

Shulga, O.V., and Yanyshenska, L.M.

Research Institute «Mykolaiv Astronomical Observatory»,
1, Observatorna St., Mykolaiv, 54030, Ukraine, tel. + 380 512 477014

195-YEAR ANNIVERSARY OF MYKOLAIV OBSERVATORY: EVENTS AND PEOPLE



The basic stages of the history of Mykolaiv Astronomical Observatory have been outlined. The main results of the RI «MAO» activities have been as follows: creation of catalogs of stars, major and minor planets of Solar system and space object positions in the Earth orbit. Information about qualitative and quantitative composition of Observatory, cooperation with other Ukrainian and foreign observatories, as well as about significant projects carried out in the Observatory has been given.

Keywords: positional astronomy, catalogs, stars, planets, solar system, and telescopes.

Mykolaiv Astronomical Observatory was founded in 1821 as the Naval Observatory to provide the Black Sea Fleet with the exact time and nautical maps and to organize training in the astronomical methods of orientation for the naval officers, as well as to certify the navigation devices and watches. The top of Spassky mound, the highest hill of Mykolaiv, was chosen as a place for the construction of the Observatory. The initiator of construction of the Observatory in the southern Ukraine became a military governor of Mykolaiv Admiral Alex Greig (1775–1845), a famous scientist in astronomy, hydrography, economy and engineering.

The Observatory was subordinated to the Russian navy and as naval one existed for 92 years (from 1821 to 1912). In the early twentieth century, Mykolaiv Observatory was transferred to the Main (Pulkovo) Astronomical Observatory by order of the Naval Ministry and eventually was subordinated to the Academy of Sciences of the USSR (1913–1991). In 1992, Mykolaiv Astronomical Observatory (MAO) became an independent research institution that belonged to

the Ministry of Education and Science of Ukraine. In 2002, it was awarded the status of research institute. And in 2007, RI «MAO» was included in the tentative list of UNESCO World Heritage sites of Ukraine as one of the oldest observatories in the South-Eastern Europe with the perfectly preserved equipment, astronomical instruments and a unique fund of scientific old-printed literature (see: <http://whc.unesco.org/en/tentativelists/5116/>).

Today, it is a leading institution in Ukraine in the sphere of positional astronomy with a well-stocked staff of employees who are constantly expanding a field of its research activities. During the period of 1911–2015, 5 observatory employees defended their DSc theses and 22 ones defended CSc theses. Ten employees of RI «MAO» are members of the International Astronomical Union and four researchers are members of the European Astronomical Society. A list of scientific papers of RI «MAO», as of 2016, accounted for 1 151 publications.

Throughout its existence, Mykolaiv Observatory has been performing the positional observations of stars, minor and major planets of the Solar system, meteors, satellites and space debris.

Results of the positional observation of stars conducted by absolute and differential methods with the meridian instruments have been published in the form of catalogs.

In the 19th century (1830–1834), the fifth sheet of the star map of the Berlin Academy [1] was created by K. Knore.

In the second half of the 20th century, three absolute catalogs were created. They were included as a part of fundamental catalog FK4 (1963). Two catalogues were obtained with the transit instrument made by Freiberg-Kondratiev, namely catalogue of Pulkovo stars (1950–1959) and Nik60 catalogue of right ascensions (1959–1963). Nik60 catalogue of declinations was obtained in 1957–1963 with the Repsold vertical circle.

As well, in the second half of the twentieth century, eleven differential catalogs were created. Using observations with the Repsold Meridian Circle, six catalogues were compiled:

1) Catalogue of 2601 faint stars was obtained in 1956–1966.

2) Catalogue of proper motions of 12 545 stars was obtained in 1956–1965.

3) Catalogue of 726 southern bright stars and 5969 southern reference stars was obtained in 1964–1966.

4) Catalogue of 8832 zodiac stars was obtained in 1969–1972.

5) Catalogue of right ascensions of 584 stars was obtained in 1974–1976.

6) Catalogue of high luminosity stars in equatorial zone was obtained in 1984–1986.

Five observational campaign were carried out with the Zonal Astrograph:

1) Bilyawski's polar zone (1973–1975).

2) Ecliptical zone (1975–1983).

3) Ecliptical zone for stars of A. Mikhailov's list (1976–1977).

4) Stars of ROAS program (1978–1981).

5) Equatorial zone (1990–1993).

Using observations with the Axial Meridian Circle in 1996–1998, three differential catalogues were created:

1) Catalogue of HIPPARCOS stars (AMC1A).

2) Catalogue of USNOA-2.0 stars (AMC1B).

3) Catalogue of GSC stars around 190 extragalactic radio sources (AMC1C).

Using observations with the KT-50 telescope (MOBITEL) in 2011–2015, differential catalogue was created for stars up to 17-th magnitude around 540 open clusters [3].

The meridian observation of the Solar system bodies in Mykolaiv Observatory were used for the development of new relativistic theory of planetary movement, for which the researcher of Observatory, G. Petrov, together with other authors was awarded the State Prize of the USSR in the field of Science and Technology (1982).

The observation of Venus and the Moon (1924–1939), the Sun, the Moon and major planets (1950–1963), the Sun, Mercury and Venus (1964–1991) were conducted with Freiberg-Kondratiev transit instrument. The observations of the Sun, the Moon and major planets (1951–1963), the Sun, Mercury, Venus and Mars were conducted on the Repsold vertical circle; the Sun, Mercury, Venus (1961–1963), the Moon, Mars, Jupiter, Saturn, Uranus and Neptune (1960–1976) were performed with the Repsold meridian circle.

Photographic observations of minor planets were carried out at the Observatory since 1961 when a zonal astrograph ($F = 2044$ mm, $D = 120$ mm, field of view $5 \times 5^\circ$) was set. The main objects of research on the zonal astrograph (ZA) in Mykolaiv were bodies of the Solar system. Here, during 35 years the extensive observations of minor planets were conducted according to the program of the Institute of Theoretical Astronomy (ITA) of the Academy of Sciences of the USSR. During this period, the scientists received about 2.5 thousand positions of these objects. Accuracy of bright minor planet positions ($m < 10$) is characterized by a standard deviation of $\pm(0.15-0.20)''$, $\pm(0.20-0.25)''$ for faint minor planets ($m > 10$). The observations well cover a zone of $\pm 15^\circ$ from the ecliptic. The major planets were observed with the zonal astrograph approximately with the same intensity. The list of observations conducted with the zonal astrograph contains nineteen selected asteroids

according to the ITA program (1961–1997), Galilean satellites of Jupiter (1962–1998), bright satellites of Saturn (1973–1997), Venus, Mars, Jupiter, Saturn, Uranus and Neptune (1961–1997). Jet Propulsion Laboratory (JPL, USA) makes use of photographic observations made with the zonal astrograph in 1961–1997 to build the ephemeris of the Sun, major planets, the Earth and the Moon (beginning from DE409). The catalog of 2450 photographic positions of nineteen selected asteroids was placed in the database of Minor Planets Center of the International Astronomical Union (MPC IAU) [4]. The accuracy of positions of this series of observations was so high that received a mark of «h» (High-precision astrometry), and this, in turn, made it possible for Mykolaiv Observatory to enter the list of six observatories in the world that can provide consistently the high precision observations of minor planets (see: <http://cfa-www.harvard.edu/iau/special/residuals.txt>).

From the very beginning, the work program of the observatory was to provide with the exact time the Navy ships. And still, in the RI «MAO», there is a perfectly preserved collection of astronomical pendulum clocks of the 18th–20th centuries. The *Ryfler 12* brought from Odesa was the first main time keeper. First, the Time Service was primarily intended for the own needs of Observatory. In 1931, after purchasing transit instrument No. 102551 (manufactured by *Askaniya Werke*), regular observation of time correction began on this instrument. Beginning from 1938, the regular transient reception of time signals was established. In the same year, the Mykolaiv Time Service was included in a single network of Time Services of the Soviet Union (1938–1992) and due to the accuracy of its observations for many years was one of the best in the country.

Particularly active work of the Time Service affiliated with Mykolaiv Observatory was during the periods of 1957–1959 (International geodetic year, IGY) and 1964–1965 (International year of the quiet Sun, IYQS). During this time period, the Observatory replenished the latest devices and

equipment and increased the number of observations. In 1957, two transit instruments such as *Bamberg 6353* and the APM-10 were installed, and in 1958, two copies of quartz clocks of German company *Rode and Schwartz* were purchased which for a long time were effectively used for the observations. A unit from quartz clocks with the underground temperature control of crystal oscillators was installed in the basements (at a depth of 26–35 m).

During the IGY and IYQS the Time Service conducted intensive astronomical observations. During this period two thousand time corrections or nearly 34 000 observations of stars were made.

During 1983–1984, Mykolaiv Time Service took part in the main international program MERI and was awarded a diploma of the AstroCouncil of the Academy of Sciences of the USSR for the high accuracy of astronomical measurements of time corrections.

The Time Service of Mykolaiv Observatory received nearly 70 thousand observations of stars to determine the time corrections. On this basis, nine catalogs of stellar right ascensions of Time Service were created. These data were stored in the database in Pulkovo and Prague.

One of the new usages of astronomical clocks is the use of mechanical watches of famous engineer F.M. Fedchenko in the seismic studies. It turned out that they could be used as highly sensitive seismograph and gravimeter which made it possible to carry out in the Observatory the regular monitoring of seismic events simultaneously with the seismograph of Institute of Geophysics of the National Academy of Sciences of Ukraine [5]. The intensive development of the near-Earth astronomy began at RI «MAO» in 2000. Due to the development of the combined method of observation [6]. The basic principle of the combined method of observation is division of processes of the image formation of reference stars and space objects (SO). Using the full-frame matrix enables to obtain a dot image of both types of objects in such modes and with such expositions that are the best for obtaining a high level of signal /noise

ratio. A frame-shift accumulation method was developed for the observations with the use of video CCD-cameras. The method enables in the real-time mode to accumulate the images of space objects with shift in the direction that corresponds to their movement within the field of view of the telescope. For the first time, the combined observations of geostationary space objects were obtained with the multi-channel telescope ($D = 160$ mm, $F = 2044$ mm), in 2001. The first observations of space objects showed the need to develop the specialized automated telescopes and special methods of observation. During 2001–2010, five automated telescopes were developed at RI «MAO» [7].

Mykolaiv Observatory organized a number of expeditions to conduct the positional observations under the best seeing conditions.

In 1970, it organized the expedition to the mountain region of Azerbaijan, the settlement of Agder. A 30-day trip to the border area was intense: pavilion construction, installation of column for tools and devices and nine series of observations. The observations were conducted using a *Askania-Werke* portable transit instrument. The observations showed 1.5–2 times increase in the accuracy, and therefore the future prospects of positional observations in the mountains.

From 1974 to 1977, the Observatory organized an expedition to the island of Spitsbergen to clarify the benefits of high-latitude observatories for absolute determinations of star positions. A head and initiator of this expedition was the famous astronomer G.M. Petrov, doctor of physical and mathematical sciences. The observatory staff was given a task within a short time to arrange housing and establish life, install telescopes and devices, and then to exercise the star observations and to determine the exact time. Within three polar nights the expedition members received more than 15 thousand star observations, 25 series lasting from 18 to 155 hours. These observations made it possible to make up a unique, in terms of accuracy, catalog of absolute right ascensions of 531 stars which was later used to

create a new fundamental catalog of star positions FK5. The work of expedition was recognized by AstroCouncil as the best in the field of astronomy for 1977.

In 1981, new expedition began to work near the town of Kislovodsk in the North Caucasus. Observations of the Sun, Mercury and Venus were conducted with transit instrument made by *Askania Werke* and the APM-10. As a result of expedition, the Academic Council of the Main Astronomical Observatory of the USSR took a decision on the organization of regular observations of the Sun and planets with the large transit instrument and with the vertical circle made by *Ertel* firm.

The following projects can be attributed to the important works carried out in Mykolaiv Observatory: hydrographic expedition along the coast of the Black and Azov seas for the compilation of the first informative Black Sea Atlas (1829–1837); providing the fleet and population of Mykolaiv with exact time (since 1873); participation in sessions of simultaneous observation of satellites (1957–1970); production of limbs for meridian circles (1973–1986); study of ground refraction (1975–1986); development of the Axial meridian circle (1979–1996) which received the status of national heritage in 1999; creation of automatic devices for measurements of astronegatives (1979–1987); development of the Ukrainian network of optical stations to study the near-Earth space, since 2011; observations of telecommunication geostationary satellites by the radio-interferometry method, since 2014.

Mykolaiv Astronomical Observatory actively supports the international relations with many observatories and astronomers throughout the world: China, Latvia, Russia, Romania, Slovakia, Slovenia, Turkey, France, and Czech Republic. In Ukraine, Mykolaiv Observatory collaborates with almost all astronomical observatories or agencies of Kyiv, Kharkiv, Odesa, Lviv, Uzhgorod, Dunaevtsy, Mukachevo, and Rivne.

Throughout its history, Mykolaiv Astronomical Observatory has performed important and urgent

tasks in the positional observations of stars, Solar system bodies, and since the second half of the twentieth century has carried out the positional observations of space objects in the geocentric orbits. Constantly upgrading the existing and creating the new astronomical instruments, improving the methodology of observation and processing, Mykolaiv Observatory staff provides the mass observation of celestial bodies with high accuracy. Due to the professionalism and high scientific experience of employees, RI «MAO» has been widely known throughout the world, and the work of Mykolaiv astronomers has become a significant contribution to the knowledge base of sciences.

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О.В. Шульга, Л.М. Янишевська

Науково-дослідний інститут
«Миколаївська астрономічна обсерваторія»,
вул. Обсерваторна, 1, Миколаїв, 54030, Україна,
тел. + 380 512 477014

195 РОКІВ ІСТОРІЇ
МИКОЛАЇВСЬКОЇ ОБСЕРВАТОРІЇ:
ПОДІЇ І ЛЮДИ

Викладено основні етапи історії Миколаївської астрономічної обсерваторії. Представлені основні результати діяльності установи: створені каталоги положень зір, великих і малих планет Сонячної системи, космічних об'єктів на навколосемних орбітах. Надана інформація про якісний і кількісний склад обсерваторії, співпрацю з обсерваторіями України і зарубіжних країн, а також про значні проекти, виконані в обсерваторії.

Ключові слова: позиційна астрономія, каталоги, зірки, планети Сонячної системи, телескопи.

А.В. Шульга, Л.Н. Янишевская

Научно-исследовательский институт
«Николаевская астрономическая обсерватория»,
ул. Обсерваторная, 1, Николаев, 54030, Украина,
тел. + 380 512 477014

195 ЛЕТ ИСТОРИИ
НИКОЛАЕВСКОЙ ОБСЕРВАТОРИИ:
СОБЫТИЯ И ЛЮДИ

Изложены основные этапы истории Николаевской астрономической обсерватории. Представлены основные результаты деятельности учреждения: созданы каталоги положений звезд, больших и малых планет Солнечной системы, космических объектов на околоземных орбитах. Дана информация о качественном и количественном составе обсерватории, о сотрудничестве с обсерваториями Украины и зарубежных стран, а также о значительных проектах, выполненных в обсерватории.

Ключевые слова: позиционная астрономия, каталоги, звезды, планеты Солнечной системы, телескопы.