SURVIVING DALLMEYER PHOTOHELIOGRAPH SOLAR IMAGES AT VILNIUS OBSERVATORY

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Abstract: This paper presents, for the first time, 283 previously unpublished solar photographs obtained with the Vilnius Dallmeyer photoheliograph, the second instrument of its kind in the world, and the first constructed by John Henry Dallmeyer. Built in 1863 and installed at Vilnius Observatory in 1864 the instrument embodied key innovations in optics and mechanics, inspired by the earlier Kew model. Despite its promise, the program faced dramatic setbacks: the successive deaths of two Directors, Friedrich Sabler and Matwej Gussew, in 1865 and 1866, soon after the project was launched, and a devastating fire in 1876 that destroyed the Western Dome and the photoheliograph itself. Nevertheless, under the direction of Pavel Smyslov, regular solar imaging was conducted from 1868 to 1876, resulting in approximately 900 photographs. Of these, the 283 surviving images, long overlooked and previously unpublished, are here catalogued, ordered, and partly illustrated for the first time, providing a unique, continuous record of sunspot activity from this early period of solar photography. In a future study, we plan to analyze this dataset in detail, shedding new light both on nineteenth-century solar variability and on the development of early astrophotographic methods.

Keywords: Vilnius Observatory; Dallmeyer heliograph; solar activity cycle; sunspots.

Here is the link to the 283 surviving images on ScienceDB: https://doi.org/10.57760/sciencedb.31949

1 INTRODUCTION

The invention of photography in the nineteenth century brought a profound transformation to astronomy. For the first time, celestial objects could be allegedly recorded with objective precision, removing the subjectivity of hand-drawn sketches. It revolutionized astronomy in ways that earlier generations could scarcely have imagined.

As Holmes (1918) reflected, had the medium existed in the time of William Herschel (1738–1822), many mysteries might have been clarified decades earlier. However, progress was swift once photography had been established. Holmes credits Louis Daguerre (1787–1851) and Joseph Nicéphore Niépce (1765–1833) with its public introduction in 1839, building on early chemical experiments by Thomas Wedgwood (1771–1805) and Humphry Davy (1778–1829). The first successful astronomical photograph is usually attributed to John William Draper (1811–1882), who captured an image of the Moon in 1840 (see e.g. Brasch, 2017; Brothers, 1866; Hughes, 2013; Trombino, 1980).

Only a few years later, Hippolyte Fizeau (1819–1896) and Léon Foucault (1819–1868) obtained the first daguerreotype of the Sun in 1845, marking the real beginning of solar photography (Flammarion and Quénisset, 1945). By the 1850s, Warren De la Rue (1815–1889; Hirshfeld, 2014) was producing high-quality lunar and solar photographs and had developed the first photoheliograph (Le Conte, 2011), used for daily solar observations beginning in 1862.

Other pioneers included Harvard's George Phillips Bond (1825–1865), who photographed stars and clusters in the early 1850s, and Lewis Morrison Rutherfurd (1816–1892), who advanced both celestial imaging and stellar spectroscopy in the 1860s.

These developments established photography not only as a visual supplement to astronomy but as a rigorous observational method. Among its most transformative applications was photoheliography—the systematic photographic recording of the solar disk—through which sunspots, prominences, flares and granulation could be measured with unprecedented consistency and objectivity (see e.g. Dominguez-Castro and Vaquero 2018; Harvey et al., 2017).

The first dedicated instrument for solar photography, the Kew Photoheliograph, was commissioned in England in 1854. It marked the beginning of regular solar imaging, establishing a model that observatories across Europe would soon follow. As photography rapidly advanced, solar observation emerged as a new frontier in astrophysical research. One of the earliest and most important instruments of this kind was built by the renowned British optician John Henry Dallmeyer (1830–1883).

In 1863, Dallmeyer constructed a custom photoheliograph for Vilnius Observatory. Commissioned by the Observatory's Director, Georg Friedrich Sabler (1810–1865), and approved by the influential astronomer Friedrich Georg Wilhelm von Struve (1819–1905), the instrument arrived in Vilnius in 1864 (Klimka, 1997). As noted in the *Dictionary of National Biography* (Stephen, 1888):

> To aid celestial photography Dallmeyer constructed a photo-heliograph for the Wilna observatory of the Russian government in 1863 ... This instrument was a complete success, and the Harvard College Observatory was supplied with a similar one in the following year.

The Dallmeyer photoheliograph of Vilnius was a precursor to a broader series of instruments. Dallmeyer went on to build at least eleven photoheliographs between 1863 and the 1870s, many of which were used in the 1874 transit of Venus expeditions sponsored by the British Government (Hughes, 2013). In anticipation of the transit,

> … instructions [had] therefore been given to Mr. Dallmeyer to construct, under the able supervision of Mr. De La Rue, five photo-heliographs, of a similar design to that made by him for the Wilna Observatory, and which has produced Sun-pictures of extreme sharpness of definition without sensible distortion. (RAS, 1872).

These expedition instruments were later assigned to the Royal Observatory and used for daily solar photography.

During the latter half of the nineteenth century, photoheliography expanded rapidly. At the Royal Greenwich Observatory, daily solar photography began in 1874, and a long-term series of measurements was compiled from images taken at multiple observatories using different telescopes and photographic techniques (Willis et al., 2016). In Melbourne, a Dallmeyer photoheliograph was used to capture the 1874 transit of Venus (Clark and Orchiston, 2004). Meanwhile, at the Infante D. Luiz Observatory in Lisbon, astronomers initiated a program of daily solar photography between 1871 and 1880 to investigate correlations between sunspot activity and geomagnetic variations (Bonifácio et al., 2007).

While the Vilnius Observatory photoheliograph is cited in various documents chronicling the early history of solar photography (e.g. Rayet, 1887; Scheiner, 1897), it is not discussed in broader monographs on the history of solar physics (e.g., see Hufbauer, 1991). This paper tells the story of the first Dallmeyer photoheliograph, the second of its kind in the world. We examine its origins, the challenges faced by early observers, its contributions to nineteenth-century solar astronomy, and the enduring scientific and historical value of its surviving photographs.

It is important to emphasize that the history and legacy of the photoheliograph at the Vilnius Observatory are significant not only from a historical perspective, but also because the recovery of its archival material (consisting of early solar photographs) is of great interest to contemporary geophysicists and solar astronomers. Numerous studies have been made possible thanks to photographic plates preserved in the archives of scientific institutions. The most prominent example is the Royal Greenwich Observatory (Willis et al., 2016), though several other notable cases also exist (see e.g. Aparicio et al., 2022; Carrasco et al., 2014; 2018; Curto et al., 2016).

2 THE ORIGINS OF THE VILNIUS PHOTOHELIOGRAPH: EARLY OBSERVATIONS AND CHALLENGES

Vilnius University Observatory, founded in 1753 (Figure 1), holds a unique place in the history of astronomy, not only as one of the oldest observatories in Europe, but also as one of the first observatories in the world established through the patronage of a woman, Elżbieta Magdalena Ogińska-Puzynina (~1680–1767). Her support, alongside the vision of the Jesuit mathematician and architect Thomas Żebrowski (1714–1758), allowed the project to begin at a time when scientific infrastructure was still rare in the region (see e.g. Klimka, 1997; 2003; Matulaitytė, 2004; Žitkevičius, 1979).

Throughout the eighteenth and early nineteenth centuries, the Observatory flourished. Directors such as Martin Poczobut (1728–1810) and Jan Śniadecki (1756–1830) expanded its capabilities with precision instruments from leading British and European makers like Jessie Ramsden (1735–1800) and John Dollond (1706–1761), and contributed significantly to the study of planetary motion, asteroids, and comets (Klimka, 2003). Even after the closure of Vilnius University by the Russian Empire in 1832, the Observatory remained active as a branch of the Pulkovo Observatory, laying the groundwork for a new era of astrophysical research.

Figure 1: Vilnius Observatory in summer 1875, photographed by Konrad Brandel. The right-hand dome housed the Dallmeyer photoheliograph (destroyed in the 1876 fire); the left-hand dome held the Schwerd photometer (which was saved). This is the only known nineteenth-century photograph showing both domes (credits: Konrad Brandel. From the album *Souvenir de Vilna*, 1875; courtesy: Hugo Scheu Museum, F3510-7).

That transformation began under Friedrich Sabler, who served as Director of Vilnius Observatory from 1854 until his death in 1865. In 1862, recognizing the growing importance of solar physics, Sabler proposed the acquisition of a photoheliograph, an instrument specifically designed for photographing the Sun. His initiative received the support of Wilhelm Struve, Director of the Imperial Pulkovo Observatory, who ensured institutional and financial support for this bold step (Klimka, 2003). That same summer, Sabler traveled to Cranford in London, where he received training in astronomical photography under the supervision of Warren De la Rue (RAS, 1863).

At that time, the Kew photoheliograph was operating at high capacity (De la Rue et al., 1867; 1869). According to the Kew Committee's 1862 report, a custom photoheliograph was already being constructed for Vilnius by John Henry Dallmeyer, a British optician known for his work in photographic and astronomical optics, incorporating all the improvements derived from Kew. The report noted that the instrument was expected to become operational in the spring of 1863, thus realizing the proposal by John Herschel (1756–1830) for daily solar imaging not only in England (BAAS, 1863).

The Dallmeyer No. 1 photoheliograph, delivered to Vilnius in 1864, incorporated several improvements over the first Kew instrument, including a motorized equatorial mount and an optical system with a four-foot focal length that projected a 100 mm solar image onto sensitized wet collodion plates. This was the most effecttive method then available for capturing fine solar detail. As Warren De la Rue (1871) later reported to the Royal Society, the Vilnius instrument produced better images than its English predecessor, due to advances in both optics and mechanics. That same summer of 1864 the Observatory recorded its first solar photographs, under the direction of Friedrich Sabler, marking a new scientific direction. However, Sabler's deteriorating health increasingly limited his ability to continue this task. As noted by Matwej Gussew (1866) in his obituary, Sabler suffered a prolonged and serious illness and passed away in Vilnius on 16 December 1865 at the age of 55.

His successor was Matwej Gussew (1826–1866), who briefly continued the photographic program during 1865–1866 but also died shortly thereafter, on 22 April 1866 (Matulaitytė, 2004). The systematic phase of solar photography at Vilnius began under Pavel Smyslov, Director from 1866 to 1891, who oversaw the construction of a dedicated dome for the instrument and initiated regular observations from 1868 onward (Klimka, 2003). He was assisted by Friedrich Wilhelm Julius von Berg (b. 1843), who was then engaged in Vilnius with celestial mechanics observations, including the determination of cometary and planetary distances based on three observations (e.g. von Berg, 1870; 1874; 1876). Von Berg was a graduate of the University of Dorpat (Tartu) and a former student of Johann Heinrich von Mädler (1794–1847; Matulaitytė, 2004), Director of Dorpat (Tartu) Observatory. Smyslow regularly submitted reports on the activities of the Observatory to the Academy of Sciences of Russia. In addition to their other responsibilities, Smyslow and von Berg prioritized the acquisition of high-quality solar images (*ibid.*).

However, the early years of the use of the photoheliograph were marked by several challenges. The deaths of Sabler and Gussew within a few years of the arrival of the instrument disrupted continuity. There were also technical and logistical delays, including the time required to construct the dome and train the staff in the use of photographic equipment. Moreover, as Gussew (1865) reported, local conditions at the Observatory severely limited image quality: atmospheric turbulence caused by solar heating of the metal dome, combined with dust and smoke from the city, led to frequent image distortion. The Sun was only visible for a few hours each day, and many exposures were rendered unusable because of blurry edges and poorly defined sunspot contours. Despite these difficulties, Gussew managed to produce at least two photographic negatives per day, one optimized for measurement and the other for printing, although more than half of them had to be discarded after microscopic inspection. Regular data collection only became sustainable from 1868 onward, once infrastructure and procedures had stabilized.

Once operational, however, the Vilnius photoheliograph became one of the earliest instruments in the world used for systematic photographic study of sunspots. Alongside other innovations, such as the acquisition of a Schwerd photometer in 1864 (Geyer, 2000) and a Merz spectroscope in 1870, the photoheliograph helped redefine the scientific identity of the Observatory in the late nineteenth century. The legacy of this instrument stands as a reminder of Vilnius' early involvement in solar astrophotography.

3 TECHNICAL SPECIFICATIONS OF THE INSTRUMENT, REGULAR OBSERVATIONS, AND SCIENTIFIC CONTRIBUTION

The Vilnius Dallmeyer photoheliograph, constructed in 1863, featured an objective with an aperture of 102 mm, a focal length of 1525 mm (f/15), and a total tube length of 2432 mm. The optical system projected a solar disk image of 100 mm at the focal plane, allowing for high-resolution photographic capture. The exposure time for each photograph was approximately 1/1000 of a second. For comparison, the first regular photoheliographic observations began at Kew Obser-vatory in 1862, using a smaller instrument with an aperture of 87 mm and a focal length of 1270 mm (f/14.6).

The Dallmeyer photoheliograph was delivered to Vilnius in 1864, and although the first solar images were taken in 1865, regular and systematic observations began only in 1868, following the construction of a dedicated dome for it. From then until 1876, when a destructive fire interrupted the program, the instrument was used to produce approximately 900 solar photographs, placing Vilnius among the earliest centers of systematic solar photography (see Hughes, 2013; Klimka, 1997; 2003; Matulaitytė, 2004; Žitkevičius, 1979).

Of these, 283 original images have survived to date, offering a rare and valuable dataset for historical solar research (Figure 2). After the closure of the Observatory, these materials were passed from one astronomer to another in an effort to ensure their preservation, particularly in view of the successive fires, wars, and looting that affected scientific collections in the region.

The distribution of the 283 surviving solar photographs taken at Vilnius Observatory between 1869 and 1874 reveals that the most productive years were 1873 and 1874, with 95 and 80 images, respectively (see Table 1), together accounting for nearly two-thirds of all preserved observations. In terms of seasonal activity (see Tables 2 and 3), the highest number of photographs were captured during the summer months, particularly in July (70 images) and August (50 images), followed by June (35). This seasonal trend reflects favorable weather conditions and longer daylight hours during the summer, which likely facilitated more consistent solar imaging. By contrast, November and December saw the fewest observations, with just 2 and 8 images, respectively.

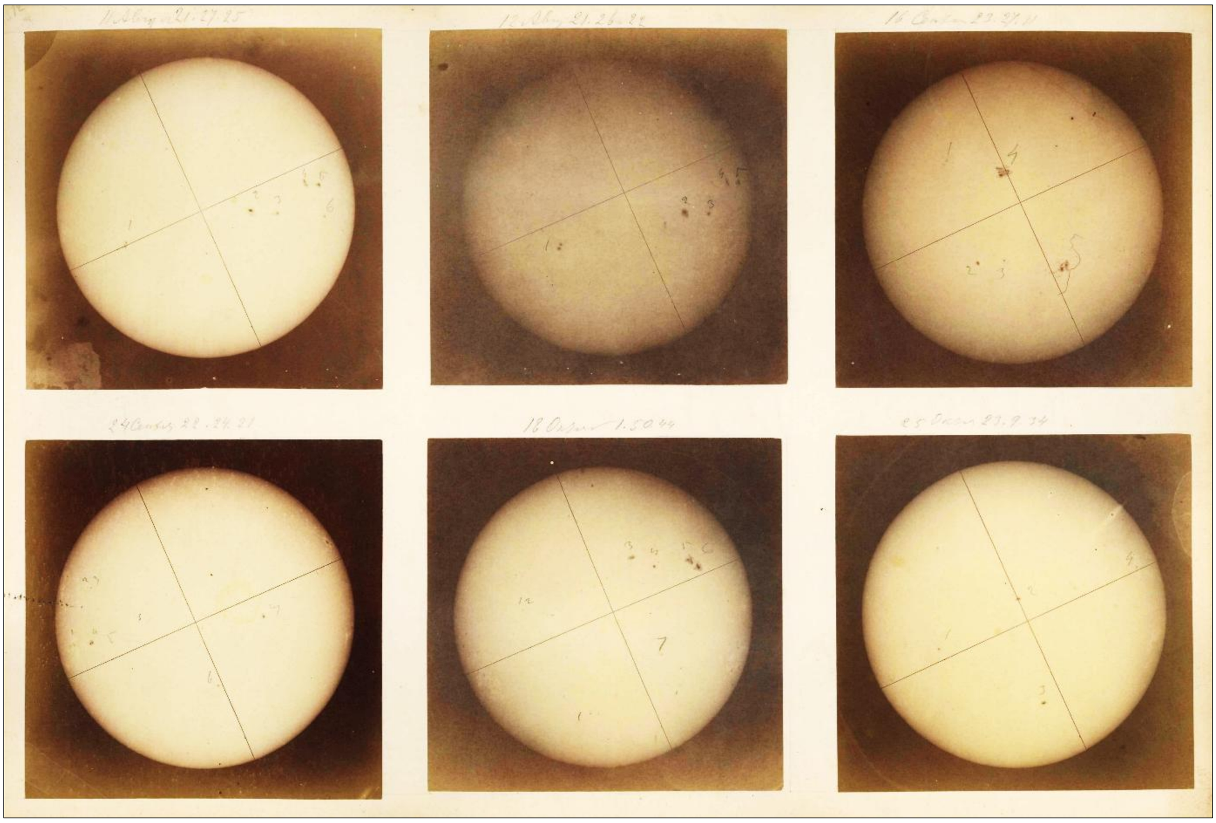

Figure 2: Solar photographs taken at the Vilnius Observatory in 1872 using the Dallmeyer No. 1 photoheliograph. The six images (dated 11 and 12 August, 16 and 24 September, and 18 and 25 October, respectively) capture sunspot activity at different stages across the late summer and autumn months. These originals are preserved today in the private archive of the authors. Links to the full set of solar images are: https://doi.org/10.57760/sciencedb.31949 (scienceDB) and https://doi.org/10.7910/DVN/SBMURU (Harvard Dataverse)

Table 1: Surviving solar photographs taken at the Vilnius Observatory between 1868 and 1876. Although approximately 900 images were originally produced, only 283 plates have survived. The most complete annual datasets date from 1873 and 1874.

Year	Images Taken	Notes
1869	18	Sparse coverage
1870	6	Sparse coverage
1871	60	Partial year
1872	24	Fragmentary
1873	80	Nearly complete
1874	95	Nearly complete
Total	283	Surviving images

The scientific significance of the Vilnius solar series lies in its early and regular documentation of sunspot activity, which complements parallel efforts at Kew and later at Greenwich. These observations, produced under varying seasonal and atmospheric conditions in Eastern Europe, contribute to the broader reconstruction of solar behavior during a crucial period in the development of solar physics.

4 THE 1876 FIRE AND LEGACY OF THE VILNIUS PHOTOHELIOGRAPH

Vilnius Observatory became renowned for its solar observations and recordings, establishing

Table 2: Total number of surviving solar photographs per month and year (1869–1874).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1869	0	0	0	0	0	6	0	10	2	0	0	0	18
1870	0	0	0	0	0	0	6	0	0	0	0	0	6
1871	0	0	6	0	2	8	26	18	0	0	0	0	60
1872	0	0	0	0	5	7	6	2	2	2	0	0	24
1873	4	9	5	0	0	0	16	14	10	15	0	7	80
1874	2	6	10	9	10	12	14	7	5	6	2	1	95
Total	6	15	21	9	17	33	68	51	19	23	2	8	283

Table 3: The 283 surviving solar photographs, organized by date. Each number represents the day of the month; numbers in parentheses indicate how many images were taken on that day.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1869						12, 13, 17, 26, 28, 29		4, 6, 14, 17, 20, 21, 26, 27, 28, 30	3, 4			
1870							8(2), 9, 11, 15(2)					
1871			19, 20, 22, 23(2), 25		23, 24	4, 15, 16(2), 17(4)	2(2), 3(2), 4, 7(3), 10(2), 11, 12(5), 13, 14, 16(2), 19, 22, 23, 24, 28, 29	3(2), 4, 8, 10(4), 12, 13(3), 23(2), 28(3), 29				
1872					15, 21, 27, 28, 31	1(2), 3, 4, 6, 7(2)	18, 21(2), 23, 25, 27	11, 12	16, 24	18, 25		
1873	26, 27, 28, 29	1, 3, 4, 5(2), 12, 16, 23, 26	10(2), 20, 23, 24				3, 6, 8(2), 9, 10, 19, 25, 26(2), 27(4), 31(2)	8(3), 9, 10, 12, 15, 16(2), 19, 22, 23(2), 26	13(2), 15, 17(2), 24, 27(2), 29, 30	2(2), 4, 6, 7, 8, 9, 14, 19, 20, 24, 28, 29, 30(2)		2, 4, 10(2), 12, 28, 29
1874	31 (2)	4, 9, 10, 24, 26, 28(2)	1, 5(4), 10, 16(2), 21, 23, 24, 25(2)	3, 6(2), 7, 10, 11(2), 21, 22, 24	3, 5, 6, 10, 11, 14, 17, 18, 22, 26	3, 5, 6, 9, 14, 15, 18, 23, 24(2), 25, 26, 29(2)	3, 4(3), 7(2), 9, 11(2), 12, 19, 20(2), 23(2), 27	8, 10(2), 13(2), 17	14, 21, 22, 23(2), 30	1, 3, 16(2), 17(2), 20, 30	2, 3	4

contact with numerous scientific institutions and and individual scholars in England, Austria, Italy, France, Germany, and even South Africa (Matulaitytė, 2004). The program of systematic solar photography at Vilnius Observatory came to an abrupt end in 1876, when a devastating fire swept through the Observatory building. The flames completely destroyed the Western Dome, which housed the Dallmeyer No. 1 photoheliograph, along with associated equipment, photographic archives, and much of the Observatory's infrastructure. Although some instruments such as the Schwerd photometer (only four units of which had been manufactured, *ibid.*), were recovered from the Eastern Dome (see Figure 3), the loss of the photoheliograph brought the Observatory's pioneering solar imaging program to a close. No further photoheliographic observations were conducted at the Observatory during the nineteenth century.

Figure 3: Present-day detail of F.M. Schwerd's visual photometer, originally located in the Eastern Dome, one of the few instruments that survived the 1876 fire (photograph: Carlos Viscasillas Vázquez).

5 CONCLUDING REMARKS

Despite its relatively short operational lifespan, the Vilnius photoheliograph project holds a special place in the history of astronomy. It was the second institution in the world, after Kew Observatory, to undertake systematic solar photography. At a time when astrophysics was emerging as a discipline distinct from classical positional astronomy, the work done in Vilnius represented a bold and early shift toward the use of imaging technologies to study solar activity.

The instrument itself, Dallmeyer No. 1, was the first photoheliograph ever constructed by John Henry Dallmeyer and served as a prototype for later instruments, including those used in the 1874 Transit of Venus expeditions. Its design, based on the optical and mechanical innovations of Warren De la Rue and supported by the scientific vision of personalities like Friedrich Sabler and Wilhelm Struve, helped define the technical standards for solar imaging in the decades that followed.

The surviving 283 solar photographs from Vilnius remain an invaluable scientific and historical resource. In particular, the nearly complete sets from 1873 and 1874 offer rare continuous records of sunspot activity during this early period. These images continue to be studied by historians of science and solar physicists alike, contributing to reconstructions of long-term solar variability.

Preserving the legacy of the Vilnius photoheliograph is essential not only to honor the contributions of this early observatory and to improve our understanding of the global development of solar astrophysics and astronomical instrumentation in the nineteenth century but also to provide a better assessment of the solar activity in that period. We must not forget the important role that the solar images described in this paper can play as a natural bridge between the early sunspot photographs taken at Kew and those later taken at the Royal Greenwich Observatory. The international scientific community continues to work on catalogs of sunspots (and other observable features on the solar disk), merging the data obtained by several observatories, with the goal of obtaining catalogs covering long periods of time (Lefevre and Clette, 2014). The Vilnius images could be an important element in carrying out these activities. We hope to present a detailed analysis of the early photographs described in this work in future works.

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His research focuses on the chemical and dynamical evolution of the Milky Way. He is the Principal Investigator of the project "Unveiling the Nature of Hot Subdwarfs". Dr. Viscasillas Vázquez is actively involved in major international collaborations, including the Gaia ESO Survey, the High-Resolution Multi-Object Spectrograph, the William Herschell Telescope Enhanced Area Velocity Explorer, and the Wide-Field Spectroscopic Telescope.

He is a member of the Executive Committee of the European Association for Astronomy Education, a Board member of the Advanced Composition Explorer Baltic, and a member of the Committee of the Northern Europe Hub of the Europlanet Society. At the International Astronomical Union (IAU) he serves as Vice-National Outreach Coordinator for Lithuania and is a member of several Divisions and Working Groups, including the Working Group (WG) on Star Names and the Executive Committee WG on Junior Members.

He also contributes to the *AstroGen Project* of the American Astronomical Society. In 2025, he was awarded the Rector's Science Award of Vilnius University.

Dr. Kazimieras Černis (born in Vilnius, Lithuania) is a Senior Researcher at the Institute of Theoretical Physics and Astronomy, Vilnius University. He earned his PhD degree from Vilnius University. Since 1994, Černis has been a member of the IAU.

He has conducted observations at Molėtai Observatory (Lithuania), Maidanak Observatory (Uzbekistan), Mount Lemmon Observatory and Mount Graham Observatory (Arizona, USA), as well as at Baldone Observatory (Latvia). His research focuses on stellar photometry, spectral classification of stars, astrometry of small Solar System bodies, and the discovery of new asteroids and comets.

His main work is related to the investigation of dust cloud distributions and their absorbing properties in various directions in the Galaxy, including star-forming regions and dark clouds in Taurus, Perseus, Camelopardalis, Orion, Aries, Aquila, Cygnus, and other Galactic regions. The primary goal of these studies is to determine the interstellar extinction law in the densest regions of dark clouds, as well as to establish distances to dark clouds and young stellar objects.

In addition, Černis has been actively involved in the discovery of new comets and asteroids. He discovered three comets using visual instruments: C/1980 O1 (Cernis–Petrauskas), C/1983 O1 (Cernis), and C/1990 E1 (Cernis–Kiuchi–Nakamura). He also discovered 23 comets using CCD images taken by the Solar and Heliospheric Observatory (SOHO), including the short-period comet 322P/SOHO and several bright SWAN comets (discovered with the Solar Wind Anisotropies Instrument on SOHO).

Using various photographic telescopes, Černis discovered about 500 asteroids, 150 of which have been named. He is a co-discoverer of two trans-Neptunian objects (2012 BX85 Praamžius and 2021 XD7), three Centaurs (2009 HW77 Orius, 2012 DS85, and 2012 VU85), as well as many Trojan and near-Earth objects.

José Manuel Vaquero is Professor of Earth Physics at the University of Extremadura (Spain).

His research focuses primarily on solar–terrestrial relations and climate variability over the past several centuries, while also extending to the history and teaching of astronomy and the geosciences.

His work on reconstructing four centuries of solar activity from historical sunspot records was featured on the cover of *Nature Astronomy* in March 2019. He is co-author of *The Sun Recorded Through History* (Springer, 2009, with M. Vázquez) and has published in Spanish a biography of Galileo (2003), a guide to sundials in Extremadura (2020), and a translation with critical commentary of Gauss' *General Theory of Terrestrial Magnetism* (2021).

A dedicated bibliophile, he also collects old scientific books.