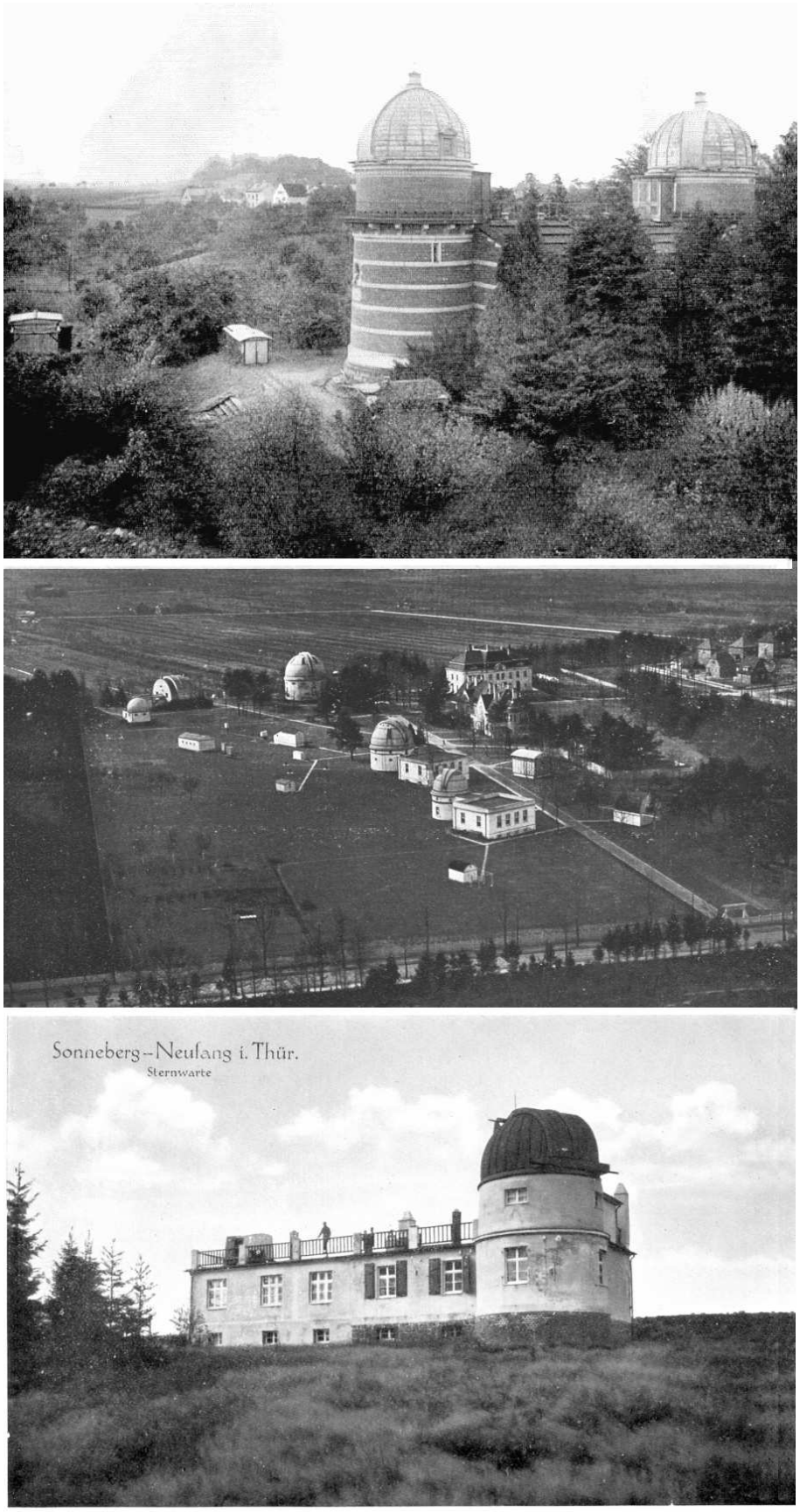

Figure 34.1: *Above: Bamberg Observatory around 1930. Middle: Hamburg Observatory around 1930. Below: Sonneberg Observatory 1930 (with Cuno Hoffmeister at the balustrade). (Bamberg Observatory, Hamburg Observatory, Archive Björn Kunzmann)*

34. Real and Virtual Heritage – Historical Astronomical Plate Archives in Sonneberg, Bamberg and Hamburg Observatories, the Evolution of Astrophysics and their Influence on Human Knowledge and Culture

Björn Kunzmann (Hamburg, Germany)

Abstract

The rise of astrophysics around 1860 introduced new instruments, methods and research areas. Of course, the increasing number of foundations of new observatories around the world starting at that time was forced by that new scientific discipline, too, but especially by the usage of photographic instruments. At the end of the 19th century the formation and development of photographic methods and techniques had reached a level of sufficient stability for productive usage in astronomy and astrophysics, their new instruments, methods and goals. The fundamental meaning of star light analysis for astrophysics by increasing discoveries of Variable Stars and the systematic search for moving Solar System objects had basically driven the beginning of large photographic sky patrols at that time, using photographic glass plates as detectors and information storages.

Sky Patrols, especially systematic long-term monitoring of the whole sky or of well defined selected areas and Sky Surveys were (and still are) an important key method that forced the evolution and progress of astrophysics. Important scientific results by famous astronomers, for example Walter Baade, Cuno Hoffmeister and Harlow Shapley depended on the analysis of photographic plates.

Today, there are around 50 photographic plate archives world-wide. Most of them, unfortunately, are in a quite poor condition and not yet digitized. Following Harvard College Observatory with an estimated total of 600,000 plates, Sonneberg observatory harbours the second largest archive world-wide (around 300,000 plates) among other large ones in Germany like Bamberg (40,000 plates) and Hamburg (35,000 plates).

These plate archives form an important heritage with a total of roughly two million direct plates and some ten or hundred thousands of spectroscopic plates. A lot of progress has been made by transforming this real heritage to a virtual one by systematic digitisation of the plates, but perhaps only 15% of them have been digitized so far. Although technical problems as the rapid changes in information technology, formats, description languages and limited life times of various storage media are not negligible the main problem remains the poor funding of different digitisation initiatives throughout the world.

34.1 Introduction

Until 1860 astronomy mainly deals with observation and calculation ofpositions and motions of celestial objects. With the rise of astrophysics at that time analysis of star light became a new task in science, starting up with our sun, the nearest star. Astrophysics uses three key methods: Spectroscopy (Kirchhoff/Bunsen 1859)[1], Photometry (Pogson[2] / Zöllner[3] 1856/1865) and Photography (Daguerre[4] 1837/39, Bond[5] 1857, Swan[6] 1871, Draper [7] 1872, Huggins[8] 1874). Photography, utilizes photographic glas plates as detectors since 1871, opened the essentiell possibility to monitor and analyse celestial objects independent of observations of astronomers at telescopes. Since the plates contain permanent pictures of the status of the sky at time of the exposure, they represent long-term collectors of historic astronomical information. The productive usage of photography (direct and spectral) in astrophysics and astronomy was introduced around 1880 – this was the beginning of the photographic revolution in astronomy and astrophysics. Large unique spectroscopic and astrometrical investigations (collecting the databases of so-called *Durchmusterungen*) were launched out. At that time systematic sky patrols were established, based on the following tasks: systematic searches for moving Solar System objects, and – mainly – the systematic search for variable stars. Variable Stars were considered peculiar until the works of Argelander,[9] who forced systematic searches, and became crucial objects of astrophysics.[10] Compared with life-time of human beings, time scales in the evolution of stars are extremly large, they undergo no evident changes. But variable stars are changing their brightness, changing their brightness, caused by geometric or – more often – intrinsic physical processes. The periods of their variability are in the range of some

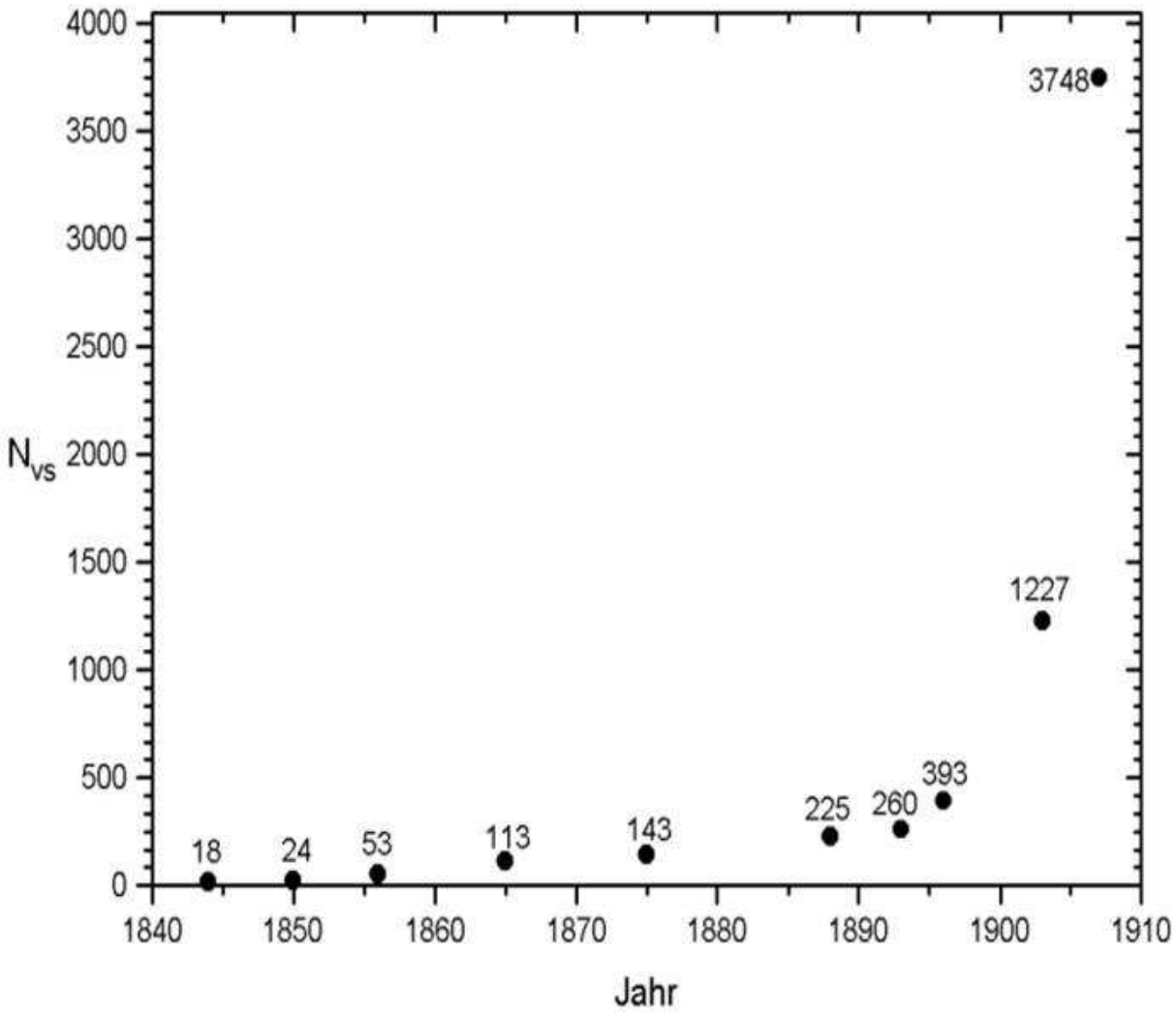

Figure 34.2: *Discoveries of Variable Stars (Diagramme compiled by Björn Kunzmann)*

minutes to some decades, mainly between 0.2 and 400 days. Thus, their varability may be detected well with the help of systematic sky patrols, covering the whole visible sky or selected areas. Caused by comprehensive photographic sky surveys discoveries of variable Stars significantly increases around 1900.

Variable stars act as physical probes, providing information about the dimensions, properties and distances of stars. In a first step, human knowledge about the structure of our galaxy, the stellar evolution and structure and cosmic distances in general depended on the information recorded in plate archives, evaluated by many famous astronomers, for example Walter Baade (1893–1960), Ejnar Hertzsprung (1873–1967), Edwin Hubble (1889–1953), Henrietta S. Leavitt (1868–1921), Cuno Hoffmeister (1892–1968), Henry Russell (1877–1957) and Harlow Shapley (1885–1972). Milestones of astrophysics are based on variable star data analysis stored on photographic plates, for example: Period-Luminosity-Relation (cosmic distances – Leavitt 1908/1912), Hertzsprung-Russell diagram (evolution of stars – Hertzsprung / Russell 1913), Analysis of globular clusters (dimensions of the galaxy – Shapley 1919), Cepheids in Spiral Nebulae (distance of M 31, Hubble 1923/25), Two-stellar-population theory and correction of period-luminosity relationship (evolution of stars, determination of distances – Baade 1944/1952).

34.2 Real and Virtual Heritage – Historical plate archives in observatories

Large direct-wide and spectral sky surveys were first performed at Harvard College Observatory (HCO) beginning in 1885, followed by many other observatories around the world. Nowadays HCO harbours 605,767 plates, Sonneberg observatory the second largest archive world-wide (around 300,000 plates) among other large

ones in Germany like Bamberg (40,000 plates) and Hamburg (35,000 plates).[11] These plate archives form an important heritage, and are providing significant databases for future investigations. At present plate archives consists of an estimated total of 3,000.000 astronomical photographic plates in more than fifty observatories. The international astronomical community undergoes efforts to preserve this heritage, based on IAU Resolution B3.[12] In order to store digitised plate archives, large databases were established, for example *Wide-field Plate database* (WFPDB)[13], *Uccle Direct Astronomical Plate Archive Centre* (UDAPAC) and others. But only a fraction of the plate archives is yet digitized and only some observatories own scanning devices. The main problem remains the poor funding of different digitisation initiatives throughout the world.

34.2.1 Sonneberg Observatory

More than 11,000 galactic variable stars, being a quarter of all yet known, have been discovered on plates at Sonneberg observatory[14]. Information on this topic is presented in Peter Kroll's article *"The Plate Archive in Sonneberg – Digitisation, Preservation and Scientific Programme"*.

34.2.2 Bamberg Observatory

Bamberg observatory[15] was founded in 1889. Variable star research was its main domain for several decades, introduced by its first director, Ernst Hartwig (1851–1923). The plate archive[16] is complete and consists of around 40,000 high quality plates primarily taken for variable star research, covering time period 1913/1928 until 1982. Bamberg observatory take part in famous German sky patrol project *"Photographische Himmelsüberwachung"*[17] (Observatories in Babelsberg-Potsdam, Bamberg, Sonneberg, temporarily Wolfersdorf, Thuringia) established by Paul Guthnick[18], Cuno Hoffmeister and Richard Prager[19] in 1928. The aim of this project was to monitor variable stars in the northern hemisphere. An important southern sky project on variable stars was the *Bamberg Southern Photographic Patrol Survey* (BSPPS), covering time period 1962–1976 and taken at observation sites in New Zealand, South Africa and Argentina, with limiting magnitude 14–17. The digitisation of Bamberg's plate archive is still in progress, a catalogue is available online.

34.2.3 Hamburg Observatory

Hamburg observatory[20] plate archive harbours around 35,000 plates of northern and southern sky (direct and spectral plates), covering 1912–1999, with limiting magnitude 15–20. While Bamberg and Sonneberg plate archives primarily originate from variable star surveys, Hamburg plate archive is more heterogeneous concerning its content. Hamburg observatory performed some large projects, covering miscellaneous astrophysical, astronomical or astrometrical research areas. Earlier projects are the *"Bergedorfer Spektraldurchmusterung"* (1923–1933), determining the spectral types of stars in selected areas of the northern sky and the astrometric catalogues AGK 2 (1929–1930) and AGK 3 (1956–1964). Newer photographic projects are, for example, *Hamburg Quasar Survey* (HQS – 1980–1997, full coverage of northern extragalactic sky), *Hamburg/ESO survey* (HES – 1990–1999, full coverage of southern extragalactic sky) and the *Second Cape Photographic Catalogue* (CPC2), an astrometric, photographic catalogue covering the entire southern sky. Hamburg plate archive includes a large quantity of substantial plates of variable star research and stellar clusters, too. The archive is almost complete, a catalogue is available online. The digitisation of newer plates has already been concluded.

34.3 Virtual Heritage – concluding remarks

- Evolution and development of astrophysics substantially depends on the information we got from photographic plates, especially those of sky patrols and sky surveys.
- Historically, human knowledge about the structure and dimensions of the Milky Way, the position of the solar system, cosmic distances etc. significantly results from variable star research based on photographic monitoring projects.
- This heritage stored in astronomical plate archives contains more than a hundred years of historic information. These data are of highly scientific value and at present the only possibility to explore long-term processes.
- Some observatories, many of their buildings and instruments around 1900 were formed for photographic observation purpose. Therefore astronomical plate archives are of course an important part of cultural heritage, being worth to be preserved.

---

1. Gustav Robert Kirchhoff (1824-1887) and Robert Wilhelm Bunsen (1811–1899).
2. Pogson, Norman: On Variable Stars, 1856.
3. Zöllner, Karl Friedrich: Photometrische Untersuchungen, 1865.
4. Louis Daguerre (1787–1851), inventor of photography, 1837–1839.
5. George Phillips Bond (1825–1865), first photography of a star.
6. Joseph Wilson Swan (1828–1914), inventor of photographic dry plate.
7. Henry Draper (1837–1882), first photographic stellar spectrum in 1872.
8. William Huggins (1824–1910), introduces dry plates in astrophotography in 1874.

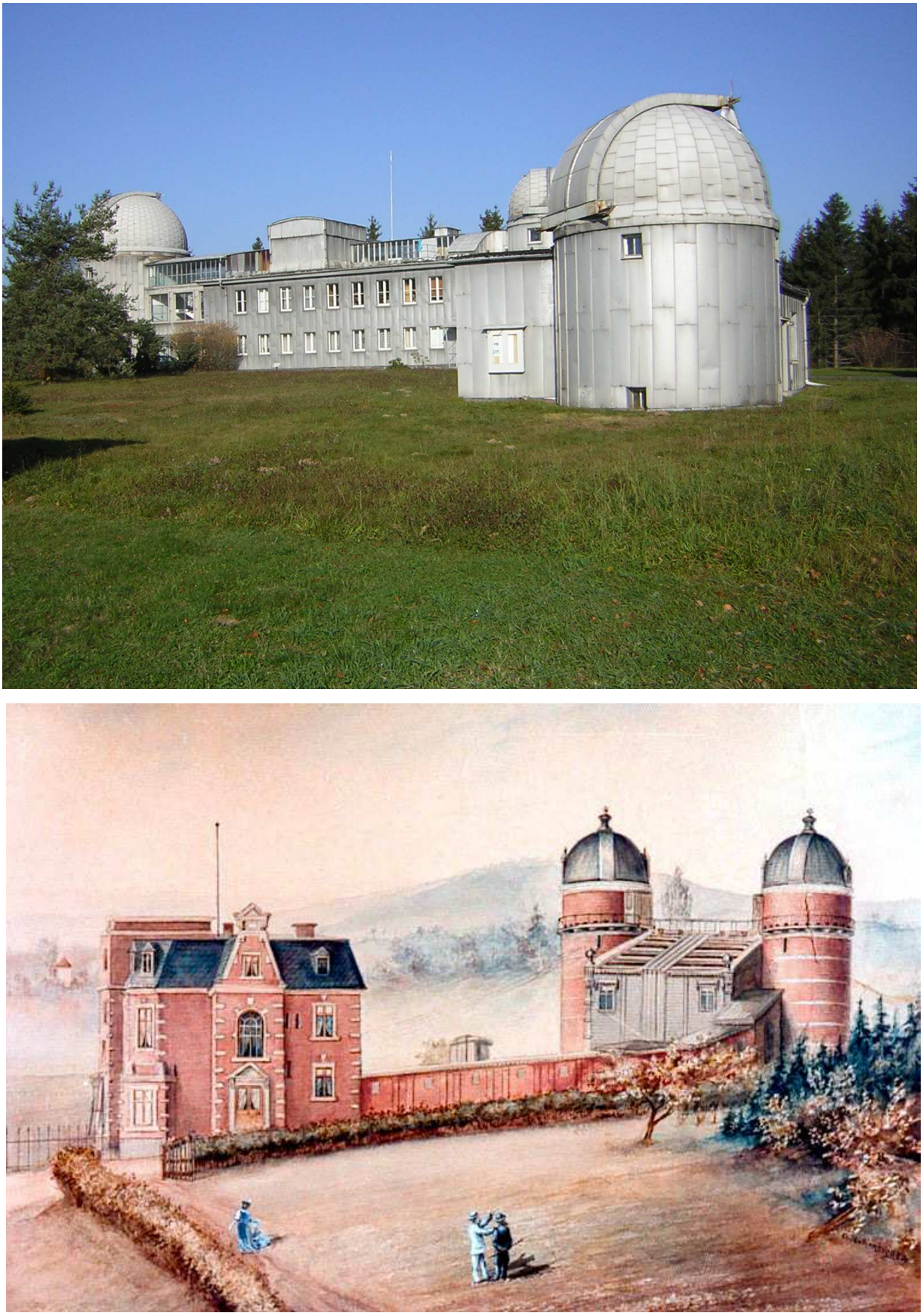

Figure 34.3: *Above: Main building of Sonneberg Observatory; Below: Dr. Remeis-Sternwarte Bamberg (Photo: Björn Kunzmann, Archiv Dr. Remeis-Sternwarte Bamberg)*

9. Friedrich Wilhelm Argelander (1799–1877), established variable star research.
10. Key papers on this topic are: Argelander 1844, Pickering 1883, Bailey 1906. For a comprehensive treatise of early Variable Star research history, see Kunzmann 2009.
11. Tsvetkov 2000, p. 613–617 and `http://www.skyarchive.org`.
12. IAU Resolution B3 (August 2000): Safeguarding the Information in Photographic Observations, `http://www.iau.org/static/publications/ib88.pdf`.
13. http://www.skyarchive.org.
14. For an introduction to observatory's history, see Kunzmann 2008, p. 205–239.
15. Wolfschmidt 2008, p. 155–191.
16. Hudec 1999, p. 33.
17. Kunzmann 2008, p. 224.
18. Paul Guthnick (1879–1947), astronomical photoelectric photometry 1912.
19. Richard Prager (1883–1945).
20. Hudec 1999, p. 34.

34.4 Bibliography

Argelander 1844
: Argelander, Friedrich Wilhelm August: *Aufforderung an Freunde der Astronomie zur Anstellung von eben so interessanten und nützlichen, als leicht auszuführenden Beobachtungen über mehrere wichtige Zweige der Himmelskunde.* In: Schumacher, Heinrich Christian (ed.): Jahrbuch 1844, Stuttgart und Tübingen 1844, p. 122–254.

Bailey 1906
: Bailey, Solon Irving and Pickering, Edward C.: A Durchmusterung of Variable Stars. In: *Harvard College Observatory Circular* **116** (1906), p. 1–3.

Hudec 1999
: Hudec, René: *An introduction to the world's large plate archives.* In: Kroll et al. 1999, p. 28–40.

Kunzmann 2008
: Kunzmann, Björn: *Cuno Hoffmeister und die Sternwarte Sonneberg.* In: Wolfschmidt 2008, p. 205–239.

Kunzmann 2009
: Kunzmann, Björn: Veränderliche Sterne und ihre Bedeutung für die Entwicklung der Astrophysik. In: Wolfschmidt 2009, in preparation.

Kroll 1999
: Kroll, Peter; Dous, Constanze la and Hans-Jürgen Bräuer (eds.): *Treasure-Hunting in Astronomical Plate Archives.* Proceedings of the International Workshop held at Sonneberg Observatory, March 4 to 6, 1999. Frankfurt am Main: Harri Deutsch (Acta Historica Astronomiae 6) 1999.

Pickering 1883
: Pickering, Edward C.: A Plan for Securing Observations of the Variable Stars. In: *The Observatory* **6** (1883), p. 46–51 und 79–82.

Pogson 1856
: Pogson, Norman: *On Variable Stars.* In: *Monthly Notices of the Royal Astronomical Society* **17** (1856), p. 24.

Tsvetkov 2000
: Tsvetkov, M. K.; Stavinschi, M.; Tsvetkova, K. P.; Stavrev, K. Y.; Lukarski, H. D.; Christov, S. T.; Popov, V. N. and Semkov, E. H.: The Wide-Field Plate Database: Towards a European Plate Center. In: *Baltic Astronomy* **9** (2000), p. 613–617.

Wolfschmidt 2008
: Wolfschmidt, Gudrun (ed.): *Astronomisches Mäzenatentum.* Proceedings des Symposiums in der Kuffner-Sternwarte in Wien, 7.–9. Oktober 2004: "Astronomisches Mäzenatentum in Europa." Norderstedt: Books on Demand (Nuncius Hamburgensis – Beiträge zur Geschichte der Naturwissenschaften; Band 11) 2008.

Wolfschmidt 2008a
: Wolfschmidt, Gudrun: Karl Remeis (1837–1882) und die Stiftung der Bamberger Sternwarte. In: Wolfschmidt 2008, p. 155–191.

Wolfschmidt 2009
: Wolfschmidt, Gudrun (ed.): *Entwicklung der Astrophysik.* Proceedings des Kolloquiums des Arbeitskreises Astronomiegeschichte in der Astronomischen Gesellschaft am 26. September 2005 in Köln. Hamburg: Tredition (Nuncius Hamburgensis – Beiträge zur Geschichte der Naturwissenschaften; Band 4) 2009.

Zöllner 1865
: Zöllner, Karl Friedrich: *Photometrische Untersuchungen mit besonderer Rücksicht auf die physische Beschaffenheit der Himmelskörper.* Leipzig 1865.