CONCLUDING REMARKS

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Seventeen years ago, the Hipparcos project was accepted within ESA's scientific programme, as the first space mission specifically devoted to the accurate measurement of stellar positions. As the result of an unprecedented and productive collaboration between ESA and the European astronomical community, the Hipparcos project has reached a decisive milestone.

The Hipparcos and Tycho Catalogues were completed in August 1996, and made widely available in June 1997, when they were published by ESA as the 17-volume publication ESA SP–1136. Volume 17 includes all data files, and documentation, in the form of six ASCII CD-ROMs. The catalogues can be obtained from the ESA Publications Division, with full details (and an order form) given on the Hipparcos www page, http://astro.estec.esa.nl/Hipparcos. The full catalogues are also available via ftp from the CDS, Strasbourg, where the catalogue data are also linked to the cross-identifications in the SIMBAD data base, and through the VizieR relational data base queries.

The Hipparcos www page also supports remote interrogation of the catalogues, either by object (HIP or TYC) identifier, or via a search range in right ascension and declination. Active links allow the user to follow selected HIP or TYC identifiers, entering the associated annexes (Variability Annexes, and the Double and Multiple Systems Annex) or inspecting the light-curve (in PDF form) when provided. A more comprehensive search and interrogation facility will become available at the end of 1997 in the form of a CD-ROM (Celestia 2000) with access and display software prepared for IBM PC and compatibles running under Windows 3.1, Windows 95, or Windows NT.

ESA has distributed an order form for the catalogues to most major astronomical institutes, observatories and libraries; and has made the 17-volume catalogue available free of charge to *bona fide* institutes for whom the purchase cost of the catalogues would likely be prohibitive.

The following are representative of some of the general questions that have been asked about the Hipparcos and Tycho Catalogues, addressed here in order to help orientate prospective catalogue users:

(a) are new versions of the Hipparcos and Tycho Catalogues expected? The answer is no; the three years between the end of satellite operations (mid-1993) and the catalogue publication (June 1996) was devoted to a full calibration, reduction, and documentation of the catalogues. No further global reductions of the data are planned or expected. Intermediate astrometric data, and photometric measurements at each epoch of observation, are published as part of the ASCII CD-ROM set, and these will allow users to undertake detailed investigations of individual objects – for example, for new variability period searches, or for revised orbital element determinations in conjunction with ground-based observations.

(b) What kind of errors been found already in the published catalogues? A full list of reported errors is maintained on the Hipparcos www page. Presently (September 1997) this list is very short, and restricted to minor editorial-type corrections.

(c) Can users trust the data? Our short answer is yes! A very considerable effort was devoted to the calibration and validation of the catalogue data (and the documentation of these tasks). The catalogue compilers are presently confident about the quality of the published data. Users should take fully into account the published standard errors and correlations, and the various notes and qualifiers related to the catalogue data. There is no present evidence that the astrometric data are affected by quantified systematic errors, or that the accompanying standard errors do not adequately reflect the true (external) errors.

J. Andersen (ed.), Highlights of Astronomy, Volume 11A, 586–587.

Accompanying the release of the Hipparcos and Tycho Catalogues, a major Symposium was organised in Venice in May. This represented the end of the formal involvement in the Hipparcos Project by ESA and the four scientific consortia: INCA (led by Catherine Turon, Meudon) responsible for the Hipparcos Input Catalogue; NDAC (led by Lennart Lindegren, Lund) and FAST (led by Jean Kovalevsky, CERGA), jointly responsible for the Hipparcos Catalogue; and TDAC (led by Erik Høg, Copenhagen) responsible for the Tycho Catalogue.

At the Venice Symposium roughly 200 oral and poster contributions were presented, communicating early results of investigations that had been undertaken during the one-year proprietary period following the catalogue completion. The resulting Proceedings, amounting to about 1000 pages, has been published as ESA SP–402 in September 1997.

These early analyses addressed a wide variety of subjects: in stellar physics, Galactic structure and evolution, reference frames, age and distance scale determinations, photometry and variability, studies of solar system objects, etc. In the three months between the Venice Symposium and the IAU Joint Discussion in Kyoto, progress has been evident on a number of fronts.

First, the Venice Symposium drew attention to some of the subtle considerations that needed to be accounted for in the detailed interpretation of the Hipparcos parallaxes (in particular) – especially in the context of the transformation of parallaxes to distances and the resulting consequences (e.g. the 'Lutz-Kelker' type effects), and in the correct use of the published correlations between astrometric parameters. Without due care, ignoring these effects may lead to incorrect astrophysical conclusions, and incorrect inferences about the data quality.

Second, a number of preliminary results presented at the Venice Symposium created some puzzlement: for example, the distance of the Pleiades was significantly different from the pre-Hipparcos value; similarly, comparisons between the pre- and post-Hipparcos distance estimates of a number of open clusters revealed some surprising results; and the various attempts to determine ages of certain Galactic tracers on the basis of stellar evolutionary models led to rather different age estimates, and to different conclusions about what these different estimates might mean.

In the short interval between these two meetings, there appears to have been already a significant increase in the confidence ascribed to the Hipparcos astrometry. In particular it does appear that investigators are now placing more confidence in the published data, and therefore in the discrepancies that these results are revealing. In parallel, different groups are starting to probe the implications that previous models of internal stellar structure and evolution might indeed have been too simplistic, and therefore do not adequately fit the new results.

These trends were evident in a number of areas presented at the Venice Symposium and again at the present Joint Discussion. Over the next few months, the Hipparcos implications about the distance and age scales, distribution of stars and hidden mass in the disk, Galactic rotation, and many other areas of astrophysics, should become much clearer.

The Hipparcos satellite data has already had a significant impact in a number of areas, and the early literature has already brought the relevance of space-based astrometric measurements more clearly into discussions of a wide range of astronomical disciplines. For the future, the value of significantly improved astrometric measurements is becoming ever more evident. Within ESA, plans for a 'super-Hipparcos' – a global astrometric interferometer which might reach 10 microarcsec accuracy at 15 mag, and which could allow the measurement of as many as 1 billion stars down to about 20 mag – are progressing. Distances accurate to 10 per cent could be measured out to 10 kpc, and proper motions corresponding to 1 km/s accuracy in the velocity vector would be possible out to 20 kpc. Some of the astrophysical problems that could be addressed with such an instrument have also been raised at this Joint Discussion.

As one major astrometric space programme is successfully concluded, the prospects for greatly enhancing our understanding of our Galaxy with improved positional measurements appear highly promising. At this level of accuracy, everything in our Galaxy would be seen to move. In years to come, the present gap in our knowledge of distances and motions within the Galaxy might seem surprising. But Hipparcos has certainly made a huge step towards acquiring this fundamental understanding.