THE HISTORY OF BELGRADE RESEARCH OF STAR POSITIONS AROUND QUASARS

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Among the tasks which appeared in the frameworks of fundamental astrometry and observational one, during the last decades of the XX century, simultaneously with formation of qualitatively new coordinate systems, an important place belongs to the study of orientation of the traditional, optical, fundamental systems with respect to the new coordinate systems linked to the compact extragalactic radio sources.

- One of the ways to realise an inertial system of reference of high accuracy is to link it to extragalactic radio sources (basically these are quasars).

- This has been realised by combining optical observations with the methods of long-base radio interferometry.

- The formation of such a system was followed by the assumption that the directions towards extragalactic sources do not show any changes within several decades.

Modern views and the development of technology have made it possible to form this system of reference with an accuracy within a few milliarcseconds and with the same stability within a sufficiently long time interval with regard that quasars and galaxies, due to their distances, are practically fixed on the celestial sphere.

The sources emitting at both optical and radio wavelengths are optically very faint. It is clear that the link of the FK5 system (adopted in the eighties of XX century as the official system of reference in the position determination for celestial bodies) to so faint objects can be indirect only and at that time it was represented by means of the following chain (Gulyaev 1987):

FRS – RS1 – RS2 – RS3 – RRS .

- **FRS –** a fundamental system like, for instance, FK5.
- **RS1 –** reference coordinate systems serving for the purpose of solving many tasks of positional astronomy (AGK3R and SRS).
- **RS2 –** second-order reference systems serving for the purpose of determining many coordinates for faint objects and studying the kinematics of stellar systems (AGK3).
- **RS3 –** third-order reference systems. They are used in the coordinate determination for very faint objects ($m > 12$), for instance, quasars.
- **RRS –** radio interferometric coordinate system obtained from observations of extragalactic objects at radio wavelengths.

Astronomical Observatory in Belgrade also joined this international activity by determining the positions of the reference stars in the vicinity of radio sources. From Kiev a list containing 315 stars (belonging to RS2 class) distributed within 87 fields with radio sources was obtained. The stars were distributed over the whole sky within a declination zone from –44° to +90° (Lazorenko 1982).

From 1982, when the first observations started, by 1987 with the Large Meridian Circle of the Belgrade Observatory the positions of these stars were determined by using the differential method within a declination zone from −30° to +90°.

In addition to the programme stars listed there, as reference ones, stars belonging to the FK5 system of reference were also observed.

On the basis of these observations a position catalogue containing 290 stars distributed within 78 fields with radio sources and 198 FK5 stars, with a mean observational epoch of 1984.5, resulted (Sadžakov et al. 1991).

The rms error per single determination was $\pm 0.^{s}024 \cos\delta$ in right ascension and, $\pm 0.''30$ in declination, quite as could be expected in the case of a classical instrument like the Large Meridian Circle of the Belgrade Observatory.

With regard that every star was observed on the average more than five times, we find as position errors in this observational catalogue $\pm 0.^{s}010 \cos\delta$ in right ascension, $\pm 0.''13$ in declination.

The comparisons with AGK3 and Kiev Declination Catalogue, both containing all stars observed in Belgrade, showed that the obtained results can be regarded as satisfactory.

In Resolution B5 accepted at the XXII IAU General Assembly (Information Bulletin 1995) the final list was formed which contained about 600 extragalactic objects foreseen to be considered as candidates to be included in the new reference frame, i. e. system of reference.

The Working Group for reference frames finalised the positions of these extragalactic objects during 1995 and reduced them into a single reference frame coinciding with the FK5 catalogue within the limits of its errors.

Besides, in 1996 the HIPPARCOS (**HI**gh **P**recision **PAR**allax **CO**llecting **S**atellit) Catalogue was finished.

It has a link to the mentioned objects with a deviation in the position of ±0."0006 for the epoch 1991.25 and an error of ±0."00025 per year in the rotation.

This catalogue, among others, contains positions and proper motions for more than hundred thousand stars with apparent magnitudes not exceeding m = 12.5 (Turon 1996).

Starting from this at the XXIII IAU General Assembly in Resolution B2 (Information Bulletin 1998) it was decided that from January 1, 1998 ICRS (International Celestial Reference System) had to be accepted as the IAU celestial system of reference according to the definition of the International Earth-Rotation Service (IERS).

The corresponding reference frame will be ICRF (International Celestial Reference Frame) formed by the Working Group for Reference Frames.

Here the HIPPARCOS Catalogue appears as the ICRS primary realisation at optical wavelenghths.

ICRS appears, in some way, as an extension of the FK5 system towards the radiation sources unavailable to the classical astronomical observations.

Due to the enormous distance and (angular) fixedness of quasars the new system of reference provides, within a sufficiently long time interval, an increased position accuracy for the case of extragalactic objects and, in this way also, of the objects covered by FK5 (stars and Solar-System bodies).

References:

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Thank you for attention