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Review paper

THE CHARACTERISTICS OF THE BELGRADE MERIDIAN CIRCLE AND ITS CONTRIBUTION TO THE FUNDAMENTAL ASTROMETRY

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SUMMARY: The authors present the characteristics of the Belgrade Meridian Circle and the results of the observations of stars, the Sun, Mercury, Venus and Mars during the last 35 years - 1960-1995.

1. INTRODUCTION

Fundamental astrometry whose principal aim is the compiling of fundamental catalogues, though among the oldest branches of astronomy, keeps its importance nowadays too and in the future an increase of its importance might be expected.

A fundamental star catalogue is a resulting mean catalogue derived from observational ones of various observatories and it defines a fundamental coordinate frame. Without it the activities time service, celestial mechanics in geodesy and of many other astronomical fields are not imaginable. It should be said immediately that the requirements for increasing the accuracy of star catalogues have grown simultaneously with the development of the fields just mentioned. The requirement that the real errors in the postion of the fundamental stars do not exceed the amount of 0."002 and the one in the proper motion that of 0."0001 per year has not been satisfied yet.

The difficulties not allowing the desirable accuracy to be achieved are mainly due to the circumstance that the way of clearing the star catalogues of systematic errors has not been sufficiently perfected. The systematic errors of a fundamental catalogue are largely consequences of the systematic errors in the observational catalogues of various observatories from which the fundamental one is compiled. The appearance of the systematic errors in observational catalogues is caused by inadequate meridian instruments, observational conditions and by methods of observational reduction. A meridian circle is still a crucial instrument for precise determination of both star coordinates - right ascension and declination - by using both absolute and relative methods. It is important to emphasize that meridian circles are still essentially of the same construction as they were at the end of the last century, but the improvement of the auxiliary equipment (impersonal micrometer, automatic tracking of stars, printing chronographs, photographic and photoelectric limb reading) has been accompanied by the rash technological progress and consequently in the fields of observational precision and registering a much greater progress has been achieved.

The main problem, thorough examination of the instruments, still constitutes the principal question of eliminating the systematic errors of instrumental origin.

While with vertical circles it is flexure that one struggles with, with the meridian circles there is another difficulty - the determination of the nadir point with a mercury mirror. For some meridian circles, for instance the Greenwich one, the systematic deviations in the observations of true and reflected star images have attained even 0."9.

The reasons for such and similar phenomena are different for different instruments, but their sources are largely in the instability of the piers, effects of temperature variations during the observation during the evening or night, as well as in the irregularities of the pivots. The systematic errors are especially a great problem in the absolute determinations of the star coordinates with meridian circles.

As the majority of meridian circles, except those at Washington, Greenwich, Cape and one in the former USSR, are mainly used for the relative determination of both coordinates, the influences of the systematic errors of this kind are smaller. When the relative method is used, one observes in a series fundamental and programme stars and there is no need to determine the zero point of the circle since the declination of a programme star is obtained from the position difference "fundamental star minus programme star". In absolute observations there is the danger of systematic errors and the sources are hidden in inperfectly polished pivots, in the limb division, as well as in the limb position with respect to the rotational axis.

Over the last fifty years of this century the collimation and its variations have been studied more thoroughly for all types of meridian circles and it is recommended the aperture of the collimator objective to be equal to the one of the instrument's objective.

The instrument's organs, the pivots, the circle and the collimators, form the essential elements of the instrument. Certainly, the levels, the microscope-micrometers and the eyepiece micrometer are essential too. Their examination is part of the general instrument examinations.

2. THE BELGRADE MERIDIAN CIRCLE

Some characteristics and properties of this instrument have been the subject of earlier papers (e. g. Šaletić, 1968; Mijatov and Sadžakov, 1970). According to the original plan the Meridian-Circle pavilion was to be located in the meridian of the Small-Transit-Instrument, where today is the pavilion of the Large Transit Instrument. The pavilion desiner made the general and the final plan respecting the instructions of the firm which delivered the instrument. It should be noted that the original decision was changed and another pavilion, situated more towards the northeast, at a distance of about 75 m from the original location on a level of 241 m, was erected for the Meridian Circle. Thus in that pavilion, following a decision of the Council of the Belgrade Observatory from 1960, was mounted the Large Transit Instrument.

The pavilions, housing these two instruments, are identical regarding their construction. There were very serious discussions concerning the place of their installation. Reputed world experts were invited and consulted in connexion with this problem. The conclusions following from a discussion with R. Aitkinson (Greenwich), N. Stoyko (Paris) and M. S. Zverev (Pulkovo - Leningrad) should be mentioned. All of them agreed that the places of the instruments should not be changed and that the Meridian Circle should remain on that place where it is today. They especially emphasized the danger due to the effect of the asphalt road and the doorman's booth on the declination determination. In the relative determinations of both coordinates it is assumed that the external conditions are the same within the time period needed to observe the fundamental stars and those whose coordinates are to be determined. Since this time interval can attain even 45 minutes, the same external conditions cannot be guaranteed within a pavilion situated by an asphalt road and having a close-by building in its meridian.

Based on all mentioned above it could be clearly seen that the prospects of the Meridian Circle, on the place where it is today, free of all mentioned difficulties are favourable and that one may carry out its subtle rectification and thorough examination.

3. RECTIFICATION OF THE INSTRUMENT AND EXAMINATION OF ITS MEASURING ORGANS

The mounting of the Meridian Circle was performed by D. Šaletić, Lj. Paunović and M. Kralj. It is true that the instrument mounting took place in 1960, but many shortcomings were noticed which, had first to be removed so that the rectification and the examination of the instrument could begin. First one had to solve the question of conducting the rainwatler from the roof construction as far away from the pavilion as possible. Then a concrete protection was built surrounding partly the pavilion. Also some faults in the roof construction were removed which hampered its functionig, especially at the opening of the dome.

Its first rectification and the examination of the eight microscope-micrometers were performed in 1961 by Lj. Dačić and I. Pakvor. Further work on this instrument was stopped in 1962 when the head of the M.C. Division, Lj. Dačić left Belgrade. His post was entrusted to B. Ševarlić who at that time had led the Latitude Division. In addition, with one third of the working time, were engaged three engineers of geodesy and one technical coworker. From January 1964 begins an intensive work on the preparing and examining of this instrument. The first observations with this instrument started in April 1964 and their results gave a first picture of its quality and usability, indicating what had still to be done. In the course of this work, including the examination of its organs, and computations there was a close cooperation and mutual aiding between the M.C. Division and the Vertical Circle (V.C.) Division. The members of the two Divisions, together with the two technical coworkers (from January 1964 this Division got one more technical coworker), did the following instrument rectification and examinations:

1) The lost motion of the eight microscope-micrometers was examined at -1^{th}, 0^{th}, $+1^{th}$ revolutions with ten settings at turning on and ten at turning off. A negligibly small amount was found.

2) The periodical errors of the eight microscope-micrometers were determined according to Ridberg's method at intervals of 3/4 and 3/5 revolutions. Three revolutions were examined on the either side of the zeroth one. The setting was done 12 times in each position beginning with divisions 0.5, 10 for the interval of 3/4 and with 0.4, 8 for the one of 3/5 revolutions. The errors were determined and analysed. They are between ± 0.1 circle divisions. 84% of these errors were within the limits of ± 0.05 circle divisions.

The progressive errors were not determined because there is no application of them with microscope-micrometers. The conclusion was that all of the eight microscope-micrometers were very well preserved and of a very good quality and that their systematic errors, being extremely small, did not require their application in the reductions of observations. The "runs" of all micrometric microscopes were reduced to values less than 1 circle division.

3) The lost-motion for the right-ascension screw of the eyepiece micrometer was determined from four series, each with ten settings, whereas in the case of the declination screw the number of series was six (also ten settings each). Negligibly small amounts were obtained.

4) The determination of the periodical errors for the two eyepiece-micrometer screws was carried out by applying Ridberg method at intervals of 3/5, 5/8 and 3/4 revolutions. For each interval there were 30 measurement series. The obtained values for the periodical errors were within the limits of ± 0.3 circle divisions indicating a good quality of the micrometer.

5) The examination of the progressive errors was carried out by applying a quasi-Ridberg method at intervals of 1.0, 2.0 and 3.0 revolutions. From a total of 12 series the results obtained by using Ridberg's method were confirmed.

6) The eyepiece-micrometer constants were also determined; wire separation, contact width and the angular revolution value for both frame.

The wire separation was measured with 20 settings on each fixed wire on the right-ascension screw.

The width of each contact was determined from ten settings on the beginning and end of each contact on the chronograph band. The mean value of a contact width is 0.020 revolution.

The angular revolution value for the right-ascension screw was derived from meridian transits of 23 stars and 229 independent intervals between the contacts. A value of $2.^s700 \pm 0.^s001$ was obtained.

The angular revolution value of the declination screw was derived from the connection micrometer-circle and a value of $20.''510 \pm 0.''020$ was obtained.

7) The level on the horizontal axis was examined by applying Vasilev method. For the mean value of the division was obtained $0.^s075$.

8) The examination of the limb excentricity and noncoaxiallity of the horizontal-axis pivots was performed by measuring the circle shift in the circle plane with a contact indicator and the micrometric microscopes and a maximum shift of 0.25 *mm* was found.

A shift perpendicular to the limb plane due to the limb inclination with respect to the horizontal axis, the limb deformities and to the component of the noncoaxiallity of the horizontal-axis pivots was also measured with a contact indicator. A maximum shift of 0.08 *mm* was found.

9) The examination of the limb division was performed by applying several methods, at each 4^o, 1^o, $0.^o5$ division, whereby the methods of Heyfeling, Bruns and Nikolić were used. On the other hand every division line was examined by applying Podobed method and that of Šaletić and Sadžakov. On the basis of the results of these measurements it may be concluded that the circle is of a mediocre quality, comparable to the limbs of the similar instruments of majority of world observatories.

10) The use was made possible of the collimators borrowed from a meridian circle of 110 *mm* aperture because the original ones, belonging to this instrument larger in size, had been earlier lent for use with the Large Transit Instrument which was without collimators. The use of a mercury mirror with a Gauss eyepiece was practised. The instrument constants: inclination (i), collimation (c) and azimuth (a) were determined in a few successive approximations both from observations of stars and also from the collimators, horizontal-axis level and mercury mirror to be finally reduced by rectification to the following respective amounts:

$$i = -0.^s396; c = +0.^s087; a = +0.^s512 .$$

The verifications of the value of the horizontal-axis inclination and that of the collimation were performed by using the mercury mirror. With this state of the instrument the horizontal wires of the eyepiece micrometer were carefully adjusted to coincide with the daily parallels and the wire plane was definitively set to coincide withthe focal plane. The system of the instrument reversal was adjusted in both clamps. The collimation was measured before and after every observation and it was found that its value varied depending on the temperature, within the limits $0.^s130$ and $0.^s274$.

11) Since the instrument has pivots subsequently made (at Messrs "21. maj", Rakovica Belgrade, because the original ones had been damaged in World War II and not usable), contact indicator measurements were executed in the working-section plane of the new pivots in order to obtain a true insight in their quality. Detailed examinations of the pivots were carried out in spring 1965 with interferometers purchased in USSR.

4. TEST DETERMINATION OF RIGHT ASCENSIONS AND DECLINATIONS

On finishing the examination of the instrument's measuring organs and after removing some minor instrument deficiencies, the test determinations of right ascensions and declinations of fundamental stars could begin.

In 1964 219 stars at 535 transits were observed. In the same year the reduction and analysis of the entire observational material took place and it was concluded that there were significant systematic

errors in the quantities obtained at the two clamps. It was found that the difference between the readings of the diametrically positioned microscopes varied systematically, an indication of the effect usually known as "swimming" of the rotational axis.

It was found that this effect was significantly diminished when the pivots pressed their bearings more strongly, namely in the difference of the microscopes readings was impossible to find any variation already for a burdening of about 30 kg. With such a load on the pivots a series of 41 $FK4$ stars was observed in early 1965 along the entire meridian at both clamps. The obtained results were not astisfactory and additional work, comprising the improving of the instrument rectification and the repair of some parts of the instrument (pivots polishing) was required. The procedure of reexamining the instrument's system by observing fundamental stars along the whole meridian and in such a way gradually was achieved an error typical of instruments such as our Meridian Circle. Currently the burdening of the pivots is 12 kg, the instrument's system is more than twenty years within the allowed limits and the errors with which star positions are determined are quite acceptable in visual observations like ours.

5. CADRES

By the first systematisation three posts within the Group of Relative Coordinates charged with the work with the Meridian Circle were envisaged: the head, an assistant or astronomical collaborator and a calculator. First, till 1962 was engaged Lj. Dačić and I. Pakvor who remained in this Group till 1963. From 1963 on the Group was led by B. Ševarlić, up to 1973. Engaged with one third of the full time there were three engineers of geodesy: Lj. Nikolić and A. Vojnović between 1963 and 1977 and D. Šaletić from 1963 to 1980. Vera Radogostić was in this Group in the period 1963-1964 as a technical collaborator and as an assistant or astronomer from 1964 to 1987; B. Kubičela was engaged, as a technical collaborator from January 1964 to middecember 1967; L. Djurović was engaged in the same capacity from 1. 1. 1968 to 14. 1. 1969. V. Erceg began her career as a technical collaborator in the period 10. 7. 1967 - June 1969 and from that time till 13. 4. 1973 as an astronomer. S. Sadžakov began her activity in this Group as an assistant on 15. 12. 1968 to become its head in 1973. Working in the Group she acquired all the scientifical degrees. M. Dačić began his activity in this Group as a volonteer with bachelor degree on 1. 9. 1969 to begin his full-time career on 1. 1. 1970 as an astronomer; now he is a research fellow. V. Protić-Benišek began her career in the Group as an astronomer on 1. 3. 1972 and she remained till 24. 3. 1975. Predrag Radmanović, at that time student of mathematics, was engaged for a few months as a calculator in 1974 (when M. Dačić was performing his military service). V. Trajkovska was an astronomer in the Group between 1. 1. 1977 and 2. 2. 1988. Z. Stančić joined the Group in May 1984 as a graduated astronomer; after obtaining her M.S. degree she became a research fellow. As astronomers in the Group also were T. Angelov, between 1. 2. 1969 and 1. 6. 1970, Matorčević Nadežda as a volonteer 1975 and G. Damljanović, between 1. 12. 1989 and 1. 7. 1991.

The following was performed by individual collaborators of the Group:

a) Trainee's papers

Miodrag Dačić, 1971, title "The Equator-Point Problem in the Relative Declination Determination",

Trajče Angelov, 1969, title "The Measurement of the Inclination and Collimation of the Belgrade Meridian Circle by using two Methods",

Vojislava Protić-Benišek, 1973, title "The Longitude Determination by using two Methods",

Veselka Trajkovska, 1977, title "The Examination of the Limb Division for the Belgrade LMC on every half Degree by applying Bruns Method",

Zorica Stančić, 1985, title "The Determination of the Collimation and Flexure from the Küstner Series",

Goran Damljanović, 1991, title "The Equator Point, the Horizontal-Axis Inclination, the Collimation as Function of Temperature".

b) Master-of-Science Theses

Sofija Sadžakov, 1968, title "The Behaviour of the Levels in the Field of Horizontal Temperature Gradients",

Miodrag Dačić, 1980, title "The System of the Large Meridian Circle",

Zorica Cvetković (formerly Stančić), 1991, title "The Analysis of the Most Recent Double-Star Catalogues".

c) Ph.D. Theses

Ljubodrag Nikolić, 1965, title "A Contribution to the Examination of the Divisions of the Circles and Optical Micrometers of Geodetic and Astronomic Instruments",

Sofija Sadžakov, 1977, title "Examination of the $\Delta\delta_\alpha$ type Systematic Errors in the Latitude Observations of various Observatories on the basis of their Comparison with the Belgrade Derived Latitude-Stars Catalogue (IKŠZ) and with the photographic $AGK3$ Catalogue.

6. THE COMPILING OF STAR CATALOGUES AND DIURNAL OBSERVATIONS OF THE SUN AND INNER PLANETS

After concluding the rectification and the detailed examination of all organs of the instrument, and determing the parameters, the observations of stars of latitude programmes could be started. On the basis of the observational material of this programme and the results following from it was found that the instrument still did not satisfy the set up criteria and therefore that an additional rectification, as well as examinations of some additional instrument's organs were necessary. This was done and the rerectified instrument was used in the final observation of the latitude stars which lasted from February 5, 1968

till December 7, 1970. The basie treatment of the observational material was performed in Belgrade, whereas the testing and the final treatment, the reductions to the year beginning and equinox of 1950.0 for the observational epoch, as well as the analysis of individual values and the derivation of the mean declinations for the mentioned observational equinox and epoch, were done by S. Sadžakov at the GAO AN SSSR in Pulkovo.

The calculated observational quantities are presented as "KATALOG ŠIRINSKIH ZVEZDA" (KŠZ - Catalogue of Latitude Stars). This catalogue contains 3956 stars with positions given with an accuracy of $\pm 0.''34$. Each star was observed four times, twice at clamp east (CE), twice at clamp west (CW). No difference between the two was noticed. The stability of the instrument was pursued by way of the results obtained by observing the Küstner series.

The Küstner series were regularly observed every month two times at both CE and CW clamps. Based on such a material, obtained from observations of stars and laboratory examinations, the systematic differences "$FK4$ system minus the instrument's system" were examined. The instrument's parameters were determined from the $(O-C)$ differences by using the least-square method. The results showed that the instrument was very stable and that in no declination zone there were any significant deviations.

After finishing KŠZ, along with its treatment and analysis, the observations were started for an international programme, drawn up by Haruo Yasuda (Tokyo Observatory), involving the stars assigned to photographic zenith-telescopes.

These observations started on June 28, 1973 and were finished on May 22, 1980. The basic treatment was carried out in Belgrade, whereas the testing and the reduction to 1950.0 were done by S. Sadžakov in Pulkovo, at the GAO AN SSSR. A part of the observational material analysis was performed at the Computing Centre of the Tokyo Observatory thanks to the courtesy of Dr H. Yasuda to whom were sent the observational data reduced to the beginning of the year of the observation. This catalogue comprising the $NPZT$ Programme stars contains positions of 1685 stars in right ascension and declination. The average number of observations of a single star is 6.4 in right ascension and 6.7 in declination. The root-mean-square error of a single observation is $\epsilon_\alpha cos\delta = \pm 0.^s030$ in right ascension, and $\epsilon_\delta = \pm 0.''24$ in declination respectively. The mean observational epoch in right ascension is 1977.02, and 1976.78 in declination respectively. This catalogue was a part of an international cooperation comprising ten observatories and it was included in the derived NPZT-Star Catalogue compiled at the Tokyo Observatory in 1980.

The third observational catalogue is a result of the double stars observations. The observations started on February 26, 1981 and were finished on April 6, 1987. The basic treatment, testing, reducing to the year beginning, equninox of 1950.0 with the old constants and with the new ones to that of 2000.0 for the observational epoch took place at the Belgrade Observatory with a SHARP MZ-731 computer; the analysis and the deriving of the mean values in right ascension and declination also took place in Belgrade, in the Geophysical-Institute Computing Centre with a VAX 11/750 computer. The catalogue contains the positions of stars for the equinoxes of 1950.0 and 2000.0 and for the corresponding observational epoch. Each programme double star (DS) was observed on the average 4.32 times in right ascension and 4.43 in declination. The mean epoch is 1983.90 in right ascension, and 1983.84 in declination respectively. The root-mean-square error of a single position for the stars from the DS Catalogue is $\epsilon_\alpha cos\delta = \pm 0.^s023$ in right ascension, and $\epsilon_\delta = \pm 0.''32$ in declination respectively. This catlogue forms a part of an international programme. Based on this and other observational catalogues the so-called Derived DS Catalogue was compiled, of importance in the studies of stellar astronomy.

The fourth catalogue is that compising the stars in the vicinity of radio sources. It contains 285 stars distributed within 78 parts of the celestial sphere. The star positions were given for the equinoxes 1950.0 and 2000.0 and the corresponding observational epoch. The root-mean-square error of a single observation in right ascension is $\epsilon_\alpha = 0.^s024 sec\delta$, and $\epsilon_\delta = \pm 0.''30$ in declination respectively. The mean observational epoch in right ascension is 1984.66 and in declination 1984.74. Every star was observed on the average 5.5 times in right ascension, and 5.6 times in declination respectively. The difference in star positions $(CE-CW)$, obtained from the entire observational material, is $+0.^s007$ in right ascension, and $-0.''02$ in declination respectively. The results following from these observations will be used for deriving an international catalogue containing the stars in the vicinity of radio sources of importance in radio interferometry.

The fifth observational catalogue is that of positions of 223 Ondrejev FZT stars. The positions were given for the equinox of 2000.0 and the corresponding observational epoch. The root-mean-square error of a single observation of programme stars in right ascension is $\epsilon_\alpha cos\delta = \pm 0.^s020$, and $\epsilon\delta = \pm 0.''30$ in declination respectively, whereas the ones for the positions of fundamental stars, observed simultaneously, are $\epsilon_\alpha cos\delta = \pm 0.^s017$ and $\epsilon\delta = \pm 0.''25$, respectively. The mean observational epoch is 1987.34 in right ascension, and 1987.37 in declination respectively. The positions of the programme stars were determined from 3.95 observations and those of the fundamental ones 3.87 observations.

The sixth observational catalogue is the one of 146 HLS and 78 radio stars observed by applying the relative method. The star positions are given for the equinox and equator 2000.0 and the corresponding observational epoch. The root-mean-square error of a single star-position in right ascension is $\epsilon_\alpha cos\delta = \pm 0.^s025$, and $\epsilon\delta = \pm 0.''32$ in declination respectively, whereas in the case of 186 $FK5$ stars the amounts are $\epsilon_\alpha cos\delta = \pm 0.^s22$, and $\epsilon\delta = \pm 0.''30$ respectively. The mean observational epochs are 198 and 198 in right ascension and declination, respectively.

The seventh observational catalogue concerns the stars in the vecinity of 238 extragalactic optical radio sources in the declination zone between -30^o and $+30^o$. More than 85% of all observations have been realised; some of the zones between 2^h27^m and

5^h00^m, and between 12^h45^m and 14^h53^m in right ascension are still unobserved.

Among the activities of this Group have been also the compilations of derived catalogues. Let us mention the catalogue containing declinations and proper motions of the International-Latitude-Service stars which is based on the meridian catalogues published between 1929 and 1972. Thereto belong two catalogues named BSKŠZ1 and BSKŠZ2 containing positions-declinations, proper motions for the corresponding observational epoch. The positions are given for the equinox of 1950.0 in the FK4 system. The material was gathered at the Royal Astronomical Observatory in Brussels, copied onto punchcards, the computing treatment having been carried out at "Boris Kidrič" Institute at Vinča, near Belgrade. The root-mean-square errors in positions and proper motions are: ±0.071" and 0."0023 (respectively). The mean epoch of the catalogue is 1954.0.

The second catalogue of this kind is "Izvedeni katalog širinskih zvezda" (IKŠZ - Derived Catalogue of Latitude Stars) containing declinations and proper motions for 3895 stars in the zone from 19° to 90°. These quantities were calculated on the basis of the material obtained from observations with the meridian instruments in the period 1929-1972.

This catalogue is the first of the kind in the world, preceding an international current project of coordinated position determination for stars whose positions have been determined by using meridian instruments. The root-mean-square errors are: ϵ_δ = ±0."06 (position) and μ_δ = ±0."005 (proper motion). The mean observing epoch of the catalogue is 1954.44.

On the basis of this catalogue, AGK3 and 15 catalogues obtained with VZT and PZT an analysis of star positions was undertaken. It was found that the results of the latitude observations had systematic errors of $\Delta\delta_\alpha$ type so that the opinion accepted up to now that the errors in those observations were negligible, was disproved. Modern mathematical methods of error examinations were also used and an attempt was made to answer the question concerning the origin of these errors and the way of removing, or diminishing, them. Proceeding from the IKŠZ and the AGK3 a thorough examination was performed concerning both the systematic errors of these and some other catalogues and the analysis of errors in the programmes of the 15 latitude catalogues, mentioned above, offering new data. Among the most important results of this work is the conclusion that the observing accuracy of many latitude stations was not as high as it had been believed previously. This applies even to the stations of the International Latitude Service. This important conclusion was reached by comparing the latitude-observation data to the general standard given in the IKŠZ. Such an analysis was the first of the kind in the world and it was published as "Examinations of the Systematic $\Delta\delta_\alpha$ type Errors in the Latitude Observations of Various Observatories based on their Comparison with the Belgrade Derived Catalogue of latitude Stars and Photographic AGK3".

The derived Catalogue of Double Stars was obtained on the basis of six observing catalogues. The accuracy of the derived coordinates is $\epsilon_\alpha cos\delta$ = ±0."019, ϵ_δ = ±0."27. It was found that the right-ascension errors decreased with declination increasing, whereas those in the declination decreased with zenith-distance decreasing.

The existence of the orbital motions of the observed components is clearly noticeable from the analysis of the derived proper motions.

In addition to the observations of stars for the purpose of obtaining stellar catalogues there have been from 1973 on systematic observations of the Sun, Mercury and Venus and also of Mars from 1980 on. The results of these, diurnal, observations have been published every two years, whereas the values of their orbital elements and that of the solar diameter obtained from these observations are periodically communicated.

7. PUBLISHING

The members of the Group of Relative Coordinates published a great number of papers in the period 1962-1995 in both Yugoslav and foreign publications.

S. Sadžakov published, or prepared for publishing, 132 papers, D. Šaletić 34 papers, M. Dačić 77 papers, Lj. Nikolić 5 papers, I. Pakvor 1 paper, V. Sekulović (Radogostić) 6 papers, V. Trajkovska 3 papers, V. Protić-Benišek 3 papers, Z. Cvetković (Stančić) 44 papers, B. Ševarlić 47 papers, G. Damjanović 1 paper.

8. FUTURE WORK

Currently in the world and also in this country one of the most important tasks is the improving of the accuracy in the coordinates determination of stars and Solar-System bodies. The Belgrade Observatory has a plan of modernising its instruments in connexion with which something has already been effected. Until the full modernisation of the instruments is completed, the systematic determining of the positions for the Sun, inner planets, Mars and the stars in the vicinity of radio sources should be continued. Both subjects have an international importance and are of current interest to astronomy and kindred sciences.

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КАРАКТЕРИСТИКЕ БЕОГРАДСКОГ МЕРИДИЈАНСКОГ КРУГА И ДОПРИНОС РАЗВОЈУ ФУНДАМЕНТАЛНЕ АСТРОМЕТРИЈЕ

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