Figure 16.1: *The main building of the new institute at Budapest-Svábhegy, completed in 1927*

16. The First 50 Years of Konkoly Observatory

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Abstract

The second half of the 19th century experienced a revolution in astronomy. It coincided with a new start of professional astronomy in Hungary through the work of Miklós Konkoly Thege (1842–1916) who is considered as a pioneer of current astrophysical activity in our country. He played an outstanding role in organizing scientific life and institutions, too. He started observations in his newly founded Observatory at Ógyalla in 1871. Sunspots were regularly observed in the observatory from 1872. In 1874 Konkoly began regular spectroscopic observations of comets and emphasized the importance of parallel laboratory works. An important field of Konkoly's astronomical activity was the observation of surface patterns of planets, particularly that of Jupiter and Mars. Spectroscopic observations of stars were also a significant part of the activity of Ógyalla Observatory. In the last period of the Konkoly era (starting in 1899) stellar photometry became the main field of research. At the end of WWI the institute was moved to Budapest from Ógyalla and started a new life based on a completely new infrastructure: *"... all era are followed by a new one, with its new tasks, in which the scope of activity changes correspondingly, in which enthusiasm is mostly manifested. It was different in the forties when our nation found itself following the word of the founder of our Academy, it was different in the fifties and sixties when we have to defend our nation against foreign aggression, and it became different since the sixties when, our existence being guarantied, we also have to make an effort, beside strengthening it, to get as distinguished a position among the civilized nations as possible."*[1]

16.1 Prelude

Cardinal Péter Pázmány founded the Jesuit University in Nagyszombat (today Trnava in Slovakia) in 1635. Calendars have been published already from 1665 regularly (Kiss 2005). In 1756 the University established an observatory which published astronomical observations in its "Observationes". The director Ferenc Weiss was in regular correspondence with his colleagues abroad (Vargha 1990–1992). In 1777 the Observatory was moved into the Royal Castle of Buda.

In 1815 a new Observatory began its work on the top of Gellért Hill (Blocksberg), Buda. It had permanent contact with other European Observatories. As a consequence of the fall of the Hungarian revolution in 1849, it was blown up by the Austrian Army in 1852, and for more than twenty years there was no astronomical observatory in Hungary (Kelényi 1930).

16.2 New Era in the Development of Astronomy in Hungary

Because there was no professional astronomical institute in Hungary after the destruction of the one on Gellért Hill, it had a great significance that a private observatory was established by Konkoly Thege (1842–1916) in Ógyalla in 1871. Its main profile was astrophysics. In this time the circumstances were appropriate for creating an institute devoted primarily for this new field of research. The 1870's saw revolutionary changes in astronomy.

Kirchoff and Bunsen (1860) discovered spectrum analysis – that is, the method by which it was possible to draw valid inferences about the composition and physical properties of the emitting sources from their spectra. Until this time astronomy was concerned mainly with determining the positions of celestial bodies – that is with helping navigation and cartography, or with developing mathematics by celestial mechanics (for example Gauß was nominally earning his wages as the director of Göttingen observatory).

The introduction of spectrum analysis into astronomy made it possible to study those physical processes that produce the electromagnetic radiation observed through the telescopes. The epoch-making importance of this discovery was immediately recognized by Konkoly Thege, who decided at the beginning to make observational astrophysics the primary objective of his institute.

16.3 Scientific Life at Ógyalla

Konkoly was not simply a rich landowner but an educated scientist as well. He started his studies at the Astronomy Department of the University of Berlin in 1860, where he could learn up-to-date astronomy under the guidance of Encke. Encke was the intellectual leader of a whole generation of astronomers, for example J. H. Mädler, J. G. Galle, G. Spörer, B. Gould.

Konkoly's contemporaries who studied under Encke were C. Rümker, A. Krüger, W. Förster, B. Hoffman and F. Tietjen.

Figure 16.2: *Miklós Konkoly Thege (1842–1916); he founded his observatory at Ógyalla in 1871*

Hermann Kobold who worked in the Ógyalla Observatory between 1880 and 1883 wrote about his director: *"Herr v. Konkoly hatte in Berlin Naturwissenschaften, besonders Physik und Cemie studiert. Er hatte aber auch anderen Gebieten, besonders in der Technik, grosse Kentnisse. Er besass auch das Befähigungszeugnis al Kaptän für die Donaudampfschiffahrt. In einem der Wirtschaftsgebäude in Ógyalla war ein Werkstatt mit Präzisionsdrehbasnk, an der Herr v. Konkoly häufig arbeitete. Nach den von ihm selbst angefertigten Werkzeichnungen waren hier schon manche physikalischen und astronomischen Instrumente hergestellt... Die wissenschaftliche Tätigkeit des Observatoriums hatte bis zu meinem Eintritt fast ausschlieslich auf dem Gebiet der Astrophysik gelegen, entsprechend den Neigungen des Herrn v. Konkoly und der Ausrüstung des Observatoriums, die eine grosse Anzahl von vorzüglichen Instrumenten für spektrometrometrische, photometrische und kolorimetrische Beobachtungen und Messungen umfasste."*[2]

16.3.1 Chronology of the Beginning of Scientific Activity in Ógyalla

In the following we give a short chronology of the main events of the first decade of regular activity in Ógyalla:

1872: Start of regular sunspot observations.

1874: New building was completed, equipped with a 10.5-inch Browning mirror telescope. Start of the long series of cometary observations.

1875: A network of meteor observers was established comprising several places in the country. The reductions was done at Ógyalla.

1879: Konkoly included the study of the Red Spot on Jupiter in the program of the institute.

1879: The first yearbook was published with observations from the first period (Vargha 1999).

This rapid and surprising development would not have been possible without using state of the art instrumentation

16.3.2 Instrumentation

At the beginning of the eighties the Observatory already acquired a wealth of excellent instruments, some of them made in Ógyalla. The following list gives a short inventory of the more important items:

Telescopes

- 10″ Browning reflector
- 10″ Merz refractor
- 6″ Merz refractor
- 3″ Rheinfelder & Hertel refractor for observing sunspots.

Chronographs, clocks

- 4 chronographs
- 7 pendulum clocks
- 4 chronometers

Spectroscopes

- 12 stellar spectroscope
- 4 laboratory spectroscope
- 3 mobile spectroscope

Miscellanea

- Several physical equipments (Vargha 1999).

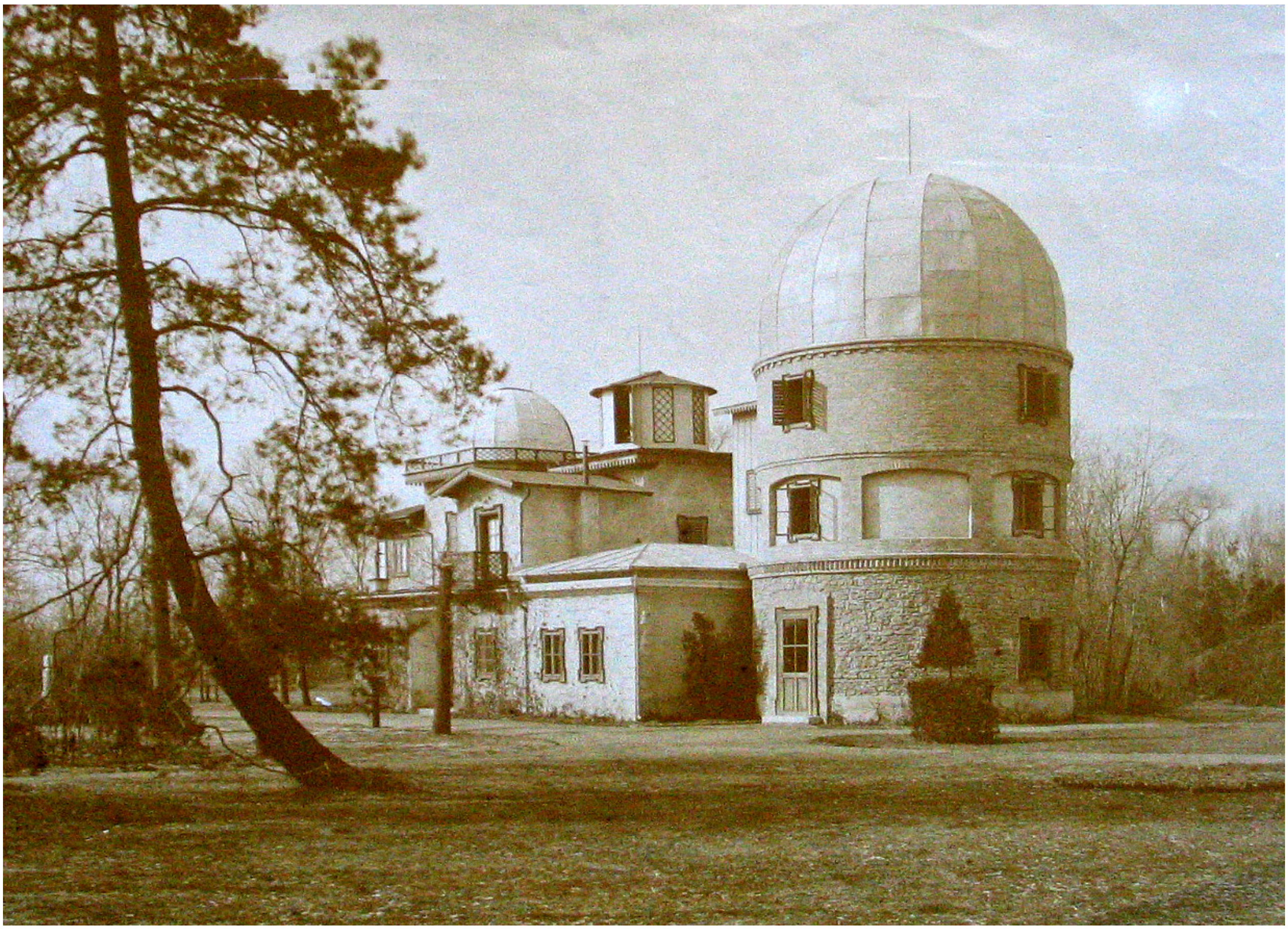

Figure 16.3: *Konkoly's observatory at the end of the 19th century*

16.3.3 Solar Physics in the Observatory

Although sunspots were discovered by Galilei and they provided continuous interest for astronomers all the time, though their regular and internationally coordinated observations started only in the second half of the 19th century.

Sunspots were regularly observed in Ógyalla since 1872 (e.g. Schrader 1877). Publication of heliocentric coordinates began in 1880. Since the beginning of 1885 the Wolf relative numbers were computed daily, reaching back to 1872 using the drawings that had been made in the observatory. The whole series for the period of 1872–1884, complete with the Zürich relative numbers, appeared in the publications of the observatory. Konkoly regularly sent the sunspot data to Zürich starting from 1885 (Konkoly 1885). The Hungarian contribution was especially significant after the death of Rudolf Wolf in 1893.

Beside good observations, Konkoly made a remarkable contribution to the instrumentation of Solar physics. He built a photoheliograph, and two spectroscopes for studying solar prominences in 1905 (Terkán 1913).

Konkoly played an important role in organizing other stations for solar observations in the country (the most important being the Haynald Observatory at Kalocsa, see Mojzes, 1986). Gyula Fényi, S. J. became the director of this observatory in 1885 and he regularly made hand drawings of solar prominences for 28 years. It is the longest and most complete series of observations on solar prominences in this period.

16.3.4 Comets, Meteors, Minor Planets

Historically, the observation of comets were connected with astrology. Later on the determination of the laws governing their motion was an important task of celestial mechanics. The study of their physical nature become possible only by regular spectroscopic observations. The observations relevant to the physical nature of comets belonged to a new field of research in the second half of the 19th century. When Konkoly started regular spectroscopic observations in 1874, he was among the first in the world to observe cometary spectra.

In order to identify the physical nature of comets Konkoly emphasized the importance of parallel laboratory works. He measured several gas mixtures in the laboratory at different pressures and temperatures, trying to simulate real cometary spectra. In some cases when the compound to be measured was too dangerous (e. g. case of the cyan) he was given free access to the well-equipped laboratories of the University of Budapest. Combining the observations with laboratory

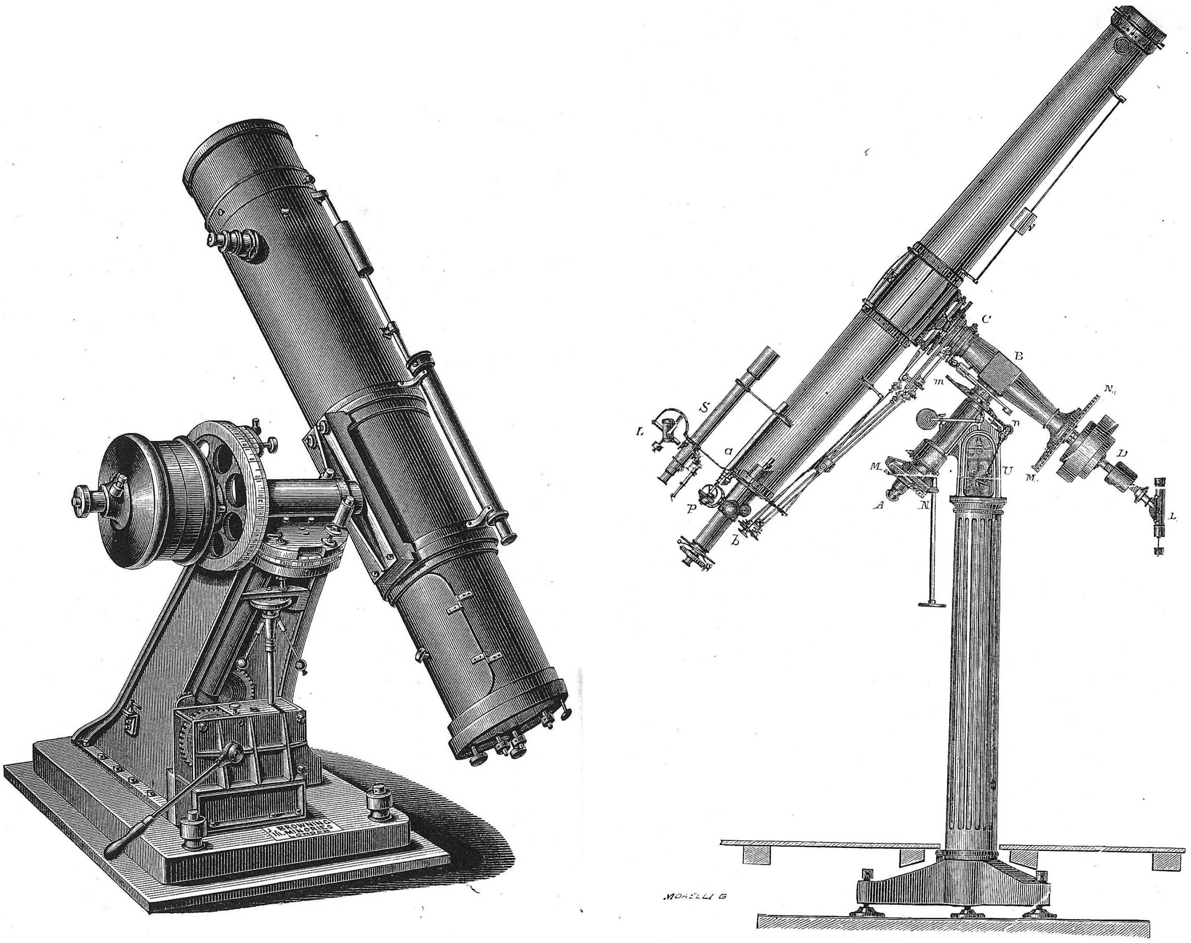

Figure 16.4: *Main observing instruments of Konkoly's observatory: 20-inch Browning reflector (until 1881, left). 20-inch Merz refractor (from 1882, right)*

results Konkoly confirmed the similarity of cometary and hydrocarbon spectra:
"I myself observed forty comets twenty-seven out of those were also evaluated spectroscopically. Thus I can assert without boasting, that in the field of observing and spectroscopically analyzing comets, the achievement secures for me the first place amongst European and American astronomers."[3]

The first comet he observed spectroscopically was comet Coggia (1874) and the last one he studied was comet Halley (1910). Comet Zlatinsky (1914) was the last in the series which was observed in Konkoly's era (Konkoly 1874, 1911, 1916).

A favorite topic of Konkoly's astronomical interest was an extensive study of meteors, particularly their spectra. He often observed the characteristic line of sodium projected onto a continuous spectrum and occasionally the lines of Mg, Li, Fe, etc. and carbohydrates. Based on the spectroscopic observations he recognized the relationship between comets and meteors.

He also organized an observational network for the determination of spatial positions of meteors at the request of E. Weiss, director of the Vienna Observatory. Konkoly equipped several stations with the appropriate instrumentation (microscope, time basis) in addition to his own institute. The observations were reduced in Ógyalla. The network enabled one to calculate the spatial positions and velocities of the meteors. Based on these results they established a close relationship between meteor streams and comets. Among the regular observations at Ógyalla a very spectacular meteor fall can be found on Nov. 27, 1872, when 38 meteors were observed in one minute.

Konkoly and his collaborators regularly observed minor planets using telescopes and meridian circles. They supplemented the observations with theoretical calculations of the orbits taking secular perturbations also into account. Honoring the international level of his research two minor planets were named after him and his observatory, namely (1259) Ógyalla (Reinmuth and Mündler 1933) and (1445) Konkolya (Kulin 1938a, 1938b).

16.3.5 Planetary Research

An important part of Konkoly's astronomical activity was the observation of surface patterns of planets, particularly that of Jupiter and Mars. These observations were regularly published in the observatory publications. Shortly after the appearance of the big red spot on Jupiter in 1878 they made regular follow up observations

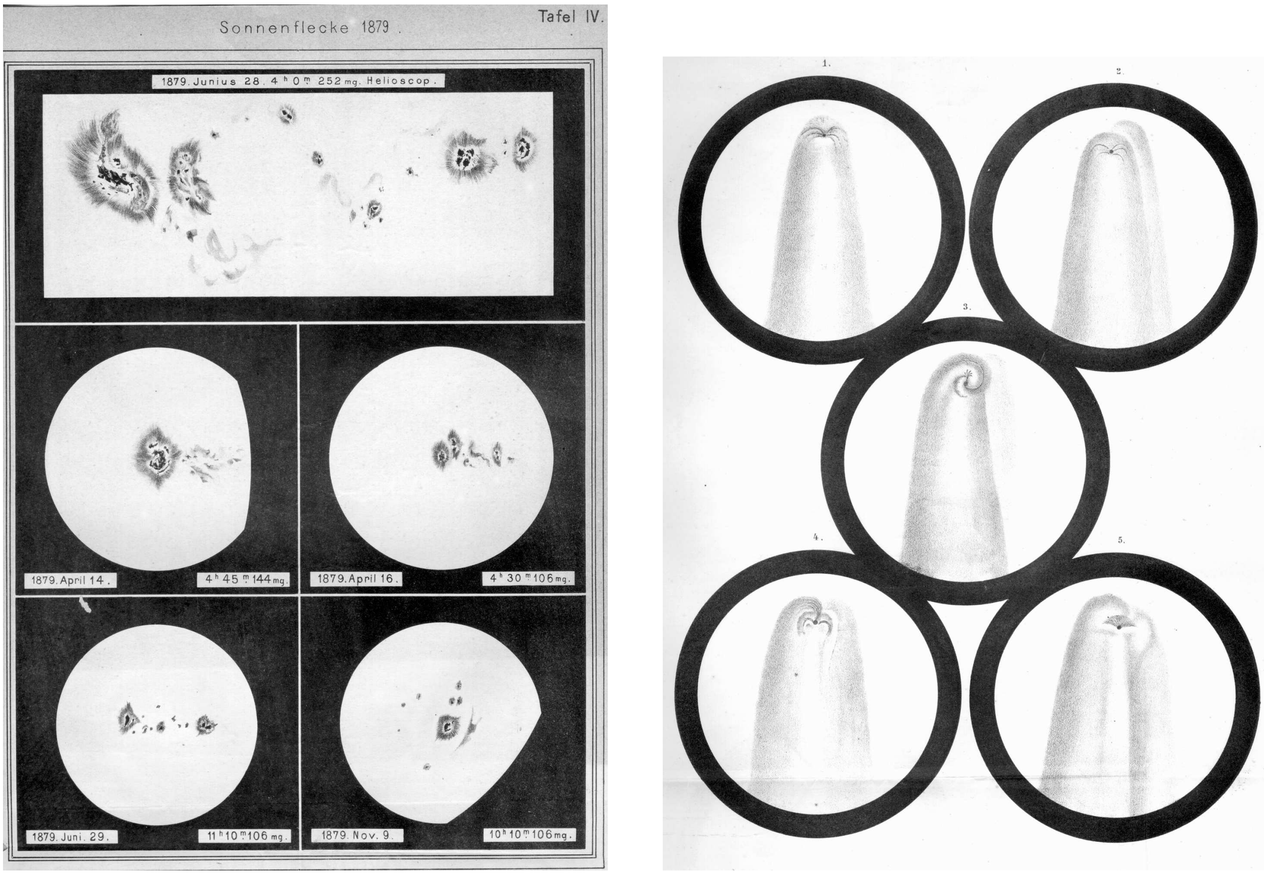

Figure 16.5: *Left: Hand drawings of sunspots made in Ógyalla Right: Hand drawing of the head and spectrum of Comet 1881 III*

for several years until the spot faded again. Between 1879 and 1885 Konkoly and his staff made 54 drawings which were used for determining the rotation period of the planet. When Hermann Kobold worked in Ógyalla in the period of 1880–1883 he did the bulk of the planetary observations.

Ernő Massányi added further 24 observations to this collection in 1902. Besides the determination of the rotational period of Jupiter he investigated the belt activity as well. On the basis of these observations Massányi rejected the idea of a connection between sunspot activity and the period of belt activity, but he did not have enough data to draw a conclusion on the possibility of a correlation with orbital phase. (Massányi 1904).

16.3.6 Stellar Spectroscopy – The Ógyalla Spectral Program

Thanks to the interest of Konkoly in astrophysics and to the rich collection of appropriate instruments stellar spectroscopy was a very important part of the observatory's scientific activity. H. C. Vogel, director of the Astronomical Observatory in Potsdam, motivated by the fundamental discovery of Kirchhoff and Bunsen and the necessity of making a spectroscopic reference system for future studies of spectral variations, initiated a spectral survey of the stars in 1875 which was completed in 1883 for the zone of $0° - 20°$ declination down to 6.5 magnitude. This survey was continued by Nils C. Dunér (1884) in Lund Observatory up to the North pole. Konkoly decided to participate in this work. He first observed and published the spectra of 160 stars (Konkoly 1877) and to extend Vogel's work he added the $-15° - 0°$ zone to the survey. The vast majority of the spectroscopic observations was carried out by Kövesligethy in the years 1883–1886. The instrument was a 6-inch Merz refractor equipped with a Zöllner stellar spectroscope. The catalogue (Konkoly 1887) 2022 stars down to 7.5 magnitude.

16.3.7 Kövesligethy's Spectral Theory

Kövesligethy was not satisfied simply to observe stellar spectra. He studied physics at the University Vienna from 1881 and he completed his PhD thesis in the theory of stellar spectra in 1884. He thought that thermodynamics will play the same role in interpreting the light emission properties of celestial bodies as Newtonian mechanics did it in the case of their motion. In his PhD thesis he derived an equation for describing the functional form of the continuous radiation of celestial bodies and its dependence on the temperature. As a byproduct he discovered Wien's displacement law. Developing his theory further he attempted to estimate the surface temperature of stars.

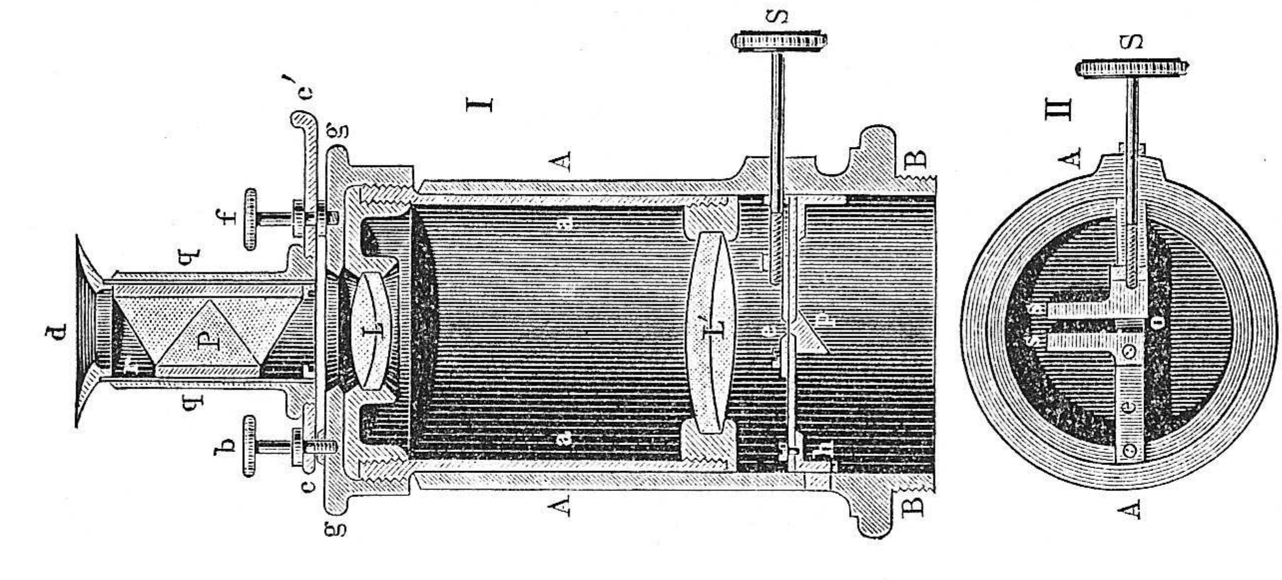

Figure 16.6: *Zöllner type ocular spectroscope used in the spectral programme*

For deriving his spectral equation Kövesligethy made several assumptions which were quite reasonable on the basis of the accepted views of contemporary theoretical physics. He made the following assumptions:

- the radiating matter consists of interacting particles,
- the form of interaction is an inverse power law,
- radiation field is represented by the aether,
- the aether also consists of interacting particles,
- the light is the propagation of the oscillation of the aether particles,
- there is an equipartition between the oscillation energies of material and aether particles.

Starting from the above assumptions he derived the spectral equation in the following form

$$L(\lambda) = \frac{4}{\pi}\mu\Lambda\frac{\lambda^2}{(\chi^2+\mu^2)^2}$$

In the above equation μ means the wavelength of the maximum intensity and Λ is the total emitted energy.

Kirchhoff predicted the existence of the blackbody radiation function *B(λ)* in 1860 by stating that the ratio of emission *e(λ)* and absorption *a(λ)* is *e(λ) / a(λ) = B(λ)*, where *B(λ)* is independent of the quality of the radiating matter. Kirchhoff, however, could not determine the functional form of *B(λ)*. Kövesligethy emphasized that his spectral equation was also the solution of Kirchhoff's problem.

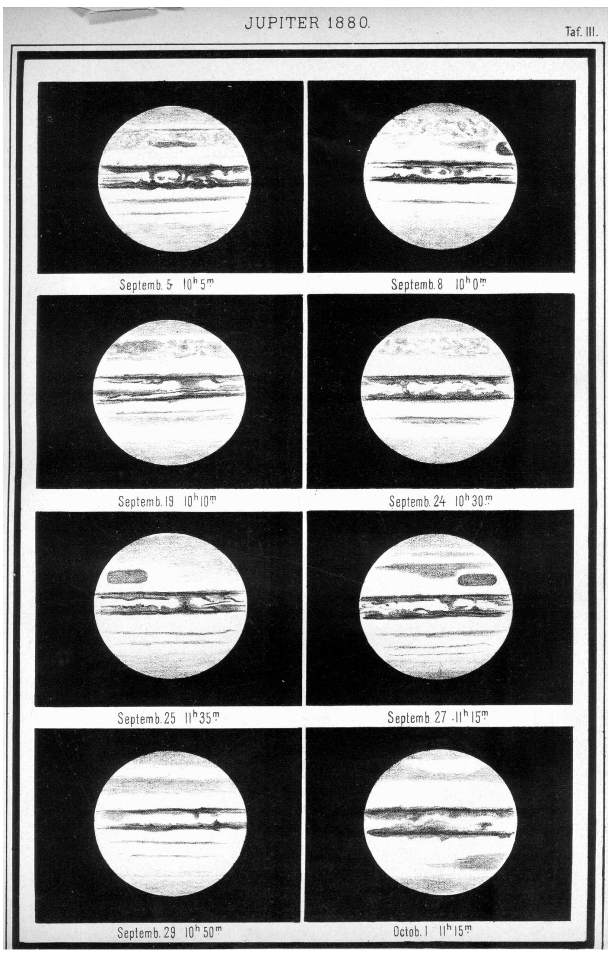

Figure 16.7: *Hand drawing of Jupiter's Red Spot*

16.3.8 Kövesligethy vs. Planck

It is the accepted view in the history of science that Max Planck succeeded to solve properly Kirchhoff's problem in 1900 by assuming the quantum hypothesis. As we mentioned at the end of the previous paragraph, Kövesligethy, however, succeeded 15 years before Planck. It is clear at the first glance that Köveligethy's spectral equation (discovered in 1885) does not have common assumptions with those of Planck (1900). However, it is worth making a comparison as we did it in Fig. 16.8, p. 158. This figure demonstrates that there is a striking similarity between the two curves, although their mathematical form is completely different.

Planck used state of the art results of statistical thermodynamics on the functional form of the most probable distribution of particles in phase space supplemented with the revolutionary assumption of the quantized nature of energy. In Kövesligethy's theory the radiating field, the aether, also consists of discrete oscillators, the energy, however, is not quantized. In this respect he can not be considered as a precursor of Planck. However, he was the first who solved Kirchhoff's problem by finding a spectral equation of the black body radiation which predicted a finite total emitted energy.

It is worth mentioning that Kövesligethy thought the observatory at Ógyalla was an ideal environment for theoretical works as well (Kövesligethy 2003).

16.3.9 Discovery of Wien's Law (Kövesligethy 1885) – Temperature of Celestial Bodies

Combining his spectral equation with the first law of thermodynamics and assuming an equipartition between the thermal energy of the emitting body and the oscillating aether particles Kövesligethy succeeded to obtain a relationship between the parameter μ in his spectral equation, which is in fact the wavelength where the *L(ë)* curve reaches its maximum, and the absolute temperature of the radiating source.

He discovered the displacement law of Wilhelm Wien (1893) eight years earlier than Wien himself. The inverse proportionality between the temperature and the parameter μ enables the observer to estimate the surface temperature of the emitting body.

Kövesligethy's spectral equation has a nice property: if at two different *ë'*, *ë″* wavelengths *L(ë')* = *L(ë″)*, then *ë'ë″*= μ^2. This property enables the observer to determine the surface temperature of a celestial body in a very elegant way. Since μ is a geometric mean of *ë'*, *ë″*, after estimating these two wavelengths it is very easy to obtain this parameter. The ratio of the two μ's in the spectral equation gives the ratio of two temperatures of the corresponding sources. Kövesligethy compared the spectrum of the Sun with that of melted platinum. He obtained μ^2=0.314 in the case of the Sun and μ^2=2.341 in the case of platinum. Since the melting temperature of platinum is 2045 K, the ratio of these *ì*'s resulted in T_{Sun}= 5584 K which is surprisingly close to the currently accepted value.

16.3.10 Impact on Contemporary Astrophysics

When Kövesligethy reached his significant theoretical results Konkoly's Observatory was already in the mainstream of developing astrophysics in Europe. Since 1873 Konkoly has been publishing his works regularly in *Astronomische Nachrichten.* He started his own observatory publications in 1879.

He regularly exchanged his *Beobachtungen* with other observatories, and had a regular correspondence with colleagues abroad, e. g. W. Huggins, A. Secchi, H. C. Vogel, J. K. F. Zöllner on spectroscopy, G. Spörer on Sun spots (Vargha 1999).

He performed an important role in establishing other observatories in Hungary: Kalocsa in 1877, Herény (Szombathely) in 1881 and Kiskartal in 1886.

Konkoly became director of the Hungarian Meteorological Service in 1890. As a director he helped Ógyalla Observatory whenever he could. There was a close connection between the Institute and the Observatory from 1890 until the nationalization of the latter.

16.4 Royal Hungarian Astrophysical Observatory

In the eighties Konkoly realized that his richness was not enough to keep his institute competitive on an international level and recognized that its operation by the state was the only way to survive:[4]

"As I am childless, constant fear is that my observatory built at great cost in time and effort , share the lamentable fate of other privately owned observatories. . . . Such was the fate of the observatory of the Baron Comphausen in Rüngsdorf, near Bonn; also of that Fr. Brödel, Saxony, the Umkrechtsberg in Olmütz and many others. Under the influence of these sad cases I have decided to donate my observatory to the state, as its stands, lock, stock, and barrel with three stipulations.

1. *The state will take responsibility for the operation of the observatory and employ three officials to do this.*
2. *The observatory will not be moved from Ógyalla during my life (it is hoped that, even after my demise, no minister will contemplate such as idiocy, considering , considering the investments which will have been made since nationalization).*
3. *As long as live and am capable, I shall remain the director of the Observatory, but without ever receiving any remuneration for my services."*

He was a member of the Astronomische Gesellschaft (AG) from 1873. Thanks to his personal contacts the AG meeting was held in Budapest in 1898. An important motivation for organizing this meeting in Budapest

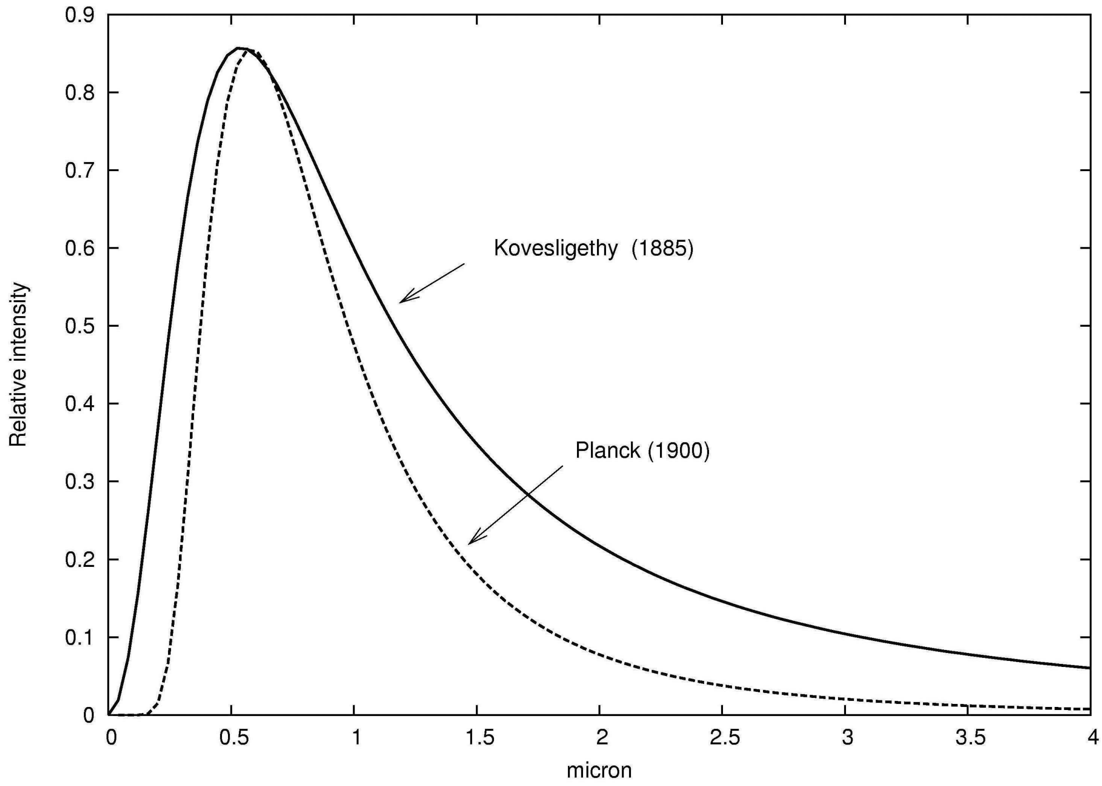

Figure 16.8: *Comparison of the spectral equations of Kövesligethy (1885) and Planck (1900) assuming T=5000 K black body temperature. The total radiated energy is finite in both cases. Note the striking similarity between the two curves although the assumptions and the functional forms are different in the two cases.*

was to have some international support for donating his institute to the Hungarian state.

The donation took place on May 20, 1899 and with the inauguration the Royal Hungarian Astrophysical Observatory began its activity. The scientific leadership of the Observatory consisted of

- Director: Miklós Konkoly Thege,
- Dep. Director: Radó Kövesligethy,
- Observer: Baron Béla Harkányi,
- Assistants : Antal Tass and Béla Szántó.

The donated institute was accepted by Baron Gyula Wlassics, minister of cultural affairs, who promised in the name of the state a new building and instruments.

16.4.1 The Scientific Programme of the 'Magyar Kir. Astrophysikai Obs'

The main program of the new institute (Royal Hungarian Astrophysical Observatory) was photometry. Photometry, that is the quantitative examination of light reaching us from celestial bodies, was born at the same time as spectroscopy and it was part of the process by which astrophysics revolutionized astronomy. They began photometry at Ógyalla by observing variable stars. The Observatory took part in the Potsdam program. Besides photometry regular observations of the Sun were carried out and simultaneous observations of meteors with other institutions were made, too. The Observatory provided "Time Services" for the Hungarian State Railways.

A significant event for them was the return of Comet Halley (1910). Regular observations of this comet were made at Ógyalla.

16.4.2 Stellar Photometry

As we mentioned above during the last period of the Konkoly era (starting with the donation in 1899) stellar photometry became the main field of research of the observatory. In order to get appropriate auxiliary equipments for stellar photometry they purchased a Töpfer wedge photometer and two (small and big) Zöllner photometers. Stellar photometry developed fast at the end of the 19th century and the new state observatory joined this work. The photometric survey carried out at Ógyalla supplemented the work performed in Potsdam. The catalogue, containing the magnitude of 2122

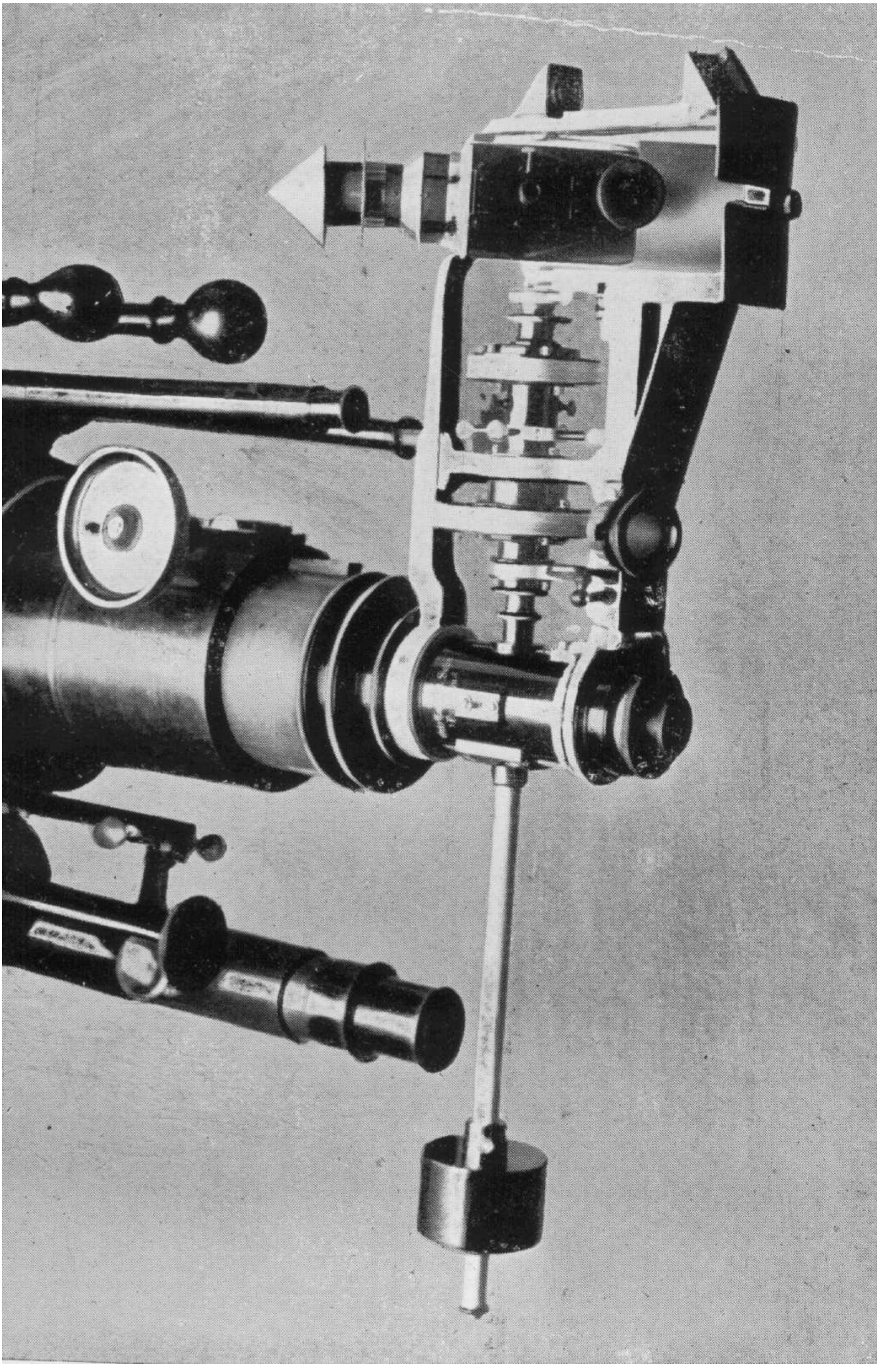

Figure 16.9: *Large and small Zöllner photometers, used in Ógyalla photometric programme*

stars brighter than 7.5 mag. in the $-10° - 0°$ zone, was published in 1916 (Tass & Terkán 1916).

Comparing the data with those made in the Harvard observatory, good agreement can be found (the standard deviation of the difference was about 0.1 mag., Zsoldos 1992).

They made photometric investigations of variable stars. From Sept. 19, 1900 regular observations of long period variables and some short period ones were made (from Tass (1904) to Tass (1918–1925).

A significant contribution was the 195 measurements of Nova Persei made by Baron Harkányi (Harkányi 1901). The last work on variables was the publication of the results on Nova Aquilae in 1918 (Kobold 1918).

16.4.3 Last Investments

In 1905 a new telescope – a photoheliograph – was purchased by the Hungarian State. It was followed by a 20-cm Heyde refractor in 1908.

The purchase of a 60-cm Heyde reflector was decided in 1913. The new state observatory also needed a bigger office building which was finished in 1913. The continuous development of this institution – among many other similar ones – was, however, broken by World War I. The purchase and installation of the 60-cm reflector was made only after the war and on the new place of the observatory at Svábhegy, Budapest.

The situation had changed from worse to disastrous. Miklós Konkoly Thege, the founder and the director of the Observatory died in 1916. The Austro-Hungarian Monarchy collapsed in 1918 and it resulted in separating Ógyalla from Hungary, being on the territory of the newly created Czechoslovak Republic. Since the instrumentation was the unalienable property of the Hungarian state it was transferred to Budapest.

16.5 Epilogue

It was decided in 1921 to build a new astronomical observatory on Svábhegy in Budapest. The first building, a small dome, housed a passage instrument: The observations started at the fall of 1922. The main building was completed in 1924–26, the big dome with a 60-cm telescope, Heyde-Zeiss, in 1927–28. The new era, the second 50 years has started.

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1. Eötvös 1964.
2. Kobold 2004.
3. Vargha 1999.
4. Vargha 1999.

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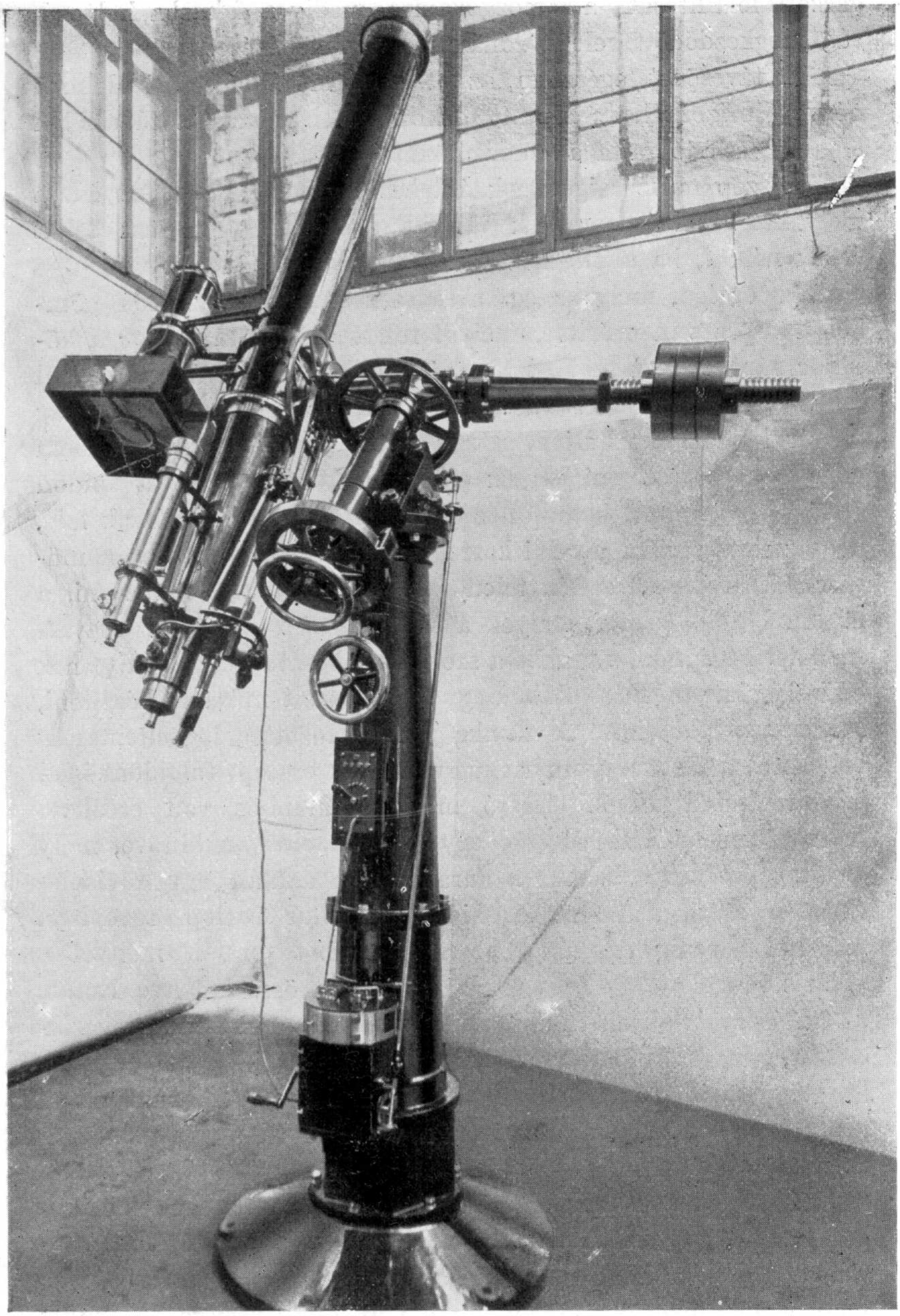

1. ábra. A 200 $^{m}/_{m}$ nyilású refraktor Heyde Gusztávtól Dresdenben.

Figure 16.10: *The last major investment: the 20 cm Heyde refractor (1908)*

Figure 16.11: *Main dome of the Konkoly Observatory*

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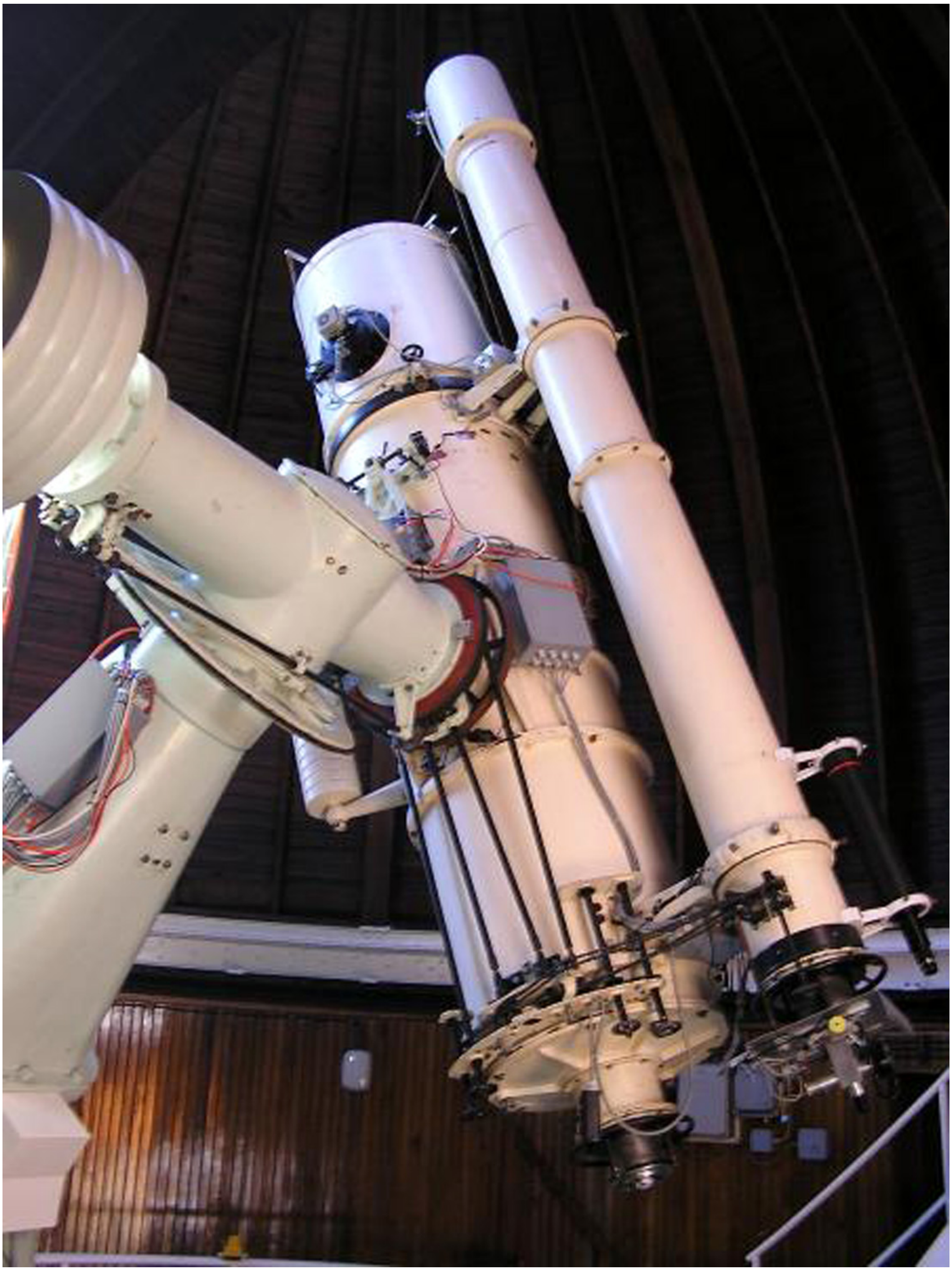

Figure 16.12: *Konkoly Observatory 60 cm Cassegrain reflector, Heyde-Zeiss (1928)*