The Hipparcos and Tycho Catalogues

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The Hipparcos and Tycho Catalogues

Astrometric and Photometric Star Catalogues

derived from the

ESA Hipparcos Space Astrometry Mission

A Collaboration Between

the European Space Agency

and

the FAST, NDAC, TDAC and INCA Consortia

and the Hipparcos Industrial Consortium led by

Matra Marconi Space

and

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Cover illustration: an impression of selected stars in their true positions around the Sun, as determined by Hipparcos, and viewed from a distant vantage point. Inset: sky map of the $B-V$ colour index from the Tycho Catalogue, in galactic coordinates.

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Volume 4

Construction of the Tycho Catalogue

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with the support of

members of the TDAC Data Reduction Consortium

Volume 4: Construction of the Tycho Catalogue

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FOREWORD

The Tycho experiment was not part of the Hipparcos mission approved by ESA in March 1980, nor had it been considered during the previous feasibility studies of the mission. The star mapper slit system was only intended for observation of the transit times of bright reference stars with known positions when they crossed the slits. These transit data were to be used to determine the satellite attitude in real time, as required for the observation of the planned 100 000 stars on the main modulating grid, and for the later accurate Hipparcos data reductions on ground.

It was during a study in March 1981 to define suitable meridian circle observations of reference stars for the attitude determination that the Tycho project was conceived by this author. The great potential of the star mapper for astrometric and photometric observations became clear and was immediately presented to the Hipparcos Science Team in three short technical notes. Incidentally, it gave rise to a project that looked more like a competitor to meridian circles than a helper. Since then the limiting magnitude of meridian circles has however improved from visual magnitude 10 to about 16 mag, whereas the limit for Tycho is about 11 mag.

Later, in 1981, ESA formally approved the Tycho project after a detailed assessment of the scientific return versus cost had been presented to the Science Programme Committee. At that time it aimed at determining magnitudes and positions for at least 400 000 stars. Had the Tycho proposal come a couple of months later, the satellite design would have been frozen, and the idea of the Tycho project would have been a lost opportunity. This wonderful idea would have been difficult to forget about, even though we were immersed in the fascination of the main mission, and in all the work it gave us.

The Tycho project required a very different approach to the data reductions to that of the main mission. The Tycho Consortium had to be set up, a very difficult task since practically all European astrometric expertise was busy with the main mission. But new dedicated teams were formed at Copenhagen, Heidelberg, Strasbourg, and Tübingen, and we obtained unfailing support from members of the Hipparcos Science Team, and from the FAST, INCA and NDAC Consortia, in defining the data reduction scheme, supplying photometric standard stars, satellite attitude, mathematical formulations, instrument calibrations, and other early access to results and data bases. We had to invent the data reduction scheme which in principle was very simple, but in practice became very complex, partly because satellite observations are never simple, partly because the Tycho astrometry had to be closely tied to the Hipparcos reference frame, and partly because we wanted to utilize every bit of information contained in the data. The extensive data simulations carried out before launch were very useful, but the real satellite data immediately posed many unforeseen problems, such as ‘spikes’ in the photon counts, and the complexities of the background determination. A quick response to new ideas was paramount to our work, whilst keeping a focused and concerted effort on the timely reduction of the 100 Gigabytes of data.

The care and optimisation invested in the data analysis were rewarded with a final Tycho Catalogue of more than one million stars. The timely reduction also succeeded, and the Tycho results were eventually finalized about one year earlier than expected before launch. This was early enough to allow the common completion, verification, and publication of both catalogues, and the introduction of the V_T magnitude, and the derived $B - V$ and $V - I$, into the main Hipparcos Catalogue. The addition of the

colour indices from Tycho greatly enhances the astrophysical value of the Hipparcos parallaxes, supplying otherwise missing accurate abscissae in the Hertzsprung-Russell diagram for about half of the Hipparcos Catalogue stars.

The late addition of the Tycho project meant that particular efforts, not foreseen during the Phase A study, had to be mobilized rapidly. This was accomplished within the European Space Agency, the scientific community around Hipparcos, and their supporting institutes and space agencies. The support of the four institutes where the main Tycho data reduction was carried out deserves our special gratitude: Astronomisches Institut, Tübingen; Astronomisches Rechen-Institut, Heidelberg; Centre de Données astronomiques de Strasbourg; and Copenhagen University Observatory. The support of the Space Telescope Science Institute in providing early access to the Guide Star Catalog for the Tycho Input Catalogue production was crucial for the Tycho project.

The scientific utilisation of the Tycho results has barely begun, with all available effort to date having been devoted to the catalogue completion and publication. The Tycho Catalogue will be central to the astrometric reductions of photographic plates and CCD images, at the same time providing a dense net of two-colour photometric reference stars. The derivation of accurate proper motions for all Tycho stars by means of observations at earlier epochs, especially the Astrographic Catalogue, has started. The discovery of new variable stars by means of the Tycho epoch photometry has just begun, and the study of colour variation in known variable stars has been envisaged.

Despite the thorough reduction of the observations carried out by the Tycho Consortium it is possible to do more, because the one million star catalogue is now available as a starting point, and because modern fast computers and large disk arrays have become available. A second Tycho reduction has begun in a collaboration between Copenhagen and Heidelberg and is expected to measure about 3 million stars. The immense potential of space astrometry has been opened up.

E. Høg, Tycho Consortium Leader