# I. Future infrastructure

We deconstruct buildings materially
and semiotically, all the time.
*Thomas Gieryn (2002)*

Our story begins in the 19th century when Telegrafenberg received its name and gradually became a place to do science.

**Ethnographic note, part 1**

I walk ten minutes from my apartment in the Berlin city district of Neukölln to Hermannplatz and take the underground U8 to Alexanderplatz. At Alexanderplatz, a major square and traffic hub, I switch from the city transport system BVG to a regional train connecting the German capital with its surrounding federal state of Brandenburg. The train heads west and travels past Berlin's center and sights – Brandenburger Tor, Tiergarten, the government area, Charlottenburg – before entering the rural and forested areas of Brandenburg. I leave the train at Potsdam central station and cross its forecourt, which is usually crowded by international tourists. The city does not only accommodate its 175,000 inhabitants and a vital research community, but is also host to many historical and cultural landmarks of international reputation. An organized touristic visit to Berlin typically includes a one-day trip to Potsdam, where visitors are compensated for the lack of historical buildings in Berlin. Until 1918, Potsdam served as the residence of the Prussian kings and the German Kaiser, equipping the area with a variety of picturesque castles, colorful gardens and spacious parks. Arguably the most impressive architecture, the new Palais commissioned by legendary Prussian King Frederic the Great, now accommodates the University of Potsdam. I briefly walk from the train station through a residential area. I then walk up a small road towards Telegrafenberg, a forested hill about 100 meters high. On the way up, I usually walk besides other wayfarers, all scientists who seem to be absorbed in thinking about their scientific projects, experiments and meetings. The walk up the hill is a boundary time-space, helping to leave the private life in Berlin behind and attuning the mind to scientific work. Arriving at the top, all newcomers to the *Science Park Albert Einstein* need to cross a security barrier with a turnpike and gatehouse, but the contact with the guards is usually limited to an apathetic nodding or mumbled, "Good morning." First-time visitors may stop at a glass vitrine at the wall of the gatehouse, showing a schematic map of the science park, its architecture and infrastructure.


Figure 3: Schematic map of the Science Park Albert Einstein.
Source: Own photo

During my time at Telegrafenberg, I often came back to the vitrine and map, seeking orientation for my investigations. After a while, I substituted the consultation of the vitrine with a paper brochure received from the GFZ press office. In that way, I could walk around and learn while traveling. Later, when I was drawing together the data for analysis, the paper map was again exchanged for a digital version that I found on the web. Such schematic maps of places, institutional structures, machines, models, algorithms and datasets have been valuable data for this study. Some of those maps are also represented in this final text, hopefully providing a means of orientation for the reader.

**Ethnographic note, part 2**

After passing the security area and some parking lots, the first major building comes into sight on the right: A branch of the *Alfred Wegener Institute (AWI)*, an internationally renowned institute for polar and marine research. Continuing on my way, I pass the German Research Centre for Geosciences (GFZ), a cafeteria and a kindergarten. On the top of the mountain sits a monumental piece of architecture with three cupolas, the Michelson House, today hosting the Potsdam Institute for Climate Impact Research (PIK).

Telegrafenberg had served as an astrophysical observatory for many years before the climate scientists took office at the edifice in 1992. More than that, the Astrophysical Observatory Potsdam (AOP) has been one of the central places for the construction of astrophysics as a scientific field and discipline. Reciprocal manufacture of and experimentation with the telescopic instruments on the hill pioneered the primary method of astrophysics – spectral analysis.

**Ethnographic note, part 3**

I walk around the architecture, passing through an English garden structure, ending at the Great Refractor, a gigantic optical telescope. On my left, I catch sight of the architectural celebrity on the hill; the Einstein Tower built by

Erich Mendelssohn, regularly environed by groups of international tourists and architectural students. Descending the hill through a beaten trail, I arrive at my final destination – PIK's new office building referred to as the House in the Woods.

Figure 4: Michelson House. The former Astrophysical Observatory, now the headquarters of the Potsdam Institute. Source: Own photo

While I have taken this path to my field site and office hundreds of times, the place has never ceased to impress me with its atmosphere lost in reverie. Working on the hill for some time, one becomes soaked into this spiritual feeling of the place that has been cautiously created, layered and refined for over a century.

## The becoming of Telegrafenberg

The Prussian administration under Frederic William III began to construct the first state-run semaphore chain on German ground in 1832. In a time of social unrest and political instability, improving the channels of communication was seen by the Prussian military as a promising mean to establish control over the highly dispersed territories of the Reich: Brandenburg (Berlin, Potsdam) and Rhineland (Cologne, Koblenz).[5] The semaphore line installed was nearly 600 km long and consisted of sixty-one optical telegraphs, masts about six meters high, passing on encoded information by pivoting shutters or blades (see Fig. 5).

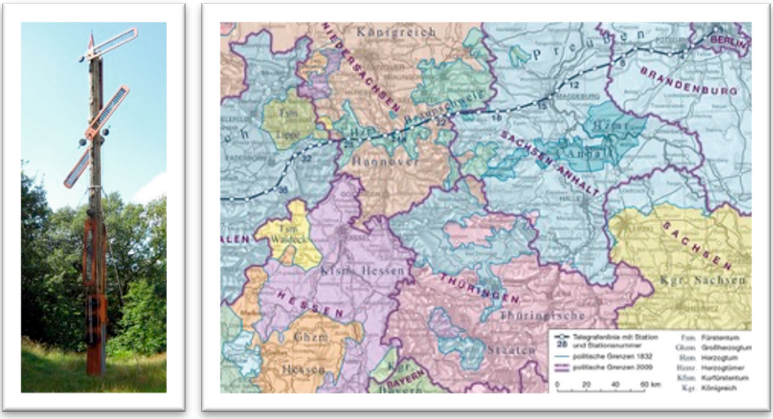


Figure 5: reproduction of the original telegraph on the hill (left) and map of the telegraph line Berlin–Koblenz (right). Source: www.optischertelegraph4.de

The fourth mast was erected on a hill near Potsdam, residential city of the Prussian emperors, and served as its namesake – *Telegrafenberg* (telegraph hill). While the name has survived until today, the semaphore telegraph chain had only a short life as a communication infrastructure and was suspended in 1852, after innovations in the field of information transmission technology, namely electrical telegraphy (Wilderotter, et al. 2005: 88). Nevertheless, the telegraph line had been a major event in the structuration of the Telegrafenberg, drawing physical and symbolic lines between the topographic elevation near Potsdam

5 It is a funny coincidence that the telegraph line connected the locations of my working place (Rhineland), my residential city (Berlin) and my field (Potsdam).

and existing networks and infrastructures of the Prussian administration. It put the location 'on the map,' making it visible, addressable, formable and manageable.

The attribution of the Telegrafenberg as a place to do science can be traced back to the 1860s and 1870s. The ontology of these traces preferences a specific way to tell history – as a history of great men, heroes and inventors. Science and technology studies has always problematized such versions of the 'great man theory,'[6] which limit agency to single, human male, historical figures. This theory translates to diffusionist models for science-society interactions, as illustrated by Bruno Latour:

> Nobody shapes science and technologies except at the beginning, so, in the diffusion model, the only reasonable explanation of novelty lies with the initiators, the first men and women of science. (1987: 134)

We will see later in this study that the contemporary scientific practice is incompatible with such diffusionist views of science-society interactions. However, we also have to consider that historic traces of science are often configured in a way that drives and limits certain interpretations. The primary documents from the 19$^{th}$ century are basically accounts by great men telling the history of other great men, thereby mutually amplifying their relevance in the succession of events. To a certain degree, the present analysis will have to reproduce this narrative structure. We will later give more weight to additional resources that help to disrupt these dominant perspectives on the history of the hill and science park.

6 Versions of the 'great man theory' have long been dominant in historical analysis. An example of a theoretical conceptualization is Thomas Carlyle's *On Heroes, Hero-Worship, and the Heroic in History* (1993).

## Imagining astrophysics

It was astronomer Wilhelm Foerster, who firs[7] formulated ideas for an institutionalization of astrophysics and construction of an interdisciplinary observatory in Potsdam. Foerster had been the director of the Berlin observatory, which later was named after him (Wilhelm-Foerster-Sternwarte in Schöneberg, Berlin). In his memorandum *Denkschrift betreffend die Errichtung einer Sonnenwarte* of 1871 (Hermann 1975), he conceptualized astrophysics as a new scientific field and argued that this new field of study would require a dedicated place and infrastructure to take shape. He brought up a number of arguments that should convince the Prussian administration to support the construction of the novel facility. First of all, he mentioned a number of scientific discoveries in solar research that could serve as a basis for the scientific practice in astrophysics. As a matter of fact, Prussian scientists had been key in advancing solar research, including the discovery of the sunspot activity cycles (Samuel Heinrich Schwabe), sunspot positions and their rotation (Gustav Spörer), spectral analysis techniques (Gustav Kirchhoff), as well as new insights into aspects of thermodynamics (GFZ 2017: 43; Herrmann 1975: 246). These discoveries changed the way scientists had seen the sun and other stellar phenomena. Previously, the sun had basically be seen as the origin of a tremendous mass attraction and source of powerful light and heat effects. By contrast, people were not so interested in the temporal changes in these dynamics. However, some newer studies revealed the periodicity and magnitude of fluctuations, awaking a new interest in the consequences of these changes for other objects and dynamics within the solar system and universe (Herrmann 1975: 247). Pointing to these new scientific matters of concern, Foerster argues: “Therefore, it should be clear that the

7 Foerster’s proposal builds on ideas formulated by school teacher and scientist Gustav Spörer, who had brought the issue of institutionalization to the attention of the Astronomical Society.

construction of a solar telescope of this kind would be a scientific act of eminence" (ibid.: 250, translated by the author). According to the memorandum, further advances in solar research would only be possible by combining them with the measurements from other fields, such as meteorology and magnetism research. The observations could support nonscientific actors, such as miners and field measurers, in their daily work (ibid.: 250). In that sense, Foerster was a pioneer of not only interdisciplinary research practice but also co-benefits between science and society. Finally, Foerster evoked the 'scientific arms race' between Prussia and other major geopolitical powers of the time, in this case, Great Britain:

> Finally, it should be mentioned that England already operates something similar to the solar observatory described, in its facilities for solar observations and magnetic observations in Kew near London. However, on the basis of the present plan, our construction will be more effective and comprehensive than the one set up in Kew. (ibid.: 251, translated by the author)

In sum, Foerster's letter mainly bows down to three recommendations: Firstly, Prussia should engage in the construction of a new type of techno-scientific instrument, a solar observatory, in order to keep its pioneering role in astronomic and solar research. Secondly, it would be necessary to restructure the entire Prussian research infrastructure for earth and astronomic research to enable effective astrophysical work and discipline scientists behind the becoming field of study. Thirdly, it would be necessary to draw this new conglomerate of scientific institutions together in a new place, supposedly in Potsdam. Of course, a well-formulated letter alone does not make a new institute, but Foerster definitely showed a talent for science-political argumentation mobilizing allies for his ideas. He also had a feeling for constellations, and the letter certainly included the right words at the right time: Considering Prussia's victory over France in 1871 and its strengthened position in Europe's power structures, the time may have been conducive for an institutional reshuffling and financial windfall celebrating the new patriotism. At least, this is how contemporary figures interpreted and narrated the *Entstehungsgeschichte des Astrophysikalischen Observatoriums* (Genesis of the Astrophysical Observatory) a few years later:

> The history of the origins of the Potsdam Astrophysical Observatory teaches us that a stimulating thought alone is not enough to enable such a formidable institute […], but that a political upswing of the fatherland was necessary to enable the realization of the plan [...]. (Hurtig 1890: 4f, translated by the author)

It is true that the consolidation of the German Reich after the wars of 1870 and 1871 enabled the release of considerable financial funds, which were invested in not only trade and commercial matters but also the arts and the sciences. Consequently, a political blessing for the Telegrafenberg project was given immediately after the German victory (ibid.: 4f).

## Installing a base for astrophysics

We will now attempt a change of perspective, drawing away from great men and emphasizing the role of material infrastructure in the making of science. If one is able to listen, infrastructures tell intriguing stories, in this case, stories about scientific engagement for over a century. As Susan Leigh Star has highlighted, infrastructures can serve as information-collection devices for investigations into science, technology and society (Star 1999: 387). By cumbersome work, we may be able to bring to the surface the master narrative of infrastructure, which normally operates invisibly and unnoticed, but no less powerfully in the background of human activities; or, as Star describes it, "a single voice that does not problematize diversity," which "speaks unconsciously from the presumed center of things" (ibid.: 384). Employing a term coined by Geoffrey Bowker, the aim is to engage in an "*inversion of infrastructure*" (Bowker 1994), taking a firmly temporal and relational perspective on such structures. Star and Ruhleder (1996) have famously highlighted this aspect: Instead of asking *what* infrastructure is, we should think more about *when* an infrastructure is. With this temporal definition of infrastructure, they challenged the commonsense understanding of infrastructure as a stable material structure that is "just there":

> Common metaphors present infrastructure as a substrate: Something upon which something else "runs" or "operates," such as a system of railroad tracks upon which rail cars run. This image presents an infrastructure as something that is built and maintained, and which then sinks into an invisible background. It is something that is just there, ready-to-hand, completely transparent. (ibid.: 112)

According to the authors, this understanding of infrastructure of a "system" and "thing" is problematic, as it fails to capture relationships between practice and technology properly: The internet may serve as an infrastructure to support communication for some but fails to do so for others (e.g. a blind person). For the plumber, the water system is not a background support infrastructure but the crucial target object in his/her daily work (ibid.). We should think about infrastructure as something that is relational, temporal, built *in situ* rather than as stable structure serving everybody. These aspects are deeply interwoven in the sense that infrastructure merges when a constellation of related elements is reached within a situation, enabling the functioning of another system. This relational argument builds on the work of others, such as Yrjo Engeström (1990), Geoffrey Bowker (1994) and Gregory Bateson (1987). Bateson argued in his *Steps to an Ecology of the Mind* (1987) on a general level that "What can be studied is always a relationship or an infinite regress of relationships. Never a 'thing'" (Bateson quoted in Star/Ruhleder 1996: 112). In the following, we will trace the established relationships between infrastructural elements in the becoming science park on Telegrafenberg. To assist the reader, the text is loosely structured as a linear timeline, beginning in the early 19th century and ending in the present. However, occasional disruptions of these temporal linearities are needed to grasp the essence of the science park as infrastructure.

## Adding a place to the map

The Prussian parliament commissioned the construction of the AOP on Telegrafenberg, a forested hill near Potsdam, in its winter session of 1873/1874 (Hurtig 1890). The AOP was not only the first astrophysical research facility in the world, but also the first of Prussia and Germany's non-university scientific institutes, which since then, have incubated a multitude of techno-scientific innovations. The design, planning and oversight of the construction work for becoming AOP was charged to the relatively unknown architect Paul Emanuel Spieker. Why did the Prussian administrators and scientists involved choose Telegrafenberg for this establishment of astrophysics – a remote location for a highly prestigious infrastructure? Why not build in Berlin or another major city of the Reich? As a matter of fact, such a construction within the capital had been planned initially. However, the first idea had then been discarded due to the fast expansion of Berlin, which caused severe problems for astronomical observation. The fast urbanization had already stripped away much of the functionality of the existing observatory built in the 1830s.

> Thus one has turned one's gaze here to the south bank of the Havel, where large forest complexes were in the possession of the state and situated high up. An outstanding place, 'Telegraphenberg,' was found to be particularly suitable. It rises with its highest peak up to 95 meters above the zero position of the Amsterdam level. (Spieker 1879: 1, translated by the author)

According to Spieker, the Telegrafenberg fulfilled all the requirements for the experiments imagined to be carried out in astrophysics:

> The high position provides a free horizon in all possible directions, while the surrounding forest area in the hands of the state keeps away any disturbing settlements. At the same time, the vegetation prevents the heat radiations, which are detrimental to the observations. (ibid.)

The susceptibility of the sensing technologies to disruptions from the outside and the resulting issue of biased data has been a major issue in astronomy similar to other scientific disciplines dependent on measurements. It has long been clear that data bias cannot be achieved by deleting all environmental influences but by carefully choosing or redesigning a 'natural' habitat. This suitability of parklands to serve as a habitat for scientific sensing technologies had also been widely discussed in the sciento-architectural literature of the time (Wilderotter et al. 2005: 89f).

On the other hand, Potsdam was a convincing location through its relative proximity and connectivity to the networks of political power in Berlin: "The location, […] the proximity of the Berlin-Potsdam Railway, provides a convenient connection to the outside world, and the capital in particular" (Spieker: 1879: 1, translated by the author). As Wilhelm Foerster had already argued in his memorandum of 1971, Potsdam was located at a perfect distance from Berlin; far enough to prevent disturbances from the cacophony of signals and politics but still near enough to ensure an attribution of scientific work to the capital and empire: "It would be advisable to set up the institute not in Berlin itself, but in such close proximity to the capital that its achievements will benefit the scientific reputation of the capital" (Herrmann 1975: 251, translated by the author).

## Instrument, representation, and support

The new science compound in Potsdam was originally imagined as a twofold structure, including an astrophysical institute (for the study of the sky) and a telluric institute (for the study of the earth). However, the concept was dropped due to political (fear of exceeding the concentration of power) and organizational concerns (unmanageability of an oversized telluric institute) (Galle 1926: 67; Hurtig: 1890: 6). More pragmatically, the astrophysical institute was soon complemented by the Royal Observatories for Meteorology (1890) and Geodesy (1892). The spatial composition and aesthetic design of the science park aimed at a reconciliation and demarcation between different purposes of architectures: Representation, scientific instrumentation and support of scientific work.


Figure 6: The Royal Observatories of the Telegrafenberg.
Source: Boch (2008)

These aspects of reconciliation and demarcation can be illustrated by an account of the astrophysicist A. Galle from 1926:

> The buildings on the Telegrafenberg site were positioned according to technical requirements. Nevertheless, one has the impression that one is standing in a palace garden with structures arranged pursuing aesthetical considerations. They seem almost like mosques of an oriental city and appear like luminous stones in the frame of Potsdam's city- and landscape. (ibid.: 65, translated by the author)

As an illustration of the time shows (see Fig. 6), the main buildings of the three institutes (geodesy, astrophysics and meteorology) were built almost equidistantly on a straight line from north-west to south-east. Together with the entrance, they form an isosceles triangle. The position of the main buildings, on the top of the hill and along the triangle base, demarcated the equality and congeniality of the three scientific fields and institutes. All other constructions, along the two legs of the triangle at a lower elevation, hosted supporting infrastructures that *enabled* such scientific work but were not seen as being *part* of the scientific processes. Spieker also confirmed this demarcation in his construction report:

> These subordinated installations may have been sufficiently described by now, considering that their characteristics and use are hardly of general interest. In the following, only the more important buildings for scientific purposes will be subject to a deeper discussion […]. (Spieker 1894: 6, translated by the author)

As a matter of fact, many of these "subordinated installations" were the first ones erected on the hill (Hurtig 1890: 8). These structures served as security (gatehouse), staff accommodation (director's house), maintenance of technology (accommodation for the machinist personnel), provision of alimentation (farmyard) and water (a well system), and electricity (gasworks, generator).[2] Telegrafenberg had been electrified years before the neighboring (major) city of Potsdam (Spieker 1894: 1).

An intermediate position in this demarcation between different infrastructural classes is taken up by scientific technology. Technology at the science park was highly visible (and is still today). The most prominent examples within the 19th century park were optical and photographic telescopes. Considering a focus on astrophysical experimentation, the telescopes of the Potsdam observatories had to be very different from the traditional ones in astronomy. In the latter, telescopes were used to measure the positions of celestial bodies, thereby enabling a continuous and ever more exact and detailed mapping of the sky. By contrast, telescopes serve as light collectors for spectral analysis within astrophysical experimentation. Spectroscopy was the key scientific method in the becoming field of astrophysics. The theoretical fundament of the method was laid throughout the 19th century. Joseph Fraunhofer had already noted dark lines in the spectrum of sunlight at the beginning of the century, but a formalized interpretation of this phenomenon was only given much later by Gustav Kirchhoff and Robert Bunsen. Their development of spectral analysis made it possible to determine the chemical composition and physical state of hot gases and vapors. Scientists were then able to make statements about a star's physical states and processes, its chemical composition and its dynamics by dispersing the light according to wavelengths (GFZ 2017: 46). Potsdam's Telegrafenberg had been a major place to conceptualize, probe and further refine the instrumental settings for these novel experiments. Over time, the setting on the Telegrafenberg enabled groundbreaking experiments, such as those by physicist Albert Abraham Michelson. Michelson carried out his first interferometer experiment in the basement of AOP in 1881, aiming at a scientific proof of ether, a postulated medium for the propagation of light (Michelson 1881). The 'failure' of these experiments (i.e. to identify ether) was one of the theoretical prerequisites for the special theory of relativity described by Albert Einstein in 1905.

## Layering infrastructure

Once disruptive for existing structures, science on Telegrafenberg gradually became institutionalized and stabilized. On a material level, the architectural compound designed by Spieker gradually became the infrastructural base for all scientific work on the hill. The functions of the numerous buildings there have changed many times since then, but they are still the formative structure of the entire place. The relationship between the existing structures and arriving newcomers is not always without friction. Be it by submission or rebellious behavior, all subsequent architectures, institutes and scientists had to position themselves regarding the historically accumulated and arranged elements already in place. As Star and Ruhleder highlight,

> Infrastructure does not grow *de nova;* it wrestles with the 'inertia of the installed base' and inherits strengths and limitations from that base. Optical fibers run along old rail-road lines; new systems are designed for backward-compatibility; and failing to account for these constraints may be fatal or distorting to new development processes […]. (Star/Ruhleder 1996: 113)

As we will see later in this study, these characterizations are equally true for the case of physical infrastructures as for those within the digital realm. In the following, I will discuss some tactics that have been helpful to unravel the 'inertia of the installed base' and the layering of infrastructure at Telegrafenberg. During my investigation of Telegrafenberg as an infrastructure, I have collected a variety of visual representations of the hill's architectures. These include my own photos of buildings, all sorts of maps and plans, drawings, and satellite and drone imagery. The most instructive ones have probably been the schematic maps, such as that shown in Figure 7.

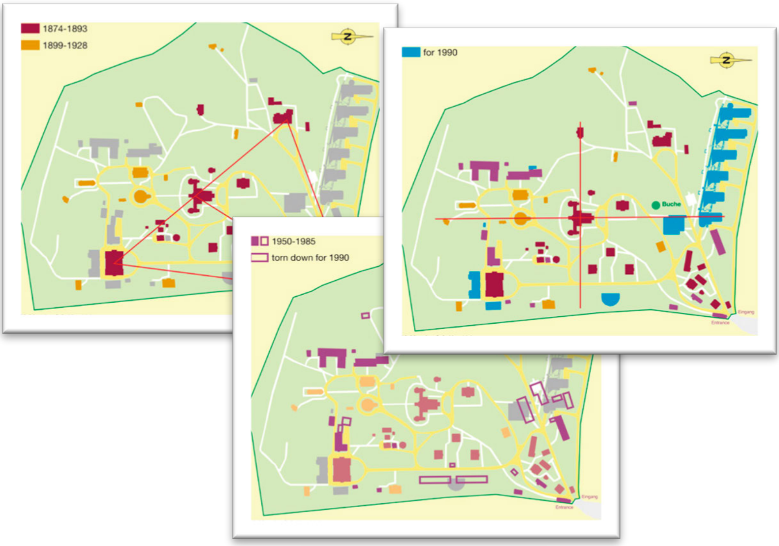


Figure 7: Layers of infrastructure on Telegrafenberg.
Source: http://www.optischertelegraph4.de/telegraphenberg/index.html, retrieved on July 4, 2019.

The maps show different generations of buildings, the original Spieker complex (1874 – 1893), supplements until World War II (1899 – 1928), the era of the cold war and German division (1950 – 1985), and the period from 1990 to the present. Different classes of buildings are highlighted according to their time of formation (map layer, color) and geometric position (auxiliary lines). The maps have been designed by a number of current and former employees of the GFZ, maintaining a website about Prussian telegraphy (www.optischertelegraph4.de) and the history of Telegrafenberg. This work of (what we might call) 'citizen scientists' has been exceptionally helpful as a starting point for my own investigations.

Similar to me, the developers of the 'optischertelegraph4' website engage in activities of infrastructural inversion, surfacing what is normally kept invisible (Bowker 1994; Star 1999). One has to consider that such activities do not only surface but also co-construct certain patterns and perspectives. Accordingly, the maps and descriptions of 'optischertelegraph4' reflect how its developers perceive reality and make sense of the world around them. In this particular case, this view is framed by techniques of professional vision (Goodwin 1994) operationalized in geodesy and the geosciences. The maps of 'optischertelegraph4' helped me to navigate the time-spaces of the science park and to make connections between different elements. As for the 'intertia of the installed base,' all the buildings constructed on Telegrafenberg between 1991 and 2010 pay tribute to the 19th century base by mimicking its geometric forms, materials and colors. The clinker brick facades of the new GFZ and AWI buildings, which were both erected in the late 1990s, are an example of this eclecticism. On the one hand, this meant subordination to a certain tradition of scientific practice that is represented by the Spieker architecture (i.e. the natural sciences, geo- and spatial sciences, physics). On the other hand, it also enabled the new institutes to inherit the reputation of all the scientists, instruments and institutes ever hosted by the science park.

Apart from these aspects of inheritance, the Spieker architectures have been repurposed multiple times in view of changing infrastructural entanglements and challenges. The former house of the director, for example, now serves as a kindergarten and today's 'Café Freundlich' was originally the residence of astronomer Erwin Freundlich (see next paragraph). During my time at PIK, I had the honor of giving a presentation at the 'great cupola,' which once hosted the main telescope of the AOP. Finally, the former Institute for Geodesy has now been repurposed as a central library shared by all organizations on the hill. The library does not only store and make available publications in book form but has become a central node providing digital infrastructure to the institutes of the science park, most notably open data repositories, platforms and services (see chapter V).

## Promises of infrastructure

Concentrating on inheritances and disruptions in the time-space of Telegrafenberg as an infrastructure, some elements fairly drop out of the formalistic discipline; these include the Einstein tower, the remains of architecture built during the Cold War era and the House in the Woods. In the following, I will concentrate on the first element – the Einstein Tower.

Figure 8: Einstein Tower. Source: own photo

The history of Telegrafenberg is interwoven with the physical theory of relativity and the person of Albert Einstein for a number of reasons. The material manifestation of the connection to the physicist was the construction of the Einstein tower in 1926 and the experiments undertaken within its solar observatory. But equally, the connection to the famous scientist has been enforced strategically by branding Telegrafenberg as *Science Park Albert Einstein* in 1992. The driving force behind the construction of the Einstein Tower was the mathematician, astronomer and astrophysicist Erwin Finlay Freundlich, who had worked at the astronomic observatory in Berlin and was in regular contact with Albert Einstein. Einstein had repeatedly urged the necessity of proving his theory of relativity by empirical means. He wrote in a letter to Freundlich in 1913: "Theory is not the way forward here" (Wilderotter et al. 2005: 136, translated by the author). Einstein was referring in his letter to the expected eclipse of the sun in 1914 and the opportunity to prove one of the conditions for the general theory of relativity in this context, namely, gravitational lensing; the distribution between a distant light source and an observer that is capable of bending the light from the source as the light travels towards the observer.[8] In order to engage in empirical investigations of the theory of relativity, Einstein managed to organize funding for an expedition and experiments to be carried out by Freundlich. Unfortunately, the First World War rendered the implementation of this scientific project impossible. During the war, a number of scientists engaged in empirical experiments trying to prove or disapprove Einstein's theory. Potsdam astrophysicist Karl Schwarzschild, for example, tried to prove the relativistic redshift of solar spectral lines by means of a small apparatus installed on the roof of the employee accommodation on Telegrafenberg. However, it appeared that the data available did not dispose the necessary qualities to enable the essential proof of the theories. It became apparent that this objective would only be achievable with an instrument that would first have to be invented and constructed. This ambitious project was tackled in 1920, when architect Felix Mendelsohn was given the opportunity to design the shell for a sun observatory on Telegrafenberg, near the AOP installations. The tower should unite a domed observatory with an underground laboratory. The specifications by Erwin Freundlich determined the geographic location, general elevation and ground plan of the building and Mendelsohn should design and build the appropriate architectural structure to host the instrumental setting. Under these circumstances, Mendelsohn created a building (see Fig. 8) that had been perceived as eccentric and untraditional as the scientific

8 https://en.wikipedia.org/wiki/Gravitational_lens, retrieved on July 4, 2019.

concepts to be approved inside. It brought Mendelsohn great fame but also created a lot of controversy in architectural circles.[9] German publisher and art historian Paul Westheim may have characterized Mendelsohn's working practice and architecture appropriately when he wrote in 1926:

> What architecture is really about, he does not seem to know, but also does not care. If he was more of a proper architect, his construction [...] would have more structural consistency, but probably also much less of the swing, through which he draws attention to himself. He has the grandiose self-confidence that is peculiar to the genius and the dilettante. His technical unorthodoxy may hinder him from being a master builder in the true sense of the word. But it also allows him to manage the construction material in a naïve way, from which many architectural professionals who think of matters of functional design would shy away. (Westheim quoted in Wilderotter et al. 2005: 101, translated by the author)

It is undisputed that Mendelson ignored major traditions of statics and structural engineering. Four years after its finalization, the tower was in severe need of renovation and was characterized as a 'construction error.'[10] The damage was so severe that a first comprehensive renovation had to be carried out as early as 1927/28. In this process, nearly all horizontal components were reinforced by sheet metal and the originally textured outer walls were smoothed (ibid. 2005: 117). Interestingly though, these functional deficiencies did not jeopardize the critical reception of the tower, which today is considered as one of the major style-forming objects for expressionist and organic architecture.

A recurring theme in the critical reception of the tower has always been the relationship between Mendelsohn's architecture, Einstein's

9 See https://c20society.org.uk/botm/einstein-tower-potsdam/, retrieved on July 3, 2019.

10 Neologism by Christine Hoh-Slodczyk, cited in Wilderotter et al. (2005: 117).

theoretical work and the scientific experiments carried out in the tower by astronomer Freundlich and his team. Art historian Fritz Hellwag, for example, declared in 1926 that the architecture of the Einstein tower represents the embodiment of a new age of physics:

> Just as Einstein's discovery represents a sharp cut from previously imaginable research activities, so too has [the Einstein tower's] architect used new construction methods that have hardly anything in common with those practiced earlier. (Hellwag 1926, cited in Wilderotter 2005: 9, translated by the author).

Against the 'newness' of the Einstein tower and theory, cultural and art historian Hans Wilderotter has argued that the tower had not only been erected by quite conventional means, but that it also had some references to older architectural traditions. Equally,

> [...] the new physics had numerous lines of connection to classical physics, as Albert Einstein repeatedly emphasized, and that research at the Einstein Tower would have been unthinkable without the pioneering spectral analyses of the Astrophysical Observatory. (Wilderotter 2005: 10, translated by the author)

As these differing interpretations illustrate, the emphasis on tradition or innovation is also a matter of framing and political choice. Nevertheless and corresponding with the Thomas theorem, the fact that people believe in the reality of a situation, the latter are real in their consequences (Thomas and Thomas, 1928). It is undisputed that the Einstein Tower had been seen as a sign of the beginning of a new era in architecture, physics and beyond.

Once constructed, the Einstein tower enabled the conduction of various experiments on solar spectral analysis. In fact, the installation is still in use today by the successor of AOP, the Leibniz Institute for Astrophysics Potsdam (AIP). On the occasion of the Long Night of the Sciences, a yearly event opening the doors of science to the public, I was able to visit the inside of the Einstein Tower, including its underground laboratory. A current employee of the AIP introduced me to the way the sun observatory produced and hosted data documenting sun activity by means of photogrammetry.

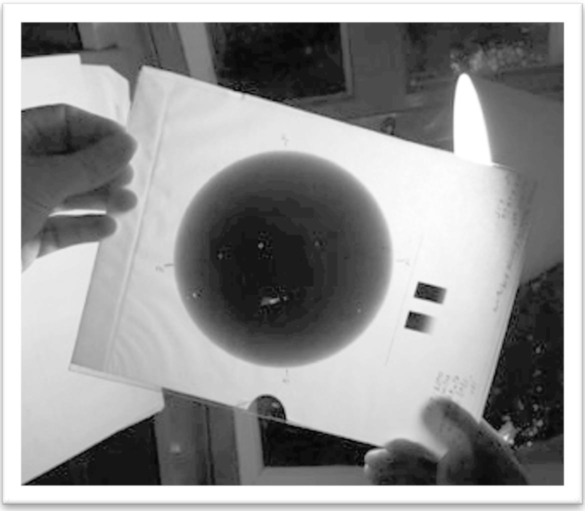

Figure 9: 'Data' in astrophysics. Photo Source: own photo

Figure 8 depicts an example of such 'data.' It shows a negative photographic image of the sun, inscribed as a layer of photo emulsion on a glass plate. As the AIP scientist was highlighting, the data collected and stored since World War II[11] is extremely valuable for contemporary research on sun activity. As a result, the data inscribed on the photogrammetric plates are currently digitalized to make them deployable in state-of-the-art spectroscopic technology and infrastructure.[12]

11 The data collected before World War II have been destroyed as a result of the bombardments of Telegrafenberg by allied forces.

12 Information gathered and photo (Fig. 9) taken during discussions with AIP personnel at the *Long Night of the Sciences* 2019 (June 15). There is more

Considering the interest in the architecture, guided tours had to be offered to the public. The scientists at the Einstein Tower were not only expected to engage in scientific experimentation but to represent these practices on a daily basis. They r became accountable to not only funding agencies and political administrators but an unspecific and unpredictable new category of 'the public.' The task of providing the guided tours was taken up by Harald von Klüber, an employee of scientific director Erwin Freundlich. Von Klüber soon had to learn that people were not interested in the techno-scientific nitty-gritty of astrophysics but absorbed by the monumental architecture on the hill. To deal with this situation, von Klüber experimented with analogy: He did not only relate the theory of relativity to the architecture of the Einstein tower, but put these into perspective with older structures on the hill and more traditional theories in physics (ibid.: 9). Within this storyline, the once revolutionary AOP had become a symbol of the 'old,' while the Einstein tower represented the 'new,' the innovative. This relational set between material structures, architectural patterns and physical theorems had a very improvised character. Von Klüber did not have at his disposal an expertise about architectural design and its history but a lot of knowledge about 'old' and 'new' physics. Nevertheless, his improvised narrative strategy had been quite popular on the hill and was echoed by cultural commentators of the time. And Albert Einstein? It is said that the physicist was conservative in his architectural taste and could not really connect to Mendelsohn's tower. After having been shown through the building by Mendelsohn, he gave a one-word review by whispering into the architect's ear: "Organic."[13]

information on the digitalization project APPLAUSE via https://www.aip.de/de/aktuelles/scientific-highlights/historische-sterndaten-digital-verfuegbar, retrieved on June 3, 2019.

13 https://c20society.org.uk/botm/einstein-tower-potsdam/, retrieved on April 2, 2019.

## Division and reunion

The Einstein tower and many other structures on Telegrafenberg were severely damaged during World War II. Many scientific facilities, instruments and data collections were destroyed and it took the infrastructure considerable time to recover. Later, during the time of the German division, the German Democratic Republic (GDR) and cold war, the institutes on the hill were reorganized and merged into the Zentralinstitut für Physik der Erde (ZIPE; the Central Institute for the Physics of the Earth). *Inter alia*, ZIPE included the former Institute for Geodynamics (Jena), the Geodetic Institute (Potsdam), the Geomagnetic Institute (Potsdam and Niemegk), the Geotectonic Institute (Berlin) and the GDR working group for extraterritorial geodetic and geophysical research in Potsdam (Kautzleben 1999: 34). This fusion was accompanied by disciplinary research restructuring, leading to the establishment and emancipation of *cosmic physics* as a new field of research, and the strengthening and emancipation of geo- and astrophysical sciences within the GDR. Cosmic physics included the subdomains of astrophysics, earth physics, solar-terrestrial physics, oceanography and geography (ibid.: 35). A number of new buildings were erected on Telegrafenberg during the communist reign in East Germany. As was often the case in the GDR, the constructions purposely broke with the architectural traditions of the Kaiserreich and emphasized other aspects, such as functionality and social utility. As the historiographers of optischertelegraph4.de note on their website, the GDR buildings "[…] were not always erected with a noticeable geometric connection to the existing buildings."[14] Based on our observations about the Einstein Tower, we could go further than that and argue that the GDR spared no effort to make clear that its new facilities broke with every single aspect of the hill's traditions – in a geometric, aesthetic and

14 http://www.optischertelegraph4.de/telegraphenberg/index.html, retrieved on April 2, 2019.

political sense. As we have seen before, the embeddedness of infrastructures (Star/Ruhleder 1996: 113) involves more than physical structures (e.g. optical cables along old railway tracks) and includes social arrangements and technologies.

The story repeated itself after the fall of the Berlin wall, when most of the GDR constructions were torn down (illustrated by the maps in Fig. 6). The reunited Germany had a strong desire to remove the traces and reminders of its painful division. By contrast, it began to restore the architectural remains of its 19th century scientific grandeur. All employees of ZIPE were dismissed in 1991 and a new restructuring on the hill took place. Some existing structures and some of the ZIPE personnel were taken over by a newly founded institute for geosciences, now operating under the name of the *Helmholtz Centre Potsdam – GFZ.* A comprehensive architectural compound was built to host this newly established hub for the geosciences in Germany as a replacement for the GDR buildings demolished. On the top of the hill, within the former headquarters of the Astrophysical Observatory, another institute became part of the science park: The Potsdam Institute.

The PIK is now a major global player in the fight for climate change, but the institute started small in 1992. The German Federal government decided to found a climate institute prior to the environmental summit in Rio de Janeiro (1992) to show its commitment and demonstrate its leading role in matters regarding sustainability. Hans Joachim Schellnhuber, then Professor for Theoretical Physics at Oldenburg University, saw an opportunity and offered himself and a concept (see chapter II) for the institute. The research center started with about 30 employees, mostly physicists, in Berlin in 1991. Two-thirds of the employees had been taken over from the Academy for the Sciences of the recently collapsed GDR. Manfred Stock, one of the then employees remembers the first two working days:

> [...] we drove to Normannenstrasse in Berlin and entered a building within the former Stasi[15] headquarters. These were our first offices. Cameras were staring at us from everywhere. (Hoffmann 2017, translated by the author)

However, the researchers could not stay there for long and the search for a new location for the institute building began. The result was Telegrafenberg in Potsdam. Stock, who was deeply involved in the search, remembers: “We first moved into a container construction – temporarily, as we were told. But the temporary measure then had to hold until 2001” (ibid.: 2017). Eventually, the PIK researchers were allowed to move into the prestigious Spieker architectures distributed on the hill, such as the former Astrophysical Observatory (now ‘Michelson House’) and the Meteorological Observatory (now ‘Süring House’). This set was supplemented by a new construction built specifically for the PIK, the ‘House in the Woods,’ in 2015.

## Heterogenous temporalities of infrastructure

In ethnography, the outcome of analysis may resemble more of a collage than a traditional master narrative with a single voice. As sociologist Herbert Kalthoff has argued, a collage is not about theoretical saturation but about the mobilization of different relevances. For him, the methods and elaborated research results represent contexts for each other which are enriched by contradictions and frictions. They do not have to be brought into agreement:

> Such a collage documents, firstly, the constructiveness of the research methods, secondly, the tension between the individual elements and, thirdly, the aesthetics created by the materiality and arrangement of elements. (Kalthoff 2010: 363, translated by the author)

15 *Ministerium für Staatssicherheit,* the secret police agency of the GDR.

Our collage of the Einstein Tower and its entanglements has implications regarding the characterization of infrastructure: It highlights the crucial aspect of future temporalities, imaginaries and promises for the being of infrastructure. The related structures on Telegrafenberg do not only represent a great past and are functional in the present, they also make bold promises about the future. As Nikhil Anand, Akhil Gupta and Hannah Appel have highlighted in their anthology on *The Promise of Infrastructure*:

> Material infrastructures, including roads and water pipes, electricity lines and ports, oil pipelines and sewage systems, are dense social, material, aesthetic, and political formations that are critical both to differentiated experiences of everyday life and to expectations of the future. They have long promised modernity, development, progress, and freedom to people all over the world.
> (Anand et al. 2018: 11)

Every infrastructure makes such promises about the future: A library promises to make books (i.e. knowledge) available for anyone, the internet promises to connect all human beings on the earth, and highways can potentially take you anywhere. The differences between infrastructures may often bow down to different promises they make about the future and how explicit they are about their future imaginary. As a matter of fact, I prefer the term 'promise' to related terms of the 'imaginary' (Jasanoff/Kim 2015) and the 'master narrative' (Star 1999). Infrastructures do not always speak with one single voice or construct a homogenous imaginary. By contrast, they may well promise different things to different people at different times. The Einstein Tower as a research infrastructure is a good example of such a collage of future promises, but so are other buildings on the hill. I will introduce PIK's 'House in the Woods' and its promises of a future of deep sustainability in chapter II.