HIPPARCOS - PREPARATION OF THE MISSION: EARTH-BASED PHOTOMETRY

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ABSTRACT. The contribution of earth-based photometry to the preparation of the Input Catalogue for the Hipparcos mission is summarised for the pre-launch, the mission itself and the post-launch phases. An evaluation of the needs for new data and a progress report are also presented.

1. THE SATELLITE OBSERVING TIME PREDICTION

The nominal performances of the satellite are achieved if adequate observing time is allocated to each programme star at each crossing of the satellite field of view. This observing time is a non-linear function of the star magnitude m_{H_p}, a measurement of the stellar flux with a broad-band filter covering the wavelength interval 350-790 nm. A consequence of this large bandwidth is a significant dependence of the effective wavelength on the star colour, i.e. λ_{eff} = 495 to 580 nm for (B-V) = -0.25 to +1.50 (Grenon 1985a). As a function of (B-V) the variations of (H_p-V) and (H_p-B) are as follows:

(B-V)	-0.25	0.00	0.50	1.00	1.50
(H_p-V)	-0.10	0.00	0.16	0.25	0.29
(H_p-B)	+0.15	0.00	-0.34	-0.75	-1.21

Some knowledge of the star colour is then necessary in addition to a single magnitude for the accurate prediction of m_{H_p}. In order to optimise the observing time allocation it is specified that m_{H_p} should be known with an error less than 0.5 mag. If the required accuracy is not achieved from the existing data the star has to be re-observed from the ground before the end of the Input Catalogue compilation. Before including a proposed star in the preliminary catalogue it is also necessary to check whether the expected number of photon counts exceeds the satellite detection threshold. The corresponding limiting magnitude is presently taken to be m_{H_p} = 12.4 mag.

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2. THE OBSERVING PROGRAMME

The B and V magnitudes available from the Strasbourg Data Base are of very heterogeneous quality depending on the source catalogues. The stars with photoelectric magnitudes originally represented only 12 per cent of the total stellar sample proposed by the astronomical community. The other stars have either photographic photometry in one or two bands, or only rough estimates of their red, visual or blue magnitudes. Moreover some 8000 stars are without blue magnitudes and some 7000 without visual magnitudes.

Magnitudes from AGK2, the Cape Photographic Catalogues and part of those listed in the GC or the HD Catalogues are accurate enough for the evaluation of m_{H_p}. When only the visual magnitude is known, m_{H_p} may be derived from m_v and the MK spectral type as the range of (H_p-V) variations is small.

Stars having a blue magnitude only, faint DM stars ($m > 9$), proper motion stars from the NLTT or from the Giclas Catalogues, and stars found in objective prism surveys, clearly needed to be re-observed.

In the original list of 210 500 stars, the number of stars with too uncertain magnitudes was estimated to exceed 110 000. With the introduction of the pressure parameter which allows the selection of stars whose time demand does not exceed the total observing time in a given sky area, this figure was reduced to 5150. Magnitudes are doubtful for 8700 additional stars, and these have to be checked.

The majority of stars to be re-observed belongs to the southern sky, and 80 per cent of them are measurable from the ESO Observatory at La Silla.

3. THE WORK ORGANISATION

Since B and V magnitudes will be accurately known from the Tycho experiment, the new ground-based observations are performed using multi-colour systems. The purpose is to provide at the same time the data necessary for the mission operations and those complementary to the expected outputs from Hipparcos and Tycho, namely M_V, T_{eff}, log g, E(B-V) and, when possible, [M/H].

Part of the stars are observed directly by the proposers using the UBV, ubvy, Walraven, Geneva or Vilnius photometric systems. They are mainly massive stars, high proper motion stars, population II stars and high galactic latitude stars. These programmes represent several thousand stars, and are already partially executed.

The remaining stars are observed by collaborators of the INCA Consortium, working at the rate of 2-4 observing runs per semester, mainly at ESO and in Spain.

For a given site, telescope and photometric system, the programme stars are selected according to a spectral type interval in order to optimise the number of astrophysical parameters which can be obtained from that multi-colour data. The integration times are chosen in such a way that the photon noise should be less than 1 per cent for non-extreme colour stars. The late-type stars included in the Input Catalogue only

because they are elements of a reference frame, are observed less accurately in UBV. When possible, multi-channel photometers are preferred as they allow a quick execution of the programmes.

The observations are conducted at small telescopes, not always equipped with accurate pointing systems. It is then necessary to provide observers with identification charts. Some 5300 charts have now been edited at Geneva for the INCA programmes.

So far, ten observing runs have been prepared, with observers belonging to almost all countries in the INCA Consortium. The data are reduced either by the observers themselves or by experienced photometrists at Copenhagen, Leiden or Liège. A total of 127 nights has been devoted to Hipparcos programmes at La Silla, with full financial support from the ESO organisation. Several weeks of observation have also been dedicated to Hipparcos stars at Calar Alto and La Palma Observatories using Spanish time.

The quantities m_{H_p}, m_v and (B-V) are deduced from the multi-colour data using the transformation equations given in Grenon (1985b) - these will also appear in the final Input Catalogue.

Double stars are difficult to observe, both by Hipparcos and by photometrists. Joint photometry is performed if $\varrho < 10$ arcsec. The systems with $\varrho, \Delta m$ values leading to inaccurate photometry have been provisionally rejected from the programmes, but the systems' characteristics are described by the observers when they are newly discovered. Double stars of astrophysical interest will be observed with a CCD device at La Palma by members of an international working group especially set up for this project. Accurate values of colours and magnitudes, and of the parameters $\varrho, \theta, \Delta m$ are expected for several thousand multiple systems.

To date, new multi-colour data are available for 1650 stars. The precision of the results is generally very high as most stars were observed twice during different nights in order to check the identifications and to check for stellar variability. As the Input Catalogue compilation is an iterative process, a number of the stars with new photometry will ultimately not be included in the final Input Catalogue - nevertheless their measurements will be available at a later stage.

During the mission itself, the contribution of the photometrists will be restricted mainly to the monitoring of irregular variables in order to define the observability windows by the satellite if their brightness falls below the detection threshold and observing times. The observations are being carried out in close collaboration with amateur astronomers.

3. THE PHOTOMETRIC PAYLOAD CALIBRATION

The present satellite design allows the accurate determination of the H_p, BT and VT magnitudes. For a star of B = 9.0 mag the achievable accuracy on m_{H_p} is 0.01 mag per observation. The production of mean magnitudes of high precision and the detection of micro-variable stars imply detailed calibrations, on ground and in orbit, of the payload sensitivity using photometric standards in order to monitor the detector

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gain variations. The calibration of the short-time variations require the availability of more than 3500 standards well distributed in magnitude and colour, and well distributed over the sky. The standards must meet stringent conditions regarding the accuracies on the predicted m_{H_p}, the long-term stability of their magnitudes and colours, and their binarity. Their present number exceeds 5200 but the number of faint stars is clearly insufficient. Therefore the faint Hipparcos programme stars are being measured from the ground with an accuracy sufficient for their inclusion as standards if they are demonstrated to be non-variable.

4. THE PRESENT AND FUTURE PHOTOELECTRIC MEASUREMENTS

Among the 111 500 stars presently considered as observable by Hipparcos, according to the maximum pressure criterion, a large number have already been observed in one or more photometric systems. Statistics performed by M. Mermilliod on the Lausanne photometric data base indicate that 41 800 stars now have available photoelectric data - 20 650, 22 355 and 15 600 stars have measurements in UBV, Strömgren and Geneva systems respectively. 13 600 stars have been observed in more than one system. The stars observed recently by INCA observers are not included in these statistics.

Considering the acquisition rates of the photometrist teams, we may tentatively estimate that the percentage of stars with photoelectric measurements could increase from 37 per cent, the present value, to about 50 per cent at the end of the Input Catalogue compilation. Bearing in mind that for the majority of Hipparcos stars the distances will rely on photometric estimates and that the quantities E(B-V), M_v, T_{eff} and [M/H] are necessary for a full exploitation of the astrometric results of the mission, it appears very worthwhile to observe all stars of astronomical interest in multi-colour photometry. Such a project appears feasible through a coordinated effort during the years 1987-1992.

REFERENCES

Grenon, M., 1985a, 'Standard Stars for the On-Orbit Photometric Payload Calibration', ESA SP-234, 117.

Grenon, M., 1985b, 'New Ground-Based Photometric Observations', ESA SP-234, 113.