HIPPARCOS - LINK WITH EXTRAGALACTIC REFERENCE FRAMES

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ABSTRACT. The link of the Hipparcos Catalogue to an extragalactic reference system will be carried out on two time-scales: the first, coinciding with the duration of the mission, to provide data for immediate use by the data reduction consortia, and the second over a longer term to provide for subsequent reappraisal of the final Hipparcos catalogue. The first will be based on radio stars and on an indirect link to extragalactic objects by means of observations with the Hubble Space Telescope; for the second we hope for longer term programmes with the Hubble Space Telescope, together with a variety of ground-based links.

1. INTRODUCTION

Inertial reference systems based on extragalactic radio sources have been in use in conjunction with VLBI for some years now (Meuller 1981). They provide high-precision monitoring of the earth's precession, nutation, spin rate, polar motion and crustal deformations. The accuracy required of the reference system is at the milli-arcsec level, since an uncertainty in a reference source of one milli-arcsec corresponds, for a VLBI baseline length of 400 km, to an uncertainty in the derived baseline length of 1 cm which is of the order of the plate tectonic movement over one year.

An optical reference system accurately linked to such a frame is urgently needed for the interpretation of the motions of solar system objects and of stars in the galaxy. To establish such a system, a working group was set up by IAU Commission 24 in 1978 to select sources having suitable radio and optical properties. This group has published its selection of 235 sources (Argue et al. 1984). Up to the time of this publication most of the VLBI activity had been confined to the northern hemisphere, and in the report the need for additional sources south of declination -40 deg was highlighted. Current work, particularly in Australia, is rapidly making good that deficiency.

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2. IMPLEMENTATION

While it is obvious that the ready-made system just referred to is a convenient starting point for a Hipparcos link, there is a practical difficulty in that only one or two of the extragalactic objects contained in the list are bright enough for observation by Hipparcos. This is being surmounted in the following ways:

(i) bright radio stars: work is now in progress to extend the IAU 1984 list to give a selection of these. Not being extragalactic, they did not feature in the 1984 list. A report on this extension is to be presented to Commission 24 in the current session (de Vegt 1985). At present the proposed list of radio stars is made up of 50 objects all bright enough for direct Hipparcos observation (typically $V < 12$, although this can only be regarded as a rough figure because these stars are variable). In the report the provisional nature of the list is stressed. There still remains much work to be done in both the optical and radio domains to establish the suitability of each star for astrometric work at the level of accuracy demanded. These difficult problems have been reviewed recently at the Hipparcos Colloquium held at Aussois (Turon & Perryman 1985). The list extends only as far south as declination -30 deg at present, and an extension to the south equatorial pole is urgently needed, if possible. Once proper motions relative to extragalactic sources have been determined by VLA and VLBI, a direct link of the Hipparcos catalogue to this extragalactic system would in principle be achieved without the interposition of other optical instruments.

(ii) faint extragalactic objects: these may be tied using observations either with the Space Telescope or with large ground-based telescopes. The Space Telescope link has been reviewed by Hemenway et al. (1985). Briefly, it is based on the measurement of the angular separation, and of its variation with time, between each extragalactic object and a suitable Hipparcos star within the field of the Fine Guidance Sensor (optimally 4 x 5 square arcmin) of the Space Telescope. The ground-based methods are essentially a variation of this that use either CCD or classical photographic astrometry.

2.1. The FAST-NDAC Link

The essence of this link is that the observations needed for it shall have been substantially completed by the end of the Hipparcos operations in 1990 in order that they can be incorporated into the completed Hipparcos Catalogue which is due in 1993. Because of this urgency, the link is to be restricted to (i) bright radio stars, and (ii) measurements with the Space Telescope as just described.

(i) According to simulations by Froeschlé & Kovalevsky (1982), 20 radio stars alone would yield elements of the transformation matrix with accuracy 1 milli-arcsec per year for residual rotation of the frame and 2 milli-arcsec for offset;

(ii) P.D. Hemenway and R.L. Duncombe plan to devote 40 hours of their guaranteed observing time on the Space Telescope to the link. They have selected 40 extragalactic objects mostly from the IAU list. Practically

all are north of declination -25 deg. In an application to be made to Space Telescope before 31 March 1986, in collaboration with FAST-NDAC, Hemenway and Duncombe hope to smooth out the gaps in the surface distribution of their selection by adding 20 more extragalactic objects, predominantly radio quiet QSOs selected from the catalogue of Hewitt & Burbidge (1980) and the Palomar Bright Quasar Survey (Schmidt & Green 1983). Radio quiet QSOs of course can act only as rotation stoppers and do not contribute to a comparison of the Hipparcos with the radio reference frame. This comparison of frames is important, both for testing for systematic errors in the frames and, as a practical application, in accurately pinpointing optical emission centres on radio maps; nevertheless from the point of view of the Hipparcos catalogue the tying down of the residual rotation is of overriding importance because of its critical role in the dynamics of the galaxy.

An extension of the Space Telescope observations to the south equatorial pole must also be included in the future application, based on about 30 extragalactic objects now being selected at CSIRO in Australia. After an interval of three or four years, towards the end of the Hipparcos flight, it would be desirable to repeat the whole Space Telescope programme in order to tie down the proper motions more accurately. An error budget drawn up by Kovalevsky shows that, in this last case, the accuracy of the residual rotation determination would be 0.5 milli-arcsec per year. This is approaching the instrumental zonal errors anticipated for the Hipparcos output catalogue. (These have not been properly assessed, but are not expected to exceed a few 0.1 milli-arcsec, or a few 0.1 milli-arcsec per year). By comparison, the random errors of Hipparcos for bright stars should be in the range 1-2 milli-arcsec or 1-2 milli-arcsec per year.

2.2. The Long-Term Link

A ground based programme of conventional photography with large telescopes extending over a period of ten years and involving 230 sources ought to yield about the same accuracy for the residual rotation as that anticipated for the FAST-NDAC link, 0.5 milli-arcsec per year.

Mention ought also be made of the long-term programmes of photographically determined proper motions of stars relative to galaxies being carried out at Lick, Pulkovo, Tautenberg and Bonn. Large numbers of these stars are known to be included in the Hipparcos Input Catalogue.

All these long-term investigations will provide valuable cross checks between one another and with the FAST-NDAC link.

3. INCA SUBGROUP 2130

This subgroup of the Hipparcos Input Catalogue Consortium is responsible for the detailed review of objects to link the Hipparcos system to an extragalactic reference frame, in co-operation with the data reduction consortia and the Space Telescope Astrometric Team. The composition of the subgroup is given in Argue (1985).

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