Acta Universitatis Carolinae. Mathematica et Physica

Izold Pustylnik

Petzval astrograph of Tartu observatory

Acta Universitatis Carolinae. Mathematica et Physica, Vol. 46 (2005), No. Suppl, 233--238

Persistent URL: `http://dml.cz/dmlcz/143838`

Petzval Astrograph of Tartu Observatory

IZOLD PUSTYLNIK

Tartu

Received 20. October 2004

In 1908 Tartu observatory acquired an 8 inch Zeiss refractor as a substitute for the famous Fraunhofer refractor from 1824. A year later the observatory purchased for the needs of astrophotography a Petzval type objective photocamera. The telescope arrived to Tartu and was installed in the late autumn of 1911. Beginning from 1927 the Petzval camera was in use as a stand-alone astrograph. To this end the camera was mounted upon the heliometer support and placed in the former pavilion of the zenith telescope. Throughton telescope (1806) tube served as a guide. Much later a wide-field camera previously used for observations of the Earth artificial satellites was added as a finder. Petzval astrograph's diameter is 160 mm, focal length 79 cm. In the twenties and the thirties of the XXth century the Petzval astrograph was widely in use for observations of planets, meteors, stars and even for obtaining images of M31 by Ernst Öpik.

It became obvious already at the end of XIX century that the state of the famous 9 inch Fraunhofer refractor, the principal telescope of Wilhelm Struve and Johann Mädler which served for more than three quarters of the century for measurements of stellar parallaxes, detection of visual binaries and multiple systems at Tartu Observatory drastically deteriorated. Repairing such an old instrument meant a complete substitute of all its worn off mechanics and would have been a very costly enterprise with no clear prospective in view, since with an advent of astronomical photography visual observations gradually but irrevocably lost in their importance. Therefore in 1908 Tartu astronomers ordered a new Zeiss 8 inch refractor. A relevant application for funding has been submitted to the tsarist Russian Ministry of education and it took more than a year to overcome several bureaucratic obstacles until finally in December of 1909 the sum of 15522.5 of former Deutsche Marks (or equivalent 7186 roubles and 95 kopeecks) were allocated for this new instrument. For a small institution like Tartu Observatory that was quite

Tartu Observatory, 61602, Estonia

a serious investment. To compare with it, the annual budget having been in Konstantin Pokrovski's disposal (the director of Tartu Observatory in the early XXth century) for keeping in order observatory premises and acquisition of the new books for the local library amounted barely to 1170 roubles. K. Pokrovski in an early XXth century immediately realized that the next step in renovation of the instruments of the old Tartu Observatory should be a purchase of a new astrograph and he made an effort to raise necessary funds for the purpose. At first he seemed to be lucky by finding a benefactor in the face of a certain Mrs. E. Witte living in Russia in Voronezh, a widow of a former graduate of Tartu University (benefactor's spouse Adolf Witte studied in Dorpat University between 1842 and 1846) who kindly donated a lump sum for acquisition of the astrograph for the needs of Tartu Observatory. Pretty soon a mechanician Hans Heele from Berlin delivered an astrograph at a reasonable cost to Tartu astronomers. Alas, its quality appeared to be so poor that the deal was cancelled and the device was returned to its owner.

In view of serious financial troubles facing the observatory it was decided to abandon the original ambitious plan of a stand-alone astrograph in favour of a purchase of Petzval camera as an auxiliary tube fixed rigidly on the same mounting with the Zeiss telescope, with the aperture of the camera of 160 mm and a focal length of 79 cm. The new refractor arrived and was installed in the autumn of 1911. In addition to the 4 eyepieces adjusted for 4 micrometer and enabling in combination with the objective lense magnification of 120, 200, 288 and 500, the set included also revolving eyepieces with the magnifications of 60, 90, 144, 200, 288, 514 and 720.

Unfortunately, the World War I and the ensuing political turmoil in Russian Empire and its provinces interfered with the plans of Tartu astronomers. With an imminent menace of a too close approach to Tartu of the military activities the most valuable astronomical instruments along with auxiliary equipment and the most valuable books were evacuated to Nizhni Novgorod and subsequently to Perm where they were remained preserved between 1915 and 1921. Soon after the peace treaty between bolshevik Russia and a new borne republic of Estonia was negotiated and signed Zeiss telescope returned and was reinstalled, this time foreover in Tartu Observatory.

In 1927 Petzval astrograph was detached from the Zeiss telescope and mounted along with the old Throughton telescope guide on the support of the heliometer and placed in the former pavilion of the Repsold zenith telescope. Since that time it has been used for many years as a stand-alone astrograph (see the Figure 1).

It is time now to describe in brief the main observational programs in Tartu realized with the aid of Petzval camera prior to the World War II. Most of them are associated with the name of Ernst Öpik, his colleagues and students. E. Öpik returned to Tartu as a graduate of Moscow University in December of 1921 almost contemporaneously with the arrival of the previously evacuated instruments.

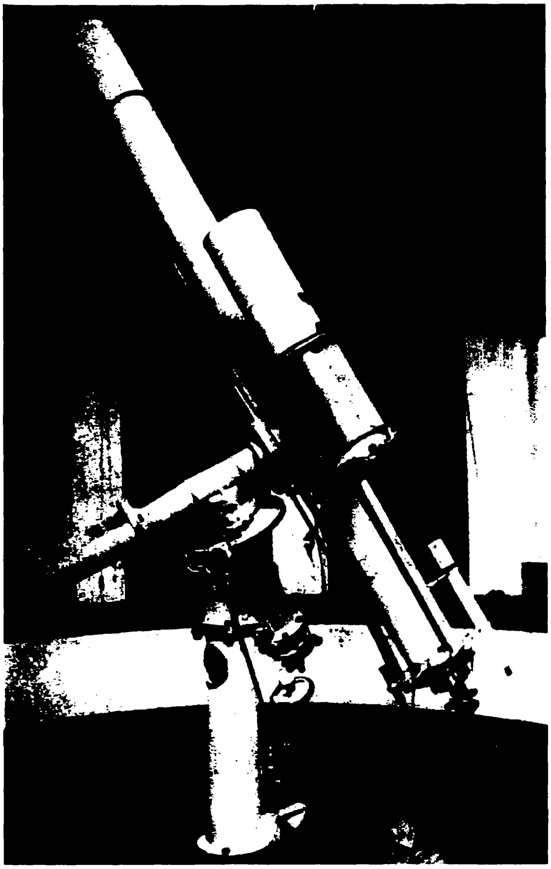

Fig. 1 Petzval astrograph of Tartu Observatory.

Probably it was a mere coincidence but it may be regarded as the hand of providence because in Tartu Öpik with no delay was nominated to the position of astronomer-observer. Whatever it was, a whim of fate or just a lucky chance Öpik proved to be a right man in a right place: for more than 20 years before his emigration to the West he supervised all the observational program carried out in Tartu Observatory and made a lot of observations himself. Bearing in mind the topic of our discussion we concentrate here only on the list of observational programs realized with the aid of Petzval camera during the two decades prior to the World War II (more details see in an article by Kipper 1984 and a book "Astronomical Observatory of Tartu (Derpt, Dorpat) University in 1805–1949" by Zhelnin 1969):

1. Measurements of the variations of brightness of Neptune aimed at establishing the giant planet's rotational period (1922–1923, Öpik and Liivländer).

2. Determination of the brightness of globular clusters and nebulae (1922–1926, Öpik).

3. Photography of the selected areas of the Milky Way aimed at the discovery of varaible stars (1927–1932, Simber, Muizhnek).

4. Photography of Mars with the purpose of measuring its color-index (1926, 1928 Liivländer).

5. Photography of a small planet Pallas (1923, Liivländer) and of the comets 1922c (Baade) and 1930c (Vilk) plus of the solar eclipse on June 19 in 1936 (Kipper, Keres, Simberg).

6. Photography with the aid of objective prism of the spectra of cepheids (1935 –1937, Kipper, Simberg), also of the spectrum of ζ Aurigae during its minimum (1935, Kipper), spectrum of Nova Herculis (1935, Kipper, Simberg), finally spectra of some bright stars (1937–1940, Kipper, Simberg).

Determination of the ultraviolet indices of the stars by the use of the so-called Tichov's method proved to be one of the most extensive programs carried out with the aid of Petzval camera. The essence of the method lies in the use of chromatic aberration of the objective lense for measuring the colors of the stars. The underlying idea was to put photoplates behind the focal plane where a stellar image looks like a spot in the center surrounded by a dark ring. The ring is formed by the radiation emitted in photographic (blue) wave-length range, whereas the spot is caused mainly by the ultraviolet emission (in 16 cm objective of Petzval astrograph chromatic aberration was corrected in the photographic wave-length range but it was not fully compensated in the red and ultraviolet light). Placing a diaphragm in front of the objective lense effectively cuts off the central part of the image and enhances the resulting effect even more. In this way a catalogue was compiled with color indices for 428 stars (for more details see Öpik 1925). At that time Öpik was preoccupied with the structure of the red giants and one of his dominant motives was a desire to discriminate between main sequence stars and giants through mass determinations of color indices by the methods of stellar photographic photometry instead of high resolution spectroscopy which was time consuming and demanded larger telescopes than Tartu Observatory could afford itself.

In view of the limited format of this contribution we singled out for our report a more detailed description of the planet Neptune observations carried out with the use of Petzval camera at Tartu Observatory in order to familiarize the reader with some technical peculiarities of the arrangement of observations, their reduction and the sources of the attendant errors. The below-given description is taken from two Öpik's articles, a brief one published in German in "Astronomische Nachrichten" (see Öpik 1923) and the detailed one in English which appeared next year in Tartu Publications (Öpik 1924). During these series of observations the photographs of Neptune were taken at a distance 5–8 mm behind the focus (the scale of the focal images was 1 mm = 260.5 arcseconds). The latter distance proved to be optimal giving fairly uniform extrafocal images, measurable on microphotometer and with an exposure time of 10 minutes producing the images of Neptune dense enough for precise determination of its brightness. To control the distance from the focus an arrangement was adopted similar to the method of Hartmann for testing the quality of the objectives. A diaphragm was placed before the objective having a central aperture of 80 mm and four side-holes. In this way each extrafocal image of a star reproduced the figure of the diaphragm having a central disk and 4 "satellites". The distance between the satellites measured on a Repsold machine determined the distance from the focal plane. The use of the diaphragm only improved the quality of the images as it reduced the intensity of the background of the sky and the probability of overlapping stellar images about 4 times. The photographs were obtained with the aid of a special rotating plateholder. This arrangement allowed to obtain on 9×12 cm plate two independent photographs of a circular area of 52 mm diameter, a circular window of this diameter with its center on the optical axis was placed before the plate. The latter could be rotated about an axis 107 mm distant from the optical axis and placed in 2 positions, so that the images of the window fell upon 2 different places on the plate.

All the above-enumerated technicalities permitted Öpik and other observers to reduce to a minimum attendant errors due to a) variations in transparency of the terrestrial atmosphere, b) systematic differences in the sensitivity of the different parts of photoplates, c) inequality of the distance from the focus of different images, d) influence of the background of the sky and overlapping images of the bright stars, e) errors in the plate constant needed to transfer photodensity into stellar magnitudes, f) influence of the background (veil) of the plate. The abovegiven descriptive picture exemplifies in our view the well-known truth: with a thoughtful planning and a due attention to all subtleties of the measurement and reduction processes astronomer can achieve reliable observational results of a high quality even with disposal of a modest instrument while working in far from ideal astroclimatic conditions. In this way Öpik succeeded in measuring 0.08–0.15 magnitude variations in brightness of Neptune due to the axial rotation of the giant planet.

In 1922 E. Öpik published an article in Astrophysical Journal (Öpik 1922) in which he made a pretty accurate estimate of the distance of Andromeda nebula from us – 450.000 pc. This was about two times higher value than the one obtained by E. Hubble. The estimate obtained by Öpik was rather close to the modern value. Öpik's estimate was based on the rotation velocity curve for M31 obtained by F. G. Pease in 1918. The underlying idea of the method employed by Öpik was an assumption that the same mass-to-luminosity ratio can be adopted for our Galaxy and the spiral nebulae. The formula used by Öpik involved the rotational velocity of M31 but when applying the relation one should know also the oblateness of the central part of M31. The oblateness was found by Öpik from the photoplate of M31 taken with the aid of Petzval astrograph of Tartu Observatory.

Acknowledgements

This investigation has been supported by the Estonian Science Foundation, Grant Nr. 5760.

References

[1] JÕEVEER M., 1994 Geodeet, Nr. 30, 11.
[2] KIPPER A., 1984 Tartu Observatory Publications **50**, 8 (in Russian).
[3] TRAAT P., 1995 Tartu Tähetorni Kalender 1955 aastaks **55**, 60 (in Estonian).
[4] ÖPIK E., 1922 The Astrophysical Journal **55**, 406.
[5] ÖPIK E., 1923 Astronomische Nachrichten **217**, 159.
[6] ÖPIK E., 1924 Tartu Observatory Publications **25**, 1.
[7] ÖPIK E., 1925 Tartu Observatory Publications **26**, 1.
[8] ZHELNIN G., 1969 Tartu Observatory Publications **37**, 1.