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INTERNATIONAL SPECIAL PROGRAMMES OF MERIDIAN OBSERVATIONS OF REFERENCE AND PROGRAMME STARS

S. SADŽAKOV, Z. CVETKOVIĆ and M. DAČIĆ
Astronomical Observatory, Volgina 7, 11050 Belgrade, Yugoslavia
E-mail ssadzakov@aob.aob.bg.ac.yu

Abstract. The new methods in astrometry have aided the development of fundamental research in astrometry. At many observatories in the world the compilations of star catalogues containing a large number of stars proposed by the IAU are in progress. The accuracy of the determined star positions and proper motions is expected to increase due to the applications of VLBI, Hipparcos satellite, as well as of the automatic meridian circles.

1. INTRODUCTION

In the recent time the spectrum of astrometric programmes has become less comprehensive. Once defined as a "science of the measuring of angles on the celestial sphere" through a "science about space and time", astrometry is nowadays most clearly defined as a science which studies geometrical and kinematical characteristics of some celestial bodies, of their groups, as well as those of the universe as a whole (Yatskiv, 1983); or astrometry is the science determining the positions, motions, sizes and geometry of celestial bodies, as well as their distances.

Astrometry is a foundation of astronomy, it yields a high-accuracy system of celestial coordinates, the distance scale in the universe and a consistent system of astronomical constants.

A large body of data obtained from astrometrical observations is used in stellar astronomy for the purpose of studying the structure, kinematics and dynamics of stars, stellar systems and galaxies and also in celestial mechanics for improving the theory of motion of the Solar-System bodies.

The astrometric research offers to related sciences for their practical needs all necessary data concerning the Earth's rotation, the positions of the Solar-System bodies, defines the reference coordinate systems used in cartography, navigation, etc. There is a close relationship between astrometry and gravimetry, astrometry deals with the spatial determination of the coordinates of celestial bodies, it studies their translatory rotational motion on the basis of observations (largely terrestrial).

The realization of the reductions of astronomical observations is impossible without using the results and methods of gravimetry and celestial mechanics in view of their close relationship through astronomical constants and astrometric observations.

In the epoch of active space exploration the practical role of astronomy becomes more important every year and the practical necessities stimulate the development of the fundamental astrometric research.

2. THE GREAT CATALOGUES REALIZED RECENTLY

At many astronomical observatories all over the world the praxis of producing stellar catalogues containing a large number of stars from various proposed and accepted lists of the international astronomical institutions has been continued.

At Brorfelde a catalogue containing 6427 stars (1969-1975) brighter than $m = 11$ was compiled by using a meridian circle with photographic circle reading. The stars originate from the lists of NPZT, FK4 Sup, high-velocity O-B stars inside 20 *pc*, fainter than in GC from associations and stars around them. The reference stars are from FK4. The mean-square error of a single measurement in right ascension is $0''.086$, i.e. $0''.104$ in declination. The average number of observations is 5. For the purpose of a better linking to the reference system an additional smoothing has been done (Helmer and Fogh Olsen, 1982).

After the circle modernization by installing a photoelectric micrometer the so-called Carlsberg Authomatic Meridina Circle (CAMC) was obtained. In the period 1981-1982 it was used for observing 1577 stars up to $m = 11$. This programme includes 425 FK4 stars being reference for it, or more precisely : 167 stars from AGK3 in the zone $+88° - +89°$, 115 stars around the north galactic pole, as well as FZT, GC stars, the reference ones in the vicinity of radio sources appearing in the earlier programmes of this instrument. The mean-square error of a single observation is $\pm 0^s.0138$ and $\pm 0''.216$ (Helmer et al., 1983).

The other catalogue obtained with CAMC is from the period 1982-1983. It contains 1071 stars as follows : 146 AGK3 stars from the zone $+88° - +89°$, 68 stars situated in the vicinity of the north galactic pole, FZT-programme stars, reference stars from the vicinity of radio sources. The FK4 reference stars are not in the general list. The determination accuracy is the same as in the first catalogue. This meridian circle was mounted at the La Palma Observatory and from May 1 to December 12, 1984, 35154 transits of 5292 stars were observed, or more precisely : 2369 AGK3R stars, 1296 SRS ones, 838 reference stars between $m = 11$ and $m = 13$ within a solid angle of $1° \times 1°$ around the radio sources from the IAU list, 227 FZT stars, 406 AGK3 stars and 139 SAO stars. The mean-square error of a single observation is $\varepsilon_\alpha \cos\delta = \pm 0''.193$ $\sec z$, $\varepsilon_\delta = \pm 0''.184$ $\sec z$. At the zenith distance $z = 30°$ the accuracy is the same as at Brorfelde, but the number of observations is higher.

At the Cerro Calan Observatory in Chile several catalogues have been compiled with various instruments. The Absolute Pulkovo Catalogue for right ascension in the southern sky, the so-called *SPu*71 has been examined for the purpose of discovering and also removing the systematic and random errors which earlier were not taken into account. For each observing night are formed the equations for the correction determination of the Bessel-reduction-formulae coefficients. The calculation of these corrections shows that they are negligible, indicating that the catalogue is free of large systematic errors. In the process of examining another version of the catalogue

has been obtained, more accurate as for the random errors. The observations with the Repsold Meridian Circle between 1963 and 1970 have yielded two catalogues. The first one contains 18 583 measurements for 2756 SRS stars, 336 BS stars and 215 reference ones from FK4 in the zone from $-20°$ to $-40°$. The system of the instrument was determined from 59 reference-stars series with 1936 measurements within the zone from $+41°$ to $-68°$. The mean-square error for the equator-point determination was $\pm 0''.33$ (Carrasco, 1978).

The other catalogue compiled by the Pulkovo astronomers is due to the classical observations using the relative method, whereas the treatment was performed by using the quasi-absolute method and the corrections were applied only for FK4 stars. Detailed examinations and analyses of the obtained results were done. The right-ascension catalogues were given in the instrumental system realized on the basis of the quasi-absolute method, whereas the declination ones were given in the FK4 system. The SRS Catalogue contains 5491 stars, out of them 828 BS stars, 356 DS stars, whereas the programme stars were taken from the zone between $-50°$ and $-80°$, i.e. from a belt of interest to the determination of coordinates of these stars. The mean-square errors for the reference stars are $\pm 0^s.015$ and $\pm 0''.39$, and for the programme stars are $\pm 0^s.018$ and $\pm 0''.41$ (Zverev et al., 1983).

With the Airy Meridian Circle of the Greenwich Observatory were performed observations between 1942 and 1954 on the basis of which their last catalogue was compiled and published. After March 30, 1954 there have been no observations with this instrument. For the observational-data treatment the absolute method was used. In addition to 255 fundamental stars the catalogue also contains 255 FZT Herstmonceux stars and 76 stars situated in the vicinity of the north celestial pole and observed in both culminations (Tucker et al., 1983).

At Herstmonceux with the Cook Meridian Circle brought over from Greenwich have been obtained the first three absolute catalogues based on 76 azimuthal and 235 hour stars from the FK4 fundamental catalogue.

The catalogue $1H_x50$ contains 18 114 stars and the observations meant for its compilation were performed between 1957 and 1961. The origins of its stars are : 835 $FK4$, 1408 $FK4Sup$, 13 803 $AGK3R$, 635 from various FZT lists, 1045 from Blau's list and 37 $FK3$ double stars not included in $FK4$.

The second catalogue $2H_x50$ was compiled between 1961 and 1969. It contains 816 other $FK4$ stars, 1352 $FK4Sup$ ones, 5866 stars from the common catalogue of line-of-sight velocities, $GCRV$ (for the purpose of improving their proper motions), 352 variable stars and stars in the vicinity of quasars, $FK3$ double stars not included in $FK4$ and a few others. The total number of stars in the catalogue is 8736 stars.

The third catalogue $3H_x50$ contains 835 other $FK4$ stars, 3539 from the catalogue $Wash$ 50 Zod, 1715 NPZT stars, 251 variable stars from $GCRV$ etc. The total number of stars is 6728 stars.

With $Washington$ 6" Meridian Circle 14 916 stars were observed between 1963 and 1971 by applying the absolute method and a catalogue known as W_{50} was obtained. It contains 1147 $FK4$ stars (out of them 203 hour, 34 azimuthal, 98 refraction and 812 others), 3681 BS bright stars (including 1409 $FK4Sup$ ones), 154 stars situated in the vicinity of radio sources, 9631 SRS Programme stars, 141 stars of the Washington

and Richmond *FZT* programmes, 121 carbon stars and 33 high-proper-motion ones (Hughes and Scott, 1982).

3. THE CHARACTERISTICS OF PRESENT STAR CATALOGUES

From the appearance of the first fundamental catalogue of Auvers the idea to define a coordinate system purely kinematically has not been seriously considered.

The astronomers need a fundamental system defined through the equatorial coordinates which also involves the elements describing the Earth's rotation in space (precession and nutation), as well as the equinox motion.

The positions of the true equinox and of the true equator are time functions in a determined coordinate system and they offer a dynamical definition of this coordinate system, as well as of the true-equator-coordinate-system motion.

The daylight observations of the Sun, inner planets, stars, as well as of the Moon, are very important for the equnox correction of a star catalogue. In praxis also appear other difficulties in the determination of the dynamical equinox for the right-ascension origin in star catalogues, which gives rise to a disagreement between the definition and realization of used stars, especially when this incoincidence is in correlation with the ephemeris-time.

In the precession-constant determination use has been made of dynamical and kinematical methods, together or independently. The kinematical determinations of the precession constant by using the galactic-rotation models are more accurate than purely dynamical solutions.

Such a pragmatical approach has allowed a final accuracy of the *FK*5 Catalogue, the highest possible in view of the available observational results, being of the order of $0''.15$ per century.

In order to achieve an improvement of the *FK*5 system, a system based on the dynamical definition and knowledge of the motion of one celestial body, in our case that of the Moon, is considered.

There are results of the 15-year cycle of laser observations, as well as those referring to the motion of a point near the Moon's mass centre which in its motion has an orbit of 40 cm in diameter corresponding to $0''.001$ - $0''.002$ in longitude in the dynamical coordinate system for more than ten years. There are difficulties affecting good knowledge of the lunar motion because the order of the errors is $0''.3$ due to the bad determination of the systematic deviation of the apparent-lunar-figure centre, as well as due to the movement of its mass centre.

On account of a low number of the zodiacal stars which occult the Moon, in a fundamental catalogue it is difficult to improve the parameters used in the classical determination of the celestial coordinate system on the basis of the lunar laser data.

Nowadays one utilizes VLBI with which extragalactic radio sources are observed, and used as fundamental points of a fixed coordinate system.

In this case one should know the exact equator position in the system because the observed declinations are referred to the instantaneous terrestrial rotation axis. Only relative right ascensions are obtained giving rise to a new problem of an independent equinox determination.

In addition to the declination determination of a pulsar by using VLBI the ecliptic longitude and latitude are derived from the analysis of the pulsar retardation during the Earth's orbital heliocentric motion. The method precision exceeds $0''.1$ and it does not attain the desired accuracy.

A great progress is expected by the realization of the Hipparcos Programme which comprises 100 000 stars whose positions and proper motions will be determined with an accuracy of $\pm 0''.002$ per year. The Hipparcos System will not be inertial and the coordinate system will be *a priori* defined so that its residual ro ation is inevitable.

This system will be connected to VLBI and the Hipparcos Catalogue will materialize a geometrically constant celestial sphere accurate to $0''.002$. This accuracy will gradually decrease due to the accumulation of random errors in proper motions.

The Hipparcos System will be fixed, it will be independent of any terrestrial motion parameter and it will be used as a reference for all motions.

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