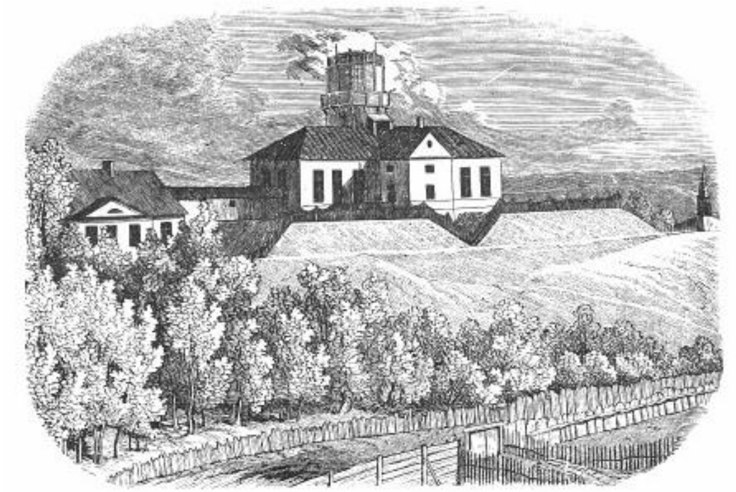
HISTORY OF THE TARTU OBSERVATORY

(1805-1948)

TARTU OBSERVATOORIUM & ELUS

GEORGI ZHELNIN



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TARTU 2020

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Translated from:

Georgi Želnin

„Tartu Observatoorium 1805-1948"

2004 Tartu Observatooriumi Virtuaalne Muuseum

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ISBN: 978-9949-9715-5-8 (pdf)

Table of Contents

Part I – Introduction

From the editor

In the years 1962-1971 Georgi Zhelnin published a series of articles on the history of Tartu Observatory in the *Observatory Calendar* (Tähetorni Kalender). Later, he compiled a Russian-language book based on these articles, published in the 37th issue of the Tartu Observatory Publications. This edition of the Tartu Observatory Virtual Observatory is an attempt to repeat the same in English.

All original articles have been left unchanged and contain details or assessments that may not all be of interest to the modern reader, or coincide with current views of history. We hope that the discerning reader will be able to observe the facts somewhat objectively by including the context within which his or her worldview and habits comfortably coexist.

As in all publications from the Tartu Observatory Virtual Museum, the place and time of original publication are listed in the headings of the articles (sections). The abbreviation TK denotes the *Observatory Calendar*.

In addition to this collection, a wealth of additional material can be found at the Tartu Observatory Virtual Museum.

About the author*

Georgi Zhelnin was born on October 28, 1910 to the family of a civil servant in St Petersburg†. On the first day of the revolutionnary year (1917), when the economic situation in Petrograd deteriorated, he came with his grandmother to live in the Estonian city of Valga. Since his early school age he had had to work during the summer holidays. After graduating from high school in 1929 he spent a compulsory year in military service, after which he worked for a year on the railway to earn money for university. In 1936, with a graduation diploma (*cum laude*) issued from the Department of Mathematics at the University of Tartu, the young specialist could only obtain a job as a mathematician-calculator at the military topo-hydrographic department. In 1940, after several courses he started to work as a Lieutenant in the military triangulation office. This did not last long, however, due to the outbreak of WWII. G. Zhelnin then took part in the battles for the Estonian Soviet Socialist Republic from beginning to end of the war. After being released from military service, he worked for a short time at the Tallinn Polytechnic Institute, and from 1947 in the newly founded Institute of Physics, Mathematics and Mechanics at the Estonian Academy of Sciences (now the Institute of Astrophysics and

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* L. Vallner TK 53 1977 92-93

† Up to 1914 it was St Petersburg, between 1914 and 1924 Petrograd, from 1924 to 1991 Leningrad, and since 1991 St Petersburg.

Atmospheric Physics)*, where he began to study the accuracy of triangulation performed in the thirties. In 1951, as a result of this study, he prepared a dissertation and after its successful defense he was awarded a degree of candidate in physics and mathematics.

Georgi Zhelnin (1910-1985)

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* The Institute of Physics, Mathematics and Mechanics was founded in 1947 and renamed the Institute of Physics and Astronomy in 1952. In 1973 the Institute of Physics and Astronomy was renamed the Institute of Astrophysics and Atmospheric Physics, and finally in 1995 the institute regained its original name, the Tartu Observatory.

When the Baltic Geodetic Commission was convened in Warsaw in 1924 to discuss the establishment of a unified levelling network for the study of the contemporary movements of the crust in the Baltic republics, nobody believed that the initiator of this work would be G. Zhelnin.

In 1952 preparations started for the repeating measurements on the levelling tracts founded and measured by the Estonian department of the Baltic Commission in 1930-40. With the direct participation and guidance of G. Zhelnin, high-precision levellings were made for about 2500 km. Thanks to Zhelnin's entrepreneurial spirit and defiance of organisational difficulties, the vertical movement of the crust has been studied in our republic more thoroughly than in Latvia or Lithuania. As a result of the large-scale work, several isobatic maps have been drawn, expressing the character of the current vertical movement of the crust in our republic.

G. Zhelnin was an outstanding scientist whose scientific work was recognised both in the Soviet Union and abroad. In 1972 he was awarded the Soviet Estonia Prize for his work cycle *Current Movements of the Earth's Crust in the ESSR.*

In addition to his main work G. Zhelnin also successfully worked on researching the history of science, compiling a history of the Tartu Observatory in both Estonian and Russian. He was a member of the Estonian Department of the National Union of Soviet Natural and Technical Sciences historians. In 1959 he was included in the Commission of the History of Astronomy by the Presidium of the Astronomical Council of the USSR Academy of Sciences. On G. Zhelnin's initiative, a committee coordinating the investigation of the current movements of the crust both in Estonia and other Baltic states was organised, in the work of which he actively participated.

There are 72 articles in the list of research papers by G. Zhelnin, 37 of which are on the current vertical movements of the crust, and 35 on the history of science. (*Tartu Observatory Publications* no. 52).

G. Zhelnin played an active part in the social life of the institute and the city of Tartu, being a long-term associate of the Tartu City People's Court, an associate of the Supreme Court of the ESSR, and a member of the Institute's party* bureau and national control group.

G. Zhelnin had a sense of perspective. He was a good, attentive and joyful colleague. His humour, rejection of tiredness and friendly wit remained characteristic of him even during the difficult time of illness.

For his exemplary and conscientious work, G. Zhelnin received a number of decorations, medals and orders.

* At that time *party* meant only the Communist Party of the Soviet Union.

Part II – Under German leadership

The Beginnings of Astronomical Observation in Tartu*

Ernst Knorre: The first astronomical observations in Tartu

The Tartu Observatory library holds two large manuscripts. These are the diaries of Ernst Knorre's astronomical observations and calculations. Ernst Knorre (1759-1810) was a resident of the city of Tartu, a teacher at a girls' school, an organist and from 1802 an extraordinary professor of mathematics at University of Tartu and an astronomer-observer.

The first notes in the journal are from 1795. Although Knorre had no astronomical tools, he determined the geographical latitude of Tartu in this year. Using a lead, he secured four plates with circular holes in a vertical row on the wall of a two-storey building. The diameters of the holes ranged from 2 mm at the bottom to 10 cm at the top. Using a mirror placed beneath the lower hole, Knorre observed which of the stars, with a declination between 58° and 59°, passed through the top hole along the diameter. This turned out to be δ Ursae Majoris, although he could not be certain that the star moved exactly along the diameter of the upper hole.

Even so this was the first (almost) reliable determination of the geographical latitude of Tartu, with an error of 10

* G. Zhelnin TK 38 1962 44-50

minutes of arc. Knorre subsequently determined many latitudes, using gnomons; in 1798 he made observations using a small Hadley's octant with 20 second divisions.

Ernst Knorre

Knorre did not have professional astronomical education – he was only an amateur-enthusiast. He started making observations at the age of 35, and neither his difficult financial situation, the workload nor the concerns of his large family were able to reduce his interest in astronomical observation and this great persistence led to recognition. A whole circle of astronomers was gathering around him, including Pastor Trämer from the Äksi congregation, merchant Gauger, etc., who helped Knorre and also made observations using sextants obtained with Knorre's help.

It is possible that this renown played a decisive role in Knorre's appointment as assistant professor of mathematics at the University and as an astronomer-observer at the Observatory in 1802. In this context, Knorre's economic situation improved somewhat, allowing him to fully commit to astronomy. With his help, University of Tartu obtained some sextants and ordered essential instruments for the future observatory.

Knorre characterised the purpose of his activity using the following words in his observer's journal: "I consider myself happy if I can be useful to our observatory as a practical astronomer. I feel the great importance of these astronomical observations."

Knorre did not perform astronomical observations only in Tartu. He wrote: "With the publishing of the Mellin map, I was quietly hoping to be able to measure the land myself." In the summer holidays of 1803 and 1804 Knorre travelled in Estonia in order to determine the geographic latitudes of various points. He carried out observations in Antsla, Rannu, Paistu, Sangaste, Karula, Kanepi, Tarvastu and at three points in Latvia, Ērgļi, Medsula and Liesere.

However, the main part of Knorre's work was done in Tartu. In the period of March, 1803 to the end of 1804, he measured 384 geographical latitudes with a sextant in Tartu, observing the sun's altitude near the meridian. The difference in results varied within a 2 second range, meaning that the results did not exceed the accuracy of the first determinations. Knorre continued these observations in 1805, although the results are not recorded in his observer’s journal (still present in the observatory’s library). Unfortunately, the effort spent on observations did not produce the desired results. Knorre’s lack of astronomical knowledge, lack of experience in the use of observational tools, and lack of accuracy of the sextants themselves led to the value of the work being almost zero.

In 1806 Knorre started to determine the geographical latitude of Tartu. To do this, he used solar eclipse observations (which he had used for the first time in August 1802) to determine the angular distance between the Moon and the stars, and observed the eclipse of the stars by the Moon. The accuracy of these observations was not worth the work done and the effort spent. From all the latitude and longitude measurements made by Knorre, Struve used only one, specifically that of 1810 using the eclipse of Aldebaran by the Moon.

In 1804 Johann Wilhelm Pfaff was appointed Professor of Mathematics. From the beginning, the relationship between Knorre and Pfaff was not normal. Whether it was due to a difference in characters, or perhaps Pfaff not trust Knorre's astronomical knowledge and skills, but Knorre was almost completely excluded from the work of the temporary observatory. Until Pfaff's departure in May 1809, Knorre worked in isolation and continued to observe with a sextant. Unfortunately, there are no notes of any kind in the observers’ journals of this period.

After Pfaff's departure, Knorre took over the instruments in the temporary observatory, but did not carry out any observations there. It is also unknown whether Knorre played an active role in building the permanent observatory. He died in December 1810 shortly before the new observatory was opened. He could not "be useful to our observatory as a practical astronomer", and he could hardly have done so given his equipment and methods.

Knorre did however bring a different form of benefit to the observatory in that he first attracted interest to astronomical observations in the population, and was the first to reliably determine the coordinates of Tartu and some other sites.

J. Pfaff: The first temporary observatory

With the arrival of J. Pfaff, a new page was turned in the development of astronomy in Tartu. Pfaff started energetically and professionally to secure the position of astronomy at the University of Tartu. He took part in the design of the permanent observatory and the selection of the site. He ordered the equipment, chose talented assistants from among the students, and gathered astronomers around him. Soon after Pfaff's arrival, the tools ordered by Knorre arrive, too. With the consent of the University Council, Pfaff rented the attic of Lenz House for the storage and partial use of incoming equipment and utilities. Although this building has not survived it was located at the corner of the current Poe and June 21st [now again Rüütli] streets. The attic windows were were south facing.

On June 1st, 1805 the first Tartu astronomical observatory started its work. In addition to Pfaff, the students M. Paucker and K. Viljams, and the tutor, the future famous astronomer Dr H. Schumacher, took part in its work. To a smaller extent, Knorre also participated.

Student K. Viljams, a Latvian, was released from serfdom because of his "outstanding mechanical talent" and "presented to liberty and science" (J. Pfaff. Astronomische Beiträge). Pfaff instructed Viljams to make a small passage instrument. Viljams started working in November 1804 and finished the tool at the end of 1805 [not in 1808 as has been mistakenly written by G. Zhelnin and P. Müürsepp in their paper in TK 35, 1959]. Here is some information about the first astronomical instrument made in Tartu: the length of the horizontal axis was 70 cm, the length of the longitudinal tube was 75 cm, magnification 50 times using a Dollond 2.5-inch lens. The tool was placed on a massive iron base fixed between the two side windows.

Student Paucker worked under the guidance of Pfaff whom he helped with observations and calculations, as well as observing independently. Paucker later used his knowledge and experience in working with the sextant to measure the Emajõgi bed. In this work, triangulation was first applied on Estonian territory. After Knorre's death, Paucker worked for a short time as an astronomer-observer but later moved to Miitavi (Jelgava) as a high school teacher.

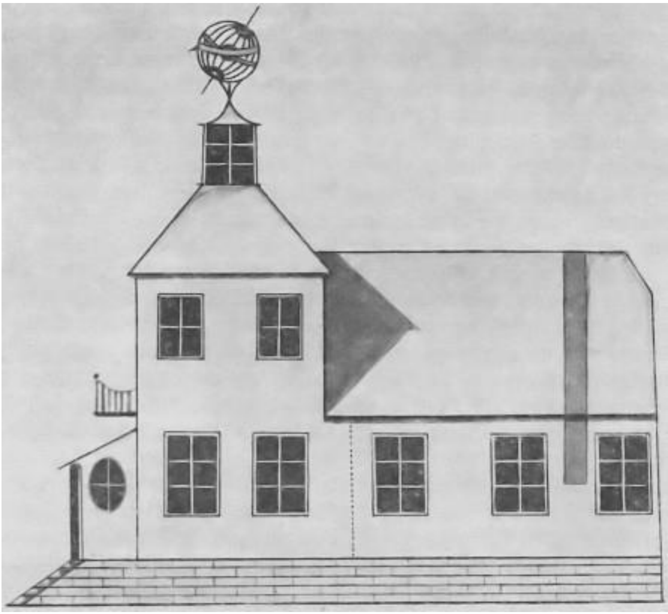
Heinrich Christian Schumacher

Paff's third colleague, doctor of legal sciences Heinrich Christian Schumacher, lived during the years 1805-1807 in Tartu working as a tutor. Under the influence of Knorre, and especially of Pfaff, he became interested in astronomy and devoted himself fully to this science. Later, Schumacher was the director of the Altona Observatory and founded the *Astronomische Nachrichten* journal.

Heinrich Christian Schumacher

During his stay in Tartu, Schumacher actively participated in the work of the Observatory and carried out observations even at home. Together with Pfaff he designed astronomic-trigonometric measurements on the territory of Livonia. This work was brilliantly done by Struve in 1816-1818.

At the start of the temporary observatory, Pfaff already had a number of astronomical tools at his disposal: several sextants, a 16-inch Troughton mirror circle, multiple chronometers, Viljams' small passage instrument, and a 3-foot telescope. Soon, Baumann's 16-inch repeating circle arrived.



Elevation of the Lambert observatory (according to Pfaff)

In the temporary observatory there were no base pillars for the observation tools nor the meridian slot in the roof. From the windows where the observation tools were placed, only part of the southern sky was observable. The placement of instruments in the window openings made it difficult to make observations, causing inconvenience in handling the instruments. To observe the northern sky the passage instrument was taken to another building located 15 m south of Lenz House.

With existing instruments, Pfaff, along with his assistants, determined the geographic coordinates of the observatory. The Troughton mirror circle was used to measure the Sun's height. In this way, 230 geographical latitudes were determined. With Baumann's repeating circle the zenith distance of the Sun and the Polar star was measured. This was a rather cumbersome job because 50 and more repetitions were made for one measurement. The repeating circle, passage instrument and chronometers were used to determine the longitude by occultation of stars. In co-operation with Professors Goldbach, Beitler and Sandt, the longitude differences between Tartu and Moscow, Miitavi and Riga were determined.

Pfaff's great achievement was the publication of the *Astronomische Beiträge*, a collection of articles by Pfaff and his collaborators on research into use of astronomical instruments, the results of observations, etc., released in three editions between 1806 and 1807 in Tartu.

It must be said that the activities of the first temporary observatory were very fruitful. In addition to the many observations that were made scientific contact with other observatories was established, the foundation for extensive geodetic work was laid and the work of the Observatory was published in Tartu, and elsewhere. Astronomy was on the rise in Tartu.

Another temporary observatory

The temporary observatory was supposed to stay in Lenz House until 1 June 1807. However, in order to implement the newly arrived large instruments (Dollond's passage instrument and Herschel's mirror telescope), Pfaff had to find new premises for the temporary observatory. The passionate astronomer Andreas von Lamberti helped to resolve this problem by agreeing to build a small observatory at his own expense and on his own land. On May 1st, 1807 the University of Tartu agreed to pay 250 roubles a year for the maintenance and heating of this observatory. The expiry date for the contract was spring 1811, although ultimately only a small amount of compensation was ever paid to Lambert and the building of the observatory became his selfless donation to science.

What little we know of Andreas von Lamberti is that he was born in 1771 and at the end of the century came to Livonia, where he was land surveyor for the Livonian knighthood. He later rented a mansion near Tartu. Lamberti was a doctor of philosophy (PhD) and with an interest in astronomy. His small observatory in Tartu was, according to Pfaff, equipped with good instruments. Lamberti's articles and survey results were printed in the *Dörptsche Zeitung* newspaper and in *Astronomisches Jahrbuch* (Berlin). Interestingly, Lambert suggested determining the relative positions of the stars by triangulating.

Later Lamberti left Tartu and lived in St. Petersburg, where he worked as a secretary to the Military-Scientific Committee.

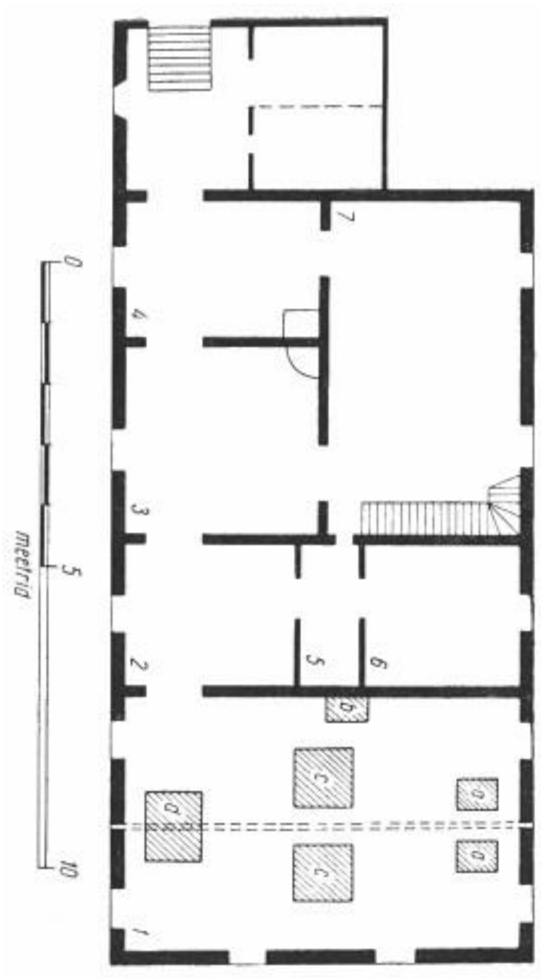
According to the contract he had signed Lamberti had to build a small pavilion of three rooms. One of these rooms had to be for a meridian circle. The plan for the pavilion under construction was made by Pfaff, although in fact Lamberti set up a much larger building. There were five rooms and a meridian hall on the ground floor that were much larger than Pfaff's. In the meridian hall there were stone pillars for the Dollond passage instrument, for the small Viljams passage instrument, for the Baumann repeating circle and for the Brockbanks clock. The rooms on the first two floors were originally used by Lamberti himself before he moved in November 1809 to a new house built on Riga road.

Under the agreement, Lamberti also had to build an Observatory garden, which was located near Riga road at the then botanical garden. The university bought a plot of land for a botanical garden near Riga road in 1803. In the autumn of the same year, land purchased from the owner of Tähtvere Manor was added, including the territory of the current Vanemuine Theater and the adjacent park. Levitski writes that, according to one of the inhabitants of Tartu, the Lamberti Observatory building was located on the current Õpetaja street and that a building reminiscent of an observatory still existed. We think that No. 11 Õpetaja street, which somewhat resembles the observatory, could be the building described here, although the orientation does not meet the requirements for the placement of the meridian slit, and furthermore the building is not on land formerly owned by Lamberti. From archival materials (plans, descriptions) it turns out that Lamberti's land was located outside the then city boundary in territory belonging to Tähtvere Manor. The northern boundary of Lamberti's land was 15-20 m south of Õpetaja street, i.e. between Õpetaja and Vanemuise streets, although the eastern border was parallel to Pälson (now Pepleri) street and 50 m to the west. The other boundaries are not marked on the city plan, but apparently the southern boundary was Riga road, the western border passed through the park belonging to Vanemuine theatre and was parallel to the eastern border. The exact location of the observatory has not been made clear, because the plans for buildings that were outside the city have not been found. The

National Historical Archives hold Lamberti's request for the construction of a road to the northern boundary of his plot. The hearing into this lasted from 1813 to 1820. Lamberti's request shows that a road was necessary to access his house, as the end of the road that joined Riga road was closed. It can be assumed that the part of the plot along Riga road was sold. It follows that the observatory was located in the northern part of the plot near Vanemuise street.

No material has been retained relating to this version of the Observatory's activities. Since the rent for Lenz House was paid only until June 1807, it can be assumed that after the due date the equipment was taken to a new observatory. The Dollond passage instrument was placed in the hall of Lenz house. Pfaff investigated this instrument, and in the *Dörptsche Zeitung* (No. 1, 1808) newspaper mentions that in December 1807 he observed a bright comet. What further observations were made in the years 1808-1809, or whether they were performed at all, could not be established.

The impression is that Pfaff lost interest in astronomy, perhaps because of a lack of assistants, perhaps because Schumacher left Tartu in 1807 and Paucker went to survey the bed of the Emajõgi river. What is known is that in the spring of 1809 Pfaff left Tartu. Knorre took the Observatory under his care, but apparently didn't carry out any observations there, his death in December 1810 leaving the University without astronomers. This situation lasted until August 1811, when J.S.G. Huth was elected professor of mathematics and Paucker started work as an astronomer-observer. A major development at this point is that by this time the two were now working in the permanent observatory, on Toomemägi hill.



Plan of Lambert’s Observatory: **1** Meridian Hall, poles for: a) Viljams Passage Instrument, b) Brockbanks Clock, c) Dollond Passage Instrument, d) Baumann Repeating circle; **2** Space for astronomers; **3** and **4** heated rooms for astronomers; Access to attic and rooms at Lamberti's disposal

The other temporary observatory did not live up to expectations. Lamberti's unselfish help did not bear fruit and good instruments stood virtually unused. Even before astronomy in Tartu could get wind in its sails, it had to lower them helplessly – and for several years. Only at the end of year 1812 did Wilhelm Struve begin to energetically continue the work of the Observatory.

The first ten years of operation, 1811-21*

By 1811, a small but unique white building with a spherical bubble on top emerged on the hillside of Toomemägi. This was the University of Tartu Observatory. But even now the newly built observatory was completely unused for more than half a year. There was no opening of the observation windows and slots, nobody directed a telescope towards the stars and there was no master in the house.

The first professor of mathematics, J. Pfaff, left Tartu in 1809; the first astronomer-observer E. Knorre died on December 1, 1810, i.e. one month before the adoption of the Observatory by the Commission. The existing astronomical instruments were brought from Lamberti's temporary observatory to the university's main building and placed in the care of rector Parrot. By the end of 1809, Huth had been elected Professor of Mathematics and Director of the Observatory, although his arrival from Kharkov was delayed. In the meantime former astronomer Paucker performed the function of astronomer-observer.

At the same time there was increasing interest in astronomy among students in Tartu. Enthusiasts appeared and talents were growing. Every so often the thoughts and eyes of W. Struve, a graduate of the philological faculty, were on the new observatory.

* G. Zhelnin TK 40 1964 31-38

Figure 3. Tartu Observatory on its first day

W. Struve's student years

W. Struve entered the University of Tartu, Faculty of Philology, arriving from Altona, today a suburb of Hamburg. This present us with a reasonable question: why did the future astronomer-geodesist come so far to study at the newly opened and yet unheard of University of Tartu? And why did he join the Faculty of Philology?

In order to find answers to these questions, we have to go back to 1808, when fifteen-year-old Wilhelm studied at Altona high school, where his father, a well-known philologist and mathematician, was director. In Germany, these were difficult times: the French army was master, and adolescents were recruited into the army. Young Wilhelm succeeded in escaping the soldier's greatcoat, while at the same time Schumacher was returning from Tartu to Altona, giving a gratifying assessment of both Tartu and the University. As Wilhelm's older brother Karl Struve already lived in Tartu and worked as a teacher of Greek at the University, the choice became Tartu. Upon arriving, Wilhelm Struve entered the Faculty of Philology at the University, beginning with lectures on mathematics and physics at the same time. He probably chose Philology because his father had recommended it, but his excellent philology in secondary school had an influence. However, participation in the lectures on mathematics and physics showed Struve's strong interest in hard sciences. In order to overcome economic difficulties he started work as a home teacher with Count Berg's family in Sangaste Manor. Berg spent winters in Tartu where Struve could teach, while the summers were spent in Sangaste.

In addition to his pedagogical work, Struve was still engaged in sports, for example riding and long walks. There is a story of an occasion when the local peasants arrested him because they took him for a French spy because he was studying the landscape from the viewpoint of triangulation, which once again underlines the real interests of this philology student.

As a student, Struve made friends with rector Parrot's son and was a frequent guest of the professor's family. Parrot noticed his remarkable talent in natural sciences and advised him to deal with the exact sciences. Despite working as a tutor, Struve graduated from the Faculty of Philology in 2½ years even receiving a gold medal for one of his works in philology.

After graduating from the university in 1811, Struve was offered the post of senior school teacher at Tartu gymnasium. However, under the influence of Professor Parrot, Struve abandoned his career as a tutor to Count Berg's family, turning down what could have been a fairly brilliant career (for a twenty-year-old) as a senior teacher.

The Rector applied for a scholarship for Struve from the University of Tartu and recommended that he study mathematical disciplines more seriously. Struve chose astronomy, possibly because of Schumacher, who had been a student of Struve's father and a friend of the elder brother Karl. Despite Schumacher being a doctor of law he had also found his calling in Tartu, i.e. astronomy. Schumacher planned a trigonometric survey of Livonia in Tartu with Pfaff, and this may have been the driving force behind the preparation of the triangulation work from the first days of Struve's arrival in Tartu.

Between 1811 and 1813, Struve consistently and persistently studied the secrets of the mathematical sciences. He was probably assisted in this with practical advice by Professor Huth, and Paucker. The doors of the Observatory had opened to Struve.

The first Director of the Observatory, J. Huth

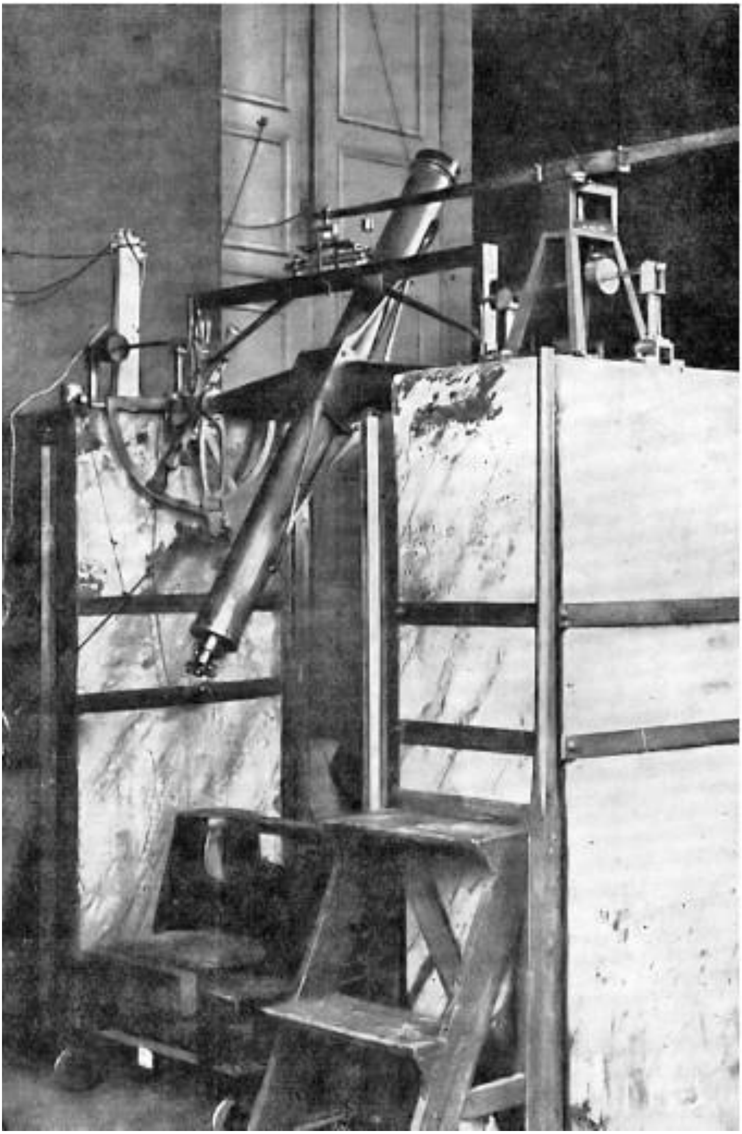
J. Huth (1763-1818) finally arrived in Tartu in the second half of 1811, after being elected professor in 1809, from Kharkov, where he had worked as professor of applied mathematics. In a small temporary observatory built in Kharkov Huth had determined the geographical coordinates and had planned to determine the arc lengths along the parallel and meridian.

When he arrived in Tartu, Huth was apparently uninterested in supplying the Observatory's equipment and made no effort to start observations. He may have been disappointed with the unsuccessful planning of the Observatory building, but the cause could also have been his bad health. In any case, Huth did not start immediately as master of the observatory. In 1812, however, he tried to obtain granite pillars to mount the passage instrument. Then in 1817 he asked for a dwelling for the director to be built near the observatory.

In seven years spent in Tartu, Huth published only two papers, including observations of the 1811 comet, although at the same time his pedagogical activity was very intense.

M. Paucker, former associate of Pfaff at one of the temporary observatories and in the geodetic survey of the Emajõgi riverbed and an astronomer-observer, was as passive as Huth. In 1811, Paucker came from Vyborg to replace Knorre. What work he did at the Observatory (if he did anything at all) is unknown. The impression is that in 1811 and 1812 Paucker's main activity was preparing a dissertation. After defending the dissertation at the beginning of 1813, he was awarded simultaneously Master's and Philosophy Doctor's degrees. In 1813, Paucker left the University of Tartu and went on to become a senior teacher of physics and mathematics at Miitavi (Jelgava).

At the same time (1811-1813) Struve studied the exact sciences closely while also learning observation techniques and writing a dissertation. In 1812, he practiced measurement with a sextant in a small triangulation net established near Tartu and determined the geographical coordinates of the observatory using existing instruments. His dissertation "The Geographical Location of the Tartu Astronomical Observatory" was based on this material, for which he, like Paucker, received a Master's and Philosophy Doctorate, in 1813.



The Dollond passage instrument

W. Struve, director of the observatory and astronomer-observer

On November 25, 1813, Struve was assigned to replace Paucker, who left Tartu, in the post of astronomer-observer, in this way the Observatory gaining a promising young, vigorous and completely science-minded, scholar. Professor Huth no longer took part in the work of the Observatory, relying entirely on his young assistant.

The Observatory still had old Pfaff-era instruments which, due to their scarcity and small size, were lost in the large and high halls of the Observatory. The main instrument – Dollond's four-inch passage instrument – was still packed in boxes. So Struve's first task was to install the passage instrument, although the granite pillars ordered by Huth had not been received so the bottom pillars had to be laid out of bricks.

After installing and adjusting the instrument, Struve studied its accuracy with high precision and care, and also the stability of the pillars. Further, the work plan of the observatory had to be drawn up and the passage instrument to be applied to observations. Here, Struve's special talent was revealed, that of finding a suitable task for every existing instrument, which would be one of many necessary tasks. Struve consistently attempted to refine Huth’s work and improve on its accuracy. He used new methods, supplementing the design of the existing instruments or obtaining the new, more precise instruments.

One such task was to clarify and supplement the coordinates of the stars in the Piazzi catalogue (compiled in Palermo) with respect to the northern stars.

Friedrich Georg Wilhelm Struve

By using a passage instrument it was only possible to determine a single coordinate of a star, the right ascension, but Struve took on this task. He included the determination of right ascension of all the stars brighter then magnitude 5 in the interval of declinations + 45 ° and + 90 °. On January 20, 1814, systematic observations began at Tartu Observatory. Later, observations of all the circumpolar stars were added to the program, with each star being observed at both culminations, if possible. Struve gave himself up to observation. Often he worked with the instrument for 18 hours in a row. On such nights, he was able to observe nearly 100 stars, with each observation consisting of registering the moment of meridian passage using five threads in the instrument.

Observation with the passage instrument was Struve's main work in 1814 and 1815, during which time he was able to record the transit of 3078 stars. In addition to this, he observed the Olbers comet using Troughton's achromatic telescope and determined the exact geographical location of the observatory. Based on the 1814 and 1815 surveys, he specified the right ascension of 215 stars. While observing the right ascensions Struve began to be interested in double stars. He estimated the difference of the right ascensions, and estimated the differences of their declinations by eye. Using these results he calculated the approximate position angles and distances, studying 16 double stars during this period.

On the basis of the materials of the period in question, the first volume of the observatory publication *Observationes astronomicae in specula universitatis* was issued in 1817. In the summer of 1814 and 1815, Struve visited other observatories, where he became familiar with the instruments and the work done there, renewed acquaintances with well-known astronomers such as Olbers, Gauss, Bessel, Bode, etc., and with famous instrument makers such as Reichenbach, Fraunhofer and Baumann.

In 1816, Struve got a new job, which he had already dreamed of as a student, when he accepted the proposal of Livonian Utility and Economic Society to conduct a trigonometric survey of Livonia. The University encouraged this work by allowing Struve to use the summer months for the next three years. In solving this problem, Struve's great ability to approach challenges creatively emerged once more and with small and incomplete instruments he was able to carry out extensive and fairly accurate measurements.

Struve was engaged in this survey for two and a half years using Troughton's 10-inch sextant as the only instrument, apart from a special piece of hardware, a horizontal sector, designed by Struve himself to measure elevation.

It seems that the years 1816-1818 were mainly spent on triangulation measurements and processing of measurement data. There were no assistants and he probably did not perform any astronomical observations during that period. The most important events of these years include the publication of the first part of *Observationes astronomicae in specula universitatis* Apart from this one should note the ordering of the Reichenbach meridian circle and arrival of Hubert's pendulum clock.

Huth's death did not cause any changes in Struve's life or activities. He remained an astronomer. The University had already elected him professor of astronomy, even though the position didn’t officially exist, because the University Council wanted to encourage astronomy to become a separate profession. Unfortunately, however, the final decision on this was delayed.

Huth's grave in Tartu

At the end of 1818, when the basic geodetic works were completed, Struve returned to observations with the Dollond passage instrument. By the end of 1819, 5315 star observations had been performed, with the moment of the meridian passage of each star recorded by seven threads. Double and multiple star observations were performed to a large extent and a catalogue of 15 double and 68 multiple stars was compiled. To help with this, the university mechanic made a micrometre thread for the Troughton telescope. In addition to this there were comet observations, some parallax test observations, and a determination of aberration.

The first assistants to Struve at the observatory were student K. Knorre and Finnish astronomer H. Walbeck.

By 1820 the Observatory's instrumentation had not improved and consequently the observing program remained the same. In 1820 and 1821, 4510 moments of meridian passage were recorded. Double and multiple stars became more and more important objects for Struve. The Troughton telescope was equipped with a Fraunhofer micrometre. There were already 795 stars in the Double Star catalog. Struve´s diligent helpers K. Knorre and H. Walbeck compiled tables for the position of the Polar Star for each day in 1820-1822. Knorre and Walbeck also observed the eclipses of the stars by the Moon. Walbeck's work also included examining the accuracy of the passage instrument.

Struve was again interested in geodetic surveys. He received consent and support to measure the length of the arc along the Tartu Meridian. In the summer of 1820 Struve travelled abroad to find the instruments needed for the up-coming work and to get acquainted with the equipment used elsewhere. In addition he used the time to visit Schumacher and the Danish arc measurements. He also had to hurry Reichenbach to send the ordered meridian circle faster.

On September 9, 1820, Struve was appointed Professor of Astronomy and Director of the Tartu Observatory. Although life at the Observatory went on pretty much as normal, the change in Struve's position caused the post of astronomer-observer to be removed and it was only restored in 1827. In the meantime Struve applied for a permanent assistant. In 1821 a living house was built at the Observatory and Struve moved in. In the same year, geodetic signals were built and arc measurements started. The possibility of performing triangulation in Finland began to be studied more closely and to this end, Struve and his assistant Preuss visited Finland, coming to a cooperation agreement with Walbeck, although unfortunately this plan came to nothing because of Walbeck's early death.

In 1821, the Reichenbach universal instrument necessary for the current work was obtained. The largest geodetic work of the nineteenth century was started – measuring the length of the meridian arc from the Arctic Ocean to the Danube.

The first ten years of the Tartu Astronomical Observatory were characterised by a lack of instruments, which limited the amount of work that could be performed. The arrival of Struve revived the activities of the Observatory and work began that would later bring world recognition to both Struve and the Observatory. New instruments were commissioned and Struve gained unrivalled mastery in observations.

The Blossoming of Tartu Observatory (1822-1839)*

In the foreword to the first volume of Tartu Observatory publiccations, W. Struve wrote:

> *When I was appointed astronomer-observer three years ago, I thought for a long time, and seriously, whether the current instrumentation could be used to enrich our knowledge of the starry sky. I wanted to obtain experience in astronomical observation techniques that later, when the observatory got the desired instruments, meant I could choose better observation methods thanks to the experience gained. I believe that anyone who holds a booming science dear is required to contribute to it according to his or her abilities.*

The long-awaited moment arrived in 1822: new observation instruments began to arrive at the Observatory. First the Reichenbach and Ertel meridian circle arrived, then after waiting two years, the great achievement in design and instrument making of the day, the nine-inch Fraunhofer refractor, arrived. Geodetic instruments indispensable for arc measurement also began arrive one after another. This ended the preparatory period during which Struve had acquired mastery of astronomical and geodetic observation techniques. At this time Struve's

* G. Zhelnin TK 41 1965 59-67

students also worked as assistants at the Observatory making it now possible to begin the second stage of the program, the further development of astronomy for the collection of accurate and large-scale observation material. However, Struve was not confined to observing only the stars, but he was also very interested in determining the size and shape of the Earth. The years 1822-1839 can be called the flowering of the observatory, both in terms of the supply of instruments and the work done.

This period can be broadly divided in two, based on the main research directions. Of course, such a division is arbitrary, because thanks to Struve's great energy and workmanship, several significant tasks were carried out simultaneously.

The first period (1822-1827) can be called the period of geodetic work. Struve did not start the geodetic work accidentally, and it soon became international, attracting attention to a small observatory – the later geodetic centre. The Observatory's fame contributed to the moral and financial support that was essential to the development of the Observatory.

During the second period (1828-1839) various astronomical observations were made, with the central problem being the study of double and multiple stars. Unfortunately, the trouble associated with the construction of the Pulkovo Observatory often led Struve away from scientific work, making the last years of the period less productive. No great theoretical work appeared, but rather observation material was collected that both Struve and his companions would later use in their scientific work. Let us consider the two periods mentioned above in more detail.

The first period (1822-1827)

The main work of the period was the measurement of the arc along the meridian of the Tartu Observatory (cf. G. Zhelnin and L. Vallner's paper in the 1964 *Observatory Calendar*). The fieldwork done within this framework required a huge amount of time and great mental and physical strain from Struve. Every year the field measurements were carried out on average over six months from May to October. Let us consider, for example, the works done in summer 1827. At the end of April, the baseline was specified. In May, when there were better observation conditions, directions from the triangulation points near the seashore were measured to the northern tip of the arc in Gogland (the target was 70 km away). This was followed by the measurement of the main triangle and the base line of Simuna in late autumn. The measurements of the angles of the base network were completed with snow and hard frost in mid-November. In addition, preparatory work, instrument research and verification, comparison of the length-measuring instrument with the reference standard, and current calculations were added. Struve's only comfort was the fact that the summer period was astronomically inappropriate anyway. However, not all years were so intense. For example, in 1822 the meridian circle arrived at the Observatory, the installation and investigation of which hindered the timely start of fieldwork. Neither could notable fieldwork be performed in the summer of 1825. On November 19, 1824, the Fraunhofer refractor arrived. At first it was mounted in the Western Hall of the Observatory, but for better use the small tower had to be rebuilt quickly with a stationary dome, as Struve was planning to observe the August 1825 Encke comet. The rotating dome project was in the hands of Parrot, a professor of physics at the university, and the whole summer of 1825 passed in the construction work, although despite the effort the construction was not complete in time. The Fraunhofer refractor was placed in its new location in the tower only in November 1825.

Because money was so scarce during this period, some of the old instruments had to be sold to cover the purchase of the Fraunhofer refractor. In this way, Baumann's repeating circle and some sextants were sold to the Moscow Observatory to replace instruments destroyed by fire and the passage instrument made by Latvian Viljams under the guidance of Professor Pfaff was sold to St. Petersburg.

In addition to the Fraunhofer refractor and the meridian circle, the instrumentation of the observatory was supplemented with some geodetic and smaller astronomical tools and precision clocks.

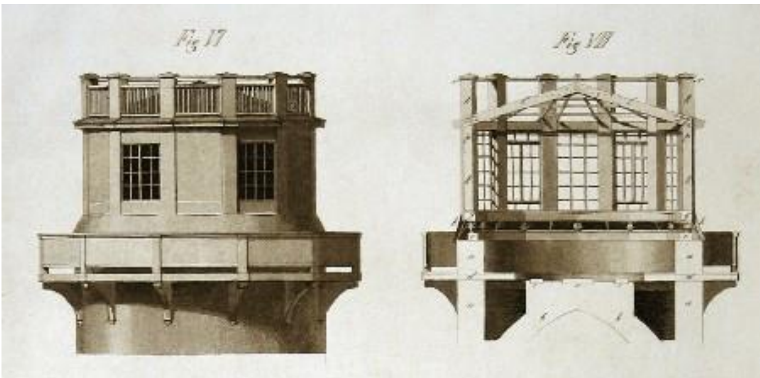
It was clear that several observers were needed to use the existing instruments, however in 1827 only the director and a helper who was later referred to as assistant worked at the observatory.

This changed for the better when, starting in 1827, the post of astronomer-observer was reinstated. W. Preuss (Ernst Wilhelm Preuss, 1796-1839), a pupil of Struve and a tireless and interesting man, gained the post in 1821 on Struve’s recommendation. Struve got to know Preuss accidentally at the hospital in Tartu and took an active part in the concerns of the young weaver. He helped Preuss find a clerk’s post and later to attend a pedagogical seminar at the University of Tartu. Preuss’ love of work, great ability and interest in astronomy enabled Struve to bring him to the Observatory and later to appoint him, first as assistant and later as astronomer-observer.

An ambitious and skilful assistant Preuss completely justified Struve's hopes, helping to gather accurate observation material that was later used for theoretical generalisations and conclusions. In 1823, on the recommendation of Struve, Preuss took part as an astronomer in the scientific round-the-world journey on the sailboat Predprijatije (Undertaking) under the leadership of captain Kotzebue. In 1826, Preuss returned from the expedition and continued his work as astronomer-observer at the Observatory.

The Fraunhofer refractor. From Beschreibung des grossen Refractors von Fraunhofer

While Preuss was engaged in the expedition he was replaced as assistant by a student, B. Lemm, and after Lemm, V. Fjodorov (1802-1855; 1838, professor at the University of Kiev, founder and director of the Kiev Observatory). Fjodorov's life too is interesting as he was one of the pupils of the St. Petersburg home for children who was sent in 1823 by the government to study at the University of Tartu. [H. Raudsaar's article in the 1955 *Observatory Calendar*].



Rotating Dome. Drawings of W. Struve's work. From *Beschreibung des grossen Refractors von Fraunhofer*

So far, we've only talked about Struve's regular personnel. However, Struve also had many good and efficient associates among the officers who, since 1822, had attended an astro-geodetic training at the Observatory. The most prominent of these was W. Wrangel, who took part in the Baltic trigonometric survey for five years.

Let's take a closer look at the astronomical work done in the winter months. In the autumn of 1822, it was possible to begin the observations with the Reichenbach and Ertel meridian circles, which were placed on granite pillars obtained from Finland in the observatory's western hall. On October 26, 1822, Struve began systematic surveys with the instrument as a continuation of the work started with the Dollond passage instrument in 1813. With the new instrument it was possible to determine both coordinates of the stars, right ascension and the declination. During the work, special attention was paid to the determination of the coordinates of double and multiple stars. First, the coordinates of 795 double stars previously identified by Struve and catalogued in 1822 were determined with each star measured six times, three times in both positions of the circle. Struve conducted observations with the meridian circle until the end of 1826, during which period observations were made as follows: in 1822, 784 stars were measured on 46 nights; in 1823 4506 stars on 184 nights; in 1824 4042 stars on 208 nights; in 1825 2390 stars on 215 nights; and in 1826 506 stars on 87 nights. 84 stars were observed for a maximum of one night.

The years 1825 and 1826 were particularly strained for Struve. The Fraunhofer refractor was still in the western hall of the observatory, making it difficult to observe through the window. Nonetheless, Struve started the observations necessary to discover double stars. The observation program included all the stars up to the ninth magnitude from the North Pole to a South declination of 15°. Observations were made in zones of 7.5 to 10 degrees wide. Preliminary observations with the refractor gave promising results. In a letter dated 20 March 1825, Struve informed Schumacher that where, according to Herschel's data and the catalogue compiled in 1822, there should have been only 40 double stars, Struve had found another 113.

Between 1825 and 1826 Struve was conducting three major tasks at the same time: arc measurement, meridian circle observations, and use of the Fraunhofer refractor. At the end of 1826, when Preuss came back from the round-of-the-world expedition, the observations with the meridian circle became his job. Struve’s heavy workload continued in 1827 because he had also to finish the arc measurement and the sky observation.

A great deal of work was done in two-and-a-half years with over 120 000 stars observed and 3112 double and multiple stars discovered, among others. During this work, micrometric measurements of the stars were also partially performed (mainly for the development of the methodology and to check the accuracy of the micrometre).

At the beginning of 1827, a new catalogue was published, *Catalogus novus stellarum duplicium et multiplicium maxima ex parte in specula Universitatis Caesareae Dorpatensis per magnum telescopium achromaticum Fraunhoferi detectarum*. Having completed the star catalogue Struve started the micrometric measurements of the double and multiple stars, a task that lasted until 1837. During the period other work was also done, for example the occultations of the stars with the Moon were observed, the diameter of the sun was determined (73 measurements), the culmination of the Moon was observed with Troughton's achromatic telescope, and the Encke comet and Saturn and Jupiter were observed. Observations of star occultations were performed simultaneously on multiple instruments. For example, in the observations in 1822, Struve took part using the Troughton telescope, Preuss with the Herschel reflector, Wrangel with Ramsden, and Livron with the Dollond telescope. Each observer determined the moment of occultation using a different clock.

(Occasionally, guest astronomers also took part in the observations. So, for example in 1824, Moscow astronomer D. M. Perevoshchikov was present at the observation.)

In addition to the interesting astronomical events listed above, Struve was also interested in studying the surface of the Moon. In his letter of February 3, 1822, he told Schumacher that he was looking at a bright spot with magnitude 8 in the area of the Aristotle Crater, which may have been caused by volcanic activity in that crater.

At this time the Observatory's publishing activity also expanded. Two volumes of publications (IV and V) were issued and a number of other large works: a description of the large refractor, the catalogue of double and multiple stars, and numerous notes and articles in astronomy periodicals.

Struve and the observatory led by him gained great fame and authority, and in 1822 Struve was elected correspondent member of the St Petersburg Academy of Sciences.

The second period (1828-1839)

Thanks to the director's tireless work, the Observatory continued to obtain new instruments. Below is the list of these instruments as of August 1, 1836 (the data is from the inventory compiled by Struve, which has been kept in the Observatory Library):

1) *Telescopes* - 7 (including the Fraunhofer refractor, Herschel reflector and Troughton's achromatic);

2) *Angle measurement instruments* - 18 (including the meridian circle, passage instrument, vertical circles, universal instrument, small passage instrument and theodolite);

3) *Precision clocks* - 18 (pendulum clocks and chronometers);

4) *Length measuring instruments* - 15 (measuring instruments and length reference standards);

5) *Meteorological instruments* - 9;

6) *Auxiliary instruments* - 38;

7) *Special and supplement instruments* - 17

In total, the observatory had 122 instruments large and small. In 1834, Struve planned to partially renew the Observatory's instrumentation. For this, he ordered a large meridian circle from Repsold, although unfortunately the Tartu Observatory did not receive it, rather it was sent to the newly built Pulkovo Observatory.

Personnel of the observatory remained unchanged: director, astronomer-observer, assistant. Preuss worked as the astronomer-observer until the end of this period. Fyodorov, the assistant, took part in two expeditions (from 1829 to 1830 as part of the Parrot expedition to Mount Ararat, and from 1832 to 1837 as part of the expedition to West Siberia). At that time, U. Porth (who later worked as the first mechanic at Pulkovo Observatory) replaced Fyodorov, and for the later expedition Fyodorov was replaced by G. Sabler, who studied at the University Of Tartu institute Of Professors. The institute of Professors was organised in 1828 with the aim of preparing professors for Russian universities. In 1834, Professor A. Savitš, a candidate for the University of St. Petersburg and G. Sabler, a graduate of the University of Tartu, participated in the professorship. Both of them, especially Sabler, were Struve's able helpers at the Observatory. In addition, assistant professor A. Shidlovski (later director of the Kharkov Observatory) and students G. Fuss (later an astronomer in Pulkovo), K. Senff (later professor of mathematics at the University of Tartu), and Otto Struve (successsor to his father in the post of director of the Pulkovo Observatory) took part in the work of the Tartu Observatory. W. Döllen (later an astronomer at Pulkovo); of the military geodesists Rosenius, Olberg and Kalmberg could be mentioned.

The geodetic work of this period was mainly limited to calculations and preparation for the publications. The book *Beschreibung der Breitengradmessung…* was published in 1831. In 1828 as a continuation of the arc measurement Struve and Tenner’s arcs were joined creating a total length of arc of was 8° 2.5′. Astronomical measurements and comparisons of length measurements were made by Struve while Tenner measured the angles. In 1830, the measurement of arc continued north. Struve did not take part in the measurements directly, his responsibilities were general expedition management and calculations.

In 1833, Struve and Sabler took part in a maritime chronometric expedition, the purpose of which was to determine the geographical lengths of a number of points along the Baltic Sea. During the expedition, Sabler assigned local time at the temporary observatory on Hogland. Other geodetic works include the two expeditions of Fyodorov and an expedition to determine the difference between the Black and Caspian Sea levels, in 1836. This was attended by three of Struve’s students, Savitš, Sabler and Fuss, and Masing, the university's mechanic. The expedition used the instruments of the Tartu Observatory with a work methodology developed by Struve and checked in Tartu.

In the field of astronomy, two major problems were the focus of attention: observations of the meridian circle performed by Preuss (until his death), and the micrometric measurements of double and multiple stars, carried out by Struve using the Fraunhofer refractor. Struve's work was generally completed in 1835 and published in 1837 under the title *Stellarum duplicium et multiplicium mensurae micrometricae per magnum* Fraunhoferi *tubum annis a 1824 ad 1837 in specula Dorpatensi institutae auctore.* For the first time, this work contained a reliably determined parallax of Vega. Struve had already been engaged in the determination of the parallax of the stars in 1818-1821, proving that the accuracy of the existing instruments did not allow astronomers to determine the parallax. Having received a precise micrometer equipped with a Fraunhofer refractor, Struve returned to parallax determination, continuing with this in Tartu until 1838.

The observation of comets with the Fraunhofer refractor should also be highlighted. In 1828 the Encke comet was observed, in 1832 Biela and in 1835 Halley's comet. The positions of the comets were determined using the Fraunhofer refractor in comparison with a bright star close to comet. The coordinates of the comet were later refined using the meridian circle. The observation of Halley comet is discussed in more detail in a monograph published in 1839.

Between 1832 and 1835, the work determining the direct ascension of the Moon and the nearest stars was intense. The surveys were mainly performed by Sabler using Dollond's passage instrument. The occultations of the stars by the Moon were also observed, this was done by all the personnel at the Observatory. Other length determination methods were also tested. For example, Fyodorov watched the culmination of the Moon, and in addition Saturn was examined to determine the dimensions and inclination of its orbit to the ecliptic plane. The astronomers of Tartu also registered the shadows of Jupiter's moons and studied sun spots. In 1826, Struve discovered a new star in the constellation of Orion (Orion's Trapeze), which was probably a nova. Unfortunately, from 1835 the observatory's work was partly offset by the large responsibility placed on Struve's shoulders: as the future director of the Pulkovo Observatory and a member of the relevant committee, he had to monitor the construction of a new observatory. Therefore, he often had to stay away from Tartu at the new building, at meetings of the St Petersburg Academy of Sciences, which he had been a member of since 1832, and when ordering instruments abroad for the new observatory. He also visited Moscow where he familiarised with the observatory.

Despite such a heavy load, the tireless Struve did not forget the concerns of the Tartu Observatory. In the interest of the work, it was imperative to have an apartment for the astronomical observer that as near the observatory. According to a decision of the University Council, a new house would be built in the north-eastern corner of the area of the Observatory, containing servants' apartments, heated rooms for storing equipment, an auditorium and a small workshop. However, unfortunately, this plan has never been realised.

Struve's great achievement was the creation of the Observatory Library. In 1830, he donated his own personal library to the Observatory, with many books being presented to him by the authors. By 1839 there were already 715 volumes, with publishing strengthening towards the end of this period. Volume VI and VII, and a series of monographs such as *Beschreibung der Breitengrad-messung in der Ostseeprovinzen Russlands* (1831), *Stellarum duplicium et multiplicium mensurae micrometricae per magnum* Fraunhoferi *tubum annis a 1824 ad 1837 in specula Dorpatensi institutae auctore* (1837). and *Beobachtungen des Halley'schen Cometen bei seiner Erscheinung im Jahre 1835 auf der Dorpater Sternwarte angestellt* (1839) were published. There were also articles and notes in *Astronomische Nachrichten* journal and the periodicals of the Academy of Sciences.

Struve and Tartu Observatory became more and more famous. The Observatory was visited by prominent domestic and foreign astronomers and geodesists: in 1828, by General Tenner (cf. A. Vuuk's article in the *Observatory Calendar* 1969); and in 1832 by Argelander from Finland and South from England.

There were changes in Struve's family life. In 1834, his wife, with whom he had harmoniously shared life for 19 years, died. Struve had to take care of 8 of their own children (of 12, four having died young) and 3 of his brother's children. In 1835 Struve married for the second time and the children got a new mother.

In 1839, a new page turned in the life of the meritorious astronomer. Although he was still present on March 19 at the observations of occultation of the Pleiades by the Moon, the departure time was close. On April 12, due to the transfer to Pulkovo observatory, Struve was released from his position as Director of the Tartu Observatory. New jobs, new successes and new achievements awaited him in Pulkovo. Sabler, Otto Struve and Porth followed their teacher to Pulkovo.

In addition, on April 26, Preuss, the tireless workman and experienced observer, died. The Tartu Observatory was now empty of employees, its future now depended completely on the new director.

Tartu Observatory activities 1840-72*

Shaping the Tartu Observatory as an outstanding scientific institution was Struve's life work and so when he left Tartu he was naturally very concerned about his successor. To whom should he leave the management of the Observatory? Who would further develop the scientific direction he had founded?

Ultimately Struve's choice was Peter Andreas Hansen, director of the Seeberg (Gotha) Observatory and a prominent German astronomer (1795-1874). Hansen was just as energetic and pragmatic as Struve. He had obtained new instruments for Seeberg Observatory and improved the old ones, was a very good observer, and geodesy was no stranger to him. To this man, Struve could trust the management of the Tartu Observatory with a calm heart. Hansen agreed to take up the position because the richly decorated Tartu Observatory promised good working conditions. But German scientists were not allowed to go abroad so easily, and just as with Gauss in 1809, Hansen was offered more favourable working conditions at home and decided to stay in Germany.

* G. Zhelnin TK 42 1966 70-79

Until the election of the new director, the leadership of Tartu Observatory was entrusted to a student of Struve, Karl Eduard Senff (1810-1849), professor of mathematics at the University. Astronomer-observer Aleksei Savitš was also a pupil of Struve, educated at the Institute of Professors, who defended his doctoral thesis in 1839 and, as early as 1840, left Tartu to become a professor at St. Petersburg University.

On March 16, 1840, an election took place for the positions of astronomy professor and director of the observatory. The Faculty Council presented the candidature of Acting Director K. Senff, and of Berlin astronomer and well-known researcher of the Moon Surface Johann Heinrich Mädler (1794-1874). Mädler it was who won election as the more experienced candidtate.

Mädler was the director of the Tartu Observatory for 25 years. During this time (from 1842) his closest assistant was the astronomer-observer Thomas Clausen (1801-1885), who in 1865 became director of the Tartu Observatory. Since Clausen was director for quite a short time (7 years), and the observatory's activities and management did not change significantly during that time, we can treat this period as a whole.

Let's pause before analysing the work of the observatory and its employees, illuminating in more detail the biographies of Mädler and Clausen.

Observatory employees

Johann Heinrich Mädler was born in 1794 in Berlin. After graduating from secondary school he was unable to enter the university immediately because after the death of his parents the care of his younger sisters was left to him. Working as a teacher at the seminary, he studied in parallel at university. Together with his student Wilhelm Beer, he organised an observatory at Beer´s summer cottage in Tiergarten (now a suburb of Berlin), featuring a Fraunhofer 4.5 foot [1 foot = 30.48 cm] focal length telescope.

J. H. Mädler

In 1830, this teacher and student began systematic surveys of the surface of the Moon, the planets, double stars and the Sun in his observatory, resulting in a map of the surface of the Moon and a description based on the survey results. This work was published in 1837 receiving several awards and bringing the authors recognition and popularity. For example, Jules Verne mentions Mädler in his novel *Flight to the Moon*. After graduating from university, in 1833, at the request of the Prussian government Mädler carried out local time determination at a temporary observatory organised on the island of Rügen to serve a large Russian chronometric expedition (1833-1834).

In 1836, Mädler got a post at the Berlin Observatory as an assistant. It has not been possible to identify when and for what work a doctorate was awarded to Mädler. In the articles published in *Astronomische Nachrichten* magazine, however, "Doctor" was used before his signature from 1835. Mädler paid great attention to popularising astronomy and shortly after his arrival in Tartu, a book titled *Populäre Astronomie* (1841) was published in Germany, followed by seven republications, the last two posthumously. In 1840 Mädler married poetess Minna Witte.

Witte’s mother was an artist and amateur astronomer who made a spherical relief model of the moon's surface. As director of the Tartu Observatory, Mädler hoped to continue his research with the Observatory’s powerful Fraunhofer refractor.

Thomas Clausen was born in 1801 in a fisherman's family near Schleswig. At the age of eleven, he still couldn't read. The local pastor who taught him languages, mathematics, astronomy, and natural sciences for seven years was interested in the fate of the boy. In 1823, Clausen presented to Schumacher, the director of the Altona Observatory at the time, his first scientific work on determining geographical latitudes using the observational data of the occultations of stars by the Moon. Schumacher published this article in *Astronomische Nachrichten* (No. 40, 1824), edited by him, with the following prophetic words: "The name of Thomas Clausen will be called among those who took the torch of science and carried it forward." Soon Clausen became astronomer-observer at Altona Observatory where he worked without breaks, including short-term work at the Utzschneider Institute of Optics, until he settled in Tartu in 1842. In the period 1824-1842, Clausen published a large number of scientific articles. By the time he came to Tartu, he was already a well-known scholar and theorist with diverse interests. His work included several disciplines: mathematics, optics, mechanics and practical astronomy.

T. Clausen (photo from T. Rootsmäe Archive)

From 1842 to 1865 he was an astronomer-observer, and from 1865 to 1872 director, at the Tartu Observatory. During this period, the assistant's duties were performed by:

1840-1844 W. Döllen,

1844-1846 A. Struve

1846-1849 L. Schwarz,

1849-1850 A. Wagner,

1850-1861 G. Lais,

1861-1865 C. Bursy,

1865-1866 F. Berg,

1866-1868 C. Fleischer,

1868-1868 F. Kuhlberg,

1868-1871 E. Block,

1871-1872 C. Laurenty.

As is apparent, assistants changed quite often. They were mainly students who, after graduation, left the Observatory and moved to permanent posts leaving no trace of their activities. Let's just mention a little more about those who devoted themselves to astronomy and to whom the work in the Observatory was a kind of education at the beginnings of their life work.

Wilhelm Döllen, W. Struve’s son-in-law, later worked at the Pulkovo Observatory. In old age he returned to Tartu, where he is buried.

August Struve, son of Ludwig Struve, Professor of Medicine at the University of Tartu, brother of Wilhelm Struve, later moved to Pulkovo. Early death cut short this promising astronomer's life.

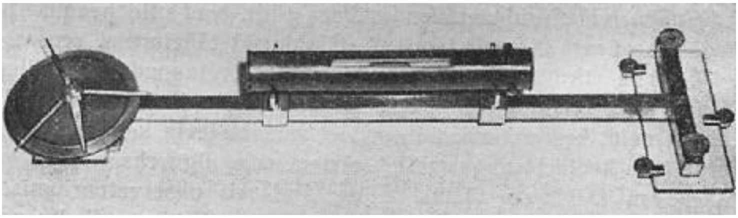
Ludwig Schwarz was an astronomer-observer at the Observatory in 1865 and director from 1872. Let's return to him in the description of the next period in the history of the observatory.

August Wagner was later deputy director of the Pulkovo Observatory. Friedrich Berg worked at the Pulkovo and Vilnius Observatories and was one of the pioneers of photometric work in Russia. Eugen Block continued his work at the Observatory of the University of Odessa.

The installation of the observatory

Unfortunately, neither Mädler nor Clausen did not take care of the modernisation of the observatory’s instrumentation and the famous Tartu Observatory lost its shine as the best observatory. Although it was unable to compete with Pulkovo Observatory, it could still have maintained the previously high level even within the limits of the Observatory’s equipment.

For example, the great meridian circle planned by W. Struve was not obtained, although money was available for it. The order of the heliometer was apparently blocked by Pulkovo and was only obtained from Repsold in 1873, when the Tartu Observatory director was Schwarz. However, it cannot be said that the observatory’s equipment was not improved at all, it was, but only with a variety of smaller devices that were acquired randomly and arguably were little needed. Examples include pantographs purchased from the heirs of Admiral Greigh, the uranoscope and relief images of the moon surface acquired from Dickert (23 boards). A large refractor kit was supplemented with a prism micrometre (the mechanical part of this device was manufactured by university mechanic Brücker). For the meridian circle, collimators were obtained. An apparatus for reversing the instrument and apparatus for examining the pins was obtained. In addition, a set of meteorological instruments was purchased. One interesting instrument that is of historical value is the gauge, made by Uno Porth, Pulkovo's first mechanic and a student of W. Struve, used to check the water levels.



U. Porth's gauge for checking water levels

The Observatory's tower was repaired soon after Mädler came to Tartu. A new floor was made in the West Hall, columns were set for collimators and the revolving dome was repaired. During the repair, the meridian circle and the large refractor were removed and cleaned. Unsurprisingly, however, W. Struve's plan to build a second residential building near the Observatory remained unfilled. The Observatory's library was also not systematically upgraded during this period and not many valuable publications were obtained.

Activities in the Observatory

While at the time of W. Struve, the main goal of the Observatory was to carry out systematic surveys, process the materials obtained and compile catalogues, then in the period 1840-1872 the scope of the observations decreased sharply. Systematic observations with the meridian circle (as a continuation of Preuss' work) only took place until 1844. Observations with the Fraunhofer refractor acquired a random character during Mädler's tenure as director, while during Clausen's time it might not have been used at all. On the other hand, the theoretical work gained more importance, although it was not always related to the general direction of the observatory's activities.

Observations

Mädler made observations with the Fraunhofer refractor following an observation program that was the same as Struve's, including double stars, planets, comets and, in addition, observations of the Moon. A prism micrometer was ordered to help here, although the surface of the Moon was not thoroughly and systematically observed due to unfavourable climatic conditions. The main content of Mädler's observations were double stars and the determination of their orbits and rotation periods.

In 1860, Mädler conducted 38 double star measurements. Struve and Bessel (Struve observing with Fraunhofer's great refractor and Bessel with the Königsberg Observatory's heliometer) were known to have differed by +0.192 seconds of arc, although whether the difference was instrumental or because of individual mistakes by the observers is unknown. Having travelled to Königsberg (now Kaliningrad) Observatory in 1860, Mädler used the same instruments as the Observatory's director Luther to repeat the Struve-Bessel observations. The program was completed, producing almost the same difference, +0.223 seconds of arc, alluding to instrument error.

Mädler also used the Fraunhofer refractor to observe planets (Venus, Mars, Mercury, Saturn, Uranus), asteroids (Vesta, Juno, Flora, etc.) and comets (Biela, Donati, Encke, etc.).

What kind of observation Clausen performed is unknown. Probably his old age prevented observation work.

The meridian circle continued the work interrupted by the death of Preuss, i.e. working on the positions of stars, first and foremost double stars.

In the 1839-1844 period, assistant Döllen performed these observations. The data of the measurements were printed in Volume VIII and IX of the Observatory Publications. Clausen started observing with the meridian circle in 1844. What observations he performed in the 1844-1865 period is hard to say, because the data have not been published. Astronomer-observer Schwarz started a new series of observations with the meridian circle in 1870. The Tartu Observatory also switched to the collective work to determine the exact positions of the stars in the Bonn review catalogue. We will discuss this work in more detail in the next article.

Assistant A. Wagner used the Dollond passage instrument to measure the right ascension of some of the stars in the Bradley catalogue in 1849-1850. The data from these observations were published in Volume XI of the Observatory Publications and used by Mädler to determine the movements of the stars.

Smaller instruments (Troughton's telescope with a 5-foot focal length, the 2.5-foot Fraunhofer telescope, Mädler's personal telescope, etc.) were used to observe solar and lunar eclipses and the occultations of stars by the Moon. Several observers took part in these surveys.

Systematic meteorological observations formed a new task. Three times a day temperature, air pressure, and wind speed and direction were determined. These observations were usually performed by Mädler himself.

Scientific work

One of the main topics of Mädler's scientific work was the study of the orbital motion of components of double stars. In order to have a comparison for his observation data, he used the results of earlier measurements as well as Struve's results. Another, equally important, task was the study of the movement of stars. To do this, Mädler made great preparations, recalculating the Bradley catalogue data (3222 stars). Based on the widespread idea that stars like the solar system rotate around a central body[*], Mädler assumed that this centre could be the centre of gravity of the whole stellar system. By studying the movement of stars, he placed the geometric centre in the Pleiades cluster, more specifically close to the star Alcyone. He even calculated that the Sun would make one full rotation around that centre every 18 million years. Although his work, *Die Centralsonne* (1846), called for lively discussion and sharp criticism, we can rightly consider Mädler to be the founder of stellar dynamics.

[*] Mädler wrote in his book *Die Centralsonne* that our galaxy does not have a massive central body – T. Viik.

A number of Mädler's articles and notes relate to the determination of planetary sizes and rotation periods.

Clausen mainly published his articles in *Astronomische Nachrichten*, publishing during the 1842 to 1850 period many articles about mathematics, physics and astronomy (for example, in 1842 he published 15 articles here). One of his articles from that year "Determination of the orbit of Comet 1770" received a high rating from Bessel, who wrote: "What a great, more correctly a masterful work… This is the achievement of our time that our offspring will not forget." In 1850 Clausen interrupted the publication of his articles in the columns of *Astronomische Nachrichten*, possibly due to the death of the journal publisher, Clausen's teacher and friend, Schumacher, or possibly for other unknown reasons. Only two articles by Clausen appeared in the *Observatory Calendar*, in the XVI volume, "The Determination of the orbit of Comet Tuttle (1790-1858 I) and its Rotation Period" and a theoretical justification of the rare celestial phenomenon, a triple halo of the Sun, observed in Tartu on June 5, 1849. Königsberg University awarded Clausen a doctoral degree for his scientific achievements. Clausen was also a corresponding member of the St Petersburg Academy of Sciences.

The works of assistants from this period included the observations of W. Döllen and A. Wagner, and posthumously the dissertation by A. Struve. *Calculation of Orbits of Neptune's Satellites* (Observatory Publications Volume XIII).

Scientific expeditions and duty trips

During the 1840-1872 period the Tartu Observatory organised two scientific expeditions, both to observe full solar eclipses. The first expedition, to Brest in 1851, was attended by Mädler and Clausen. (The expedition failed because of bad weather.) The second expedition was to Vitoria, Spain, in 1860. Mädler, his wife, the Observatory servant Martin Saar, and Rennenkampf, the owner of Helme Manor, took part in the expedition detailed in Mädler's letters (published in *Inland* Nos 46-49). The expedition was a success. Mädler observed the Sun's corona and protuberant while his wife observed the colour of the clouds at various stages of the eclipse. Martin Saar, who had exceptionally good eyes, was tasked with observing stars visible during the eclipse and mark them with a pen on a special hemisphere. Apart from the planets Jupiter, Venus, Saturn, and Mercury, he saw 8 more bright stars (Castor, Pollux, Regulus, Capella, etc.). Rennenkampf mainly conducted meteorological observations.

Mädler made six other scientific trips abroad to study the work of other observatories and instruments in addition to which he made a tour of Russia. Mädler visited the Pulkovo Observatory twice, the first time after coming to Tartu, the second time in 1865 to work in the library.

Mädler and Clausen's activities in Tartu

It is worth noting Mädler's popularisation activities. He wrote books, such as *Populäre Astronomie*, *Astronomische Briefe*, *Astronomie zum Schulgebrauch*, etc., gave popular lectures in Tartu, and contributed to magazines, etc. He also took an active part in the city's social life and was one of the initiators of the Dorpat Naturalists’ Society, which in 1851 [formally registered in 1853] became the Estonian Naturalists’ Society.

Mädler followed Struve in the Observatory, and so their relationship is of interest. It is quite likely that Mädler's election as director of the Observatory did not correspond to Struve's wish. The characters of these two researchers, of the same age, were too different as were their attitudes to work. Discipline, prudence, perseverance at work and modesty in life characterise Struve. Self-aggrandisement and a laissez-faire attitude to the tasks entrusted him – these seem to have been Mädler’s characteristic features. Two such differing characters would never understand each other, and they did not get on.

The close ties connecting Struve with the Observatory weakened and he visited the Tartu Observatory only once after taking up his new position, in 1852 in connection with the 50th anniversary of the University.

In his book *Astronomers of the University of Tartu*, Levitski omits relations between Mädler and the University Council, and the actions of Mädler, which were not worthy of his high office because they do not show the best aspects of Mädler’s character. He was not very friendly with the students, and was well enough disliked in general that in 1846 someone apparently shot him through the window of his apartment. It is also believed that the frequent changes of assistant were down to the director’s unfriendly nature.

Mädler left Tartu in 1865 when he retired due to an eye disease that made it difficult to make observations and a desire to devote himself to literary activity. He was based in Germany where he lived in Wiesbaden, Bonn and Hannover, dying in Hannover in 1874 after a long illness.

We have no data on relations between Clausen and Mädler, despite the fact that they worked together for 23 years. One might think that Clausen was quiet, modest, closed in his theoretical studies – a conscientious employee and a good-natured person. He had no real interest in observation and did not deal with it. As an astronomer-observer, he did not lecture at the university although he shared his rich knowledge with those students who visited the observatory. Clausen retired at the age of seventy, having worked at the University of Tartu for 30 years. Upon his retirement, the University Council commended him for his "long-term work for the University". Clausen lived in Tartu, where he died in 1885. His tomb has been restored and the personnel of the observatory keep it in order.

Articles on the Tartu Astronomical Observatory describe the period of Mädler's and Clausen's directorships (1840-1872) as the fall of the observatory. In our opinion, this is not entirely correct. The Observatory, as the base of astronomical investigation, its installations and their expansion can be described with the expression “stationary extinction". There was nothing new, no improvements, no attempts to obtain new astronomical instruments; the methods that were in practice at that time are no longer visible. The Tartu Observatory fell further and further behind other Russian observatories, not to mention the Pulkovo Observatory. There was no move towards better instruments or more advanced observation. Compared to the high level of W. Struve, the quality of the observations themselves also dropped, and the volume of work remained largely unchanged from the previous period. In our view, there were two reasons for this: first the lack of a well-thought-out observation program connected with theoretical work, and second the ripe age of observers.

However, there was a step forward in the theoretical work. For example Mädler’s thorough research on the movement of single and double stars, some cosmological theories (for example the central Sun theory). There was also widespread popularisation activity, which in combination with the theoretical activity raised the prestige of the observatory. Mädler's name became widely known – even Engels quoted him.

Clausen's theoretical studies were a major contribution to science. The results were published in eight volumes (IX-XVI) of the Observatory Publications, now issued under the name *Beobachtungen.* (During Struve’s time, scientific publications had been in Latin.) It was a worthwhile achievement. Whereas in Struve’s time Publications consisted mainly of the results of observations, now there was more space for theoretical work.

The Observatory also maintained its program of astronomers' training and five young astronomers (L. Schwarz, A. Wagner, A. Struve, F. Berg, E. Block) dedicated their lives to science. The Observatory of Tartu continued – albeit not as rigorously as before – to pursue the development of science.

Observatory during L. Schwarz's directorship 1872-91[*]

The council of the University of Tartu elected Ludwig Schwarz the new director of the Observatory and professor of astronomy in place of the retired Clausen in 1872. Schwarz worked for 22 years as director. Like his predecessors Mädler and Clausen, Schwarz started to lead the Observatory when he was relatively old (at the age of 50). He no longer had the strength and initiative needed to develop new scientific directions and find new perspectives. Working for a long time as an assistant and astronomer-observer, Schwarz had also become accustomed to the modest possibilities of the Observatory, the nature of the work, and the management style of previous directors, and he could not and did not try to reorganise the Observatory or bring anything new to its life. All attention and all available forces were in that period targeted at the great task started during Clausen's time, determining the coordinates of stars in the northern sky in a range of declinations, the so-called Zone Observations. It was a collective endeavour initiated by the International Society of Astronomy (Astronomische Gesellschaft) in which the Tartu Observatory took part.

This work had taken over 25 years but was still unfinished because of a lack of the necessary instruments (the meridian circle was outdated) and the quite frequent changes

[*] G. Zhelnin TK 43 1967 68-80

of astronomer-observers. Routine observations required a lot of time and effort and prevented other research and new tasks.

This period in the Observatory can be described as work that served the task of Zone Observations, no other major theoretical or observational work was done. We can mention only two important moments: pioneering work on noctilucent clouds and discovering a new star, which later turned out to be the first supernova outside of our galaxy. However, a greater achievement was the training of astronomers for domestic and foreign observatories.

Observatory employees

The number of posts in the Observatory remained unchanged since Struve: **1)** The director of the Observatory, who was also professor of astronomy at the University, **2)** astronomer-observer, who from 1873 was responsible for giving lectures in mathematics, **3)** observatory assistant.

These duties were performed by:

Director: 1872-1894; L. Schwarz

Astronomer-observer: 1873-1876; H. Bruns

1876-1879; O. Backlund

1879-1884; A. Lindstedt

1884-1886; E. Hartwig

1886-1894; L. Struve

Assistant: 1873-1894; G. Grofe

Students of that time and graduate students who had applied for candidate degrees took part in the work of the Observatory: H. Struve, F. Renz, E. Lindemann, Th. Wittram, J. Seyboth, B. Wanach, F. Blumbach, et al., all of whom later devoted themselves to astronomy.

To some extent, retired astronomers living in Tartu were also connected with the work in the Observatory: former director of the Tartu Observatory Clausen, Kiev astronomer A. Shidlovski, former director of Tbilisi Meteorological Observatory A. Moritz and Pulkovo astronomer W. Döllen, the last three of whom were students and associates of W. Struve.

We present short biographies of the above mentioned observatory personnel.

Peter Carl Ludwig Schwarz was born on 23 May 1822 in Danzig (Gdansk, Poland). His childhood and adolescence passed in St. Petersburg, where his father worked as an artist at the court theatre. Ludwig graduated from high school in St. Petersburg and, thanks to the teachers' material support, entered the University of Tartu in 1841, graduating in 1846. He began his work in the Observatory as a student, performing astronomical observations under Clausen's guidance. After graduating from university, he began work as an assistant at the Observatory. In 1849, on the recommendation of W. Struve, he took part in an astronomical expedition to the other side of Lake Baikal and the Amur River. Four years passed in difficult expedition conditions in uninhabited and roadless areas. From this expedition, Schwarz brought rich observation material and experience in astronomical field surveys.

Not a year passed before Schwarz was appointed head of a similar expedition. The expedition was organised by the Russian Society of Geography for the physical geographic exploration of East Siberia, including Sakhalin Island and part of China's North Provinces. Again four years passed in the expedition, in misery and danger that demanded great valour and endurance. With three assistants, one of whom tragically perished in the first year, Schwarz determined the geographic coordinates of many points (α and λ were determined at 109 points, and routes of 15 000 versts were measured[*]).

After returning from the expedition in 1858, Schwarz devoted four years to the processing of the material and to compiling a map of the territory studied. A complete report was ready in 1862 and published in 1864. The Geographical Society appreciated Schwarz's work, rewarding him for his tireless efforts with a medal and a prize, while the government gave him a lifetime pension.

Neither the expeditionary conditions nor the success and recognition that followed reduced Schwarz's interest and attachment to scientific work. Before going on the first expedition, he completed a candidate's dissertation, titled *Determining the latitude with the astronomical universal instrument without a clock.* The materials of the second expedition enabled him to present his master's dissertation in 1865, on *Reducing apparent and true distances on the Moon.*

[*] Approximately 9943 miles – T. Viik

L. Schwarz (photo of the Central Archives of National History)

Great experience in geodetic field measurements and mastery of astronomical measurements in observations, made Schwarz a good candidate for a post at the Pulkovo Observatory. They needed a scientist whose duties included the training of military geodesists, a task that was performed by W. Struve and later by W. Döllen. But Schwarz chose another path in life, according to his scientific interests. Despite his age and marital status (he was the father of three children), he received a mission abroad from the Ministry of Education which was to prepare young people for professorship. Between 1863 and 1865 he studied in Berlin and Gotha and visited the Netherlands and England.

In 1865, Schwarz returned from the mission and took up the post of astronomer-observer at the Tartu Observatory – in the meantime Clausen had been elected director of the Observatory. In his new post, Schwarz began the significant task of observing the Tartu zone, which was to be the main bulk of his scientific work. In 1872, Schwarz became the Director of the Observatory.

Before we begin to describe the life of astronomer-observers working in this period, we should take a look at the causes of the frequent changes in this position. It is worth noting Schwarz's serious attitude to his choice of assistant. After all, the main task of the observatory – to observe the stars in the Tartu zone – fell on the shoulders of the astronomer-observer. Foreigners, young promising scientists, doctors of science who had good theoretical training, were usually invited to fill this post, which for them was a step forward, although the low salary (it was lower at Tartu University than in other Russian universities), maths lectures, and lack of additional earning opportunities or promotion prospects forced them to look for better jobs. Two or three years passed and these young scientists returned to their homeland, where they had better prospects. Only Backlund stayed, in Russia at the Pulkovo Observatory. None of the astronomer-observers except Hartwig left a noticeable impression on the activities of the Tartu Observatory.

H. Bruns

Heinrich Bruns (1848-1919) was born in Berlin and graduated from university there. In 1871 he defended his doctoral dissertation, and in 1872 became a calculator at the Pulkovo Observatory. In 1873 he entered the post of astronomer-observer at the Tartu Observatory, where, besides his direct work, he had to give lectures in special fields of mathematics by order of the department. In 1876, Bruns left Tartu and soon became the director of the Leipzig Observatory. He is known for his work in astronomy, applied mathematics and geodesy. While he was in Tartu he published one paper in mathematics.

O. Backlund

Johann Oskar Backlund (1846-1916), a Swedish national, graduated from Uppsala University in 1872. In 1875 he was awarded a doctor's degree and became an assistant at the Stockholm Academic Observatory. In 1876 Backlund came to Tartu to fill the vacant post of astronomer-observer. Here he continued to observe with the meridian circle and, in parallel to his main job, lectured on mathematics. Backlund paid great attention to theoretical issues. In 1879 he went from Tartu to Pulkovo and in 1883 he was elected academician. Between 1895 and 1916, Backlund was the director of the Pulkovo Observatory. Backlund is known for his works in the field of celestial mechanics. His name is associated with the study of the Encke comet.

A. Lindstedt

Andreas Lindstedt (1854-1939) was also a Swedish national. He graduated from Uppsala University with a candidate's degree and worked one year as the astronomer-observer at the Hamburg Observatory, then continued his studies in Leipzig. In 1877 he defended his doctoral thesis and took up the position of associate professor at Lund University. Lindstedt was supposed to become the second astronomer-observer at Lund Observatory, where there he would perform the zone observations. But there was no second post, and in 1879 Lindstedt came to a similar job in Tartu instead. In addition to his work at the Observatory, he gave lectures in special fields of mathematics and in 1880 organised the first seminar in mathematics at the university. While at Tartu, Lindstedt completed several scientific studies on celestial mechanics and integral calculations, which brought him fame. In 1883, he was elected professor of applied mathematics in the University of Tartu. In 1886 Lindstedt returned to Stockholm, where he continued his pedagogical and scientific activities.

E. Hartwig

Karl Ernst Albrecht Hartwig (1851-1923) was born in Frankfurt am Main, Germany, and studied at the Universities of Erlangen, Leipzig, Göttingen and Munich. Having obtained a higher education he pursued the profession of teacher of mathematics and physics. In 1874, Hartwig became a teacher in Strasbourg, where he continued to work as an assistant in the local observatory. Here he was involved in work on expeditionary observational material on Venus' transition across the solar disc (1874) and investigations using the expedition's heliometer. In 1880, Hartwig was awarded a doctor’s degree.

In 1882 he went on scientific missions in Russia, Sweden, Finland and Denmark. That same year, he led a German expedition to Bahia Blanca in Argentina to observe Venus's transition over the solar disk.

In 1884, Hartwig moved to Tartu as an astronomer-observer. He spent a year and a half at Tartu Observatory and in January 1886 returned to Germany to lead the construction of the Bamberg Observatory, which he was then director of until his death.

It seems strange that in Tartu, Hartwig did not take part in the main work of the observatory, i.e. determining the coordinates of the stars with the meridian circle, which was usually the task of astronomer-observers. The reason seems to be that in the 1883-1886 period Schwarz himself worked with the meridian circle, checking his measurements for the years 1870-1873. In Tartu, Hartwig mainly observed with a heliometer. His pioneering work on observing noctilucent clouds and the discovery of the first extragalactic supernova in the Andromeda Nebula also took place in Tartu.

L. Struve

Gustav Wilhelm Ludwig Struve (1858-1920), grandson of W. Struve, was born in Pulkovo. He graduated from the University of Tartu with a candidate's degree in 1880, then worked as a supernumerary astronomer in Pulkovo. In 1883, L. Struve defended his Master's degree in Tartu and went on to study abroad. He then worked in Bonn, Milan and Leipzig, and in 1886 he moved to Tartu to the post of an astronomer-observer. Here in 1887 he defended his doctoral thesis. The main works of L. Struve at the Tartu Observatory were observing the zone stars and working on his and Bruns' observation materials. In 1894 he was appointed professor of astronomy and geodesy at the University of Kharkov.

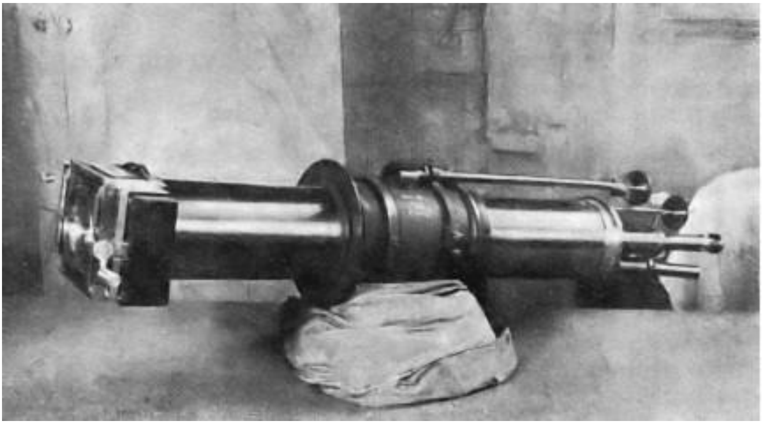
To give a more complete picture of the personnel of the Tartu Observatory during the 1872-1894 period one should name an assistant who worked here for more than 20 years.

Gustav von Grofe (1848-1895) was born in Moscow and graduated from the University of Tartu. He started working at the Observatory as a student. In 1873, he became an assistant in the Observatory (confirmed in the post in 1875). Here he mainly worked on calculations, processing data relating to the zone stars but not observing independently. In 1894 Grofe took up the post of associate professor of applied mathematics at the University of Tartu.

Observatory status

During the tenure of the subsequent directors, the well-equipped Tartu Observatory from the period of W. Struve was not significantly renewed in terms of instrumentation. The instruments were old and could no longer satisfy the increased demands of observation practice. A similar backward trend also occurred during Schwarz's directorship with plans to rebuild the hall and obtain a large meridian circle remaining unfulfilled.

As a new instrument, a Repsold heliometer (diameter 108 mm, focal length 165 cm) was obtained. The instrument was commissioned at the initiative of the Pulkovo Observatory to monitor the transition of Venus over the solar disc in 1874. This rare phenomenon was observed by Schwarz with the heliometer in Nertshinsk. In 1876, this unique instrument was sent to London for a scientific exhibition at the request of Repsold. In 1882, the instrument was temporarily given to a French expedition to Martinique Island in the Caribbean Sea to observe the transition of Venus, where it was used by Tisserand, a well-known French astronomer.



Repsold Heliometer Dismantled (Photo: E. Sellekese)

Hartwig used the heliometer further in Tartu. The instrument is currently dismantled in the old Tartu Observatory.

In addition to the heliometer, the Herbst's passage instrument was procured during this period from the Pulkovo Observatory's workshop. It is interesting to note that the Pulkovo mechanic W. Herbst (1842-1908) came from Estonia, specifically from Helme (Valga district).

In addition, a pendulum clock (Hohwü), two prism rings (Pistor's and Steinheil's), two levels and one level theodolite were also purchased. The six-inch Repsold telescope and a Dallmeyer heliograph were received for temporary usage from the Pulkovo Observatory. A wooden pavilion on the northeast side of the Observatory was adapted to accommodate the heliometer, and in 1889 a similar pavilion was built at the south-east side of the main building for the Herbst passage instrument.

Observatory activities

Basic work. During this period, the main work of the Observatory was to organise the zone observations in connection with its participation in an international scientific project.

The initiator of this great and complex work was the German Astronomical Society, founded in Heidelberg, Germany in 1863, with the aim of combining forces and resources for extensive scientific projects. The first such work was the repetition of the observation of stars in the Bonn Review Catalog (Bonner Durchmusterung) by Argelander in 1859-1862. Stars up to the 9th magnitude with a declination of –2° and + 80° had to be observed. The range of 80° to 90° was missed because this work had been completed at the Observatory in Kazan and Hamburg. Later on, the observation program was extended to southern-sky stars up to -23°. Thirteen observatories from Europe and America took part in this collective work. The zone for the Tartu Observatory was between 70° and 75°. The Pulkovo Observatory undertook to determine the coordinates of the 539 base stars in relation to which the coordinates of the observed stars were determined.

The work program was printed in the fourth edition of the 1868 journal *Vierteljahrsschrift der Astronomischen Gesellschaft,* providing the following differential observation method: The work would begin in 1879 and take ten years; each star would be observed twice to produce the star's average position by the beginning of 1875. In the case of large differences, the star had to be observed for a third time. For checking purposes, the zones overlapped from 5' to 10'. The magnitude of each star should also be evaluated.

For these observations the Observatory could use the old meridian circle of Reichenbach and Ertel, which had been used continuously since 1822 and was now outdated for such work. However, a new meridian circle had not been obtained. To use the old instrument, it was necessary to upgrade its optics to some extent and supplement the reading device. Since the meridian circle optics did not allow the observation of stars of the 9th magnitude, the object lens had to be polished in 1875. It did not produce significant results and in 1877 the lens was replaced with a new lens from Merz. The old lens was mounted on a Dollond passage instrument, the tube of which had to be shortened. There was also a need to supplement the reading system, as the divisions of vernier had faded to such an extent that they could not easily be read. The microscope micrometers were assembled on the alidade (with divisions on the circle). To set the alidade ready for work required too much time, so Bruns took out the micrometers from the alidade in 1874 and placed them on a special bracket attached to the western base of the instrument. However, this remodelling failed (so some measurements had to be repeated later), and in 1877 Backlund returned the micrometers to the alidade. In 1884, the Kessel pendulum clock from 1831 was replaced with a Hohwü clock.

Before starting this work the number of stars to be observed was counted in the Bonn catalogue - there were 3102 stars. Consequently, a minimum of 6204 observations had to be made. When comparing this number to Struve's and Preuss's pace of work [*Observatory Calendar* 1965] on the same instrument, it seems that all observations could have been made in 2-

3 years. However, the work was delayed. From 1870 to 1873, Schwarz completed only 25% of the task. The work continued with Bruns (1874-1875) and Backlund (1876-1879). By 1877, 75% of the work was complete, and it was finished by Lindstedt, who worked with the meridian circle, between 1880 and 1882.

Thus, the program was formally completed in 12-13 years. But Schwarz, whom we know as a pedantic and demanding observer, began to question the quality of the observations from 1870-1873 (before the instrument was repaired) and those of 1874-1875 (when the micrometres were placed on the bracket) and decided to repeat them. Between 1883 and 1886 Schwarz checked his previous measurements, and in 1887–1888 L. Struve repeated Bruns' observations. The length of the task was primarily due to the age of the meridian circle (a lot of time was spent on repairing the instrument and repeating the work) and the frequent change of observers (time was needed to get to know the instrument and gain the necessary skills to handle it). Some other factors also slowed down the pace of work, for example unfavourable climatic conditions and the peculiarity of the meridian circle itself. The influence of the city was also felt in the noise and vibration caused by traffic along the newly paved Vallikraavi Street which made hearing the ticking of the clock difficult and disturbed the balance of the mercury horizon.

Observation materials and reduced data were published in the Observatory Publications: Schwarz's observations in volume XVII; observations by Bruns and L. Struve in volume XVIII (1891); Lindstedt's observations in volume XX (1893), and Backlund's observations in volume XIX (1899). Volume XIX appeared after volume XX because the recalculations of Backlund's observations, as performed by the assistant Grofe's, were not rigorous enough and had to be performed by the Pulkovo astronomer Seyboth. The zone's general directory was not compiled.

Various observations:

1) Schwarz observed with the Repsold heliometer in years 1873-1875, initially to study the instrument, and then on the expedition to observe the transition of Venus across the solar disc, and after the expedition to study the instrument once more. In 1884-1885 Hartwig worked with the heliometer. Unfortunately, his observation materials have not been preserved in the observatory (Hartwig took them with him), so it is difficult to know the total volume of his observations. These include an examination of the instrument's errors, determination of the diameters of planets, the Sun, and the outer ring of Saturn, the position of the supernova found in the Andromeda Nebula, determining Saturn's position relative to star ξ Tauri, measuring Jupiter's satellites, determining the position of the Mösting crater relative to the edge of the Moon, etc.

2) In 1884, student Renz determined the geographical latitude of Tartu Observatory using the Herbst passage instrument.

3) No systematic observations were made with Fraunhofer's large refractor. This instrument, like other telescopes, was only seldom used. So, in 1874, Bruns observed the solar eclipse with the big refractor and Clausen with a five-inch telescope. The students Osse and Hellmann observed with the 2.5-inch telescope and comet finder.

Observations of noctilucent clouds. This was a new direction in the Observatory's activities. The pioneers of investigation of this interesting phenomenon was V.K. Tserasski (Moscow) and O. Jesse (Berlin), as well as Hartwig. In Tartu, Hartwig observed noctilucent clouds 11 times during 1885. The concomitant discovery of noctilucent clouds in Moscow, Tartu, and Berlin is probably due to the fact that astronomers observed with special interest and attention at this time to the extraordinary twilight phenomena (intense red dawns, coloured rings around the Sun, etc.) caused by the contamination of the upper atmosphere as a result of 1883's colossal eruption of Krakatau. Therefore, observations of noctilucent clouds come from the Hartwig's time.

Theoretical study. In terms of theoretical study, this period is rather poor. Interestingly, all the young scientists who worked at the Tartu Observatory at that time enriched later science considerably. Tartu, where they were for quite a short time, was a kind of school where they learned and passed the test before putting these abilities to work independently.

Schwarz's basic theoretical investigations are part of the study of the basics and instruments of practical astronomy. His doctoral thesis is devoted to the same questions "The member depending on the double sine of the zenith distance in the curvature of the Dorpat meridian circle" (1871). Schwarz's final work was to study the accuracy of the star coordinates in a catalogue called *The History of the Starry Sky,* the results of which were necessary for the intended work on proper movements of stars.

From the work of the astronomer-observers we name Bruns's and Lindstedt's research on mathematics, two of Backlund's work on celestial mechanics, and a series of Hartwig articles and notes on his work in the *Astronomische Nachrichten* journal. Ludwig Struve published 7 works in Tartu, 3 of which deal with the occultations of stars during eclipses of the Moon.

Expeditions. Tartu Observatory's participation in observation of the transition of Venus across the solar disc must be noted. Every Russian observatory took part in this great scientific work with 27 observation stations organised, some of them abroad (Egypt, Persia, China and Japan). The general manager of the surveys was the Pulkovo Observatory, which organised the ordering of new instruments, allocation of the existing ones and determination of the coordinates of the stations. At the end of 1873 and beginning of 1874 expedition participants conducted special exercises in Pulkovo.

The transition of Venus was seen on December 8, 1874. The observation conditions were favourable in only 13 observer stations, including Nertshinsk near the Chinese border, where Schwarz was observing. The location of the observation station was familiar to Schwarz from previous expeditions. The Tartu Observatory expedition included a Repsold heliometer, a smaller telescope, a small Ertel passage instrument and two chronometers. Schwarz was assisted by a helper from the local meteorological observatory. Observations took place at -18° C. Unfortunately, the expedition did not produce the expected results because of damage to the passage instrument leading to an error in determining the time.

In 1887, L. Struve took part in an expedition to observe a full solar eclipse in the province of Smolensk, but unfortunately the expedition failed because of bad weather.

The training of scientific personnel. During Schwarz's directorship, the Tartu Observatory became a forging place for astronomers who came to work or practice here and gained experience in observation. Students who graduated in astronomy from the University of Tartu received something like mission credentials for their scientific life.

Among these were astronomer-observers Bruns, Backlund, Hartwig, Lindstedt, and L. Struve, as well as Viktor Knorre, the grandson of Ernst Knorre, the first astronomer in Tartu [*Observatory Calendar* 1962] (Viktor would later work at the Berlin Observatory.)

The observers who received a candidate's degree in Tartu and later worked in other scientific institutions, are: I) Pulkovo Observatory: Hermann Struve (1854-1920), from 1895 Director of the Königsberg Observatory and Director of the Berlin Observatory from 1904; F. Renz (1860-1941); J. Seyboth (1855-1916); T. Wittram (1854-1914) and E. Lindemann (1842-1897). Of these, H. Struve and T. Wittram also defended their doctoral degrees in Tartu. (II) Employees of other scientific institutions: B. Wanach (1867-1923), astronomer at Strasburg Observatory and then the Potsdam Institute of Geodesy; F. Blumbach (1864-1949), Mendeleyev's closest associate at the Institute of Dimensions and Weights, from 1940 head of the astronomy department at the Latvian State University; Ludwig Struve, Tartu Observatory.

Professor of mathematics, first at University of Tartu and later at Tomsk University, F. Molin (1861-1941) was also an alumnus of the Tartu observatory. Unfortunately, we failed to identify the destinies of astronomy candidates Klot and Hellmann, other than they worked briefly at Pulkovo.

Schwarz's activities in Tartu

For almost 30 years Schwarz has lived permanently in Tartu, devoting all this time to the University. At the Observatory he had different posts: assistant (1846-1849), astronomer-observer (1865-1872), and director (1872-1894). He was elected Dean of the Faculty of Physics and Mathematics for two three-year periods. He was loved and respected among his students and colleagues. For example, he was honoured in 1877 by being asked to represent the University of Tartu at Uppsala University’s anniversary celebrations. Schwarz took an active part in teaching and other educational work at the University. He can be regarded as a professor during whose time a remarkable rise in the level of teaching astronomy took place. One might also mention Schwarz's participation in a major geodetic work, the Livonian general triangulation, for which Schwarz prepared thorough instructions. A student of Schwarz, Hellmann, played an active part in this work.

Throughout his life, Schwarz devoted himself to serving astronomy, but he had no significant effect on the development of astronomy, or even on the work of the Tartu Observatory. Schwarz was extremely conscientious, ambitious, hard-working, fully committed to his beloved activities, and yet without a particular talent. The massive work of re-measuring the stars in the Bonn catalogue, which Schwarz was directly involved in and which he directed, cannot be considered a major achievement as the work was left incomplete and was in any case repeated by Courvoiser, an astronomer at the Berlin Observatory, in 1905-1906.

Schwarz's attempts to renew the Observatory's instrumentation were also unsuccessful and his plans to obtain a new meridian circle and rebuilding the Observatory were not supported.

Schwarz always prioritised the work entrusted to him, even over his own health and comfort. Over time the difficult conditions and efforts of the expeditions caught up with him and his health began to deteriorate. Even though the pain became intolerable, Schwarz put up with it in fortitude, his beloved work helping him to ignore his health issues. In the last years of his life, he was also required to deliver lectures in Russian, which was not easy for this ageing man. In September 1, 1894, at the age of 72, Schwarz retired. It often happens that people who are constantly and actively working quickly pass away when they become inactive, and this is the case with Schwarz, who died on September 17, 1894. The speech he had prepared from the celebration of Struve’s 100th birthday was read instead by Professor Levitski at a festive meeting in Tartu. Schwarz is buried in Tartu's Maarja cemetery, where his partner, well-known artist Julie Hagen-Schwarz, also rests. Their graves are tended by personnel of the Institute of Physics and Astronomy, and the Art Museum.

With the death of Schwarz, another stage in the life and activities of the Tartu Observatory ended. This could be called the Observatory’s German Period because the work was led by German professors Mädler, Clausen and Schwarz, the observers were mainly foreigners, too, again German, and teaching and administration took place in German. During this period, the position of Tartu Observatory as the best observatory, largest scientific centre and initiator of major research events waned. It was a period of surviving and, to some extent, of conservative directors resting on laurels. The only thing that preserved and even increased the importance of the observatory was the training of young astronomers – Tartu remained the centre of training for astronomers.

In 1894, the entire personnel of the Observatory changed for the second time (the first change occurred in 1839). Schwarz died, and a result of russification of the Baltics, L. Struve was assigned to Kharkov and assistant Grofe left the observatory. Professor G.V. Levitski, of the University of Kharkov, took the post of head of the Observatory, while other posts were mainly filled by scientists of Russian nationality. A new period, called the Russian Period, began, lasting until 1918.

Part III – Under the leadership of Russians

Observatory activities 1894-1908*

In the 1880s, the policy of russification in the periphery, which was particularly pronounced in the Baltics on education issues, was gaining momentum. Thus, in 1889, it was suggested to professors at the University that they start lecturing in Russian, while vacancies were only filled with Russian researchers. In 1893 Tartu was re-named Jurjev, and the university the University of Jurjev. The obligatory transition to Russian reduced the University's scientific level as many former professors had to leave. However, the situation for Russian-speaking students improved, but the teaching personnel and students had changed profoundly.

The Tsarist government's new policy and the pressure that came with it also had an effect on Schwarz's successor. It would have been logical to choose Ludwig Struve, who had worked as an astronomer-observer at the Observatory since 1886, but instead G.V. Levitski, from Kharkov University, was assigned and L. Struve was sent to Kharkov to be director there.

In order to simplify the Observatory's Russian Period it will be divided into two stages here, 1894-1908 and 1908-1918. The Russian Period started with a clean page because it had almost no connection with the previous work. Only Sirel, the observer's servant, remained, and the zone observations continued as an unfinished work. The new director brought new scientific directions of Sun observation and seismology from

* G. Zhelnin TK 44 1968 51-61

Kharkov to Tartu. The scientific profile of the Observatory changed radically and links with the Pulkovo Observatory strengthened.

This period came to a conclusion after in the revolutionnary events of 1905, which also left a profound impression on University life.

Observatory personnel

During the period from 1894 to 1908 the Observatory was under the directorship of G. Levitski. He had not worked as a professsor at the University for the previous year and a half, as K. Pokrovski had been elected professor on February 16, 1907. Levitski had been working at the Observatory as the astronomer-observer since 1895. After selecting Pokrovski as Professor of Astronomy at the University, astronomer B. Modestov was elected astronomer-observer at the Observatory. However, Modestov did not come to Tartu and so Pulkovo astronomer A. Orlov, who had already worked at the Observatory in 1905-1906 as a supernumerary assistant, was elected as the new astronomer-observer. Orlov took up his duties on December 7, 1907, but his activities fell mainly in the following period.

S. Scharbe, a scholar from the University of St. Petersburg who worked in Tartu to the end of 1906, became a personnel assistant, on January 1, 1907 ceding the position to E. Schoenberg, who had just graduated from the University of Tartu.

Levitski managed to slightly increase the personnel of the observatory with, in 1896, the post of paid supernumerary assistant, and in 1904 a second, unpaid, position. The following people worked as non-personnel assistants:

I supernumerary assistant in 1896-1898; G. Schröder

1899-1900; A. Seen and W. Liebermann

1900-1902; W. Block

1902-1907; W. Abold

1907-1908; J. Standrovski

II supernumerary assistant 1904-1905; J. Sykora

1905-1906; A. Orlov

J. Sykora, a student of Levitski from Kharkov, had already worked at the Observatory from 1898 to 1903 as a scholar of the Ministry of Education.

Below we present short biographies of key observers.

Grigory Vasilyevich Levitski was born on October 27, 1852 in Kharkov. In 1874 he graduated from the University of St. Petersburg, remained a student there while he prepared his Master's thesis. At the same time, he worked at the Pulkovo Observatory, initially as a supernumerary astronomer, and from 1876 as a calculator. In 1879 he defended his Master's Thesis on "The determination of orbits of double stars"; he started work the same year at the University of Kharkov, first as an associate professor and then from 1884 as professor of astronomy. Levitski's achievement was in founding a stationary astronomy observatory in Kharkov. There he carried out a number of tasks, for example determining the geographical latitude of the observatory, the distance in geographic latitudes of the Kharkov and Nikolayev observatories, systematic observation of the Sun, and the founding of a seismic department. Levitski moved to Tartu in 1894.

G. Levitski (reproduction from the *Porträtgallerie der Astronomischer Gesellschaft* collection, Stockholm, 1904)

Konstantin Dorimedontovich Pokrovski was born on May 11, 1868 in Nizhny Novgorod (now Gorki), where he also completed his secondary education. In 1887 he entered the Faculty of Physics and Mathematics at the University of Moscow.

K.D. Pokrovski (reproduction from the archives of the TA Literature Museum)

In 1891, after graduating, Pokrovski was appointed a supernumerary astronomer at Moscow University Observatory at the same time taking up the chair of O. Schwabe's private observatory, which was actually for amateurs. At the University Observatory, Pokrovski was engaged in observing the occultations of stars by the Moon, the eclipses of Jupiter's satellites, and meteors. While working at the private observatory, he learned about the astronomic interests of the people, which later stimulated his popularising activity. Several editions of Pokrovski's book *The Celestial Guide* have been published and he was rewarded in 1893 with a period at Pulkovo to widen his education. In 1895 Pokrovski came to Tartu where he defended his Master's degree and worked until 1917.

During the school days of A.H. Tammsaare, at Hugo Treffner Secondary School, Pokrovski taught astronomy, apparently so engagingly that he gave the future writer the inspiration to portray an old cosmography professor in the second volume of his novel *Truth and Justice.*

Sergei Scharbe was born on September 18, 1871 to a family of doctors. In 1893 he graduated from St. Petersburg University Department of Mathematics, and then as a scholar for a scientific degree. During his studies in St. Petersburg, Scharbe, on behalf of the well-known geodesist General Tillo, took part in the levelling of the city (then the capital). At the end of 1895 he was appointed assistant at Tartu Observatory, on Levitski's recommendation. In 1904 he defended his dissertation, for the right to deliver lectures (*pro venia legendi*), on “The final determination of the orbit of Comet 1898 X" and became a private docent at the university, while remaining an assistant at the Observatory.

Scharbe was basically a mathematician, so he was mainly interested in mathematical problems in astronomy. At the end of 1906, Scharbe left Tartu and headed for Yekaterinoslav (Dnepropetrovsk) to be a mathematics teacher at the high school. In 1917 Scharbe visited Tartu to defend the dissertation for his Master's degree "Oppolzner’s method for determining the final orbit of comet 1900 III". During the war, Scharbe worked selflessly as a teacher of mathematics in Dnepropetrovsk and later as a professor of astronomy at the Open University, also in Dnepropetrovsk. In parallel with his pedagogical work he was engaged in astronomical observations until his death (1932). Scharbe is known for his work on the determination of comet orbits. He was one of the first serious investigators of variable stars in Russia.

We do not touch on the biographies of supernumerary staff, except to mention that four of them (Schröder, Seen, Liebermann and Block) were employees at the Observatory who, after graduation, left both the Observatory and astronomy.

We talk instead about assistants W. Abold and A. Orlov because their main work in Tartu took place at the time of Director Pokrovski. (We have no data on the fate of J. Standrovski.)

We will also briefly discuss the activities of the scholar and supernumerary assistant J. Sykora (1904-1905). The biography of this young astronomer, who quickly became recognised, but abandoned astronomy, is quite interesting.

Josif Sykora was born in 1871 to a family of Austrian nationnality. It is not known when the family settled in Kharkov, but Russian citizenship was given to Sykora only in 1893. Astronomy was apparently a hobby for the whole family. In Kharkov, his brother and sister also took part in Sykora's astronomical observations. In 1892 he graduated from the University of Kharkov and began his pedagogical work while continuing to work at the University Observatory, where he observed sunspots and protuberances under Levitski's guidance. In 1896 he was appointed head of the expedition organised by the Russian Astronomical Society to observe a full solar eclipse. The expedition travelled to Iitto in Lapland with Sykora's task to photograph the Sun's corona and protuberances. The expedition was successful.

In 1898 Sykora came to Tartu Observatory as a scholar of the Ministry of Education for two years. 1899 his stay in Tartu was interrupted because he was appointed to the arc measurement expedition to the Spitzbergen Islands. Sykora travelled there with the first group of workers and spent the winter there, dealing with observations of the northern lights. In the winter of 1900/1901 Sykora continued to spectrally observe the northern lights on the Kola Peninsula, where he organised three observation stations. In 1902 he was rewarded for the expedition work. In the same year, he returned to Tartu, where he defended his dissertation "On the northern lights in Spitzbergen in winter of 1899/1900 and in Murmansk in winter of 1900/1901". After the expiry of the grant in 1904 Sykora was appointed as the second supernumerary assistant. This last factor is probably why Sykora left Tartu in 1905 for Tashkent and the post of astrophysicist at the Observatory. In 1911 he left this post and became an inspector of the Shavli (Šiauliai, Lithuania) secondary school. It is puzzling why he left the Tashkent Observatory, and science in general, and changed his field of activities despite already being a well-known scholar and inventive scientist. His next life period is unknown to us, although it is known that he later worked for a short time at Kharkov University (1920-1922).

Sykora was one of the most active and energetic astrophysicists at the turn of the 20th century.

The situation at the Observatory

Levitski found a neglected observatory. The richly-equipped station had not been improved over the previous 50-60 years in terms of its instrumentation and remained at the level of Struve’s period. The only difference was that the existing instruments were worn out, outdated and did not respond to the increased needs of observation practice. There were absolutely no instruments for performing astrophysical observations. The Library of the Observatory was also in poor condition.

With great energy, Levitski started to improve the situation of the observatory. He demanded a large sum of money (30 000 roubles) for the repair of instruments and buildings, replenishment of the library, and acquisition of new instruments, in particular the meridian circle and photoheliograph. Levitski had already told the board of the University in 1895: "During this period, the most important instruments of the Observatory were dismantled and repaired, the recondition of the premises was completed, and the library underwent a detailed and complete audit." No big instruments were obtained. In order to create the necessary conditions for the continuation of the observations of the sunspots, Levitski again appealed to the management to allocate money to take the necessary steps. At the same time, he turned to the director of the Pulkovo Observatory requesting temporary use of Dallmeyer's photoheliograph and Repsold's 6-inch refractor. Observation screens were made in Tartu and the photographic heliograph and refractor arrived in 1897.

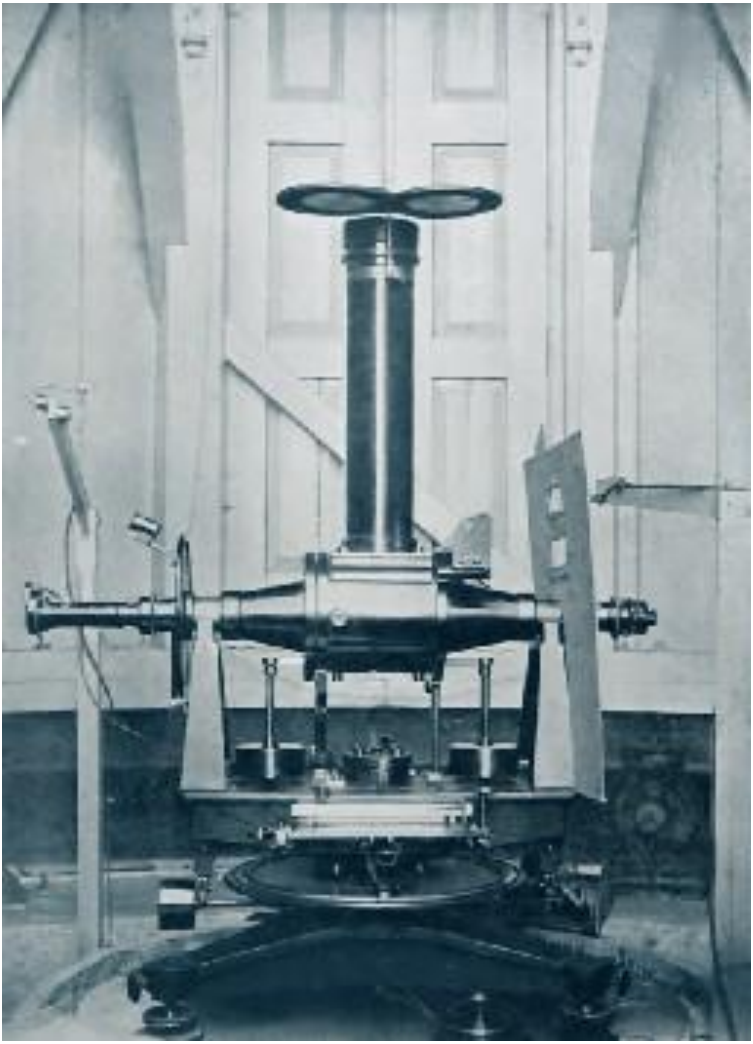
From 1896 onwards, horizontal pendulums of different designs were commissioned for seismic measurements. In total, four pendulums were obtained: one Rebeur-Paschwitz pendulum with photographic registration, two Zöllner pendulums, modernised by Levitski and Repsold, and one Zöllner heavy pendulum with mechanical registration. In addition, Fechner's registration apparatus and other aids were purchased. Levitski also used pendulums and seismoscopes, which were commissioned to Russia via the Seismic Central Committee of the Academy of Sciences (especially the Stückrath heavy pendulum).

Of other procurements the zenith telescope should be noted, bought from Repsold and Sons in 1897.

In 1895 the Erikson chronometer was bought, in 1896 the Repsold measuring instrument, and in 1900 the Vanschaf normal meter. At the same time, Levitski raised the issue of securing two universal instruments instead of the universal instruments of the military topographic department that were used temporarily at the observatory.

As we can see, during the Levitski period, the Observatory instrumentarium was not significantly improved, what was procured was mainly specialised gear for the seismological station. The Observatory's library now grew on average by 180 books and 55 publications per year.

During this period, the complex of Observatory buildings expanded slightly. In 1897 a cylindrical stone pavilion with rotating roof was built northwest of the main building on the edge of Toome hill. For the placement of horizontal pendulums, the old gunpowder cellar was adapted (Fig. 3 and 4), built under Toome hill during Catherine II's reign, with dimensions of 23.5 m x 10.5 m x 11.0 m, with one stone exterior wall and a 3 m thick ceiling.



Repsold zenith telescope (reproduction of the volumes of the Observatory publications XXI, 1908)

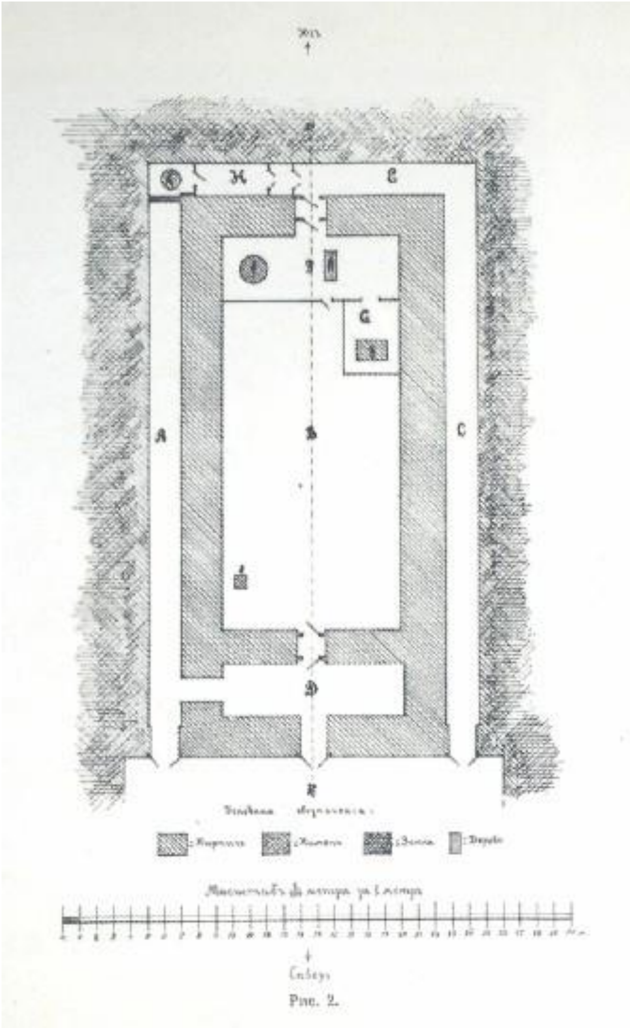
Pavilion of the zenith telescope on the Toome Hill (currently the Pavilion of the Petzval Astrograph). Photo by Ed. Sellekese

Former gunpowder cellar, Toome Hill (reproduction volume of Observatory Publications XXIII, 1911)

The cellar was vented through a vertical well and entrance is by Lätte Street. The conditions in the cellar were ideal for the seismic equipment because temperature fluctuations did not exceed two degrees and city noise and vibration from transport did not affect the room. Some of the horizontal pendulums were placed in the cellar under the Observatory building. There was also a photo lab.

Observatory activities

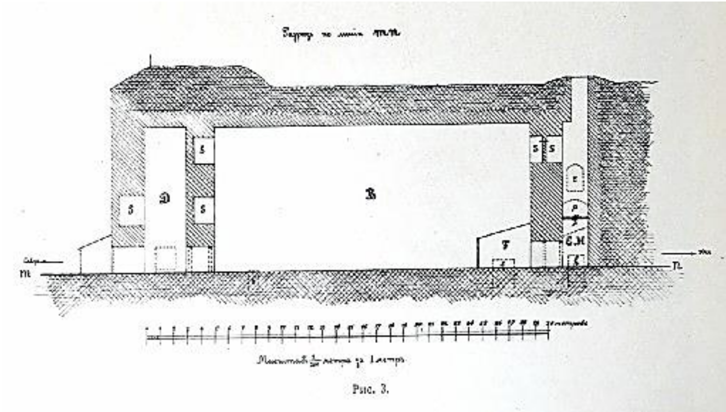
No characteristic basic scientific direction can be highlighted in the activities of the observatory during this period. Much work was carried out, but nothing to the extent that it would have left a mark on science. The reason apparently lies in both the inadequacy of the observation base and the difference in the scientific interests of leading observatory forces. Even a small group of astronomers fragmented. The director mainly dealt with seismology, a non-astronomical scientific direction, and the supernumerary assistants were also employed for this work. The astronomer-observer and assistant cultivated so-called pure astronomy, which dealt with observation and theo-reticcal research. Because of the seismological investigations, most of the money allocated to the Observatory went to the acquisition of equipment relating to the seismological station, thereby reducing the possibilities to upgrade astronomical equipment. Popularisation and research into the history of astronomy occupied a large part of the Observatory's work.



Basic plan of the Toome hill cellar (this and the following figure are reproduced in the volumes of the Observatory Publications XXIII, 1891; each section on the scale corresponds to one meter)

Seismology. This scientific direction was started by Levitski in 1893 in Kharkov and continued in 1897 in Tartu. In order to investigate seismological phenomena, Levitski used horizontal pendulums placed in the deep basement. On the proposal of the Central Commission of Seismology a seismological station was organised at the Tartu Observatory which was given a task of studying seismographs arriving in Russia. Apart from the registration of earth quakes the main work of the seismological station was to collect and process data obtained from other seismological stations and prepare the collected data for the Commission's published bulletins, edited by Levitski. The investigation and improvement of the used and newly obtained instruments occupied a large part of the station's work. For example, during the work it appeared that the Rebeur-Paschwitz pendulums had significant drawbacks, and so Levitski developed a new pendulum design. The new Zöllner-Repsold-Levitski pendulum was acquired and used in Tartu in 1899.

Levitski devoted great attention to the development of the seismological service in Russia despite no noticeable theoretical findings being made in this area. Levitski was assisted by Abold, Orlov, Standrovski and Sykora, and M. Sirel, the Observatory's servant, in the work of the station and in publishing the bulletin.



Vertical section of the Toome hill cellar

Observations. In performing large planned observations the lack of instruments proved to be an obstacle, although the surveys were still performed. Here it should be noted that the observations of the sunspots, comets, meteors and noctilucent clouds, and other celestial objects and phenomena, as well as the completion of the zone surveys, started in 1870.

Levitski had already started observing sunspots in Kharkov and continued with this in Tartu in 1895, despite the fact that the instruments were imperfect. Before receiving the heliograph from Pulkovo, observations of the sunspots were made by projecting the Sun's image onto a screen and manually recording the spots, work that was mainly performed by Scharbe. For such observations, Levitski even prepared instructions [*Journal of the Russian Astronomical Society* No 5, 1896]. From the year 1897, the photoheliograph was used. This work can be considered the first astrophysical work carried out at Tartu Observatory.

Comets, meteors and noctilucent clouds were mainly observed by Pokrovski and Scharbe. Simultaneous observations of meteors and noctilucent clouds were performed in Tartu and Kallaste, or in Tartu and Jõgeva. Noctilucent clouds were first photographed by Pokrovski from the balcony of the Tartu Observatory on June 25, 1896. He prepared special instructions for the observation and measurement of these clouds [*Journal of the Russian Astronomical Society* No 6, 1898].

For the observation of comets Fraunhofer's large refractor and Pulkovo's six-inch refractor were used. Students were also interested in observing meteors. Apart from Observatory personnel, students Schröder, Block and Volokobinski (who gave a mathematics course to the older students at Hugo Treffner High School in Tartu between 1894 and 1902), took part in the observations of the Leonid meteors in 1896.

In 1906 student Wedenski and Master of Science Serebrianski took part in the observations of the Perseid meteors.

Pokrovski's first observations were a continuation of the zone observations with the meridian circle. The volume of work that he did is unknown but selecting at random he performed mainly group observations, observations of the occultation of the Pleiades (9 March 1897) and observations of partial eclipses of the Sun and the Moon. Pokrovski used a photographic method in all these cases.

Theoretical studies. These focused mainly on the determination of comet orbits, which were the subject of a large number of reports and articles in *Astronomische Nachrichten*. Most of the dissertations were also devoted to the same question, such as the candidate dissertations of Schröder, Abold and others and two dissertations by assistant Scharbe. A series of theoretical papers on seismology was published by supernumerary assistant Orlov in 1905-1906.

Studies of the history of astronomy and popularisation activities. Levitski had begun to deal with the history of astronomy in Kharkov where, he wrote the history of Kharkov Observatory. In Tartu, he continued his historical research. Levitski had already published *Astronomers of Jurjev University 1802-1894*, in 1899. For the 100th anniversary of the University of Tartu, he wrote the biographical lexicon of professors at Jurjev University and an overview entitled *The Faculty of Physics and Mathematics at the University of Jurjev*. The widespread social initiative of bringing knowledge to the people turned out to be a great contribution to the Observatory's popularising activities, with Pokrovski particularly active in this area. His popular lectures in astronomy attracted such large audiences that lectures had to be held in the University assembly hall. Pokrovski's lectures attracted attention not only in Tartu, but also in Jelgava, Riga, Saratov and other cities. As many as ten articles by Pokrovski were printed in popular journals each year. *The Celestial Guide* and *The Star Atlas* secured him a good reputation among young people.

Training astronomers. During this period an average of 6 or 7 students completed annual practice at the Observatory. Many defended candidate dissertations here, although only a few selected astronomy for their future activities, including Abold and Schoenberg, more of whom in the next article. During this period, V. Serebrianski was preparing himself for observations before going on an expedition, and N. Lapin worked at the Observatory before moving to Pulkovo. Unfortunately, we have no data about the further fate of either of these astronomers.

Scientific trips. Compared to previous periods, the number of scientific trips to various cities in Russia increased significantly. Particularly close ties were established with the Pulkovo Observatory, which was visited by Tartu astronomers almost every year. Similarly the directors of the Pulkovo Observatory also felt a keen interest in the life and activities of the Tartu Observatory - F. Bredihhin visited Tartu in 1895 and O. A. Backlund in 1896 and 1903. Participation of Tartu astronomers in the Russian Astronomical Society also required frequent visits to St. Petersburg. Scientific trips to different places in Russia were mainly related to the organisation of seismographic services (Levitski visited Strasburg in 1899 and the Caucasus in 1902, and Scharbe visited Ferghana in 1903), while other foreign travel related to international conferences (Levitski visited Strasburg in 1901 and 1903, Rome in 1906, The Hague in 1907 and Pokrovski visited Germany twice, in 1898 to familiarise himself with the methodology of meridian observations and in 1904 to study the movement of comets).

Levitski's activities in Tartu

Levitski worked in Tartu for 14 years, from 1894 to 1908. When he arrived at Tartu, he had a master's degree in astronomy so was initially appointed acting professor in accordance with the regulations in force. It was only in 1898, when he was awarded a doctoral degree (*doctor honoris causae*) for his work at the University of Kharkov that he was confirmed as professor. In 1904 he retired from his 30-year pedagogical career, with the right to continue working. In 1905 he was awarded the title of Honorary Professor.

In autumn 1903, Levitski was appointed Rector of Tartu (Jurjev) University for a 4-year term, but was released from the post in autumn 1905. It is believed that release was related to student unrest and the revolutionary exodus of 1905, after which Levitski no longer delivered lectures. Pokrovski was elected new astronomy professor in February 1907. Levitski continued in the position of Observatory director for a year and a half and was allowed to live in Struve's house in consideration of his scientific achievements and the beneficial work he had done for the Observatory.

During the entire period of Levitski's directorship the Tartu Observatory continued to degenerate both in terms of equipment and work. Levitski's energy and organisational talent alone were not enough to refresh the equipment or obtain funds. He did not deal with astronomy in Tartu or perform any observations, but rather he devoted his strength and time to seismology. And although he didn't achieve any important results, he can still be regarded as one of the founders of Russian seismology and a pioneer of the use of horizontal pendulums for seismological purposes. In Tartu he trained valued assistants and inspired some to follow the work he started. These include Abold, Orlov and Sykora. Leaving in 1908 Tartu, Levitski could hand over his favourite seismological station to Orlov, which in 1909 led Orlov to a new job, the investigation of the tides in the Earth's crust. At the university, Levitski gave lectures in general astronomy, higher geodesy, practical and theoretical astronomy. As a former Levitski student, the well-known Georgian seismologist E. Buss admits Levitski was not able to attract students with his lectures, the attendances of which were poor.

In particular, Levitski's work on the history of astronomy at Kharkov and Tartu Observatories should be underlined. In 1896 at a meeting of the Russian Astronomical Society, Levitski raised the question of erecting a monument to W. Struve in Tartu or Pulkovo. Seventy years have since passed, and a monument to Struve will be erected on Toome hill in front of the observatory in the near future. It will perpetuate the memory of all directors of the Tartu Observatory, including Grigory Vasilyevich Levitski, whose death occurred 50 years ago.

Observatory activities 1908-18*

The second half of Tartu Observatory's Russian Period (1908-18) essentially coincides with the directorship of K. Pokrovski.

K. Pokrovski. (Reproduction from the archives of Odessa astronomer B. Novopashenny)

* G. Zhelnin TK 45 1969 48-61

Pokrovski took over the directorship of the Observatory in September 1908 after his predecessor Professor of astronomy G. Levitski moved to a new job in Vilnius. Pokrovski remained director until 1917, although in reality after Pokrovski left for Perm in 1915 the management of the Observatory was left to astronomer-observer E. Schoenberg until the end of the period.

This is not long, only 10 years, but they were years that saw the tumultuous events of the First World War. In Estonia, the second half of the period was particularly dramatic. The approach of front to Estonia's borders led to the evacuation of government agencies, including University equipment. After the victory of the Great October Revolution, power in Estonia went for some time to councils of workers and soldiers. In February 1918, the Estonian Republic was proclaimed and immediately afterwards German occupation forces invaded Estonia. The revolution in Germany (3rd November 1918) interrupted the occupation, after which Soviet power was restored in Estonia, remaining from 21 December 1918 to 14 January 1919 when the bourgeoisie won the civil war.

The events in Tartu (Jurjev) were particularly painful and the normal course of education was interrupted repeatedly. Due to the evacuation of the inventory, the University was left without the necessary equipment to provide a solid training base. The student body was restless and joined the working class in its revolutionary struggle. At the beginning of the military action, many students and faculty members joined the army.

On May 31, 1918, the University of Tartu (Jurjev) was closed. In the autumn of the same year teaching was started by the German occupation authorities in the so-called Landesuniversität zu Dorpat. After the Germans left, it was decided to reopen the University of Tartu and lectures began on 6th October 1919. Despite these events and the changing powers, Tartu Observatory continued its work. Indeed, depending on the change of instrumentation and personnel, the direction and pace of scientific activity also changed over the last few years of this period with, for example, the Observatory's activity in the last few almost completely stopping.

Observatory personnel

From 1904 to 1915, the Observatory consisted of a director, astronomer-observer, assistant and two supernumerary assistants. Starting in 1909 the second supernumerary assistant received a salary (300 roubles per year). In 1915 University posts were reorganised. Only the job titles and salary rates changed in the Observatory. Here we present the posts and their executors:

Director of the Observatory, 1908-1917; K. Pokrovski
1918 ; T. Banachiewicz

Astronomer-observer, 1907-1912; A. Orlov
1913-1918; E. Schoenberg

Assistant, 1907-1913; E. Schoenberg
1913-1915; V. Berg

Senior assistant, 1915-1917; V. Berg

I Supernumerary assistant, 1909-1913; W. Abold
1913-1914; M. Orlova

Junior assistant, 1915-1918; T. Banachiewicz

II Supernumerary assistant, 1911-1912; E. Büss

Calculator, 1916-1917; M. Ventzel

As can be seen from the list, the position of the second supernumerary assistant generally remained vacant, the reason being too small a salary.

In addition to the aforementioned people, Tartu students T. Rootsmäe, E. Büss, I. Djukov, J. Busch, B. Beletski, S. Sokolov, M. Mikhailovski, P. Obraztsov, K. Kupffer, E. Svenson and others were still working at the Observatory. Many graduated from the University and obtained degrees in astronomy. Academician G. Shain, who later became famous, studied for a short time at the University together with Professor N. Barabashov, now director of the Kharkov Observatory.

Here we present short biographies of key Observatory employees during this period.

We discussed the story of the director of the Observatory **Konstantin Dorimedontovich Pokrovski** in the previous article. Here are some additional facts. As a member of the evacuation committee, Pokrovski travelled to Nizhny Novgorod (now Gorki*) and to Perm to receive inventory sent from Tartu in September 1915.

In Perm, Pokrovski took over the obligations of the rector of the Perm branch of Petrograd University. In April, 1916 he was awarded the degree of Doctor of astronomy. From Perm Pokrovski travelled to Tomsk (1919), where he became

* Now again Nizhny Novgorod – T. Viik

head of the Department of Astronomy at the local university, but by 1920 he was already working as a senior astronomer at Pulkovo Observatory. In November 1922 he visited Tartu to take with him the data for the work he had done there. From 1934 he worked as the director of the Observatory in Odessa, where he survived World War II and the temporary German occupation. Pokrovski died in July 1945.

Tadeusz (Thaddeus) Banachiewicz was elected to the vacant post of professor and director of the Observatory at the University of Tartu on March 6, 1918, i.e. three months before the University was closed. In fact, he could not take up his duties in Tartu.

T. Banachiewicz was born in Warsaw on February 13, 1882, where he acquired a secondary education. In 1904 he graduated in astronomy from the University of Warsaw and went on to complete his studies in Göttingen and Pulkovo. In 1908 he became a junior assistant at the Warsaw Observatory and in 1910 at the Kazan Observatory, and from 1915 worked in the Tartu Observatory where he mainly dealt with the theoretical issues of celestial mechanics. In 1915 Banachiewicz was awarded the private associate professor degree and in September defended his master's degree in Tartu. In 1918 Banahiewicz returned to Poland, where he was the director of the Krakow Observatory from 1919 until his death on November 17, 1954. He was Vice-President of the International Astronomical Union between 1932 and 1938 and in August 1935 visited the Tartu Observatory as a participant in the 8th conference of the Baltic Geodesy Commission.

T. Banachiewicz (reproduction from *Acta astronomica*, vol. C vol. 5, 1955)

Astronomer-Observer **Aleksandr Yakovlevich Orlov** [T. Rootsmäe's article in the 1955 *Observatory Calendar*]. Orlov was born in Smolensk on March, 23 1880. He completed his secondary education in Voronezh. In 1898 he joined the Faculty of Physics and Mathematics at the University of St. Petersburg and worked at the Pulkovo Observatory at the same time. In 1901 Orlov published his first scientific paper. After graduating from university, he was left as a scholar to prepare for a professor's post. For that reason he was on scientific assignment between October 1, 1902 and June 1, 1905. In Paris and Lund he dealt with celestial mechanics while at Göttingen he studied seismology. Orlov married in Paris. Coming back from the trip, he started to work as the unpaid second supernumerary assistant at the Tartu Observatory at the end of 1905, as his scholarship expired. Apparently for economic reasons, Orlov left Tartu in December 1906 and moved to Pulkovo Observatory to take up the paid position of calculator. 1906 was a very productive year in Orlov's scientific activities. He published 12 papers on various problems of astronomy, celestial mechanics and seismology. Throughout the year, Orlov worked at the Pulkovo Observatory, carrying out observations with the big zenith telescope to determine variations in latitude. This work, as well as that done in Tartu, determined the direction of Aleksandr Orlov's subsequent activities. In December, 1907 Orlov was elected astronomer-observer at the Tartu Observatory. Here he began to study the movement of the earth's crust due to the attraction of the Sun and the Moon. At the end of 1912 Orlov moved from Tartu to Odessa to the post of director of the Observatory. He defended his Master's thesis (1910) and Doctor's degree (1915) at St. Petersburg University. In both dissertations Orlov used material collected in Tartu. Orlov worked in Odessa until 1934 when he was succeeded by his former co-worker from Tartu, K. Pokrovski. Orlov's further activities were related to his organisation of the Poltava Gravimetric Observatory (1926), where he was director for short intervals until 1951. In 1927 he was elected correspondent member of the Soviet Academy of Sciences, and in 1938 became an active member of the Ukrainian Academy of Sciences. Orlov died on January 28, 1954.

A. Orlov (reproduction from the archive of P. Kulikovsky)

Erich Karl Wilhelm Schoenberg, a pupil of the Tartu Observatory, became Orlov's successor in the post of astronomer-observer. Schoenberg was born on December 27, 1882 to the family of a teacher of classical languages at a local high school in Warsaw. Erich's father had graduated from the University of Tartu in 1868 and obtained a Doctor's degree in Philosophy. Erich was the sixth child in the family. After graduating from secondary school he intended to enter the marine corps and with this in mind worked in the Riga shipyard, and even at sea. In 1902 he entered the Faculty of Physics and Mathematics at the University of Warsaw, although because of the revolutionnary unrest among the students in 1905 the University of Warsaw was closed and Schoenberg's studies terminated. In the meantime in order to avoid losing the semester he was attending lectures at the University of Strasburg, and in the autumn of 1905 wrote an application to enter the University of Tartu. Schoenberg asked to be matriculate to the third year of the Faculty of Physics and Mathematics. A little later, Schoenberg's parents also moved to Tartu. In December 1907, he was awarded a Candidate Degree for his work "The determination of the orbits of double stars".

E. Schoenberg (reproduction from *Mitteilungen der Astronomischen Gesellschaft*, No. 20, 1965

In June 1907, Schoenberg began to work as an assistant at the Observatory.

In 1912 Schoenberg defended his doctoral thesis at Kiel University. Since degrees awarded in Germany were not recognised in Russia, Schoenberg was still required to defend his Master's degree. The defense of the dissertation took place on March 21, 1918 in Tartu. From September 1915 when Pokrovski traveled to Perm, until 1919 when T. Rootsmäe was appointed director of the Observatory, Schoenberg was the de facto manager. After passing the chair to Rootsmäe, Schoenberg worked as an astronomer-geodesist in the topography department at the Estonian Army Headquarters. In 1920, he went to work to Finland, at the Observatory of Helsinki without interrupting his work in the topography department. Over a number of years (1921-1924) Schoenberg conducted astronomical-geodetic investigations in the northwestern part of Estonia, although his work was unfortunately not completed. In 1925 Schoenberg with his young wife moved from Finland to Germany and from 1926 to 1943 he led the work of the Breslau (now Wroclaw) Observatory.

In 1934 Schoenberg visited South West Africa where he organised a temporary observatory for photometric observations. Schoenberg had to leave Breslau because of the Second World War and moved to Munich where he was director of the local observatory until his death on January 23, 1965.

Viktor Berg (1891-1942), senior assistant at the Observatory, was a relative of Professor Pokrovski and took part in the work of the Observatory as a student. After graduating from Tartu University and obtaining a candidate's degree, Berg took up the post of assistant at the Observatory in 1913, taking on the post of senior assistant in 1915. In 1917 he evacuated to Voronezh with the last pieces of University of Tartu equipment, working in Voronezh until 1925 as a professor. In 1925 he moved to Pulkovo, where he worked as an astronomer until his death during the Leningrad Blockade. Berg earned international acclaim for his work determining the geographical latitude of a site using the zenith telescope.

Let us also briefly look at the lives of those observers and students of the Observatory who continued their scientific activities in Tartu. These include W. Abold, M. Ventzel, E. Büss, I. Djukov and T. Rootsmäe. The first female worker of the Observatory was Maria Orlova, a supernumerary assistant (and not a relative of A. Orlov).

Wilhelm Abold (1879-1948) worked at Tartu Observatory as a supernumerary assistant for almost ten years. Abold was the closest assistant to Levitski and Orlov at the seismic station. In connection with astronomical-geodetic work he visited Siberia in 1909 and 1910. In 1913 Abold left Tartu and started working for the University of Tomsk. From there he moved to the post of Professor of Astronomy at the University of Irkutsk. His name is linked to the systematic observation of change in geographical latitude at the Irkutsk Observatory in 1924.

Mikhail Ventzel (1882–1963) came from Tartu. He graduated from the department of mathematics at the University of Moscow as an astronomer in 1916. As the director and inventory of the observatory were in Perm at that time, Ventzel also went there. In 1918 he was elected astronomer-observer and associate professor at the Mezhevoi Institute (currently Moscow Central Institute of Geodesy, Aerial Photography and Cartography), where he worked as the head of the chair of astronomy until retirement in 1960.

Eugen Büss* *(Bus, Püss)* (born June 1st, 1885 in Tartu, died June 15th, 1969) was one of the organisers of the modern seismographic service in the Caucasus. He graduated from the Faculty of Physics and Mathematics at Tartu University and worked at the Tartu University Observatory in 1911-1912. In 1912 he moved from Tartu to Baku. Between 1912 and 1920 he was head of the Baku Seismographic Station and between 1921 and 1923 of the Tbilisi Seismographic Station. From 1933 he worked at the Institute of Geophysics at the Georgian Academy of Sciences, where he was a leader of seismological works. His main works centred on seismicity in the Transcaucasian territory. Eugene Büss's research has been the basis for the seismic zoning of the Transcaucasia and the establishment of earthquake-proof constructions. At the suggestion of Ivane Javakhishvili, in order to clarify the date of the introduction of Christianity to Georgia, he conducted a survey of the conditions of solar eclipse visible in Georgia in the first half of the 4th century. In 1946 Büss was named Honoured Scientist of Georgia, Doctor of Physics and Mathematics in 1963, Professor 1965, Geophysicist [Georgia: Encyclopedia: T. I. – Tb., 1997. – p. 443]

* The biography of Eugen Büss is thanks to Prof. Maya Todua, director of the Abastumani Observatory

I. Djukov (1888–1961), a student of the Tartu Observatory, worked at the Engelhardt Observatory in Kazan. In 1942–1946, Professor Djukov was the Chairman of the Committee of Astrometry in the USSR Council of Astronomy.

We shall discuss the life of the Professor and Director of Tartu Observatory T. Rootsmäe (1885-1959) in more detail in the following article.

The Observatory's renewal plans, and reality

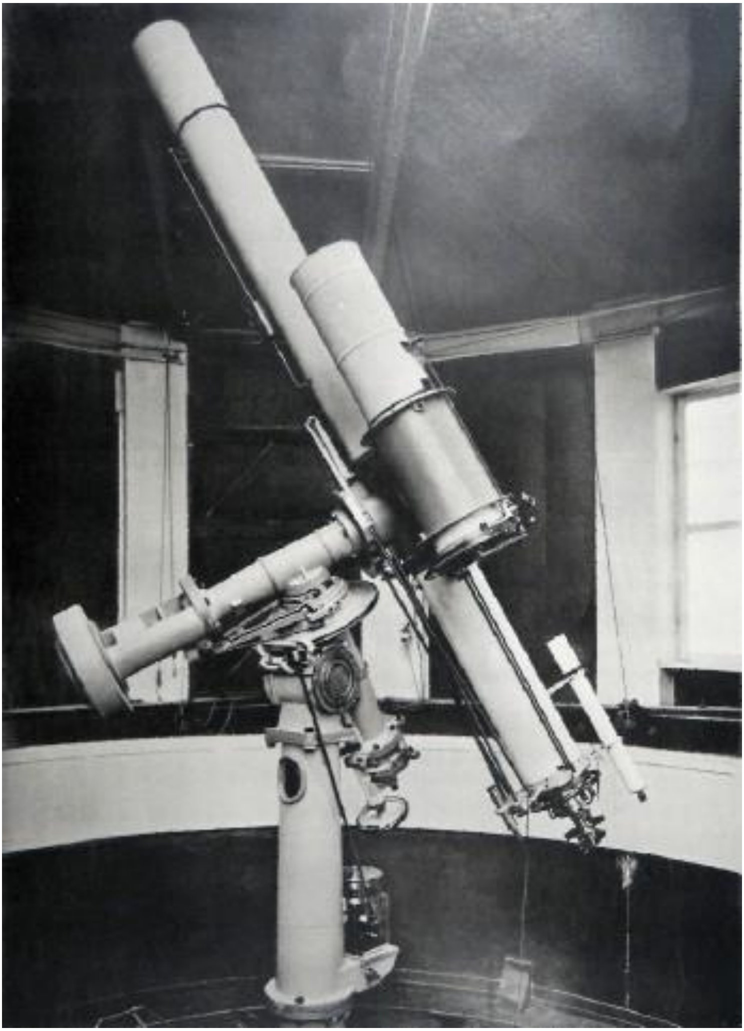
At the end of 1908, the university planned to construct new buildings, including a new astronomical observatory. In 1909 and 1910 the plans for the construction and supply of a new observatory were discussed at various levels. These plans were drawn up by K. Pokrovski and architect J. Mayer [The article by G. Zhelnin and P. Müürsepp in *Observatory Calendar* 1969]. The main drawback to these plans was the design of the new observatory at the old location, in the middle of a growing city. But this time, the modernisation and construction plans for the observatory remained only on paper, cancelled again, this time because of the outbreak of World War One. Only those buildings deemed absolutely essential were constructed.

In 1909, a granite tower with a wooden roof on rails was built to east of the main building of the Observatory to facilitate observation with small instruments. In the zenith telescope pavilion the hatches were expanded and the floor raised.

The upgrading of instruments was quite successful. In 1911 an 8-inch (200 mm) Zeiss refractor was obtained together with a Petzval short-focus camera. The history of ordering this instrument is briefly as follows. The necessity of a new large refractor had long been apparent – the 85-year-old Fraunhofer refractor was already outdated and its mounting so worn that it could no longer provide the required accuracy. Initially the issue of a new mounting arose, but it turned out that it was possible to get a new instrument for the same sum of money, though of a slightly smaller size. The Zeiss company agreed to produce a new 200mm refractor for 7100 roubles which could be paid in instalments over 4 years. The order was completed at the end of 1908.

At the same time E. Witte from Voronezh donated 1000 roubles to obtain instruments for the Observatory in commemoration of her lost husband. The observatory had a desperate need for a short-focus astrograph, but the price was much higher than the donated amount. The Zeiss company proposed upgrading the refractor which was being constructed for Tartu with a camera with a 160 mm Petzval-type lens and 800 mm focal length.

When the Zeiss refractor arrived at the beginning of 1912, as the Observatory's new main instrument, it was lifted into the tower to replace the old Fraunhofer refractor. In the same year, the first observations were made using the Zeiss and the Fraunhofer refractor was placed in the Observatory's eastern hall.



Zeiss refractor. (Reproduction from the Observatory Publications XXIV, 1914.)

During this period, a number of smaller instruments and devices were added to the Observatory: the Hildebrand universal instrument, the Zeiss-Tessar lens (D = 37 mm, F = 165 mm), the Voigtländer photographic lens, two computers, the instruments needed to observe solar eclipses (camera, photometer, lens with a focal length of 4 meters) and a round Steinheil mirror with a diameter of 128 mm. In addition, the university mechanic B. Messer, along with E. Schoenberg, made an optical microphotometer.

From the Pulkovo inventory, Dallmeyer's heliograph was used until 1911 and the Repsold 6.5-inch refractor until 1913.

From the Observatory's own inventory two horizontal pendulums, used by A. Orlov in Tartu, were given to Tomsk seismology station in 1912.

Observatory activities

Although the list of Observatory activities in this period is not long, it can be divided into three fairly discrete categories:

1) 1908-1912 - continuation and further development of work started by Levitski;

2) 1912-1915 - work with the new Zeiss refractor;

3) 1915-1918 - theoretical studies (the scope of observation was reduced due to evacuation inventory).

The first category can be called geophysical. The main investigator was then A. Orlov who, at Levitski's suggestion, studied the tidal movement of the Earth's crust. Assistant Schoenberg determined the variations in the geographical latitude of the observation site. Both tasks were performed with great consistency and accuracy and made a significant contribution to the scientific activities of the Tartu Observatory.

Investigations that are now considered classical were made by A. Orlov using horizontal pendulums. The pendulums were set up in the old gunpowder cellar [see the paper in the *Observatory Calendar* 1968]. Observations were carried out in two series, the first starting on February 20, 1909 and ending on November 12, 1909. One pendulum was placed in meridian and another in the first vertical and readings taken photographically. The aim of the first series of observations was to explore the possibilities of implementing horizontal pendulums to determine the movement of the crust caused by tidal waves. A. Orlov achieved high accuracy in the measurements with the instruments even recording the soil sinking under 1.5 cm of precipitation. In the second series of observations (August 29, 1910–March 3, 1911), two pendulums were used, both located in the first vertical. The purpose of these measurements was to show, by comparing the pendulum readings, that the differences in the pendulum readings of the first series of observations did not depend on the individual differences in the pendulums being used.

The work with the horizontal pendulums brought public recognition to A. Orlov. In 1908 the University of Tartu proposed electing A. Orlov instead of Levitski to the permanent committee of seismology at the Academy of Sciences. In 1911 Orlov was commissioned to represent the commission at the International Conference on Seismology in Manchester. At the suggestion of Orlov, the conference decided to organise tidal wave investigation stations inland as far away from the sea as possible to avoid the effect of sea waves. Such an observatory was opened in 1912 in Tomsk, with the initial use of the Tartu pendulums. In the same year, the Russian Astronomical Society assigned Orlov to the Central Siberia expedition to the Surgut and Narym regions to measure gravitational acceleration at nine points.

Orlov also dealt with geodesy issues. He instructed the construction of a small triangulation network near Tartu and levelling along the Viljandi highway to the starting point of the Suur-Emajõgi River in Lake Võrtsjärv (the track is 40.5 km long). The levelling was carried out from Tartu to Puhja in 1909 and from Puhja to Jõesuu in 1910. The work was done by students J. Busch, E. Büss, B. Beletski, and T. Rootsmäe. The results of the work were used by J. Busch when preparing his candidate dissertation.

Orlov was also productive in astronomy, especially in the study of comets. In 1911 while on a mission abroad, he visited the Yerkes Observatory, where he studied photos of comet tails.

Another important scientific direction of this period was the study of the variations in latitude of the observation site. This question was dealt with by assistant Schoenberg, who for the first time in the practice of the Tartu Observatory conducted independent scientific work as an assistant. Orlov was undoubtedly interested in Schoenberg’s work because before he came to Tartu he studied similar problems at Pulkovo and later devoted his activities to these problems.

Schoenberg observed using Repsold's zenith telescope, which was in the Observatory’s round pavilion. Two series of observations (September 13 to October 17 1907 and March 14 to

April 16 1908) were performed using the Talcott method and one series (22 March to 29 May 1909) using the Pevtsov method. All observations were made with great precision. During the preparation of the observations, Schoenberg visited Pulkovo several times. Schoenberg used the observation material in his doctoral dissertation, which he defended in 1912 at Kiel University.

Students who, between 1909 and 1910, were engaged in levelling between Tartu and Lake Võrtsjärv. From left to right: B. Beletski and J. Busch, sitting E. Büss and T. Rootsmäe (reproduction from the archive of E. Büss)

Pokrovski's works did not play a leading role in the Observatory's activities during this period. Being a Bredikhin student, Pokrovski was mainly engaged in the physical processses of comet tails and comets. He was also interested in meteors and their relationship with comets. However, the lack of a short-focus astrograph prevented the acquisition of the necessary observation material.

It cannot be said that no astronomical observations were made during this period (1908-1912). Observations were made with the old Fraunhofer refractor, the 6.5-inch Repsold refractor and with the small portable instruments. Students were employed in these observations instructed by Schoenberg in observing the occultations of the stars by the Moon and the eclipses of Jupiter’s satellites. Pokrovski instructed synchronous meteor observations in Tartu and Elva.

On April 17, 1912 the Observatory personnel observed an annular solar eclipse. Some employees watched this phenomenon in Tartu (Orlov, student Obraztsov and mechanic Messer) and some at Keeni station (Pokrovski, Schoenberg, Abold, Berg and Rootsmäe).

During this period Observatory personnel took part in scientific expeditions (Abold determined geographical coordinates in 1910 and 1911, and Orlov measured gravity in Siberia in 1910) and were on business trips abroad (Pokrovski in 1910, Orlov in 1911, Schoenberg in 1910 and 1912 and Abold in 1910). The Observatory issued three volumes of Observatory Publications (volumes XXI-XXIII). All in all, the activities of the Observatory in this short period must be considered productive.

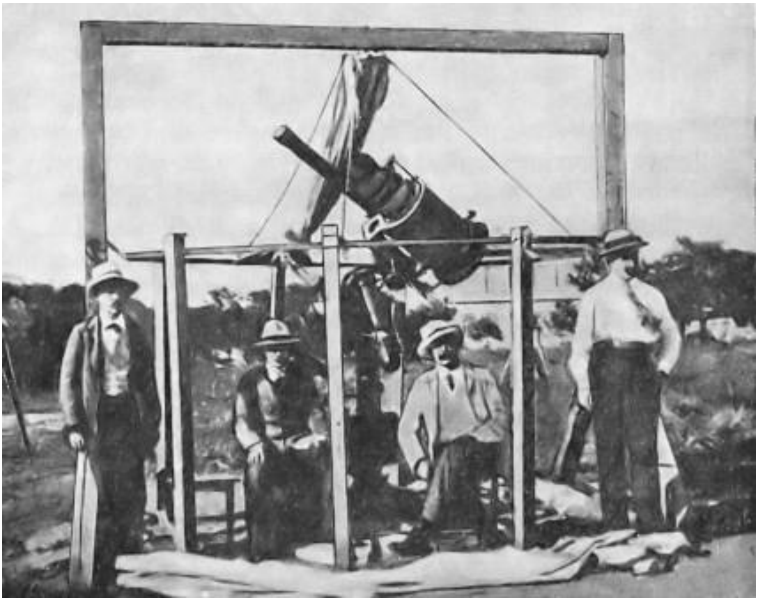
The new Zeiss refractor, which was set up in the main tower, features in the second stage of this period (1912-1915), during which Pokrovski, Schoenberg, and Berg worked in the Observatory, as for a short time did Abold and Maria Orlova, as supernumerary assistants.

To characterise the activity of the Observatory in this period, we quote Pokrovski in the annual report 1913: “Many observations have been made in the Observatory. Unfortunately, it was only possible to work with one new refractor, as a result of which this instrument proved to be overloaded. The time of the observations had to be divided between two and even three observers who were engaged in different tasks.”

The tasks were for Pokrovski photographic observation of comets and planets; for Schoenberg examination of the instrument and photometric measurements of the brightness of the planets; for Berg photographing asteroids and determining their position using these photos; for the supernumerary assistants processing astrophotos. Asteroids were photographed 5 times in 1912, 53 times in 1913, and 49 times in 1914. Comets were photographed once in 1912 and 3 times in 1913.

A major event in the Observatory's life was the organisation of a scientific expedition to observe a complete solar eclipse on August 22, 1914. The area of the complete eclipse went through Russia, Riga, Kiev and Feodosia (Crimea). In terms of atmospheric conditions, Feodosia was the most suitable place. In order to ensure the success of the expedition, it was decided to observe in two groups: Pokrovski, a former Tartu trainee, astronomer Ljapin of the Odessa Observatory and Messer, a mechanic from Tartu in Feodosia; in Kiev Schoenberg and Berg. The first group had the task of photographing the protuberances and the solar corona, the other group made photometric observations of the brightness of the corona.

The expeditions were equipped as follows: the first group had two horizontal cameras (objective diameter 100 mm and focal length 4 m), a two-dimensional heliostat, the Petzval camera (dismantled from the Zeiss telescope) and a telescope with a one-meter lens from Odessa. The latter two were mounted on a parallactic base equipped with a clock mechanism. The second group had three photometers and a camera with a Voigtländer lens.



1914 Feodossia group of the solar eclipse expedition. From left: B. Messer, V. Berg, K. Pokrovski, N. Ljapin. (Reproduction from *Priroda,* 1914.)

Schoenberg could not go to Kiev due to the outbreak of war and was forced to organise an observatory in Riga. However, Berg had to remain in Feodosia, where he had been assisting Pokrovski in preparing the observation site since June. Both solar expeditions – in Feodosia and in Riga – were successful.

The training of students in observation and practical and theoretical work decreased significantly during this period. From the graduates of the University E. Büss in 1912, T. Rootsmäe in 1913 and V. Berg in 1914 defended their theses. The first part of the Observatory Publications (volume XXIV) was published.

At the beginning of the third stage (1915-18), the property of the Observatory was evacuated. The first signals of a possible evacuation came already in June 1915. A list of equipment to be evacuated was compiled by the Observatory, as with other university institutions, and the order of dispatch was determined. In August 1915, the first set of instruments and books were packed, and in September 136 wagons of the University inventory went to Nizhny Novgorod (Gorki). There were 49 boxes loaded from the Observatory: 32 instrument boxes and 17 boxes of books. Of the large instruments the Zeiss refractor, the Reichenbach meridian circle, and the Repsold heliometer were evacuated; of the small instruments sextants, pendulum clocks, etc. As a member of the evacuation committee, Pokrovski travelled to receive and install incoming inventtory. However, the Nizhny Novgorod city authorities did not secure the placement of inventory in suitable premises. Another city had to be found to house the inventory of the Observatory, Perm.

In February, 1916 22 wagons were sent from Tartu to Perm, in March another 22. Altogether there were 34 boxes of instruments and 28 boxes of books. Of the instruments the boxes included Repsold's zenith telescope, Herbst's passage instrument, Ertel’s universal instrument, horizontal pendulums and other smaller instruments. At the end of 1916, this part of the inventory sent to Nizhny Novgorod also reached Perm.

The rooms in Perm were acceptable for placement of the Observatory inventory. As mentioned, Pokrovski remained in Perm where he began working at the Perm branch of the University of St. Petersburg with Ventzel, a calculator from the Tartu Observatory. To arrange astronomy studies, Pokrovski asked the Council of the University of Tartu for permission to use some of the instruments sent to Perm. He needed Zeiss's refractor, the zenith telescope and the universal instrument. Pokrovski later moved to Tomsk, where he also took the zenith telescope.

In August 1917 some of the inventory, consisting of 5 boxes of instruments and 3 boxes of books, was sent to Voronezh. Senior assistant V. Berg was evacuated there as well after which the evacuation of the University was interrupted.

So, at the end of 1915, only the old Fraunhofer refractor, which was put back in the Observatory’s main tower, and the Dollond passage instrument, i.e. two instruments from the time of W. Struve, remained. Astronomer-observer E. Schöenberg, junior assistant T. Banachiewicz and, to begin with, senior associate V. Berg continued to work in the Observatory. Of the students K. Kupffer and E. Svenson worked during this period.

E. Schoenberg measured surface the brightness of planets using a microphotometer constructed in Tartu. These measurements had been started with the Zeiss refractor in 1913, but because of the evacuation work continued with the old

Fraunhofer refractor and the 15-inch Repsold refractor in Pulkovo. Banachiewicz examined the theoretical problems of celestial mechanics. The personnel left in Tartu had to travel to other libraries during this period, whether in Pulkovo, Helsinki or Stockholm.

The end of 1917 and beginning of 1918 could be called conclusion of the Russian Period of the Observatory's activities. Three Master's degrees were defended almost simultaneously. First on September 12, 1917 T. Banachiewicz defended his thesis "On the Gauss equation sin (z-g) = m sin z"; next on November 23, 1917 was former Observatory assistant S. Scharbe [cf. Zhelnin's paper in the *Observatory Calendar* for 1968] on "The Oppolzner Method for the Final Determination of the Orbit of Comet 1900 III"; and lastly on March 21, 1918 E. Schoenberg "On the Illumination of Planets". The dissertations of Banachiewicz and Schoenberg were published in the second part of the XXIV volume of the Observatory publications in 1917.

This title of this volume was in French, *Publications de l'Observatoire astronomique de l'Universite de Juriev (Dorpat).*

We note here that in 1916 the University's faculty of Physics and Mathematics asked that T. Rootsmäe be left at the University as a scholar to prepare for a professor's post. Unfortunately, the application remained unrealised due to the evacuation of the University.

On May 31, 1918, the university was closed down. The Observatory also closed its doors, although former astronomer-observer E. Schoenberg continued his work in the empty rooms of the Observatory. The remaining instrumentation was looked after by the servant M. Sirel.

The long-standing idea to open University, this time as an Estonian university was finally realised in 1919. Commissions were established and committees charged with creating a university inventory and staffing the university with professors and lectors. The inventory of the Observatory was taken over by prof. H. Jaakson. Former University student T. Rootsmäe, who had been working as a secondary school teacher in Tallinn, was named director of the Observatory by the curator of the University on December 19, 1918.

The Observatory entered a new period, the Estonian Period. The only staff member of the observatory remaining in place was the servant Sirel, who reopened the doors of the Observatory to the new scientists.

Part IV – The Estonian Period, confusing times

Observatory activities 1919-40[*]

During this period, the foundations for the present-day Observatory activities were laid: scientific directions that have not lost their relevance even today were started, and young astronomers who are now in the first ranks of astronomy and its neighbouring sciences were trained and directed towards creativity.

In order to simplify the description of the Observatory's activities they are here divided as follows: 1) activities of the observatory between 1919 and 1940; 2) activities during the initial period of the Soviet regime, 1940-1948 including the Second World War and the years of fascist occupation.

The organisational work related to the opening of the University of Tartu began at the end of 1918. Candidate of sciences Taavet Rootsmäe, an alumnus of the University and teacher at Tallinn Girls' Gymnasium was invited to take up the post of astronomy professor and director of the University Observatory (until 1936 his name was David Rootsman[†]). The commission that had to take over the Observatory buildings and other inventory ran into some difficulties. Although the former astronomer-observer E. Schoenberg gave commission member professor Jaakson the Observatory's instrumentation, he agreed to hand the Observatory as a whole over only to an

[*] G. Zhelnin TK 46 1970 50-68

[†] In 1936 a campaign was started to change first names from German to Estonian.

astronomy specialist. It was not suggested that Schoenberg remain the supervisor of the Observatory's work, which he apparently expected. This was probably due to Schoenberg's active participation in organising the *Landesuniversität* during the German occupation. The Observatory, which was now incorporated into the University's faculty of mathematics and natural sciences, was handed over to the new director in September 1919.

Education at the University began on October 6th, although the University's festive opening ceremony took place only on December 1, 1919. The new director of the Observatory and his only assistant, servant Mihkel Sirel, who had been at the Observatory since 1878, began work in almost empty rooms. Professor Rootsmäe gave lectures at the university, searched for scientific companions and applied for the return of evacuated property and premises taken over during the war (until July 1922, Struve’s house was used as a radio station). In 1920 A. Pohla took the assistant post and in 1921 the evacuated instruments began to arrive. The Observatory came alive once again.

Observatory personnel

Until 1931 there were the following posts in the observatory: head of the observatory (also professor of astronomy), astronomer-observer, and senior and junior assistant. In addition, the Observatory employed one auxiliary person and two or three calculators. In 1931 the post of senior assistant was changed to assistant, the junior assistant was converted to supernumerary assistant, and the auxiliary person renamed permanent lab technician. The total number of posts did not change.

The people in these posts were:

Head of the Observatory, 1919-1948; T. Rootsmäe

Astronomer-observer, 1921-1933; E. Öpik

1933-1934; R. Livländer

1934-1944; E. Öpik

Senior Assistant (from 1931 assistant), 1927-33; R. Livländer

1933-1944; A. Kipper

Junior Assistant (from 1931 supernumerary assistant),

1920-1925; A. Pohla

1925-1927; R. Livländer

1927-1929; O. Silde

1930-1931; A. Kipper

1931-1934; H. Muischneek

1934-1936; R. Põder

1936-1938; H. Keres

1938-1940; V. Riives

Auxiliary Person (from 1930 lab technician), 1922-1939; P. Simberg; 1940; G. Kusmin

Several students, including almost all subsequent assistants and auxiliary personnel, had worked as calculators. For example such students as J. Gabovich (1937-1939) and G. Kusmin (1938-1939).

In addition to the above-mentioned staff and auxiliary personnel, private docent Dr. W. Anderson, and student E. Mielberg also took part in the work of the observatory (the life work of Mielberg, who passed away too early, is described by R. Livländer in the *Observatory Calendar* 1933). To some extent also Professors J. Vilip and J. Nuut were working at the Observatory.

The list of Observatory workers would not be complete without mentioning the commandants (servants). Until 1922, M. Sirel, then R. Pallav, served as commandants. Former Tartu students would find it difficult to imagine the Observatory without R. Pallav, the master of this temple of science. He was known as a miraculous storyteller and populariser of astronomical knowledge (providing sightseeing tours of the observatory). [R. Hallimäe gave a short biography of Pallav in the *Observatory Calendar* of 1956.]

We shall now present biographies of the leading people of the Observatory, director prof. T. Rootsmäe and astronomer-observer Dr. E. Öpik, as well as biographies of the two assistants who have passed away, R. Livländer and H. Muischneek.

Many of the present-day pupils of the observatory continue their scientific or pedagogical activities in the Estonian SSR. These are academicians A. Kipper, H. Keres and correspondent member of the Academy, G. Kusmin (who work at the Institute of Physics and Astronomy), DSc. V. Riives at the State University of Tartu, docent O. Silde at Tallinn Polytechnical Institute and docent J. Gabovich at the Estonian Agricultural Academy.

Taavet Rootsmäe

Taavet Rootsmäe [cf. R. Hallimäe's paper in the *Observatory Calendar* of 1960 and G. Kusmin's paper in the *Observatory Calendar* of 1955] was born on June 27, 1885 in Roosa farm, Kastre-Võnnu parish, Tartu County to a peasant family of many children. He received his secondary education at Tartu's Hugo Treffner High School. After graduating in 1906 he entered the University of Jurjev (Tartu) Faculty of Mathematics. As a student, he devoted himself fully to astronomy, and during his studies he actively participated in astronomical group observations and practical geodesic work (under the guidance of A. Orlov) [G. Zhelnin's paper in the *Observatory Calendar* 1969]. In 1911 Rootsmäe graduated from the University with good marks and started to write his candidate's thesis.

Meanwhile, on April 17, 1912, Rootsmäe took part in observations of the annular solar eclipse. In a couple of years he completed his thesis on "Calculating the Orbit of Planet 1906 JW" and in 1913 was awarded a scientific degree.

Observatory workers in 1929 (from left to right: O. Silde, T. Rootsmäe, E. Öpik, R. Livländer, standing A. Piiri, P. Simberg, R. Pallav, H. Juhannson)

Director of the Observatory prof. Pokrovski greatly appreciated the abilities and love for work of T. Rootsmäe and asked the University council if he could remain as a scholar to prepare for the professorship. However, the events of the First World War did not allow this plan to be realised immediately, T. Rootsmäe had to go to Tallinn temporarily for pedagogical work. However, some time later, due to his effective pedagogical activities and popularisation of astronomical knowledge, he was considered a worthy candidate for the position of head of the astronomical observatory and professor of astronomy at the University. On December 19, 1918 the University curator made a proposal to T. Rootsmäe. At the beginning of 1919 he was given the opportunity to prepare for a new post. On September 12, 1919 T. Rootsmäe was appointed Acting Professor of Astronomy and Astrophysics. Since then, his future activities were inseparable from the work of the observatory. And although the observatory joined the system of the Academy of Sciences of the Estonian SSR in 1948 and prof. Rootsmäe was no longer the director of the Observatory but belonged to the university's personnel, but he did not leave the work of the Observatory. His cabinet was left for him in Struve's old house and he usually talked to students there (he was the Head of the Chair of Astronomy and Geophysics until the end of his life). The personnel of the observatory, his former students, often turned to him for advice and help. T. Rootsmäe died on June 27, 1959.

Ernst Öpik[*] was born on October 22, 1893 in Kunda township, Viru County, Estonia. In 1911 he graduated from gymnasium in Tallinn with a medal. At school, he showed an interest in astronomy and organised a circle called Vega with his brother and other schoolmates interested in astronomy. Together they bought a 3-inch telescope with which Öpik made observations. He used the results in his first scientific paper, published in 1912.

[*] cf. the paper by M. Jõeveer in the *Observatory Calendar* 1969

Observatory workers in 1932-1933 (from left to right: P. Simberg, R. Pallav. R. Livländer, T. Rootsmäe, A. Piiri, H. Muischneek, M. Blum, R. Põder, A. Kipper)

In the same year, E. Öpik entered the University of Moscow, graduating in 1916 in astronomy. The money needed for his subsistence and study expenses he acquired by giving private lessons. After graduating from University, he was left to prepare for the professorship. He then worked as an assistant at the University Observatory and in 1920-1921 as an Associate Professor in Tashkent returning to Estonia at the end of 1921 and taking up the position of astronomer-observer at Tartu Observatory on November 25 of that year. Two years later, he defended his doctoral thesis on "The Method of Corresponding Statistical Observations and its Application for Observation of Meteors" in Tartu. Astronomer-observer E. Öpik worked intermittently until autumn 1944 when he went abroad, working first in the Hamburg Observatory then at the Harvard Observatory in 1931-1932 [Described by E. Öpik in the *Observatory Calendar* 1932] before moving on to Armagh Observatory in Northern Ireland, where he still works*. In 1932 he was elected a member of the Commission of the International Astronomical Union and in 1938 a member of the newly established Estonian Academy of Sciences.

E. Öpik

* E. J. Öpik died in 1985 – T. Viik

R. Livländer

Robert Livländer was born on February 1, 1903 to a family of workers in Tallinn. In 1921 Livländer graduated from the Tallinn Secondary School of Science and entered the Faculty of Mathematics and Natural Sciences at the University of Tartu. While a student (from 1922) he started working as a temporary assistant in the Observatory. After graduating, R. Livländer was a junior assistant at the Observatory. In 1927 he was promoted to senior assistant after receiving his master's degree, in which post he worked until 1934 when he was appointed a University of Tartu associate professor (in geodesy). In 1932 he defended his doctoral thesis "Determining the geographical longitude of the Tartu Observatory" in Tartu. In 1936 Livländer went to work at Tallinn University of Technology, first as an associate professor, later as a geodesy professor and finally between 1941 and 1944 as rector. In autumn 1944 he left Estonia, presumably perishing at sea.

R. Livländer began his scientific career as an astrophysicist, but in 1927 focused on astrometry and geodesy. His first job – determining the coordinates of the observation site – was performed with an old Dollond passage instrument. It is believed that participation in the astro-geodetic work of the Estonian military topo-hydrographic department aroused R. Livländer’s interest in the problems of geodesy. He visited Potsdam, Stockholm and Helsinki in order to become acquainted with astrometric and geodetic work. In 1938 Livländer started gravimetric measurements in Estonia. He also compiled and published the first Estonian-language textbook in geodesy for universities.

Herbert Muischneek was born on June 10, 1903, in the town of Vyatka (Kirov), to the family of an engineer. He received his secondary education in Stavropol. In 1921 the Muischneek family came to Tartu. In 1928 H. Muischneek graduated as a mathematician from the Faculty of Mathematics and Natural Sciences at the University of Tartu. In 1930 he defended his Master's theses in the field of aerial photography and came to Tartu Observatory in 1931 where, in 1934 he was a junior assistant, then a geodesy assistant. Together with his supervisor Livländer, he moved to Tallinn University of Technology in 1936, where he worked first as an assistant, later as an associate professor, and finally as head of the geodesy department. From 1952 to his death (October 16, 1966), H. Muischneek was the

Dean of the Estonian Agricultural Academy and Head of the Chair of Geodesy.

H. Muischneek is remembered for training Estonian geodesists.

H. Muischneek

Observatory equipment

Instruments. When E. Schoenberg handed over the Observatory to the National Commission the building was almost empty. In the tower there was the old Fraunhofer refractor, in the eastern hall the even older Dollond passage instrument, and these were the only major instruments. In addition there were a few dozen smaller instruments: the Herschel reflector, the small Voigtländer astrograph (d = 10 cm, F = 32 cm), the Repsold measuring apparatus for determining the coordinates of stars from photo plates, four chronometers, two theodolites, Ertel's small passage instrument and two pendulum clocks.

The Heyde Reflector

Initially the observatory had to work with these instruments, although the Heyde reflector, d = 19 cm, F = 76 cm, donated by a private individual, was added. Only in 1921 did the Observatory receive back most of the pre-war equipment that had been evacuated to Russia between 1915 and 1917. However, the Herbst passage instrument was missing from the shipment, as were a large universal instrument, some watches and many smaller devices. The Repsold zenith telescope arrived only in 1934 and the horizontal pendulums and pendulum clocks were missing some parts when they arrived, making them initially unusable.

In 1921 when the Tallinn Marine Observatory closed, the Tartu Observatory obtained a small Fraunhofer refractor (d = 100 mm, F = 145 cm), a pendulum clock, two chronometers and a chronograph.

Thus, the Zeiss refractor with the Petzval camera, the small Voigtländer astrograph, the Heyde reflector, the Fraunhofer four-inch refractor and the three-inch refractor from the Vega circle of amateur astronomers (currently in the Tallinn Observatory) could be used for observations. The old and small instruments were not suitable for scientific work.

During the first years the personnel were busy organising and setting up the existing instruments. The Zeiss refractor was taken to the tower again, and a large Fraunhofer refractor was placed in the corner of the eastern hall, where its use was limited even for teaching purposes. The work begun with the Zeiss refractor and Voigtländer astrograph required the expansion of the observation base. There were a number of observers who could only dream of obtaining new and modern instruments because of the meagre sums of money from the University. Observatory workers had to upgrade existing instruments and equip them with accessories. The new instruments were designed by assistants A. Kipper, R. Livländer, O. Silde and P. Simberg, a lab technician, and were made by mechanic P. Siilbaum-Vaigro.

Fraunhofer's small refractor

The Petzval astrocamera was separated from the Zeiss refractor and an independent instrument, the Petzval astrograph, was built. The astrograph was mounted on the Repsold heliometer base and the Troughton telescope used as a guide. Parallactic mounting was prepared by the university workshop. In 1927 the new instrument was placed in the Observatory's small tower, where it is still located.

The following devices were also made:

1) Two comet finders for visual and photographic observation (d = 6 cm, F = 10 cm);

2) A device for measuring the brightness of stars with the help of non-focal images;

3) An objective-prism (polished by A. A. Kipper);

4) Apparatus for studying personal observation errors;

5) Oppolzer's apparatus for reading chronograph tapes;

6) A four-meter camera and heliostat for observing solar eclipses;

7) A new mounting for the Vega refractor.

Many other devices were also made. In 1936-37 an electric microphotometer was made based on a design by A. Kipper.

Some smaller instruments were also available for purchase (a radio receiver, two pairs of marine binoculars, a chronometer, a sky globe, a couple of lenses, a precision level, an instrument for polishing lenses, etc.). Over twenty years the Observatory's inventory was supplemented by 17 astronomical instruments and 18 accessories. However, the observation base was still inadequate. Most of the personnel of the Observatory had to solve theoretical problems using observation material from other observatories.

Library. In 1923 the main part of the Observatory library returned from Russia. In total, there were 9538 publications and about 3500 stellar maps. Each year, the Observatory sent its publications to the world's most important observatories (the list of recipients included nearly 200 subscribers) and received their publications in return. On average, the library increased by an average of 420 units a year. By 1940, the library had 16 408 publications and 3872 star maps.

C) Construction. Construction work at the observatory was limited to minor repairs and alterations. The southeast pavilion was repaired, a new pillar was built and the moving roof was rebuilt. In 1935-1936 a radio antenna was installed at the Observatory. In 1933 the Observatory got plumbing, before that water was brought in drums three times a week. In 1934 the photo lab, which had been in a cold and humid corridor, was moved to Struve’s house.

Plans and projects for new construction were drawn up many times [the article of G. Zhelnin and P. Müürsepp in the *Observatory Calendar* 1959]. In 1928 a separate pavilion with a rotating dome was planned for the Fraunhofer refractor so that it could be used for study and popularisation work and the square in front of the Observatory was chosen as the location. Architect P. Mielberg prepared a construction plan, but it remained just that, a plan.

In 1935, in connection with the reconstruction of the university buildings, the following alterations were planned:

1) a fireplace was planned for the western hall of the Observatory and along the walls at the height of 3 meters 2.5 m wide balconies; the hall had to be adapted for the library, lecture hall and reading room;

2) a special pavilion was planned for the large Fraunhofer refractor (according to the 1928 project);

3) a new and larger house was planned for use instead of Struve's house.

In 1936 this plan was updated and clarified. The reconstruction plan for the Observatory was then as follows (the author of the project and the plan was E. Öpik):

1) *A library* was to be installed in the western hall and a lecture room in the eastern hall. Both halls had to be equipped with fireplaces and balconies. In the western hall the meridian circle would be preserved as a museum specimen. The passage instrument in the eastern hall would be moved;

2) *Additional pavilions* were planned for the Zeiss refractor and Dollond passage instrument on the Toome hill near the Observatory. The Fraunhofer telescope would be lifted into the main tower again;

3) *An assisting observatory* was planned together with a small house outside of Tartu (with a guard room, observer's room and photo lab) and two pavilions, one for the Petzval astrograph the other for a new astrograph (d = 400 mm, F = 400 cm) to be ordered. This observatory was planned to be built in the Vapramäe area where the new Tõravere Observatory is currently located;

4) *A two-storey house* would be built for the personnel of the Observatory to be used instead of Struve's house.

Unfortunately, this plan also failed to materialise.

Observatory activity

The Observatory of Tartu, as a university observatory, had two main tasks: to be a learning base, and a place to carry out scientific work where students with relevant interests could work. In addition, during this period, the task of the Tartu Observatory was to provide the state with the exact time and to ensure the performance of basic astronomical-geodetic works.

During the more than one-hundred years of activity of the Observatory, the pedagogical work had always been the responsibility of the director. From 1873, astronomer-observers, whose principal activity was scientific work, were also employed in teaching, i.e. the assistants had to take part in both scientific and pedagogical work.

The division of responsibilities and tasks was also maintained during this period. Professor T. Rootsmäe was burdened with teaching and guiding the observatory. Only at the expense of his free time could he study the theoretical issues of stellar astronomy. The observations did not come under discussion.

Astronomer-observer Dr. E. Öpik was mainly engaged in scientific work, three to hours of pedagogical activity a week was not a hindrance to this. Assistants R. Livländer and A. Kipper were also active in scientific work.

Pedagogical and popular science activities. According to the university's curricula, a general astronomy course was given for students of the Department of Physics and Mathematics at the Faculty of Mathematics and Natural Sciences for two semesters. Workshops and practical exercises were conducted. Faculty courses were taught by T. Rootsmäe (the foundations of celestial mechanics (1933), the theory of aberrations in celestial mechanics and astrophysics (1934), selective questions of stellar astronomy (1935), the dynamics of the stellar system (1937)) and other courses by Dr. E. Öpik (practical astronomy and the methods of astrophysics (1934), stellar statistics (1935, 1936), astrophysics (1939) and others).

Those students interested in astronomy were especially fond of the lectures and seminars of E. Öpik on astrophysical research methods (1934/35) and astronomical research (1936-1938, 1941) at which research papers were analysed, research methodology was discussed and results debated. The seminar participants were assigned to independent work and were given scientific tasks. The talented and energetic seminar manager amazed the audience with the depth and breadth of his scientific interests, infecting them with his enthusiasm and erudition. Therefore, the participants of the seminar, J. Gabovich, G. Kusmin and V. Riives, were already involved in scientific work as students.

In addition to astronomy, T. Rootsmäe taught graduates of the Faculty of Mathematics and Science the methodology of cosmography in a tutorial seminar every year for one semester. Alongside the work in the university, T. Rootsmäe compiled astronomy programs and text books for secondary schools and was active in developing the Estonian astronomy terminology. The astronomy books prepared by him and J.

Lang were in use until 1947. Professor T. Rootsmäe was an active promoter of astronomical knowledge. Between 1919 and 1940 he published 32 popular science articles and held 18 popular science lectures. The collective of the Observatory took part in popularising astronomical knowledge. This took place both through the *Observatory Calendar*, which started to appear in 1924, and through excursions to the Observatory. During this period, an average of 2200 people visited the Observatory each year (the maximum was 2900 people 1938-1939). R. Pallav was the main tour guide in the Observatory.

Performing national tasks. From 1921 the observatory had to provide the state with the exact time. Prior to this, Tallinn Maritime Observatory fulfilled this task. At that time, local time in Tallinn was in use around Estonia. After the closure of the Maritime Observatory and transfer of the time service to Tartu, Eastern European time, which differs from Greenwich by two hours, was introduced to Estonia as of 1 May 1921 on the suggestion of the Observatory. The time service in the observatory consisted in checking the movement the precise clock (Löhner) against rhythmic signals and in passing the signals at 13:00 to all agencies. The time service was managed by the junior assistant and the servant of the observatory.

Astro-geodetic works on Estonian territory were also national in nature. They started in 1924 when Estonia joined the Baltic Geodesy Commission. The Commission investigated the shape of the Baltic Sea region geoid. The Observatory was supposed to determine the geographical coordinates of the Estonian points of the triangulation chain around the Baltic Sea and measure the difference between the geographical longitudes of the starting points (Tallinn and Pulkovo). Outside the program, later on the observatory determined astronomical coordinates of 8 triangulation points together with the military topo-hydrographic department. Astronomical-geodetic studies were led by senior associate R. Livländer.

Scientific activities. Dr. E. Öpik was the principal researcher in the observatory, especially in the first half of this period. The wide range and versatility of his scientific interests determined the entire scientific work of the Observatory. The following main subjects can be mentioned here:

A) *Meteor astronomy.* These studies were based on observation material Dr. Öpik had acquired from Tashkent (1920-21), the Arizona Expedition (1930-32) and Tartu Observatory.

B) *Stellar astronomy as related to stellar evolution.* Statistical research was mostly based on material obtained from processsing the catalogues of other observatories. Independent observations were organised in Tartu to resolve specific issues.

C) *Astrophysics.* Observation material obtained in Tartu was also used in the investigations. The share of observations and theoretical studies is characterised to some extent by the number of published works, shown in the table below.

The table shows the leading role of Dr. Öpik in the activities of the Observatory during this period. He published 65 scientific papers, of which 5 were in collaboration with other authors. The remaining 41 works are distributed by author as follows: Kipper 11, Livländer 8, Gabovich 6, Anderson 6, Riives 3, Kusmin 2, Rootsmäe, Pokrovski, Mielberg, Nuut and Vilip 1 each.

Directions	Observa-tional	Theo-retical	Öpik	Others	Together
Meteor astronomy	7	16	20	3	23
Stellar astronomy	5	25	17	13	30
Astrophysics	10	28	28	10	38
Other problems	6	9	-	15	15
Total	28	78	65	41	**106**

Meteor observations. Observer A. Kipper

Since the scientific work of the observatory is divided into observations and theoretical studies, we will look at both separately, and then classify the observations according to the instruments used.

Observations. E. Öpik started to observe meteors in Tashkent and continued these observations after returning to Estonia. E. Öpik's doctoral dissertation, which he defended in 1923, also dealt with meteor observation methods. In Tartu, meteors were observed visually from 1922 to 1924 and with the Steinheil comet seeker from 1928 to 1930. One of the comet seekers was located on the first floor of the Struve house and was oriented to the North Pole. The observers were Öpik, Silde and Kipper.

Corresponding observations were started in 1938 in three cities (Tartu, Valga, Petseri), which were located 80 km from each other. According to the program compiled by E. Öpik, these observations were to be made within five years. Observers for the first year were G. Kusmin, M. Kull and R. Hallimäe. They observed in heated booths built for the purpose through an opening that was equipped with an ordinary spectacle lens. At all three points the direction of observation was towards a point close to the zenith, which was at a height of about 90 km. Meteor trails were determined in respect to a grid fixed in front of the opening. Observation data together with respective time was plotted. In addition, E. Öpik determined in between 1934 and 1938 the speeds of meteors using an apparatus of his own design (an oscillating mirror).

The following observations were made on the main instruments of the Observatory.

1) Double stars were observed with the **Zeiss refractor**

(Öpik, 1924-1930; Riives, 1938-1940). Planets, asteroids and comets: asteroid Eros (Kipper, 1931), Mercury transition over the solar disc (Öpik and Livländer, 1924), the occultations of Jupiter's satellites (Muischneek, 1932); star occultations (1923 and 1932); the method of determining the declinations of the polar stars was studied by means of a mercury horizon (Kipper and Livländer, 1932-1934).

E. Öpik at the Zeiss Refractor

2) Petzval's astrograph was used to study the change in brightness of Neptune to determine its rotation period (Öpik and Livländer, 1922-1923); the brightness of globular clusters and nebulae was measured (Öpik, 1922-1926); the method of longitudinal spectrograph and the possibilities of its application were studied; the colour indices of stars in the Oxford zone were determined (Öpik, 1923-1927); the spectral indices in the ultraviolet region of the spectrum were determined using the longitudinal spectrograph (Simberg, Muischneck and Kipper, 1930-1934); individual areas of the Milky Way were photographed to identify variable stars (Simberg and Muischneek, 1927-1932); the planet Mars was photographed (Livländer, 1926 and 1928); the comets of Baade (1922) and Wilk (1930) and the solar eclipse on June 9, 1936 were observed (Kipper, Search, Simberg); spectra were photographed using objective prism (Kipper and Simberg, 1935-1937); the spectrum of x Aurigae in its minimum (Kipper, 1935) and the spectrum of Noova in the constellation of Hercules (Kipper and Simberg, 1937-1940) were photographed; a focal photometric method was tested (Kipper, 1940).

3) The small Voigtländer astrograph was used to photograph some selected areas of the Milky Way (Simberg, 1923-26). These observations had already been made with a Petzval astrograph after 1927. The Voigtländer astrograph was no longer used because it did not meet the requirements.

4) A complete solar eclipse (1927) was observed in Sweden using **Steinheil comet seeker**; meteors were observed (Öpik, Silde and Kipper, 1928-1930), Mars (Livländer, 1931) and the comet Jurlow-Achmarof-Hassel (Riives,

1939) were photographed using the comet seeker attached to the Zeiss refractor.

5) The following observations were performed with the **old instruments**. With the Dollond passage instrument, R. Livländer measured the geographic longitude of the Observatory (1927). He also determined the magnitude of the personal error of the Dollond passage instrument with his own apparatus and examined the accuracy of the Reichenbach and Ertel meridian circle. The small Fraunhofer refractor was used to observe the occultations of stars by the Moon (1933), the solar eclipse (August 21, 1933), a meteor shower (April 9, 1933) and other phenomena.

6) With the **portable Bamberg passage instrument**, R. Livländer determined the geographical coordinates of the Estonian triangulation network points (1928-1936).

7) Student E. Mielberg investigated the variations of gravity with the **gravimeter** made in Tartu and placed in the old gunpowder cellar (1923-1931).

Calculation and laboratory work. This work was quite important in the operation of the observatory. Usually the calculations were done by hired calculators. Their salary was paid out of the specially prescribed sums and out of the money received from the sale of the *Observatory Calendar*. Two to four computers worked at the same time.

Some of them worked in the observatory for a long time [A. Piiri 1923-1934 and M. Koppel (M. Blum) 1928-1940]. Major calculations were required in 1922 when the study of the star maps of the Paris zone started (the aim was the discovery of dark nebulae) and the processing of the material from the double-star catalogues began (1924-25). For the latter, a card file system was created from 17 000 cards. Statistically, the proper motions of stars and the colour dependence of stars on their spectrum and absolute brightness were studied. The results obtained with the longitudinal spectrograph were processed mathematically.

Between 1932 and 1934 the Harvard Observatory's calculation bureau worked in parallel with a group of observers at the Tartu Observatory and data from the Arizona meteor observation expedition were investigated. The supervisor was E. Öpik.

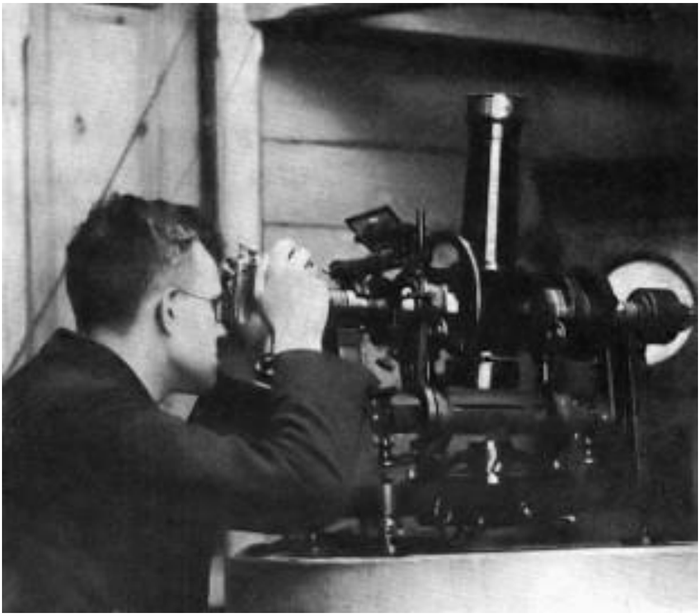
Photographic work was performed by lab technician P. Simberg, although the laboratory measurements were done by the researchers themselves. The Repsold measuring apparatus (from 1896), the Hartmann microphotometer (from 1914), and the electric microphotometer (manufactured in 1937 according to A. Kipper's design) were used.

Theoretical Investigations*. In addition to the meagre number of observations, theoretical research with the following scientific directions was the main focus of the time period.

In meteor astronomy meteor height, velocity and frequency statistics were under study, meteor orbits were calculated, the causes of meteor luminosity and meteorite craters were studied. The main result of the statistical processing of meteor observations in Tartu and Arizona proved that sporadic

* G. Kusmin's 1946 handwritten reports is used.

meteors are mainly of interstellar origin. This work was performed by E. Öpik.



R. Livländer at the Bamberg Passage Instrument

In the field of stellar astronomy, E. Öpik also published theoretical works of great importance. In the first cycle of works written in Tartu, *Stellar Statistics and Evolution* (1922) Öpik put forward a hypothesis (which he later abandoned) about the cyclic evolution of stars through the "nova stage". To check this hypothesis, double stars were extensively studied in the Observatory. In this work, Öpik's well-known rotation cube law on the space frequency of satellites was published. The law of the satellites' spatial positions according to their luminosity was derived and a catalogue of double stars. In the same cycle of works, the proper motion of stars was studied statistically and the distribution of brightness and density, the determination of the absolute brightness of the stars by their colour and motion. A catalogue of colour indices and absolute stellar magnitudes has been compiled and the surface distribution of the star locations is statistically studied to explain the location of dark nebulae on photo plates. The sphere of spatial velocities of the statistical studies of T. Rootsmäe on spatial velocities of stars and H. Keres's Master Thesis "Dynamics of Eclipsing Variables" also belong to the field of stellar astronomy.

Astrophysical studies used observation materials from the Observatory of Tartu, but there were also works of a purely theoretical nature. Observations were needed to determine the brightness and rotation period of Neptune, to determine the colour of Mars, to study cepheid pulsation and to find the wavelength dependence of light aberration (the Becker effect).

Theoretical work included studying the pulsation of cepheids and the pulsation of the star Mira Ceti, determining the density of stars, taking into account the absorption of titanium oxide, and studying the spectra of stars and gas nebulae. A. Kipper's doctoral thesis on "The movement of gases in the atmosphere of pulsating stars" is also included.

In 1938 E. Öpik published a study on the internal structure and evolution of stars. The nuclear synthesis of chemical elements was postulated as a source of stellar energy. The orientation of orbits of double stars was studied, the dependence of luminosity on star mass, the interstellar absorption and the luminosity of the dark nebulae were also studied theoretically. In addition to E. Öpik, A. Kipper, W. Anderson, J. Gabovich, G. Kusmin and V. Riives also published.

A group of meteor calculators. On the left, E. Öpik

The geographical coordinates of the observation points were determined in astrometry. Corresponding high-precision measurements and calculations were made by R. Livländer who, together with A. Kipper, measured the declinations of stars near the zenith.

Seven papers were published by W. Anderson and J. Nuut in cosmogony and the work of E. Mielberg on gravimetry was published *post mortem*.

Expeditions and business trips

In 1927 the University of Tartu organised a scientific expedition, including E. Öpik, R. Livländer and P. Simberg, to observe a full solar eclipse. The city of Gällivare in Sweden was chosen and an observation area organised. The expedition was equipped with a 4-meter astrocamera, a 5-inch coelostate, a small Fraunhofer telescope with two Steinheil comet seekers attached, and two chronometers. The observation of the eclipse, which took place on June 29, 1927, was successful [E. Öpik's article in the *Observatory Calendar* 1928].

E. Öpik stayed on a long-term mission at the invitation of the Harvard Observatory (October 1, 1930 to September 20, 1932) in the USA, where he lectured and directed a meteor observation expedition to Arizona.

In addition, he was working at Harvard Observatory between April 1 and September 20, 1933, and February 1 to June 1, 1934. By that time Öpik had been released from his astronomer-observer duties at the Tartu Observatory and this post was filled by R. Livländer. Dr. Öpik took part in the congresses of the International Astronomical Union held in Leiden (1928), Cambridge (USA, 1932) and Stockholm (1938).

Solar expedition to Sweden (from left: P. Simberg, E. Öpik, R. Livländer)

Prof. T. Rootsmäe travelled to Germany in 1929 to get to know the astronomical observatories there [T. Rootsmäe's article in the *Observatory Calendar* 1930]. He was in Kaliningrad (Königsberg), Berlin, Potsdam, Hamburg, Bonn, Heidelberg, Munich and Jena. He also visited the Riga Observatory during his trip. T. Rootsmäe met the optician B. Schmidt at the Bergedorf Observatory (Hamburg), with whom he talked in German without knowing that the latter was Estonian [P. Müürsepp's article in the *Observatory Calendar* 1959].

Senior Assistant R. Livländer spent the summers of 1928-1936 on the measurement of geographic coordinates of triangulation points carried out by the Estonian Military Topo-Hydrography department. In preparation for this, he spent four months as a university scholar at the Institute of Geodesy in Potsdam in 1928 and 17 days in Pulkovo in 1929 to determine the differences in longitudes between the main points of the Baltic polygon (Tallinn-Pulkovo). In 1934 he visited the geodesists in Helsinki and Stockholm. As a representative of Estonia, he took part in congresses of the Baltic Geodesy Commission in 1924 in Helsinki (with T. Rootsmäe), in 1928 in Berlin, in 1932 in Warsaw, and in 1935 in Tallinn and Tartu. Assistant A. Kipper visited the Stockholm and Uppsala observatories in 1936 to get acquainted with the optical instrumentation there.

During this period, former directors of the Observatory K. Pokrovski (1922) and T. Banachiewicz (1935) visited the Observatory.

Publishing activities

In 1922, after a five-year break, the scientific papers of the Observatory were again published through the series A publications of the University of Tartu (Acta Commentationes Universitatis Tartuensis). The Observatory editions were titled *Publicationes de l'Observatoire Astronomique de l'Universite de Tartu* and, as they were successive to the previous editions, began with the number XXV. Each volume consisted of seven booklets and a total of 6 volumes (XXV-XXX), i.e. 42 booklets, were published. One booklet (XXX-5), published in 1940, was one of the publications of the Estonian Academy of Sciences. In terms of volume, the booklets were not equal, ranging from 7 pages (XXVII-2) to 176 pages (XXVI-2). Basically, there was one article in each booklet, but there were exceptions, such as XXX-1 which contained 9 articles. 80% of the articles were in English and 20% in German.

Publication of the *Observatory Calendar* began in 1924. There were also popular science articles besides the calendar. Up to 1941, 17 issues of the *Calendar* were published. The main authors of the articles were T. Rootsmäe (18 articles), E. Öpik (18), R. Livländer (17), A. Kipper (10), R. Põder (10), and G. Kusmin (2). In the 1924-1940 period, 89 articles were published in the calendar.

Tartu astronomers also published their works in foreign journals *(Astronomische Nachrichten, Zeitschrift für Astrophysik* and *Harvard Observatory Bulletins, Circulars and Annals*). The number of articles published by the Observatory staff in different countries is as follows:

In Estonia, 61; 58%
In Germany, 20; 18%
In USA, 20; 20%
Elsewhere, 4; 4%
Total, 106; 100%

The Observatory had no administrative-economic personnel (except the servant). All correspondence, library services, publishing and distribution of the *Calendar* had to be done by the scientific personnel themselves. Technician P. Simberg maintained the instrumentation and it was always fine. He repaired the instruments, designed and manufactured the accessories, worked in the photo lab and also observed at nights.

1934 the composition of the Observatory began to change. R. Livländer left and became a geodetic associate at the University. As auxiliaries, the students of the Observatory began to participate in the work of J. Gabovitš, V. Riives and G. Kusmin. They were educated by Professor Rootsmäe and scientific supervisor Dr. E. Öpik.

The period described is only 20 years. But in this short time, the Observatory of Tartu was able to restore its former name, which had faded after the Struve period. The work done in the Observatory was a serious contribution to science and work done by Tartu astronomers was widely quoted in the world of astronomical literature. The original observation methods introduced at the Observatory were recognised abroad. E. Öpik was invited to lecture in America several times and to supervise scientific expeditions. His election to the Meteoritic Commission of the Intenational Astronomical Union was also recognition for the Tartu Observatory.

In 1940, a socialist regime was established in Estonia, and Estonia joined the Soviet republics. A new era began in the life of the Observatory.

Observatory activities 1940-48*

This article is the last in the series on the history of Tartu Observatory. It only takes into account the eight-year period from the re-establishment of Soviet power in Estonia to June 30, 1948, when the Observatory went being under the University of Tartu to the Institute of Physics, Mathematics and Mechanics (now the Institute of Physics and Astronomy) of the Academy of Sciences of the Estonian SSR. However, we have to look at the activities of the observatory in three different stages: 1) the first year of the reestablishment of Soviet power (1940–1941), 2) the years of German occupation (1941–1944), and 3) post-war years of rebuilding the economy (1944–1948). Since all three periods were quite short, they could not bring anything new from the point of view of the development of the Observatory.

The reintroduction of the Soviet regime in Estonia initially did not bring about any noticeable changes in the life of the observers. In 1940 the summer months passed as usual with employees on vacation. At that time the director of the Observatory was Professor T. Rootsmäe, astronomer-observer Dr. E. Öpik, assistant Dr. A. Kipper, help assistant V. Riives, lab technician R. Hallimäe, calculators G. Kusmin and M. Koppel and servant R. Pallav. But by the beginning of 1941, the astronomers' job titles and responsibilities changed with the re-organisation of the University's administrative structure. The chair of astronomy was created with Professor T. Rootsmäe as

* G. Zhelnin TK 47 1971 76-83

head; members of the chair were associate professor E. Öpik, assistants V. Riives and G. Kusmin, senior lab technician R. Preem, lab technician R. Hallimäe, senior preparator R. Pallav and junior preparator M. Koppel. Doctor A. Kipper was excluded from the personnel of the chair because he was appointed the professor of physics and also a vice-rector for education. It was also expected that the personnel of the chair would be changed, as the new structure of the university provided for a research institute which should also include the astronomical sector (observatory). However, the Second World War changed these plans.

Research on stellar statistics, theoretical astrophysics and meteor astronomy continued in the chair. Corresponding observations of meteors in the observation points of Tartu, Valga and Petseri were also continued. V. Riives performed photographic observations of comets with the Steinheil camera attached to the Zeiss refractor. Scientific contact was established with the Astronomy Council of the USSR Academy of Sciences, to which an activity report was submitted. In January 1941, Dr. E. Öpik had to participate in the work of the Astronomy Council's plenum and in the autumn in the Stalinabad conference of meteoric astronomy. While the first trip was cancelled for random reasons, the cancellation of the second was already due to the outbreak of war.

In 1941, the popular article "On the Possibilities of Life in Space" by E. Öpik was published by a Moscow publishing house. V. Riives wrote an overview of the observations of comets carried out in Tartu for a central journal. An article by G. Kusmin on the dynamics of Milky Way dust was ready. Another *Observatory Calendar* was published. During this period Moscow time was made the official time in Estonia.

It was only possible to work peacefully for one year under the Soviet regime. Already in the summer of 1941, the Second World War reached Tartu. Three years of heavy occupation followed. The former regime was restored at the university. The chairs were liquidated. A. Kipper returned to the post of assistant of the Observatory, V. Riives remained the help assistant, G. Kusmin was at first a calculator, and from May 1942, after defending his Master degree, he became a PhD student.

Despite the occupation, the observatory was able to maintain its normal mode of operation. Professor T. Rootsmäe continued statistical research on the relationship between the kinematic and physical characteristics of stars and E. Öpik developed generalised stellar models. The results were published in the 1st booklet of the XXXI Volume of Publications in 1943. A. Kipper worked in the field of astrophysics. The work of young astronomers V. Riives and G. Kusmin gained increasing weight. The first was an active observer at that time. In the spring of 1943, he photographed the Whipple-Fedtke-Tsevadze comet with the Voigtländer camera.

At the time, the Observatory's personnel used the *Observatory Calendar* to publish their scientific work, and the volume increased considerably (from 50 to 60 pages to 100-120); the content became more scientific.

As an achievement of this period (1941-42), we must mention the defense of V. Riives' and G. Kusmin's Master's degrees.

In the third year of occupation, the assault of the Soviet Army was increasingly felt in Estonia. Dr. E. Öpik left his homeland when the battle front was approaching.

The personnel of the Observatory did everything possible to save the property of the observatory. The Zeiss refractor was dismantled partially, it had been standing under the open sky for a long time because there was a military observation point. The second transition of the battle front over Tartu resulted in heavy casualties for the Observatory, the dome of the main building was hollowed out like a sieve, the walls of the main building and roof were damaged by shell shrapnel and bullets, the windows were broken. However, thanks to the selfless activity of the Observatory personnel, especially the servant R. Pallav, the buildings were saved from fire. All chronometers disappeared from the toolbox, some of the apparatus was completely broken, some parts of the instrument were scattered (for example, the eyepiece tube of the Fraunhofer large telescope was found in the Toomemägi shrubbery in 1945).

On August 25, 1944, Tartu was liberated, but the battle front remained very close to the city. It was only on September 17 that the enemy's defensive line broke down on the River Emajõgi and the military action moved northward. Although the war was still going on, the city started its restoration work. The University of Tartu also became operational.

The chair of astronomy was re-established at the University, and, according to the plan of 1941, the University's research institute was set up, one part of which was the Observatory. The chair consisted of Professor T. Rootsmäe, head of the chair; V. Riives, assistant; lab technician M. Kull, and R. Pallav, preparator. The senior researcher, G. Kusmin, and a younger researcher, R. Hallimäe, began to work in the Observatory as a subdivision of the Institute.

These astronomers' jobs continued until the autumn of 1947, when the positions of scientific personnel at the Academy of Sciences system were liquidated due to the upcoming transition of the Observatory to the Academy. In October 1944, Dr. Kipper was appointed Professor of Physics and Vice-Rector for Education at the University. In April 1946 he was elected Vice President of the Academy of Sciences of the Estonian SSR.

A. Kipper conducts solar eclipse observations (June 9, 1945)

Regardless of the administrative reorganisation, the main topics of the work of the Tartu astronomers were stellar statistics of the galaxy and its subsystems, galactic evolution, small bodies of the solar system, etc. The Petzval's astrographer was soon harnessed for observation. V. Riives started photographing comets and asteroids. The *Observatory Calendar* started to appear again. In 1946, V. Riives's *work On the Photometry of Comets* was published in the proceedings of the University (as the second issue of the XXXI volume of Observatory Publications). In December of the same year, a lecture entitled Cosmic Dust Environment was presented by Kusmin at the scientific session of the University.

T. Rootsmäe

At the same time, the personnel of the chair also thought about improving the Observatory. In 1945 V. Riives again compiled plans to rebuild the Observatory according to which the old Observatory building should be preserved.

However, a new building for the laboratories, auditorium and flats of the workers (with a useful surface of 940 m2) was to be built, instead of using the Struve house. The plane roof would be used for observations with small instruments. Outside the city (in the Kuuste region), an observation tower for the Zeiss refractor was to be built.

Contacts with other astronomical centres in the Soviet Union strengthened. Astronomical literature was obtained from the Astronomy Department of the University of Leningrad. In the autumn of 1947, G. Kusmin took part in a cosmogony and cosmology meeting in Moscow, where he presented a report introducing the work on stellar evolution in Tartu to the astronomers of other Soviet republics.

In connection with the upcoming transition of the Observatory to the Institute of Physics, Mathematics and Mechanics of the Estonian Academy, preparatory work was started in spring 1947 on the initiative of academician A. Kipper and Director of the Institute A. Humal. Under the leadership of V. Simm, Deputy Director of the Institute, the premises of the Observatory were repaired and the dome of the main building, which had suffered during the war, was repaired. The Zeiss refractor was cleaned and repaired. The construction of two photographic cameras was started. During the transition period, the duties of head of the observatory were taken on by academician A. Kipper, who later in August was replaced by V. Riives. Assistant G. Kusmin (afterwards the senior teacher) remained in the personnel of the Chair of Astronomy. So the astronomers of Tartu were divided between the University and the Academy, but their premises were still in the old Observatory. The scientific secretary of the Institute, Dr. H. Keres, and the new lab technician, H. Albo, were also employed here.

A. Kipper

On June 30, 1948, the Observatory, with its instruments and library, were finally transferred to the Institute of Physics, Mathematics and Mechanics.

A new era began in the Observatory, where the possibilities for scientific activity were much wider [The booklet of the Tartu Observatory appeared in this period. The Estonian National Publishing House, Tallinn 1964].

We have been looking at nearly 150 years of history at the University of Tartu Observatory. We are now endeavouring to assess the long-term activities of the Observatory and to explain its contribution to the development of science as well as to the training of astronomers.

The special position of Dorpat's Imperial University (such was the name of the University of Tartu at that time) among other Russian universities undoubtedly influenced the work of the Observatory, especially during the first century of operation. Its functions included preparing professors for Russian universities. For this purpose, a special so-called Institute of Professors was created at the University. In the field of astronomy, the Tartu Observatory had to help solve these tasks.

Thanks to its first director, Fr. G. W. Struve’s boundless energy, immense organisational capabilities and, above all, scientific achievements, the Observatory secured first place among other observatories and therefore strongly influenced the development of astronomy in Russia. "Here in Tartu, the first impetus was given to the development of astronomy in Russia"; "Here began modern Russian geodesy"; "It was the best equipped observatory in the world". This is how the Struve-period Observatory was characterised.

The Tartu Observatory had to gradually give up the fame of ‘best observatory’. By the end of the last century, its instruments and buildings were still largely at the level of Struve, in addition to which it was in the middle of a growing city.

Observatory achievements were now depending only on personnel. The scientific council of the University considered the selection of the directors of the observatory extremely seriously. The council wanted to have well-known astronomers in that position. Distinguished scientists, like W. Struve, H. Mädler, T. Clausen, L. Schwarz, G. Levitski, K. Pokrovski and

T. Rootsmäe had worked as directors in the Observatory and the University wanted to continue this tradition.

V. Riives

Astronomer-observers such as W. Preuss, H. Bruns, O. Backlund, E. Hartwig, A. Orlov, E. Schoenberg and E. Öpik were also known as scientists.

The scientific profile of the Observatory changed several times according to the scientific interest of it directors. During some periods observational activity dominated, then at others astronomers dealt with purely theoretical problems. "It could be said that the Observatory's scientific events have been very diverse, and there is hardly any broad astronomical branch that the Observatory would not actively cultivate."

[Quote from T. Rootsmäe's article in the *Observatory Calendar* 1947].

G. Kusmin

Let's outline these achievements. W. Struve's pioneering work on double stars, continued by H. Mädler and E. Öpik; stellar astronomy work, where the trend was also directed by W. Struve and further developed by H. Mädler, T. Rootsmäe, E. Öpik and G. Kusmin; observational and theoretical studies of astrophysics by E. Schoenberg, E. Öpik and A. Kipper; The works of S. Scharbe, R. Berg and T. Rootsmäe in determining the positions and orbits of comets and asteroids; K. Pokrovski's and V. Riives' research on the physics of comets; E. Öpik's fundamental results in meteoric astronomy; observations by E.

Hartwig and K. Pokrovski in the field of noctilucent clouds and works in theoretical astronomy by T. Clausen and T. Banachiewicz.

The Observatory of Tartu University

The astrometric and geophysical work of the Observatory can be given separately: E. Schoenberg's work in measuring changes in geographic latitude; R. Livländer's research in determining the coordinates of a point of observation; A. Orlov's work on the tidal movements of the earth's crust; and G. Levitski's seismic studies.

There was also historical significance in astrogeodetic expeditions. These include the measurement of the Russian-Scandinavian arc initiated by W. Struve, the work of his students A. Savitsh, G. Sabler and G. Fuss in determining the difference between the Black and Caspian Sea levels and W. Preuss, V. Fyodorov, L. Schwarz and W. Abold's participation in geographic expeditions.

While there were some low tides in the scientific work of the Observatory, it did not have a significant effect on the training of the scientific personnel. Many of the Observatory protégés have become prominent astronomers who later worked fruitfully in other Russian observatories. Let us name K. Knorre, V. Fyodorov, A. Shidlovski, G. Sabler, A. Savich, W. Döllen, A. Wagner, F. Renz, F. Wittram, L. Struve, A. Djukov and R. Berg. The most famous of the geodesists – of the Observatory protégés – are W. Wrangel, B. Lemm, S. Zelenoi and M. Vrontshenko.

The long-term activities of the University of Tartu Observatory have borne fruit and deserve full respect.

By completing this historical review, I would like to express my gratitude to all those who helped to gather the necessary factual material in drafting the work. I would like to express my utmost gratitude to L. Vallner and K. Õllek.

EESTI LUS