column headers are self-explanatory and the Hipparcos field is indicated in the last row of the header, so that the detail explanation can be found in the Introduction to the Hipparcos and Tycho Catalogues. The column labelled *Sce* indicates the source of the new information that has been found and which motivated the reprocessing. It has the following meaning:

- TYC: The Tycho positions of each component of a double were used to derive the relative parameters. For single stars the astrometric solution allowed to correct the remaining grid-step errors in the approximate position.
- SS1 - SS2: A double star has been identified in the STScI Digitized Sky Survey (SS1: first epoch, SS2: second epoch) and approximate ρ and θ were determined directly on the image as shown in Figs. 1-2.
- CUY, LAM, OBL: Recent CCD observations of wide binaries have been provided by Cuypers et al. (1998), Lampens et al. (1998) and Oblak (1998). These data were very useful to get rid of the remaining grid-step errors in the relative astrometry of these systems.
- HIC: The Hipparcos Input Catalogue was the source for an updated separation. The information was previously available, but not comprehensively used during the mass processing.

The column F1 gives the percentage of rejected observations while F2 is the goodness-of-fit of the astrometric solution to the accepted observations. For a Gaussian

Table 1. Stars with no Hipparcos astrometric solutions. In Tables 1-7, column numbers follow the field designation of the published Hipparcos Catalogue

ID	**Pos: ICRS – J1991.25**		**Par.**	**Prop. Motion**		**Standard errors**					**Soln.**		**Multiplicity**					
HIP	α	δ	π	$\mu_{\alpha*}$	μ_δ	$\sigma_{\alpha*}$	σ_δ	σ_π	σ_{μ_α}	σ_{μ_δ}	F1	F2	Sce	θ	ρ	σ_ρ	ΔHp	σ
	deg	deg	mas	mas/yr			mas		mas/yr		%			deg	″	″	mag	mag
1	8	9	11	12	13	14	15	16	17	18	29	30		63	64	65	66	67
1338	4.18700521	41.06905721	18.92	190.14	27.75	4.4	3.6	6.6	6.3	4.5	21	2.93	TYC	331	9.922	0.013	1.15	0.03
18045	57.84982093	−25.93298679	21.42	273.72	167.93	2.8	2.5	4.3	2.9	3.1	33	2.61	SS2					
27464	87.24506095	63.69702032	4.12	5.07	−98.19	9.3	11.7	16.0	10.3	13.7	16	4.38	TYC	259	4.180	0.023	0.32	0.03
31132	97.98452970	−27.72950422	17.95	21.31	217.87	1.8	1.7	2.6	2.2	2.3	6	4.80	TYC					
34226	106.43757563	26.14031575	21.74	18.58	−10.54	11.7	6.6	12.0	13.1	9.7	40	2.93	HIC	213	1.666	0.015	0.07	0.01
35311	109.41026120	−29.01434479	7.92	−4.53	−7.01	6.1	8.4	11.4	7.7	11.5	8	1.27	SS2	161	8.311	0.018	0.80	0.02
41884	128.10658000	−0.95292566	−2.02	−6.15	13.79	2.6	2.8	3.7	3.4	2.8	36	3.49						
51496	157.76458366	−21.64374499	21.86	240.98	−355.39	3.4	2.9	3.1	3.1	2.6	36	3.40	TYC					
59154	181.96462412	−75.92111154	68.10	−159.60	−107.29	5.4	11.1	7.4	6.4	15.6	60	2.06	TYC	268	1.042	0.009	0.06	0.01
81402	249.38478619	−5.50508816	24.33	−104.04	12.86	9.2	7.5	9.3	15.4	14.0	9	2.11	TYC	10	6.726	0.008	0.05	0.02
81694	250.32376113	30.10980007	75.41	−96.76	86.94	6.8	12.8	11.6	9.1	16.4	35	2.31	TYC	155	0.595	0.015	0.78	0.02
86405	264.83534539	−75.07618015	−1.24	6.63	−7.45	4.4	4.5	6.5	5.1	5.4	19	2.87						
98713	300.75640066	−76.13312308	14.78	188.39	−169.99	1.2	1.6	1.9	1.4	1.8	21	4.04	TYC					

distribution of the residuals, F2 follows a standard normal law of zero mean and unit variance so that values of F2 less than 2–3 are typical for a good fit.

Each table, or group of two tables for the largest, refers to a single category of re-examined solutions listed in Sect. 3. No star appears in more than one table.

5.1. Stars with no Hipparcos solutions

Among the 263 entries with no astrometric solution, a certain number already appear in the Catalogue notes with a solution derived after the Catalogue was finalized with absolute and/or relative parameters different from those appearing in the standard layout. These entries have not been re-examined and consequently are not included in the accompagnying table. The 13 genuine new solutions from this subset are given in Table 1. Most were recognized as overlooked double stars, or known double stars with unsatisfactory relative solutions such that the astrometric parameters could not be derived.

Specific comments

• **HIP 1338**: While the Tycho Catalogue was the basic source for the relative astrometry, a similar separation was found in the Digitized Sky Survey and in recent ground based observations. The Hipparcos solution given here can be considered as reliable. The residuals remain fairly large which can be attributed to the photometric variability detected from the Hipparcos data. The astrometric parameters are found to agree with the Tycho solution, but both the parallax and proper motions are more accurate.

• **HIP 18045**: The SS2 has been used to search for a star close to the position given in the Hipparcos Input Catalogue. The Hipparcos target was about 20 arcsec from the actual star and consequently the signal recorded was weak and highly variable according to the detector pointing and too far away from the true value to allow a convergence of the software. However the SS2 position was good enough as starting values and the iteration converged to an acceptable solution. A note in the Hipparcos Catalogue indicates that TYC 6451-1246-1 ($\alpha = 57.854\,289, \delta = -25.929\,220$) could be the corresponding star. In fact this is very likely a spurious solution (nothing seen in the SS2 there) while TYC 6451-122-1 is within 20 mas of our solution and with comparable magnitude (allowing for the attenuation effect due to the pointing offset). The new solution provides a reliable parallax and proper motion with standard errors of about 3 mas.

• **HIP 27464**: This is probably an optical pair (different proper motions in the Tycho solutions). The solution agrees with TYC 4098-5-1.

• **HIP 31132**: The observation target was 7 arcsec from the star and the proper motion in right ascension and declination were so far from the true values that no convergence was possible. A dedicated setting in the software overcame this problem and yielded a good solution in terms of standard errors but with a questionable goodness-of-fit.

• **HIP 34226**: A binary with components of similar brightness which accounts for the very large standard errors. The two components appear as TYC 1899-1444-1 and 1899-1444-2, but the Hipparcos solution lies somewhere in between. With a separation less than 2 arcsec the two components were hardly discernible with the Tycho detection system.

Table 2. New component solutions for stars flagged *C* in Field 61 of the main Catalogue

ID	**Pos: ICRS – J1991.25**		**Par.**	**Prop. Motion**		**Standard errors**					**Soln.**		**Multiplicity**					
HIP	α	δ	π	$\mu_{\alpha*}$	μ_δ	$\sigma_{\alpha*}$	σ_δ	σ_π	σ_{μ_α}	σ_{μ_δ}	F1	F2	Sce	θ	ρ	σ_ρ	ΔHp	σ
	deg	deg	mas	mas/yr			mas		mas/yr		%			deg	″	″	mag	mag
1	8	9	11	12	13	14	15	16	17	18	29	30		63	64	65	66	67
8035	25.79679313	−58.00966878	24.30	−149.96	−187.83	1.6	1.9	2.1	1.7	1.8	2	4.10		323	11.917	0.102	3.75	0.63
8035	25.79679300	−58.00966727	22.86	−147.52	−186.35	1.8	1.9	2.3	2.0	2.1	0	2.79	CUY	338	13.313	0.031	2.65	0.05
11241	36.17354217	−20.03946141	13.89	−10.81	−15.61	2.1	2.0	2.6	2.3	2.1	1	3.21		269	4.004	0.063	3.21	0.31
11241	36.17354338	−20.03946045	15.81	−12.47	−19.23	2.1	1.6	2.5	2.2	1.9	15	0.24	SS1	206	17.300	0.020	2.50	0.10
13725	44.19785540	−36.15195895	17.32	−171.34	−267.13	47.5	45.7	7.3	6.1	7.8	0	2.98		311	0.331	0.130	1.28	1.18
13725	44.19783994	−36.15194820	16.41	−173.11	−264.55	1.0	1.0	1.6	1.3	1.4	0	0.48						
23525	75.85924636	70.82497191	5.56	−7.51	−0.92	1.1	1.6	1.9	1.1	1.6	1	4.21		356	4.418	0.036	3.11	0.15
23525	75.85924652	70.82497258	2.87	−7.05	−4.83	1.6	2.3	3.3	1.8	2.5	1	2.35	OBL	34	7.565	0.015	2.22	0.05
30473	96.09494454	5.32410878	0.34	−0.91	−3.26	2.6	1.9	2.5	3.1	2.4	0	3.04		273	4.095	0.045	2.66	0.11
30473	96.09494363	5.32410944	3.23	−3.07	−6.73	2.5	1.9	2.8	3.4	2.6	0	−1.40	SS1	192	9.486	0.020	2.40	0.04
31577	99.13421012	7.71037953	5.78	−1.19	−8.18	3.9	2.8	3.7	4.0	3.1	0	3.29		201	3.153	0.021	1.86	0.18
31577	99.13421071	7.71037807	2.00	−5.85	−1.36	4.4	3.4	5.0	5.1	4.3	11	−0.39	SS1	44	10.399	0.011	1.57	0.03
35580	110.13591229	−36.91725203	2.58	−6.57	−0.31	1.6	1.9	1.9	1.7	1.9	0	3.68		190	1.432	0.047	2.96	0.27
35580	110.13591126	−36.91725318	1.30	−4.83	0.75	2.2	2.4	2.9	2.4	2.8	0	0.95	SS2	220	14.591	0.032	2.40	0.08
38479	118.21548125	−7.97139762	−1.23	−6.50	1.26	1.8	1.9	2.6	1.9	1.9	10	1.15		253	8.211	0.014	2.34	0.07
38479	118.21548086	−7.97139764	1.25	−6.17	−0.05	1.8	1.7	2.6	2.2	2.1	0	1.48	CUY	251	9.372	0.011	2.25	0.03
44488	135.96513193	−72.38565507	6.48	−29.62	49.15	1.9	1.9	1.9	2.1	1.9	2	6.49		206	9.065	0.048	3.01	0.26
44488	135.96512167	−72.38565686	3.76	−29.04	47.23	1.9	1.8	2.0	2.4	2.0	2	0.08	CUY	191	11.961	0.017	2.26	0.05
68743	211.07160495	−57.47373259	7.14	−53.26	−20.72	1.5	1.6	2.1	1.7	1.8	7	0.65		14	14.741	0.115	3.53	0.51
68743	211.07160488	−57.47373212	7.37	−54.96	−21.89	1.3	1.3	1.9	1.7	1.7	0	2.92	CUY	29	17.215	0.014	2.50	0.05
69736	214.10562748	−52.41683655	4.31	−49.83	−26.52	4.8	4.9	6.4	5.3	5.8	3	4.68		357	4.518	0.058	2.32	0.38
69736	214.10562828	−52.41683681	9.78	−54.92	−28.31	2.3	2.4	3.3	2.9	3.0	0	2.09	SS2	34	16.418	0.029	2.31	0.10
71867	220.49095889	17.88542451	25.17	29.64	−134.33	7.4	6.6	9.1	8.6	7.7	26	5.05		213	3.982	0.046	1.75	0.26
71867	220.49095841	17.88541837	13.88	36.44	−136.87	0.9	1.0	1.3	1.0	1.2	0	0.13	SS2					
72918	223.53947413	−39.27834474	10.49	−0.12	−24.03	3.0	2.7	3.0	3.0	2.8	5	3.97		271	1.016	0.065	2.65	0.32
72918	223.53947840	−39.27834278	12.28	−3.67	−24.69	2.1	1.8	2.4	2.4	2.2	0	3.64	SS2	266	18.384	0.014	1.75	0.05
76435	234.17000813	−42.13015514	15.64	−44.99	−83.52	4.0	3.1	4.6	3.9	3.4	15	5.36		250	4.296	0.044	2.12	0.12
76435	234.17000648	−42.13015486	14.35	−44.57	−87.23	2.0	1.5	2.5	2.3	2.2	0	2.36	TYC	183	13.523	0.009	1.80	0.04
79902	244.64330072	−51.55184226	2.05	13.81	−1.07	1.7	1.3	2.0	2.0	1.6	5	0.57		227	16.761	0.104	3.46	0.53
79902	244.64330082	−51.55184201	1.92	12.31	−2.96	1.4	1.0	1.9	1.7	1.5	0	0.57	LAM	346	3.689	0.010	3.60	0.06

Table 3. Hipparcos solutions with time dependent proper motions (stars flagged G in field 61 of the Hipparcos Catalogue)

ID	**Pos: ICRS – J1991.25**		**Par.**	**Prop. Motion**		**Standard errors**					**Soln.**		**Multiplicity**					
HIP	α	δ	π	$\mu_{\alpha*}$	μ_δ	$\sigma_{\alpha*}$	σ_δ	σ_π	σ_{μ_α}	σ_{μ_δ}	F1	F2	Sce	θ	ρ	σ_ρ	ΔHp	σ
	deg	deg	mas	mas/yr			mas		mas/yr		%			deg	″	″	mag	mag
1	8	9	11	12	13	14	15	16	17	18	29	30		63	64	65	66	67
23266	75.08710013	1.00657023	10.79	64.42	16.87	1.9	0.9	1.8	2.3	1.1	0	3.60						
23266	75.08709728	1.00657071	7.05	47.38	20.16	2.3	1.3	2.4	2.9	1.5	4	0.85	SS2	189	7.387	0.025	3.50	0.08
38297	117.69563985	−49.37514976	10.56	−57.19	152.08	0.9	0.9	1.1	1.0	1.0	1	2.90						
38297	117.69563969	−49.37514988	8.32	−58.68	153.71	1.3	1.3	1.4	1.5	1.4	3	1.49	SS1	60	15.389	0.028	3.80	0.10
92741	283.48761242	15.25989924	1.14	−0.16	−0.99	1.0	0.9	1.2	1.4	1.1	0	1.95						
92741	283.48761202	15.25989956	1.60	1.46	−6.21	2.3	2.0	2.7	2.5	2.3	4	0.47	SS2	9	12.569	0.047	3.28	0.13
99522	302.96915835	3.80153592	5.59	−1.91	−9.50	1.0	0.9	1.1	1.3	1.0	0	3.11						
99522	302.96915810	3.80153606	5.83	−4.14	−9.53	1.3	1.0	1.6	1.9	1.4	0	1.22	SS2	168	20.759	0.029	2.50	0.10

• **HIP 41884**: Solution at 30 mas from TYC 4862-794-1, but large pointing offset (15 arcsec) due to a poor position in the Input Catalogue.

• **HIP 81402**: The initial separation and position angle were taken from the Input Catalogue and confirmed by Tycho. The Hipparcos solution for the relative astrometry is excellent. However the large standard errors in the astrometric parameters are a consequence of the very small magnitude difference between the two components.

• **HIP 81694**: Orbital double star not resolved as double by Tycho. The target was at 18 arcsec from the actual star position and is responsible for the instability of the signal and the large standard errors.

Table 4. Suspected doubles (HIP < 60 000) flagged S in field 61 of the main Catalogue

ID	**Pos: ICRS – J1991.25**		**Par.**	**Prop. Motion**		**Standard errors**					**Soln.**		**Multiplicity**					
HIP	α	δ	π	$\mu_{\alpha*}$	μ_δ	$\sigma_{\alpha*}$	σ_δ	σ_π	σ_{μ_α}	σ_{μ_δ}	F1	F2	Sce	θ	ρ	σ_ρ	ΔHp	σ
	deg	deg	mas	mas/yr		mas			mas/yr		%			deg	″	″	mag	mag
1	8	9	11	12	13	14	15	16	17	18	29	30		63	64	65	66	67
820	2.51916096	86.02305546	1.08	23.08	0.90	0.8	0.9	0.9	0.8	0.8	2	3.05						
820	2.51916477	86.02305529	0.34	21.32	2.20	1.1	1.2	1.3	1.2	1.2	0	1.13	SS1	109	13.300	0.024	3.90	0.10
11498	37.07185012	68.65631480	1.01	−4.30	−1.52	0.8	0.9	1.3	0.8	1.0	2	3.27						
11498	37.07185020	68.65631505	0.62	−2.41	−4.15	1.2	1.4	2.0	1.4	1.6	0	−0.49	SS1	3	7.399	0.031	3.40	0.05
12469	40.13193708	61.22933035	5.65	0.62	1.63	1.6	1.4	2.3	2.0	1.8	5	1.98						
12469	40.13193744	61.22933194	2.75	−1.78	−2.27	3.2	2.7	4.3	4.0	3.6	0	0.08	SS1	165	11.654	0.038	2.70	0.09
21000	67.55216585	5.29852669	84.76	106.90	119.86	4.3	3.7	4.7	5.5	5.2	20	2.67						
21000	67.55220109	5.29849446	4.50	48.49	−2.80	7.1	5.4	7.5	9.3	8.1	0	1.09	SS2	289	4.370	0.006	0.30	0.01
21568	69.45081896	68.54668243	3.29	4.27	−1.20	0.5	0.8	1.0	0.7	1.0	5	1.76						
21568	69.45081853	68.54668183	2.74	1.52	−3.70	0.8	1.2	1.6	1.1	1.5	0	0.23	SS1	249	17.902	0.035	3.20	0.10
23290	75.14656227	−46.65648460	7.26	14.60	−45.24	0.8	0.8	0.9	0.9	0.9	3	1.22						
23290	75.14656257	−46.65648470	7.52	15.17	−48.20	1.5	1.5	1.7	1.8	1.8	0	0.52	SS2	286	7.966	0.050	3.75	0.10
26850	85.50569483	40.26013788	8.74	−25.57	−4.26	1.4	1.1	1.5	1.7	1.2	3	3.92						
26850	85.50569457	40.26013689	6.05	−26.09	−7.17	2.4	1.8	2.6	3.2	2.3	0	−0.24	SS1	273	17.994	0.033	2.50	0.10
31803	99.73607181	−30.05761786	2.06	4.32	13.52	0.9	1.0	1.3	1.0	1.2	2	3.93						
31803	99.73607215	−30.05761783	2.53	5.06	10.66	1.1	1.3	1.7	1.3	1.6	0	2.32	SS2	335	24.198	0.022	1.50	0.10
33310	103.92936618	8.46021842	1.79	−1.15	−3.11	1.1	0.8	1.3	1.0	0.8	5	3.52						
33310	103.92936681	8.46022007	1.48	−2.16	−4.58	4.2	3.1	4.7	4.4	3.7	0	0.49	SS2	203	10.072	0.029	2.56	0.18
39673	121.60958885	−9.23732093	2.97	−2.81	3.50	0.8	0.8	1.2	1.0	0.9	9	2.36						
39673	121.60959062	−9.23732133	3.55	−3.88	2.69	1.8	1.5	2.3	2.1	1.9	9	−0.87	HIC	324	1.410	0.051	3.70	0.10
42159	128.91409862	9.49909613	2.20	−12.29	−4.92	1.3	0.9	1.4	1.6	1.2	0	3.19						
42159	128.91409741	9.49909691	2.96	−12.64	−4.65	2.1	1.4	2.3	2.6	1.9	0	−0.36	SS1	337	7.015	0.063	3.80	0.09
44632	136.42156224	−8.26096964	0.52	−22.10	−29.51	1.9	1.6	2.2	2.0	1.6	5	3.10						
44632	136.42156328	−8.26097114	3.01	−21.88	−28.61	3.0	2.7	3.7	3.2	2.6	5	−0.37	SS2	346	16.535	0.034	2.50	0.10
45434	138.89003877	−54.96621382	2.40	−14.71	10.46	0.7	0.8	0.8	0.8	0.8	5	1.51						
45434	138.89003854	−54.96621359	2.32	−14.26	10.15	0.8	1.0	1.0	0.9	1.1	2	0.67	SS1	162	26.211	0.026	1.35	0.10
46115	141.06822209	−26.25526021	−0.32	5.50	−14.37	1.0	1.0	1.7	1.4	1.2	0	1.57						
46115	141.06822181	−26.25526023	−0.10	4.82	−15.56	1.4	1.3	2.2	1.8	1.6	0	−0.28	SS1	186	17.077	0.018	3.15	0.05
47289	144.55556442	−52.69311119	1.29	−15.74	4.09	0.5	0.6	0.7	0.5	0.6	3	2.82						
47289	144.55556434	−52.69311127	3.15	−15.98	4.46	0.8	0.9	1.0	0.9	1.0	2	1.58	SS2	100	16.658	0.034	3.55	0.08
55098	169.21216488	−61.08555370	7.64	−31.03	2.30	0.9	0.8	1.1	1.0	0.9	3	3.55						
55098	169.21216391	−61.08555386	6.91	−29.25	2.06	1.4	1.3	1.8	1.7	1.5	0	0.45	SS1	8	16.519	0.038	3.25	0.10
59193	182.08585165	43.90709433	15.16	−51.22	41.10	0.7	0.7	1.2	0.8	1.1	3	3.37						
59193	182.08585025	43.90709444	14.91	−50.75	39.91	1.6	1.5	2.5	1.9	2.4	0	−0.22	TYC	266	16.824	0.054	2.95	0.10

• **HIP 86405**: No new input data were used but the case by case processing allows a better control of the outliers and more observation were a priori rejected.

5.2. Stars with new component solutions

Table 2 corresponds to solutions of double stars published in the Hipparcos Catalogue and in the Double and Multiple Systems Annexe C. In all of these cases we have found that the relative astrometry of the double was wrong by one or several grid-steps or, in two cases, that a single star solution fitted the data much more satisfactorily. Thanks to new ground based observations or again from the two Digitized Sky Surveys it was possible to determine a more reliable separation and position angle and to solve the grid-step ambiguity unresolved by Hipparcos.

The improvement in the final astrometric solution shows up clearly in the number of rejected observations, the quality of the goodness-of-fit and/or the standard error. The solutions refer to the primary components of the double systems. In general the astrometric solutions are not very different from that of the Catalogue, primarily because the double stars involved generated a weak deviation from the single star signal and the absolute astrometry was not too sensitive to an error in the separation of the two components. However the multiplicity data given here supersede the Hipparcos values.

Specific comments

• **HIP 8035**: The relative astrometry of the Hipparcos Catalogue is proved wrong by subsequent ground based observations. Using this constraint the standard error of the separation concluded from the Hipparcos data is greatly improved. The new astrometric solution fits the data more closely.

Table 5. Suspected doubles (HIP > 60 000) flagged *S* in field 61 of the main Catalogue

ID	Pos: ICRS – J1991.25		Par.	Prop. Motion		Standard errors					Soln.		Multiplicity					
HIP	α	δ	π	$\mu_{\alpha*}$	μ_δ	$\sigma_{\alpha*}$	σ_δ	σ_π	σ_{μ_α}	σ_{μ_δ}	F1	F2	Sce	θ	ρ	σ_ρ	ΔHp	σ
	deg	deg	mas	mas/yr		mas			mas/yr		%			deg	″	″	mag	mag
1	8	9	11	12	13	14	15	16	17	18	29	30		63	64	65	66	67
61439	188.83949395	−10.61293188	2.41	32.37	−19.79	1.3	1.0	1.5	1.3	0.9	4	4.31						
61439	188.83949199	−10.61293089	4.81	31.84	−18.00	1.8	1.4	2.1	2.0	1.3	0	1.52	SS1	230	8.167	0.014	3.47	0.06
66644	204.91865397	−60.85161857	1.91	−11.68	−6.64	0.7	0.8	1.2	1.0	1.0	3	2.02						
66644	204.91865408	−60.85161852	2.33	−11.41	−5.69	1.2	1.3	2.1	1.7	1.7	0	0.31	SS1	240	8.005	0.040	4.00	0.10
67079	206.22221636	8.36798862	3.09	−0.87	6.53	1.2	0.9	1.5	1.3	1.0	0	1.38						
67079	206.22221620	8.36798899	2.63	−1.46	5.44	1.6	1.3	1.9	1.7	1.4	0	0.26	SS1	357	17.912	0.044	3.70	0.08
67722	208.10465008	−51.82267438	−2.64	−8.49	−0.60	0.8	0.8	1.3	0.9	0.9	3	2.90						
67722	208.10464872	−51.82267410	1.39	−10.49	0.28	1.2	1.1	1.8	1.4	1.2	0	0.48	SS2	215	13.033	0.025	3.40	0.05
69440	213.24941275	−55.33238806	1.21	−7.30	−8.85	0.9	0.7	1.1	1.0	0.8	1	3.49						
69440	213.24941351	−55.33238801	1.38	−6.91	−5.16	1.3	1.1	1.8	1.6	1.4	0	−1.09	SS1	221	13.462	0.035	3.70	0.10
70053	215.03859190	−4.86884902	8.68	−3.28	−89.20	1.6	1.0	1.6	1.8	1.2	8	3.34						
70053	215.03859086	−4.86884852	9.95	−3.53	−87.39	2.2	1.5	2.3	2.6	1.8	0	1.33	SS1	109	22.416	0.024	1.50	0.10
72144	221.34644463	29.18163308	1.77	6.60	−1.88	0.9	1.1	1.8	1.1	1.4	3	2.30						
72144	221.34644446	29.18163382	5.03	7.90	−4.11	1.4	1.7	2.6	1.7	2.0	0	−1.35	SS1	125	13.680	0.028	3.50	0.10
73487	225.28660710	−36.84555936	8.22	−11.80	−11.94	1.2	1.0	1.4	1.5	1.2	6	3.14						
73487	225.28660762	−36.84555922	11.03	−13.00	−11.24	1.8	1.5	2.1	2.3	2.0	0	0.91	SS2	9	13.731	0.004	3.15	0.10
73545	225.47086047	−38.31727803	3.69	−0.23	−13.48	1.3	1.3	1.6	1.4	1.5	0	2.43						
73545	225.47086096	−38.31727835	3.08	0.62	−14.80	1.7	1.7	2.1	1.9	1.9	0	1.07	SS1	114	8.752	0.022	3.80	0.10
74830	229.39554772	−24.47721988	13.84	−17.97	−7.11	2.4	1.6	2.7	2.8	2.4	13	3.70						
74830	229.39554902	−24.47721874	1.50	−11.69	−5.61	3.9	3.1	4.9	4.9	4.4	6	−0.47	SS2	118	15.870	0.013	1.60	0.08
75408	231.11827177	−25.76277981	7.28	−5.27	2.60	1.4	1.1	1.8	1.6	1.3	0	2.51						
75408	231.11827271	−25.76278014	2.75	−7.33	1.75	2.2	1.8	3.1	2.5	2.1	0	−1.84	SS2	330	15.177	0.038	2.90	0.05
78263	239.70896160	−32.05224055	8.17	−12.57	−27.24	1.1	0.7	1.4	1.5	1.2	7	3.60						
78263	239.70896161	−32.05224048	11.05	−11.89	−26.29	1.6	0.9	1.9	2.1	1.6	0	0.49	SS2	266	14.874	0.022	3.40	0.05
78503	240.40068138	−15.22195278	4.05	16.13	−29.86	1.6	0.8	1.8	1.8	1.5	2	3.68						
78503	240.40068122	−15.22195274	2.33	14.64	−28.39	2.1	1.0	2.3	2.3	1.9	0	1.84	SS1	71	19.120	0.007	3.20	0.10
78804	241.32283335	−70.05854450	4.46	1.85	−9.43	0.7	0.9	1.3	0.7	1.0	4	1.97						
78804	241.32283416	−70.05854419	2.39	2.35	−10.93	1.1	1.5	2.0	1.2	1.8	0	0.39	SS2	307	12.215	0.023	3.40	0.09
80198	245.59029970	−31.25108578	3.56	4.68	−8.80	1.1	0.7	1.2	1.3	0.9	4	3.00						
80198	245.59030138	−31.25108613	2.02	3.59	−6.16	1.7	1.1	1.9	2.0	1.4	0	1.75	SS2	269	18.480	0.044	2.95	0.08
80582	246.79603256	−47.55473590	8.16	−13.72	−20.63	0.8	0.5	1.0	0.9	0.7	0	1.00						
80582	246.79603359	−47.55473559	4.89	−14.63	−19.25	1.3	0.7	1.7	1.3	1.0	0	−0.16	TYC	334	22.801	0.018	2.60	0.10
82536	253.06283884	−15.88301349	7.81	14.36	−0.73	2.0	1.2	2.4	2.2	1.6	10	4.59						
82536	253.06284251	−15.88301530	5.85	12.59	−1.01	3.0	1.9	3.6	3.6	2.5	0	−1.93	SS2	102	5.340	0.028	2.70	0.05
87345	267.71809592	−33.70566613	15.46	2.95	−2.84	2.3	1.3	2.4	2.0	1.4	13	1.94						
87345	267.71809804	−33.70566835	0.96	4.18	−2.58	2.3	1.5	2.7	2.7	1.9	0	1.06	SS1	219	14.397	0.013	2.40	0.06
88643	271.46779856	−37.82042532	6.23	−6.01	−19.53	1.8	1.2	2.0	2.4	1.3	13	3.35						
88643	271.46779976	−37.82042489	5.70	−3.19	−27.77	3.0	2.0	3.3	4.2	2.2	4	0.47	SS1	169	10.722	0.027	2.65	0.05
88737	271.72943557	14.13894075	21.30	38.82	−238.49	1.3	1.6	2.0	1.7	2.0	7	2.22						
88737	271.72943461	14.13894533	17.95	38.28	−238.39	2.4	2.5	3.6	3.0	3.2	0	−1.59	SS1	130	6.444	0.009	2.40	0.07
92029	281.36972769	−41.91777690	8.11	−2.94	−30.13	1.2	0.8	1.4	1.5	1.0	2	1.92						
92029	281.36972953	−41.91777752	8.15	−4.23	−29.13	2.3	1.5	2.6	2.9	1.9	0	−0.70	SS2	135	11.947	0.046	3.35	0.10
93477	285.55372091	−32.53908757	0.72	4.51	−6.65	5.8	3.5	5.9	8.8	5.0	0	2.78						
93477	285.55371956	−32.53908920	9.31	12.84	−7.88	8.4	5.0	8.6	12.7	7.1	0	−0.02	SS1	6	11.116	0.036	2.45	0.10
93626	285.99593107	−4.31718217	−7.64	0.04	−7.11	2.2	1.5	2.8	2.7	2.3	12	2.52						
93626	285.99592997	−4.31718404	5.29	1.34	−1.91	3.5	2.5	4.3	4.7	3.8	4	0.43	SS2	325	18.594	0.040	2.00	0.10
99348	302.46205314	−37.53067595	3.32	−9.35	−16.92	1.4	0.9	1.7	1.8	1.2	4	3.97						
99348	302.46205561	−37.53067603	2.03	−9.84	−17.06	2.4	1.3	2.6	3.2	1.8	4	1.87	SS2	123	8.271	0.027	3.60	0.10
102418	311.30817730	−30.95548849	14.95	83.72	−64.47	1.3	0.7	1.4	2.1	1.0	8	2.09						
102418	311.30817687	−30.95548854	11.89	88.11	−64.25	1.8	1.0	1.9	2.9	1.3	4	0.30	SS2	81	19.532	0.020	2.70	0.10
103582	314.81456971	−38.33244624	1.08	14.53	−14.67	1.2	0.8	1.5	1.3	1.1	0	1.24						
103582	314.81457044	−38.33244721	3.96	17.82	−10.64	2.0	1.3	2.4	2.2	1.8	0	−1.20	SS2	312	11.377	0.020	3.05	0.05
104162	316.56287372	25.72005140	0.12	22.24	12.29	1.0	0.8	1.5	1.2	0.8	2	3.19						
104162	316.56287333	25.72005182	1.90	21.88	12.05	1.8	1.4	2.6	2.1	1.4	2	−0.81	SS1	153	6.331	0.033	3.45	0.06
109340	332.26209612	51.04586398	−1.53	−3.81	−3.78	1.0	0.8	1.2	1.2	0.9	8	4.44						
109340	332.26209456	51.04586348	0.45	0.20	−0.77	1.5	1.3	1.7	1.7	1.4	0	−0.13	SS1	81	2.633	0.018	2.95	0.05

Table 6. Stochastic solutions (HIP < 60 000) flagged X in field 61 of the main Catalogue

ID	Pos: ICRS – J1991.25		Par.	Prop. Motion		Standard errors					Soln.		Multiplicity					
HIP	α	δ	π	$\mu_{\alpha *}$	μ_δ	$\sigma_{\alpha *}$	σ_δ	σ_π	σ_{μ_α}	σ_{μ_δ}	F1	F2	Sce	θ	ρ	σ_ρ	ΔHp	σ
	deg	deg	mas	mas/yr			mas		mas/yr		%			deg	″	″	mag	mag
1	8	9	11	12	13	14	15	16	17	18	29	30		63	64	65	66	67
1860	5.87929684	77.18918134	50.71	−840.75	45.38	2.4	2.3	2.7	3.3	2.6	0	0.00						
1860	5.87929271	77.18918156	50.75	−837.60	44.51	2.9	2.9	3.4	4.1	3.5	0	−0.26	SS1	62	11.198	0.038	2.68	0.07
2487	7.88898014	−62.96544985	18.95	87.95	−45.79	3.6	3.3	4.3	4.1	4.0	0	0.00						
2487	7.88899819	−62.96545398	19.49	97.56	−48.70	1.1	0.8	1.1	1.4	1.0	18	3.33	HIC	293	0.594	0.004	1.53	0.01
4189	13.34933515	−41.23799485	42.61	14.99	−198.96	8.9	11.2	15.5	10.2	11.3	0	0.00						
4189	13.34932884	−41.23800160	34.67	35.48	−205.83	7.7	9.4	13.6	9.4	9.6	0	−1.91	SS2	195	4.748	0.027	1.17	0.04
8236	26.51068410	−56.95888982	10.53	47.63	14.72	2.1	2.7	3.0	2.9	3.2	0	0.00						
8236	26.51068501	−56.95888925	8.35	46.47	18.54	1.8	2.4	2.6	2.5	3.0	0	0.50	LAM	347	6.221	0.030	2.95	0.08
13785	44.36792795	52.47761573	24.81	393.77	−146.04	7.0	6.1	9.6	7.9	7.7	0	0.00						
13785	44.36792720	52.47761396	23.37	398.70	−147.38	3.3	3.1	4.9	3.9	3.9	17	1.01	SS2	57	16.864	0.035	1.90	0.10
13876	44.67744846	−48.73240196	4.73	−3.72	18.81	2.3	2.3	2.8	3.0	2.6	1	0.00						
13876	44.67744730	−48.73240147	2.79	−1.07	18.03	1.4	1.3	1.7	1.9	1.6	5	2.63	SS2	351	20.913	0.028	2.00	0.05
14813	47.81333881	−46.51858820	34.48	195.51	401.27	4.2	4.1	5.0	4.9	4.6	1	0.00						
14813	47.81334082	−46.51858944	35.87	202.36	399.37	2.6	2.5	3.0	3.4	3.2	2	1.78	SS1	63	20.369	0.042	2.20	0.09
20169	64.84140412	7.16150291	6.27	4.52	71.69	23.1	19.4	26.0	32.4	25.8	0	0.00						
20169	64.84142283	7.16150551	6.20	24.18	32.28	7.6	5.7	8.3	10.9	9.2	0	2.88	SS2	23	7.265	0.011	0.65	0.03
23222	74.96284299	0.51081529	−28.02	5.10	10.07	29.7	17.7	33.7	33.9	21.8	0	0.00						
23222	74.96284984	0.51081466	−0.69	20.00	3.13	7.8	5.3	9.0	9.2	6.3	4	3.53	SS2	298	5.188	0.019	0.80	0.02
24770	79.66790485	38.71055638	0.94	0.16	−2.56	2.7	1.7	3.1	3.2	1.9	0	0.00						
24770	79.66790392	38.71055733	−3.60	0.28	−3.27	2.7	1.7	3.1	3.1	1.8	0	−0.37	SS1	249	11.902	0.030	2.80	0.10
25457	81.67131482	−5.15673396	6.14	2.29	−3.38	5.1	3.7	6.1	5.6	4.0	0	0.00						
25457	81.67131651	−5.15673429	2.19	9.50	−2.41	2.2	1.5	2.5	2.4	1.6	4	1.04	SS1	254	20.746	0.021	1.65	0.05
27783	88.19300620	29.76805406	−6.01	94.91	−28.67	19.8	13.5	21.5	30.1	19.3	0	0.00						
27783	88.19301041	29.76805096	20.32	−31.05	−77.60	7.0	5.0	6.9	13.0	7.7	20	2.88	SS1	58	16.116	0.011	0.55	0.06
28376	89.91991753	75.13309885	11.20	−5.69	14.95	2.6	3.3	4.1	2.8	4.0	0	0.00						
28376	89.91992285	75.13309881	10.03	−6.92	20.38	1.9	2.4	2.9	2.1	3.0	0	0.00	SS1	180	11.345	0.023	2.55	0.05
30076	94.94205596	−4.50988255	−0.80	−2.24	−3.19	2.5	1.9	2.8	2.5	2.1	0	0.00						
30076	94.94205537	−4.50988205	0.63	−2.10	−5.14	1.7	1.2	1.9	1.8	1.4	4	0.34	SS1	97	15.269	0.023	3.28	0.08
31365	98.65067353	8.35212795	−5.93	5.80	−0.45	6.1	4.9	6.9	6.6	5.7	0	0.00						
31365	98.65067403	8.35212685	1.20	2.03	−1.69	2.5	2.0	2.9	2.9	2.5	0	0.16	SS1	272	11.151	0.013	2.20	0.05
32628	102.09229738	−15.32980187	−2.80	4.78	−13.25	14.2	12.2	15.4	16.1	14.7	0	0.00						
32628	102.09229562	−15.32980649	7.48	14.18	−25.42	2.9	2.8	3.6	4.1	3.2	24	1.89	TYC	138	8.544	0.009	1.30	0.02
33383	104.14343386	28.96575498	23.46	−24.81	−11.41	24.7	15.0	27.0	26.4	18.6	0	0.00						
33383	104.14342855	28.96574925	6.07	1.76	−7.16	5.6	3.6	6.0	7.7	5.4	0	1.44	SS1	4	9.980	0.004	0.75	0.03
34690	107.77447030	21.53366762	7.38	7.91	−22.02	2.4	1.4	2.7	2.6	1.9	0	0.00						
34690	107.77447176	21.53366847	6.03	8.56	−23.36	2.3	1.3	2.4	2.5	1.8	16	0.38	SS1	209	10.596	0.050	3.30	0.04
34707	107.82073969	−9.29985356	14.57	2.64	5.08	5.6	3.8	6.1	6.0	4.5	0	0.00						
34707	107.82073958	−9.29985367	4.56	−4.73	3.07	2.4	1.7	2.8	2.7	2.0	0	0.30	SS1	183	12.139	0.011	2.00	0.04
36611	112.93390739	−43.28983172	5.65	−16.84	20.99	1.7	1.8	2.0	1.8	2.0	0	0.00						
36611	112.93390800	−43.28983124	4.68	−20.01	23.18	1.5	1.5	1.8	1.5	1.7	2	0.58	TYC	209	16.436	0.030	2.40	0.05
38461	118.17627356	−38.61210483	−4.05	−2.61	−2.79	4.3	5.2	6.0	4.8	5.3	0	0.00						
38461	118.17627411	−38.61210622	1.52	1.46	−3.56	2.9	3.5	4.0	3.2	3.3	2	1.55	SS1	32	18.466	0.021	1.25	0.05
44041	134.52821029	−38.87106969	−3.82	−37.77	128.21	18.3	19.6	25.3	20.7	20.0	0	0.00						
44041	134.52821753	−38.87107535	1.36	−26.48	89.19	10.2	11.5	13.4	12.2	12.4	12	3.10	SS2	275	16.227	0.023	0.14	0.02
44284	135.28776373	−15.39136984	2.04	2.53	−13.25	1.0	0.7	1.4	1.1	0.8	1	0.00						
44284	135.28776269	−15.39136988	2.26	2.42	−13.64	1.2	0.8	1.6	1.3	0.9	0	0.69	SS1	237	7.221	0.015	3.90	0.10
45316	138.53792554	25.29227359	−1.02	−18.53	4.08	2.4	2.0	2.8	2.8	1.5	5	0.00						
45316	138.53792543	25.29227462	1.15	−17.15	1.21	2.0	1.7	2.5	2.4	1.2	0	2.21	SS1	242	10.187	0.018	2.97	0.07
46948	143.53037362	−21.06820874	1.24	−8.12	2.84	2.7	2.5	3.7	3.3	2.7	0	0.00						
46948	143.53037495	−21.06820793	6.02	−14.94	1.77	2.3	1.9	2.9	2.8	2.0	2	2.00	SS1	33	17.574	0.021	1.63	0.03
46949	143.53021188	−37.13084617	2.42	−10.16	−17.86	1.4	1.6	2.4	1.4	1.6	2	0.00						
46949	143.53021178	−37.13084645	5.86	−9.71	−14.74	1.3	1.4	2.1	1.3	1.4	2	1.79	SS2	131	19.687	0.018	2.00	0.05
49796	152.47171942	−25.39261753	3.43	−11.31	7.93	3.3	2.9	3.7	3.5	3.2	2	0.00						
49796	152.47171902	−25.39262027	4.66	−16.77	16.18	2.8	2.3	3.0	2.7	2.3	0	2.34	SS1	358	22.180	0.019	0.35	0.05
53938	165.54874131	−42.49791251	4.79	−17.51	5.60	1.0	1.2	2.0	1.1	1.3	2	0.00						
53938	165.54874144	−42.49791291	4.05	−17.34	6.01	0.9	1.0	1.7	1.0	1.1	3	3.19	TYC	196	19.201	0.017	2.15	0.05
54972	168.84525409	58.40168591	1.90	15.51	−2.64	1.7	2.0	2.9	2.0	2.1	0	0.00						
54972	168.84525398	58.40168611	2.77	18.19	−0.05	1.6	1.9	2.7	1.9	2.1	0	1.60	SS2	86	9.927	0.032	3.47	0.10
55215	169.61011885	60.59709595	11.16	−108.99	−12.75	1.6	1.8	2.6	1.8	1.8	0	0.00						
55215	169.61011837	60.59709607	9.13	−110.36	−15.41	1.9	2.1	3.0	2.1	2.0	0	1.50	SS2	17	6.260	0.054	3.30	0.05

Table 7. Stochastic solutions (HIP > 60 000) flagged X in field 61 of the main Catalogue

ID	**Pos: ICRS – J1991.25**		**Par.**	**Prop. Motion**		**Standard errors**					**Soln.**		**Multiplicity**					
HIP	α	δ	π	$\mu_{\alpha*}$	μ_δ	$\sigma_{\alpha*}$	σ_δ	σ_π	σ_{μ_α}	σ_{μ_δ}	F1	F2	Sce	θ	ρ	σ_ρ	ΔHp	σ
	deg	deg	mas	mas/yr			mas		mas/yr		%			deg	″	″	mag	mag
1	8	9	11	12	13	14	15	16	17	18	29	30		63	64	65	66	67
60296	185.45864396	−54.40026798	5.38	−0.45	3.29	1.8	2.2	3.4	2.5	2.5	0	0.00						
60296	185.45864414	−54.40026741	3.91	−1.82	0.79	2.1	2.7	4.3	3.0	3.0	0	−0.05	SS2	1	10.399	0.023	2.53	0.10
60360	185.65229071	−49.32612013	10.07	−24.46	−3.46	1.1	0.9	1.6	1.2	1.0	2	0.00						
60360	185.65229111	−49.32612061	7.91	−23.21	−5.51	1.5	1.2	2.0	1.6	1.2	0	1.76	SS1	200	13.071	0.049	3.75	0.15
61408	188.74458453	17.54000711	8.58	81.25	−80.50	3.4	2.6	4.2	4.2	2.9	2	0.00						
61408	188.74458299	17.54000776	6.08	80.27	−81.28	2.7	1.9	3.3	3.6	2.2	3	1.96	SS1	11	15.250	0.021	2.15	0.05
64241	197.49812263	17.52911621	69.81	−445.95	129.69	22.9	19.0	27.6	25.5	15.7	0	0.00						
64241	197.49813794	17.52916976	59.00	−432.21	142.42	7.0	7.7	9.4	8.0	8.1	31	2.27	HIC	191	0.465	0.010	0.10	0.03
64425	198.07345539	−59.92053651	9.42	−28.54	−17.46	0.8	0.9	1.5	0.9	1.0	1	0.00						
64425	198.07345430	−59.92053636	11.12	−30.55	−18.35	0.6	0.7	1.1	0.7	0.8	0	−2.51	HIC	7	1.903	0.016	3.72	0.05
66600	204.77934328	−10.39015227	1.64	10.00	−21.61	1.6	1.0	1.7	1.9	1.0	2	0.00						
66600	204.77934445	−10.39015277	3.03	11.00	−21.08	1.6	1.0	1.7	1.8	0.9	0	0.03	SS1	2	17.392	0.025	3.00	0.10
69139	212.29181155	−30.23252008	3.75	−26.99	−35.45	7.8	5.8	9.1	8.8	7.7	0	0.00						
69139	212.29180976	−30.23251827	1.20	−43.11	−27.83	3.7	2.7	4.8	4.4	3.9	0	0.24	SS1	327	6.918	0.014	1.70	0.03
71966	220.78531956	−57.01147820	4.23	−68.01	−42.07	1.3	1.1	1.8	1.7	1.6	0	2.77						
71966	220.78531812	−57.01147728	5.76	−63.19	−41.42	2.9	1.9	4.1	3.4	3.6	0	−0.42	SS2	272	14.678	0.058	2.90	0.05
74163	227.30228711	−63.51587670	1.97	−2.53	−0.34	1.0	1.0	1.8	1.3	1.5	1	0.00						
74163	227.30228764	−63.51587642	2.69	−2.75	−0.68	1.1	1.2	2.1	1.5	1.7	2	3.21	SS1	45	18.984	0.043	2.70	0.05
78332	239.92192818	−10.79904977	12.65	−43.96	10.39	3.6	2.2	3.8	4.5	3.2	0	0.00						
78332	239.92192735	−10.79905075	5.67	−54.59	1.77	4.6	2.2	4.5	6.0	3.6	5	−1.52	SS1	257	15.411	0.079	2.65	0.10
78392	240.06514819	73.93555504	3.18	−27.93	31.23	1.1	1.1	1.2	1.0	1.3	0	0.00						
78392	240.06514817	73.93555509	3.20	−27.31	31.76	1.0	1.0	1.1	0.9	1.1	0	0.83	SS2	312	8.239	0.025	3.65	0.06
83944	257.37626919	−61.08949381	12.18	19.63	−14.57	8.8	8.2	12.5	9.0	8.2	0	0.00						
83944	257.37627429	−61.08949303	12.06	1.89	−10.68	8.3	6.8	13.2	9.7	7.2	0	0.95	SS1	286	10.007	0.026	1.60	0.02
84000	257.56523383	21.45490156	3.03	23.29	−13.92	4.7	5.2	8.0	6.8	6.7	0	0.00						
84000	257.56523315	21.45490101	1.41	24.41	−10.00	3.4	4.1	6.3	4.6	5.2	0	1.24	SS1	95	9.417	0.023	1.95	0.05
84306	258.54019408	19.31197763	4.69	−16.16	−6.01	4.0	4.1	5.3	3.7	4.8	0	0.00						
84306	258.54019543	19.31197523	3.99	−11.68	−6.45	5.0	4.8	6.5	5.0	5.9	0	−0.04	SS1	335	8.947	0.043	2.25	0.10
86644	265.55685964	4.92742286	26.21	−276.98	−13.21	3.8	2.6	4.7	3.8	2.5	0	0.00						
86644	265.55685943	4.92742356	27.80	−271.50	−16.22	3.5	2.3	4.6	3.6	2.3	0	0.25	SS2	268	6.505	0.039	2.86	0.10
87461	268.06164945	−53.28932730	4.99	−20.56	−6.37	4.1	2.9	4.8	5.1	3.3	2	0.00						
87461	268.06165021	−53.28932907	4.18	−26.24	−1.43	3.5	2.4	4.2	4.1	2.5	0	0.19	SS1	313	11.269	0.021	2.25	0.05
88108	269.91720148	22.07074851	1.72	−3.95	−5.79	1.1	1.3	1.9	1.4	1.4	0	0.00						
88108	269.91720165	22.07074824	1.09	−0.99	−6.13	1.1	1.2	1.9	1.3	1.4	2	2.86	SS1	334	17.323	0.033	2.90	0.06
88378	270.71034919	38.25219676	2.42	−5.31	−0.73	2.5	2.6	3.1	3.3	3.1	3	0.00						
88378	270.71035224	38.25219673	4.28	−10.62	−3.02	2.3	2.2	2.6	3.0	2.7	0	−0.14	SS1	248	11.349	0.018	2.30	0.06
88633	271.45014684	−48.50756928	12.86	−125.68	−15.74	9.6	6.9	12.0	11.8	7.6	0	0.00						
88633	271.45015676	−48.50757685	20.11	−104.03	−7.76	8.2	4.5	9.8	9.1	4.9	7	0.82	SS1	62	6.906	0.021	1.88	0.07
89247	273.18072583	24.39353629	20.32	−126.81	−33.13	0.7	1.1	1.5	0.9	1.3	0	0.00						
89247	273.18072583	24.39353641	19.21	−124.35	−35.43	0.9	1.4	1.8	1.1	1.6	0	1.63	SS2	240	12.764	0.025	3.50	0.10
91607	280.23595676	−35.11149933	−8.54	14.08	−3.88	7.3	4.7	8.7	9.4	5.7	0	0.00						
91607	280.23595562	−35.11149995	4.23	8.61	−6.60	2.6	1.7	3.2	3.4	2.0	0	−0.27	SS1	178	9.266	0.013	1.94	0.02
91866	280.93066778	−32.48901977	6.34	12.28	−0.35	4.0	2.3	4.1	4.3	2.8	0	0.00						
91866	280.93066822	−32.48901986	3.53	4.66	0.63	3.0	1.7	3.1	4.1	2.4	0	0.32	SS1	339	13.421	0.030	2.70	0.08
94466	288.40305651	−43.24966590	−2.64	−82.71	−65.22	21.8	14.7	24.5	29.6	18.1	0	0.00						
94466	288.40305088	−43.24966675	2.07	−31.67	−68.86	6.3	4.9	6.7	9.2	6.9	22	2.35	SS1	251	8.151	0.014	0.79	0.02
99590	303.16592612	33.49561323	0.37	2.62	−1.23	0.9	1.0	1.3	1.0	1.0	2	0.00						
99590	303.16592588	33.49561331	−0.95	3.38	−1.93	1.2	1.4	1.8	1.4	1.5	2	0.23	TYC	165	21.285	0.042	1.83	0.05
100506	305.70379994	13.33671141	5.44	7.79	10.43	2.1	1.7	2.6	2.3	2.0	0	0.00						
100506	305.70380026	13.33671159	1.61	7.19	9.05	1.4	1.1	1.8	1.6	1.4	0	1.64	SS2	1	15.303	0.014	2.78	0.04
101399	308.25145892	−62.49587106	18.48	−2.91	−201.95	1.1	1.0	1.7	1.2	1.1	0	0.00						
101399	308.25145924	−62.49587114	20.25	−1.45	−201.00	1.1	1.0	1.6	1.3	1.1	2	1.30	SS1	310	17.593	0.021	3.35	0.10
101553	308.69762243	−7.23241259	−2.23	−1.25	−1.75	4.8	3.1	5.7	8.5	4.9	0	0.00						
101553	308.69762099	−7.23241302	4.12	6.25	−3.32	2.5	1.6	3.2	4.5	2.5	0	1.70	SS2	52	13.328	0.019	2.53	0.05
104635	317.92542809	−66.34447019	10.31	28.65	−25.14	1.6	2.1	3.1	1.7	2.5	0	0.00						
104635	317.92542700	−66.34446929	8.82	30.27	−25.77	1.4	1.9	2.8	1.6	2.6	1	1.64	SS1	99	22.610	0.030	1.20	0.08
105041	319.14687994	−27.76472365	9.14	−9.88	48.05	17.0	13.7	19.0	22.1	11.3	0	0.00						
105041	319.14688956	−27.76472381	11.76	−23.39	34.83	6.4	4.1	6.6	9.4	3.7	0	−0.01	SS2	175	5.735	0.012	1.38	0.05
106621	323.93720196	−16.65560562	4.29	−14.71	−33.19	2.3	1.6	2.5	3.0	1.6	0	0.00						
106621	323.93720333	−16.65560468	6.12	−18.01	−31.01	2.7	1.8	3.3	3.6	1.8	4	0.81	SS1	155	9.556	0.063	3.40	0.10
109020	331.29405069	44.06460738	2.53	9.33	−0.67	2.4	2.5	3.5	2.8	2.9	0	0.00						
109020	331.29404878	44.06460754	3.32	10.86	1.97	2.4	2.3	3.3	3.1	3.0	2	3.01	SS2	194	20.792	0.039	1.25	0.05
114344	347.36834449	68.42844722	3.19	9.02	−0.90	1.2	1.3	1.5	1.5	1.8	0	0.00						
114344	347.36834536	68.42844721	2.68	7.71	−0.78	0.9	1.0	1.1	1.1	1.3	0	0.37	SS1	306	8.637	0.014	3.25	0.05

• **HIP 13725**: The FAST solution retained for the final publication was subsequently considered as very doubtful. In addition no companion was seen on SS1 or SS2 with separation larger than 5 arcsec. While this do not preclude this star to be a close binary, we think that in this case the magnitude difference should be larger than 4, with a negligible influence on the Hipparcos signal. A single star solution is then preferable and yields an excellent fit.

• **HIP 38479**: The recent ground based observation shows clearly that the Hipparcos position of the secondary is wrong by exactly one grid-step. The final fit is obtained with no observation rejected, although the goodness-of-fit is not as good.

• **HIP 44488**: The recent ground based separation (12 arcsec) is definitely incompatible with the SS1 image taken 40 years ago with $\rho = 19$ arcsec. The new Hipparcos solution is however excellent and leaves no room for a different separation. One may hypothesize that the system is in fact an optical binary comprising a distant star and a faint and nearby fast moving star. Additional observations, old or new, should help resolve the problem.

• **HIP 69736**: The Input Catalogue gives this system a separation of $4''\!.2$ and a magnitude difference $\Delta m = 4$. From the Digitized Sky Survey a much larger separation should be adopted, which eventually leads to a better astrometric solution. The system is actually triple, and the largest separation corresponds to the two brightest components.

• **HIP 71867**: There is no double possible with that separation in the image of the Digitized Sky Survey. The single star solution is excellent and left no room for improvement with a double star model.

• **HIP 76435**: Triple system from the Tycho Catalogue. The separation used here is for the detached components which yields a better fit to the Hipparcos data.

• **HIP 79902**: The Hipparcos relative astrometry with $\rho =$ 16 arcsec is not seen in the Digitized Sky Survey. On the other hand the solution using the Input Catalogue value of $3''\!.3$ or the new ground based observation leads to a much better fit.

5.3. The acceleration solutions

We have re-examined systems which were solved in the Hipparcos standard solution with the extended single star model, allowing for a time dependent proper motion. Most of the acceleration solutions published in the Hipparcos Catalogue (2622 in total) are of good quality and were not reconsidered in this work. As for the other groups we focussed only on the questionable solutions. It happens that among those classified as *doubtful* (360 with a goodness-of-fit larger than three), very few appear in our data base of detected or suspected binaries, which means that no new processing could be attempted. Finally quite often the separation we found from the FAST data was too small and could not be confirmed or rejected from the Digitized Sky Survey.

These facts account for the very small yielding in this group, since only four new solutions are proposed, all based on actual detection of a companion in images of the Digitized Sky Survey. The subsequent Hipparcos solutions for the separations given here have fairly good standard errors and the final astrometric fits are all of good quality. Given the separations and the distance it is unlikely that the acceleration proposed in the Hipparcos Catalogue should be real, unless the primary is also a close astrometric binary.

• **HIP 23266**: The new solution has a much better fit to the data than the published solution, but with larger standard errors due to the error propagation from the double star model. The difference between the old and new proper motion is much larger than the expected statistical error, although the double star signal is very weak with $\Delta m =$ 3.5. However the acceleration components in the published solution are large (respectively 40 and -9 mas/yr^2) and not fully independent of the first order term.

5.4. The suspected doubles and multiples

This group comprises a set of solutions for entries detected as non single from the Hipparcos data and for which no definitive solution for the separation, position angle and magnitude difference was possible without ambiguity at the time of the Catalogue publication. In general, for this specific group of stars, NDAC and FAST concluded their processing with two very different solutions with no external way to decide if at least one was correct. The abscissa were eventually processed as for single stars, leaving a non negligible scatter in the residuals due to the imperfection of the model.

The new solutions are given in Table 4 (HIP $< 60\,000$) and Table 5 (HIP $> 60\,000$). There are no Hipparcos data in the multiplicity columns and the second line of each entry gives the relative astrometry derived from the Hipparcos observations and using the approximate ρ and θ provided by the quoted source. The change in the goodness of fit is the best indication of the improvement in the solutions and at the same time confirms to some extent the relative astrometry and photometry. When the double star has magnitude difference less than 1.5 the change is spectacular.

Due to the error propagation in the double star model, the standard error of the astrometric parameters are usually larger than with the single star model although the goodness-of-fit is much improved by allowing for the duplicity.

• **HIP21000**: This is the most striking case of this group with a distance twenty times larger and a much smaller proper motion in the new solution. This star appears as a double system in the Input Catalogue with $\rho = 4''.4$. It was processed with the single star model in Hipparcos because FAST and NDAC could not agree on the relative astrometry of the system. With the confirmed separation it is clear that the double star model is better, even though the standard errors are larger because of the small magnitude difference. All the 15 observations were used with no rejection.

5.5. The stochastic solutions

This is the largest single group of doubtful solutions in the Hipparcos Catologue and is in fact a mixture of various categories. All the new solutions presented in Table 6 (HIP $<$ 60 000) and Table 7 (HIP $>$ 60 000) follow from the discovery of updated multiplicity parameters which proved sufficient to reprocess the double star data. Without exception the final goodness-of-fit statistics are all acceptable (the Hipparcos values for F2 were conventionally set to zero in the Catalogue). The main interest of these new solutions lies in the derivation of accurate parameters for the relative astrometry of the double systems and the more reliable parallaxes that are subsequently obtained.

6. Conclusion

This work undertaken directly in the wake of the Hipparcos Catalogue publication is probably not the ultimate, although we have gone through the Hipparcos data bases in a very systematic way. We think that we have done outside the rigourous time constraint of the project what could be achieved without departing too much from the standard models used in the mass processing.

However it remains a significant number of well observed targets with poor solutions, or no solution at all, for which no satisfactory explanation has been given so far. It is very likely that they belong to three main sources: (i) the target pointed is at more that 20 arcsec from an actual star, and in this case there is virtually no hope to retrieve any valuable science information; (ii) the star observed is in fact a double system with an orbital period between 1 and 10 years and a full solution cannot be obtained without additional input data and extensive software development, for example to split the observation period in two or three sub-intervals; (iii) the target is a multiple system with weak hierachy, involving at the same time a very complex model and too many unknown parameters for a reliable solution to be concluded from the Hipparcos observations alone. The publication of the intermediate data and that of the calibrated signal parameters provided on the Catalogue CD-ROMs is the basic material from which any new investigation should start to solve these very troublesome cases.

Finally after the examination of nearly a thousand systems, we are still left with more than two hundreds suspected non single stars, now confirmed at least double in the images of the Digitized Sky Survey, but which did not yield an acceptable solution with the Hipparcos raw data. As most of these stars are new binaries, this list is of interest for double star observers and it will be put into a convenient format and posted on the Hipparcos website.

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References

ESA 1997, The Hipparcos and Tycho Catalogues, ESA SP-1200

Cuypers J., Seggewiss W., 1998, Double star observations (to appear in AAS)

Lampens P., Oblak E., 1998, Double star observations (to appear in AAS)

Oblak E., 1998 (private communication)