The Great Refractor of the Potsdam Astrophysical Observatory - 100 years old -

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Foundation and Scientific Objective of the Astrophysical Observatory Potsdam

On August 26, 1999, the Great Refractor of the Potsdam Astrophysical Observatory will celebrate its one hundreth birthday. It was the main telescope of the observatory until it was put out of operation in 1968. Due to its importance as an outstanding mechanical and optical scientific instrument of the late Nineteenth Century and for the progress in astrophysical research, the telescope and its dome have been listed as protected monuments since the 1980s.

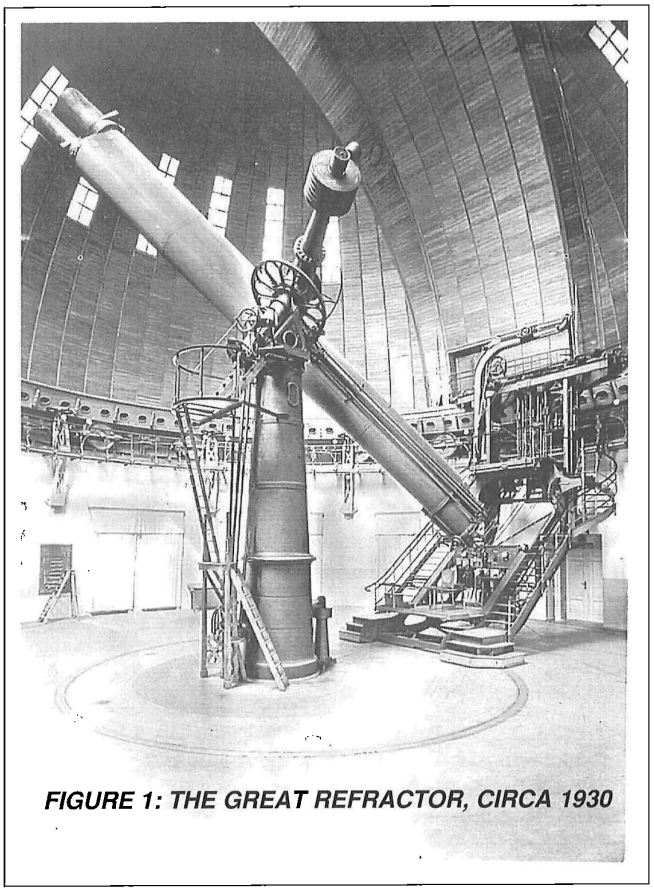

FIGURE 1: THE GREAT REFRACTOR, CIRCA 1930

The Potsdam Astrophysical Observatory, founded in 1874, was the first astronomical institute in the world devoted exclusively to research in astrophysics. This new branch of astronomy was born in the 1860s, and was based on the method of spectral analysis of hot gases established by Gustav Kirchhoff and Robert Bunsen at Heidelberg about 1859. This technique enabled astronomers to determine the previously unknown chemical composition and the physical state of celestial bodies.

Now, astronomers had an efficient tool for the measurement of the motions of stars in the line of sight, as well as angular velocities, i.e. across the line of sight, by measuring the shifts of the spectral lines caused by the Doppler effect. The first director of the Astrophysical Observatory, Hermann Carl Vogel, did pioneering work by introducing the photographic plate for the determination of radial velocities, thus replacing visual observation. This resulted in a significant increase in accuracy. A renowned scientific achievement was the unambiguous proof of the existence of spectroscopic binaries, inferred from periodic line shifts in the spectrum of the variable star Algol in 1889; as well as his publication of a catalogue of the radial velocities of 51 bright stars in collaboration with Julius Scheiner in 1892. These observations were carried out with a rather modest telescope of 30cm aperture. In order to extend the observations to fainter stars, i.e. to achieve a larger sample of objects, the acquisition of a more powerful telescope was urgently needed. Several observatories in Europe and North America had meanwhile acquired or were about to acquire large efficient telescopes with apertures reaching one meter, and more. Thus, discussion of the idea to construct what was considered a huge telescope began shortly after the foundation of the observatory.

In 1890, Hermann Carl Vogel submitted a memorandum for the acquisition of a new large telescope, and a commission was set up in order to determine the instrumental equipment needs of the observatory. An important part of the discussion was whether a refractor or a reflector should be acquired. The preference for a refractor over a reflector was due to the lack of experience in reflector technology and its application to astronomical observations at that time; whereas the necessary technical experiments with

large lenses could be carried out in the observatory's own laboratories. The dimensions of the lenses could be carefully calculated according to laboratory tests of the properties of different kinds of glass. Another argument favouring a refractor was that a reflector was thought to be more sensitive to pollution and humidity in the earth's atmosphere than a refractor. Several years later, Hermann Carl Vogel admits that the decision would have been much more difficult if the successful use of the reflectors installed in America had already been known. Nevertheless, he still favoured the refractor for the Potsdam site.

The double refractor which had been mounted in 1889 (with apertures of 32.5cm and 23.5cm, and a

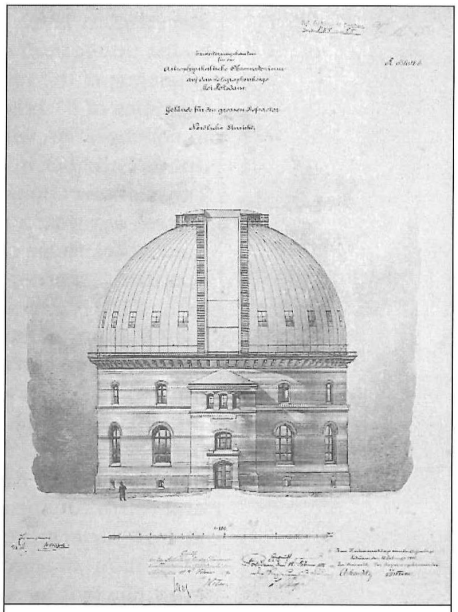

Figure 2: Original design of the dome, 1896.

focal length of 3.4m) possibly served as an example for the new telescope. It was dedicated to the stars of the northern hemisphere, as part of the observatory's contribution to the Carte du Ciel, initiated by the Paris Congress of Astronomers in 1887. For spectroscopic observations, the larger telescope could be equipped with a spectrograph. A very important result of the early spectroscopic investigations was the detection of the Ca II-activity in late-type stars at the beginning of the Twentieth Century. Though this telescope was very effective and successful in taking photographs of star fields, it was too small to cope with a vast spectroscopic programme for the determination of radial velocities.

For several years, the efforts of the telescope commission failed to convince the treasury to grant the necessary funds. Finally, by imperial order in 1895 the erection of the Great Refractor and its dome was started ... and completed within 4 years. On August 26, 1899 the telescope was inaugurated in the presence of Kaiser Wilhelm II, which demonstrates the importance of the telescope in its time.

Construction and Optical Parameters of the Great Refractor

The telescope is a double refractor with two tubes fixed parallel to one another on a parallactic German mounting. The larger telescope has an objective with a diameter of 80cm and a focal length of 12.2m, chromatically corrected for the wavelength 425nm, i.e. optimized for the photographic spectral region. It was the world's fourth largest refractor and due to its colour correction, the largest photographic lens. The smaller objective, with a diameter of 50cm and a focal length of 12.5m, is corrected for the visual spectral region of about 600nm. Originally, this smaller scope was used as guiding telescope. Both objectives are doublets, comprised of crown and flint glass elements. The telescope is mounted within an impressive revolving cupola with a weight of 200 tons, with an inner diameter of 21m and a height of 18m. It was built by the firm Bretschneider and Kruegner in Berlin.

The construction of the telescope and its auxiliary equipment was undertaken by renowned firms of the time. The blocks of raw optical glass for the lenses were supplied by the firm Schott und Genossen at Jena, a company which still exists today. The manufacture of the objectives was entrusted to the firm C.A. Steinheil of Munich, which had supplied the optics for the smaller double refractor of 1889. The C.A. Steinheil firm was chosen because it was experienced in manufacturing large lenses, having produced the 70cm objective for the refractor of the Archenhold-Sternwarte in Berlin-Treptow 3 years earlier, a telescope which is still in use for educational purposes.

Unexpected difficulties arose with the refractor at Potsdam. Particularly, the 80cm objective revealed zonal chromatic errors and an irregular astigmatism which could not be removed even after being refigured several times. Finally after refiguring again in 1942, the quality of the lens was considered good and usable for many observational projects. The 50cm objective, on the other hand, had been rather good from the very beginning and was further improved by retouches carried out in 1911 and 1914 by Bernhard Schmidt, who made it one of the best and most valuable refractor objectives of this size in the world. At that time, Schmidt was still an unknown optician; later he became famous by the

invention of the "Schmidt Telescope", named after him. These early failings of the objectives motivated Johannes Hartmann to develop extensive methods for testing the quality of lenses, tests which are still in use today and are well-known as the "Hartmann-Tests".

The mounting of the telescope was constructed by the well known firm A. Repsold und Söhne at Hamburg. Until the 1920s, this firm was a leading manufacturer of astronomical instruments. Without a doubt, the success of many European observatories is credited to the outstanding technical equipment made by Repsold. Even the excellent observer's lift for the Great Refractor, constructed by C. Hoppe in Berlin, is based on an idea of Repsold. The electrical system for the telescope and its subsidiary equipment was carried out by Siemens and Halske in Berlin.

Observations and Scientific Results

The scientific observing programme of the observatory comprised spectrometric and spectrophotometric work based on the use of the photographic plate. The astrophysical investigations and scientific photography research in which the Great Refractor was involved gave rise to fundamental insights into the qualitative and quantitative description of photographic material, e.g. the dependence of the characteristic curve on the Schwarzschild exponent, the marking of the sensitivity by the Scheiner gradation and the Eberhard effect, influencing the development of photographic plates. The astrophysical observations with the Great Refractor were especially concentrated on investigations of binaries and of novae. A remarkable scientific result was the detection of interstellar matter by Johannes Hartmann and a contribution to the nature of novae outbursts by Walter Grotrian.

Unfortunately, the efficiency of the spectroscopic observations was affected by the length of the tube and by the constraints in size and weight imposed upon the spectrographs necessary to be carried by the telescope. The long focal length, however, made the telescope ideally suitable for the photographic observation of visual double stars. This programme was originally introduced by Ejnar Hertzsprung, a member of the staff from 1909 to 1919, in order to determine the orbital components of double stars. Though merely an astrometric one from the point of observational technique, it is of fundamental astrophysical importance for the determination of stellar masses. After World War II, this programme resumed and became the last scientific activity of the Great Refractor.

In the last weeks of World War II, the telescope and its dome were badly damaged by an air attack. The repair work, which lasted several years, was finished in 1953, with a complete renovation and modernization of the telescope by the firm Carl Zeiss at Jena. The telescope served as a scientific instrument again until its closure in 1968.

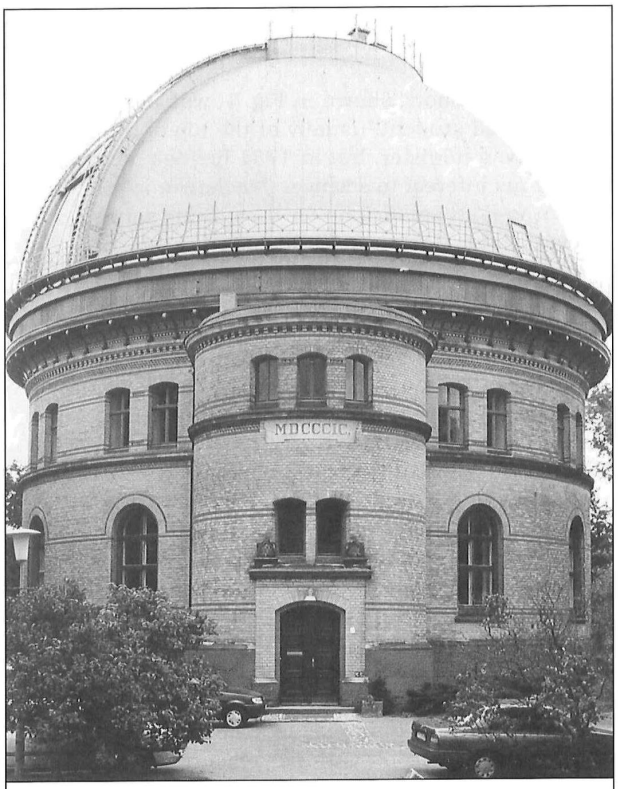

Photo 3: Dome of the Great Refractor, 1996.

Outlook

In March 1997, an association was founded with its objective to restore the Great Refractor and its dome and to save the facility as a scientific monument which could be made available to the interested public. The government of the Land Brandenburg and the Astrophysikalisches Institut Potsdam, as the responsible authorities, support this objective. On the occasion of the telescope's centenary, the first steps in the refurbishment have begun, including removing the rust and applying a coat of paint to prevent further deterioration. A complete restoration, however, can only be achieved through the support of generous sponsors.