HIPPARCOS : AN EXAMPLE OF ASTROPHYSICAL USES OF ASTROMETRIC DATA.

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ABSTRACT. Hipparcos will measure positions, proper motions and parallaxes for about 110 000 stars brighter than B = 13, with an expected mean error of 2.10^{-3} arcsec in positions and parallaxes and 2.10^{-3} arcsec/year in proper motions. The contents of the first provisional catalogue with respect to astrophysical problems is described, and the star distribution versus spectral type, magnitude and distance is given. All types of stars are well represented (spectral types, various evolutionary stages, giants, white dwarfs, ...). Precise parallaxes for 29 000 stars closer than 100 pc will provide a new base for luminosity calibration, and will allow accurate stellar masses to be determined from double stars with known orbits. Precise proper motions, in conjunction with the improved distances, will substantially improve our knowledge of galactic structure. All types of stars used for the cosmic distance scale calibration are well represented : Cepheids, RR Lyrae, supergiants, open cluster stars.

1. INTRODUCTION.

The aim of the Hipparcos mission is to obtain positions, parallaxes and proper motions of about 110 000 stars up to the magnitude B = 13, evenly distributed over the sky, most of them being brighter than B = 10. The expected mean errors in the astrometric parameters depend on both stellar apparent magnitudes and ecliptic coordinates ; mean accuracies of 0.002 arcsec in positions and parallaxes and 0.002 arcsec per year in proper motions are expected (Perryman and Schuyer, 1985).

For a satisfactory achievement of the mission (satellite operation, data reduction and best scientific results), the list of stars to be observed - the Input Catalogue - has to be built and tested before launch (for details, see Turon, this issue ; Proceedings of the Aussois Colloquium, 1985, C. Turon & M.A.C. Perryman, Eds. ; Gómez and Torra, 1986).

The scientific impact in astrometry, astronomy, and astrophysics, due to the drastic improvements of Hipparcos astrometric measurements has been emphasized in several papers (see for example, the Proceedings of the Padova Colloquium, 1979, C. Barbieri & P.L. Bernacca, Eds ; and the Proceedings of the Strasbourg Colloquium, 1982, E. Høg et al., Eds). The construction of the Input Catalogue and the astrometric contents of the first preliminary version called IC1 (issued in February 1987) are described by Turon (this issue). The aim of this paper is to describe more specifically the contents of IC1 with respect to astrophysical problems : calibration of luminosities, fine structure of the HR diag-

S. Débarbat et al. (eds.), Mapping the Sky, 259–264.

Table 1

IC1 : Distribution in V-magnitude and distance, for different spectral types

a) O-B stars

V \ r(pc)	⩽ 100	100 - 500	500 - 1000	› 1000	TOTAL
⩽ 6	177	744	81	55	1 057
6 - 8	–	3 105	509	634	4 248
8 - 10	5	2 063	1 529	929	4 526
› 10	–	1	94	232	327
TOTAL	182	5 913	2 213	1 850	10 158

b) A0-A9 stars

V \ r(pc)	⩽ 100	100 - 500	500 - 1000	› 1000	TOTAL
⩽ 6	816	99	5	21	941
6 - 8	352	6 357	22	77	6 808
8 - 10	18	8 310	653	61	9 042
› 10	1	110	359	69	539
TOTAL	1 187	14 876	1 039	228	17 330

c) F0-F9 stars

V \ r(pc)	⩽ 100	100 - 500	500 - 1000	› 1000	TOTAL
⩽ 6	577	27	6	31	641
6 - 8	5 669	539	60	95	6 363
8 - 10	5 915	9 791	–	115	15 821
› 10	29	1 863	10	9	1 911
TOTAL	12 190	12 220	76	250	24 736

d) G0-K1 stars

V \ r(pc)	⩽ 100	100 - 500	500 - 1000	› 1000	TOTAL
⩽ 6	770	333	24	66	1 193
6 - 8	3 120	7 521	194	160	10 995
8 - 10	8 943	13 541	1 394	209	24 087
› 10	347	1 349	208	43	1 947
TOTAL	13 180	22 744	1 820	478	38 222

e) K2-M8 stars

V \ r(pc)	⩽ 100	100 - 500	500 - 1000	› 1000	TOTAL
⩽ 6	288	694	16	49	1 047
6 - 8	177	5 084	147	83	5 491
8 - 10	929	4 025	4 300	288	9 542
› 10	868	171	189	230	1 458
TOTAL	2 262	9 974	4 652	650	17 538

f) All spectral types together.

V \ r(pc)	⩽ 100	100 - 500	500 - 1000	› 1000	TOTAL
⩽ 6	2 628	1 897	132	222	4 879
6 - 8	9 318	22 606	932	1 049	33 905
8 - 10	15 810	37 730	7 876	1 602	63 018
› 10	1 245	3 494	860	583	6 182
TOTAL	29 001	65 727	9 800	3 456	107 984

ram, determination of masses of already well measured double stars, stellar kinematics, cosmic distance scale, etc.

2. THE HR DIAGRAM.

The Input Catalogue will contain field stars of different spectral types and luminosity classes, belonging to various stellar populations ; binary stars ; variable stars like Cepheids, RR Lyrae, LPV, etc. ; special types of stars like white dwarfs, central stars of planetary nebulae, Wolf-Rayet stars, etc. ; stars in about 200 open clusters, and finally, stars belonging to the Magellanic Clouds.

Table 1 shows the V-magnitude distribution versus the heliocentric distance (in pc) for different spectral types. Among the 115 000 stars contained in IC1, it was possible to estimate distances for about 108 000 stars. The distances were estimated from the HD type (or MK if available), and apparent V-magnitude ; only in the case of O- and B-type stars, a reddening correction was applied. In order to improve this rough estimation of the distances, the stars without luminosity class coming from proposals containing well-known types of stars (e.g. red dwarfs, subdwarfs, etc.) have been considered with the luminosity class corresponding to their type. The remaining stars without luminosity class have been considered as dwarfs for spectral types earlier than G0 and as giants for stars later than G9. In the case of G-type stars, 60% have been assumed to be dwarfs and 40% to be giants. The results show that each spectral interval, as defined in Table 1, contains more than 10 000 stars, most of them being brighter than V = 10, and that about 100 000 stars are nearer than 500 pc. For about 29 000 stars closer than 100 pc (mainly dwarfs but also some subgiants and giants), direct use of the Hipparcos parallaxes will allow to calibrate individual luminosities. Table 2 gives the expected accuracy in the individual absolute magnitudes, $\epsilon(M_V)$ (adapted from Mennessier, 1987). These figures take into account only the accuracy in the parallax, which is a function of the apparent magnitude (see Perryman and Schuyer, 1985). Stars closer than 25 pc and brighter than V = 10 (about 1500 stars) will have $\epsilon(M_V)$ smaller than 0.1 mag, which will allow the fine structure study of the main sequence. Moreover, up to 50 pc, about 10 000 stars will have $\epsilon(M_V) < 0.2$ mag. For stars located between 100 and 500 pc (about 65 000 stars), Hipparcos will provide parallaxes valuable for statistical use.

Table 2
Accuracy on individual absolute magnitude

V \ r(pc)	< 25	25 – 50	50 – 100
< 8	0.084	0.17	0.33
8 – 10	0.097	0.19	0.39
> 10	0.13	0.25	0.50

https://doi.org/10.1017/S0074180900139671 Published online by Cambridge University Press

3. STELLAR KINEMATICS.

As we have seen earlier, Hipparcos will provide a much more precise (based on many more stars) luminosity calibration of different types of stars. Studies in stellar kinematics will be drastically improved by direct use of Hipparcos proper motions up to 1 kpc, in connection with distance determinations, and, eventually, radial velocities. From Table 1, it can be seen that about 75 000 stars are expected between 100 pc and 1 kpc, allowing for the first time to perform a reliable kinematic study of stars out of the solar neighbourhood.

4. MISCELLANEOUS.

Among the different types of stars contained in IC1, the inclusion of binaries with known orbits, variable stars used for calibrating the distance scale of the Universe, and stars from catalogues of nearby stars or surveys, will be briefly commented.

4.1. Binaries with known orbits.

The importance of a precise knowledge of the parallax for the determination of masses of binaries is well known. The contribution of Hipparcos to this problem is shown in Table 3 which gives the number of visual binaries with a known orbit, as a function of the distance to the sun.

4.2. Variables for the cosmic distance scale.

All indirect methods used to calibrate the distances in the Universe are initially based on the parallaxes of the nearest stars. It has already been shown that Hipparcos will drastically improve the calibration of luminosities of different types of stars. Hipparcos will also observe the 11 nearest open clusters (up to 250 pc) and about 100 Hyades stars. Finally, all the classical Cepheids (55) and RR Lyrae stars (26) up to 1 Kpc, which constitute the most fundamental distance indicators in extragalactic astronomy, will be measured by Hipparcos.

Table 3
Number of visual binaries with known orbit within 100 pc

r (pc)	N
< 25	128
25 – 50	234
50 – 100	328

4.3. Nearby stars.

Nearby stars (most of them faint stars) are well represented in IC1. It includes 95% of Gliese's catalogue (1800 stars), most of the observable LHS stars (1000 stars), and a selection of about 7000 NLTT stars.

https://doi.org/10.1017/S0074180900139671 Published online by Cambridge University Press

4.4. Survey stars.

Finally, Hipparcos will perform a survey of about 53 000 bright stars, selected as a function of apparent magnitude and galactic latitude (for the definition, see Crifo et al., 1985 ; Turon, this volume).

5. CONCLUSION.

The above description is by no means exhaustive. However, it should be underlined that **all** known types of stars present within 1 Kpc will be observed. This amount of new and very accurate astrometric data will allow a large variety of applications in astrophysical problems.

6. ACKNOWLEDGEMENTS.

We thank F. Arenou and D. Morin (Meudon) for their help in the preparation of this work.

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Discussion:

GLIESE We expect a valuable contribution by HIPPARCOS to the determination of precise parallaxes of brighter dF to dK and even gK stars with parallaxes and luminosities still uncertainly known. In the new Yale Parallax Catalogue (van Altena) there are still a remarkable number of such objects.

https://doi.org/10.1017/S0074180900139671 Published online by Cambridge University Press