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National and international astronomical activities in Chile 1849–2002

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Abstract. At all times and in many ways, Chilean astronomy has been influenced externally, either by astronomical expeditions from other parts of the world, or by astronomers that immigrated from other countries. We outline the history of the Chilean National Observatory, beginning with its origins out of Gilliss' US Naval Expedition to the Southern Hemisphere, over its directors Moesta, Vergara, Obrecht, Ristenpart to the middle of the 20th century, as well as the astronomical development at the Universidad Católica. In addition, various international expeditions, which aimed at observations of solar eclipses, the Venus transit of 1882, and the Mars opposition of 1907, were carried out. While a major photometric project of Harvard Observatory was active for only six weeks in the north of Chile, the spectroscopic Mills expedition of Lick Observatory in Santiago lasted several decades, and the solar observatory of the Smithsonian Astrophysical Observatory near Calama even longer. Finally we give a brief overview of the evolution and the actual state of the international observatories Cerro Tololo, La Silla, Paranal, and Las Campanas.

1. Introduction

Because of its excellent climatic conditions, Chile has become the "mecca" of observational astronomy. Large international observatories like the Cerro Tololo Inter-American Observatory (CTIO), the European Southern Observatory (ESO, with observing stations on the mountains La Silla und Paranal), and Las Campanas Observatory (LCO) of the Carnegie Institution of Washington were established in recent decades. Chile will remain in focus of astronomical research in the future, when the Atacama Large Millimeter Array (ALMA) and the next generation of large optical telescopes will be built there. Therefore it appears to be of interest to examine the astronomical activities in Chile's past, which date back 150 years.

All students of the history of astronomy in Chile will highly esteem Keenan et al.'s (1985) book *The Chilean National Astronomical Observatory (1852–1965)*. It did not have a wide circulation, and focuses on the history of the National Observatory (and its successor, the present Astronomy Department of the Universidad de Chile at Cerro Calan). Another precious account on the history of the National Observatory till about 1923 was given by Pyenson (1993). I have extracted valuable information from these sources, but I have

Figure 1. Gilliss' (1855) observing station on the hill of Santa Lucia in Santiago. The two observing huts are located on the right side of the mountain. Illustration from Vol. I of Gilliss' report.

tried to describe in similar detail activities of other persons and institutions, to give a more general, albeit necessarily compact overview on the evolution of optical astronomy in Chile.

2. The beginnings of the Chilean National Observatory

When James M. Gilliss (1811–1865), Lieutenant of the US Navy and founder of the US Naval Observatory, spent the time between December 1849 to August 1852 with his assistants in Chile, he not only made astronomical observations of stars and planets from the top of Santa Lucia (Fig. 1) – a picturesque hill at the outskirts of Santiago, but he also described the country and its inhabitants, geography and geology, animals and plants, commerce and politics, earth's magnetism and seismology. Four large volumes of the description of his expedition were presented to the House of Representatives. Two out of the planned six volumes, containing catalogues of 1963 and 16748 stars, respectively, appeared with a delay of several decades, in 1870 and 1895, the reason being lacking financial support to pay (human) calculators (Gilliss 1855).

The aim of Gilliss' *US Naval Expedition to the Southern Hemisphere*, which had been supported by congress with $ 5000, was a new determination of the solar parallax, based on simultaneous observations of the declinations of the planets Venus and Mars, carried out simultaneously from the northern and southern hemisphere of the Earth. The method had been proposed by Christian Ludwig Gerling (1788–1864), a mathematics professor at Marburg University in Germany (Gerling 1847), and had been enthusiastically accepted by Gilliss (1850). These measurements were to be carried out around the time of the opposition of Mars (when Mars is closest to Earth), and at the times of stationary phases of Venus (when Sun, Venus and Earth form a right triangle). Unfortunately it was

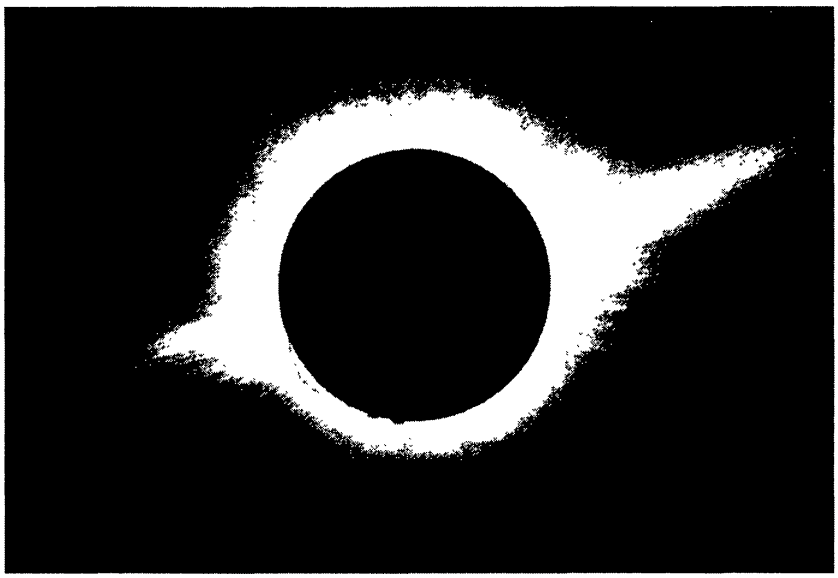

Figure 2. Illustration of the solar eclipse of November 30, 1853, from Moesta (1854a) (US Naval Observatory Library).

later found that the planned simultaneous observations in the northern hemisphere, carried out in Washington, Greenwich and Cambridge (England), were inferior to those of Santiago both in number and quality. Benjamin A. Gould (1824–1896), who analyzed the material, obtained a value of $8''.5000$ for the solar parallax (Gilliss, 1855, vol. III). From the modern point of view, this was no improvement, compared with the value of $8''.57116 \pm 0''.0370$ derived by Encke (1824) from the observations of the famous Venus transits of 1761 and 1769. Nevertheless, Gilliss' expedition marks the beginning of astronomical research in Chile. He obtained permission to sell his instruments to the Chilean government: a 4-inch meridian circle and a 6-inch equatorially mounted refractor. They became the basis of the Chilean National Observatory.

In 1849, Carl Wilhelm Moesta (1825–1884) had obtained his PhD in Marburg under Gerling with the thesis *Über ein neues Krümmungsmass für die Curven im Raume*. Afterwards, he went to Chile, and first took part in the geodetic survey. But soon he was one of the local assistants of Gilliss on Cerro Santa Lucia. Recommended by Gilliss and Gerling, he was appointed first director of the National Observatory.

One of Moesta's first documented astronomical activities was the observation of the total solar eclipse of November 30, 1853, about which he wrote articles in the *Astronomical Journal*, the *Monthly Notices of the Royal Astronomical Society*, and the *Astronomische Nachrichten*, as well as in the – perhaps first – special astronomical publication in Chile, written in Spanish (Moesta 1854a). This 22-page pamphlet reports Moesta's sea trip to the Peruvian coastal town Pisco, which he thought unsuitable because of the frequent cloud cover, the continuation of his trip to the inland town Ica, the capital of the province of the same name, and from there to the hacienda Ocucaje, where he could observe the eclipse under clear shies. The report includes an illustration (Fig. 2), which shows, besides an extended prominence and the streamer-type corona, also two

strange lunar mountains of quadratic form, extending from the lunar limb by one arc minute. This phenomenon, presumably seen also by other observers, remains unexplained till today. Meteorologic observations and position determinations of Ocucaje, Ica and Pisco conclude the report.

Moesta's observations in Santiago soon revealed that the place of the Santa Lucia observatory was unsuited for precision work, and that the instruments were too imprecise. He showed that the daily solar irradiation caused a periodic motion of the position of the mountaintop and the observing station (Moesta 1854b), and submitted plans for a new observatory, and the Chilean government started its construction in 1857 in the suburb of *Quinta Normal.* Also, new instruments were acquired. The Astronomische Nachrichten carry numerous articles by Moesta on solar and lunar eclipses, as well as observations of comets and minor planets. 1859 saw the publication of a catalog of positions of 999 stars, which is based on the meridian circle observations on Santa Lucia, carried out in 1853–1855 (Moesta 1859). In 1862, he undertook with his assistants meridian circle observations of Mars, in collaboration with eight other observatories, for the determination of the solar parallax. An analysis of the observations was made, in 1867, by Newcomb (1867), and yielded a value of 148 800 000 km for the astronomical unit, correponding to a parallax of $8''.832$. Thus the earth-sun distance was for the first time determined with an accuracy of 0.1 per cent; the result superseded that based on the Venus transit observations of 1761 and 1769, as derived by Encke.

In 1865, Moesta undertook a trip to Germany in order to acquire new instruments. He participated in the first meeting of the Astronomische Gesellschaft in Leipzig (31.8.–2.9.1865), where he reported on the work carried out at "St. Jago" observatory since its foundation, but because of his declining health, he did not return to Chile. Reports by the observatory mechanic Louis Grosch (–1902) on two expeditions to observe total solar eclipses in 1865 and 1867, were sent to the editors of the Astronomische Nachrichten, the first one by Moesta (1865), the second one by Grosch (1867). While the total solar eclipse of April 25, 1865, which was observed from the hacienda San Cristóbal (south of Concepción), did not produce valuable results because of clouds and cirrus, the second one of August 29, 1867, observed from the hacienda Colchagua (south of Santiago at the latitude of San Fernando at the river Tinguiririca), was much more interesting. Besides a series of well-developed prominences, noticeable coronal polar streamers were observed, which are typical for the time of a solar spot minimum.

In 1865, Moesta settled in Dresden, where he served as Chilean consul. He kept his contacts with the former collaborators in Santiago, he continued to publish in the *Astronomische Nachrichten*, and edited a second catalog of 3309 stars, which appeared in Dresden (Moesta 1875), and was based on the measurements of 1856–1860. When he died in 1884, observations and reductions from later years, when the observatory had already moved to the Quinta Normal, remained unpublished and were lost (Drechsler 1884).

When after a few years it became clear that Moesta would not return to Chile, his former assistant José Vergara (1832 (1837?)–1889) was appointed director of the National Observatory. He kept this appointment from 1867 to 1875 and from 1881 to 1889. Since Vergara was also in charge of meteorological, geographical and seismic studies, and furthermore became *Intendente* of the

Figure 3. The German Venus transit expedition members in Punta Arenas, November 1882. From left to right: Kempf, Küstner, Auwers, Steinmann, Schwab, and the servant Bohne. (Akademiearchiv, Berlin-Brandenburgische Akademie der Wissenschaften).

Talca region, as well as secretary of justice, of learning and of the interior, his astronomical activities remained at low level.

3. The Venus transit of December 6, 1882

The Venus transit of December 6, 1882 was mainly visible in the western hemisphere, and several groups of astronomers also came to Chile: from France, Belgium, the United States of America, and from Germany. The first three groups chose Santiago and its nearer surroundings as an observing ground, while the German team, one out of four expeditions financed by the German Empire, went to Punta Arenas in Southern Chile. Its members were Arthur Auwers (1838–1915) and Friedrich Küstner (1856–1936), both from Berlin Observatory, Paul Kempf (1855–1920) from the Astrophysical Observatory Potsdam, the mechanic Friedrich Schwab (1858–1931) from Marburg and the geologist Gustav Steinmann (1856–1929) from Strassburg.

A detailed report is given by Auwers (1889). The participants left Hamburg on September 10, 1882, and, after a stopover in Montevideo, reached Punta Arenas on October 17, where they carried out heliometer and other observations until January 2, 1883.

In 1883, Luis Zegers (1849– after 1906), a professor of physics at the University of Chile, wrote a report on the three other research expeditions. Zegers himself served as an assistant with the French expedition. This group, lead by Octave-Marie-Gabriel-Joachim de Bernardières (1845–1900), had installed an

observing station on the grounds of the hacienda Cerro Negro, near the small town of San Bernardo, 20 km south of Santiago. Two equatorially mounted refractors of 8 and 6 inch aperture, as well as a portable meridian circle (which was also used for finding the geographical position), were used to determine the times of contact. A final report of the 1882 French expeditions was apparently never published.

The Royal Observatory of Brussels had sent out two expeditions, equipped with specially constructed heliometers. One expedition, headed by the director Jean-Charles Houzeau (1820–1888), was bound to San Antonio, Texas, the other one to Santiago de Chile. Members of the southern expedition were the astronomer Louis Niesten (1844–1920) and his brother Joseph, a commanding artillery captain, and the assistant astronomer Charles Lagrange (1851–1932). The expedition left Antwerp on July 31, 1882, and arrived on August 27 in Valparaiso. On September 2, they erected their telescopes in the garden of the National Observatory. December 6, 1882, the day of the transit was sunny, the transit was observed from 9 am to 5 pm. Departure from Santiago was on New year's day 1883, and the expedition returned to Europe by the end of February. The report of the two expeditions comprises a collection of drawings of the transit, mainly phenomena connected with the second and third transits.

The heliometers employed by the Brussels astronomers were equipped with half-objectives with different focal lengths (i.e. the short-focus lens was positioned deep in the telescope tube), so that a bright solar image could be brought in coincidence with a practically equally big Venus image, thereby permitting the determination with higher precision of the path of Venus across the solar disk. From the paths observed in San Antonio and Santiago, Houzeau and his collaborators derived a solar parallax of $8''.911 \pm 0''.084$ (Houzeau 1884).

The third group in Santiago was the US-American, directed by Lewis Boss (1846–1912). They planned mainly photographic observations, which had been put aside – after the experiences of the Venus transit of 1874 – by the German astronomers, because they were thought to be unreliable. Boss and his assistants put up their instruments on the grounds of an ammunition factory in Santiago. Observing stations in Washington (DC), Cedar Keys (Florida), San Antonio (Texas), Cerro Roblero (New Mexico), Princeton (New Jersey), Lick Observatory (California), Wellington (South Africa), Santa Cruz (Patagonia) and Auckland (New Zealand) contributed 1475 photographs, which according to Harkness (1888) yielded a solar parallax of $8''.847 \pm 0''.012$.

The last 50 pages of Zegers' report deal with the activities of the National Observatory, where Vergara, after his intermezzo as governor of the Talca region had resumed his activity. Even Moesta, as a *grey eminence* in the background, had participated in Paris, in 1881, in an international conference for the preparation of the second Venus transit of the 19th century.

Zegers first gives a report on the history of the observatory since its foundation. and then mainly describes the problems arising: instruments covered with rust, insufficient library holdings, foreign publications kept back at the Valparaiso customs office, missing funds for the publication of own works, assistants with failing health. Zegers' notes indicate that besides the director, only his son Luis Vergara and the above-mentioned observatory mechanic Louis Grosch assisted in the observations. This 50-page lamento on the situation of the National

Observatory is followed, without further commentary, by a seven-line section on contact times, to which is added, as a footnote "we owe this data to the alacrity of the director of the National Observatory."

4. The activities of Harvard and Lick in the North of Chile

Harvard College Observatory used a grant received by U. Boyden, amounting to 238 000 US-Dollars, in order to install a Southern Station which had been planned for a long time (Jones & Boyd 1971). The first station was installed, in 1889, by Solon I. Bailey (1854–1931) on the mountain "Mt. Harvard" in Bolivia. There the climatic conditions turned out extremely unfavorable, and the following year it was decided to move the station to Arequipa (Peru). Under the direction of William H. Pickering (1846–1938), brother of the director of Harvard Observatory, a station with a luxurious villa was constructed in early 1891 in the outskirts of the city. The construction of the villa used up a major part of the funding, led to a rapid dismissal of W. Pickering, and the installation of Bailey as the director of the southern station. Only in 1927, after comparative climatical studies, the Harvard southern station was moved from Peru to South Africa, into the vicinity of the small town Bloemfontein, where it remained in operation until the 1950s. In the course of time, other telescopes from other countries and organisations were put up at the South African station. This is the reason why for a long time European astronomers favored South Africa as the place where the telescopes of the European Southern Observatory should be put up: Bloemfontein is a better place than Arequipa – but the north of Chile has a much better climate than both these locations, as had been shown by other expeditions before.

Before the setup of the station in Arequipa, Bailey carried out between 1889 and 1891 photometric observations of southern stars by means of a visual meridian photometer. These observations served as a foundation for the Harvard photometry (brightness measurements of all stars in the sky up to 6th magnitude). This photometry later served as a base of the Harvard Revised Photometry and the Bright Star Catalog, which until today is a useful tool of the astronomer. Part of the observations was carried out – besides Mt. Harvard (Bolivia) and Arequipa – during a six-week stay in Pampa Central, in early 1890 (Bailey 1895). Pampa Central is a salpeter mine and a railroad station between Antofagasta and Calama. In the immediate surroundings of Pampa Central, one encounters today the relatively well-preserved remains of the salpeter mine Chacabuco, which served as a camp for political prisoners in the time of the military dictatorship, and which has now been converted into a museum.

Already Bailey had pointed out the excellent observing conditions in Pampa Central; because of the lack of water and the poor accessibility of this location, it was decided that the permanent Harvard southern station should be put up in the vicinity of the major city Arequipa.

After the installation of the station in Arequipa, William H. Pickering, the Harvard College Observatory director's brother, undertook an expedition to the totality zone of the solar eclipse of April 16, 1893, accompanied by his assistants Andrew E. Douglass (1867–1962) and Abbott L. Rotch (1861–1912). Their camp was put up in Mina Aris, near the former iron foundry Agua Amarga (located

Figure 4. The eclipse camera of J.M. Schaeberle (right), as well as other observing instruments, erected on a slope near Mina Bronces. J.M. Schaeberle is in front of the eclipse camera. (Lick Observatory, prepared by A.A. Misch).

between the towns of Domeyko and Vallenar, near the location of today's observatories La Silla and Las Campanas), which today is just a collection of huts. Also the director of the Chilean National Observatory and his assistant had travelled there to observe the eclipse. In spite of the fact that the observing conditions were splendid, results of these expeditions are poorly documented.

Another North American observer was John Martin Schaeberle (1853–1924) of Lick Observatory, who undertook the expedition single-handedly. In Mina Bronces, a mine in the eclipse zone, he hired a crew composed of mine workers and leading employees to assist him in his observations. They assembled his main instrument, a long focus camera, which did not have a mounting but was simply put up on a suitable slope and pointed towards the calculated solar position at the time of the eclipse (Fig. 4). With the help of this camera, he obtained a series of remarkable photographs of the solar corona, and on one of the plates he discovered the sungrazing comet of 1893 (Schaeberle 1895).

Another short-lived astronomical activity in the north of Chile took place at the time of the opposition of Mars in 1907. David P. Todd (1855–1939), astronomy professor at Amherst College, Massachusetts, and Earl C. Slipher (1883–1964), astronomer at Lowell Observatory, Flagstaff, Arizona put up the 18-inch refractor of Amherst College in Alianza, a mine located about 70 km inland of the coastal city of Iquique, which is situated about halfway between Antofagasta and the northern border. In the course of three months, 13 000 photographs of Mars were taken, which are among the best earthbound photographs of this planet. A selection of these photographs is shown in Slipher's (1962) book on Mars.

5. The National Observatory under Obrecht and Ristenpart

Shortly before Moesta's death in 1885, Vergara had asked him to hire two German assistants for the National Observatory, but these – Adolf Marcuse (1860–1930) and Wilhelm Wickmann – stayed only for a short time: after a quarrel with the director, the first one returned to Berlin where he became a private docent at Berlin university, the second one went to Quito (Ecuador), where he held the position of observatory director between 1887 and 1895; according to the list of members of the Astronomische Gesellschaft, he was still living there in 1904. After the somewhat disappointing experience with German assitants, Vergara, in 1888, appointed three French astronomers as assistants. The position of first assistant was held by Albert Obrecht (1858–1924), who originally came from Alsatia, but had been trained in Paris. After Vergara's death, in 1889, Obrecht was appointed director of the National Observatory.

In 1887, Vergara had promised to the international astrophotographic conference, which was held in Paris to prepare the enterprise of the *Carte du Ciel* and the *Astrographic Catalogue*, that Santiago would take over the observations and reductions of the zones $-17°$ to $-23°$, and Obrecht saw himself involved in this project. But his astronomical activities, which were focused more on theoretical studies, were even more hampered by teaching activities. The astrographic camera was delivered in 1893, and erected in the following year. The assistant who had been sent to Paris for training died, spare parts of the camera were lacking, the delivery of large-sized photographic plates turned out to be problematic: in short, the project did not make progress. Obrecht's assistant Ernst (Ernesto) Greve, of German-Chilean origin, undertook a trip to Europe in 1905–06 to undertake studies at observatories in order to bring forward the project of the photographic sky map. But after his return, Greve did not see any promotion at Santiago observatory, and he took a position in the office of geodesy, where he became soon involved.

When the Chilean president Pedro Montt, who took an active personal interest in astronomy, came into power, he was not pleased with the work at the National Observatory. Since Moesta's departure, hardly any astronomical progress had been made at the observatory, no significant publications, just intentions to do something. Therefore, in 1908, Pedro Montt appointed Friedrich Wilhelm Ristenpart (1868–1913) to be the new director of the National Observatory, and put him in charge to re-organize it, while Obrecht continued his teaching activities at the university. Before his appointment, Ristenpart had been private docent at Berlin University and employee of the Berlin Academy (head of the office for the work on the *Geschichte des Fixsternhimmels*, which had been brought into existence by Ristenpart himself). He brought his assistants from Germany: Richard Prager (1883–1945) and Walter Zurhellen (1880–1916), which were appointed heads of the "calculating department" and the "astrophotographic department". Thus Zurhellen was in charge of the project of the photographic sky map. Under Ristenpart's leadership, the National Observatory moved from the center of the city (Quinta Normal) to the southern suburb *Lo Espejo*, where it remained until the early 1950s, when it was moved to the present location, Cerro Calán in the east of Santiago.

Fate would turn out to be harsh to the German team. In 1912, Zurhellen sent in his resignation, because of personal problems with his director. The sky

map project, for which half of the plates had been taken, hardly experienced any progress, and was finally taken over by other observatories. Zurhellen became a member of the Berlin-Babelsberg Observatory, and took part in a solar eclipse expedition to southern Russia in summer 1914. Interned because of the outbreak of WW I, he could return to Germany only after one year, and, in 1916, lost his life at the western front.

Pedro Montt died in 1910. After the president's protecting hand was missing, Ristenpart was faced with increasing difficulties with the Chilean government. Even a press campaign was started against him. Facing the fact that his contract would not be renewed, he committed suicide in 1913.

Subsequently, his assistant Prager returned to Berlin-Babelsberg Observatory, where he remained for another 25 years, mainly occupied by compiling an extensive bibliography of variable stars. Discharged by the Nazis, he found a place to work at Harvard College Observatory, and died in 1945.

After Ristenpart's death, his predecessor Obrecht again assumed the directorship of the National Observatory, and tried to push back all the changes that had occurred in the meantime. Work at the observatory came almost to a complete halt.

6. The Mills expedition, Cerro San Cristóbal and the astronomy at the Universidad Catolica

In the meantime, in 1903, an observing station of Lick Observatory had been installed on Cerro San Cristóbal, a small mountain rising at the outskirts of Santiago. The new director of Lick Observatory, William W. Campbell (1862–1938), had started an ambitious radial-velocity survey on Mount Hamilton, which should comprise all naked-eye stars, and therefore made observations on the southern hemisphere necessary. At Lick Observatory, the spectrograph was attached to the world's second largest refractor, the 36-inch, which had cost a fortune and had taken decades until completion. The New York banker Darius O. Mills granted the necessary funds to build a – noticeably less expensive – 0.94-m reflecting telescope equipped with a spectrograph, and to put it into operation in the southern hemisphere. The telescope remained under the auspices of Lick Observatory for 25 years, and was then sold to a Chilean philanthropist, who donated it to the Universidad Católica. In the Lick days, more than 10 000 spectrograms were taken with this instrument.

The first astronomers from Lick Observatory who went to Chile as observers, were in 1903 William H. Wright (1871–1959) and his assistant Harold K. Palmer (1878–1960). After three years, they were replaced by a second pair, Heber D. Curtis (1872–1942) and George F. Paddock (ca. 1879–1955). During Curtis' time in Chile, Ristenpart became director of the National Observatory (Fig. 5). He offered to Curtis the post of head of the astrophysics section at the National Observatory, but Curtis declined, and the post was subsequently never filled.

Curtis returned to Lick Observatory in 1909, where he took charge of the 0.9-m Crossley reflector, and carried on the sky survey for nebulae, which had been started by the former director James Keeler. On the direct images, Curtis recognized that spiral nebulae are *island universes* like the Milky Way, which consist of stars, gaseous nebulae and dust. In 1920, Curtis became director of

Figure 5. A meeting of astronomers of the Mills Expedition of Lick Observatory with astronomers of the Chilean National Observatory in spring 1909. Left to right, first row: H.D. Curtis, J.H. Moore, G.W. Paddock; second row: W. Zurhellen, F. Ristenpart (fourth director of the Chilean National Observatory), R. Prager (with premission of the Mary Lea Shane Archives, Lick Observatory).

the Allegheny Observatory of Pittsburgh University, and ten years later director of the observatory of his alma mater, the University of Michigan. Today, his name is best known because he was the opponent of Harlow Shapley in the *Great Debate*, which took place in 1920 during a meeting of the National Academy of Sciences in Washington. While Shapley had somewhat more correct views about the size and structure of the Milky Way, Curtis expressed the modern view that the Milky Way is similar in structure and size to the spiral nebulae.

Before Campbell decided that Santiago should be the place for the Lick southern station, he had his eye on possible locations in Australia, but all reports from astronomers indicated that Chile would be a better location. He decided to put up the station near Santiago, where articles of daily use were easy to obtain. Around the turn of the century, light and air pollution in Santiago were no things to worry about. Nevertheless Campbell urged Wright and Curtis to collect information from travellers, mining engineers, and farmers about the climatic conditions in various parts of the country. Already a few weeks after his arrival, Wright reported in a letter to Campbell about the *land of small rains* in the region of Copiapó in the north. Curtis, who had acclimatized himself well in Chile, was asked by Campbell to make a short exploratory trip to the region of Copiapó before his return to the United States. Around this time, Campbell planned to send the double-star observer Robert G. Aitken (1864–1951) with a 0.6-m refractor to the southern hemisphere, to complete his survey

of double stars. Curtis' 22-page report on his trip to the north, illustrated by own photographs, is kept in the Mary Lea Shane archive of Lick Observatory.

It is interesting to compare Curtis' requirements for an astronomical site in the desert with modern ones. The site should, of course, have good climatic conditions, undisturbed by clouds and coastal fog. It also should have good seeing conditions, and should be protected against heavy storms. But it should also be easily accessible. Curtis travelled by ship from Valparaiso to Caldera, the seaport of Copiapó, and used the first Chilean railroad, which since 1852 connected Caldera with Copiapó, and later with some mining towns further inland. These train stops east of Copiapó are higher and thus out of reach of the coastal fog, which often extends to Copiapó during nighttime. Curtis' first choice for an astronomical site was a hill ("little Cerro") in the Varas plain (Llano de Varas), which could be reached easily by foot or horse from the next train station. Extracts from Curtis' report were published by Duerbeck et al. (1999).

While the *little Cerro* was without doubt a better site than San Cristóbal, Curtis pointed out to his director that he and his assistant encountered more clear nights in Santiago than they could use effectively, and that it would be useless to move the observing station without the dispatch of more observers. It would be more expensive to supply the desert observatory with the necessary goods, and only a few astronomers would be willing to live there for years, especially if they had a family. A move would be costy; Mills, the potential donor, died in the following year, and Campbell did not succeed any more to raise the necessary funds to send the double star observer and his refractor to the southern hemisphere. Curtis' report was filed and practically forgotten.

The Lick radial velocity program was continued until the observing station on San Cristóbal was given to the Pontificia Universidad Católica de Chile (PUC) in Santiago, in mid-1928, with financial assistance of the Chilean maecenas Manuel Foster, and the PUC installed a section for physics and astronomy (Heilmeier 1940). At the same time, the results of the Lick radial velocity program appeared in print (1928). The astronomer Erich P. Heilmeier (1909–1992), who had come from Germany, used the telescope in the 1940s; observations were carried out sporadically also later on, in spite of the fact that the technical standard remained that of the turn of the century, and that the observing conditions became worse because of the growing metropolis.

7. The Smithsonian Astrophysical Observatory solar program

In spite of the fact that a Lick station in the north of Chile never materialized, it should be mentioned that the Smithsonian Institution established one of its observing stations for measuring the solar constant in the north of Chile. In mid-1918, the station started work in Calama and in mid-1920 moved to Mt. Montezuma, 12 miles south of Calama, where it remained active till mid-1955, when air pollution from the nearby mines became a serious problem. Among the dozen stations of the Smithsonian Astrophysical Observatory installed for this research, only the station at Table Mountain, California, has a longer period of activity (1925–1962). The Mt. Montezuma station was run by a director and an assistant, who stayed there for a period of three years (as had been the

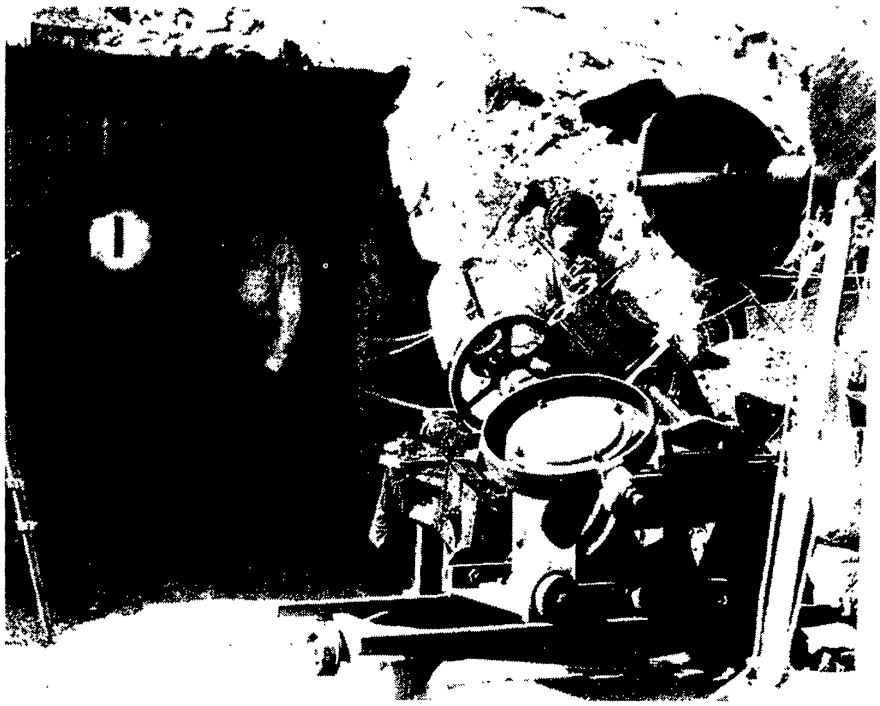

Figure 6. The heliostat of the Smithsonian Astrophysical Observatory station, Mt. Montezuma, Chile, in the 1920s. Smithsonian Institution Archives, Record Unit 95, Box 34, Folder 26, Negative no. 33668.

case at the Lick southern station). It was equipped with a heliostat that fed a spectrobolometer. Futhermore, there were pyrheliometers and pyranometers to measure the solar radiation, and a theodolite to measure the solar altitude. Hoyt (1979) gives an overview of the Smithsonian Astrophysical Observatory solar constant program. In spite of the fact that early results indicated noted solar variations and influences on the Earth's climate, new analysis of the data indicate that the solar constant has remained constant within 0.1% over the period 1923–1955. Some details on the daily operation of the Mt. Montezuma observing station were given by Butler and Hoyt (1980); annual reports and observational data can be found in the volumes of the *Smithsonian Astrophysical Observatory.*

8. The Chilean National Observatory 1923–1962

After Obrecht had fallen fatally ill, Ismael Gajardo Reyes (1876– after 1929) was appointed director of the National Observatory in 1923. Since the observatory was directly dependent on the (sometimes frequently changing) government, both the supervision and the financial support was often insufficient. Thus it was a good solution when in mid-1927 the observatory was integrated into the faculty of natural sciences and mathematics of the Universidad de Chile (UdeC) in Santiago. The following decades did not bring noticeable changes; the observatory was responsible for the time service and for cartographic services.

Between 1929 and 1943 Rosario Castro (1885–1943) served as director, and between 1943 and 1950 the director was Romulo Grandón (1887–after 1952). He was followed by Federico Rutllant (1904–1971), who had done research before for two years in Cambridge/England. Rutllant carried out the necessary move of the observatory from Lo Espejo. There the airport of the military school, which had been put in operation in 1913 in spite of protests of Ristenpart, hampered more and more of the astronomical work. Rutllant moved the observatory to Cerro Calan, a hill at the eastern outskirts of Santiago. The observatory was transformed into a "Departamento de Astronomía" of the UdeC, which could also give university degrees of "Licenciatura".

Until 1994, no PhD degrees in astronomy were given by universities in Chile, instead, the candidates were sent to universities abroad. The first Chilean astronomer who got a PhD (at PUC) in 1994/95 is Ronald Mennickent, who is now working at the Universidad de Concepción. Even today, PhD programs are often carried out in collaboration with foreign universities: the UdeC collaborates with Yale University, the PUC with Princeton University.

9. The USA, Europe and the Soviet Union become engaged in Chile

When in the 1950s and early 1960s first plans for large European and US-American observatories in the southern hemisphere were made, the experience collected by the Lick astronomers was of some relevance. In spite of the fact that Curtis' report had been shelved, Walter Baade (1893–1960), an astronomer working at the Mt. Wilson and Palomar observatories and a strong supporter of the idea of a European Southern Observatory (ESO), learned from the Lick astronomers about the excellent observing conditions in Chile. Nevertheless ESO's first activity was focussed on the collection of intense series of climatological data of various sites in South Africa. Only after the US-American AURA (Association of Universities for Research in Astronomy) had decided for an observing station on a Chilean mountain top, ESO changed its mind almost at the last moment, and started looking for a suitable place in Chile.

The interest of the US-American had been aroused by a visit of the director of the Chilean National Observatory, Federico Rutllant, in the US in May-June 1958 (Edmondson 1997). While the observatories on the west coast showed only little interest in his offer for collaboration, especially Gerard Kuiper (1905–1973), director of the Yerkes and McDonald observatories, showed much interest, and he undertook first steps for the realisation of a southern station. In 1960, the project moved into the hands of AURA, which was already running the Kitt Peak National Observatory near Tucson, Arizona. In 1962, it was decided to build the observatory on Cerro Tololo, and it was named Cerro Tololo Inter-American Observatory. By the end of 1964, the founding stone was laid, and the first small telescopes went into operation the following year. The 150-inch telescope, a twin of the Mayall telescope installed on Kitt Peak in Arizona, was inaugurated in 1974. Later on it was named after Victor Blanco (born 1918), the director of CTIO from 1967 to 1980.

In recent years the southern 8.1-m Gemini-Telescope has been built on Cerro Pachón, still on AURA grounds. It was put into normal operation in 2001. (The northern twin is located on Mauna Kea, Hawaii.) Gemini is an

international project of the USA, Great Britain, Canada, Chile, Australia, Brazil and Argentina.

After the first negotiations of interested astronomers from various European countries, which took place in 1954, ESO had focussed its interest on South Africa, since some countries had already for quite a long time astronomical activities there: in Pretoria, the Cape Observatory, the Union Observatory, and the Harvard Boyden Station in Bloemfontein (Blaauw 1991). However, ESO got notice of the US-American activities in Chile – a former astronomer from Hamburg Observatory, Jürgen Stock (born 1923), was in charge of site testing for the University of Chicago. Another proponent of Chile was P. Bernhard Starischka SVD (1913–1999), who had obtained his Ph.D. in astronomy in Bonn, and had worked before and afterwards for the German School in Santiago. He had good contacts to Chile's political circles, and paved the road to many important persons for Otto Heckmann (1901–1983), then Director general of ESO, during his first stay in Chile in May/June 1963.

The first European site tests took place in 1962 in various places: on the mountain La Peineta, which is located inland, between Copiapó and Chañaral, only about 40 km to the north-east of the hill selected by Curtis half a century before; on the mountains Cinchado and Morado, located near Cerro Tololo; on the mountain Guatulame, located about 50 km to the south of Cerro Tololo, and southeast of the town Ovalle; finally on a mountain named Cinchado-North. The results of the US-American site tests were confirmed, and the climatic conditions turned out to be superior to all collected before in South Africa. In early 1963, a group of five astronomers of the ESO committee travelled to Chile to establish first contacts, and to look into a possible collaboration with the US-American AURA. Since some of the mountain tops (Cerro Moreno, Cinchado) near Cerro Tololo had been bought by AURA, and were therefore only available for lease, the ESO group soon looked into alternatives for the site of the observatory.

In early 1964, Chile was definitively given preference instead of South Africa as the location of the European Southern Observatory, in the middle of 1964 La Silla (the former Cinchado-North) had been taken into the closer choice, and by the end of October 1964, La Silla was bought. A major part of the site was state property, but a few minor sections, and the mining rights (the permission to carry out or to restrict mining) had to be paid.

Four years later, the first astronomical data were collected, and the solemn inauguration of La Silla took place in March 1969. A report on early activities is found in Aldunate (1975). The construction of the 3.6m telescope – one of the major topics of the original plan of a southern observatory – was delayed for quite a long time, but in November 1976, the first photographs were taken with this instrument. The construction office that had been founded for the construction of the telescope developed its own dynamics, which resulted in the construction of the 3.5-m NTT (New-Technology-Telescope, inaugurated 1989) and the 4×8-m VLT (Very Large Telescope, on the mountain Paranal near Antofagasta, first plans in 1983, inauguration of the first telescope in 1998, the subsequent ones in the following years).

A project of the Carnegie Institution of Washington, which took care of the telescopes of Mt. Wilson and Palomar Mountain, shows some similarities. They had the plan for a 200-inch telescope in the southern hemisphere (CARSO =

Carnegie Southern Observatory). Again, first tests were carried out on AURA areal in the vicinity of Cerro Tololo, but later the mountain Las Campanas in the vicinity of La Silla was purchased. The project of a 200-inch telescope failed, but in 1971, the 1-m Henrietta-Swope-Telescope was put into operation, and in 1976 the 2.5-m Irenée-du Pont-Telescope. For a number of years, the University of Toronto had installed a 0.4m telescope on Las Campanas; in the meantime, Warsaw University runs a 1.3-m telescope. A 1986 project called Magellan, which consisted on an 8-m telescope, had been realized in the meantime in modified form: it consists of two 6.5-m telescopes, put into operation in 2000 and 2002, and which are run by the Carnegie Institution and four US American universities (Arizona, Harvard, Michigan, MIT).

The observatories La Silla, Cerro Tololo and Las Campanas were put up in the mountains north and east of the town La Serena. They lie about half-way between Santiago and the Llano de Varas, which had been visited by H.D. Curtis in 1909. The llano itself is about half-way between ESO La Silla and Paranal.

Finally it should be noted that between 1962 and 1973 astronomers of Pulkovo Observatory collaborated closely with astronomers from Cerro Calán; with the Repsold meridian circle, and with modern instruments a catalog with the positions of more than 11000 stars between $-25°$ and the south celestial pole was constructed. A 40-inch Maksutov astrograph was put up on Cerro Robles in 1967–68, to connect the stellar reference frame with galaxies. The military coup of September 1973 led to the untimely return of the Russian team of astronomers; also plans for the erection of a Russian 2.5-m telescope in the north of Chile were shelved.

10. Astronomy in Chile today

Besides the National Observatory, which is now incorporated into the University of Chile in Santiago, astronomy is taught – since about 1930 – at the Pontificia Universidad Católica de Chile in Santiago. Also at PUC, German scientists were among the astronomy professors: Erich Paul Heilmaier, who had obtained his PhD in Leipzig in 1935, and Nikolaus Vogt (born 1940), who graduated from Bonn and obtained his habilitation in Bochum.

Besides minor activities at the universities of Valparaiso, La Serena and the Universidad de Atacama in Copiapó, two additional active groups have existed for a few years: the astrophysics group at the University of Concepción, initiated by R. Mennickent, and the institute of astronomy at the Universidad Católica del Norte (UCN) in Antofagasta, directed by L. Barrera. Also in these two places, close links to European astronomers and institutions exist. Because of the guaranteed access to almost all telescopes at international sites, the Chilean astronomers can take advantage of a major amount of observing time.

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