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ASTROMETRIC RESEARCH IN UKRAINE AT THE XIX –  
BEGINNING OF XX CENTURIES

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**ABSTRACT.** The paper presents the stages of development of astrometric research at the Ukrainian observatories in the XIX-beginning of XX century. In XIX century university observatories in Kyiv (1845) Odessa (1871), Kharkiv (1888) were founded. Mykolaiv (navy) observatory was founded in 1821 for navigation needs with assistance of Admiral O.S. Greig. The absolute catalogs compiled at Pulkovo and Mykolaiv Observatories made a significant contribution to the international work of compilation of a high precision for that time fundamental FK3 system. Special attention paid to the scientific activity of the oldest observatory on the territory of Ukraine - the Astronomical observatory of Lviv University (1771). Researches at observatory mainly concerned the field of geodesy and meteorology. Despite the short first period of its scientific activity observatory (near 10 years), it gave impetus to some famous scientists. Resurgence of observatory become only at the last decades of XIX century.

Southern departments of Pulkovo observatory in Odessa (1899) and Mykolaiv (1912) played an important role in extension of Pulkovo absolute catalogues to the southern hemisphere. Systematic observations of the Sun conducted at departments contributed to the more precise determination of the position of vernal equinox. In XIX century Ukrainian observatories participated in International programs, such as AGK (Astronomischer Gesellschaft Katalog), the photographic catalog "Carte du Ciel" (France). Special attention was paid to actual observational programs of zodiacal stars (M.P.Ditchenko in Kyiv), near-pole stars observed by (V.I.Fabritius, R.P.Fogel, M.P.Ditchenko in Kyiv, L.O.Struve K.N.Kuz'menko in Kharkiv, I.O.Djukov, L.F.Cherniev in Odessa). In the frame of observations of Bonner Durchmusterung (BD) and its southern continuation, organized by the German Astronomical Society, observations of the equatorial zone were organized I.E.Kortazzi at Mykolaiv observatory in XIX century, B.V.Novopashenny at the Astronomical Observatory of Odessa University in 1930-th years.

Needs of astrophotography lead to the organization

of a project "Catalog of the faint stars". In 1932 at the First Astrometric Conference in Leningrad Pulkovo astronomers B.P. Gerasimovich and M.I.Dniprovsky suggested the idea of using extragalaxy nebulae as static repers for determination of the absolute motion of the stars. Among the tasks to be solved at the project was compilation a general catalogue (KSZ) and a fundamental catalog of faint stars (FKSZ) and to establish a connection between them. It was planned to involve all meridian instruments of the USSR as well as foreign ones, especially in the southern hemisphere. The idea of orientation the coordinate system of KSZ on the observations of small planets suggested by B.V. Numerov. Astronomers of Mykolaiv Astronomical Observatory participated in the international part of this project (AGK3R -catalogue).

The Poltava gravimetric observatory was founded by A.Ya Orlov in 1926 for large-scale study of gravity and for observations of latitude on a zenith -telescopes. The main research fields of the Main Astronomical Observatory of the NAS of Ukraine (MAO NASU) founded by Orlov in 1944, were related to the astrometry both theoretical works and observational. We defined three "genealogical scientific trees" of astrometric schools, two of them were formed under the leadership of outstanding personalities of the XX century: Prof. Alexander Ya. Orlov (the founder and first director of the Observatory, 1944–1948, 1950–1951), who moved to Kyiv from Poltava, and Prof. Avenir A. Yakovkin (director of the Observatory in 1952–1959), who moved to Kyiv from Kazan. The third genealogical tree has grown from the Pulkovo astronomical school. Formation of main directions of scientific researches and its transformation are discussed.

**Keywords:** astrometric research, observatories, scientific directions, photographic catalog, fundamental astrometry.

**АНОТАЦІЯ.** У статті представлені етапи розвитку астрометричних досліджень в обсерваторіях України у XIX -початку XX століття. У XIX столітті були створені університетські обсерваторії у Києві (1845), Одесі (1871), Харкові (1888). У 1921 році за

сприяння адмірала О.С. Грейга була заснована Миколаївська (Морська) обсерваторія. Абсолютні каталоги, створені у Пулковській і Миколаївській обсерваторіях, зробили значний внесок в міжнародну роботу зі створення високоточного на той час фундаментального каталогу FK3. Особливу увагу приділено науковій діяльності однієї з найперших обсерваторій на території України- Астрономічній обсерваторії Львівського університету (1771). Дослідження в обсерваторії стосувалися переважно геодезії і метеорології. Незважаючи на перший короткий період існування обсерваторії (біля 10 років), вона надала імпульс відомим науковцям. Відродження обсерваторії відбулося лише наприкінці XIX століття. Південні відділення Пулковської обсерваторії у Одесі (1899) і Миколаєві (1912) зіграли визначну роль у розширенні Пулковських абсолютних каталогів на південну півкулю. Систематичні спостереження Сонця, проведені у відділеннях, сприяли більш точному визначенню положення точки весняного рівнодення.

У XIX столітті обсерваторії України брали участь у міжнародних програмах, зокрема, таких як AGK-каталог (Німецького Астрономічного Товариства), фотографічний каталог "Карта неба" (Франція). Особлива увага приділялася актуальним спостережним програмам, зокрема із спостереження зодіакальних зір (М.П. Диченко у Києві), біляполюсних зір (В.І. Фабриціус, Р.П. Фогель, М.П. Диченко у Києві, Л.О.Струве, К.Н. Кузьменко у Харкові, І.О. Дюков, Л.Ф. Чернієв у Одесі). В рамках спостережень за програмою Боннського огляду (BD) і його південного продовження, організованого Німецьким Астрономічним Товариством, проводилися спостереження зір екваторіальної зони (І.Є. Кортацці у Миколаївській Астрономічній обсерваторії, Б.В. Новопащенко у Астрономічній обсерваторії Одеського університету).

Потреби астрофотографії сприяли розширенню фундаментальної системи зір на більш слабкі зорі, зокрема до організації проекту "Каталог слабких зір". У 1932 році на Першій Астрометричній конференції в Ленінграді пулковські астрономи Б.П. Герасимович і М.І. Дніпровський висунули ідею використання позагалактичних туманностей у якості нерухомих реперів для визначення абсолютних рухів зір. Серед задач, які мали бути розв'язані у ході проекту-створення загального каталогу слабких зір (КСЗ) та фундаментального каталогу слабких зір (ФКСЗ) і встановлення зв'язку між ними. До проекту планувалося залучити всі меридіанні інструменти як СРСР, так і закордонні, особливо у південній півкулі. Ідея орієнтування координатної системи КСЗ за спостереженнями малих планет була висунута

Б.В. Нумеровим. Астрономи Миколаївської астрономічної обсерваторії брали участь у міжнародній частині проекту (каталог AGK3R).

Полтавська гравіметрична обсерваторія була заснована О.Я. Орловим у 1926 році для масштабного вивчення сили тяжіння, земних припливів і для широтних спостережень. Головні напрямки наукових досліджень Головної Астрономічної обсерваторії (ГАО НАНУ) заснованої у 1944 році стосувалися астрометрії як теоретичної так і спостережної. Виділено і проаналізовано три "генеалогічних наукових дерева" астрометричних шкіл два з яких сформувалися під керівництвом видатних постатей XX століття: професора О.Я. Орлова (засновника і першого директора обсерваторії, 1944-1948, 1950-1951), який переїхав до Києва з Полтави, і професора А. О.Яковкіна (директор обсерваторії у 1952-1959 роках), який переїхав до Києва з Казані. Третє "генеалогічне дерево" розвинулося з Пулковської астрометричної школи. У статті висвітлюється формування головних напрямів наукових досліджень та їх трансформація.

**Ключові слова:** астрометричні дослідження, обсерваторії, наукові напрямки, фотокаталог, фундаментальна астрометрія.

Regular astronomical research in Ukraine have begun after foundation of universities observatories in Lviv (1771), Kyiv (1945), Odesa (1871), Kharkiv (1888) in XIX century. An important role in the development of astronomical research played the southern departments of the Pulkovo Observatory – in Odesa (1899) and Mykolaiv (1912). From the first years of their activity, the observatories were collaborated with the Pulkovo Observatory – some astronomers of Ukraine worked at the Pulkovo for some time, outstanding Pulkovo astronomers participated in the organization of most Ukrainian observatories. The XIX century is the period of the international cooperative works, in particular on creation of zonal catalogs AGK (Astronomischer Gesellschaft Katalog), the photographic catalog "Carte du Ciel" (France). In the 1930s, in order to extend the fundamental system to faint stars for the needs of astrophotography, the project "Catalogue of Faint Stars" (or KSZ) was initiated. In the 1932, at the I All-Union Astrometric Conference in Leningrad, the Pulkovo astronomers B.P. Gerasimovich and M.I. Dniprovsky suggested the idea of using extragalactic nebulae as fixed reference points for determining the proper motions of stars. Astrometric reference to galaxies makes it possible to obtain absolute proper motions of stars and create an almost perfect inertial coordinate system, independent from motions in the Galaxy. The determination of zero-point (vernal equinox) for right ascensions and declinations

was planned to be realized by observations of small planets.

The Kyiv University Observatory was the coordinator for the Moon theme in the former USSR [11].

Observatory of Odessa University was founded in 1870-1871 by the first professor of astronomy of Odessa University L.F. Berkevich. The scientific activity in the observatory was developed in the 80s at the XIX century due to the efforts of A.K. Kononovich [19]. Despite of the planned astrophysical direction of scientific research, since 1912 at the observatory started systematic research on astrometry under the supervision of the director A.Ya.Orlov. As he noted, "The Odessa Observatory has quite favorable climatic conditions for astronomical work. The clean air, mild climate and a large number of clear days make it possible to conduct observations which are not available under otherwise similar conditions for other university observatories". The first work with the Repsold Meridian Circle ( $D = 135$  mm,  $F = 1980$  mm) was to determine the positions of 125 near-polar stars (I.O. Dyukov, 1920-1921 pp.). The work was continuation observations of the near-polar stars conducted by M.P. Ditchenko. The subsequent determination of the positions of these stars was carried out by L.F. Cherniev. Catalog of declination of 125 near-polar stars for the epoch and equinox 1950.0 (declination zone from  $+ 80^\circ$  to  $+ 90^\circ$ ) was compiled based on his observations. In 1930-1935 B.V. Novopashenny observed positions of more than 5000 stars in the equatorial zone from  $+ 2^\circ$  to  $- 1^\circ$  in declination (so called "Mykolaiv zone", earlier observed by I.Kortazzi) [1].

Since 1912, the observatory was headed by A.Ya. Orlov, who conducted studies of the Black Sea tides and deformations of the Earth. Among other his projects- restoration of the triangulation network from the Dnister river to the Dniper, leveling the Odesa coast for determining the movement of soil, development of an Ukrainian gravimetric network for mineral's search. At the zenith telescope a series of observations for determination the influence of the motion of the Earth's poles on the variation in the latitude of Odessa (in parallel with the previously begun similar observations in Pulkovo) was made.

Astronomical study in Kharkiv University was founded in 1808, long before the foundation of the permanent astronomical observatory (1888). The beginning of the research at the permanent astronomical observatory founded due to Levitsky's activity considered as a year of a setting up a meridian circle made by Repsold ( $D = 106$  mm,  $F = 1930$  mm). During the nineteenth and early twentieth centuries, meridian astronomy was a priopitet direction of research. Thus observations of the zodiacal stars were carried out by L.O. Struve and M.M. Jewdokimov ("Catalogue of declinations of 779 zodiacal stars") [20]. Also L.O.Struve conducted observations of the stars of the near-pole

zone. The result of this investigations published as a "Catalogue of 1407 near-pole stars in the FK4 system for the middle epoch of 1911" (K.N. Kuzmenko). Later observations under this program were carried out by Kharkiv astronomers K.N. Kuzmenko, V.Kh. Pluzhnikov and S.M. Grishchenko. The obtained coordinates of vision were compared with the observations of 1909-1914 by L.O.Struve. A joint processing of both series of these observations (K.N. Kuzmenko, V.M. Kirpatovskiy, R.M. Shutyeva, L.S. Pavlenko) was carried out in order to obtain the proper motions of stars. In the early twentieth century, a number of observatories took part in an international program observations of the reference stars for the planet Eros in order to determine parallax of the Sun in the most accurate way for that time, and thus to establish the scale of the solar system. Parallax of the Sun corresponded to a distance of 149.6 million km [23]. Among the works on the IAU program in 1929-1933, B.P. Ostashchenko-Kudryavtsev carried out observations of 51 stars from the Kopf-Renz list, additionally included in the NFK catalog and three series of determinations of declination of large planets (observers – M.M. Jewdokimov, K.G. Ginze, V.A. Mikhaylov). In the field of geodesy and meteorology geodetic network on the left bank of Ukraine were carried out. Activity at this field conducted in close cooperation with the Ukrainian Geodetic Institute. [9]. The observatory carried out observations of Moon's occultations, determination of star parallaxes (M. Jewdokimov), as well as the proper motions of stars and the orbits of double stars (L. Struve). At the 80s of the nineteenth century L.O. Struve predicted the phenomenon of the rotation of the Galaxy [3].

The Time Service of the Kharkiv Observatory established in 1920-1930 was one of the first in the country to entered with its results into the International Time Service. In 1933, the first time radio signals were sent to Pulkovo relative to the universal time scale, short-period irregularities in the rotation of the Earth were detected.

Mykolaiv (Naval) astronomical observatory was founded in 1821 on initiative of Admiral A.S. Greig for naval navigation needs. In the same year K.Kh.Knorre (the student of the V.Struve) arrived to Mykolaiv at Greig's initiative at the astromomer position.

In 1837, the observatory was equipped with a meridian Reichenbakh-Ertel telescope ( $D = 108$  mm,  $F = 1650$  mm), with its help, the director of the observatory K.Knorre participated in the compilation of the catalog, the so-called "fifth sheet" of the Berlin academic star charts (from 3h56m to 5h54m in right ascension and from  $-15^\circ$  to  $+15^\circ$  in declination) [18].

The Mykolaiv Observatory participated in the observations of the Bonner Durchmusterung (BD) and its southern continuation, organized by the German Astronomical Society. During 1872-1899 I.E. Kortazzi

carried out observations of 5954 stars in the zone of declination  $-2^{\circ}10' \div +1^{\circ}10'$  ("Mykolaev zone"). Since 1912 Mykolaiv observatory continued its activity as a southern department of Pulkovo observatory.

The purpose of the southern departments of the Pulkovo Observatory – in Odessa (1899) and Mykolaiv (1912) – was extension the Pulkovo absolute catalogs of stars to the southern sky, namely to  $-30^{\circ}$  in declination, to clarify the position of the point of the vernal equinox and for Sun observation.

The first work at the Odessa department carried out in 1901-1902 by B.P. Ostashchenko-Koudriawtzev, were observations for the catalog of declination 407 stars, 202 stars in which were in the zone of declination from  $-15^{\circ}$  to  $-30^{\circ}$ . The observations were carried out as a continuation of the Pulkovo catalog of 1900. The next program carried out in the department was the compilation of the catalog of 199 stars – the continuation of the Pulkovo catalog Pu 1905 to the southern sky to the declination  $-30^{\circ}$  (1904-1907). In 1912 the department was transferred from Odessa to Mykolaiv. The first observers in Mykolaiv were the Pulkovo astronomers P.I. Yashnov, M. V. Zimmerman, and B. P. Ostashchenko-Koudriawtzev.

According to his opinion, the absence of cloudy weather in Mykolaiv, as in Odessa, gives advantages to Nikolaev, especially during daytime observations with meridian instruments. A Freyberg-Kondratyev passage instrument ( $D = 108$  mm  $F = 1300$  mm) and a Repsold vertical circle ( $D = 108$  mm  $F = 1400$  mm) were transported to Mykolaiv from Odessa. The Mykolaiv department in cooperation with the Pulkovo Observatory participated in observations of stars for the compilation of the fundamental catalog "Carte du Ciel" (Bucklund-Hof stars). Meridian observations for this program were carried out at 10 observatories in both hemispheres. Most of these observations north of 10 degrees were combined in two catalogs-write ascension catalog, compiled at Pulkovo by F.F. Renz, and the declination catalog, by M.I. Dneprovsky compiled at the Astronomical Institute. In 1928, the Pulkovo Observatory began meridian observations to refine the positions of the NFK fundamental catalog vision. The Mykolaiv Observatory carried out sightings from the pole to  $-30^{\circ}$  [13].

The absolute catalogs of 1930 created by the Pulkovo and Mykolaiv Observatories made a significant contribution to the international work on the high-precision fundamental system FK3. 9 absolute Pulkovo and Mykolaiv catalogs of 1915, 1925, and 1930 were used at the FK3 compilation [14].

The observatory participated in observations under the program of observations of "1334 geodesic stars" (the organizer of the program – Pulkovo astrometrist M.V. Zimmerman). This program was organized because of by the lack of sufficient number of 5-6 magnitude stars important for time and geodesy services in

catalogs of F.F. Renz and M.I. Dneprovsky. 5 observatories took part in observations which were continued from 1933 till 1938. Total processing of obtained observations and their integration with the Pulkovo catalog 1925 was completed in 1941. Established in 1931, the time service of Mykolaiv Observatory participated in all-Union and international programs for determination the time which since 1938 involved in the work of all-Union and international programs to determine the time. There was established a regular reception of radio signals to the exact time of the Soviet and foreign radio stations. Since 1949 the Mykolaiv Time Service equipped with new timekeeping devices became a part of the USSR uniform time services system [17].

The problem of studying the rotation of the Earth and the motion of the poles was developed with the foundation of the Poltava Gravimetric Observatory (1926). The importance of studying the motion of the Earth's poles caused by the fact that their movement causes changes in the geographic coordinates, azimuths of points and affects the results of the exact time.

One of the main scientific activities of the observatory in the early years was the study of terrestrial tides. Beginning from the 50th years of the XX century, observations at many Earth-tidal stations and certain characteristics of lunar-solar tidal interaction is more than 25 points were carried out. The study of periodic members in latitude variations based on observations of two zenith bright stars in the Poltava Observatory was carried out by M.A. Popov. In the late 40th of the twentieth century, the founder of the Poltava Observatory A.Ya. Orlov proposed as the main task of latitude observations to study the slow changes in latitude and the nutation motion of the Earth's axis [21]. The International Latitude Service, which had already been working for half a century at that time, could not solve this problem due to deficiencies in its organization. There was a need for a fundamentally new program, built on new principles to study not only the periodic, but also the secular motion of the pole. Such a program was developed in the late 40's at the Poltava Observatory by E.P. Fedorov ("Poltava program"). The main purpose of observations under this program was to study the slow variations in mean latitude and the secular motion of the pole. It was also supposed to study the nutation movements of the Earth's axis, obtain data on periodic variations in latitude for calculation the coordinates of the pole and study the nature of non-polar variations in latitude. Some Soviet and foreign observatories conducted observations on the Poltava program. To study the motion of the Earth's poles in the Poltava Gravimetric Observatory parallel observations on three zenith telescopes were conducted: Zeiss ( $D = 135$  mm  $F = 1760$  mm), Bamberg ( $D = 110$  mm,  $F = 1230$  mm) and ZTM-180 domestic production ( $D = 180$  mm,  $F = 2340$  mm).

The question of organizing a new astronomical obser-

vatory in Ukraine arose in connection with the beginning of the great work in the USSR on the creation of the Catalogue of Faint Stars (KSZ). The decision about foundation observatory was accepted by the AA Ukr SSR and supported by the Government of the Ukrainian SSR. Among the directions of scientific research of the observatory, founded in 1944 by O.Ya. Orlov – positional astronomy (astrometry and the study of the rotation of the Earth). Thus, in a letter to A.Ya. Orlov, a well-known expert in celestial mechanics M.F. Subbotin recommended observations of large and small planet on photographic instruments, was relevant in connection with the development of work on the KSZ to correction the positions of the zero-point coordinate system.

During 1945-1946 the Observatory received the first instruments: a double short-focus astrograph ( $D = 12$  cm  $F = 70$  cm) made by N.G. Ponomaryov, a vertical Vanshaff circle ( $D = 19$  cm  $F = 252$  cm), a double long-focus astrograph ( $D = 40$  cm  $F = 550$  cm) made by Tepfer. According to the final report of the GAO for the first five years of activity, the following tasks were carried out: for the problem of the catalog of faint stars – setting up of 40 cm astrograph and vertical circle, photographing galaxies in order to tie positions of faint stars in distant objects, determination of declination of stars and a complete study of the vertical circle. Planned work on cataloguing "geodesic stars" was not carried because of the lack of appropriate equipment [22].

Among the main directions of research, formed during the first decades of the MAO – astrometry and global geodynamics, founded by O.Ya. Orlov and continued by his followers in particular Y.P. Fedorov (studies of latitude changes and pole movements, astronomical constants, in particular nutation, works on classical astrometry-compilation catalogs according latitude programs, program of the catalog of faint stars, etc.) [15]. The development of fundamental and photographic astrometry in MAO was under the head of the Pulkovo Astrometric School. Thus, the founder of the direction of photographic astrometry at MAO, I.G. Kolchinsky, was a representative of the Pulkovo Astrometric School, completed his postgraduate studies under the scientific head of A. Tikhov. After setting up the instruments, he began work on photographing small planets and galaxies (as part of the project Catalogue of Faint Stars) with A.B. Onegina (who completed her graduate studies under the guidance of the famous Pulkovo astrometrists A.N. Deich) and I.V. Gavrilov. Among other works begun by I. Kolchinsky at MAO, we note studies of astronomical refraction anomalies. This direction of research was a continuation of the traditional Pulkovo studies on astronomical refraction. In the 50s of the twentieth century, an outstanding astrometrists A. Yakovkin in MAO was founded a new branch of research-fundamental astrom-

etry and the study of the Moon. Subsequently, the subject of research expanded, which led to the formation of a new astronomical science – selenodesy. Research in the field of selenodesy and of lunar dynamics has become one of the main scientific directions of MAO.

Scientific research conducted at the Observatory of Lviv University, the oldest on the territory of modern Ukraine founded on the initiative of Rector D. Zelyonka at 1771, was mainly related to geodetic works, in particular the mapping of Galicia and Volyn' territories. Although the observatory existed a little more than 10 years, during this time it became an authority scientific organization, giving impetus to scientific activity for young scientists – F. von Tsakh, S. Serakovsky [12].

The new stage of development astronomy in Lviv in the late XIX century associated with the development of the Lviv Polytechnic. At the beginning of the twentieth century the seismographic station began to work. And already in 1918 it was equipped with three basic astronomical instruments: a passage instrument (Troughton and Simms), a refractor with 122 mm objective (Fraunhofer and Ressel), the Ertel instrument, made at the beginning of XIX century with 81 mm objective. In addition to these instruments, the observatory had several astronomical pendulum clocks, chronometers.

Observations of Sun and Moon eclipses, the passage of Mercury across the Sun's disk were observed. The results of the observations were mainly published in the journal "Astronomische Nachrichten". At the end of the nineteenth century the Department of Astronomy at the Lviv University was founded. In addition to observations to determine the time, there were observations of planets and comets, determination latitude by the Talcott method, observations of eclipses, occultations stars by the Moon, variable stars, meteors, new stars, the passage of Mercury across the solar disk. Headed by Prof M. Ernst observatory was equipped by Mertz refractor ( $D = 134$  mm,  $F = 180$  cm), a universal instrument, a pendulum clock, a solar chronometer, and a number of small laboratory instruments were acquired. The subject of astronomical research extended significantly in 1932, when E. Ribka was appointed at a director's position. The observatory was enlarged with new instruments: star and solar chronometers, a camera with a Zeiss triplet lens ( $D = 100$  mm,  $F = 50$  cm), pavilions for Mertz refractor, astrocamera ( $D = 140$  mm,  $F = 70$  cm) and for Zeiss refractor ( $D = 130$  mm,  $F = 240$  cm) were bought. E. Ribka carried out studies on photographic photometry of stars, observations of individual variable stars of different types, new stars, occultations stars by the Moon.

From 1939 a new stage in the development of astronomy at the Lviv University began. Studies of variable stars, photographic and stellar photometry, as well as on celestial mechanics were significantly expanded. After the war, the Astronomical Observatory

had three departments: astrophysics, astrometry, and celestial mechanics. In 1945 photographic observations of variable stars and comets were restored, as well as systematic observations of the Sun. The new methods of perturbation theory were developed to clarify the orbits of celestial bodies (1948-1953).

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