Publ. Astron. Obs. Belgrade No. 60 (1998), 118 – 121 *Contributed paper*

PAST AND FUTURE OF ASTROMETRICAL WORK AT BELGRADE OBSERVATORY

V. PROTITCH-BENISHEK, I. PAKVOR and G. DAMLJANOVIĆ
Astronomical Observatory, Volgina 7, 11160 Belgrade-74, Yugoslavia
E-mail vprotic@aob.aob.bg.ac.yu
E-mail ipakvor@aob.aob.bg.ac.yu
E-mail gdamljanovic@aob.aob.bg.ac.yu

Abstract. There are ten instruments at the Belgrade Astronomical Observatory ($\lambda = 1^h22^m E$, $\varphi = +44^\circ48'$, $h = 254m$), mainly astrometric ones, and one of them (Bamberg equatorial of 35 cm) has never been mounted. The systematic astronomical observations have been performed as early as from 1935 by using these instruments, and the majority of them is still in use. The Observatory has taken part in the realization of several dozens of international observing programs, campaigns concerning special phenomena, etc. Hence, it has today on its disposal a rich observational material comprising different fields of astrometrical and astrophysical research. Recently, the observations of Solar System bodies and double stars, as well as the studying of the selected solar spectral lines were improved by use of two CCD cameras – ST6 and ST7. The purchase of an ST8 camera will extend the work in some research fields and improve the quality of phenomena detection.

1. DYNAMICAL ASTRONOMY

The instruments with equatorial mounting permanently in use for the purpose of realizing various observing programs since the moment of their mounting are:

– Zeiss Refractor – aperture 65/1055 cm;

– Zeiss Refractor – aperture 20/302 cm with two photographic tubes with objectives aperture 16/80 cm;

– Zeiss Astrograph – aperture 16/80 cm with visual aperture 11/128 cm;

– Askania Photovisual Refractor – aperture 13.5/160 cm, i.e. 12.5/100 cm.

Each of them, individually, has additional devices and specialized cameras, including the CCD cameras used for all mentioned instruments.

Actual observing programs realized with these instruments according to adopted projects are:

– The 65/1055 refractor is permanently used in the observing of double and variable (eruptive especially) stars (CCD astrometry, photometry and polarimetry, micrometric measurements of pairs, as well as the finding of new double and multiple stars). With this instrument are also observed mutual phenomena of Jupiter's and Saturn's satellites, as well as the exceptional astronomical phenomena (transit of inner planet over the solar disc, solar and lunar eclipses, occultations of stars by the Solar system bodies, etc).

– The 20/302 refractor was used in the past for the purpose of regular observations of minor planets, comets and major planets. In 1973 it was reconstructed to become a solar spectrograph used in systematic observations of active processes on the Sun.

– The Zeiss Astrograph and Askania Refractor are known due to the numerous discoveries of minor planets from this Observatory and also due to other works important to the research of Solar System Dynamics. Today, thanks to the CCD cameras, they are included in regular observations of minor planets following special programs (ITA, NEO, etc), comets, occultations of major planet satellites, occultations of stars by the Moon and other Solar – System bodies. All data concerning these observations are sent to the corresponding international centers (Protitch – Benishek, 1989).

One should say that one Askania Refractor (35/700 cm) has never been mounted though it was planned in the programs where long-focus instruments are desirable.

2. ASTROMETRY

There are three fundamental instruments in the field of Fundamental astrometry: Meridian Circle, Transit Instrument and Vertical Circle. They were established in 1959 after 35 years of preservation in their cases due to financial problems.

Askania made, they were delivered to Belgrade Observatory as part of the World War I reparation.

The main characteristics of the instruments are: all three are of classical design, have objectives of 190 mm in diameter, focal distance of 2578 mm, visual eye – piece micrometer. The Meridian Circle and the Vertical Circle have 800 mm circles divided in each $2'$, with 4 micrometric microscopes, at both sides (E, W), for $1''$ readings.

The Meridian Circle and the Transit Instrument are situated in semicylindrical steel pavilions, approximatily on the same parallel, while the Vertical Circle is in the north angle of the equilateral triangle. The distances between the three pavilions are 75 – 85 meters.

The absolute observations of right ascensions and declinations of stars are planned to be carried out at the Transit Instrument and the Vertical Circle respectively. Differential determinations of α and δ are foreseen for the Meridian Circle.

After detailed examinations of the instrument's constants and certain technical reconstructions (especially at the Vertical Circle), preliminary observations started. In the mean time, vacuum meridian marks were built for the Transit Instrument at distances of 30 and 51 m, north and south, respectively. This original idea was realized by inserting two steel vacuum tubes ($\phi = 300mm$) between the marks objectives and the meridian marks themselves for the purpose of lessening the influence from the main obstacle of the precise azimuth determination – terrestrial refraction. Later, the action's full justification was shown.

After the preliminary observations by all three instruments, regular observations began. At the Transit Instrument and the Vertical Circle, simultaneous observations of Absolute Catalogue of 307 bright stars – zone ($+65^o$ – $+90^o$) took place. Unfortunately, due to the Observatory's irregular main clock, complete R.A. observations at the Transit Instrument had to be withdrawn, whilst the Catalogue of absolute declinations of 307 bright stars was published. The mean error of the catalogue declinations is $\varepsilon_\delta = \pm 0.''13$. The observations of major and minor planets also were

carried out at the Vertical Circle. It was shown that the applied method of (O – C) determination cannot entirely eliminate the systematic effects connected with the time factor, temperature, flexure and refraction.

Several differential catalogues were made using the observations at the Meridian Circle, starting with the Catalogue of latitude stars (3956 stars). Declinations are given with an accuracy of $\pm 0.''34$. The second catalogue was the Catalogue of NPZT program with the position of 1685 stars (R.A. and Dec.). The mean square error of a single observation was $\varepsilon_\alpha \cos\delta = \pm 0.^s030$ and $\varepsilon_\delta = \pm 0.''24$. The other two catalogues realized by the Belgrade Meridian Circle were the Catalogue of double stars and the Catalogue of stars in the vicinity of radio sources, also with similar accuracy; for right ascensions $\pm 0.^s023 sec\delta$ and for declinations $\pm 0.''30$. Similar accuracy was achieved for the Catalogue of positions of 223 Ondrejov PZT stars and the Catalogue of positions of high luminosity stars (HLS) and radio stars which was the last one observed with this instrument.

At present all observations by Belgrade fundamental astrometrical instruments are practically suspended, due to the fact that visual and nonautomatical observations are not only obsolete but much below modern accuracy and efficiency. There is also a problem of magnitude limitation. Belgrade Astronomical Observatory is very much interested in complete modernization, for the beginning, one of the instruments, and believes that the selection of the Meridian Circle would be the best solution. CCD camera and automatical circle readings together with a good PC are the basic requirements to join the IAU ground based observation programs in which Belgrade Observatory would like to participate.

At the end of last year Belgrade Observatory entered a cooperation with Nikolaev Astronomical Observatory with intention to modernize the Belgrade Meridian Circle in the way the Nikolaev Automatic Meridian Circle was reconstructed. It is planned in the near future to install a CCD camera for the star transit registrations and to enable automatic circle readings as well as automatic star settings using a PC. The modernization will be carried out by experts from Nikolaev Observatory.

3. THE EARTH'S ROTATION

In the field of the Earth's rotation the Transit Instrument (Bamberg 100/1000 mm) and the visual zenith – telescope (Bamberg 110/1287 mm) were used. Due to this, the Time Service and the Latitude Service were established. The regular observations at zenith – telescope started at the beginning of 1949. The data were incorporated in IPMS (from 1956) and BIH (from 1967). With the original latitude data we took part in MERIT program, HIPPARCOS program, etc. The instrument is out of operation from 1995. The new reduction, in the FK5 reference system, with PPM Star Catalogue (Roeser and Bastian, 1991) and in line with MERIT Standards (Melbourne *et al.*, 1983), was done (Damljanović, Pejović, 1995). It was in accordance with the rules of the HIPPARCOS program. Then, the investigation of some systematic instrumental, personal, refraction and star position errors were realized (Damljanović, 1994, 1995). After that, an analysis of that homogeneous latitude series was finished. Now, it is necessary to continue the investigations of latitude variations with some new techniques or to carry out necessary modernization.

The regular observations with Transit Instrument exist for the period 1964 – 1986. The data were sent to BIH and IPMS, and the Universal Time determination data were included also in the MERIT program. The homogeneous results were prepared in accordance with IERS standards. An analysis on variation of local system $UT1_{BLI}$ was carried out (Jovanović *et al.*, 1993), too. It is necessary to replace this instrument with some of the new techniques and to continue the observations in the same subject.

References

Damljanović, G.: 1994, *Bull. Astron. Belgrade*, **150**, 29.
Damljanović G.: 1995, *Bull. Astron. Belgrade*, **152**, 71.
Damljanović, G. & Pejović, N.: 1995, *Proc. of the Journées 1995, Système de référence spatio – temporels*, eds. N. Capitaine, B. Kolaczek, S. Debarbat, Warsaw, 131.
Jovanović, B., Djurović, L. & Jovanović, M.: 1993, *Publ. Obs. Astron. Belgrade*, **45**.
Mitić, Lj. & Pakvor, I. :1976, *Publ. Dept. Astron. Univ. Beograd*, **6**, 111 (english).
Mitić, Lj. & Pakvor, I.: 1977, *Bull. Astron. Obs. Beograd*, **128**, 11.
Mitić, Lj. & Pakvor, I.: 1978, *Trudi 20. Astromet. Konf. Leningrad*, 177.
Melbourne, W. *et al.*: 1983, *Project Merit Standards*, USNO Circular, **No. 167**.
Mijatov, M., Teleki, G., Bozhichkovich, Dj. & Trajkovska, V. : 1991, *Bull. Astron. Obs. Belgrade*, **143**, 1.
Pakvor, I. : 1984, *Mitt. Lohrmann Obs. Tech. Univ. Dresden*, **6**, 51, 127.
Protitch – Benishek, V.: 1989, *Publ. Obs. Astron. Belgrade*, **36**, 89.
Petković, S. & Pakvor, I. : 1993, *Bull. Astron. Beograd*, **148**, 61.
Petković, S.M. & Pakvor, I. : 1995, *Bull. Astron. Beograd*, **151**, 135.
Roeser, S. & Bastian, U.: 1991, *Positions and Proper Motions (PPM) Star Catalogue*, Astron. Rechen – Institut, Heidelberg.
Sadžakov, S. & Dačić, M.: 1989, *Astron. Astrophys. Suppl. Ser.*, **77**, 411.
Sadžakov, S. & Dačić, M.: 1990, *Publ. Obs. Astron. Belgrade*, **38**, 11.
Sadžakov, S., Dačić, M. & Cvetković, Z.: 1991, *Astron. Journal*, **101(2)**, 713.
Sadžakov, S., Dačić, M. & Cvetković, Z. : 1992, *Bull. Astron. Belgrade*, **146**, 1.
Sadžakov, S. & Damljanović, G. : 1997, *Bull. Astron. Belgrade*, **155**, 89.