Journal of Astronomical History and Heritage, 25(3), 341–438 (2022).

PIETER JOHANNES VAN RHIJN, KAPTEYN'S ASTRONOMICAL LABORATORY AND THE *PLAN OF SELECTED AREAS*

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Abstract: In this paper I discuss the Kapteyn Astronomical Laboratory during the period of Pieter Johannes van Rhijn's Directorate, which lasted from 1921 to 1957. It had developed under the founder Jacobus Cornelius Kapteyn into one of the leading astronomical research institutes in the world. When van Rhijn took over at the retirement of Kapteyn, it was in the process of coordinating Kapteyn's *Plan of Selected Areas* with the aim of determining the structure of the Sidereal System. Kapteyn had just, with the help of van Rhijn, presented a first model of the distribution of stars in space from existing observations, and on this basis he constructed a 'first attempt' model of the Stellar System including dynamics, i.e. deriving the gravitational field from the distribution of the stars and showing how the random and systematic motions of the stars, the kinematics, could provide equilibrium and stability to the system. Under van Rhijn, the work on the *Selected Areas* progressed well, but the Groningen Laboratorium went into decline, loosing much of its status and prestige.

I conclude the following. There was very little choice for Kapteyn's successor and van Rhijn was appointed effectively by default. Kapteyn himself must have seen that the future for astronomy in the Netherlands lay with Leiden Observatory, where already during his lifetime two of his protégées, Willem de Sitter and Ejnar Hertzsprung, were in charge, and to which a third one was added not much later in the person of Jan Oort. Kapteyn had his *Plan of Selected Areas* in addition to the scientific case set up as a way of ensuring the future of the Groningen Laboratorium at least for the time of this effort, arranging it to be supplied with plate material to complete the provision of the data for the final attack on the Sidereal problem.

Van Rhijn's research was solid and professional, but in his papers he invariably stopped before discussing how his findings fitted into the larger emerging picture of the structure of the Galaxy. Comparison of his work in the 1930s on the distribution of stars as a function of spectral types and Jan Hendrik Oort's determination of his 1938 crosscut through the Galaxy illustrates this. While this work by Oort constituted the second attempt following on Kapteyn's first, and may be seen as the actual completion of the research for which the *Plan of Selected Areas* was designed, van Rhijn continued adding more and more data in the context of the *Plan* without redefining the aims in the light of developments. The *Spectral Durchmusterung* carried out in collaboration with the Bergedorf–Hamburg Sternwarte and Harvard College Observatory was an enormous drain on the Groningen resources. Van Rhijn's successful attempt to obtain his own telescope resulted in very relevant and correct determinations of the wavelength dependence of interstellar extinction from photographic spectra, but these results only became available in the 1950s when the field had turned to photoelectric methods.

Kapteyn's concept of an astronomical laboratory lost its viability in van Rhijn's time when observatories were no longer interested in providing observational material for others to do research. Kapteyn's model on the other hand of a laboratory-like institution, where research is based on material obtained elsewhere on Earth or in space, is now the normal operating mode in astronomical research. The only difference is access to observing facilities primarily, which is now structured and guaranteed (subject to proposal acceptance of course), through national and international organizations rather than access on the basis of one's fame or stature.

The cause of the loss of the Kapteyn Laboratorium of its prominent place in the international context was largely van Rhijn's unwavering dedication to complete Kapteyn's work. The *Plan of Selected Areas* had been important for the progress of astronomy, but effectively reached the goals Kapteyn had in mind for it already in the 1930s with Oort's 1932 work on the vertical force field and local 'Oort limit' and his 1938 crosscut through the Galaxy.

Van Rhijn was unfortunately hampered throughout almost his entire Directorate by factors that severely limited his attempts to obtain more funding in spite of local support from his university. These were of course in the first place the Great Depression of the 1930s and World War II and its aftermath, while during most of the 1940s he suffered from tuberculosis. But, also, the remote location of Groningen compared to Leiden, where a major infrastructure led by three important protégées of Kapteyn was in place, and the Governmental bias towards support for Leiden over Groningen was an important factor.

Finally, I examine the developments in the 1950s and the circumstances that made Adriaan Blaauw accept his appointment as van Rhijn's successor in 1957 and initiate the beginnings of the revival of the Kapteyn Laboratorium under his leadership.

Keywords: Pieter Johannes van Rhijn; Kapteyn Astronomical Laboratory; *Plan of Selected Areas*, statistical astronomy; Galactic astronomy

1 INTRODUCTION

This paper concerns the 'Sterrenkundig Laboratorium Kapteyn'[1] in Groningen, the Netherlands, during the Directorship of Pieter Johannes van Rhijn (1886–1960),[2] which lasted from 1921 to 1957.

Figure 1: Pieter Johannes van Rhijn in his late twenties around the time he obtained his PhD in 1915 (courtesy: Kapteyn Astronomical Institute).

Figure 2: The painting of Jacobus Cornelius Kapteyn by Jan Veth, now located in the Senate Room of the Academy Building of the University of Groningen. It was originally intended as a present to his wife at the 40th anniversary of his Professorship, but she disliked it and a new one was painted. Veth later overpainted it with gown, barret and jabot for its present purpose. For the full story see van der Kruit (2015; 2021a) (courtesy: University of Groningen).

At the start of the academic year in 1921 Pieter van Rhijn (Figure 1) was appointed Professor of Astronomy at the University of Groningen and Director of its Astronomical Laboratory. This Laboratory had been founded by Jacobus Kapteyn (Figure 2), and on the occasion the Curators of the University and with consent of the Minister had renamed it the 'Sterrenkundig Laboratorium Kapteyn'. When Kapteyn's attempts—starting not long after he was appointed Professor of Astronomy in 1878 without any facility to speak of for research and teaching in Astronomy—to obtain a real observatory had failed, he had reverted to this 'observatory without a telescope'. Under Kapteyn it had risen to become one of the most prominent institutions worldwide, overshadowing the Sterrewacht Leiden, which was in a deep decline. Under van Rhijn the Groningen Laboratorium slipped in turn to a lower rank on the ladder of prominence, status and prestige. I will look into the circumstances, context and background to this.

I will start with context and briefly consider astronomy in the Netherlands up to around the end of this period (i.e. the 1950s). A first reference would be David Baneke's (2015) history of astronomy in the Netherlands in the twentieth century, but this still awaits publication in an English translation. In recent years a few further studies on particular aspects have been published, and also a number of biographies of Dutch astronomers of this period have appeared (a few unfortunately also in Dutch only).

Although astronomy in the Netherlands is generally considered to have started with Christiaan Huygens (1629–1695) and his 'discovery' of Saturn's rings and satellite Titan (see Andriesse, 1993), modern astronomy in the Netherlands goes back to Frederik Kaiser (see van den Berg, 2022). Kaiser was the founder of the Sterrewacht Leiden, the building modeled after Pulkovo Observatorium and opened in 1861. Kaiser had made quite a name for himself when Comet 1P/Halley was due to return in 1835. He revised calculations made earlier by renowned scientists and predicted the time of passage of the perihelion to an astounding accuracy of 1.5 hours, where many celebrated astronomers had been wrong by much larger time intervals, sometimes as much as 9 days. Under Kaiser the Sterrewacht became well-known for its extremely accurate astrometry. However, under his successor Hendricus Gerardus van de Sande Bakhuyzen (1838–1923), it lost much of its influence because he decided not to embrace photography as the new tool while in fact it turned out superior to visual observing. Under his younger brother Ernst Frederik (1848–1918), who was appointed Director in 1908, Leiden lost even more of its status of excellence. Instead Groningen took over, where Jacobus Kapteyn became one of the most prominent astronomers worldwide with his studies of the distributions of stars in space and stellar kinematics (see van der Kruit, 2015; 2021a).

The turning point for Leiden came in 1918, when after the sudden death of Ernst van de Sande Bakhuyzen, Willem de Sitter (1872–1934) became Director, having been appointed Professor of Astronomy in Leiden already in 1908. De Sitter (see Guichelaar, 2018) was Kapteyn's first student working on the structure of the system of Galilean satellites around Jupiter. In the reorganization of the Sterrewacht of 1918, in which Kapteyn had had an important voice as well, a new Department of stellar astronomy was created next to de Sitter's theoretical one (in this Einstein's General Relativity became a second focus). The new Department was headed by Ejnar Hertzsprung (1873–1967), who already was a world-renowned astronomer (there is no recent biography, but see Herrmann, 1994), but the third department on astrometry remained without a head, when the Prime Minister refused to appoint Antonie Pannekoek (1873–1960) to the post because of his communist sympathies. Pannekoek was appointed subsequently at the municipal University of Amsterdam, where he founded an Astronomical Institute and made a name by mapping the Milky Way and more impressively, founding astrophysics of stellar atmospheres, exploring ways to apply the Saha ionization formula to study the physical conditions in these outer envelopes (see Tai, van der Steen, and van Dongen, 2019). In 1925 Jan Hendrik Oort was appointed at the vacant Leiden position. Under Marcel Gilles Jozef Minnaert (1893–1970) Utrecht rose to prominence particularly for producing a detailed solar spectrum and founding a line of research in solar physics and astrophysics (see Molenaar, 2003). Later additions to the staffs until 1957 (the end of van Rhijn's term in office) were Hendrik Christoffel (Henk) van de Hulst (1918–2000) (see van Delft, 2021), Pieter Theodorus Oosterhoff (1904–1978) and Adriaan Blaauw (1916–2010) in Leiden, Herman Zanstra (1894–1972) in Amsterdam and Cornelis (Kees) de Jager (1921–2021) in Utrecht. Comprehensive biographies of these last four remain to be written.

In the twentieth century, Dutch astronomy had become a major player worldwide in the field of astronomy. Consider the large number of Dutch astronomers who were born before WWII and rose to leading positions abroad (usually directors), as listed by Oort, (1982): Jan Schilt, Willem van den Bos, Dirk Brouwer, Peter van de Kamp, Willem Luyten, Gerard Kuiper, Bart Bok, Leendert Binnendijk, Maarten Schmidt, Lo Woltjer, Gart Westerhout, Tom Gehrels and Sydney van den Bergh. To illustrate this point further, I note that almost all astronomers in the Netherlands mentioned in the previous paragraph were awarded what was probably the most prestigious honor, the Gold Medal of the Royal Astronomical Society: Kapteyn 1902, Hertzsprung 1929, de Sitter 1931, Oort, 1946, Minnaert, 1947, Pannekoek, 1951, Zanstra 1961 and de Jager 1981. Most of these also received the Bruce Medal of the Astronomical Society of the Pacific. Van de Hulst, Blaauw and Oosterhoff are missing in the Gold Medal list, but the first two of them received the Bruce Medal in 1978 and 1988. In this success story van Rhijn is conspicuously missing.

In his presentation during a symposium in 1999 in Groningen on the 'Legacy of Jacobus C. Kapteyn' (van der Kruit and van Berkel, 2000), Woodruff T. Sullivan (2000: 230) put it as follows:

> ... at Groningen after the death of Kapteyn in 1922, his eponymous Laboratory went into a period of decline coinciding with the long directorship ... of his protégé Pieter van Rhijn. Van Rhijn did some excellent work in the 1920s ... but both his research and leadership for the rest of his career were unimaginative and stuck in a rut (Blaauw, 1983) ...
>
> Kapteyn's *Plan of Selected Areas*, the study and organization of which occupied a large portion of his successor van Rhijn's career ... this work was done in a routine and unimaginative manner, and contributed to Groningen's period of decline.

In the paper by Adriaan Blaauw that Sullivan refers to in support of his case, Blaauw (1983: 56; my translation) actually is much milder:

> ... the foundation of an astronomical laboratory. But the complete dependence on the cooperation of foreign observatories that went along with that was a very heavy burden on the future of the institute. Could van Rhijn reasonably be expected to continue the special fame that the institute had acquired through Kapteyn, and which was a necessary condition for this kind of cooperation to maintain? ...
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> [Van Rhijn] was a thorough scientific researcher ... His approach to research, however, was highly schematic, strongly focused on further evaluation of previously designated properties or quantities. This benefited the thoroughness of the intended result, but came at the expense of flexibility and reduced the opportunity for unexpected perspectives; as a result, it did not lead to surprising discoveries.

Or in Blaauw's interview for the American Institute of Physics Oral History Interviews Project:

> ... the main lines at Groningen by van Rhijn, who followed very much in the course set by Kapteyn ... And in that time, he accomplished a very large amount of, you might call it routine works. But it is a very thorough compilation of photometry and proper motions in the Selected Areas and also work on such problems as luminosity functions. (Blaauw, 1978).

It may not be surprising that no comprehensive biography of van Rhijn has ever been written, but it remains remarkable that shortly after his death no extensive obituary concerning van Rhijn appeared in any major international astronomical journal. The only somewhat extensive one was written by Adriaan Blaauw and Jean Jacques Raimond (1903–1961)—both having obtained their PhDs with van Rhijn as 'promotor' (supervisor)—in Dutch in the periodical of the association of amateur astronomers and meteorologists (Blaauw and Raimond, 1960), and Blaauw's (2014b) contribution in the *Biographical Encyclopedia of Astronomers* is modeled on this article by him and Raimond. But they did not think it worthwhile, necessary or appropriate to publish an English language article to honor the life of an important astronomer. Bartholomeus Jan (Bart) Bok (1906–1983), who also obtained his PhD under van Rhijn, did publish obituaries in *Sky & Telescope* on both Pannekoek and van Rhijn (Bok, 1960). And in 1969 Ernst Julius Öpik (1893–1985), who was catching up on a suspension of the *Irish Astronomical Journal*, listed van Rhijn among a set of over twenty astronomers who had died in previous years (Öpik, 1969). But that is all.

In fact, there is not a single article on van Rhijn and Groningen Astronomy under him in the English literature other than Blaauw's article in the *Biographical Encyclopedia of Astronomers*, and in Dutch there is only the one by Blaauw (1983) that Sullivan referred to. At van Rhijn's seventieth birthday in 1954 a kind of festschrift appeared (the Dutch title translates into English as 'in Kapteyn's footsteps'; see below) with articles by his colleagues and students, but the articles are mostly in Dutch and refer to then-current research by the authors themselves and do not address van Rhijn's contributions in any detail.

In this contribution I will critically examine the Kapteyn Laboratorium during the period of van Rhijn's directorate, 1921–1957. Questions addressed include: Was van Rhijn the successor Kapteyn had wished for, or had he preferred someone else? What future might Kapteyn have had in mind for his Laboratorium? Was van Rhijn's work really so unimaginative, and how important has it turned out to be? Was Kapteyn's concept of an astronomical laboratory, an observatory without a telescope, a viable one in the long run? What precisely caused the Kapteyn Laboratorium to lose its prominent place in an international context? How important was the *Plan of Selected Areas* for the progress of astronomy, and did it ever reach the goals Kapteyn had in mind for it? Did van Rhijn get the support he deserved from his University and the Government? How influential was van Rhijn, and what was his role in the prominence of Dutch astronomy that followed during the twentieth century? What made Adriaan Blaauw accept his appointment as van Rhijn's successor?

I rely heavily on Adriaan Blaauw's (1983) chapter, and when appropriate I will quote verbatim from this in translation.

A few words on archival sources. The van Rhijn Archives are now part of the Regionaal Historisch Centrum 'Groningen Archieven', founded in 2001 by the Ministry of Education, Culture and Science and the Municipality of Groningen, where the University of Groningen has deposited its Archives. The van Rhijn Archives were transferred from the Kapteyn Astronomical Institute through the 'Archief Depot' of the University. Much of the correspondence is missing in the Groninger Archieven under the corresponding headings, including that between van Rhijn and the Curators of the university. Why these letters have been culled from the collection is unknown, but probably to avoid duplication. This, unfortunately, has made this very much less accessible.

Van Rhijn corresponded quite extensively with Jan Hendrik Oort (1900–1992) in Leiden. These letters are missing in Groningen also, but quite a collection is available in the Oort Archives (Oort 1900–1992), which contains over 400 letters between van Rhijn and Oort. These are mostly handwritten letters, of which usually no copies were kept, so most are from van Rhijn to Oort. Also a few letters from Adriaan Blaauw and Lukas Plaut to Oort proved to be relevant to this paper. These letters are almost entirely in Dutch of course. An extensive inventory of the Oort Archives has been published by Jet Katgert-Merkelijn (1991). No professional scans are available for the Oort Archives, but over 27,000 reasonable to good quality photographs, taken by me, of mainly letters and notes are available on my special Oort homepage accompanying my biography of him (van der Kruit, 2019).

Much information on the University of Groningen during van Rhijn's days is available in Part II of Klaas van Berkel's (2017) monumental history of the University. Again, this is in Dutch unfortunately, and of not much use to English-speaking researchers. An extensive English summary has been announced.

2 PIETER JOHANNES VAN RHIJN: A BIOGRAPHICAL SKETCH

I start this section with some biographical notes on van Rhijn. As mentioned, at present no comprehensive biography on him has been written.

Pieter Johannes van Rhijn was born on 24 March 1886 in the city of Gouda, some 20 km northeast of Rotterdam. His father, Cornelis Hendrikus van Rhijn (1849–1913), was a clergyman and not long after Pieter's birth he was appointed Professor of Theology at the University of Groningen. In Nijenhuis (1998) we read about C.H. van Rhijn (my translation):

> Van R. had a hard time fitting into the directional scheme of his time. The liberal, tolerant upbringing, received in the parental home, continued to influence him throughout his life. He wanted to be an unapologetic biblical theologian.

Pieter's upbringing therefore was undoubtedly relatively liberal as well. Cornelis van Rhijn had had a first marriage, which however lasted only three years after which his wife died. This marriage produced no children. Cornelis married again in 1882 to Aletta Jacoba Francina Kruijt (1859–1945), and Pieter Johannes was their second child. He had one older sister and three younger brothers, of whom one, Maarten van Rhijn (1888–1966), eventually like his father became a Professor of Theology, but at the University of Utrecht. On the Web there is a long and detailed genealogy of the family van Rhijn (earlier often spelled van Rijn) (Stichting Het Geslacht Van Rhijn, 2022). The keeper of this, Gert Jan van Rhijn, a grandson of van Rhijn's brother Maarten, has provided some very useful biographical material to me. The genealogy goes back to the year 1510 and to ancestors who lived very close to Leiden, but the famous seventeenth century painter from Leiden, Rembrandt with the same surname, did not turn out to be part of his ancestry. Pieter grew up in Groningen, where eventually he studied Astronomy with Kapteyn. In 1915 obtained his PhD with Kapteyn as supervisor.

In 1932, at the age of 46, he married Regnera Louise Geertruid Constantia de Bie (1906–1997), twenty years his junior (Figure 3). In his letters van Rhijn referred to her as 'Rein' (interestingly pronounced the same as 'Rhijn'). She had a degree in Law. The marriage certificate says she was 'without occupation'. Her father was a juvenile judge and later President of a District Court (Arrondissementsrechtbank) in Rotterdam. Van Rhijn and his wife eventually would have two children, a son and a daughter (see Figure 4).

Before his marriage van Rhijn was well occupied by the fact that his elder sister Adriana Josephine van Rhijn (1884–1976), whose nickname was Joos, lived in Groningen after being divorced in 1921. At the time of the divorce she had four children between 2 and 10 years of age, and

Figure 3: Pieter J. van Rhijn and Regnera ('Rein') L.G.C. de Bie at their wedding in 1932 (from the Website of the `Stichting Het geslacht van Rhijn', reproduced with permission).

Figure 4: Van Rhijn with his son, who was born in 1934 (from the Website of the `Stichting Het geslacht van Rhijn', reproduced with permission).

van Rhijn helped her extensively in raising the children. At the time of his own marriage these children were eleven years older and his involvement with them must slowly have become less time consuming.

During the Second World War (WWII) van Rhijn contracted tuberculosis and his recovery took a fair number of years. More about this is covered in the later sections of this paper. It did have a major impact on the rest of his life, for his vigor never fully returned.

Not much has been written about van Rhijn as a private person. Through Gert Jan van Rhijn, the keeper of the van Rhijn genealogy (Stichting Het Geslacht Van Rhijn, 2022), I have been able to get answers to some questions about Pieter van Rhijn from the latter's daughter, who is still alive (unlike his son). With his background of being the son of a clergyman and theology professor, the question arises how religious Pieter van Rhijn really was. According to his daughter (G.J. van Rhijn, pers. comm., July/August 2022) he went to church but not every week and the church he went to was that of the Remonstrants, because he did not believe the creation story.

The Remonstrant Movement had started with the liberal Leiden Professor Jacobus Arminius (±1555–1609). The view of Calvinism was that humans were predestined for Heaven or Hell and had no free will to choose to live either in virtue or in sin. The followers of Arminius (sometimes called the 'Rekkelijken' or Flexibles) opposed this and a few related points of view, which were collected in the 'Five Articles of Remonstrance' (objection or statement of defense) in 1610, which caused them to be designated Remonstrants. Their views were particularly disputed by Franciscus Gomarus (1563–1641), whose followers were called 'Preciezen' (Strict Ones) or Counter-Remonstrants. Gomarus actually already taught in Leiden when Arminius arrived there. During the Synod of Dordrecht (1618–1619) the Remonstrants were expelled by the Protestant Church and the movement separated from the Calvinists. The movement still exists in the form of the Remonstrant Brotherhood and has somewhat over 5000 members and 'friends' (sympathizers) in the Netherlands. It stands for a liberal interpretation of Christianity; their faith is characterized by a non-dogmatic attitude, in which freedom of thought and belief based on one's own insights is central and developments in modern science and insights in general are taken into consideration. There was therefore room for van Rhijn to follow modern scientific developments and to adopt evolution over biblical creation.

Van Rhijn's daughter (who like her aunt was called 'Joos' in the family) stressed that

> ... van Rhijn did not like dogmatic beliefs, but his wife had a more orthodox upbringing. At home they read from the Bible, but Pieter Johannes never led in prayer. He had a broad view and was averse to strict rules. His wife had had a strict upbringing. If something had to be done this way or that, Pieter Johannes van Rhijn would say: So, who stipulates that ['Wie stelt dat vast?', stressing that no other authority than himself would decide on his behavior, action or options].
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> They [he and his wife] went to church together. The faith was also passed on, so daughter Joos went with them to catechism. Her mother found it liberating that Pieter Johannes thought more freely about religion. (G.J. van Rhijn, pers. comm. July/August 2022; my translation).

Van Rhijn had no special functions in the church and did not participate in activities other than the Sunday service. In the Netherlands, people had (and have) attached small signs to their front doors, traditionally with the name of the man, as head of the family, imprinted on it. In van Rhijn's case his wife's maiden name was added to it.

Van Rhijn was infuriated about the German occupation of the Netherlands during WWII. He was hurt and outraged by the supposed German superiority, and the breach of Dutch sovereignty. In a letter dated December 1945 to his sister-in-law[3] he expressed this as follows:

> What has struck me most in the Germans is their unsparing arrogance ('das Herrenvolk') and their virtuosity in lying. They can lie brilliantly. Therein lies a certain merit. The Krauts only did it stupidly. And sometimes I almost burst at the pharisaism of e.g. Seys Inquart (the German Chief in the Netherlands), who said he had come to the Netherlands to protect us from Bolshevism. But those are echos from a distant past. The gentlemen Nazi leaders including Seys Inquart are now on trial in Nuremberg and within a few months they will probably no longer be among the living. (G.J. van Rhijn, pers. comm. July/August 2022; my translation).

Arthur Seyss-Inquart (born Artur Zajtich; 1892–1946) actually was not German, but Austrian.

Pieter van Rhijn played the viola, and Adriaan Blaauw (1983) has recorded his fond recollection of (my translation):

> ... the warmth of his domestic environment, where playing music together – van Rhijn was an excellent viola player – was a bright spot in the dark War years.

Blaauw himself played the flute. Van Rhijn's daughter has remarked that

> ... as a younger man in his student days he had played in ensembles. He was not good enough to play first violin ... Eventually he found it more interesting to play the viola. Later in life he did not have the strength [to play]. (G.J. van Rhijn, pers. comm. July/August 2022 my translation).

She also recorded (*ibid.*) that she went to performances of Bach's Matthäus Passion together with her father. Mrs van Rhijn sang in a choir. Van Rhijn was interested in Mozart and Schubert quartets. When recovering from tuberculosis after the War he noted in the letter to his sister-in-law referred to above that he was allowed out of bed eight hours a day and walking 30 minutes, and added that in addition to reading he listened to concerts on the radio, where Mozart was an obvious favorite. He wrote:

> Mozart is a musician who really doesn't belong on this Earth. When hearing his music, it is as if the heavens break open over this cursed world. My colleague van der Leeuw professor of theology (now a Minister) says that after hearing a Mozart concert he no longer believes in the Original Sin for three days. (G.J. van Rhijn, pers. comm. July/August 2022; my translation).

Gerardus van der Leeuw (1890–1950), a good friend of van Rhijn, was an historian and philosopher of religion, and for a short period was the Minister of Education immediately after the War.

Van Rhijn read a lot throughout his life, but particularly when he was recovering from tuberculosis, especially English novels. British authors that he liked included Howard Spring, John Galsworthy, Nevil Shute, J.B. Priestley, Graham Greene, W. Somerset Maugham, Duff Cooper, C.L. Morgan, Jane Austin and the Bronte sisters. American writers were fewer, but included J.P. Marquand, Louis Bromfield and Pearl Buck. He mentioned in the letter quoted that he also had read some excellent poetry.

As for outdoors activities, he also often went hiking to south of Groningen, one would think with his family.

Pieter Johannes van Rhijn died in Groningen on 9 May 1960 at the age of 74.

3 PIETER JOHANNES VAN RHIJN: HIS EARLY RESEARCH

Pieter Van Rhijn obtained his PhD in 1915, with a thesis consisting of two quite separate studies. For this he had spent an extended period at Mount Wilson Observatory (1912–1913), which of course had been arranged by Kapteyn with George Ellery Hale (1868–1938). The title of the thesis was *Derivation of the Change of Colour with Distance and Apparent Magnitude Together with a New Determination of the Mean Parallaxes of the Stars with Given Magnitude and Proper Motion*. The thesis was never fully published in a journal; a shorter paper appeared with the same title as the thesis itself (van Rhijn, 1916), although it treated really only the first part, which concerned the question of reddening of starlight with distance from the Sun. In 1909, Kapteyn had hypothesized that extinction of starlight would be primarily scattering rather than absorption, and that this could be expected to be stronger at shorter wavelengths, giving rise to reddening of starlight with distance (Kapteyn, 1909). Van Rhijn addressed this issue using a study called the 'Yerkes Actinometry', which was published by John Adelbert Parkhurst (1861–1925) in 1912. With this data-set, together with proper motions from other places, van Rhijn determined the change in color of stars with distance. Kapteyn had assumed (as we now know incorrectly) that the wavelength dependence was like that of Rayleigh Scattering in the Earth's atmosphere, so that reddening could be related to total extinction. Van Rhijn thus found that it amounted to "*ceteris paribus* [all other things being equal] only 0.000195 ± 0.00003 magnitudes per parsec", only about half what Kapteyn had found in 1909. Interestingly—and disappointingly—there was absolutely no discussion of this difference, either in the paper, or in the thesis itself. We will see in what follows that this is the first instance of an emerging pattern where van Rhijn never added discussion in a paper to place his findings in a wider context. Van Rhijns' value is much lower than the currently adopted value of approximately one magnitude per kiloparsec. However, this region of Parkhurst Actinometry is centered on the Celestial Pole which means almost 30° Galactic latitude. So, in hindsight, it is not surprising that the inferred extinction was smaller than in all-sky determinations or regions exclusively in the Milky Way.

The second part of the thesis formed an important step in the preparation to derive the distribution of stars in space, the ultimate aim of Kapteyn's scientific work, and was published much later after more work and there were additional data. Because it is relevant to the discussion of van Rhijn's work for the rest of this paper, I summarize first the procedure Kapteyn had designed for this very briefly. It begins with two fundamental equations of statistical astronomy. They link the counts of stars and the average parallax as a function of apparent magnitude to the distribution of the total density of stars as a function of the position in space and to the luminosity function. I will not present these here; those interested should consult the full online version in Appendix A (van der Kruit, 2021c) or (van der Kruit, 2021a).[4]

Distances of stars can be measured directly from trigonometry using as base the diameter of the Earth's orbit. But Kapteyn and others had concluded that it was not possible to do this in a wholesale manner. So, he decided to use the motion of the Sun through space as a baseline. Already in one year this amounts to four times larger a baseline, and furthermore, it only increases with time. This method of so-called secular parallaxes uses proper motions which contain a reflection of the motion of the Sun through space in addition to the peculiar motion of each star itself. His assumption was that these latter components were random and isotropic. However, because of these random motions these secular parallaxes can only be derived statistically.

Kapteyn developed the method to solve these fundamental equations basically in two papers, Kapteyn (1900) and Kapteyn (1902). The first step is to determine, with the secular parallax method, the average parallax of the stars of any apparent magnitude m and proper motion μ. We can also estimate the average absolute magnitude when we know the average parallax. Of course, for an individual star with an observed m and μ the parallax will be different from the mean. But for the problem of the distribution of the stars in space it is not necessary to know the distance of each individual star, only how many stars there are at a certain distance. Furthermore, we need to know in principle the distribution law of the parallaxes around the average value. However, Kapteyn showed that widely differing assumptions of this law led to results that differed but little. Now, since it thus becomes possible to find, for any given distance, the number of stars of each absolute magnitude, we can evidently derive the two fundamental laws which determine the arrangement of the stars in space, viz. the distribution of the stars over absolute magnitude, which Kapteyn called the 'luminosity curve' and for each line of sight the law of total stellar density with distance from the Sun.

Kapteyn developed a convenient numerical procedure of conducting these computations, after he had introduced two assumptions: (1) There is no appreciable extinction of light in space; and (2) The frequency of the absolute magnitudes (the luminosity curve) does not change with the distance from the Sun. The point then is that this procedure gives indeed both the luminosity curve in the solar neighborhood *and* the density law, but the latter up to only small distances, since stars with measured proper motions are involved. So, this really only constitutes a first step, namely determining the local luminosity function. The next is to use deep star counts to find the star density out to larger distances, but that is a separate problem of 'inverting' these two fundamental equations. This summary illustrates how the second part of van Rhijn's thesis, *A New Determination of the Mean Parallaxes of the Stars with Given Magnitude and Proper Motion*, fitted into the grand scheme of things, and that it constituted the important preliminary step before one could derive a model for the distribution of stars in space.

After his return from Mount Wilson, van Rhijn had been appointed Assistant at the Groningen Laboratorium in 1914. In addition to completing his PhD thesis, van Rhijn was heavily involved in Kapteyn's activities to prepare for his first attack on the problem of the structure of the Sidereal System. Much of this work had been done with the Assistants, first Willem de Sitter, Herman Albertus Weersma (1877–1961) and Frits Zernike (1886–1966), and later van Rhijn. The program led to major contributions in the *Publications of the Astronomical Laboratory at Groningen*: van Rhijn (1917), Kapteyn, van Rhijn, and Weersma (1918), and Kapteyn and van Rhijn (1920). All this work was part of the necessary preparatory effort to bring together information and data etc. available into a form that could be used to study the 'Construction of the Heavens'. This was finally done for the first time by Kapteyn and van Rhijn (1920), in which they presented a crosscut through the Stellar System, which came to be known as the 'Kapteyn Universe'. Since the analysis was done with count averages over all longitudes, this schematic model had the Sun by definition in the center. It was the basis for the "First Attempt at a Theory of the Arrangement and Motion of the Sidereal System" by Kapteyn (1922), which was the start of observational Galactic dynamics and moved the Sun out from the center by 0.65 kpc.

Under and in collaboration with Kapteyn, van Rhijn had been extremely productive. He even found time to complete another fundamental study, "On the Brightness of the Sky at Night and the Total Amount of Starlight" (van Rhijn, 1921). This was another old favorite of Kapteyn, who wanted to find a constraint on the distribution of stars in space by determining an observational value for the amount of integrated starlight. It had been attempted before in a PhD thesis under Kapteyn by a student named Lambertus Yntema (1879–1932), who tried to measure this from a dark site not too far from Groningen by two ingenious methods developed by Kapteyn, comparing an illuminated small surface to the sky viewed next to it and by photographing the sky through a small hole and comparing that to an exposure of the Full Moon (Yntema, 1919). He found that there was a significant amount of 'Earth light', a sort of 'permanent aurora', but he speculated that part of his observed light would be diffuse starlight. Yntema left astronomy ending up as rector of a lyceum or grammar school in Bussum. During his stay at Mount Wilson, Van Rhijn had repeated this study from the mountain top. Zodiacal light is another factor; it is in fact comparable in brightness to integrated starlight. Actual direct measurements of integrated starlight have only been obtained in recent times, particularly by the Pio-

Figure 5: The 'Sterrenkundig Laboratorium', when it had been named after Kapteyn on the occasion of his retirement (courtesy: Kapteyn Astronomical Institute).

neer 10 spacecraft on its way to Jupiter, when in 1973 it had passed the asteroid belt. The zodiacal light there was negligible and the spacecraft produced maps of the integrated star light that could be used to study the properties of the stellar distribution in the Galaxy; for details see van der Kruit (1986). Both Yntema and van Rhijn claimed values that compared to our current knowledge are not bad at all, but this must have been fortuitous. For a more thorough and detailed discussion see van der Kruit (2015; 2021a).

All of this goes to show that van Rhijn produced quite a lot of high-quality work, but this was initiated by Kapteyn and executed under his supervision.

4 KAPTEYN'S *PLAN OF SELECTED AREAS*

Kapteyn (1906) launched the *Plan of Selected Areas* in 1906 after a few years of planning and discussions. A few relevant pieces of the text are important to cite here for background to what is discussed below.

The *Plan* was designed to address a particular problem: What is the distribution of stars in space and what is the structure of the Sidereal System? But there is more to it, as we can read in Kapteyn's (1906: 3) Introduction "... to make at last definite plans for the future work of the laboratory."

So, it was more than an endeavor for the interest of answering a scientific question. It was also Kapteyn's way of providing a future for the laboratory he had founded (Figure 5). The text continues:

> After much consideration the most promising plan seems to me to be some plan analogous to that of the gauges of the Herschels.
>
> In accordance with the progress of science, however, such a plan will not only have to include the numbers of the stars, but all the data which it will be possible to obtain in a reasonable time. My intention had been all along to give to this plan such an extension that, with the exception of the work at the telescope, the whole of it could be undertaken by our laboratory.
>
> In working out details, however, I soon found out that, with a plan any ways on a scale meeting the requirements of the case, such would be impossible unless the funds of our institution were materially increased.

Kapteyn presented the *Plan of Selected Areas* as a refinement of the star gauges of William Herschel (1738–1822) and his son John Frederick William Herschel (1792–1871) (see Steinicke, 2021).

Kapteyn quoted that they covered 145 square degrees (of about 41,000 for the full 4π steradians of sky) and counted about 117,600 stars. But this work constituted only counts, no magnitudes or other properties. Kapteyn set an aim of 200,000 stars, or almost twice the number of stars in the Herschel gauges. This number for stars down to magnitude 14 required 400 square degrees, for which Kapteyn then defined 252 areas, of dimensions either rectangular with sides of order 75 arcmin or circular with radius 42 arcmin (in both cases an area of about 1.5 square degrees). This in regard of a reasonable field of view for plates in photographic telescopes. The size eventually was not a fixed property, areas could be smaller in crowded parts of the sky or larger in sparse ones. The program envisaged counts to as faint a level as possible, photographic and visual magnitudes (and thus colors), and as far as possible parallaxes, proper motions, spectral types and radial velocities. Kapteyn estimated that this (not counting 'additional short exposures') would require in total 9710 exposures on 2620 plates plus an unknown number for (hopefully) some 6300 radial velocities. The *Plan* also provided for determinations of the total sky brightness to set a further constraint.

At the insistence of Edward Charles Pickering (1846–1919), the Director of Harvard College Observatory, the *Plan* consisted of two parts, a *Systematic Plan* of 206 areas distributed evenly across the sky, as envisaged by Kapteyn, and an additional 46 for a *Special Plan* chosen to be particularly suitable for more detailed studies of the structure of the Stellar System. The *Systematic Plan* aimed for a mean separation of the areas of order 15°. The distribution of the regions 1 to 115 in the Northern Hemisphere from the Pole to the Equator is shown in Figure 6. This is a projection of a sphere onto a flat plane and distortions resulting from this hide the approximate regularity on the sky. The declinations are as required for the desired spacing in rings of 15° difference. The 24 regions on the equator are spaced by one hour or 15°.0. The rings at declinations 15°, 30°, and 45° also contain 24 regions that have spacings of respectively 14°.5, 13°.0, and 10°.6. For declination 60° the 12 regions are spaced by 15°.0, while for the 6 at declination 75° it is 15°.5. This is indeed a rather uniform distribution, except that it is not evident why Kapteyn did not restrict the declination zone 45° to 18 regions spaced by 14°.1 instead of 24 of 10°.6. The distribution is not precisely uniform because for calibration purposes they were required, if at all possible, to be centered on a star of magnitude 8.0 to 9.0. But there also should be no star brighter than this, as Pickering had stressed, since its light would scatter over much of the photographic emulsion and affect the determination of magnitudes of the faint stars.

This sounds like a straightforward selection procedure, but in fact is less trivial than it may seem, as a quick calculation shows. The density of stars between 8th or 9th magnitude in photometric band V (roughly visual) averages about 2 per square degree (in round numbers 90,000 stars for the full sky of 41,000 square degrees). A *Selected Area* covers about 1.5 square degrees. The density varies of course substantially with Galactic latitude, ranging from somewhat less than one in the poles to up to ten or more stars per square degree at low latitude (for these numbers see Figure 1 in van der Kruit (1986), which is produced with the export version of the Galaxy model computer code of Bahcall and Soneira, 1980). At high latitude this is a serious limitation for the choice of fields, since fluctuations around an average of one star per field yields a significant number of fields with none. The further condition that there should be no bright star—of, say, magnitude 7 or brighter—in the *Area* excludes a significant part of the sky; there are about 16,000 of such stars over the full sky or one star per 2.6 square degrees. This would imply that a randomly chosen field of 1.5 square degrees has a chance of one in two or so to have a star brighter than magnitude 7 in it. Kapteyn did not comment on this but his combined conditions must have been a serious constraint and have made the choice of the positions of his *Areas* far from simple.

The selection of the *Areas* for the *Special Plan* was done along a number of lines, that I will summarize as follows with excerpts from Kapteyn's (1906) original proposal:

A. Quite a number of areas (19) in which … maps show a black opening surrounded by rich parts ... or a rich part, or rich parts, between dark spaces ... or where there is at least a sudden change in star density ...

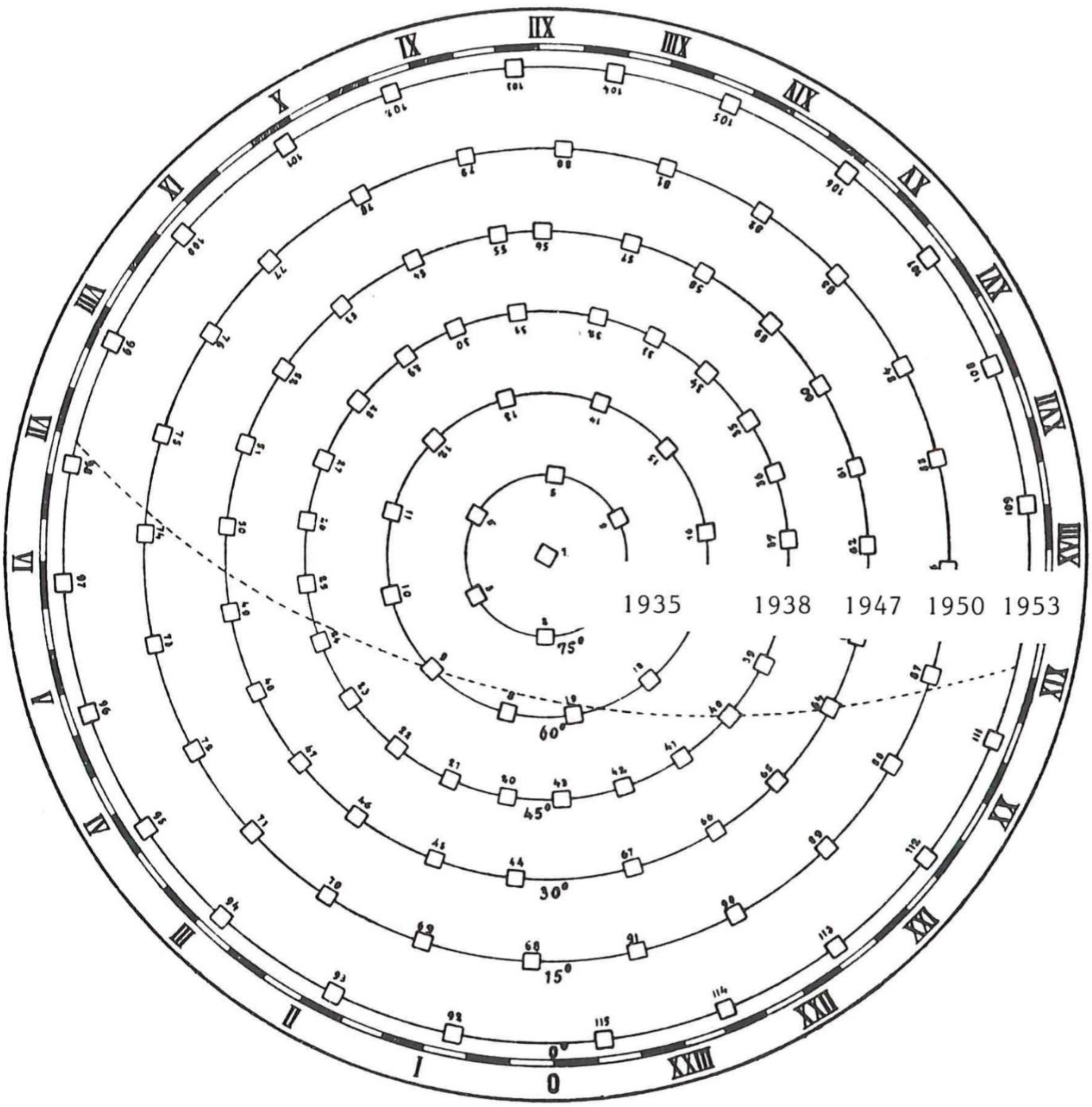


Figure 6: *The Selected Areas* in the *Systematic Plan* of the northern hemisphere; the numbers run from Area No. 1 in the center (the North Pole) to No. 115 on the equator. The scale on the border is Right Ascension in hours or 15° on the equator. Declinations are indicated next to the circles, which are spaced by 15°. The dashed line indicates the center line of the Milky Way. Year numbers indicate when the volume of the *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung* for the relevant declination range has been published (courtesy: Kapteyn Astronomical Institute).

B. A series of areas on the great branches of the Milky way and the rift between them ... Moreover several plates of the series A will very usefully serve the study of this division of the Milky way.

C. Further: very rich or very poor parts of the Galaxy … Here too, many of the plates of series A will be useful, so for instance [the one] on the border of the southern Coalsack.

D. Two Milky way areas ... for which de Sitter finds a marked difference, in the opposite direction, between photographic and visual magnitude.

E. For the rest I have included, of *extra*-galactic regions: two areas … coinciding with the richest parts of the *Nubecula minor*; *two* areas ... coinciding with the parts richest in stars and nebulae of the Nubecula major; one area ... coinciding with the part of the Orion nebula with strongest contrast in star density; one plate ... covering a part of the sky, near the North Pole of the Milky way, exceptionally rich in small nebulae. [All italics and underlinings are by Kapteyn.]

It is interesting to consider the last category (E.) in somewhat more detail. The term extra-galactic means of course away from the Milky Way on the sky, but eventually it came to mean outside our Galaxy. The *Nubecula major* and *Nubecula minor* are the Large and Small Magellanic Clouds. At the time the Magellanic Clouds were generally considered to be detached parts of the Milky Way, although the suggestion that they were separate Stellar Systems had been made (Abbe, 1867). The brightest stars in them are of apparent magnitude 9 or 10 and this by itself would also suggest relatively large distances. Kapteyn noted in a footnote that there is no field in the *Systematic Plan* that covers either of the Clouds.

The exceptional density of nebulae in the final *Area* refers to the Virgo Cluster. It is one of the interesting coincidences in galactic and extragalactic astronomy that the relatively nearby (some 20 Mpc) Virgo Cluster of galaxies is on the sky located close to the Galactic North Pole and consequently that our Galaxy would be seen close to face-on for astronomers there. The dense center of the Virgo Cluster is some 15° from the Pole, and there is only about a 3% chance to see a spiral galaxy precisely face-on (van der Kruit, 1990).[5] The region around the Galactic North Pole is indeed rich in nearby galaxies belonging to the Virgo Cluster and its extensions into the Local Supercluster. Kapteyn's Area No. 32 in the *Special Plan* is about 1° away from the actual Galactic North Pole as defined now. Kapteyn did not specify what he proposed to do with the small nebulae. In the catalogue resulting from the *Special Plan* no special attention was given to the nebulae in this *Area*.

There are two aspects that I want to stress. Although Kapteyn may have considered his plan a work of service to posterity, much like the *Carte du Ciel*, and the great star catalogues *Bonner Durchmusterung*, his own and David Gill's (1843–1914) *Cape Photographic Durchmusterung*,[6] and the *Astronomische Gesellschaft Katalogs*, he had in the first place, and in clear distinction to these works, a well-defined scientific goal in mind. He might have had some hope in 1906 that he himself would be able to use at least a major part of the data to construct a model of the Sidereal System. That hope turned out to be unrealistic, and he was forced to replace this desire with his "First Attempt at a Theory of the Arrangement and Motion of the Sidereal System" (Kapteyn, 1922), based on data available before the bulk of the *Selected Areas* had been surveyed. But he would lay the foundations for future astronomers to do so. He expected though that his successor would surely complete what he had been unable to accomplish.

Secondly, he saw it as a program for his Groningen Laboratorium to carry out completely by itself, except for the data collection at the telescopes. And this would require extra investment. However, it turned out that he should not have counted on his University for this, and certainly not on the Government. Just as when in 1886 he set out to measure up the plates for the *CPD* and reduce the data to positions and magnitudes, he had to rely for the largest part on private funds. He now had his own Laboratorium with, since 1911, adequate housing, contrary to the 1880s when Physiology Professor Dirk Huizinga (1840–1903) generously provided some working space (as it happened in the same building that later housed the Laboratorium). Luckily, he was saved then by George Hale, who in 1908 adopted the *Plan of Selected Areas* as the prime observing program for his brand new giant 60-inch telescope on Mount Wilson. Kapteyn was appointed a Research Associate by the Carnegie Institution of Washington, which enabled him to visit California annually (at least until the First World War broke out) and take charge of the execution of the program at the big telescope.

But it turned out to be unrealistic that all the work could be done in Groningen. For example, the following was an unforeseen complication. It turned out much less straightforward to derive stellar magnitudes from photographic plates taken with a large reflector than a small photographic telescope. The following illustrates this. The field of view of the 60-inch telescope was only about 23 arc minutes and many of the fields had no stars brighter than 12th magnitude. Using the same Figure 1 of van der Kruit (1986) as above it can be deduced that averaged over the whole sky the number of stars of 12th magnitude or brighter is about 70 per square degree, which means on average 10 or so per 23 arcmin field of the 60-inch. But at high latitudes it is on average one or a few, so that fluctuations will assure that a non-negligible fraction has no stars brighter than magnitude 12. This complicated matters as calibration of the zero-point of the magnitude scale relative to the standards around the celestial North Pole had to be performed in such *Areas* without making use of stars brighter than magnitude 12. Furthermore, stars away from the center of the field had distorted images from optical aberrations such as coma due to the parabolic shape of the mirror.

All this required special attention and much work was taken off Kapteyn's hands by Mount Wilson astronomer Frederick Hanley Seares (1871–1964), who took this upon himself to solve. This was an enormous effort and it was only in 1930 that the project was concluded with the publication of the catalogue (Seares et al., 1930). For manpower in Groningen Kapteyn relied on funding from various sources rather than the University, and significant parts of the manpower was actually paid for by the Carnegie Institution. The University and Government provided only one computer ('rekenaar', a person whose primary task was to perform calculations) and one clerk in addition to the Professorship and Assistant. When Kapteyn retired, the pay-roll of the University staff consisted of the Professor, one Assistant, three Computers and a Clerk (see Table 1 in Section 15 below), but that increase had only occurred in 1919.

The University of Groningen had committed to the *Plan of Selected Areas* when it agreed with Kapteyn's appointment by the Carnegie Institution (it was less generous than this suggests, since over the remaining months of the year he had to make up in teaching whatever he failed to provide during his Mount Wilson visits). To some extent the lack of financial support is understandable as Government funding for the universities in general was tight. However, due to its remoteness from 'Den Haag' (where the Government was) and the difficulty of effective lobbying, and due to low student numbers in Groningen, it was particularly tight there. With the appointment of Willem de Sitter as Director in 1918 a major reorganization had taken place at the Sterrewacht Leiden, and its staff was three or four times larger than at the Groningen Laboratorium.

The execution of the *Plan of Selected Areas* during Kapteyn's remaining years was restricted, as far as the work in Groningen is concerned, to the cataloging of stars in the *Areas* from the plates it received from Harvard and Mount Wilson, with the vital support of the Directors Edward Pickering and George Hale. The plates of all 206 *Areas* Pickering had committed to were taken at the Harvard College Observatory in the north and at its Boyden Station at Arequipa, Peru, in the south, respectively between 1910 and 1912 and between 1906 and 1916. From all of these plates stellar positions and magnitudes had to be derived. All of those measurements were performed in Groningen.

The catalogue resulting from the Harvard plates, which went down to about magnitude 16, was published in three installments by Pickering and Kapteyn (1918) and by Pickering, Kapteyn and van Rhijn (1923; 1924) in the *Annals of the Astronomical Observatory of Harvard College*. The work had been a joint undertaking between Harvard and Groningen. As Pickering wrote in the Preface to the first volume:

> It was, therefore, a pleasure to aid the plans of Professor Kapteyn in his work on the Selected Areas. We have accordingly taken the photographs needed to show the faint stars, determined the magnitudes of a sequence of standard stars in each area, and provided the means of publication of the results. Professor Kapteyn has undertaken the laborious work of measuring the plates, reducing the measures, and determining the positions and magnitudes of large numbers of stars.

The *Durchmusterung* became known as the *Harvard Durchmusterung* in spite of the fact that while the plates were indeed taken at Harvard, the bulk of the work was done in Groningen. I will therefore refer to it as the *Harvard(–Groningen) Durchmusterung* in this paper.

According to the *Third Report* of the progress of the *Plan* (van Rhijn, 1923b), the number of stars in the *Harvard (–Groningen) Durchmusterung* was some 250,000, for all of which positions and magnitudes had been measured in Groningen. An examination of the three volumes shows accurate quotes for the total number in the first two volumes, while adding up numbers in Table 1 of the third volume is easily performed. This result is a total of 84,002 + 65,753 + 82,226 = 231,981 stars, so it is actually somewhat less than what had been advertised.

The work in Groningen was quite extensive and, since great care had to be taken, very time consuming. Most of it was done by dedicated staff, but had to be overseen by an astronomer. In Kapteyn's Introduction to the first installment in 1918 on the Northern Hemisphere, he stressed that his own contribution was minor, but that the supervision of the work was left to the Assistants, which he listed as Willem de Sitter, Herman Weersma, Frits Zernike and Pieter van Rhijn. The Second and Third Volumes covering the South were authored by Pickering, Kapteyn (posthumously) and van Rhijn, and the latter added Jan Oort to this list of Assistants.

The primary plates at the Mount Wilson 60-inch of the 139 *Selected Areas* north of declination –1° were taken between 1910 and 1912, plates with shorter exposure time and/or reduced aperture were taken from 1913 to 1919, and a set of exposures of the *Selected Areas* and a field with stars in the North Polar Sequence with a 10-inch telescope in the same years. Overall more than one thousand plates were taken. The project was executed at Mount Wilson under the leadership of Frederick Seares.

For the *Mount Wilson(–Groningen) Catalogue* the work was more evenly divided than for the *Harvard(–Groningen) Durchmusterung*. In addition to the 'long-exposure plates' together with short exposure plates, that were all sent to Groningen, to facilitate the transition from faint to brighter stars, a long and thorough investigation had been conducted at Mount Wilson to learn how to do photographic photometry with large reflectors and to define a magnitude scale and zero-point in each of the *Selected Areas*. For this purpose, another set of exposures, using the 60-inch telescope stopped to smaller apertures was obtained. As a consequence, two sets of stars were cataloged: the long-exposure plates were only studied over 15 arcmin areas at low Galactic latitudes (below 40°) and 20 arcmin at high latitude. The plates measured for magnitude scales and zero points were measured over a larger area and this yielded 'supplementary' stars outside the 'Groningen areas'. The *Mount Wilson Catalogue of Photographic Magnitudes in Selected Areas 1–139* by Seares, Kapteyn, van Rhijn, Joyner and Richmond appeared in 1930. It reached magnitude 18.5 or so. The final catalogue contains 67,941 stars, of which 45,448 had been measured in Groningen.

The measurements and reductions for the plates for the *Special Plan* (van Rhijn and Kapteyn, 1952) were seriously delayed by the economic depression and associated shortage of manpower, and then by WWII, and in the end were only published in 1952. It was no longer a joint publication between Groningen and Harvard, but solely by the Kapteyn Laboratorium. The work concerned all the 46 *Areas* of the *Special Plan* and the total number of stars measured was 140,082 stars down to 15 to 16 photographic magnitude. Measurements and reductions were supervised by van Rhijn's Assistants starting with Willem Jan Klein Wassink, then Bart Bok, Petrus Bruna, Jean-Jacques Raimond, Adriaan Blaauw and ending with Lukas Plaut (and of course van Rhijn also did some of this). The plates were taken decades before the publication, most of them in 1911 and 1912, but some as early as 1898 (so before the *Plan of Selected Areas* was even defined, and at the time for some other purpose). The measurements extended only over a restricted part of the plates, in squares of roughly 50 to 100 arcmin on a side, in general depending on the structure in the star field in the particular *Area* or the richness of stars.

The production of this catalogue constituted a very large expenditure in terms of time and manpower. The use that was made of the catalogue was very limited it would seem, to some extent of course since its appearance was long overdue, decades after the plates had been taken. The NASA Astrophysics Data System ADS6 records no (zero!) citations after the publication of the *Durchmusterung*, so it is unlikely it has ever been used as source material for a study, as initially envisaged. The number of reads is only a few (except in 2021, which are due to me for this study). But then finding it on ADS merely yields the information that the publication is not available online. As we will see below (Section 9), the results were actually used in a preliminary form in the 1938 PhD thesis of Broer Hiemstra, who referred to the unpublished counts of the *Special Plan* (Hiemstra, 1938). This thesis concerned distances and total extinction of dark clouds, and contained extensive determinations of proper motions from plates other than the Harvard ones taken for the *Special Plan*. As far as I am aware, no extensive use has been made of the counts in the fields in the Magellanic Clouds; these totalled 9777 stars in the richest part of the SMC and 7818 in that of the LMC. It would not be surprising if more than

Figure 7: Willem de Sitter. This photograph comes from the *Album Amicorum* that was presented to H.G. van de Sande Bakhuyzen upon his retirement as Professor of Astronomy and Director of the Sterrewacht Leiden in 1908 (after Leiden Observatory, 1908).

maybe a few researchers of the Clouds are or were actually aware of the existence of these uniform data sets of magnitudes and star counts.

5 THE SUCCESSION OF KAPTEYN

In 1908 there had been a vacancy in the Directorship of the Sterrewacht Leiden after the retirement of Hendrikus van de Sande Bakhuyzen. It had of course been offered to Kapteyn, but—as he had done earlier, in the case of Utrecht—he declined it.

Figure 8: Herman A. Weersma. This photograph comes from the *Album Amicorum* that was presented to H.G. van de Sande Bakhuyzen upon his retirement as Professor of Astronomy and Director of the Sterrewacht Leiden in 1908 (after Leiden Observatory, 1908).

Ernst van de Sande Bakhuyzen (1848–1918) had been appointed Director and de Sitter (see Figure 7) Professor. Herman Weersma (Figure 8) in Groningen in 1908 took de Sitter's place and became Kapteyn's Assistant. Weersma had obtained his PhD in that year, with a thesis titled *A Determination of the Apex of the Solar Motion According to the Methods of Bravais* (Weersma, 1908). Kapteyn considered Weersma his probable successor, but in 1912 Weersma left to take up a position as a secondary school teacher, because he wanted to have more time to devote to his 'real interest' (which was philosophy).

Kapteyn was at a loss. There was no suitable candidate in the Netherlands. After I had written my biography of Kapteyn (van der Kruit, 2015), Professor Kalevi Mattila of Helsinki University informed me of a development. The story is as follows.

On 3 November 1912, not long after Weersma's departure, Kapteyn wrote to his long-time friend and collaborator Anders Severin Donner (1854–1938) of Helsingfors Observatorion (Helsingfors is Swedish for Helsinki) as follows:

> At present my greatest worry is to find a successor who will keep the laboratory from going into a decline. My assistant leaves me. Do you know anyone – assiduous, practical, reliable – who without too much pay (he will get immediately 2000 German Mark, but I see a possibility, if he is really good, that next year he might be paid and extra 1200 Mk) could develop in the next 9 years to become my successor? (Kalevi Mattila, pers. comm., March, 2016; my translation from German).

Professor Matilla (*ibid*.) continued his email to me:

> Donner's pupil Yrö Väisälä had just completed his Masters degree that same month and Donner approached him with this proposal. Prof. Olli Lehto published in 2005 a triple biography (in Finnish) of the three Väisälä brothers, who all became professors: Vilho (meteorologist), Yrö (astronomer, geodesist), and Kalle (mathematician). Having heard from me of this letter by Kapteyn, Vilho got access also to some private correspondence from Yrö Väisälä to his bride Martta. Yrö Väisälä was very seriously considering the great scientific opportunities offered by this position and how pleasant it would be to live among the nice and decent people of Holland [the Netherlands].[8]

> However, as he wrote to Martta: 'Away from Finland for many years, perhaps forever! I think that we would lose much when doing that. And what about my little Martta in that foreign country! What if we would become parents of even smaller Marttas and Yrös! Would they become Finns or Dutch? Or neither of them.' After such deliberations he finally asked Donner to answer with 'no' to Kapteyn. Donner explained Väisälä's refusal in a somewhat different, perhaps more diplomatic way: 'We Finns are passionate patriots'. In fact, this was a period in the history of Finland with strong national feelings when the Russian tsar tried to suppress the autonomous status of Finland. Five years later, in 1917, Finland declared its independence.

Yrö Väisälä (1891–1971) went on to found the Astronomy Department at Turku University, where he designed a Schmidt-like telescope with which he and his collaborators discovered 807 asteroids and 7 comets.

Kapteyn's next hope had been Frits Zernike, who was appointed Assistant, but he also left in 1914 to pursue a career in physics, which earned him eventually (in 1953) a Nobel Prize for his invention of the phase-contrast microscope. Blaauw (1983: 61) confirmed this. He quoted Zernike in a speech in 1961 on the occasion of the donation of the well-know Veth painting of Kapteyn to the University that Kapteyn had told him he would have liked to designate him as the next Director of the Laboratorium.[9]

In 1916 Kapteyn arranged for van Rhijn to be appointed his Assistant, who became then the probable candidate to succeed him as Professor of Astronomy and Director of the Laboratorium. We may have a brief look at other young astronomers in the Netherlands at the time as possible candidates, say those who obtained their PhDs between 1910 and 1920. Kapteyn had four students in that period: Etine Imke Smid (1883–1960, PhD thesis *Determination of the Proper Motion in Right Ascension and Declination for 119 Stars*, in 1914); Samual Cornelis Meijering (1882–1943; PhD thesis *On the Systematic Motions of the K-stars*, in 1916), Willem Johannes Adriaan Schouten (1893–1971; PhD thesis *On the Determination of the Principal Laws of Statistical Astronomy*, in 1918); and Gerrit Hendrik ten Brugge Cate (1901–1961; PhD thesis *Determination and Discussion of the Spectral Classes of 700 Stars Mostly Near the North Pole*, in 1920). These were not obviously extraordinary theses, so they were apparently not considered suitable candidates. Etine Schmid was the first female Astronomy PhD in the Netherlands and may not even have been eligible for a professorship or the directorate. The thesis was written in Dutch; I translated the title. She went to Leiden where she worked with other physicists and later Nobel Laureate Heike Kamerlingh Onnes (1853–1926), but she left scientific research in 1916, when she got married. Meijering became a teacher at a high school; Schouten had alienated Kapteyn because of his unnecessary rude remarks about von Seeliger's work, and ten Brugge Cate (who later changed his name into ten Bruggecate) also became a high school teacher.

In Leiden new PhD's in this period were Christiaan de Jong (1893–1944; PhD thesis *Investigations on the Constant of Precession and the Systematic Motions of Stars*, in 1917); Jan Woltjer (1891–1946; PhD thesis *Investigations in the Theory of Hyperion*, in 1918); or August Juliaan Leckie (1891–19??; PhD thesis *Analytical and Numerical Theory of the Motions of the Orbital Planes of Jupiter's Satellites*, in 1919). De Jong, whose supervisor was Ernst van de Sande Bakhuyzen, already became a gymnasium teacher of mathematics in Leiden before completing his thesis, which was written in Dutch (the title above is my translation). He may not have been interested in a career in Astronomy in the first place. De Jong was executed by the Germans as retaliation for an act of sabotage he had not been connected with. Woltjer became a Leiden staff member and worked on stellar pulsation theory until his death in 1946 as a result of undernourishment in the last year of the War. His interests were remote from the ongoing investigations in Groningen anyway. Leckie moved to the Dutch East Indies, where he worked at the Bandung Institute of Technology. The last two were students of Willem de Sitter and worked on theoretical subjects involving planetary satellites.

In Utrecht Adriaan van Maanen (1884–1946) had defended his thesis *The Proper Motions of 1418 Stars In and Near the Clusters h and χ Persei*, in 1911 under Albertus Antonie Nijland (1868–1936) and Kapteyn; he might have been a potential candidate, had he not moved permanently to Mount Wilson Observatory.

This list is not very long, so candidates were difficult to find. Among these who obtained their PhD's before or in 1916, there was no obvious other candidate who could have been considered as being preferred over van Rhijn for the position of Assistant at Groningen. After van Rhijn had been appointed, a further appointment would have been difficult to make, so especially after that only exceptionally promising candidate could have been considered. There was no such obvious person on the list, nor was there anyone who was so outstanding that they could be appointed as Kapteyn's successor in 1921 in place of van Rhijn.

Before 1921 van Rhijn had done relevant and excellent research. He had extensively worked on proper motion observations and with Kapteyn had used simulations to show that with counts down to magnitude 17, which the plates taken with the 60-inch would certainly be able to provide, "… the densities should become pretty reliable for the whole of the domain within which the density exceeds 0.1 of that near the Sun." (Kapteyn and van Rhijn, 1922: 242). In Kapteyn's last paper before retirement that van Rhijn coauthored, they examined Cepheid distances and the consequences for those of globular clusters, concluding that Shapley's distances were much too large. Shapley's result was indeed incorrect, due to the now known concept of Stellar Populations and the unknown differences between pulsating variables in these two Populations (for details see van der Kruit, 2015: 592). So, before he assumed the Directorship van Rhijn definitely had been quite productive, and had produced excellent astronomy, but under the direction of and on research programs initiated by Kapteyn.

The conclusion must be that given his dedication to the Kapteyn's research and the Laboratorium, van Rhijn effectively became Kapteyn's successor by default. He had done very good research, although he never seemed to have had a chance to define his own projects. This discussion serves to illustrate the problem of finding suitable candidates for leading positions in Astronomy at that time. There simply was no other option. Van Rhijn had certainly shown himself to be a competent researcher, so he was a man Kapteyn could expect to dedicate himself to the continuation of his life's work. There is no evidence that Kapteyn looked for other possible candidates abroad, being confident apparently that van Rhijn was the person to whom he could entrust the future of his Laboratorium and the further execution of his *Plan of Selected Areas*.

6 VAN RHIJN'S ASTRONOMICAL WORK UP TO 1930

When Kapteyn retired from his positions of Professor and Director at the end of the academic year in 1921, he actually left Groningen, never to return, and completely terminated all involvement in Astronomy in Groningen. During the first decade of van Rhijn's Directorship, during the 1920s, the Laboratorium still flourished. A very important part of the *Plan of Selected Areas*, the star counts in the *Harvard (–Groningen) Durchmusterung* and the *Mount Wilson(–Groningen) Catalogue* progressed vigorously. The publication of the first was completed in 1924, encompassing the *Systematic Plan* of the 206 all-sky Areas. This had been a major investment of effort on behalf of the Laboratorium, which in the meantime had been named the 'Sterrenkundig Laboratorium Kapteyn' or just 'Kapteyn Laboratorium'. The *Special Plan* of 46 areas in the Milky Way on which Pickering had insisted so much and which Kapteyn had been forced to accept to ensure his collaboration, went along at a very slow pace and was published only in 1952. The Groningen part of the work on the Mount Wilson program was also completed expeditiously, but the problem of deriving accurate magnitudes using large reflectors took much longer to solve and as we have seen, was Seares' responsibility at Mount Wilson; still, it was completed and published in 1930.

In 1923 van Rhijn had followed up the *First* and *Second Reports*, published by Kapteyn (1911) on the progress of the *Plan of Selected Areas*, by a *Third Report* (van Rhijn, 1923b). It was a booklet of almost one hundred pages, published by the Laboratorium. It was followed by a *Fourth Report* in 1930 in the *Bulletin of the Astronomical Institutes of the Netherlands* (van Rhijn, 1930). So, van Rhijn had taken up his responsibilities with vigor.

But he also did some very significant research, in providing additional observational material for the Plan, and analyses relevant to the aim of deriving a model for the Stellar System. In this he was assist-

Figure 9: Pieter Johannes van Rhijn. Reproduction of a crayon drawing donated by his relatives to the Kapteyn Astronomical Institute. It dates from 1926. It has been produced by Eduard Gerdes (1887–1945), who was a Dutch painter and art teacher. Later, in the 1930s, he would sympathize with the National Socialist Party, and hold important positions relating to art policy during WWII. Gerdes died soon after the War ended, but the cause of his mysterious death has never been determined. He was posthumously found guilty of collaborating with the German occupation. This drawing decorates the Kapteyn Room.

ed by young astronomers. Upon his appointment as Director of the Laboratorium, the vacant position of Assistant was for a short period filled by Jan Oort, who soon after this appointment was promised a staff position in Leiden by de Sitter, and then left to spend two years working with Frank Schlesinger (1871–1943) at Yale Observatory in New Haven and learning astrometry. The vacant Assistant positions were then filled by students preparing their PhD theses: in one year by Peter van de Kamp (1901–1995), who defended a thesis on *De Zonsbeweging met Betrekking tot Apparent Zwakke Sterren* (*The Solar Motion with Respect to Apparently Faint Stars*), in 1924; and subsequently by Willem Jan Klein Wassink (1902–1994), who in 1927 submitted a thesis on *The Proper Motion and the Distance of the Praesepe Cluster* (Klein Wassink, 1927). Klein Wassink left astronomy, and like so many young PhDs in Astronomy became a physics and mathematics teacher, in this case in Zierikzee in the province of Zeeland in the southwest. After him the position was filled by students who would obtain their doctorates after 1930, Bart Bok and Jean Jacques Raimond (for details see below).

In addition, van Rhijn (see Figure 9) had been the thesis supervisor of three students, who had actually started under Kapteyn. The first was Egbert Adriaan Kreiken (1896–1964; see Omay, 2011), who completed a PhD thesis *On the Color of the Faint Stars in the Milky Way and the Distance to the Scutum Group*, in 1923. Kreiken had been born in exactly the same house as Kapteyn in Barneveld, where his parents had taken over the boarding school of Kapteyn's parents after Kapteyn Sr. had died. After many peregrinations, Kreiken ended up in Ankara (Turkey), were he founded the observatory that is now named after him. Jan Schilt (1894–1982; see Oort, 1982), who in 1924 had defended his thesis *On a Thermoelectric Method of Measuring Photographic Magnitudes* (Schilt, 1924), had moved to Leiden and then went to the USA, where eventually he became Chair of the

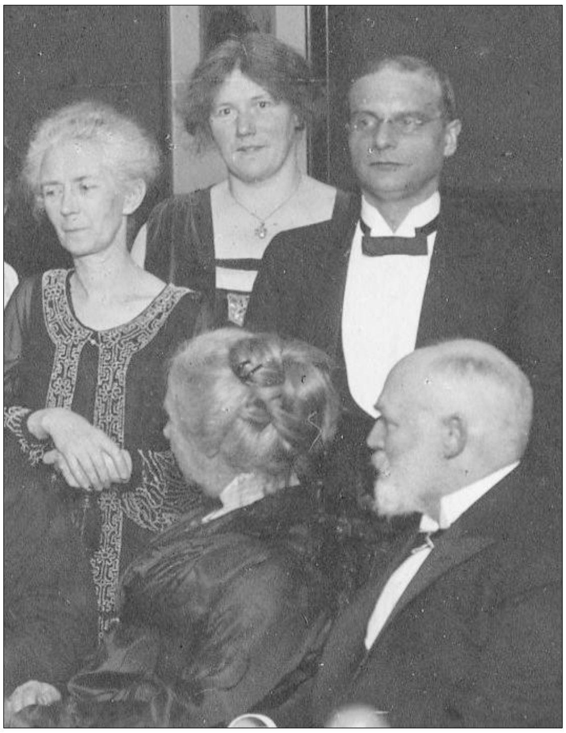


Figure 10: Pieter van Rhijn in 1926 at the dinner after the PhD thesis defense of Jan Hendrik Oort, for which he acted as supervisor. Sitting at the table are Willem de Sitter and his wife. Standing next to van Rhijn is Oort's (then future) mother-in-law and on the left Oort's mother (from the Oort Archives, see van der Kruit, 2019).

Astronomy Department at Columbia University. Jan Oort had already moved to Leiden when he defended his thesis in 1926 on *The Stars of High Velocity* (Oort, 1926) (Figure 10).

As well as working on the *Plan of Selected Areas* catalogues and associated matters, coordinating the Plan's execution and writing reports, and teaching and supervising students, van Rhijn did some very important and fundamental work. There are actually three papers in this category that I will very briefly introduce. The first concerns what we have seen as the first step to derive a model for the distribution of stars in space, using the mean parallax of stars as a function of proper motion and magnitude in various latitude zones. In 1923 van Rhijn published an improved version of what he had published with Kapteyn in 1920, but now for spectral classes separately (van Rhijn, 1923a).

Figure 11: Pieter van Rhijn around 1930 (courtesy: Kapteyn Astronomical Institute).

Secondly, after first having discussed the relative merits and comparisons of trigonometric, statistical and spectroscopic parallaxes (van Rhijn, 1925a),[10] van Rhijn produced an improved version of the luminosity curve of stars (van Rhijn, 1925b). This was a very profound paper and was cited for a long time. It presented what became known as the 'van Rhijn Luminosity Function'. Its importance today lies with studies of the Initial Mass Function (IMF) of star formation, where for stars below about one solar mass (that live longer than the age of the Galaxy) it directly follows from this local luminosity function. ADS, the NASA Astrophysics Data System, still shows of the order of 3 reads per year over the last 15 years or so. It has been of major importance. ADS is highly incomplete in citations before the mid-1950s, so we cannot illustrate its impact using these statistics.

And thirdly, in 1929 van Rhijn (Figure 11) presented a comprehensive set of star counts (van Rhijn, 1926). This was the final product of the *Harvard–(Groningen) Durchmusterung* and the *Mount Wilson (–Groningen) Catalogue*, the latter before it was actually published. It was presented as a table with positions at intervals of 10° in Galactic longitude and latitude with the number of stars per square degree at integer values of photographic magnitude down to magnitude 18. Alternatively, it was presented as a table of coefficients as a function of position for an analytical fit to the counts. The counts in the Selected Areas in the Harvard and Mount Wilson data were for magnitudes larger than 10. Between 6 and 10 van Rhijn used counts derived by Antonie Pannekoek using the *Bonner* and *Cordoba Durchmusterungs*, and for still brighter stars the *Boss Preliminary General Catalogue*. These together constituted a major milestone in Kapteyn's *Plan*.

This would have been the point in time

for van Rhijn to redo the analysis in the paper by Kapteyn and van Rhijn (1920b) and derive an improved version of the distribution of stars in space. But in the meantime, there was a general feeling among astronomers that indeed interstellar extinction did exist, see for example Oort (1927; 1931), waiting only for the final blow to the notion of the absence of absorption to be delivered by Robert Julius Trumpler (1886–1956) in 1930. In any case, van Rhijn postponed such an exercise, or he at least felt it was premature. That the matter of interstellar extinction was definitely on his mind is clear from his paper in 1928, in which he studied the matter using diameters of globular clusters (van Rhijn, 1928). This was a clever and timely exercise. Remember that the notion of an absence of absorption was primarily due to Harlow Shapley's (1885–1972) study of colors of stars in globular clusters. Shapley had found that, if Kapteyn's value were correct, the bluest stars in globular clusters had to be intrinsically bluer by of the order of two magnitudes than those in the solar neighborhood, and therefore he concluded that interstellar extinction was negligible. Now, Arthur Stanley Eddington (1882–1944) had proposed a mechanism in which no reddening would accompany extinction (Eddington, 1926). Eddington considered 'molecular absorption', by which he meant dissociation of molecules by starlight, which are continuously 'disrupted and reformed'. This is now known to be much too inefficient. Van Rhijn (1928) decided to use diameters of globular clusters to investigate this. The formal solution for the amount of extinction he obtained was 0.036 ± .021 magnitudes per kiloparsec, which meant there was very little, if any, absorption. Van Rhijn noted that this formal value would change the distance of Shapley's most distant globular cluster from 67 to 35 kpc, and he then mentioned but did not discuss the large uncertainty of this. With modern eyes this result would mean that he had found that indeed space was probably mostly transparent towards the globular clusters. It is interesting to note that this approach of diameters of globular clusters foreshadowed Trumpler's seminal analysis of open clusters two years later.

At the close of the decade of the nineteen twenties van Rhijn could look back on a productive period. The Harvard and Mount Wilson catalogs in Kapteyn's *Plan of Selected Areas* had successfully been completed and important first steps for an analysis towards a model of the Stellar System, namely star counts, mean parallaxes for the different spectral types and a local luminosity function, had been derived. Under his coordination the Plan was progressing well.

During Kapteyn's Directorship, 27 different *Publications of the Astronomical Laboratory* at Groningen had appeared in 22 years (but he had started in 1900 with a backlog of a few), whereas during the first nineteen years of van Rhijn's Directorate (1921–1939) 14 had been published. In addition to this and the *Harvard* and *Mount Wilson Durchmusterungs*, he had (co-)authored eight papers in refereed journals, a Progress Report on the Plan (and prepared another one to appear in 1930), and an obituary about Kapteyn. In addition to the three PhD students he inherited from Kapteyn, three PhD students had produced theses entirely under his supervision and two more were on their way: Bart Bok would finish in 1932 on *A Study of the η Carinae Region*, and Jean Jacques Raimond on *The Coefficient of Differential Galactic Absorption* in 1933 (Raimond, 1934) (see Figure 12).

There might have been other students as well who had an interest in Astronomy but did not pursue that, at least not in Groningen. One was Helena Aletta (Heleen) Kluyver (1909–2001). On 15 March 1929, van Rhijn wrote to Jan Oort in Leiden (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149; my translation):

> During the Easter vacations Helena Kluyver, a very interested astronomy student, will visit Leiden. She wishes to see the instruments and to get an idea of the work done at the Sterrewacht. Can you help her a little?

Heleen Kluyver ended up moving to Leiden, where she remained in various capacities at the Sterrewacht, eventually obtaining a PhD (see van der Kruit, 2019 and 2021b for more about her). Then on 12 January 1931 Oort wrote to van Rhijn (van der Kruit, 2019, Nr. 149; my translation):

> You will have heard that Heleen Kluyver has become half-assistant at the Sterrewacht. She did obtain her Candidaats [Bachelor's degree, nowadays] here. She is quiet and not very accessible, but when you get to know her she is really a very nice girl. In the be-

Figure 12: Four students of Pieter van Rhijn in 1939. From left to right Bart Bok, Jan Oort, Peter van de Kamp and Jan Schilt (courtesy: Kapteyn Astronomical Institute).

> ginning she may have been lonely in Leiden, so if the occasion arises you may make some contact with her.

During the 1930s van Rhijn's productivity in terms of number of publications took a downward turn and no new initiatives were undertaken. To examine the background and the reasons for this more closely we have to look at the program van Rhijn started soon after assuming the Directorate with the Bergedorfer Sternwarte at Hamburg and his attempts to obtain his own telescope, an undertaking that Kapteyn had failed to successfully complete.

But before that, I want to end this Section by noting a remark Adriaan Blaauw made in his 1983 chapter (Blaauw, 1983: 52; my translation), where he points out that

> ... in these days the Groningen laboratory still internationally was held in high regard, is evident from the 1933 book *Makers of astronomy* by Hector MacPherson, in which a prominent place was reserved for van Rhijn and his institute.

In his day, Hector Copland MacPherson (1888–1956), was a highly respected astronomy teacher and writer, especially of biographies of astronomers (see Brück and Gavine, 2011). In the final chapter of his book *Explorers of the Universe*, (Macpherson, 1933), the individuals presented are David Gill, Jacobus Kapteyn, Willem de Sitter, Vesto Melvin Slipher (1875–1969), Arthur Eddington, Harlow Shapley and Pieter van Rhijn. In MacPherson's view, van Rhijn was in the same class as Gill, Kapteyn, Eddington or Shapley. He discussed in detail and praised the work leading up to the 'Kapteyn Universe', giving part of the credit for it to van Rhijn, even designating it the 'Kapteyn-van Rhijn Universe'. The Laboratorium in Groningen was described as a world-famed institution. Maybe van Rhijn gets more credit here than he deserves, but the high regard Macpherson had for Groningen Astronomy is obvious.

7 BERGEDORF(–GRONINGEN–HARVARD) SPEKTRAL–DURCHMUSTERUNG

The work in the preceding section is quite substantial. But another major project had been started by van Rhijn, which however would turn out to be a major investment of time with in comparison very little return. This is called in full the *Bergedorfer Spektral-Durchmusterung der 115 nördlichen Kapteynschen Eichfelder enthaltend für die Sterne bis zur 13. Photographischen Grösse die Spektren nach Aufnahmen mit dem Lippert-Astrographen der Hamburger Sternwarte in Bergedorf und die Größen nach Aufnahmen des Harvard College Observatory bestimmt durch das Sterrenkundig Laboratorium Kapteyn.*

At the start of the *Plan of Selected Areas* it was foreseen that spectral types would be determined for as many stars as possible. Now, stars brighter than magnitude 8.5 were classified as part of the Henri Draper Catalogue, which was published by Annie Jump Cannon (1863–1941) and Edward Pickering in nine volumes of the *Annals of Harvard College Observatory* between 1918 and 1924, and contained about 250,000 stars (later extended with the Henri Draper Extension). As van Rhijn (1923b) remarked in the Third Progress Report on the *Plan of Selected Areas*, all he had to do was provide for the classification of *Selected Areas* stars fainter than m = 8.5.

The enormous task of classifying a quarter of a million stars had been accomplished almost entirely by Annie Cannon, which van Rhijn had used in van Rhijn (1923a), and which had earned Cannon at Kapteyn's proposal a doctorate *honoris causa* from the University of Groningen in 1921 (Van der Kruit, 2021d). In addition, Milton Lasell Humason (1891–1972) at Mount Wilson Observatory obtained spectral types of at least ten stars per Area between magnitudes 11 and 12 with the 60-inch telescope in all 115 northern Areas, a total of 4066 stars (published in Humason, 1932). The aim, however, was to obtain many more spectral types.

Soon after he had assumed the Directorship of the Laboratorium van Rhijn had approached Richard Reinhard Emil Schorr (1867–1951), the Director of the Bergedorfer Sternwarte near Hamburg, and proposed to set up a joint project to fill the gap. Schorr accepted and assigned Friedrich Karl Arnold Schwassmann (1870–1964) to carry out the program. Arnold Schwassmann had, after a PhD from Göttingen in 1893, worked at a number of places, until he was appointed in 1902 on the staff at Hamburg and was very much involved in moving the Observatory out of Hamburg to Bergedorf (completed in 1912). Schorr had convinced local businessman Eduard Lippert to finance an astrograph for the new site rather than setting up a private observatory. It was a triple telescope, consisting of a double astrograph with in addition a telescope according to the *Carte du Ciel* specifications on the same mount. Later, Schwassmann and Arno Arthur Wachmann (1902–1990) used it successfully to hunt for comets and asteroids. The instrument included an object prism that could be fitted to any of the three astrographs (see Figure 13).

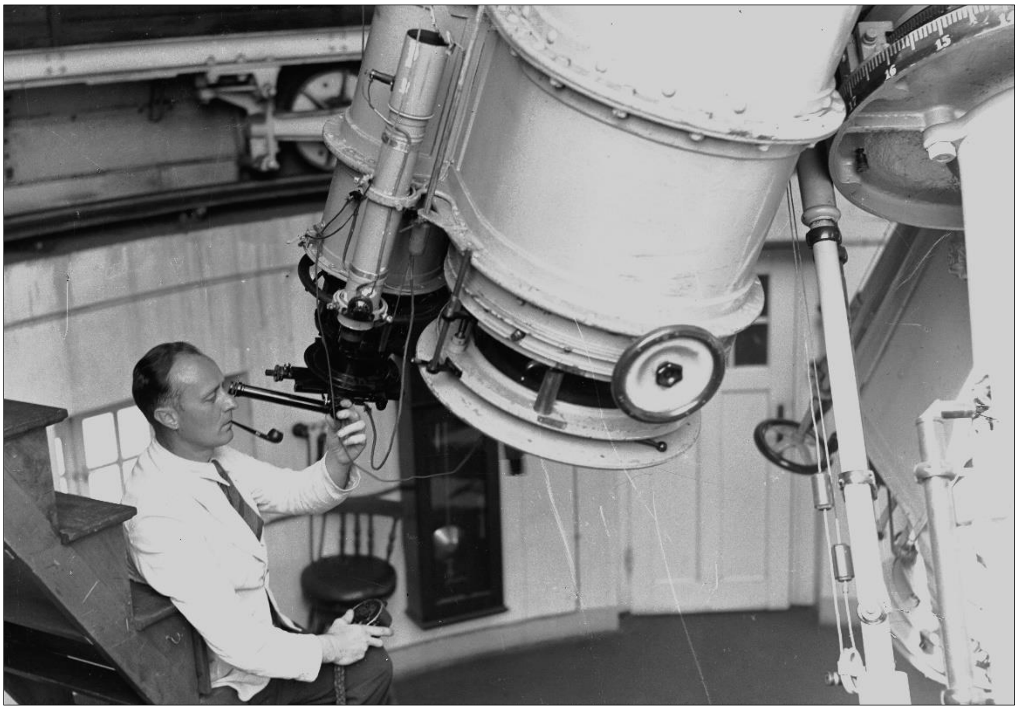


Figure 13: Arthur Arno Wachmann at the Lippert Astrograph, with which the objective prism (and accompanying direct) plates for the *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung* were taken (after Dahmke, 2016; Hamburger Sternwarte, reproduced with permission).

This survey aimed at determining spectral classes of stars in the magnitude range 8.5 to 13. The method was to take photographic images of the sky with the objective prism in front of one of the astrographs, so that each stellar image was replaced with a spectrum on the photographic plate. The other half of the double astrograph was used to take a direct plate of the same area at the same time so that the spectra could be directly related to the stars that corresponded to it. The method was tested by taking plates in the same manner of stars with known spectral type. The limit of the spectroscopic survey was magnitude13.5 or so.

The fields obtained with the Lippert astrograph measured 1.5° on a side, much larger than the 20′ in the *Harvard(–Groningen) Durchmusterung*, so that it was necessary to determine apparent magnitudes over much larger fields. The Groningen part of the project involved the determination of accurate positions and photographic magnitudes. For this, extensive new plate material was collected at Harvard with the cooperation of Director Harlow Shapley. These were measured in Groningen using the photometer that Jan Schilt had developed, first in Groningen as part of his PhD thesis work and improved while he worked at Leiden Observatory. Schilt developed this, as he noted in his thesis, following a suggestion by Kapteyn. The practice after the start of the use of photographic plates to determine magnitudes was to estimate the diameter of the image. Schilt (1922) wrote:

> At the request of Professor J.C. Kapteyn I have made lately some experiments at the Groningen Astronomical Laboratory concerning the determination of photographic magnitudes by means of a thermopile and a galvanometer. The principle is this: the image of a small circular lens is formed on the photographic plate. The image of a star on the plate is brought to the center of the circular bright spot projected on the plate by the illuminated lens; the darker the image of the star, the smaller will be the fraction of the light transmitted by the photographic plate. This fraction is measured by means of the thermocurrent. The reading of the galvanometer, which indicates the intensity of this current, is thus a measure of the photographic magnitude of the star.

A thermopile is a set of thermocouples operated usually (as in this case) in series, a thermocouple being two different materials that are electric conductors. When these have a different temperature the energy difference gives rise to an electric current (the Seebeck Effect). The temperature difference results from illumination through the photographic plate. This current then is measured with a galvanometer and the strength of the current can then be related to the amount of light transmitted by the photographic emulsion. This requires a very good thermopile, and Schilt had obtained an excellent one, produced by Frits Zernike, who after obtaining his PhD in Amsterdam had returned to Groningen and to the Physics Department.

It is illuminating to read Blaauw's (1983: 54; my translation) description:

> The measurement program carried out ... at the Kapteyn Laboratorium ... has greatly absorbed the capacity of the laboratory over a period of more than two decades, probably much longer than van Rhijn had expected. The German partner has discharged its task with full responsibility and German 'gründlichkeit', but the cooperation with the Harvard College Observatory was a bit more difficult. However, Shapley and his collaborators cannot actually be blamed for this. The difficulty lay rather in the nature of the cooperation. While in Bergedorf and Groningen the staff worked for one's own institute, it was difficult for those at the Harvard College Observatory who were charged with the recording of the photographic plates, always devoting themselves to it with the necessary altruism. It went well as long as this was in the hands of pure observers who, in the patient, careful nocturnal work with the telescope, find full satisfaction, a mentality one finds more readily among the best of the astronomical amateurs than among the 'professionals'. The work at the Harvard College Observatory required more and more effort from advanced students who were difficult to motivate and moreover, were quickly replaced by new, inexperienced ones. No wonder, then, that the work, as I sometimes heard afterwards, gradually got the name of 'the damned van Rhijn program'. That it turned out ultimately satisfactory, must be partly due to the circumstance that van Rhijn's assistant Bok became a staff member of the Harvard College Observatory and thus was able to keep an eye on things.

What we see here is a first crack (or one of the first) in the model by Kapteyn of an astronomical laboratory relying entirely on observatories elsewhere for, in this case, plate material. In part this may be the changing 'zeitgeist', a growing reluctance to work predominantly for the benefit and in the service of others. What probably played a role as well is that van Rhijn did not quite have the unquestionable authority Kapteyn had had. Blaauw continued (my translation):

> ... Bergedorfer Spektral Durchmusterung. This is not a fortunate name, for the large Groningen share is not expressed in it; in fact, the Groningen effort, counted in man-years, must have been considerably greater than the German. But it was not in van Rhijn's character to give much attention to this external aspect; the main thing was for him that the job got done.

In a paper on the history of the Hamburger Sternwarte, Dahmke (2016: 197) states:

> In the 1920s multiple survey programs began, among them the Bergedorfer Spektral-Durchmusterung by Schwassmann and Wachmann, who used the Lippert Astrograph to obtain spectra of more than 160,000 stars ...

Dahmke ignored the positional part of the project, van Rhijn's co-authorship, and the collaboration with the Kapteyn Laboratorium and Harvard College Observatory, even though these were manifestly clear from the full title of the *Durchmusterung*. Completing Blaauw's remarks on the subject (my translation):

> Many generations of van Rhijn's temporary assistants we find back in his introductions to the five issues mentioned as co-workers: in the first, of 1935 B.J. Bok, J.J. Raimond and P.P. Bruna; in the one of 1938 P.P. Bruna; in 1947 me; in 1950 and 1953 L. Plaut. To the measurement and calculation work participated G.H. Müller, W. Ebels, P. Brouwer, P.G.J. Hazeveld, H.J. Smith,J.B. van Wijk, M. Seldenthuis, D. Huisman, H. Schurer, M.L. Wagenaar and W.L. Grümmer. During the War years, cooperation with Bergedorf naturally became increasingly difficult, until it stopped completely. It must have been around 1943 that I myself, then an assistant, was summoned to come to the office of a high German official in Groningen to justify why Bergedorf no longer received any response from us (van Rhijn was staying in a sanatorium with a serious illness), but it was not difficult for me to point out to the gentlemen that for some well-known reason the delivery of the plates from Harvard had been interrupted. At that time in Bergedorf they had very little idea of the conditions prevailing here under the occupation.

Bruna is Petrus Paulus, born in Utrecht in 1906, who was an Assistant at the Laboratorium from 1934 to 1939. He did publish some work in the *Monthly Notices of the Royal Astronomical Society* on the determination of the motion of the Sun in space. The only thing in public records I could find about him is that he got married in in 1940 and he must have left Astronomy probably to take up a job as a high school teacher. In the correspondence in the Oort Archives there is one reference to him. On 15 January 1941, van Rhijn wrote to Oort (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149; my translation):

> With Bruna it is a difficult case. He has done the routine work of the Laboratorium as an assistant quite well, but he has no gifts for scientific research. Added to this is the fact that he and his wife are ill quite often and he has a busy job as a teacher. At the moment he is busy writing up the work. But that is also going slowly because the pieces he sends are poorly written. He has been working on the research for about seven years. It is indeed high time that the work is finished. I will write him again.

Bruna never completed his thesis.

A number of the computers can be found in Figure 14. The HBS mentioned in the caption is the 'Higher Civic School', instituted in 1863 by liberal Prime Minister Johan Rudolph Thorbecke (1798–1872) as part of a major overhaul of the Dutch educational system. It was designed to provide education preparing upper or middle class boys for a career in industry or commerce, but which as a result of the excellent training in science by teachers with PhD's quickly became the preferred secondary school leading to academic studies in mathematics and natural sciences.

Eventually, the results were published by the Hamburger Sternwarte at Bergedorf in five volumes, between 1935 and 1953. They boasted the ultra-long title quoted at the beginning of this section, and were coauthored by Schwassmann and van Rhijn (1935–1953). The magnitude range came out as between 8.5 and 13 photographic and the total number of stars was 173,599. As Blaauw (1983) noted, the daily supervision of the work had been the duty of the Assistants; this was a full-time job, so the preparation of PhD theses was restricted to the evenings and the weekends. In this paper I wish to honor Blaauw, van Rhijn and others at Groningen and Harvard by referring to it as the *Bergedorf(–Groningen–Harvard) Spektral–Durch-musterung*.

It should be mentioned here that a similar exercise was performed at the Potsdam Sternwarte near Berlin as the *Spektral–Durchmusterung der Kapteyn–Eichfelder des Südhimmels*, also in five volumes, published by Wilhelm Becker (1907–1996) between 1929 and 1938, partly in collaboration with Hermann Alexander Brück (1905–2000) (see Becker, and Brück, 1929–1938).

Figure 14: Computers and observators of the Kapteyn Laboratorium; photograph taken in 1926 or 1927. From left to right (caption taken from Adriaan Blaauw (Blaauw, 1983; my translation): J.B. van Wijk – appointed 1-11-1924 after HBS training and military service, celebrated 1-11-1964 his 40th anniversary in office and in 1966 wrote his memoirs of the first years. J.M. de Zoute – worked under Kapteyn and van Rhijn, initially studied theology, but had to terminate his studies to earn a living. Was a computer and wrote letters for Kapteyn and van Rhijn in the final 'neat' version before sending. He was always computing or writing standing at a high lectern (which in 1938 was still in the 'computer's room'). Was released in the crisis years due to university budget cuts. W. Ebels – appointed in the early 1920s, worked like van Wijk and Müller until his retirement. T.W. de Vries – worked for 36 years under Kapteyn, then 6 years under Van Rhijn, did in particular much measuring work. H.J. Smith – computer under van Rhijn, died in the War years. G.H. Müller – amanuensis, instrument-maker, already worked under Kapteyn, did measurement work and was van Rhijn's right hand in organizing the installation of the telescope on top of the laboratory building. P. Brouwer – affiliated with the Laboratory from September 1925 to December 1935, afterwards career with the police; helped A. Blaauw (March 1983) to identify the people on this photograph (courtesy: Kapteyn Astronomical Institute).

8 RESEARCH BASED ON THE SELECTED AREAS AND THE *SPEKTRAL–DURCHMUSTERUNG*

One might ask whether these spectral surveys have been of much use to others, and whether they constituted a worthwhile investment of funds, effort and manpower. I would think to some extent yes, but also that in the case of Groningen it went at the expense of momentum in research. The five volumes of the *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung* together have collected in ADS of order one citation every two years at a rather constant rate since the 1950s. And since the start of the current millennium it had and still has some ten reads per year. It certainly was not a major advance, although it definitely was not a complete waste, but whether it was a wise decision in view of the future of the Laboratorium to make such a long-term commitment of most of its resources is another matter. It is likely that the more useful part of the *Durchmusterung* was the spectral type information provided by Bergedorf rather than the magnitudes from Groningen.

I stressed above that the *Plan of Selected Areas* was more than a provision of fundamental data for the community at large. It was first of all designed to solve for a detailed model of the distribution of stars and their kinematics, and to study the dynamics of the Stellar System. After the 'first attempt' by Kapteyn (1922) no further attempts were made. Van Rhijn had taken the three next steps by refining the mean parallaxes for separate spectral types (van Rhijn, 1923a), determined a state of the art luminosity function (van Rhijn, 1925b) and deriving improved star counts in 1929 based on the *Harvard* and *Mount Wilson Durchmusterungs* (van Rhijn, 1929), but he stopped there and made no attempt to derive a new model of the stellar distribution. Undoubtedly, this had to do with the problem of how to allow for interstellar extinction.

Since the aim of the *Plan of Selected Areas* was to elucidate the structure of the Stellar System, it is important to stress that van Rhijn did use the *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung* for this purpose. Probably since the effects of absorption could not be very reliably eliminated, he and Schwassmann chose to study distributions of various spectral types at a Galactic latitude of 50°. Their paper (van Rhijn and Schwassmann, 1935) is in German, and it has collected only 11 citations in ADS, 9 of them after 1955 (the last one in 1985), and it has attracted about one read per year over the last two decades. It used determinations by van Rhijn of the luminosity functions for spectral type B, A, F, G, K and M, and distinguished dwarfs and giants (and supergiants) by assuming reasonable ratios between these two for each apparent magnitude. The result was quite significant and is illustrated in Figure 15. van Rhijn and Schwassmann (*ibid*.) found that the layer of B-stars was thinnest, increasing with later spectral type.

This was not entirely new as earlier studies, and in particular Oort's well-known K_z study (Oort, 1932), had shown this as well. But it was an important confirmation. In the 1930s it was not understood at all how this came about; the explanation was found only in the 1960s. Stars are born in the thin gas layer and therefore have initially the same distribution and mean vertical velocity (velocity dispersion) as the gas clouds. For any generation of stars this dispersion increases with time, due to scattering of stars by massive molecular clouds, spiral structure or in-falling satellites, and the average distance from the symmetry plane will increase with time for each generation. The sequence of stars corresponds to an increase of mean average age, and the effect reflects this so-called 'secular evolution'.

I will elaborate on this study to show the similarities and the differences in approach and in scope with van Rhijn's work. A more detailed analysis of the paper is given in my Oort biography (van der Kruit, 2019). Oort had used stars at high latitudes with known radial velocities, absolute magnitudes and spectral types (mostly from the Henry Draper Catalogue) and he first determined the dispersions of vertical velocities (the mean random motion). This showed no significant trend with distance from the plane, especially for K- and M-giants, on which most of his final analysis rested. He then used space distributions, particularly from papers by van Rhijn and others, and used dynamics to find the vertical force K_z up to 0.5 kpc. Oort then turned the problem around: if for a group of stars (range of absolute magnitudes or of spectral types) one knew the velocity dispersion, the force field could be used to calculate what the vertical density distribution for that group of stars would be. By comparing that to actual counts he arrived at an improved form for (his Table 22) luminosity function.

But that was only the beginning. First he simulated star counts for fainter stars, both apparently and intrinsically, and compared these with van Rhijn's counts. When that was satisfactory he constructed mass models of the Galaxy using a spherical mass around the center and a homogeneous ellipsoid, satisfying such constraints as the rotation parameters (rotation velocity and Oort constants). He then derived the gravitational forces, using these forces and the corresponding star counts for different assumptions of the velocity dispersions. He did (rather had his computers do) this enormous amount of work first as a function of latitude (concluding that above 15° no absorption effects were evident) and then as a function of longitude. This resulted in two important deductions. The first was the often-quoted Oort limit, the total amount of mass in a column perpendicular to the plane of the Galaxy at the position of the Sun, since he now knew the asymptotic value for the vertical force. The second was a first approximation of the stellar density in a vertical crosscut through the disk and the Galactic Center, at least away from the plane and extinction. This is reproduced here in Figure 16.

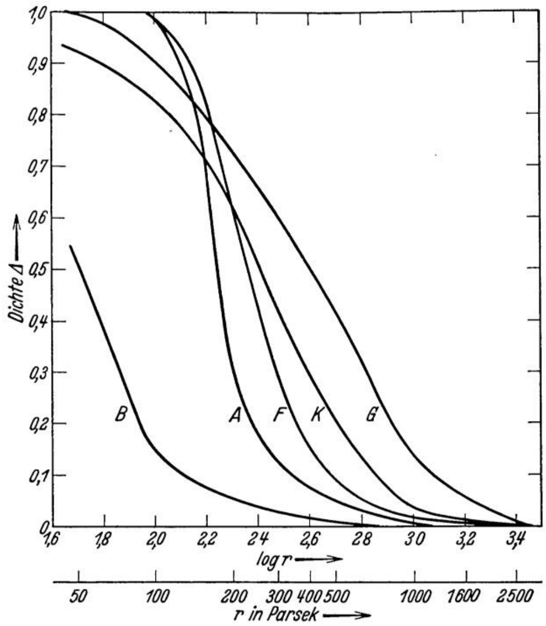


Figure 15: Density distributions ('Dichte Δ') of stars of separate spectral class with distance from the Sun at latitude +50° as determined by van Rhijn and Schwassmann (1935), based on 22 *Selected Areas* at roughly this latitude. The values have been normalized at the solar position. No distinction is made between dwarfs and giants here, but this is done in tabular form in the paper for G, K (and M)-stars (courtesy: Kapteyn Astronomical Institute).

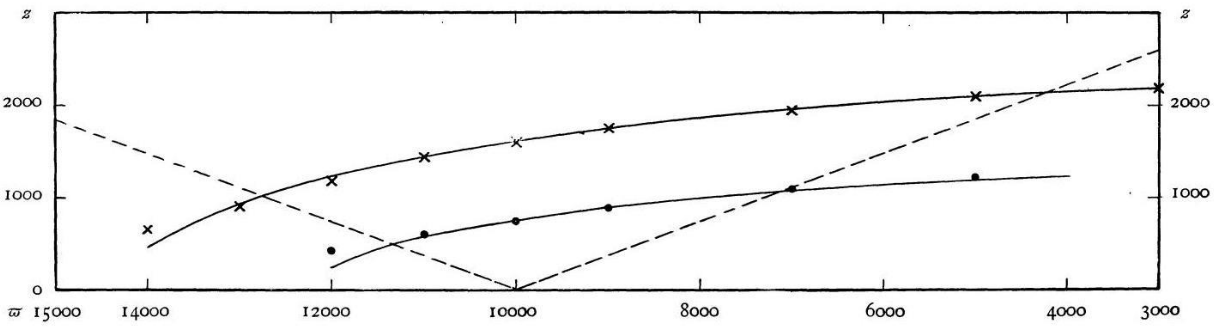


Figure 16: Crosscuts through the Galactic System from Oort in 1932. Surfaces of equal density of starlight, as ellipse fits centered on the Galactic center at 1/25th (dots) and 1/100th (crosses) of that near the Sun. The Sun is at 10000 pc, the center of the Galaxy at zero to the right. The dashed lines indicate latitude 20º (after Oort, 1932. From the Oort Archives).

It is true that in this work Oort used many results from van Rhijn's earlier investigations, and in fact the analysis would not have been possible without them. Van Rhijn and Schwassmann's conclusions did constitute a significant strengthening of Oort's conclusion as it was based on many more spectral types of fainter stars. On the other hand, Oort's work was far more imaginative and went much further. He aimed at an understanding of the structure of the local Galaxy in terms of distributions, kinematics and dynamics, and the possible presence of unseen matter, while van Rhijn and Schwassmann merely mapped distributions without addressing the deeper issue of understanding the structure of the Galaxy. Van Rhijn followed up on Kapteyn's program to collect the data, while Oort followed up on Kapteyn's final analysis and used this to map the Stellar System.

9 INTERSTELLAR EXTINCTION

In addition to the distribution of stars in space, van Rhijn had a second main line of research in studying interstellar extinction. The first half of his thesis was devoted to this (van Rhijn, 1916), on the basis of reddening of stars with distance, and he had, as we have seen, in 1928 unsuccessfully tried to determine this effect on apparent magnitudes on the basis of diameters of globular clusters (van Rhijn, 1928). I will not review in detail the history of the discovery of interstellar extinction. For a general listing of the chronology see Li (2005), and for the argument why the discovery should be credited to Robert Trumpler, as it usually is, see Seeley and Berendzen (1972).

After William Herschel had noted apparent holes in the distribution of stars in the Milky Way, and Wilhelm Struve suggested this to mean that there was an apparent decline in the number of stars with distance from the Sun which could be due to absorption, it was Edward Pickering's consideration of the star ratio (Pickering, 1903) that early in the twentieth century sparkled the debate about extinction. The star ratio is the relative number of stars between subsequent apparent magnitudes, which with fainter magnitudes deviated more and more from the theoretical value of log 0.6 = 3.981 for a uniform distribution. In 1904 George Cary Comstock (1855–1934) noted that the average proper motion decreased much less rapidly with apparent magnitude then expected (at least at low Galactic latitudes), and he proposed that this was due to extinction (Comstock, 1904). Kapteyn argued from detailed modeling that the matter was more complicated, and the effects of changes in extinction and in space density were degenerate and analyses of star counts could not resolve this. He proposed that the observed effects were a mix of the two. It was also Kapteyn who in the second of a pair of papers "On the absorption of light in space" (Kapteyn, 1909), suggested that it could be predominantly scattering, and that therefore the effects would be more severe at bluer wavelengths. He subsequently actually found these effects of increasing reddening with distance. So in addition to star counts, proper motions and studies of the distribution of stars there now was a new sign of extinction, namely interstellar reddening.

Extinction had been established beyond any doubt by Trumpler (1930), who used reddening of stars in open clusters, comparing the distances of about one hundred open star clusters, determined from apparent magnitudes and spectral types, with those from angular diameters, assuming these were on average the same. He derived an extinction of 0.7 photographic magnitudes per kpc. This was improved on in several ways by astronomers, of which I will take two examples (but without wanting to suggest that all the progress came from just these two studies). Former van Rhijn student Peter van de Kamp—who had moved to Leander McCormick Observatory—used an interesting method; he assumed extinction was zero at high latitudes and then used galaxy counts as a function of latitude to estimate average values of 0.8 to 1.4 photographic magnitudes per kpc (van de Kamp, 1932). Jean Jacques Raimond (for an obituary see Oort, 1961b) wrote a thesis in 1933. The coefficient of differential Galactic absorption, under van Rhijn in which he compared colors of stars at high latitudes with those of stars of the same spectral type in the Galactic plane. His result (Raimond, 1934) can be summarized as follows. He used magnitudes (photographic on the Mount Wilson scale, and visual on the Harvard scale) and spectral types from various sources, and estimated distances from van Rhijn's (1923a) mean parallaxes as a function of magnitudes, proper motions, spectral types and Galactic latitude or from spectroscopic parallaxes. This gave him absolute magnitudes. From stars at high latitude he calibrated the relation between colors and absolute magnitudes and then could find the reddening for stars at low latitudes. He assumed a layer of absorbing material with a thickness of 200 pc uniformly filled, and then found a reddening of (converted to units used here) 0.50 ± 0.03 magnitudes per kpc.

The problem remained what the corresponding amount of extinction would be. This required knowing the wavelength dependence of the scattering. Kapteyn had been the first to hypothesize that the signature of interstellar extinction would be a reddening of starlight with distance, and he had assumed that the effect was similar to that in the Earth's atmosphere giving rise to the blue color of the daylight sky. This is, however, the result of scattering of light on very small particles such as molecules. Most of this is Rayleigh Scattering first described by Lord Rayleigh (John William Strutt; 1842–1919) around 1870 (it is now known that Raman Scattering also plays a role, which is inelastic while Rayleigh Scattering is elastic, and results in exchange of energy). These processes occur from scattering by particles smaller than the wavelength, while it became clear that interstellar scattering really is from dust grains with sizes comparable to the wavelength. Consequently Kapteyn's initial guess that the dependence was as for Rayleigh Scattering, that is inversely proportional to the fourth power of the wavelength, was incorrect; in first approximation it actually is linear with the inverse wavelength.

It was Alfred Harrison Joy (1882–1973), who cleverly derived the relation between reddening and extinction from Cepheids, which are bright, can be seen over large distances, have relatively small random motions, and whose absolute magnitudes follow from their period of the brightness variations. He used Jan Oort's formalism in which on scales significantly smaller than the size of the Galaxy the radial velocity should increase linearly with distance as a result of differential rotation (see Section 4.5 in van der Kruit, 2019, or Section 5.4 in van der Kruit, 2021b). Joy (1939) published this result in 1939, but it was reported already in the 1932 Annual Report of the Director of Mount Wilson Observatory. Van Rhijn (1936) followed up on this by applying the method to open star clusters (with distances from the Hertzsprung–Russell diagram) and to F to M stars (in addition to Galactic rotation using spectroscopic and secular parallaxes). These together resulted in average extinctions of 1.1 and 0.55 magnitudes photographic and visual respectively per kpc.

Van Rhijn, in the same paper, used these data to do a somewhat general mapping in the plane of the Galaxy, using the northern *Selected Areas* at roughly latitude zero. Remarkably, beyond a kpc from the Sun there is a strong increase in density towards the center of the Galaxy, which is not accompanied by a rapid decrease in the anti-center direction. This was consistent with the Sun being located just outside a spiral arm, but that would have been a rather speculative claim and was not offered as an explanation by van Rhijn. In fact, there was no discussion at all about the broader view of our Galactic System or comparison to external galaxies. The two studies by van Rhijn—the one with Schwassmann on the distributions for different spectral types along a line of sight at high latitude (van Rhijn and Schwassmann, 1935) and the one on distributions in the Galactic plane corrected for an assumed uniform extinction (van Rhijn, 1936)—provided no profound new insight into the structure of the Stellar System as a second step following and improving the 1920 analysis with Kapteyn (Kapteyn and van Rhijn, 1920b). It was not the case that this was impossible, or too early, but simply that van Rhijn did not address it.

There was one more thesis completed under van Rhijn during the 1930s and that person would have been a better choice for the Assistant position than Bruna. This was Broer Hiemstra (1911–??), who defended a PhD thesis in 1938 (Hiemstra, 1938), but had not been appointed Assistant. He was born in Pingjum (a village south of Harlingen and close to where the Afsluitdijk joins Friesland) as a son of an elementary school teacher. He is not listed among the staff of the Laboratorium in the 'Jaarboeken', the Annual Reports of the University of Groningen, so he must have been supported by his parents or been supporting himself. Hiemstra had obtained his doctoral exam in November 1936, but since 1934 the Assistant position had been occupied by Bruna. In the certificate of his marriage in Dokkum (Friesland) in 1938 Hiemstra is listed as having the profession 'teacher' (according to a newspaper clipping they were engaged to marry already in 1931!, also in Dokkum), so a possibility is that, while working on his thesis, he supported himself as a part-time teacher, which turned into full-time after his thesis defense and made the marriage possible (he was 28 years by then and his bride Arendina Maria Vlietstra, an elementary school teacher, 29). They settled in Amsterdam where the young Mrs Hiemstra tragically died in 1940, one would think probably in child birth. According to a photograph in the Den Haag Municipal Archives (Nr. 1.21111), Hiemstra remarried and in 1976 at the age of 65 retired as Director of a large secondary school conglomerate there (in the Hague). So he pursued a successful career in secondary education. No more can be found on Hiemstra in official records or newspapers, except the announcement of the death of his father in 1944.

The thesis was defended in 1938 and concerned *Dark Clouds in Kapteyn's Special Areas 2, 5, 9 and 24 and the Proper Motions of the Stars in these Regions* (Hiemstra, 1938), and this study was rather ingenious and very much worthy of review here. It concerned determinations of distances and amounts of extinction in dark clouds. These Areas were four of the ones especially selected by Kapteyn for this purpose. These properties had been estimated before, usually from counts of stars projected onto the dark cloud compared to those in the immediate vicinity. The way to do this was to determine from star counts and the luminosity function what the apparent density along a line of sight was towards the cloud and one or more just next to it on the sky. The problem of using star counts was that this involved solving integral equations. Counts of stars in a particular direction as a function of apparent magnitude, followed from a summation. For each element of distance from the Sun along a line of sight each apparent magnitude corresponded to a certain absolute magnitude. The number of stars seen at that apparent magnitude from this element then was the total density of stars there multiplied by the the fraction of stars of the required absolute magnitude, which was the value of the luminosity curve at that absolute magnitude. All such contributions from elements at other distances along the line of sight, corresponding to different absolute magnitudes, then had to be added up to find the total count of stars of that particular apparent magnitude. Mathematically this was an integral, which could be evaluated in principle in a straightforward manner. But the solution required was the inverse. Given the form of the luminosity curve and the star counts at apparent magnitudes, the problem was to determine the total density as a function of distance. That meant having to 'invert' the integral and inversion of integral equations was notoriously difficult. For the solution for the 'Kapteyn Universe', Kapteyn and van Rhijn (1920b) had used Schwarzschild's analytic method for the special case that the luminosity curve could be approximated by a Gaussian. This method, which German astronomer Karl Schwarzschild (1873–1916), then from the Sternwarte Göttingen, had actually described in a paper by Schwarzschild (1912), would have played a role in Kapteyn proposing Schwarzschild for an honorary doctorate from the University of Groningen on the occasion of its tricentennial in 1914 (van der Kruit, 2021d).

In the early 1920s, Anton Pannekoek in Amsterdam had also addressed the problem of the distance and extinction of a dark cloud (Pannekoek, 1921). He used Kapteyn's density distribution and the luminosity function to compute the theoretical decrease of the number of stars of different magnitudes for different assumptions for the distance and extinction in the cloud and compared these to actual counts towards the cloud. In other words he solved the inversion problem by trial and error. Other major contributions to this field had come from Maximilian Franz Joseph Cornelius Wolf (1863–1932) at the Landessternwarte Heidelberg–Königstuhl (Wolf, 1923, and subsequent papers in the *Astronomische Nachrichten*). Wolf introduced what became known as Wolf diagrams, which compared star counts for the obscured and adjacent regions. These showed immediately at what magnitude the curves began to deviate, from which the distance could be estimated, and the amount of absorption from at what magnitude the curves became parallel again. For an interesting review of the history of this subject, see Pannekoek (1942).

All of this was based on counts of stars as a function of apparent magnitude and solving the corresponding integral equation of statistical astronomy. The innovative idea in Hiemstra's thesis was to use counts of proper motions and solve the corresponding equation, in which the luminosity law was replaced by the distribution law of space velocities. Hiemstra attempted to determine distances and amounts of extinction of the dark clouds in these areas using proper motions of stars in front of and next to these clouds. For this he measured proper motions from plates obtained at Radcliffe Observatory and made available by its director Harold Knox-Shaw (1885–1970).

The method he used is a very interesting one, so I will explain its principles. But first I will, for those unfamiliar with this, explain the notions of velocity ellipsoid and vertex deviation. Kapteyn used the effects of the solar velocity on the distribution of proper motions to derive statistical distances (secular parallaxes), which required random, isotropic motions. When he had found that in addition there was a pattern of two opposite Stellar Streams, Karl Schwarzschild quickly realized that this could also be explained as an asymmetry in the velocities, which would then be Gaussian with three unequal principal axes. Galactic dynamics required the long axis of this velocity ellipsoid to be directed towards the Galactic Center, but Kapteyn's Star Streams were directed some 20° away from this. This deviation of the vertex was not a fluke in Kapteyn's analysis, but convincingly confirmed and eventually attributed to gravitational effects of spiral structure by Oort (1940).

Hiemstra chose components of the proper motions that lined up as much as possible with the long axis of the velocity ellipsoid as given by Oort (so not assuming this pointed at the Galactic Center, but taking the vertex deviation into account) and at least 66° from the solar motion in space, both conditions ensuring a minimal effect on the parallactic motion. The distribution of proper motions was a combination of the distribution of parallaxes and that of the linear velocities and comparable integral equations could be written down for counts as a function of proper motions as for those of apparent magnitude. This function followed from a study of radial velocities and was assumed uniform with position in space. Hiemstra inverted the relevant integral equation by trial and error and in this way arrived at a distribution of parallaxes for the stars next to the dark nebula. From this he determined what star counts would look like taking only stars up to various maximum distances. Assuming that the density of stars and their luminosities was the same in the obscured region and towards the dark nebula he then arrived at an estimate of the distance of the cloud and the amount of extinction it gave rise to. The four dark clouds were at distances ranging from 300 to 1000 parsecs and their total extinctions at least 0.5 to 2 magntudes in the photographic band. This provided excellent, independent confirmation of results from other studies.

Hiemstra's paper has no citations in ADS but still averages 2 reads per year. It seems to me the conclusions are still valid according to current insight and that it constituted a very significant result that probably did not, at the time, attract the attention it deserved. For example, in his review Pannekoek (1942) only mentioned Hiemstra's publication in passing, noting that it was an illustration that his own formalism could easily be adapted for proper motions. At about the same time (1937) a study appeared by Freeman Devold Miller (1909–2000) from Swasey Observatory in Ohio, who used the 'Pannekoek equation' (the integral equation of star counts in the case of an intervening dark cloud). Hiemstra compared his work to Miller's and the results were similar. Yet Miller's (1937) paper currently has on average only one read per year. The Wolf 1923 paper has become a classic with some 1 to 2 citations and 15 or so reads per year, while the 1921 paper by Pannekoek was cited for the last time in 1993. But it is not easily accessible; it has about one read per year, probably only for the person involved to find out that the text is not on the Web. Hiemstra's thesis, it seems, still is significant.

10 OORT'S SECOND APPROXIMATION

Actually, the time was ripe for a new attempt to synthesize a model for the distribution of stars in space and the structure of the Stellar System, and it was Oort (1938) who took this step! I quote from Oort's historical discussion on "The development of our insight into the structure of the Galaxy between 1920 and 1940" (Oort, 1972: 263):

> I wanted to determine the general density distribution outside the disk as a function of Galactic latitude as well as of longitude, and thereby to extend Kapteyn and van Rhijn's initial investigation to a second approximation. It was found that beyond about 500 pc on either side of the Galactic plane, the star density increased rather smoothly toward the center. It showed a logarithmic density gradient of 0.14 per kpc at levels between about 800 and 1,600 pc above and below the Galactic plane, and the equidensity surfaces made an angle of 10° with this plane.

This paper has been summarized and discussed extensively in Section 8.4 of van der Kruit (2019) (or 6.6 of van der Kruit, 1921b), so I will only give a brief summary here in order to demonstrate the ingenuity of the approach.

When Oort started this investigation (well before the publication year of 1938) the *Plan of Selected Areas* had progressed quite well. At this point it is relevant to summarize the state of progress in the Plan at that time, say the middle of the 1930s. As for star counts, the *Harvard(–Groningen) Durchmusterung* down to magnitude 16 had been completed as well as the *Mount Wilson(–Groningen) Catalogue* of the northern Areas to magnitude 19. The next step would be to determine spectral types and most importantly, proper motions. The spectral types were not fully published but mostly available from the Bergedorfer Sternwarte for the northern fields and the Potsdam Sternwarte near Berlin for the south. Oort must have had access to all or most unpublished material from these two *Durchmusterungs* as far as available at any particular time, which meant for stars brighter than magnitude 12 or so. As mentioned above, for the northern Areas Humason at Mount Wilson used the 60-inch telescope to determine the spectral type of at least 10 stars per Area down to magnitude 13.5 or so.

Another major advance was the publication in 1934 of *The Radcliffe Catalogue of Proper Motions in the Selected Areas 1 to 115* by Harold Knox-Shaw (1885–1970) and his assistant H.G. Scott Barrett. Radcliffe Observatory, which was part of Oxford University, had a 24-inch telescope; it was first used to try and measure parallaxes in the Selected Areas, but when that was unsuccessful attention was re-directed towards proper motions. This had been started in 1909 under Arthur Alcock Rambaut (1859–1923), taking photographs in duplicate, one being developed immediately, the other stored for re-exposure at least ten years later. The second stage was started in 1924 under Knox-Shaw. The catalogue, published in 1934, contained proper motions of some 32,000 stars. The Oxford Radcliffe site was actually vacated in 1935 and the Observatory moved to a site near Pretoria, South Africa. Another important source for Oort to use was a study by Peter van de Kamp and Alexander Nikolayevich Vyssotsky (1888–1973) at Leander McCormick Observatory near Charlottesville, Virginia, which had a 26-inch refracting telescope. Van de Kamp and Vyssotsky had measured the proper motions of 18,000 stars with this telescope. All these data together already constituted a substantial fraction of what Kapteyn must have envisioned necessary for an attack on the problem when he conceived the *Plan of Selected Areas*.

But before embarking on an analysis of the available material with the aim to derive a new picture of Galactic structure, Oort went through some important preparatory exercises improving estimates for the constant of precession (vital for determining proper motions), the motion of the equinox and the Oort constants of differential Galactic rotation.[11] And from radial velocities and proper motions combined with estimated distances of spectroscopic and other parallaxes, he derived an improved estimate of the shape of the velocity ellipsoid (the distribution of velocity vectors). This left the problem of the extinction. For this Oort used galaxy counts by Edwin Powell Hubble's (1889–1953) mapping the 'Zone of Avoidance', with which he was provided by Hubble before publication. The problem was to turn the distribution of galaxy counts into one of magnitudes of extinction. Oort did that by determining the colors of fainter stars in Selected Areas and comparing these to those of nearby, unreddened stars of the same spectral type, and he found the reddening. This related galaxy counts to reddening, but he still needed to transform reddening into the corresponding actual amount of absorption. For this one would have to measure the brightness as a function of wavelength for the reddened and the unreddened stars, and in this way the wavelength dependence of the extinction. Such a study had just been published by Jesse Leonard Greenstein (1909–2002), who had calibrated spectra in terms of the brightness as a function of wavelength using photoelectric techniques, and had found the dependence of the absorption to be inversely proportional to the wavelength. Greenstein determined also the actual amount of absorption by comparing stars still visible behind dark clouds to stars just next to them, which also gave him the factor to turn color excess into actual magnitudes of extinction.

From studies of faint stars Oort concluded that in all probability a considerable fraction, if not all, of the absorption derived from the counts of nebulae must take place within a relatively small distance from the Galactic plane. He then felt justified in approximating the situation by assuming that the entire absorption indicated by the nebulae took place in front of the stars considered. He ignored the Selected Areas at too low Galactic latitude, generally below 10°, but without a strict criterion. So, with that assumption and using van Rhijn's luminosity function, for each Kapteyn Selected Area he proceeded to calculate the star density along the line of sight at three distances from the plane. He found two important things. First, there was a general and large-scale increase in stellar density towards the center of the Galaxy, and secondly, that there was symmetry

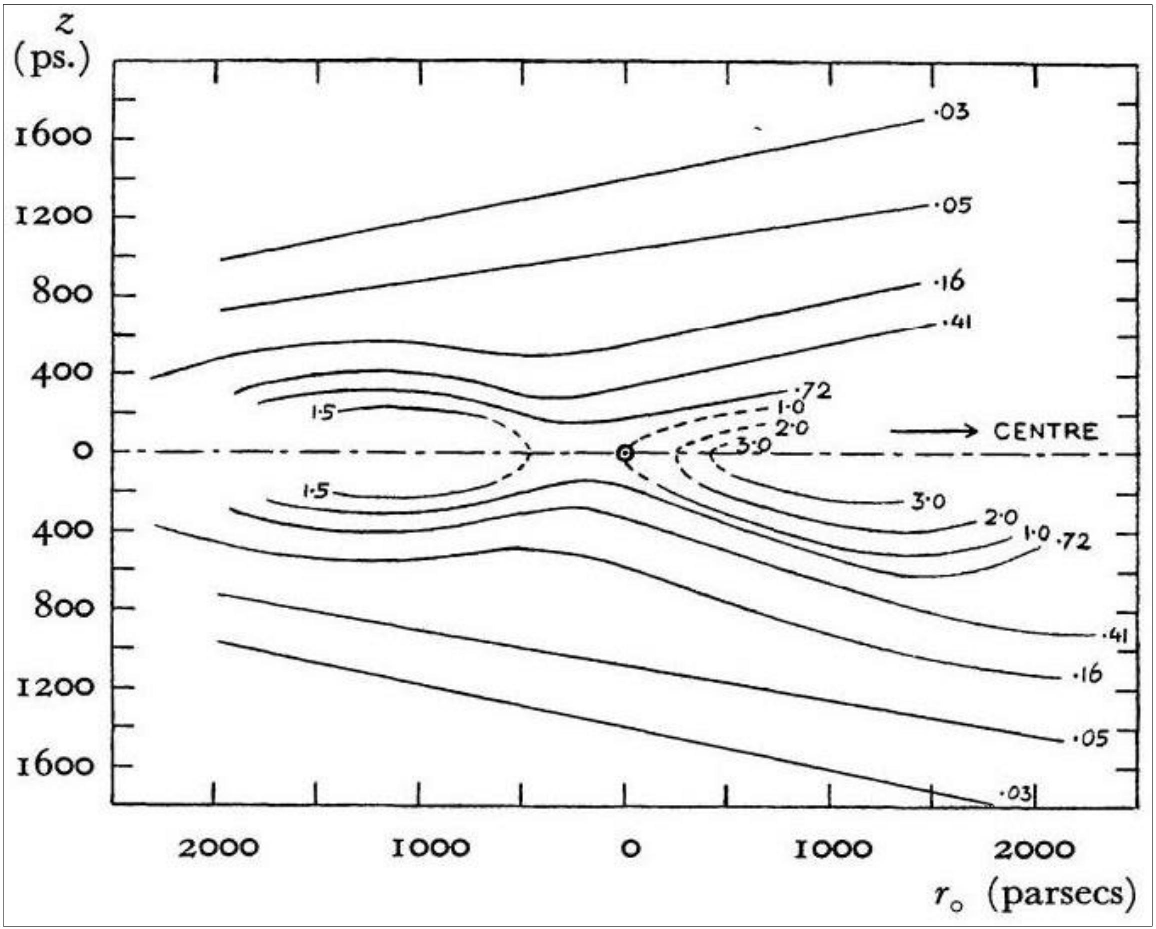


Figure 17: Crosscut through the Galactic System from Oort (1938). Surfaces of equal density of starlight, at various light densities. The Sun is at zero, the Galactic center to the right at 10 kpc (from the Oort Archives).

between both sides of the Galactic plane.

Oort continued by sketching from his data isodensity curves in a cross-cut through the Galaxy at the solar position in a plane at right angles to that of the Milky Way and along the direction towards the center. This is reproduced in Figure 17. It looks very much like what would be expected if the Galaxy had a spiral structure, just like many external systems. The precise form of the 'arms' could not be determined, but Oort was relatively certain about one thing and that was that the Sun should be between two spiral arms. At larger distances from the plane the spiral structure was replaced with a general density gradient towards the center, amounting to a factor 1.398 in the stellar density per kpc. In modern terms this corresponds to a scalelength (e-folding) of about 3 kpc; my preferred value is more like 4.5 kpc (see van der Kruit and Freeman, 2011, Section 3.1.1), but this is open to different opinions. This result is a rough first approximation, which fits current understanding quite well.

In Oort's analysis, hot and bright O- and B-stars played a significant role and these are now known to be concentrated heavily in the spiral arms, where in a spiral galaxy star formation is preferentially taking place. So, an analysis that relied heavily on short-lived OB-stars probably enhanced the real contrast between arm and interarm regions. Modern studies have revealed the spiral structure in our Galaxy in much more detail. The Sun, then, is located near a local arc or branch between the major spiral arms, as found also in modern studies (see e.g. González et al., 2021). Oort's analysis was along the lines that Kapteyn must have had in mind when he defined the *Plan of Selected Areas*, and Oort's paper was therefore a major outcome of this Plan.

I entered into this somewhat detailed discussion to illustrate that in the course of the 1930s the work on the Selected Areas actually had progressed to the point where an analysis as originally envisaged by Kapteyn was possible, and that Oort actually had performed this. Of course, more work needed to be completed and published, but I would argue that with this study by Oort the primary goal of the

Plan of Selected Areas had been accomplished. What followed was to a large extent provision of more catalogue data. After all, in his presentation of the Plan, Kapteyn (1906: 1) wrote:

> The aim of it is to bring together, as far as possible with such an effort, all the elements which at the present time must seem most necessary for a successful solution to the sidereal problem, that is: the problem of the structure of the sidereal world.

It would seem that by adding more data no substantial improvement could be achieved. A main reason for that was that the distribution of the dust that gave rise to Galactic extinction was highly irregular. Van Rhijn's (1936) study had failed to show anything fundamentally new, and indeed Oort (1938) did not even mention the outcome of this work. He referred to this paper twice, in both cases related to B-stars and Cepheids being bright and therefore more readily included in samples selected at random. So, Oort's paper and the crosscut in Figure 17 was the final result of the *Plan of Selected Areas* in terms of the goals set by Kapteyn. Significant progress in the mapping of the stellar component of the Galaxy became only feasible with the recent astrometric satellites Hipparcos and Gaia.

Although, as I stated, Oort's 1938 study constituted to a large extent what Kapteyn had defined as the aim of the *Plan of Selected Areas*, it was not at all the end of the undertaking. In 1930 van Rhijn had published the Fourth Progress Report in the *Bulletin of the Astronomical Institutes of the Netherlands*, and after that it was taken up by the International Astronomical Union as a dedicated Commission 32. Van Rhijn chaired this Commission until 1958 and edited Progress Reports in the tri-annual Transactions of the IAU (International Astronomical Union, 1923–2007). In 1958 at a meeting of Commission 33 (Structure of the Galactic System), chaired by Adriaan Blaauw, Nancy Grace Roman (1925–2018) moved a proposal to incorporate it as a subcommission of Commission 33, which after being seconded by Bart Bok was carried. The new chair was Tord Elvius (1915–1992); his last report to the IAU appeared in 1970. At the corresponding General Assembly in Brighton, Commission 33 President George Contopoulos proposed to abandon the separate subcommission and incorporate the work in that of the Commission itself. This was in fact the formal end of the *Plan of Selected Areas*.

In addition to the IAU reports, two review papers were written on the 1960s that should be mentioned here. The first of these was a very nice overview by Beverly Turner Lynds (1963), discussing developments up to that time, and the second was a presentation in 1965 in the famous Galactic Structure volume V of the Stars and Stellar Systems compendium by Blaauw and Elvius (1965).

In a sense the informal end of the Plan was marked in 1953 at what became known as the 'Vosbergen Conference', as I submitted in my Kapteyn biography (van der Kruit, 2015). This meeting, which as Number 1 marks the beginning of the IAU-Symposia Series, was a tribute to van Rhijn and therefore was held near Groningen. I will return to this later.

As I noted, significant progress in the mapping of the stellar component of the Galaxy became only feasible with the recent astrometric satellites. Still, the *Plan of Selected Areas* had a significant impact on Galactic studies, at least through the 1930s. This is not too obvious from the authoritative discussion by Robert Smith (2006) of developments in the field between 1900 and 1952. He only mentions Kapteyn's inception of the *Plan of Selected Areas* by 1906 and the latter's First Progress Report in 1924, and does not cover further studies of the distributions of stellar properties in this context during the 1920s and 1930s (such as e.g. Oort, 1932; 1938).

The canonical picture that was prevalent in the 1930s and maybe for some years before was that the Galaxy consisted of a flattened disk extending much further then extinction allowed us to see, with a system of globular clusters the centers of which coincided, and that it resembled extragalactic spiral nebulae. Oort's well-known sketch for Willem de Sitter's book in 1932 in Figure 18 sums this up well. This picture was preluded by various astronomers, such as Henri Norris's Russell (1877–1957) in an important review of the state of affairs at the end of the 1910s on "Some problems of sidereal astronomy" (Russell, 1919), or somewhat later, in 1926, by Oort in his inaugural lecture as privaat-docent (Oort, 1927, Appendix A in van der Kruit and van Berkel, 2000, for an English translation). But the new insight came, in particular, from publication of an important paper by Frederick Seares in 1928 that mainly arose out of his involvement in the *Mount Wilson(–Groningen) Catalogue* as part of the *Plan of Selected Areas.* Seares (1928: 176), see Figure 19, who put it as follows:

> As a directive aid to further research ... lead to the following picture of the probable structural relations in the stellar system: The galactic system is a vast organization resembling Messier 33, although probably larger ... It includes a central condensation,

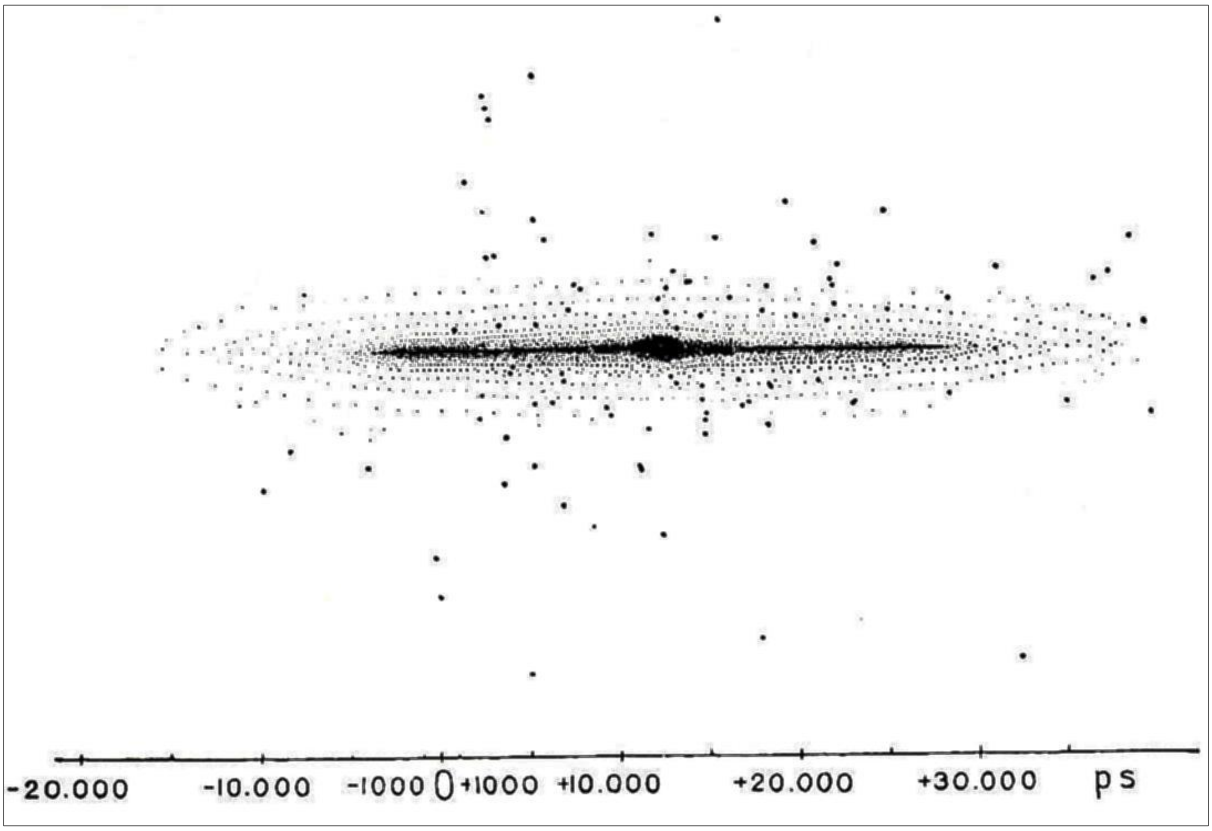


Figure 18: The structure of the Galaxy as it emerged towards the end of the 1920s as summarized by Frederick Seares (1928). This drawing has been published first by Willem de Sitter in his book *Kosmos* (de Sitter, 1932) and attributed there to 'Dr. Oort'. He probably drew it earlier than this. It was used and published by Jan Oort himself in his inaugural lecture as Extraordinary Professor in 1936 (Oort, 1936). The scale is in parsecs with the Galaxy extending from –15 to +40 kpc from the Sun (from the Oort Archives, see van der Kruit, 2019).

> scattered stars, and aggregations of stars distributed over the galactic plane ... Like the spirals, the system also includes diffuse nebulous material concentrated near the galactic plane, dark and obscuring, or luminous if stimulated to shine by the radiation of neighboring stars of high temperature. The central condensation, in longitude 325°, is hidden behind the dark nebulosity which marks the great rift in the galaxy. Stellar aggregations, seen above and below the obscuring clouds in the manner familiar in edge-on spirals, form the two branches of the Milky Way, extending from Cygnus to Circinus. The diameter of the system is large – 80,000 to 90,000 parsecs, if it may be regarded as coextensive with the system of globular clusters ... The sun is situated almost exactly in the galactic plane defined by faint stars, but a little to the north of that determined by Cepheids, faint B stars, and some other special classes of objects. Its distance from the central condensation is perhaps 20,000 parsecs ... Obscuring clouds conceal the great surface density which otherwise might be expected in the direction of the center of the larger system.

Note that this precedes Trumpler's 'discovery' of interstellar absorption. Oort's 1932 and

Figure 19: Frederick Seares at the time of his involvement with the Plan of Selected Areas commenced. This picture comes from the *Album Amicorum*, presented to H.G. van de Sande Bakhuyzen upon his retirement as Professor of Astronomy and Director of the Sterrewacht Leiden in 1908 (Leiden Observatory, 1908).

1938 papers significantly strengthened the understanding of Galactic structure; van Rhijn's work on the luminosity function was important, but in terms of a fundamental understanding of the overall structure of the Galaxy his work was not groundbreaking.

For completeness: By 1939 the distance to the Galactic Center had shrunk to 10 kpc (but is still over 10 kpc in Figure 18), on the basis, for example, of the review by John Stanley Plaskett (1865–1941) (Plaskett, 1939). As Smith (2009) also noted in the paper cited above, by the end of the 1930s the hopes that more analyses of star counts and the Plan of Selected Areas would help further understanding of the structure of the Galaxy were diminishing. Studies of light distributions and kinematics in external galaxies, as in Oort's (1940) pioneering study of NGC 3115 presented at the 1939 McDonald dedication, were promising in that he showed the feasibility of photographic surface photometry. But the field awaited larger telescopes and better observing techniques to measure stellar motions in these systems.

Star counts were not dead yet, though. Bart Bok still saw great promise in them, especially when he and his Irish student Eric Mervyn Lindsay (1907–1974) discovered and studied apparent windows in the obscuring layer along the Galactic plane (Bok and Lindsay, 1938: 9). They wrote:

> Maybe the study in or near windows in the distribution of obscuring material can help, if studies on the distribution of faint external galaxies go hand in hand with studies on the distribution of colors and variable stars, spectral surveys and star counts to faint magnitude limits on a definite photometric system. For several years our ignorance concerning galactic absorption has appeared to be the chief obstacle in the way of effective analysis of galactic structure; this obstacle can now be removed. Our knowledge of galactic structure can be further advanced if detailed studies of the distribution of stars and nebulae are made for more or less obscured fields near galactic windows as well as for the windows themselves.

But this program never produced many fundamental new insights.

11 VAN RHIJN'S PLANS FOR HIS OWN OBSERVATORY

Already in the 1920s it had become clear that Kapteyn's model of an astronomical laboratory, an observatory without a telescope, had started to show cracks. Blaauw (1983: 57) attributed this, among other reasons, to the difference in personalities between Kapteyn and van Rhijn (my translation):

> Two character traits had made Kapteyn succeed: his exceptional gifts as a scientific researcher and his engaging, optimistic personality. In these respects, what may we say of van Rhijn? He was a thorough scientific researcher and had a wide interest in the developments in astronomy, also outside his own field of research ... His approach to research, however, was highly schematic, strongly focused on further evaluation of previously determined properties or quantities. This benefited the thoroughness of the intended result, but came at the expense of flexibility and reduced the opportunity for unexpected perspectives; as a result, it did not lead to surprising discoveries.
>
> Also, van Rhijn's personality was so different from what has been handed down to us about Kapteyn; meetings with foreign colleagues, offering the opportunity for casual discussion and the development of friendships hardly occurred, because he was not very keen on travel; he liked organizing and conducting much of the work from behind his desk, admittedly very well and carefully, but in an almost impersonal way that could unintentionally come across as 'pushing'. All in all, circumstances that made working with the outside world not always run smoothly ...

At the time of Kapteyn's death and the birth of the IAU, or to be precise the first General Assembly, the *Carte du Ciel* and the *Plan of Selected Areas* were integrated into the Union as dedicated Commissions. No such new initiatives on this scale of participation were attempted after that; in the 1950s the *National Geographic Society–Palomar Observatory Sky Survey* was performed at a single observatory with a specially built telescope. Kapteyn had profited from the existence of the Helsingfors Observatorion and Anders Donner, who was interested primarily in supplying data for others: participating in the *Carte du Ciel*, but in addition providing data for Kapteyn to use for his research. No such opportunity presented itself for van Rhijn. Major observatories were no longer ready to act as service institutions and merely supply large masses of observational material for others (if they ever were). The story of the grumbling astronomers at Harvard who took plates for the 'damned van Rhijn program' illustrates this. The *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung* was performed with a clear division of tasks. Bergedorf did not supply observational material to Groningen, the Observatory obtained the spectra and classified them, while Groningen relied on Harvard plates to determine positions and magnitudes.

Blaauw attributed Kapteyn's success to both his extraordinary talent for scientific research and his outgoing personality, a combination of attributes van Rhijn did not possess. This would explain both the prominence of the Laboratorium in Kapteyn's days as well as the decline under van Rhijn. I actually would go a little further: the model of an astronomical laboratory relying on others to supply observational material simply was not a viable one and was bound to fail, not only in the long run but already as soon as Kapteyn had stepped down. Kapteyn must have realized this when he presented his *Plan of Selected Areas*, where in addition to the scientific goals quoted above he put it forward as a means to secure funding, actually increased funding, for his laboratory. As I suggest in van der Kruit (2019 and 2021a), Kapteyn must have realized that the future of Dutch astronomy lay in Leiden with a real observatory, which after the reorganization of 1918 consisted of three departments led by renowned astronomers. Groningen had no observatory, nor the support the Sterrewacht had from its university and particularly from the Ministry. It was bound to become second rate, and could only survive if there was a long-term commitment by a large group of observatories to his Plan, as concluded under Kapteyn's leadership. Van Rhijn must have realized this too. His experience with the Groningen part of the *Spektral–Durchmusterung* and the reliance on Harvard made abundantly clear that the model of a laboratory would fail. No wonder, then, that van Rhijn decided to pick up where Kapteyn had failed, and try to obtain his own telescope.

I briefly recount the story of Kapteyn's failure to obtain an observatory. He was appointed the first Professor in Groningen with the teaching of Astronomy as his primary assignment as a result of a new law on higher education that stipulated that the curricula at the three nationally funded universities should be the same. This roughly doubled the number of professors in the country and this and the stronger emphasis on research resulted in a comparable increase in the funding of the universities. However, thanks largely to negative advice from the Directors of the Observatories in Leiden and Utrecht, Hendricus van de Sande Bakhuyzen and Jean Oudemans—who did not wish to share astronomy resources with a third partner—Kapteyn's proposal to build a small observatory in Groningen was rejected. This development made Kapteyn give up hope for an observatory, and instead establish an astronomical laboratory. In the 1890s he requested funding for a photographic telescope for Groningen, proposing that Leiden should concentrate on astrometry and Groningen on astrophotography. However, van de Sande Bakhuyzen reversed his earlier position in which he had questioned the usefulness of photography and therefore refrained from Leiden's participation in the *Carte du Ciel* Project. He must have seen Kapteyn's proposal as a threat to Leiden's dominant position in Netherland's astronomy, and he submitted a counter-proposal to the Government. This was significantly cheaper than Kapteyn's since van de Sande Bakhuyzen only added to Leiden's existing infrastructure, so the choice was not difficult for the Minister.

Another possibility for Groningen to secure regular access to a telescope occurred during the late 1910s, when rich tea-planter and amateur astronomer Karel Albert Rudolf Bosscha (1865–1928) from Bandung in the Dutch East-Indies, assisted by Rudolf Eduard Kerkhoven (1848–1918), made plans to establish an observatory there (Visser, 2006). This was stimulated by Joan George Erardus Gijsbertus Voûte (1879–1963), who was originally a civil engineer, but had turned to astronomy and, without ever defending a PhD thesis,[12] worked as an observer at Leiden and Cape Town observatories before joining the meteorological office in the Dutch East-Indies. Kapteyn felt this observatory should be managed by a national committee, while de Sitter took the position that he, as Director of the Sterrewacht, should be responsible for defining the research program and organizing the interface with Dutch astronomy. De Sitter argued that the Minister's attempts at specialization and concentration could be diverted by agreeing that "Leiden specializes in everything except the specializations of Groningen and Utrecht" (from a letter to Kapteyn of 24 May 1920, see W.R. de Sitter in van der Kruit and van Berkel, 2000: 99), thereby making the latter institutions subsidiaries of the first. In the end, de Sitter's coup failed, and Kerkhoven and Bosscha went and established their observatory with the authority for the scientific program in the hands of its Director, the first of whom of course was Voûte.

De Sitter secured access to a telescope in South Africa, first through an agreement with the Unie Sterrewag in Johannesburg and later by erecting a telescope there through funding from the Rockefeller Foundation in order to lure Ejnar Hertzsprung to Leiden, but this was not offered as a national facility. Only after WWII would this situation be replaced by the establishment of national and international facilities. But, until then, Leiden kept a firm grip on access to the telescope. And, as we will see, for many years the Ministry actively supported Leiden's dominance through its funding decisions.

That this gradually changed after WWII can be appreciated from the story of the related 'Leids Kerkhoven–Bosscha Fund' (LKBF). In 1950, upon the death of his widow, it became known that Rudolf Albert Kerkhoven (1879–1940), son of Rudolf E. Kerkhoven and amateur astronomer, had left a considerable sum of money to support astronomy in the Dutch East Indies. In the meantime the Dutch East Indies had become Indonesia and the result eventually (in 1954) was the founding of the LKBF (Visser, 2006). A reasonable fraction of the allocations that the Fund provided went, and still goes, to the Bosscha Observatory. But the majority of the proceeds of the investments is spent on grants to support Dutch astronomers; and, in spite of the 'Leids' in the Fund's name, astronomers from all Dutch institutes are eligible equally. Actually, astronomers from Dutch universities other than Leiden, like myself, have chaired the Board.

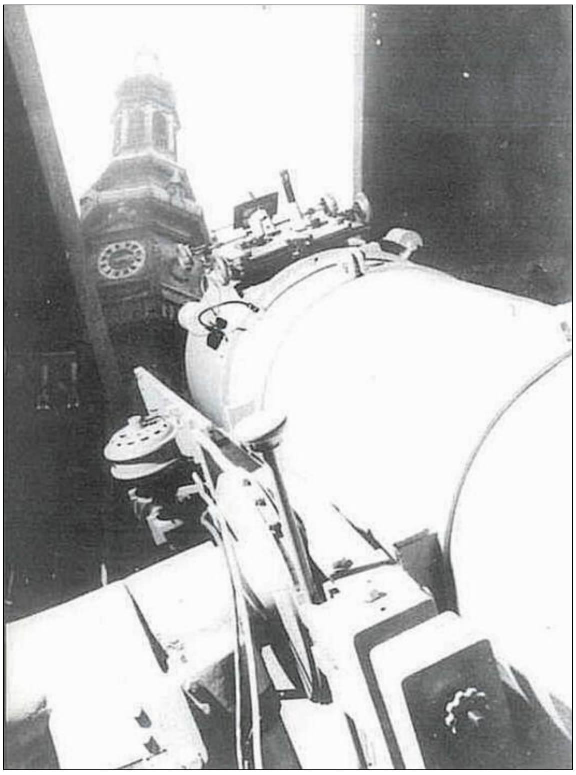
Van Rhijn revived the efforts to install a telescope in Groningen, but ran into the same problems Kapteyn had encountered earlier: although he had support from the University Curators, the Government rejected his funding application. This was not an isolated incident. The University of Groningen was systematically disadvantaged across the board by the Government, and in 1928 this induced Rector Magnificus Johannes Lindeboom (1882–1958), theologian and historian of religion, to state in the Rector's *Annual Report* in the 'Lotgevallen' (literally the report on the fates) of the University (my translation):

> It is a fact that almost every year the vacancies caused by departures to other universities have to be listed among the misfortunes ... The fact that Groningen is a bit far — actually really not that far — from the center cannot be changed. The authorities in Groningen are doing their best to make Groningen a very pleasant city to live in, and when the authorities in Den Haag [the Hague] would be willing to do the same, there is nothing else ... to worry about. But they could, for example, ensure that Groningen gets its fourth postal delivery back, and that it as the third commercial city of the country and a scientific and cultural center, no longer is, as it is at the moment, put behind almost every national establishment. All of this may — this in passing — be an explanation of the fact that your Rector believed to do the right thing by, in a letter to Z.E. [His Excellency] the Minister of Waterways and Public Works, plead the interests of the University in this matter.

At the beginning of the 1920s the Government introduced significant budget cuts when the economy—which was largely dependent on trade with Germany—suffered in the aftermath of the First World War (WWI), although it stabilized later in the decade (van Berkel, 2017). The situation worsened with the Wall Street crash of 1929. It would be logical for the Minister to look for savings in the expenses of astronomy, and with the existence of extensive infrastructure in Utrecht and especially Leiden (which had thrived after de Sitter's reorganization of 1918), it was understandable that any additional funding for the small astronomical laboratory in distant Groningen would be seen as an extravagance. However, the remoteness of Groningen affected all of the University. In 1934–1935—and not for the first time—the Government seriously considered closing down one of the universities, which would have been Groningen. An immediate extensive and intense lobby prevented this (van Berkel, 2017), but it underlined the vulnerability of the University.

In view of all this it may come as no surprise that van Rhijn failed to receive any Government support or funds for a telescope to be put on the roof of the Kapteyn Laboratorium. I quote here from Adriaan Blaauw (1983: 58; my translation):

> ... van Rhijn wanted to have a little more control over the future of the work himself by means of his own equipment. His wish was to install a telescope of modest dimensions on the laboratory building. Who would think that the fame which the Kapteyn Laboratorium had acquired internationally — few scholars, in fact, have contributed so much to the Dutch scientific reputation at the beginning of this century as Kapteyn — would be rewarded by this low-cost plan is mistaken, and can only look in astonishment at the spirit of the ministry's responses. After van Rhijn first had to acquire the telescope with the help of private funds, even his attempts at ministerial level to obtain the funds needed for the construction of the dome were rejected. In spite of the intercession of the Curators of the university ... the ministry persisted in its chosen position: there should be nothing from which it would appear that Groningen astronomy could pretend to have a claim for its own equipment ... In 1929, in response to a modern reader rather haughty letter from the Ministry to the Groningen Curators, van Rhijn patiently and extensively refuted the arguments put forward therein, but the university still got a negative response, so he decided to look for private funds for the construction of the dome as well.[13]



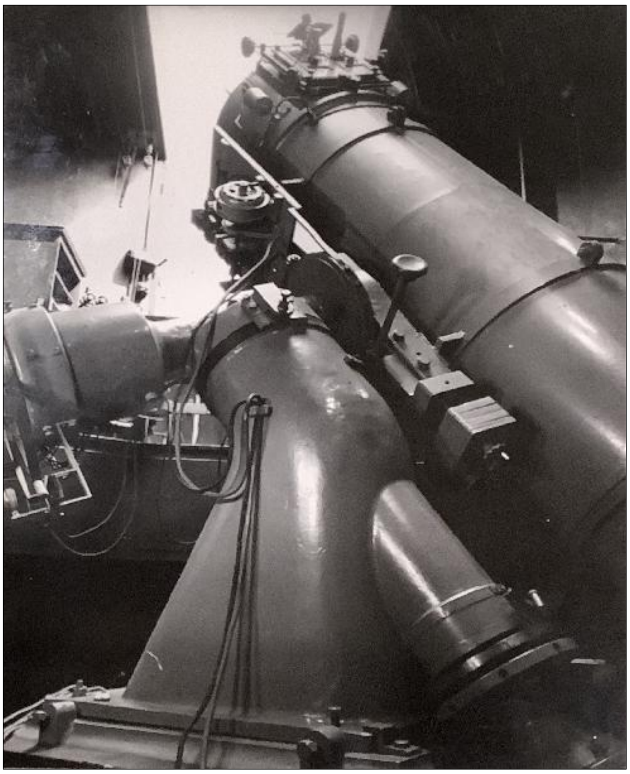


Figure 20. Left: The 55-cm reflecting telescope on top of the Kapteyn Astronomical Laboratory, pointing at the tower of the central Academy Building of the University of Groningen. The Laboratorium was located in the center of Groningen just behind this main university building with its 66 meter high tower, which is positioned to the southeast of the telescope at only some 20 meter distance (see Figure 22). Right: A view of the telescope and mounting. Note that the spectrograph and plate holder at the Newtonian focus (courtesy: Kapteyn Astronomical Institute).

In March 1930 he could report to the Curators that he had succeeded. In 1931 the telescope, a reflecting telescope of 55 cm diameter, was installed [see Figure 20].

The state of affairs described above must have been a bitter experience for van Rhijn, and it was not the only one: also in attempts around that time to bring the remuneration of his computers and observers and their future prospects to the same level as elsewhere, especially in Leiden, he also encountered this unreasonable rejection by the higher authorities. What, for example, to think of the following introductory remarks in a letter from the Minister to the Curators of 2 October 1929.[14] 'With reference to the letter mentioned, I have the honor to inform your Board that I am prepared to consider a further proposal from your Board, on the understanding that, in my opinion, in applying the salary regulation to the personnel of the Groningen Laboratorium, the University should take into account the difference between the other institutions and the Sterrewacht Leiden, also with regard to the grades to which the personnel can be promoted.'[15] But he was too much of a man of character to speak out about these matters to his co-workers at the laboratory.

Blaauw's reference to letters in the footnotes in the van Rhijn archives no longer is a valid one. As explained in the Introduction, these archives (at the initiative of Blaauw himself) have been transferred to the central archival depot of the university and from there, after inventories and removal of duplicates and irrelevant parts, to the municipal Groningen Archives for permanent keeping. In this process these letters have been lost.

12 REALIZATION OF VAN RHIJN'S TELESCOPE

So who funded the telescope? All I can find is the remark 'private sources'. There is no correspondence on the acquisition of the telescope at all in the van Rhijn Archives. Whether private sources were individuals or funds is not known, so it could in fact have been a kind of crowd-funding *avant la lettre*. The only remark on the subject in the Oort correspondence is a remark van Rhijn made in a letter to Oort, dated 24 November 1952 (more of this letter is cited in Section 20; from the Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149, my translation):

> Kapteyn has tried to establish a proper possibility for scientific research in Groningen, which he has been refused. The only possibility, which I saw to change this, was

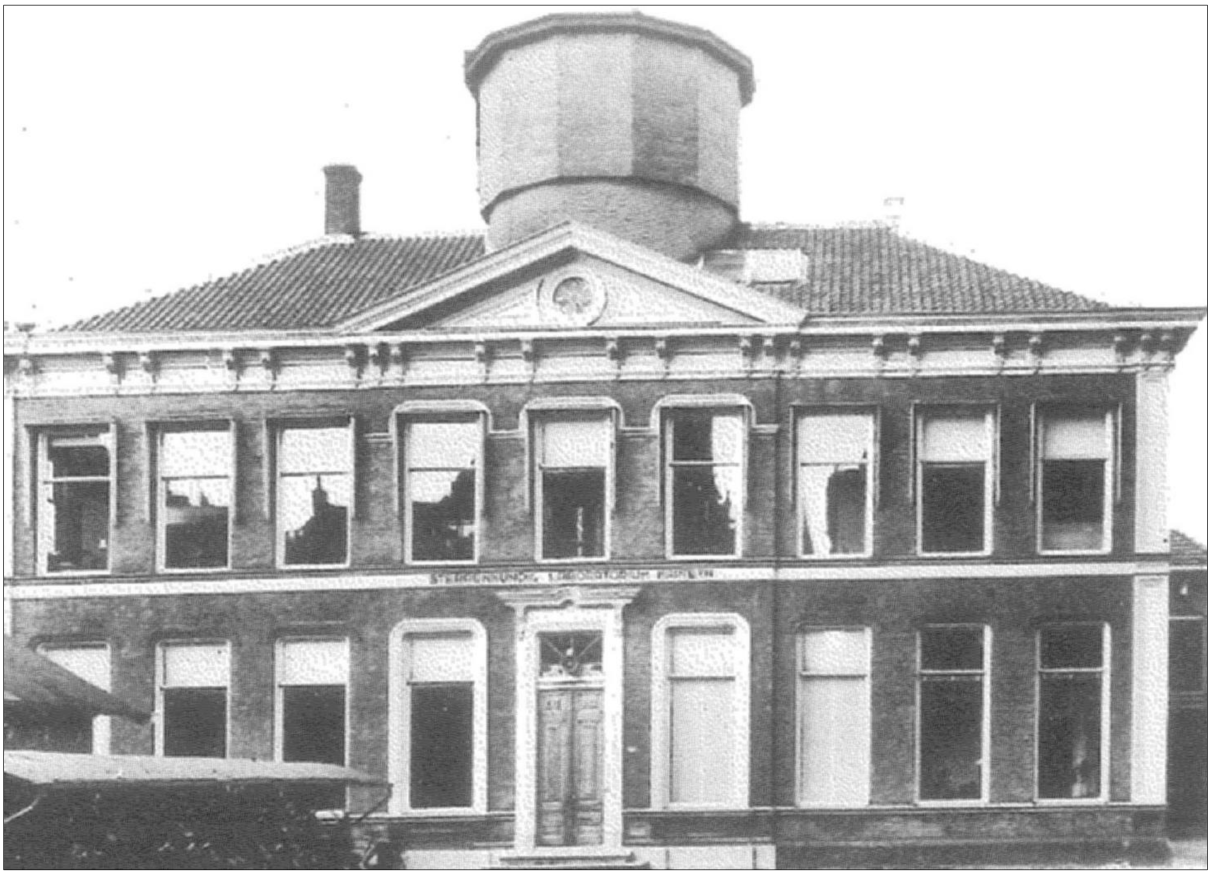


Figure 21: The Kapteyn Astronomical Laboratory with the telescope 'dome' on the roof (courtesy: Kapteyn Astronomical Institute).

> the purchase of a second-hand mirror, which happened to be offered to me at the time.

How and by whom this offer was made is not mentioned. What is known is that in the end the Kapteyn Fund and the Groningen University Fund bore most of the cost of the construction of the distinctive drum-shaped dome atop the Laboratorium building (see Figure 21). These funds might have contributed to the purchase of the telescope as well.

I digress a bit to describe very briefly the histories of these funds. The Kapteyn Fund was formally founded on 21 February 1925, by the signing of a deed at the office of a notary in Groningen. The first board encompassed the Directors of the Astronomical Institutes in the Netherlands: Pieter van Rhijn, Willem de Sitter, Albert Nijland and Anton Pannekoek, and also a person named W. Dekking. He was Rotterdam merchant Willem Dekking (1873–1923), who was a friend of Kapteyn's elder daughter Jacoba Cornelia (1880–1960). The latter had studied medicine and married a fellow-student in medicine Willem Cornelis Noordenbos (1875–1954) and lived for a short period in Rotterdam. Dekking was very impressed by Kapteyn, and offered his help in managing the Fund and soliciting donations. The deed mentioned a starting capital of "... eleven hundred sixty eight guilders and sixty-eight cents, brought together by Professor Kapteyn during his life ...", which corresponds to a current purchasing power of 18,650€.[16] This sentence survived in the latest update, of 2010, which I signed in my capacity as the Chairman of the Board at that time. The current capital is of order 70,000€. The Fund is called the Sterrenkundig Studiefonds J.C. Kapteyn and aims to support studies of students or research by astronomers from all over the Netherlands. It was and still is not a particularly large fund and the contribution to the cost of the dome must have been modest.

The Groningen University Fund (GUF) has a history (Smit, 1993), which is relevant to discuss here in the context of the support it gave to van Rhijn when the Minister had failed to do so. The GUF was founded on 4 March 1893 by the professors of Groningen University, following examples at the other Dutch universities where, in chronological order, Utrecht, Amsterdam and Leiden had established such funds. The GUF grew out of a much older fund, the 'Professor's Fund', which provided grants to promising students who had no other means of enrolling at the university. It had been established in 1843, and in addition to voluntary contributions from professors and parts of the tuition fees they received, fines were levied on professors who for no good reason failed to turn up at meetings of the Senate. A direct reason for replacing this fund with the GUF was that the law on higher education of 1876, which was also behind the creation of Kapteyn's Professorship, had severely reduced the freedom to choose where to spend the finances provided by the Minister. The GUF would, among other things, provide a buffer to offset this. It was hoped that the capital of the new Fund would be increased through private donations from professors and other supporters of Groningen University. The original statutes state as the aim (my translation:

> The University of Groningen will use the funds for the promotion of study at the University and of the flourishing of the University in the broadest sense. To this end, the following will be considered: assisting with teaching materials and financial support for talented students with limited means; expanding the University library and the academic collections; promoting scientific research and trips, to be undertaken by professors, lecturers, private tutors or students at the Groningen University; temporarily employing private tutors to the University in scientific subjects, which are not taught at a national university, and promoting actions and measures, which may increase the prestige of the University at home and abroad.

The starting capital was 4000 Guilders, equivalent nowadays to about 55,000€. In 1930 the capital had grown to about 123,000 Guilders (in current purchasing power a little over a million €). In more recent years (I was on the Board between 1997 and 2015, seven years as Treasurer and eleven as Chairman) the capital varied between 7 and 9 million €, due to economic ups and downs and new donations, while the returns on the capital were used mostly to co-fund foreign travel related to studies of several hundred students per year and scientific symposia, etc. in Groningen. The need to be dependent as little as possible upon funding for research from the Government was well justified, as the story of the financing of van Rhijn's telescope and dome clearly shows. I will continue now with the story of the telescope.

The 'Lotgevallen' for 1931 mention (my translation):

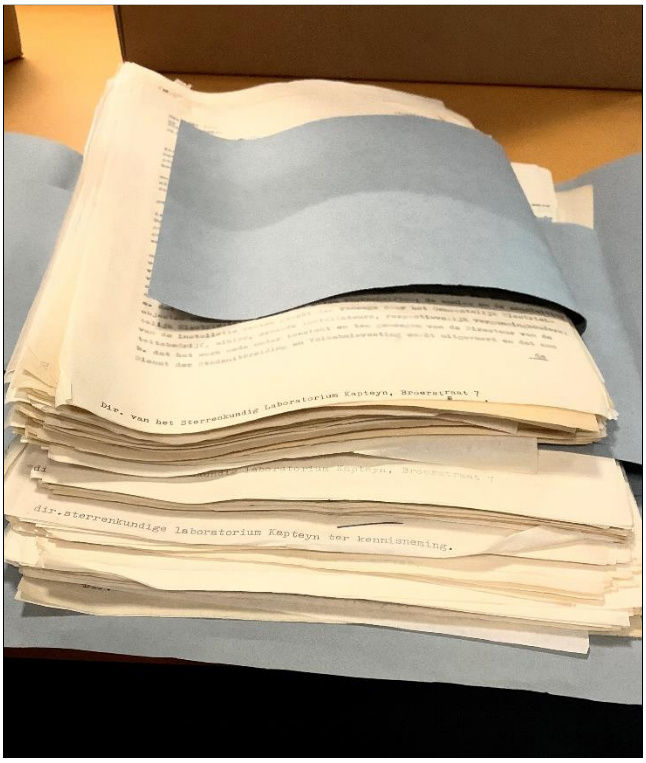
> The Kapteyn Sterrenkundig Laboratorium has undergone a metamorphosis with the construction of an observatory dome. The scientific work in this renowned laboratory is based on determining the position of stars with the help of photographs provided by domestic and foreign observatories. The director, colleague van Rhijn, has purchased an astronomical reflector in order not to be depending on others, being able to take photographs of the sky himself. The observer, Mr. G.H. Müller, has shown himself capable not only of observation, but also of designing what is required for that purpose. The costs of the dome have been covered by private funds, mainly from the J.C. Kapteyn Fund and the University Fund.

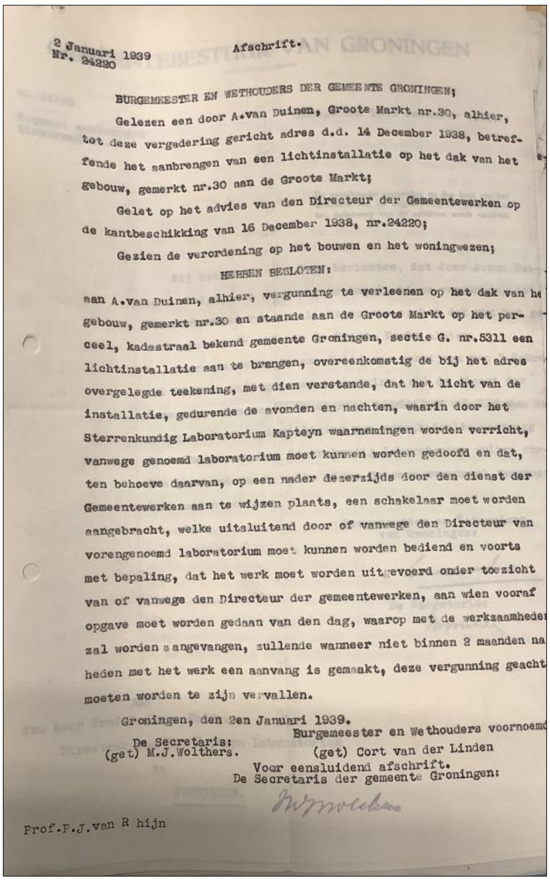
The telescope was a reflecting one with an aperture (mirror diameter) of 55 cm and a focal length of 2.75 m, and apparently the original plan was to use it for astrometric work. Later it had a spectrograph at the Newtonian focus, which means near the focus of the primary mirror the light was reflected at a right angle towards the telescope tube near its top, where at that location a spectrograph was mounted. The van Rhijn Archives contain extensive correspondence with the Karl Zeiss Company in Germany about auxiliary equipment such as a slitless spectrograph (1936) and an 'Astro-spectrograph for one or three prisms' (1952), but the latter file also contains a letter from Dr J.H. Bannier, the Director of the Netherlands Organization for Pure Research, stating that it will not honor a request for funding. There are also quotes for other extensions from Zeiss. The idea to use it spectroscopically seems to stem from the 1930s.

The only formal description of the telescope is in a few sentences in a paper in 1953 (van Rhijn, 1953), not even mentioning the constructor, but it is very likely to be the Carl Zeiss Company as well. For this paper, the first one based on material obtained with the telescope, spectra were taken with a slitless spectrograph.

The location in the center of the city of Groningen (Figure 22) posed a major problem with disturbing city lights, and when van Rhijn was intending to work spectroscopically, in particular the illumination of advertising installations on the outside of buildings, would be a serious problem. Such observations would be seriously affected by strong neon spectral lines, so Van Rhijn arranged that special conditions were attached to the granting of permits by the municipal authorities for such installations. The van Rhijn Archives contain a large folder of copies of letters from the City of Groningen concerning such permits (Figure 23). These run from the early 1930s to well into the 1950s. I estimate that this concerns some two hundred

Figure 22: The Academy Building of the University of Groningen (center) with the Kapteyn Laboratorium to the left with the cylindrical telescope dome on the roof . The photograph dates from 1952 and was taken from the southwest. The telescope was installed in 1931 and removed in 1959 (but the dome was left intact). The building was demolished in 1988. The church on the right, opposite the Academy, is the Roman Catholic Sint-Martinus Church, not to be confused with the Martini Church and Tower near the Grote Markt. It was demolished in 1982 and replaced by the Central University Library (courtesy: Aviodrome Lelystad).





2 Januari 1939
Nr. 24220

Afschrift.

BURGEMEESTER EN WETHOUDERS DER GEMEENTE GRONINGEN;

Gelezen een door A.van Duinen, Groote Markt nr.30, alhier, tot deze vergadering gericht adres d.d. 14 December 1938, betreffende het aanbrengen van een lichtinstallatie op het dak van het gebouw, gemerkt nr.30 aan de Groote Markt;

Gelet op het advies van den Directeur der Gemeentewerken op de kantbeschikking van 16 December 1938, nr.24220;

Gezien de verordening op het bouwen en het woningwezen;

HEBBEN BESLOTEN:

aan A.van Duinen, alhier, vergunning te verleenen op het dak van he[t] gebouw, gemerkt nr.30 en staande aan de Groote Markt op het perceel, kadastraal bekend gemeente Groningen, sectie G. nr.5311 een lichtinstallatie aan te brengen, overeenkomstig de bij het adres overgelegde teekening, met dien verstande, dat het licht van de installatie, gedurende de avonden en nachten, waarin door het Sterrenkundig Laboratorium Kapteyn waarnemingen worden verricht, vanwege genoemd laboratorium moet kunnen worden gedoofd en dat, ten behoeve daarvan, op een nader dezerzijds door den dienst der Gemeentewerken aan te wijzen plaats, een schakelaar moet worden aangebracht, welke uitsluitend door of vanwege den Directeur van vorengenoemd laboratorium moet kunnen worden bediend en voorts met bepaling, dat het werk moet worden uitgevoerd onder toezicht van of vanwege den Directeur der gemeentewerken, aan wien vooraf opgave moet worden gedaan van den dag, waarop met de werkzaamhede[n] zal worden aangevangen, zullende wanneer niet binnen 2 maanden na heden met het werk een aanvang is gemaakt, deze vergunning geacht moeten worden te zijn vervallen.

Groningen, den 2en Januari 1939.

De Secretaris:
(get) M.J.Wolthers.

Burgemeester en Wethouders voornoemd
(get) Cort van der Linden

Voor eensluidend afschrift.
De Secretaris der gemeente Groningen:

Prof.P.J.van R hijn

Figure 23: Left: The stack of copies of the allocation of permits issued by the Municipality of Groningen for outdoor lighting for advertising. Right: One example of a permit (from the Archives of the Kapteyn Astronomical Institute).

such permits. They invariably contain the following passage (sometimes with minor variations on this) (my translation):

> ... to grant permission ... to install a lighting installation in accordance with the attached drawing on the understanding that the light of the installation can be extinguished during those evenings and nights when observations are made by Kapteyn Sterrenkundig Laboratorium, and that for this purpose, at a location to be determined by the Municipal Works Department, a switch shall be installed which can be operated either by or on behalf of the Director of the aforementioned laboratory ...

According to Blaauw very little use was made of these switches. It would be something to see on a clear winter night van Rhijn or his assistant taking their bikes and going around the city to switch off all advertising before opening up their dome.

Maarten Schmidt (1929–2022) was an undergraduate student in Groningen in the 1940s, after the War, and in his interview for the American Institute of Physics Oral History Interviews he recollected:

> It was a reflector of about fifty centimeters in diameter and it stood on the roof of the observatory building which was next to the University in the center of the city. I took spectra of blue stars, spectra of stars to study the effects of dust in between the stars and us ...
>
> That observatory, being in the middle of the city, they had a funny system that was hardly ever used, I think, but they had gotten the municipality to require that every building that had roof top advertisements in lights would take care that there was a switch at ground level that could be handled with a particular key so that if any observer found it necessary to observe low in the sky in the direction, he would get a bike, go to that part of the city ... and turn off that darn light. [Laughs] I think we once used it or never did it. I have an inkling that we once did it and I felt very guilty ... (Schmidt, 1975).

There even was the following addition to the formal Regulations:

> 23 August 1949: Regulation amending the Police Regulations for the Municipality of Groningen ... After article 113, a new article is inserted, numbered 114, and reading as follows:
>
> 'It is forbidden to have a illuminated advertisement, facade illumination or any other light source on or in a building or in a yard, the light of which radiating upwards could be a hindrance to astronomical observation by the University or one of its institution. This prohibition does not apply to light sources for which a permit has been granted by the Mayor and Aldermen, as long as the conditions attached to this permit are complied with.'

The question is: What did van Rhijn have in mind to use the telescope for? Let me first quote Adriaan Blaauw (1983: 58–59; my translation) and then fill in the details in the next section:

> Van Rhijn imagined to attack with the telescope especially the problem of the reddening of the stars by the interstellar medium, and collected the necessary spectrophotometric equipment in the course of the following years. However, the work got off to a slow start. There was little technical assistance among the staff, which had been reduced in the crisis years, and the scientific assistant had to give attention to the main measurement programs. After the war, the work got somewhat under way and results of this color dependence research were published by van Rhijn himself and by Borgman. However, it never came to a substantial contribution, in the first place because new photoelectric techniques quickly superseded the photographic ones. Moreover, the situation of the telescope, located in the middle of the city, where city lights and smoke obstructed the sky, became an impossible one. When, during my directorate, around 1959, the new wing of the university building was being built and the walls of the laboratory that carried the heavy telescope began to show cracks, the presence of a tall construction crane was taken advantage of to lift the instrument out of the dome.

As Adriaan Blaauw told those interested (myself included) on a few occasions, he bribed the crane operator by presenting him with a box of cigars.

My colleague Jan Willem Pel, who worked at the Kapteyn Sterrenwacht (which was established in the 1960s as part of the Kapteyn Laboratorium) at Roden near Groningen, informed me that the telescope "... mirror lay in a chest under the dome in Roden; after that it ended up in the optical lab in Dwingeloo, where I think it still is." The Kapteyn Sterrenwacht had been moved in the 1990s to the Radio-sterrenwacht in Dwingeloo together with a similar workshop and staff from the Sterrewacht Leiden to form the 'Optical IR Instrumentation group' there. Later we will again meet Jan Borgman, who is mentioned here.

13 ADRIAAN BLAAUW AND LUKAS PLAUT

Adriaan Blaauw and Lukas Plaut joined the Kapteyn Laboratorium in 1938 and 1940 respectively; Blaauw when a position as Assistant became available, Plaut as a result of the antisemitism brought about by the Nazi Party and the German occupation of the Netherlands. Blaauw was appointed Assistant, which was normally (and indeed in this case) associated with the preparation of a PhD thesis. In order to put things in context I have to backtrack a little.

In the years up to 1940 much of the resources and manpower was used to carry out the work on the *Spektral–Durchmusterung* with the Hamburg and Harvard collaborators. As documented above, some other very significant and notable research was performed as well, although no breakthroughs or major new insights resulted from this. That is not to say that nothing of significance happened. I have already mentioned the PhD theses by Bart Bok and Jean-Jacques Raimond in 1932 and 1934 and Broer Hiemstra in 1938. The position of Assistant, occupied by Bok and Raimond when they had completed their theses was filled by P.P. Bruna, who, as mentioned above, left without completing a PhD thesis, and this opened up the position for Blaauw.

Figure 24: Detail from the group photograph of the Nederlandse Astronomen Conferentie in Doorn in 1941. The person on the left is Adriaan Blaauw, and in the front we see Lukas Plaut. From the Website of the Koninklijke Nederlandse Astronomen Club, the Dutch Society of professional astronomers (after Koninklijke Nederlandse Astronomen Club, 2021).

On 1 October 1938 Adriaan Blaauw (see Figure 22) joined the Kapteyn Laboratorium. Blaauw summarized the details in his prefatory, autobiographical chapter in *Annual Review of Astronomy & Astrophysics* (Blaauw, 2004). He was born in Amsterdam, the son of a bank auditor and a governess. He entered Leiden University in 1932 to study Astronomy and by 1938 had obtained his 'candidate' degree (now called Bachelor), but when he was appointed in Groningen, not yet the 'doctorandus' degree (equivalent to the current Masters). In his AIP interview (Blaauw, 1978), Blaauw stated that he obtained the degree in 1941 in Leiden before the University was closed. The University of Leiden was closed in the fall of 1940 after the famous lecture by Rudolph Pabus Cleveringa (1894–1980), protesting the dismissal of Jewish Professor of Law Eduard Maurits Meijers (1880–1954) and others. However, exams were allowed again after 30 April 1941, but forbidden again after 30 November 1941. Blaauw must have obtained his degree during this period. For more on Leiden University during WWII, see Otterspeer (2019). The Germans gave Leiden students permission to continue their studies at another university and do their exams there.

Blaauw, as we saw, at first was involved extensively in supervising the ongoing Groningen contribution to the *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung*, but this slowed down after the outbreak of WWII and stopped completely when the USA entered the War, because of course no more plates arrived from Harvard. In 1942 he married Alida Henderika van Muijlwijk (1924–2007). Because work at the Laboratorium had essentially come to a standstill he had ample time to work on research for his PhD thesis, which concerned the structure of the Scorpius–Centaurus Association. This is a star cluster that contains many hot, young stars (of spectral types O and B) and in fact is a very young cluster at about 130 parsec distance. Blaauw used improved proper motions of the B-stars in order to derive a better parallax for the association. He found that the group was expanding and dissolving, but, as he stated later, he failed to see the obvious fact that the association had to have been formed very recently. I will return to Blaauw further on.

Lukas Plaut (1910–1984) joined the Kapteyn Laboratorium in 1940 after the outbreak of the War. Since no autobiographical notes from him exist I will spend more space here on Plaut rather than Blaauw. A recent biographical chapter written by Barbara Henkes (2020) that focuses on his suffering from antisemitism and is based on extensive interviews with and material provided by his widow in the 1990s, is very much worth reading. Adriaan Blaauw (1978) has published a short obituary of Plaut in *Zenit*, the successor of the amateur periodical *Hemel & Dampkring*, and his contribution to the *Biographical Encyclopedia of Astronomers* (Blaauw, 2014a) is modeled on this. He wrote:

> Occupation of the Netherlands by the German army in 1940 forced Plaut to move first to Groningen (the Kapteyn Laboratorium, followed by a modest teaching job), then to a labor camp, and finally to the concentration camp in Fürstenau, Germany.

This is a little misleading, as it gives the impression that Plaut was imprisoned for some time in an extermination camp.[17] I will detail the story here somewhat extensively. Plaut's experience certainly was traumatic and this is not intended to take away from this aspect.

Lukas Plaut (see Figure 24) and his identical twin brother Ulrich Hermann were born in Japan from German Jewish parents. Their father was a teacher of arts and an art dealer; the parents gave the children (there was also a younger sister Eva) a liberal upbringing, hardly following Jewish rituals and only attending the synagogue occasionally. In fact Lukas was not circumcised, which may have saved his life later. When the children were teenagers, the parents sent them to their native Germany. Lukas went on to study mathematics and physics at the Friedrich–Wilhelm Universität in Berlin, after which in 1931 he obtained a position at the Neubabelsberg Sternwarte in nearby Potsdam. The boys must have continued their lives separately at some stage; the brother became an architect, married in Shanghai in 1935 and moved to Los Angeles. Lukas had in the meantime denounced Judaism, but this would not save him from measures against Jews in Germany.

In April 1933 he was expelled from the Observatory in the wake of the growing antisemitism, resulting in a boycott by the Nazis of Jewish businesses and suppression of Jews. His mother felt that he should move to the Netherlands, and she came from Japan and visit the Sterrewacht Leiden with him. As a result, he took up the study of Astronomy in Leiden, financed by his parents. He studied with Jan Oort and Ejnar Hertzsprung, eventually earning a PhD in 1939 under the latter on *Photographische Photometrie der Veranderlijke Sterren CV Carinae en WW Draconis* (Photographic Photometry of the Variables CV Carinae and WW Draconis). In 1938 he had married a (non-Jewish) Dutch woman, Stien Witte (1911–2007). This was not straightforward, as it was forbidden by German law for a (German) Jew to marry an Aryan without permission. Dutch authorities had adopted this measure (to avoid tensions with Germany), but with the support and intervention of Jan Oort and a friendly and helpful lawyer this was performed with an exceptional permit, but as quietly (and quickly) as possible. When the permit came they were called away from their work to marry within hours lest it would be repealed, which robbed Stien Witte, much to her chagrin, the opportunity to ever wear a wedding dress.

After the outbreak of WWII Plaut remained at first in Leiden, where Hertzsprung had arranged some modest allowance when transfer of funds from his parents in Japan became impossible. But increasingly measures against Jews were introduced, resulting in Plaut being ordered in September 1940 to leave Leiden and the neighboring Leiderdorp where they lived. Groningen was missing from the long list of places that were forbidden for him, so that is where he went. His wife and their young daughter came a few days later. This whole affair turned Lukas Plaut from being a supporting husband into one being protected by his wife, as she, being 'Aryan', had to take initiatives and deal with authorities. They rang the doorbell of the van Rhijn residence, but were declined shelter there (probably because va Rhijn was apprehensive about the possible consequences), but he showed them a list of places where they could rent a modest room. Van Rhijn also gave Plaut opportunities to work at the Laboratorium. From Blaauw's biographical notes it would seem that he did this with some regularity, even paying him for a little bit of (illegal?) teaching.

But things got worse and worse. They apparently kept a stipend Hertzsprung had arranged, which was however barely sufficient to survive. At the insistence of his brother in Los Angeles the Plauts filed for emigration to the USA at the American Consulate in November 1940, providing written guarantees from the brother and positive recommendations from Oort and Hertzsprung. Yet the application was turned down (the German authorities would still have had to agree as well, which rarely happened). In 1941 Plaut had to register as a non-Dutch Jew, which could mean deportation. Being married to an Aryan wife saved him from this however. On the other hand, because of their marriage Lukas lost his German citizenship and his wife her Dutch, so they became stateless! Of course, as from May 1942 Lukas had to wear the yellow star, identifying him as a Jew, and in principle he could be picked up any time on the street and deported. So he and his wife lived as inconspicuously as possible, always terrified he might be deported. In 1943 they had a second daughter.

Ultimately the inevitable happened. In March of 1944 he was called upon to enter a forced labor camp to work on the construction of an new airport near the village of Havelte, not far from Meppel, 60 km to the south-west of Groningen. The Germans had decided to build a new airport, 'Fliegerhorst Havelte', to relieve Amsterdam Airport Schiphol, which was the only major airfield in the country, and have a second airfield further to the east for military purposes. The construction had started in 1942. On satellite photographs one can still easily discern the outline of the more than one kilometer long, east-west runway. Plaut was allowed to write home regularly, and he complained of fatigue and discomfort like flu, but reported that the food was reasonable and sufficient and that he actually was paid a small salary. His wife was allowed to send him food, clothes and books, etc. In fact, the treatment of mixed Aryan-Jew marriages offered some protection. But the strenuous physical effort took its toll, just like the lack of privacy and the strain of sharing sleeping quarters with twenty-five noisy men, which he found difficult to endure. On 6 September 1944, 'dolle dinsdag' (mad Tuesday), when incorrect news spread throughout the country that the Allied forces were about to liberate the Netherlands, the guards fled and Plaut was able to return to Groningen. Although the emerging airfield was well camouflaged, the Allies of course knew about it and when it was almost completed the airport was destroyed on 25 March 1945 in a massive bombing attack that left more than 2000 bomb craters.

Plaut went into hiding in Groningen in the home of Johannes Gualtherus van der Corput (1890–1975), a Professor of Mathematics. Van de Corput has been active in the resistance movement throughout the War. He survived and after the War he first moved to Amsterdam and later the USA. Plaut was given a new non-Jewish, Aryan identity; he was supposed to be an agricultural engineer from the School of Higher Education in Agriculture, the predecessor of the current Wageningen University and Research Center. However, he no longer could send letters to his wife, who even was not allowed to know where he was, although a courier picked up his dirty laundry, brought it to her and after cleaning returned it, and she provided the necessary financial support. On 23 February 1945, a mere eleven weeks before the end of the War, Plaut, van de Corput and a third person were arrested following a tip-off the Germans had received that there were persons in hiding at the address where he lived. He was taken to the prisoner camp Fürstenau, not as a Jew but as an Aryan male hiding to avoid the Arbeitseinsatz of Dutch men in Germany, the forced labor to keep German (war) industry and economy going. His liberal Jewish up-bringing, resulting in him not being circumcised, supported his forged identity and very likely saved him from being transported to an extermination camp. As I noted above, in his contribution to the *Biographical Encyclopedia of Astronomers* Blaauw (2014a) described Fürstenau as a concentration camp, and those citing him have copied that, but it really was a prisoner camp and not an extermination facility for Jews, as this word would suggest.

Fürstenau lies some distance into Germany from the Netherlands at the latitude of Zwolle, about 130 km from Groningen. After the liberation of the camp some time in April 1945, Plaut was released and he walked to Groningen, appearing unannounced at his wife's doorstep. She had not heard from him since his arrest. In a letter from Plaut to Oort dated 19 May 1945 (see Section 14 below) he mentioned that he worked on a farm for a few weeks and returned to Groningen "... three weeks ago ..." so this must have been before the German surrender. Throughout the war he had not been in any immediate threat of extermination in a concentration camp, but the danger of arrest and deportation had been hovering over him and his wife the full five years of the war. He survived this ordeal but never was able to free himself from the trauma of the injustice, humiliation and indignation of being subjected to all of this only because of his Jewish descent. I remember him as a kind, soft-spoken man with an obvious all-consuming, but untold and unresolved grief, suffering from the post-traumatic stress syndrome that held him in its grip. His mental well-being deteriorated more and more as he grew older. He died in 1984 from an heart attack likely not unrelated to the terror and distress he had been subjected to. His twin brother had died already in 1971. His parents also survived the War, having moved to the USA, probably before Japan entered the war.

As a sideline: when Lukas Plaut retired in 1975 I was offered (and I accepted) the staff vacancy that he left at the Laboratorium. I also took over from him the Introductory Astronomy lectures he had been teaching for many years to first-year students in Physics, Mathematics and Astronomy. He had obviously enjoyed doing that; the book he used to accompany his course, *Abriß der Astronomie* by Hans–Heinrich Voigt, he translated with Nancy Houk into an English edition in two paperback volumes (Voigt, Plaut and Houk, 1974), and with obvious pride he presented me with a copy.

14 VAN RHIJN AND THE LABORATORIUM DURING THE WAR

When WWII started, van Rhijn had been in the middle of his one-year term as Rector Magnificus of Groningen University (see Figure 25). He completed his term before all the troubles with Jewish staff started. In September 1940, when he was scheduled to present the Rector's departing lecture, he was expressly ordered by the German authorities to avoid any reference to the political situation. This lecture concerned the continuity in the development of research in the natural sciences (16 September 1940). He mentioned that this subject was chosen "... in connection with a lecture course ... given by Professor Zernike on 'Principle, direction and purpose of physics'." He asked the following questions (my translation):

> But why should I believe what science teaches today when I know with a fair degree of certainty that after only a few decades natural scientists will reject our present views and perhaps teach the opposite of what we now believe to be true? What value can one place on a science that has repeatedly contradicted itself in the course of time and continues to do so to this very day?

His answer was continuity. Van Rhijn summed up the characteristics of this:

> First, the present solution of a problem is built on the previous one and forms the basis of the next solution.
>
> Secondly, the older conception is understood in the newer theory as a special case, so that for this special case the older conceptions are also considered admissible according to the newer theory.

He then proceeded to illustrate this with a description of the development of our understanding of the motions of Sun and planets, from Ptolemy via Copernicus, Brahe, Kepler, Galilei, Newton to Einstein.

As the successor to van Rhijn as Rector Magnificus, the Germans appointed a sympathizer of the Nazi regime by the name of Johannes Marie Neele Kapteyn (1879–1949)—not a relative of Jacobus Cornelius. He had been Professor of German Language and Literature in Groningen since 1924 (later also Frisian). In his traditional report on the 'Lotgevallen' of the University in the past year, van Rhijn actually did refer—in spite of the instructions—to the political situation. He apparently got away with it. It started as follows (my translation):

> Ladies and Gentlemen,
>
> Looking back on the past Academic year, one single coherent series of events dominates our thoughts: mobilization of our armed forces to protect our neutrality, war with Germany, capitulation of the Dutch army and the occupation of the Netherlands by the German Wehrmacht. We have all suffered bitterly under these battles and are suffering indiscriminately from the consequences these events have had for our country and our people.

And before transferring the office of Rector Magnificus to his successor he finished with:

> As Dutchmen, we have a reputation to sustain in the field of science and the practice of science according to our best traditions is of the utmost importance for the preservation of our independent national existence, which we so ardently wish to maintain.
>
> And finally, ladies and gentlemen students, if the courage to continue your studies fails you because the future is too dark and uncertain, let me remind you of the motto of our University: an open Bible with the words: Verbum domini lucerna pedibus nostris [The word of the Lord is a light for our feet]. It is this Word that has been the support and strength of our leaders in very difficult times.
>
> Verbum domini. The Word that leaves us in no doubt about the situation of this

Figure 25: Pieter Johannes van Rhijn as Rector Magnificus (1939–1940) of the University of Groningen. He wears the chain of office, decorated with the University's coat of arms, which includes (in abbreviation) the motto Verbum Domini Lucerna Pedibus Nostris (the word of the Lord is a light for our feet) (from the Website of the Stichting 'Het geslacht van Rhijn' (2022), reproduced with permission).

world that has turned away from God, but also opens a view far beyond this world to the Kingdom of Heaven that has been and is to come, the Word that calls us to work in the service of that Kingdom.

And what remains, with all the events of the world in which we find ourselves today, is the classic phrase: ora et labora [pray and work].

My rectorate has come to an end and I now hand over the office of Rector Magnificus of this University to my successor, Dr. J.M.N. Kapteyn.

Dear Kapteyn. You are assuming the rectorate of the University in an eminently difficult period of its existence. I express the wish that you may be granted the wisdom to lead the University in such a way that it will fulfill its mission also in these turbulent times. I ask you to come forward and while I decorate you with the sign of your dignity, I greet you with the eternal wish of salvation.

Salve, Rector Magnifice, iterumque salve! [Hail, Rector Magnificus, and hail again!].

After van Rhijn's speech mentioned above and the transfer of the rectorate van Rhijn and all, or at least most, of the professors stayed away from the usual reception to congratulate the new Rector and wish him well (see van Berkel, 2005).

In his correspondence with Oort, van Rhijn wrote (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149; my translation):

18 November 1940.

After the transfer of the rectorate Rein and I spent two weeks in Zuidlaren and we very much enjoyed that. Beautiful weather and the surrounding countryside is also very nice. It is easier to forget all the misery outside than inside the city. Furthermore we were a week at the academic summer conference in ter Apel. Approximately 200 students and professors were gathered there. It was a very successful attempt to bring more unity among the students and also between the students and the professors. It is good that professors and students do not only meet in the lecture room but also go on a fox hunt together like in ter Apel.

This summer conference, which actually took place in July 1940 was intended to be, using our current parlance, a team-building exercise. As Rector, van Rhijn had spent the full week there, underlining the need for good relations and unity among the academic community. Vossenjacht or fox hunt is a type of scavenger hunt in which participants must search for foxes within a certain area. The foxes are game leaders who walk around dressed in distinctive clothing, for example of a certain profession. In this case the foxes might have been the professors and students the hunters.

During the War the work at the Kapteyn Laboratorium came to an almost complete standstill. Arrival of new plates from Harvard ceased, and the staff, mostly male computers, went into hiding to escape internment as a prisoner of war when having served in the army or to avoid transportation to Germany in the context of the Arbeitseinsatz (labor deployment), etc.

In a letter of 24 November 1941, Pieter van Rhijn wrote to Jan Oort in Leiden:

There is so much misery and so much injustice that it is almost impossible to bear. But we will not lose courage. One can tyrannize us and destroy all that is valuable in our country. But if we remain courageous, they cannot change our disposition and thus be victorious over us. The strong language and the compassion and the trust in God and in the Wilhelmus van Nassouwe can renew our strength in these days. (My translation).

The 'Wilhelmus' is the Dutch national anthem. It would have been forbidden even to mention this, but obviously both Oort and van Rhijn trusted each other enough to do so anyway. Van Rhijn referred to God; he was religious and a church-goer, but Oort was not.

At first teaching at the universities in the Netherlands went on as usual. In November 1940 the German occupation ruled that Jewish professors had to resign, which resulted in a well-known, strong protest in Leiden mentioned above by Rudolph Cleveringa, at that time Dean of the Faculty of Law, supporting his mentor, Jewish Professor also of law, Eduard Meijers. Students distributed transcripts of this lecture. As a result of this Leiden University was closed and the possession of such a transcript was declared illegal. Many students went to other universities, mostly Amsterdam. Unlike Leiden University, the University of Groningen did not close during the War.

In a letter of 7 November 1941, van Rhijn asked Jan Oort whether there were any students in Leiden who would like to do their exams in Groningen. A week later he wrote that a student van Tulder has visited him. Johannes Jacobus Maria van Tulder (1917–1992) wanted to obtain his doctoral (Masters) degree with van Rhijn in Groningen. There is some more correspondence from the next few weeks on this in the Oort Archives, in which

Oort recommends him for it. However, van Rhijn was worried that van Tulder sympathized with the Nazi's, since he had been seen by personnel of the Laboratorium with a well-known police officer who was a member of the NSB, the Dutch Nazi party (NSB is the Dutch acronym of the National Socialist Movement). Van Rhijn wrote to Oort about this because this person (identified only by his initial K) had betrayed various persons that had been transported to Germany, and cautioned Oort to be careful in not mentioning this to van Tulder. Fortunately, van Tulder was eventually cleared when it turned out that the person showing him to the Laboratorium was another person with the same surname (van Rhijn now identifying these persons as K_1 and K_2) living in the same street, but this K_2 definitely was not a German 'colborateur'. He had been identified incorrectly by suspicious staff at the Laboratorium.

The Yearbooks (University of Groningen, 1877–1978) of Groningen University lists van Tulder as having passed this doctoral exam in April of 1942. Oort and van Tulder published three papers in 1942 in the *Bulletin of the Astronomical Institutes of the Netherlands*, but the latter dropped out of Astronomy and eventually obtained a PhD in sociology and became a professor in that discipline in Leiden. In Groningen no other exams in Astronomy were taken during the War.

The Germans initially left Groningen University alone. But in the fall of 1940—as already alluded to—Jewish professors were fired. Contrary to in Leiden, this was accepted with reservation. Next, Jewish students were told to leave the University, which again was accepted without major resistance.

Teaching continued until early 1943, when students were rounded up for transport to Germany as workforce to keep the German war economy going. The students protested this time and stayed away from lectures. To turn the tide, the Germans promised to leave them alone if they would return to attend lectures, but only after signing a loyalty statement promising no further resistance to the occupying authorities. Only a small fraction (~10%) signed. On 18 April 1943, van Rhijn wrote to Oort about this (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149):

> The situation at the universities is uncertain and changes with the day, sometimes with the hour of the day. In Groningen not even 10 percent of the students have signed, elsewhere a little more. But in any case the declaration is a failure. The Germans don't want to withdraw the declaration. The case is hopelessly deadlocked and nobody can see a way out. It will be the end of higher education in the Netherlands for the time being.

And on May 8:

> A few hundred students were deported to Germany. Only the NSB-ers, the girls and the good Dutchmen who went into hiding, remain. I have no idea what will happen to the universities now.

The University remained officially open until the liberation in April 1945. But teaching practically came to a standstill. There were no Astronomy students in the first place, but it should be remembered that for van Rhijn teaching involved mostly general Astronomy lectures for Physics and Mathematics majors. And in the last years of the War he was away being nursed for tuberculosis and a formal replacement was not really necessary.

In the first years of the War there were still some national activities in astronomy, such as one-day meetings of the society of professional astronomers, the Netherlands Astronomers Club NAC. These were supplemented by a new kind of meeting, in the beginning independent of the NAC. The first Netherlands Astronomers Conference (see Figure 24) had been organized in Doorn, a village not too far from Utrecht, in June 1941 by Marcel Minnaert. These conferences were meant to bring together the Dutch astronomical community, including students, for longer than the single half-day of meetings of the Netherlands Astronomers Club—see my more extensive discussion in van der Kruit, (2019: Chapter 9.3) or van der Kruit (2021b: Chapter 7.4).[18] A second meeting in the same place was organized in July 1942. Adriaan Blaauw attended both meetings, Lukas Plaut only the first (see Figure 24), and Pieter van Rhijn only the second one (Figure 26). Some more information and photographs are available on the Website of the NAC. After 1942 even such conferences ceased to be possible, but they were resumed after the War and are still organized annually, but now under the auspices of the KNA (Koninklijke Nederlandse Astronomen Club, 2021).[18] During the War, meetings of the Club were held every now and then, sometimes preceded by special colloquia such as the famous one in 1944 where the possibility of using the 21-cm line of neutral hydrogen in radio astronomy was announced by Henk van de Hulst.

During the War, in November of 1943 according to his letter to his sister-in-law in 1945 referred to in Section 2, van Rhijn started suffering from tuberculosis for which he was hospitalized for a long time in a sanatorium. Well after the War, in 1948 or 1949, he returned to his job (part-time before that), but his health remained fragile, and this probably played a role throughout the rest of his career. In relation to van Rhijn's attitude after the War to the start radio astronomy in the Netherlands, Adriaan Blaauw has said in an unpublished interview with Jet Katgert-Merkelijn, conducted in preparation for what came to be my Oort biography (van der Kruit, 2019; my translation):

> So the last year of the War he [van Rhijn] was in a sanatorium. He was in Hellendoorn and maybe in another place too. But when he was admitted to that sanatorium, he forced himself to continue to provide some leadership at the institute. I think he actually could have retired quite well, because he had had a severe form of tuberculosis after all. But I always felt that

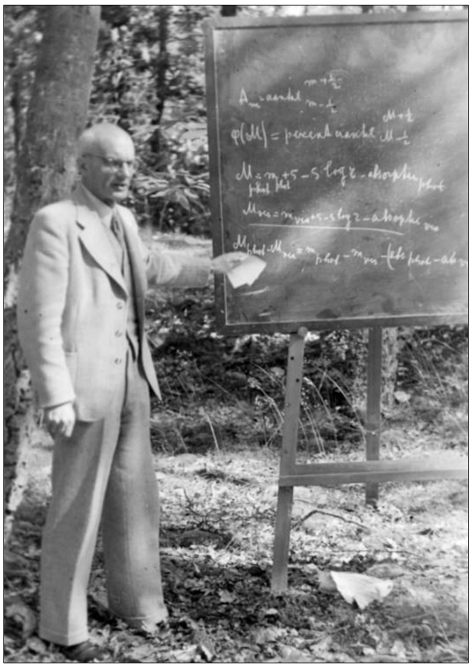


Figure 26: Pieter van Rhijn lecturing in the open air during the second Netherlands Astronomers Conference in 1942. From the Website of the Royal Netherlands Astronomical Society (Koninklijke Nederlandse Astronomen Club, 2021).

> – because he had a very young family, he married very late, so those children were younger even than the children of Oort. In any case, that he forced himself to continue anyway, to put it crudely, to keep his salary for that family. Well, so it was a man who really couldn't handle much more than he did at the time anyway. And starting such an adventure in radio astronomy, which was something very new, I think his mental and physical condition prevented him from saying, 'I'm going to participate in that enthusiastically'.

Hellendoorn was one of the larger sanatoria in the Netherlands; it now is a nursing home for persons suffering from dementia and comparable ailments. It is the name of a nearby village 90 km due south of Groningen, 15 km to the west of the city of Almelo, in a forest area with conditions favorable for treatment of tbc. Van Rhijn was nursed there from December 1943 to December 1944, when he was transported back to Groningen (see below).

Through Gert Jan van Rhijn, keeper of the van Rhijn genealogy, I obtained some more information on this period from van Rhijn's daughter. She mentioned that in the first months he was much too ill to read, and would just lie in bed in a small room. This must have been very difficult. His wife was allowed to visit him twice per month, but later during the War this became much too dangerous. He did have a few other visitors, like his brother Maarten, but this was exceptional. When it became possible, he wrote letters to his wife about four per week, on size A5 paper. By the time he was able to read he asked his wife repeatedly for two books: *Geloof en Openbaring* (Faith and Revelation) by G.J. Heering, who was a remonstrant clergyman, and *Physik der Sternatmosphären mit Besonderer Berücksichtigung der Sonne* by A. Unsöld. These could not be sent for danger they would get lost, so only a visitor could deliver them, and visiting was difficult and rare. It shows that van Rhijn divided his interest between religion and science.

The Oort Archives contain a number of letters from van Rhijn to Oort during his treatment, which contain some more information about his illness (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149). On 18 March 1944 (last letter before this is dated July 1943 before he fell ill) Rhijn wrote from the sanatorium to Hulshorst, where Oort and his family were in hiding (see van der Kruit, 2019 or 2021b for more background to this; my translation):

> I am also doing well, according to the circumstances. My temperature has been normal for weeks, the coughing is much better, and the sick spot in my lungs has shrunk a bit. I can write letters and read very simple reading material (Ivans for example) only a few hours a day. But that is progress already. Some months ago I was too tired to write or read anything.

Van Rhijn refers here to Jakob van Schevichaven (1866–1935), author of detective stories, acclaimed as the first professional writer in this genre in the Netherlands. His pseudonym, Ivans, was derived from abbreviating his name to J. van S.

And on 18 October 1944 (same source; my translation) van Rhijn wrote:

> Our expectations have since been disappointed and we have to be patient. I would very much appreciate it if you could visit me sometime. But there can be no question of that for the time being. Of course Rein cannot come either. It is quiet lying in bed day after day. The sanatorium has no shortage yet. The electricity is produced here. There still appears to be some supply of fuel. Recently my blood was tested, the result was positive. I also feel better than I did in the summer and less tired. Sometimes I even have the urge to get up! The last few weeks I have been reading through Blaauw's dissertation. Every now and then patients who lie here ask me astronomical questions, such as: How do you weigh the Earth?

On 18 December 1944 van Rhijn wrote from one of the three Groningen hospitals, called the Diaconessenhuis (Deaconess Hospital). In addition to this hospital for Protestants there was a Roman-Catholic and an academic hospital in Groningen. Van Rhijn would choose a hospital for people of his religion if at all possible. Hellendoorn on the other hand was a 'volkssanatorium', 'volks' (meaning people's) indicating open to all religions. Part of the letter reads (same source again; my translation):

> Dear Jan,
>
> Thank you for your letter of 3 December, which I received in Hellendoorn. I am now back in Groningen in the Diaconessenhuis. The matter is that in the last four weeks V2 flying bombs have been launched near the sanatorium. Several of these failed; one of the failed bombs landed a few kilometers from the sanatorium and killed 18 workers who were working in the fields. It became too unsafe in Hellendoorn. With great difficulty Rein rented a car that transported me to Groningen. It gives me peace that I am here now. It is a wonderful feeling to be so close to Rein and the children. It was difficult in Hellendoorn, especially the last few months when no more visitors came ...
>
> My illness is healing. At the end of November I was examined with favorable results. The blood is completely normal again and the sick spots in my lungs have become smaller. The doctor who treats me here is also satisfied. When I traveled in the car from Hellendoorn to here I had to get dressed for the first time in 1944. You can understand my dismay when it turned out that the top of my pants could not be closed at all anymore! There was a gap of 4 to 5 centimeters! You won't recognize me when you see me again. I have become a fat puffy guy with a double chin. This is a punishment from heaven because I used to look down on fat people. It gives something smug about the whole person. And now I am becoming such a fat person myself.

Traveling by car was rather dangerous as very often they were fired upon by Allied airplanes, but van Rhijn fortunately made it. It was only during the last few months that his children were allowed to visit him, but—as his daughter recollects—sitting on the window sill with the windows open.

During the last two or three years of the War in effect only Blaauw and observer Müller (and whenever possible Plaut) kept the Kapteyn Laboratorium going. Blaauw spent all his time on his thesis topic, but very little other research was being done. In 1946 van Rhijn wrote a short article summarizing the astronomical work performed in the Netherlands during the War (van Rhijn, 1946). He mentioned his own work on using interstellar H and K line intensities (from singly ionized calcium) as a distance criterion and deriving the density and luminosity functions of O and early B stars. This was published after the War in the Groningen Publications and I will return to it. Then there was Blaauw's work already noted and a paragraph on Lucas Plaut:

> Dr. L. Plaut has worked at the Kapteyn Laboratorium since 1940. He has been imprisoned for some time in a camp in Germany but returned safely after the liberation. He has investigated a field of 10° × 10° for variable stars with the blink comparator of the Kapteyn Laboratorium. The plates have been taken by Dr. van Gent with the Franklin-Adams camera at Johannesburg.

So, Plaut was regarded as working at the Laboratorium since his arrival in Groningen.

In his autobiographical article, Adriaan Blaauw (2004: 10) wrote:

> A curious incident occurred toward the end of the war. One day in February 1945, my doorbell rang and two lads of high school age, amateur astronomers, asked to see me. With all the bad things the War brought us, the forced blackouts at least provided amateur astronomers with a unique opportunity to watch the sky. These lads now also wanted to observe the sky and speak to a real astronomer, and of course they were welcome to enter. The lads were Maarten Schmidt and Jan Borgman; both later had excellent careers in astronomy. As one of them reported years later, my wife met them with the words, 'You are lucky, he has just been released from prison!' Why had I been in prison? I had been accused of listening to and spreading news broadcast from London – something strictly forbidden. Luckily, the War was approaching its conclus-

> ion, and although nobody could tell how long it would continue, some lower-ranking German officials were ripe for some gentle bribery. My relatives and friends collected a sufficiently persuasive sum and succeeded in getting the prison doors opened for me. Two things I recall of that memorable release on February 8, 1945 – it was my little son's second birthday, and I could at last satisfy my hunger, as far as circumstances allowed.

15 RECOVERING FROM THE WAR

The Second World War ended in the Netherlands on 5 May 1945. Soon after that astronomers started looking forward, and in renewing contacts they did relay to each other their experiences and circumstances. The following comes from the Oort Archives. Van Rhijn wrote Oort immediately on 5 May 1945 (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149; my translation). For clarity I remind the reader, that Joos is his elder sister, who lived with her four children in Groningen (see Section 2):

> Last night the news that the German army in [the Netherlands] has capitulated; it is almost unbelievable that for us the mistreatment by that execrable people has come to an end. There was quite some fighting here from April 13 to 16. Relatively few casualties (about 100). But many houses burned ... Rein and the children and Joos and her family came out of the fight unharmed; the houses only have glass damage ... Blaauw and his family got off well. Plaut has miraculously returned from Germany on foot, where he was imprisoned for a few weeks; he only had to walk.
>
> [Long list of family and friends that did not survive.]
>
> I am doing well, the diet has been now so good that I have to eat a little less to keep from getting too heavy! At the end of March there were no more bacilli in my sputum, indicating recovery.
>
> The laboratory has not suffered any damage ...
>
> There was hard fighting in the vicinity of the Diaconessenhuis. The Krauts shot from the garden of the house. It was dangerous for us though. We were in the basement of the building.

Adriaan Blaauw wrote Oort on 15 May (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 161; my translation):

> First, that Plaut did not fall prey to persecution, but resumed his work at the Laboratory. It was a close call, however: [details the hiding and capture of Plaut and his return and his own short stay in prison without mentioning why he was arrested].
>
> We went through very nervous days during the fighting around Groningen. Much has been destroyed in the city, and with more unfavorable winds the Laboratory would also have been affected by the fires. Now we got away with a few bullet holes. The staff that had been in hiding is all but one present again, so that the programs have been resumed. I myself am busy preparing my article on the Scorpio–Centaurus cluster for the printer. Unfortunately Hoitsema's entire printing facility has burned down, so printing is suspended waiting for attempts to get help. Nevertheless, I hope that the work can be started within a few days. Also burned in the fire are the 150 pages of the Special Areas and the two publications of Prof. van Rhijn, completely corrected.

And Lukas Plaut on 19 May (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 163; my translation):

> Dear Professor Oort,
>
> Now that the postal connection seems to be getting a little better I would like to write to you in a little more detail. Since last year March it has not been possible for me to do anything for astronomy. I had to go to Havelte to work on the airfield. In September I was discharged and went home again. Many were rounded up at that time and taken to Westerbork, moreover, there was compulsory digging for all men, so I preferred to go into hiding. However, in February I was arrested and after a few days taken to Germany. Compared to many I had a good time there, mainly because it was not discovered that my identity card was false. When the Allied armies arrived, I was released and worked on a farm for a few weeks before returning home. That was three weeks ago now. My wife and the children have fortunately come through the last few months well. The house did not suffer from the fighting either.
>
> Since September my wife has received financial support from an illegal fund. The fund has now been absorbed into the 'Nationaal Steunfonds' [National Support Fund], of which I do not dare knock at the door, as so many need to be supported who have lost everything. Now I would like to ask you about the possibilities of getting a job as an assistant or another scholarship. If at all possible, I would like to continue working at an observatory. I do not believe there are any other possibilities for me.

The 'illegal' fund was in fact illegal in the sense that the underground resistance movement had arranged this to support people who had no income. The National Support Fund had been set up by the Dutch Government upon its return to the Netherlands.

When the War ended in 1945 slowly business began to pick up again. In 1956 van Rhijn would turn seventy, so he still had a bit more than a decade to go. But he had not yet recovered from tuberculosis and did not fully return on his job. The other personnel did go back to the Laboratorium. For many years there were in addition to the Professor and Assistant four persons on the staff, of which one was Amanuensis (to copy letters or manuscripts from drafts), one Observer and two Computers. Three of these were already at the Laboratorium before the partial closure and returned. Already before the liberation Oort had offered Adriaan Blaauw a position in Leiden when things would be back to normal. Blaauw accepted and started his appointment in October 1945. He finished his thesis, *A Study of the Scorpio–Centaurus Cluster* (Blauw, 1946) and defended it in Groningen in July 1946.

What about Lukas Plaut? Henkes (2020) noted:

> The much-praised 'modesty', which Lukas Plaut demonstrated immediately after his flight to the Netherlands, had not diminished in the years of his persecution. Making himself invisible had become second nature to him, reinforced by the advice to the few Jews who had survived not to draw attention, 'to show modesty, and to be grateful'.

Lukas Plaut had asked Oort in his letter in May for support with finding some kind of employment. Oort had taken this up by recommending him to van Rhijn as Assistant, now that the position had been vacated by Blaauw. In the Oort Archives there is an envelope on the back of which Oort has made a note for himself that he had replied on 14 June 1945 to the personal letter from van Rhijn of 5 May (see above) and after some personal matters he wrote (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149):

> As quickly as possible proposal to appoint Blaauw. Appointment will take some time and he can stay in Groningen for a while if necessary. Need him to help build up the new spirit.
>
> What does he think of Plaut as his successor? Recommended him highly.
>
> Also mentioned van de Hulst, Objection: mainly theoretical.

Oort had taken the initiative to see if Plaut could be appointed as an Assistant in Groningen. Van Rhijn still suffered from tuberculosis so he must have hesitated, since Plaut worked on variable stars and he would have preferred someone more suited to supervise the work relating to the *Plan of Selected Areas*. Variable stars had been a major line of research in Leiden under Hertzsprung, who had stayed on as Director after reaching the age of seventy in 1943 and was now moving back to Denmark. It would seem reasonable to expect that Pieter Theodorus Oosterhoff (1904–1978) would continue this (see Figure 27). The formal appointment of Oort as Professor at Leiden University and Director of the Sterrewacht was made on 8 November 1945. And indeed on the same date, Pieter Oosterhoff was appointed Lecturer and Adjunct-Director (Oosterhoff would be appointed Extraordinary (honorary) Professor in 1948; for an obituary see Oort, 1978). So, why would van

Figure 27: Detail of the group photograph of the Nederlandse Astronomen Conferentie in 1952. The full delegation from Groningen consisted of only two persons: on the lower-left Lukas Plaut, on the lower right Jan Borgman. The latter was a second year student. In the top we see Maarten Schmidt, who by then had moved to Leiden. Other notable people are Cees Zwaan from Utrecht (top-right) and Pieter Oosterhoff from Leiden (between Schmidt and Plaut). From the Website of the Koninklijke Nederlandse Astronomen Club (Koninklijke Nederlandse Astronomen Club, 2021).

Rhijn use his single staff position for someone working in a field that was already a major line of research in Leiden? Furthermore, the Assistant had for many years been a person supervising work on the *Plan of Selected Areas* and the *Spektral–Durchmusterung*, preparing at the same time a PhD theses and then vacating the position. No wonder van Rhijn hesitated to propose Plaut for the Assistantship.

This left Plaut uncertain about his future and his wife decided to write Oort without telling her husband. She did so on 1 August, because, she explained, she no longer could handle the situation. She did not directly ask him to approach van Rhijn about the Groningen Assistantship, but asked for support in a more indirect manner (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 163; my translation):

> My husband is seriously ill (jaundice). This is otherwise a nasty disease, but harmless. However, my husband is mentally totally exhausted and no longer believes that he can get better. For a long time he has been pondering about his future, but saw no light. Now he is so exhausted physically and mentally that he is no longer able to think about it. I would like to ask you, isn't there anyone in the whole astronomical world who can help this man?

She proposed that Oort may write to Plaut to cheer him up. At the top of the letter Oort has scribbled that he had written a note to Plaut on 15 August and had ":... tried to give him some encouragement." And also that he hoped Plaut and Blaauw could visit Leiden after his trip to England. However, it took a while for Oort to make the trip. Jan Oort was General Secretary of the International Astronomical Union. The President Arthur Eddington had died in 1944, and through Vice-President Walter Sydney Adams (1876–1956) of Mount Wilson Observatory it had been arranged that Harold Spencer Jones (1890–1960), Director of the Royal Greenwich Observatory and Astronomer Royal, would be the Interim President. Oort was planning to fly to England to discuss the course of action with Spencer Jones. The trip was arranged by Gerrit Pieter (later Gerard Peter) Kuiper (1905–1973), a graduate from Leiden, but by then a naturalized American, who had come to Europe as part of the ALSOS Mission, which investigated and collected intelligence on the German atomic, biological and chemical weapons research. He is reported to have staged a daring rescue mission into eastern parts of Germany, during which he took the famous physicist Max Planck into Allied care hours before the Soviets arrived. Due to visa and other formalities Oort's trip kept being postponed but eventually took place from 23 September to 7 October. Obviously Oort had many things on his mind, busy as he was with putting the Sterrewacht and the IAU back on track.

In the meantime Lukas Plaut had writen to Oort again on 30 August (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 163; my translation):

> Yesterday morning I had a meeting with Prof. van Rhijn about the possibility of becoming an assistant here. Prof. van Rhijn, however, would have liked to have some certainty about my future after the assistantship ended and only wanted to take further steps with the trustees or the Board of Rehabilitation when, for example, I could show that there was a possibility for me to go to America. So I wrote to my brother in Los Angeles and asked him to take care of the official papers again for obtaining a visa after a few years. It is unfortunate that the decision has been delayed, so I am still in limbo for some time.

So, van Rhijn was still hesitant to allocate his Assistant position to Plaut and wanted some assurance that the position could become available again after a few years and that Plaut would have a future when it had ended. There is no further mention of this situation in the Oort Archives. In the end, van Rhijn did arrange for Plaut to be appointed Assistant, thereby filling the vacancy created by Blaauw's departure.

The appointment started on 1 October 1945, the date on which Blaauw's had ended, so van Rhijn's hesitations would not have lasted long after 30 August. Plaut had to take over part of van Rhijn's teaching because of the latter's illness and for this he was given (by Ministerial decree as required) a teaching assignment in 1946 in prodaedeutic (first year Introductory) Astronomy. He eventually remained on the staff until his retirement. Later Plaut's presence in Groningen played a major role in defining the *Palomar–Groningen Survey*, which concerned mapping a particular type of star, RR Lyrae variables, combining the study of variable stars, on which Plaut was an expert, with Galactic structure, the research field of van Rhijn and the Laboratorium. But that was only in 1953 and cannot possibly have played a role in Plaut's appointment in 1945.

16 STAFF AND WORKERS AT THE LABORATORIUM

At this point it may be appropriate to spend some time on the development of the actual manpower (no women yet) of the Laboratorium over the years. Table 1 shows the personnel between 1898 and 1960. This is compiled from the lists published annually in the Yearbook (University of Groningen, 1877–1978) of the University of Groningen and since 1946 partly in a supplement to this, the University Guide (University of Groningen, 1938–1975).

From 1900 onward Kapteyn had had an Assistant. The first appointment had been made at the beginning of the academic year 1899–1900, in the 'Lotgevallen' in the Yearbook 1898–1899 (University of Groningen, 1877–1978) it is mentioned (my translation):

> An increase in personnel is to be recorded at the 'Astronomische Laboratorium', where for the first time an assistant was appointed, namely Mr. L.S. Veenstra.

But in the same Yearbook (University of Groningen, 1877–1978) Veenstra is not listed as a staff member of the Laboratorium (Table 1 is based on these listings and presents this such that for example the line 1900 refers to the situation at the start of the academic year 1900–1901). Rather, Schelto Leonard Veenstra (1874–1951) is listed in the 1898–1899 Yearbook as a fifth-year student in mathematics and natural sciences, but I have not found him in other Yearbooks around that time in lists of students or persons who passed an exam. So, who was this Mr Veenstra? The information I have been able to uncover in the municipal archives is the following. In March 1901 Veenstra (26 years of age) married in Groningen 19-year old Doetje Heidstra and on the certificate he is described as having the position observator. They seem to have moved to Utrecht in 1908. The 'Canon Autisme Nederland', an organization concerning persons suffering from autism, notes in the description of a Cannon on the history of autism, that in 1910 (my translation)

> ... by the Ministry [of Law] an Inspector of Probation was appointed to supervise the government support of probation. According to this organization the first inspector was 'the energetic Schelto Leonard Veenstra (1874–1951), former captain of the Salvation Army, characterized ... as 'deeply religious, broad-minded'.

Veenstra probably terminated his studies and academia. It is likely he never contemplated a career in astronomy in the first place, but took the position for a short period to earn a living.

Willem de Sitter came next (Guichelaar, 2018, for an informative biography). He had passed his Doctorandus (Masters) degree in 1900, after having his studies interrupted 1897–1899 for a period of observational experience with David Gill at the Cape Observatory. While he was away Kapteyn had arranged the Assistantship for him when he returned, but on a temporary basis had appointed Veenstra to it. In 1901 de Sitter defended a thesis on *The Orbits of Jupiter's Galilean Satellites*—a subject that remained his principal interest throughout his career—and his appointment continued until he moved to Leiden in 1908. Like some of his successors, de Sitter also held an appointment as privaat docent to give lectures. His assignment (and that of his successors) is given in footnotes in Table 1. When de Sitter left for Leiden, Herman Weersma took over, but he left astronomy after a few years. Frits Zernike came next, but he left to do a PhD in Amsterdam in physics. Van Rhijn was given the position in 1915 (like de Sitter and Weersma, but unlike Zernike, this included also one as privaat docent, but only after he had defended his PhD thesis).

The position of Assistant apparently could be filled either as a temporary appointment of a student working on a PhD thesis, or on a longer or indefinite basis by a person holding a PhD. De Sitter and Weersma resigned rather than having come to the end of some term. So from Oort up to and including Blaauw, who resigned in 1945 to accept an appointment in Leiden, van Rhijn used the Assistant position for a person, who had obtained a Doctorandus (Master) degree and was now preparing a PhD thesis.

Starting with Kapteyn's share in the *Cape Photograph Durchmusterung* in the 1880s the measurement of photographic plates and the associated reductions was performed by persons employed from grants obtained especially for that purpose. Kapteyn started with T.W. de Vries, paid from grants from a number of funds, and more personnel followed. This soft money did not provide any long-term security to the employees and Kapteyn over many years sought ways to provide that to de Vries (see van der Kruit, 2019). As Table 1 shows this finally succeeded only in 1904. When the *Plan of Selected Areas* had been started, George Hale had adopted it as the primary project for Mount Wilson and his 60-inch telescope, and Kapteyn had been appointed Research Associate to the Carnegie Institution of Washington. But that was not all; the Carnegie Institution also provided funding to hire personnel in Groningen to measure the 60-inch plates. The situation did change in 1919, when the University of Groningen appointed three more computers on the university staff in addition to the amanuensis de Vries and the clerk Janssen. This was still the situation at the time van Rhijn took over from Kapteyn.

So at the start of his term as Director van Rhijn had one Assistant and four positions for technical support. Various astronomers were subsequently employed on the Assistant position. Jan Oort filled it for a short period. Then followed Peter van de Kamp, Willem Klein Wassink, Bart Bok, Jean-Jacques Raimond, Petrus Bruna and Adriaan Blaauw. Except for Bruna, all these Assistants finished and defended a PhD thesis under van Rhijn.

Not long after van Rhijn took office a fifth position was added to the Laboratorium, but at the end of the thirties during the Great De-

Table 1: Table of personnel at the Kapteyn Laboratorium from 1898 to 1960 according to the Yearbook (University of Groningen, 1877–1978) (Jaarboek der Rijks-Universiteit Groningen) and since 1946 in part to the University Guide (University of Groningen, 1938–1975) (Groninger Universiteitsgids). Years in which the personnel is the same as in the preceding one, have been omitted.

Year (a)	Professor	Assistant	Other Personnel (b)
1898	J.C. Kapteyn (c)	----	----
1900		L.S. Veensra	----
1901		W. de Sitter (d)	----
1904		W. de Sitter	T.W. de Vries
1908		H.A. Weersma (e)	T.W. de Vries
1910		H.A. Weersma	T.W. de Vries, J. Jansen
1913		F. Zernike	T.W. de Vries, J. Jansen
1915		P.J. van Rhijn (f)	T.W. de Vries, J. Jansen
1918		P.J. van Rhijn (g)	T.W. de Vries, J. Jansen
1919		P.J. van Rhijn	T.W. de Vries, G.H. Müller, J.M. de Zoute, D. van der Laan, J. Jansen
1921	P.J. van Rhijn (h)	J.H. Oort	T.W. de Vries. G.H. Müller, J.M. de Zoute, D. van der Laan
1922		P. van der Kamp	T.W. de Vries, G.H. Müller, J.M. de Zoute, D. van der Laan
1923		W.J. Klein Wassink	T.W. de Vries, G.H. Müller, J.M. de Zoute, D. van der Laan, W. Ebels
1927		W.J. Klein Wassink	W. Ebels, G.H. Müller, J.M. de Zoute, D. van der Laan
1928		B.J. Bok	W. Ebels, G.H. Müller, J.M. de Zoute, D. van der Laan, H.J. Smith
1929		J.J. Raimond	W. Ebels, G.H. Müller, J.M. de Zoute, D. van der Laan, H.J. Smith
1934		P.P. Bruna	W. Ebels, G.H. Müller, J.M. de Zoute, D. van der Laan, H.J. Smith
1939		A. Blaauw	W. Ebels, G.H. Müller, D. van der Laan, H.J. Smith
1941		A. Blaauw	W. Ebels, G.H. Müller, J.B. van Wijk, H.J. Smith
1945		A. Blaauw	D. Huisman, G.H. Müller, W. Ebels, J.B. van Wijk
1946		L. Plaut (i)	D. Huisman, G.H. Müller, W. Ebels, J.B. van Wijk
1956		L. Plaut, J. Borgman	D. Huisman, G.H. Müller, W. Ebels, J.B. van Wijk
1957	A. Blaauw (j)	L. Plaut, J. Borgman	D. Huisman, W. Ebels, J.B. van Wijk, H.R. Deen, E.R.R. Timmerman
1958		L. Plaut, J. Borgman, H. van Woerden	---- (k)
1960		L. Plaut, J. Borgman, H. van Woerden, A.B. Muller	----

Key:
(a) Situation at the start of the academic year.
(b) Functions were described as amanuensis, observator, computer or clerk.
(c) Professor of Astronomy, Probability Theory and Mechanics since 1878.
(d) Also privaat docent (additional appointment for teaching) in astronomical perturbation theory and related subjects.
(e) Also privaat docent in orbital determination and perturbation theory of celestial bodies.
(f) Also privaat docent in theoretical and stellar astronomy, later astronomy, probability theory.
(g) In addition between 1918 and 1922 A.E. Kreiken was listed as assistant b.b. ('without burden to the country's treasury').
(h) Professor of Astronomy and Probability Theory.
(i) Also a teaching assignment between 1946–1949 in propaedeutic (first year introductory) astronomy.
(j) Professor of astronomy.
(k) After 1957 no longer available in Universiteitsgids.

Table 2: University personnel employed at the University of Groningen.

Year (a)	Institutes (b)			Professors			Lecturers			p.d./l.o. (c)			Assistants, etc.			Other Personnel		
	u	n	k	u	n	k	u	n	k	u	n	k	u	n	k	u	n	k
1920	25	09	1	46	11	1	9	2	0	7	4	1	52	15	1	83	35	5
1930	31	11	1	54	12	1	9	1	0	13	5	0	81	32	1	101	45	5
1940	36	15	1	57	14	1	13	3	0	21	9	0	116	39	1	107	52	4
1950	53	14	1	76	18	1	18	4	0	35	12	0	171	47	1	135	60	4
1960	60	16	1	97	25	1	28	4	0	21	8	0	172	41	4	--(d)	--	--

Key:
(a) Situation at the start of the academic year.
(b) Here and in the further columns: u = University, n = Faculty of Natural Science, k = Kapteyn Laboratorium.
(c) p.d. = privaat docent (additional appointment for teaching), l.o. = teaching assignment.
(d) No longer listed in the Universiteitsgids.

pression this disappeared again, not to come back before van Rhijn's retirement. So, the net result was that as far as positions on the University pay-roll were concerned, the number of staff had remained the same as it was at the start of van Rhijn's Directorship.

So, how did this compare to the University as a whole? For this I refer to Table 2, which covers the period 1920 to 1960 in steps of a decade, so roughly encompassing van Rhijn's tenure of the Directorship of the Kapteyn Laboratorium. The growth of the University is understandably modest during the Great Depression and WWII, but picks up after this, especially during the 1950s. The number of Institutes is somewhat more than half the number of Professors. The column Professors, however, includes Extraordinary Professors (appointments on an individual basis in addition to the normal contingent), Honorary Professors and so-called Ecclesiastical Professors (who in the Theological Faculty teach particular subjects on behalf of churches or religious organization), so ignoring these it follows that as a rule the majority of ordinary Professors were also Directors of an Institute. The number of Professors increased by a factor 2.4 and of Institutes by 2.1, so this situation did not change much. Not surprisingly, Astronomy remained with just one Institute and one Professor. Roughly speaking, one Professor out of four was supported by a Lecturer, a senior scientist involved in research and teaching.

Although the total number of Lecturers increased, it remained relatively constant at only three or four for the Natural Sciences and—maybe a not unreasonably—none for the Kapteyn Laboratorium. The growth University-wide was in Assistants, as we have seen junior scientists, in Kapteyn's day as long term employment (de Sitter to van Rhijn), but later as temporary appointments and usually to prepare a PhD thesis (under van Rhijn from Oort to Blaauw). From the end of the WWII to the end of van Rhijn's term this was a junior permanent position occupied by Plaut. There were no new positions for junior staff in Astronomy, while this increased by a factor three in the University and Faculty of Sciences. The increase to four Assistants occurred after Blaauw took office and was part of the conditions he bargained for as a basis for his accepting the Directorate. Whereas de Sitter, Weersma and van Rhijn were appointed privaat docent in addition, this was not the case of the 'graduate students' under van Rhijn. Plaut was given a teaching assignment, but only temporarily during van Rhijn's illness. While the number of such appointments increased, none was available structurally to Astronomy. In this respect van Rhijn was worse off than his predecessor and contemporaries.

In terms of scientific staff Astronomy did not profit at all from the national and local growth of university budgets, student numbers and staff during van Rhijn's Directorship. In further personnel the situation also showed a negative trend; while there was a significant increase (by a factor 1.6 University-wide and 1.7 in the Faculty) for Astronomy it went from 5 to 4 and stayed at that level for a long time. In this category there was a modest increase as well under Blaauw as part of the conditions under which he accepted his appointment.

The Kapteyn Laboratorium remained a marginal effort in Groningen; while the University grew by a factor of about three or so between 1921 and 1957, it remained at the same level, probably below critical mass in the long run. On a national level this falling behind of Groningen Astronomy was even more evident. For nation-wide comparison the available literature in English is limited. David Baneke's (2010) book *De Ontdekkers van de Hemel* on the history of Dutch astronomy in the twentieth century is not available in English, as is also the case for a number of his other informative papers on related issues, except for a few. From all of this I compile the following numbers. In the 1930s there were eleven staff positions (Professors, Assistants, etc.) in Astronomy at Dutch universities: six in Leiden, two in Utrecht and Groningen and one in Amsterdam. Compared with the Sterrewacht Leiden the Groningen Laboratorium was insignificant. In 1933, Willem de Sitter wrote a history of the Sterrewacht on the occasion of its tricentennial (de Sitter, 1933) and listed the staff at that time: two Professors (of which one extraordinary), two Conservators (senior staff comparable to lecturer), two Observators (scientific staff), four Assistants (plus six voluntary, so not paid from the regular budget), ten Computers, two Technical Staff, a Typist and a Carpenter. The Observatory itself had various telescopes and a Southern Station in Johannesburg, South Africa, which included one telescope and access to at least two more. The teaching load (Astronomy staff taught Astronomy courses to Physics and Mathematics majors, and some times Physics or Mathematics courses) was divided between at least four persons. This is no comparison to the other universities, where all, or at best almost all, the teaching had to be done by a single person. Utrecht had an observatory as well, concentrating on solar research, but expanding into astrophysics in particular hot, massive stars (Pugliese et al., 2012). The Amsterdam Institute of Pannekoek was not significantly different from the Groningen establishment (Tai et al., 2019). Anton Pannkoek had modeled his institute along Kapteyn's lines in the sense of relying on observational material from elsewhere. Pannekoek concentrated furthermore on theoretical work, pioneering the field of stellar atmospheres. The institute remained small under his leadership, and also under his successor Herman Zanstra (1894–1972), who took over after Pannekoek's retirement in 1946.

Not only did Leiden dominate Dutch astronomy and therefore make it difficult for other universities to strengthen their Astronomy Departments, but more importantly for the Kapteyn Laboratorium, Astronomy had lost ground at Groningen under van Rhijn by failing to increase its size in step with the rest of the University.

As far as students contemplating a possible career in astronomy are concerned, the situation in Groningen was also minimal. Maarten Schmidt had enrolled as a student with a strong interest in Astronomy in 1946, and obtained his Candidaats (Bachelor) in 1949. But on invitation of Jan Oort he moved to Leiden at that stage. The single promising student left, Jan Borgman, although Schmidt's age, entered Groningen University only in 1950. He progressed in a satisfactory way, obtaining his 'Doctoraal' (Masters) in 1955 and a PhD in 1956. However the PhD degree was granted with Physics Professor Hendrik Brinkman (1909–1994) as supervisor, and concentrated on electronic variable star recognition on plate pairs. No further PhD students came forward during the rest of van Rhijn's Professorship.

Up until the first years of WWII (the period 1921–1942) the number of PhD theses under van Rhijn had been significant compared to the other universities, namely eight (Groningen) versus fourteen (Leiden), eleven (Utrecht) and two (Amsterdam). But between 1945 and 1957 van Rhijn had only one, compared to eight (Leiden), four (Utrecht) and four (Amsterdam). This one PhD was Adriaan Blaauw in 1946, but after him there were none for almost two decades, unless one counts the physics thesis of Jan Borgman. Of the total of nine Groningen PhDs under van Rhijn, however, 5 had been recruited as PhD students from elsewhere: Jan Schilt and Peter van de Kamp from Utrecht, and Jean Jacques Raimond, Bart Bok and Adriaan Blaauw from Leiden. Egbert Kreiken, Jan Oort, Willem Klein Wassink and Broer Hiemstra had obtained their Doctoraal (Masters) in Groningen, but the first two were in a sense students of Kapteyn.

Students in Physics and Mathematics do attend Astronomy lecture courses in their first years and inspiring Astronomy Professors might ignite an interest in their field. Van Rhijn did not recruit many new Astronomy students, although it must be said that after WWII his tuberculosis would have made this difficult. Klein Wassink and Hiemstra started as Groningen undergraduates and went on to a PhD; they are the only ones who can be seen as having been pure students of van Rhijn. The small number of students would not help persuading Curators or the Minister to create or assign new staff positions to the Astronomy Department.

17 THE LATE FORTIES AND EARLY FIFTIES

During the first years after WWII work at the Kapteyn Laboratorium was slow in picking up. The work on variables was painstakingly slow, but very competently executed by Plaut, and van Rhijn was out of action a large part of the time. Work on the telescope was performed but no results appeared. Van Rhijn and Plaut made up the full scientific staff, which had never grown compared to Kapteyn's days (see Figure 27). Teaching went on as normal, lectures to a large extent being given by Plaut. There was one Astronomy major student, Maarten Schmidt, but as already mentioned, he left for Leiden halfway through his studies.

During WWII the work on the *Bergedorf (–Groningen–Harvard) Spektral–Durchmusterung* had first slowed down and then essentially halted. Van Rhijn had been able to do some research, part of it probably while being nursed for tuberculosis. In any case he did publish two papers in the *Publications of the Astronomical Laboratory at Groningen*. In his review of Dutch astronomy during WWII, van Rhijn (1946) noted that

> The H and K lines are absorption lines due to calcium and can only be distinguished from stellar lines of these that have not such lines in their spectra, which means they have to be spectral types O or B.
>
> During the fighting in Groningen in April 1945 two publications, written during the War by the director, have been burned, but a copy of the manuscripts is undamaged. Dr. P.J. van Rhijn investigated the accuracy of the interstellar line intensities as a criterion of distance and reduced the known equivalent widths of the H and K lines, which appeared to be most suited to the purpose, to distances. The density and luminosity functions of the O and early B stars were derived; contrary to former results it appears that the density does not decrease with increasing distance from the Sun.

After WWII van Rhijn did not sit still in spite of his tuberculosis (from which he recovered only very slowly). A large research project that he completed in 1949, was a mapping of extinction on the basis of color excesses measured at various places all over the sky (van Rhijn, 1949). According to the Introduction:

> It is the purpose of the present paper to derive the mean differential absorption and the distribution of the amount of the differential absorption for stars at a specified distance and Galactic latitude. If, as seems probable, the photographic and differential absorption are in a constant ratio, the

> mean photographic absorption and the distribution of this absorption for stars at a specified distance and latitude can be found. These functions can be used advantageously in the solution of the equation of stellar statistics ...

For clarity I remind the reader that differential absorption is what we would now call reddening, in those days usually between photographic (blue) and photovisual (yellow) wavelength bands. The distribution of actual values in a particular direction was found to be approximately Gaussian and could be explained by a chance distribution of absorbing clouds in regions near the Milky Way. The number of clouds in a line of sight near the Milky Way was 6 per kpc on average, and the photographic absorption of a single cloud van Rhijn estimated as 0.27 magnitudes. The differential absorption of such a cloud turned out to be 0.035 magnitudes. The distribution of cloud sizes was not addressed. Interesting as this may be, the use of this to solve the equation of stellar statistics is limited, because of the severe irregularities in the distribution of extinction on the sky and along sight lines. As far as I am aware, these results have never been used for such a purpose. In ADS van Rhijn's paper has a single citation in 1963 and only an occasional read (the peak in 2021 is me preparing this paper).

It should be recorded that after WWII van Rhijn faithfully fulfilled his task as coordinator of the *Plan of Selected Areas*; he wrote a comprehensive report for Commission 32 for the IAU General Assembly in Zürich, Switzerland, in 1948. But he did not attend, and during the meeting Jan Oort took the lead as Acting President of that Commission, together with Adriaan Blaauw as Secretary.

Plaut did vigorously pursue his research in variable stars. Some of it during WWII was probably completing work he had started in Leiden before he moved to Groningen. This was extremely labor-intensive and time-consuming work of which the yield was small and progress slow. But it shows the kind of work Plaut did, and how very patient a person he was. In 1946 he published a paper on an eclipsing binary based on 341 plates taken between February 1930 and August 1936 (Plaut, 1946). The plates had been obtained at the Leiden Southern Station using the 10-inch Franklin-Adams Telescope of the Unie Sterrewag in Johannesburg, which had been donated by John Franklin-Adams (1843–1912), the maker of the first all-sky photographic survey. In the deal de Sitter had negotiated, Leiden astronomers had access to this telescope. Hertzsprung and collaborators used it primarily to study variable stars from repeated exposures. Plaut had measured these plates with the Schilt photometer (see above) to construct a detailed light curve, the form of which gave among others information on the eccentricity of the orbit.

This is not all. As noted above, van Rhijn (1946) had noted in his paper on Dutch astronomy during WWII that Plaut had been searching for variable stars on plates taken at the Leiden Southern Station with the Franklin-Adams Telescope. Obviously, this involved plates taken there by the Leiden representative, who in this case was Hendrik van Gent (1900–1947). Van Gent had worked on variable stars with Hertzsprung and obtained a PhD under him in 1932. Plaut used the blink comparator of the Kapteyn Laboratorium (rapidly switching the view between two plates of the same area) and published a paper (Plaut, 1948), in which he reported 91 variables by comparing 12 pairs of plates, subsequently estimating the magnitudes on a full set of 300 plates. These estimates were performed by eye. This was a matter of patience and extreme care. And in 1950 Plaut published a review collecting the available data on all 117 known eclipsing binaries brighter than magnitude 8.5 at maximum and determining their orbital parameters and updated that in Plaut (1953, and earlier references therein). Plaut had established himself as an authority on variable stars.

As we have seen, van Rhijn was out of action for most of the 1940s after the War and the Laboratorium relied mostly on Lukas Plaut for teaching. In the 'Lotgevallen' for 1949, covering the previous academic year, Rector Magnificus Pieter-Jan Enk (1885–1963), Professor of Latin, noted (my translation):

> It fills us with great joy that Prof. Dr. P.J. van Rhijn, after an illness that lasted more than four years, has now completely recovered and is again going to devote himself to his work with full vigor. We wish our colleague all the best in this respect.
>
> And the teaching assignment given to Dr L. Plaut in connection with Prof. van Rhijn's illness, to teach Propadeutic Astronomy, was withdrawn by Ministerial Decree of November 18, 1948.

We have seen in Section 8 that van Rhijn had been very much involved in research into interstellar extinction, in fact it was part of his PhD thesis. Summarizing the background very briefly, following Kapteyn it had become clear that it was due to some kind of scattering that caused reddening and part of the problem was to turn the amount of reddening into an amount of extinction. This is given by what is usually referred to as the ratio total-to-selective absorption. This is a dimensionless property (in fact magnitudes per magnitude) and once known can be applied without any other information: measure the reddening and with the ratio comes the extinction. The ratio depends of course on the wavelength dependence of the scattering and has a different numerical value for different photometric bands. The total-to-selective absorption depends not only on the physics of the scattering, but also on the size distribution of dust particles and cannot simply be calculated from first principles of physics.

Van Rhijn's telescope was originally intended for stellar photometry, but it soon became clear that the sky conditions in the center of Groningen were too poor for this. He therefore resorted to spectroscopy for which conditions were less critical. We have seen that in 1936 he corresponded with the Zeiss Company about the purchase of a slitless spectrograph, which he probably obtained in that same year or shortly afterwards. At that time the selective-to-total absorption was still very poorly known and he wished to improve this with his telescope by taking spectra of obscured stars and determining the energy distribution over wavelength and doing the same for unreddened stars of the same spectral type. Eventually he was aiming at using stellar spectra to more fully determine the distribution of dust in the Galaxy, and address questions about the size distribution of the particles and whether or not this changed substantially with position in space. Work on relatively bright stars was the only kind of observational astronomy that could conceivably be done as relevant research from the center of a city like Groningen. The reason is that a good fraction of the bright background in a city is concentrated in small wavelength regions of bright spectral lines. Outside these wavelength regions the city sky is more amenable to astronomical research.

This project took a very long time getting started. In the 1930s getting the telescope ready for operation was a tedious and slow process, to a large extent due to the economic depression, which prevented the hiring of additional staff, but also as a result of the enormous effort required for the *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung.* The telescope required a spectrograph, and what looks like the final quote in the corresspondence with the Zeiss Company in the van Rhijn Archives for a 'Spaltlose Einprismen–Spectrograph' (slitless single prism spectrograph) dates to 1936. Where the required 4100 RM (ReichsMark), corresponding to an estimated 70,000 € at present, came from is not explained. It may have taken a few years to raise that amount. Some observing did take place during the War, but whether useful data for this project were obtained then is doubtful. The collecting of spectra only proceeded successfully apparently after the War, as noted by Blaauw in the quote at the end of Section 11, and Maarten Schmidt described his experience about learning observing from Lukas Plaut as a student in the late forties in the citation preceding that of Blaauw. The first results on the wavelength dependence of interstellar extinction were published by van Rhijn in 1953 in a single-authored pape (van Rhijn, 1953), in which he acknowledged Plaut for taking most of the plates. His technical and computational staff, Müller and Huisman, are noted for help with the reduction, and Müller also for the observing. But it seems that the work at the telescope was mainly done by Lukas Plaut. This would have been a major effort, as it also involved obtaining experience with the equipment and the problem of the poor observing conditions in the center of the city of Groningen. Plaut never published a paper about data obtained with the Groningen telescope, and he did not use the telescope for studies of variable stars; for useful research purposes it was only used with the spectrograph.

Since then, the nature of telescopic astronomy has changed considerably. While the idea of measuring the brightness distribution of reddened stars as a function of wavelength using photographic recordings of spectra may have been timely in the late 1920s and the 1930s, it was definitely not state-of-the-art after WWII. The field of stellar photometry had been revolutionized by the introduction of photoelectric photometry (and spectophotometry), and applied to the problem of the wavelength dependence of interstellar extinction by astronomers such as Jesse Greenstein, Joel Stebbins (1878–1966), Albert Edward Whitford (1905–2002) and others, and these studies had established that it was approximately inversely proportional to the wavelength. In fact, in the first line of his paper van Rhijn (1953) did acknowledge that the detailed nature of the wavelength dependence had been addressed by Stebbins and Whitford. They had published a series of six papers, starting with Stebbins and Whitford (1943). They used the Mount Wilson 60- and 100-inch telescopes to photoelectrically measure the intensity distribution over the wide wavelength range 3530–10,300 Angstrom (they included measurements on galaxies) and found relatively small, but significant, deviations from a simple inverse-λ law.

Van Rhijn (1953) described how the photographic spectra were measured. For this he used "... the thermoelectric photometer of the Kapteyn Laboratory ...", which must be the 'Schilt photometer' built by Jan Schilt for his thesis research, and among other projects was used for the *Spektral–Durchmusterung* (see Section 6 and Schilt, 1922). The method van Rhijn had designed was to use a pair of stars of the same spectral type, one significantly reddened and one unreddened at low and high Galactic latitudes respectively. The stars used were of spectral type late O or early B, since these are stars with the weakest spectral features, the spectral lines present predominantly come from hydrogen and helium but with no significant lines of other elements (early O-type stars are unsuitable because of strong helium lines, and in later B-stars the hydrogen lines become stronger). Their apparent magnitudes were between 5.5 and 8.0. These were exposed various (usually four) times on a single plate together with exposures of a late-B or early-A star. The latter are stars with spectra with strong and sharp hydrogen lines that could be used for wavelength calibration. The spectra of the two program stars were measured at a set of seven wavelengths ranging from about 3900 to 6300 Angstrom, or a factor of about 1.6. The research reported concerned 14 pairs and it confirmed the Stebbins and Whitford result. This was followed up soon by Jan Borgman. He had spent some years working at the Philips Company, developing his technical skills and gaining experience in building electronic instrumentation. He obtained his doctorandus degree (Masters) in 1955. His PhD thesis work (defended in 1956) will be described below, but as a student he published in 1954 and 1956 two more studies (with the same title as van Rhijn's paper), extending van Rhijn's work with another 10 and 27 late O- and early B-stars (Borgman, 1954; 1956a). Again the agreement with the Stebbins and Whitford curve was very good.

The work suffered from all problems associated with quantitative photographic work in that is was tedious and had to be carried out with extreme care and perseverance. The photographic emulsion is a very alinear detector: it suffers from under- and over-exposure and the relation between the photographic density—how opaque the emulsion is, zero when the transmission is 100%, unity when this is 10%, etc.—known as the characteristic curve, varies from plate-to-plate and sometimes even on different parts of the same plate. On top of this, there is low-intensity reciprocity failure—at faint light levels the exposure of, say twice, fainter light source takes more than twice the exposure time to reach the same photographic density. Nevertheless, van Rhijn, Borgman and Plaut did overcome all these problems, and they produced reliable results.

The program was conceived by van Rhijn twenty or so years earlier and indeed worked out excellently, and could in the 1930s in all likelihood have resulted in papers that would have made a major impact, rivaling others working on this subject at that time—see, e.g., the review by Trumpler (1934) for more details. But due to very long delays van Rhijn was not breaking any new ground, merely confirming what had been determined in the meantime in particular by photoelectric techniques that held more promise for the future. But the fact that the photographic work in Groningen actually worked and could produce results that were comparable in accuracy to the photoelectric data is a tribute to the quality of the work by van Rhijn and Borgman.

18 THE VOSBERGEN SYMPOSIUM

In June 1953, the International Astronomical Union held its Symposium Nr. 1 on the "Coordination of Galactic Research" (Blaauw, 1955). The initiative for this meeting had been taken by Jan Oort, who was President of Commission 33 on 'Stellar Statistics' (at the IAU General Assembly of 1958 in Dublin this was changed to 'Structure and Dynamics of the Galactic System'). The purpose and character of the symposium, quoted from a circular letter sent to all participants—and obviously written by Oort—was described as follows:

> During the first third of this century an important concentration of work on Galactic structure and motions has been promoted by the Plan of the Selected Areas, initiated in 1906 by Kapteyn. Although the scheme outlined in 1906 has not lost its significance, it is widely felt that further research into structure and dynamics of the Galaxy should be extended beyond the original Plan. At the same time it is felt by many that some kind of coordination of effort remains highly desirable, if only because the value of many observations is greatly enhanced if the data can be combined with other data for the same stars.
>
> Several observatories have asked for suggestions with regard to future work on Galactic structure. The recent advent of several large Schmidt telescopes furnished with objective prisms, red-sensitive plates, etc., brings forward with some urgency for each of the observatories concerned the problem of how to organize and restrict the

> work with telescopes that can produce much more than can be measured and discussed by the existing observatories. The question arises, whether it is desirable to formulate a new plan of attack, and whether such a plan should also include recommendations for concentrated work on particular data would be the most urgent.

The Symposium was hosted by Pieter van Rhijn and the Kapteyn Laboratorium, and the venue was the Estate Vosbergen, which was used by the University of Groningen as a conference center. It was located near the village of Eelde 5 km south of Groningen. Lukas Plaut did the local organizing. Adriaan Blaauw (1955) edited the proceedings, which were unusual according to current standards in that they did not consist of papers based on the presentations made, but instead Blaauw merely summarized all presentations and the long discussions (Blaauw would move to Yerkes before finishing the proceedings).

The format of the Symposium was that there were introductory presentations (some of which were later published separately in full), followed by discussion. The Scientific Organizing Committee (SOC), of which Oort was Chairman and Blaauw Secretary, consisted of eight pople. Van Rhijn was not one of these, and nor was Plaut. The SOC was dominated by Oort and Blaauw from Leiden, and Wilhelm Heinrich Walter Baade (1893–1960) (see Osterbrock, 2001, or Oort, 1961a) with whom Oort had been conducting extensive correspondence and who visited Leiden in the months preceding the Symposium. This meeting also included discussions about the European Southern Observatory, which first took place in Leiden on the Sunday before the Symposium. Oort had invited a few leading astronomers from European countries to travel to the Netherlands a day earlier for this purpose. More discussions took place during a boat trip on the IJsselmeer (the dyked off former Zuiderzee) as part of the Symposium.

If the Symposium was intended to be at Groningen as a tribute to van Rhijn's dedication to the *Plan of Selected Areas* and guardian of the Kapteyn legacy, it would seem a bit of an affront not to invite him to join the SOC. Even as host this would have been appropriate. After all, van Rhijn was only three years away from retirement by now, and this would have been an excellent occasion to honor him on an international stage.[19] In addition to the eight SOC members of the Vosbergen Symposium, twenty more astronomers were invited to attend because they represented institutions that might take part in future galactic research, or because of the nature of their research.

In total, ten introductory papers were presented in seven sections. The members of the SOC all gave introductory reviews (as did a few of the other people invited to attend). Van Rhijn was not invited to present one. From the proceedings, the impression is that van Rhijn remained somewhat in the background. He is mentioned in the proceedings only when the need for understanding the wavelength dependence of interstellar extinction was discussed as an example of one having addressed that issue and for his stressing (with Oort), that a very important task for the observatories equipped with Astrographic Catalogue refractors will be the determination of proper motions in regions centered on the Kapteyn *Selected Areas*, over much larger areas than those in the *Pulkovo* and *Radcliffe Catalogues*.

The conclusions arrived at during the Vosbergen Symposium showed a change in emphasis on collecting as many data of various kinds as possible on stars in the *Selected Areas* to large programs where each concerned a particular set of objects to elucidate well-defined issues. For example, the inventory of stars in the areas defined by Kapteyn was replaced by specially designed surveys to determine the distribution of stars in the halo or the disk using tracer objects; an inventorying of the distributions of stars in the local volume as a function of age; surveys for proper motions and radial velocities of various types of objects; or programs designed to address special problems. For example, the formation and evolution of the disk could be traced by studying the distribution of stars of different spectral types on the Main Sequence or late-type giants. B-stars could be used to determine from the distribution of their radial velocities a better estimate of Oort constant A of Galactic rotation.

And two more actions would be made effective. First the establishment of two IAU Sub-committees, one within IAU Commission 33 to coordinate observational programs, and one within Commission 27 (Variable Stars) to organize further work on variable star surveys. Memberships were rather limited; for the first it was Baade, Blaauw, Lindblad, Oort, Parenago and van Rhijn; and for the second Baade, Blaauw, Kukarkin and Oosterhoff. All of these people are identified in Figure 28. Note that the total attendance was only twenty five or so. I will go into this list of members in some detail since it is remarkable. One may argue the membership of these sub-commissions within the IAU was chosen to optimize the interface with the IAU: Lindblad had just finished his term as IAU President and was adviser to the Executive Committee; Oort and Boris Vasilye-

Figure 28: Participants at the 1953 Vosbergen Symposium, *Coordination of Galactic Research*, with some of their coats, hats, suitcases, etc. stored not really out of sight in the front. People referred to in the text can be identified as follows: Second from the left Bertil Lindblad, next to him Walter Baade, four people to the right Jan Oort, in front of Oort Lukas Plaut and standing next to him Bill Morgan, between and behind them Adriaan Blaauw, and with papers in his hand Pieter van Rhijn, to the left of him, partly hidden by the lady directly to his left, Jason Nassau, and behind Nassau Pieter Oosterhoff. The two people on the right in the second row (numbers 2 and 4 from the right) are respectively P.P. Parenago and B.V. Kukarkin (courtesy: Kapteyn Astronomical Institute).

vich Kukarkin (1909–1977) were at the time Presidents of Commissions 27 and 33, while Baade was President of Commission 28 (Galaxies), Pieter van Rhijn of Commission 32 (Selected Areas); and Pieter Oosterhoff was IAU General Secretary. Pavel Petrovich Parenago (1906–1960) and Kukarkin were both from Moscow (the first specializing in stellar structure of the Galaxy and the latter in variable stars), and were to cover the Eastern countries; both were very influential in the Soviet Union.

This makes sense, but the rest of the membership involved people who were all special to Oort, and the Dutch dominance is both obvious and out of balance. Oosterhoff, Blaauw and van Rhijn were all Dutch (Blaauw was appointed Secretary of both sub-committees). Bertil Lindblad (1895–1965) had for a long time been a leading figure in the field of the structure of the Galaxy, Oort had special relationships with him and with Baade, and although they were clearly leaders in the field there were, for example, some prominent American astronomers in the audience who could have been invited to join the SOC, such as William Wilson (Bill) Morgan (1906–1994) or Jason John Nassau (1893–1965). Both had contributed very important studies involving extensive surveys of early and late type stars respectively, and I've also identified both of them in Figure 27. As a sideline, in his biography of Walter Baade, Donald Edward Osterbrock (1924–2007) wrote this about Baade and Nassau:

> The two men had the same general build, height, hair style and color, prominent hawk nose, and liked to dress alike at scientific meetings which they both attended. Frequently in group pictures they stood at opposite ends of the front row, often striking very similar poses, which

> they must have rehearsed or at least discussed in advance. (Osterbrock, 2001: 145–146).

This picture would be a notable exception.

The second desideratum was to hold another meeting soon. It was thought this could possibly take place during the 1955 General Assembly in Dublin, but it was eventually deferred to 1957 as IAU Symposium Nr. 7, the "Second Symposium on the Co-ordination of Galactic Research", which was held in Sweden, near Stockholm. There was reasonable, but not considerable overlap with the first meeting among the participants. Van Rhijn was absent. By now he was beyond retirement age, but had taken the Directorship upon himself as long as no successor had arrived. The format was the same, but Adriaan Blaauw this time coordinated a small group of editors, who shared the burden of this work. It is beyond the scope of this paper to discuss its proceedings in any detail.

The change from emphasis on completion of Kapteyn's *Plan of Selected Areas* that had been the focus of van Rhijn's efforts was replaced by directing the efforts to specific surveys related to specific questions concerning aspects of the quest to determine the structure, kinematic, dynamics and eventually formation and evolution of the Milky Way Galaxy. In this sense it was the unofficial end of the *Plan of Selected Areas*, since—as noted above—IAU Commission 32 remained operational until 1958, continuing as a sub-commission within Commission 33, and was only formally disbanded at the General Assembly in Brighton in 1970. This last action then should be seen as the official end. In all, 28 observatories from 11 different countries had contributed to the Kapteyn's *Plan of Selected Areas*.

For the Kapteyn Laboratorium the outcome of the first meeting was profound in that it provided a focus for an extensive, long-term undertaking that would occupy Lukas Plaut and a large part of the Laboratorium's manpower for many years. I will turn to this next.

19 THE *GRONINGEN–PALOMAR VARIABLE–STAR SURVEY*

One of the major desiderata of the Vosbergen Symposium was to undertake what became known as the *Palomar–Groningen Variable–Star Survey*, which concerned variable stars in the Galactic bulge and halo. This was proposed at Vosbergen by Walter Baade as a means of finding out what the stellar distribution in the bulge and halo of the Galaxy was, and to investigate the differences and similarities between our Milky Way Galaxy and the Andromeda Nebula. The halo was defined primarily by the globular clusters as tracers of Baade's Population II, introduced in 1944 upon resolving stars in the Andromeda Nebula and companion dwarf galaxies. Baade had noted that the brightest stars in the halo Population II were red (giant) stars, while in the disk Population I they were blue OB-stars. This resulted in the realization that there was a fundamental difference between stars in the disk and the halo. At the time of the Vosbergen Symposium the situation was:

> From all the evidence available at present it seems that the distribution of the population II objects is symmetrical with respect to the axis of rotation of the Galaxy. (Distribution of globular clusters in the Galaxy, distribution of population II objects in extra-galactic nebulae.) The first task of future work, therefore, will be to determine the way in which the density varies with the distance from the Galactic Centre ... The following proposal was made by Baade.
>
> For the determination of the surfaces of equal density in the halo, we can restrict ourselves to determining the density distribution in a cross-section, perpendicular to the Galactic plane and going through the Sun and the axis of rotation ... It is proposed that, to begin with, three fields be chosen, centered at approximately l = 327°, b = about 20° (latitude as close to the nucleus as interstellar absorption permits); l = 327°, b = 45°; l = 147°, b = somewhere about 10°.
>
> The ideal instrument for such a survey would be the 48-inch Palomar Schmidt, which may become free in the next few years after the sky survey is concluded. It gives fields of 7° × 7°, free from vignetting and can easily reach the 20th photographic magnitude in 10-min. exposures. This provides an ample margin to make sure that the survey will be complete up to 17.5 median magnitude corrected for absorption, i.e. distances up to 30 kiloparsecs for the RR Lyrae variables — even if the absorption in one of the fields should amount to one or one and a half magnitudes. In the case of the two latter fields it is very probable that regions of heavy or irregular absorption can be avoided. As to the first, it is a matter of searching the sky survey plates in this general direction before deciding on the most suitable co-ordinates. (Blaauw, 1955: 4–5).

These coordinates are of course 'old' Galactic coordinates with the zero-point of longitude is at the crossing of the Galactic and celestial equators. Longitude 327° then is that of the Center of the Galaxy. The fields were as close as possible above the Galactic Center, 45° up from the Center and towards the anti-center close to the Galactic plane. The sky survey referred to is the *National Geographic Society–Palomar Observatory Sky Survey (NGS–POSS)*, which was substantially completed in the middle of 1956.

At the Vosbergen Symposium it had become clear that Lukas Plaut (Figure 29) and the Kapteyn Laboratorium would be prepared to take on this project, the *Palomar–Groningen Variable–Star Survey*. For the precise choice of the fields Plaut relied on Baade, who had surveyed the region around the Galactic Center extensively both with the Palomar 18-inch Schmidt and the Mount Wilson 100-inch telescopes. The 18-inch Schmidt had been an initiative of Fritz Zwicky (1898–1974). He and Walter Baade had proposed in 1934 that supernovae were the source of cosmic rays, and Zwicky wanted a small, wide-angle telescope to search external galaxies for supernovae. The choice of a Schmidt telescope is undoubtedly due to Baade. The design of a wide-angle telescope with a spherical mirror and objective corrector plate to correct for spherical aberration was first made by Bernhard Woldemar Schmidt (1879–1935) at Hamburg Observatory where Baade worked before joining Mount Wilson Observatory in 1931. The 18-inch was the first telescope on Palomar Mountain, and became operational in 1936, well before the 48-inch (1948) and 200-inch (1949) telescopes. Zwicky was a stubborn and ill-tempered person, and regarded the 18-inch as 'his' telescope. In the beginning, he and Baade were on good terms and published together, but later they avoided each other. In the late 1930s Baade used the 18-inch, which recorded images of the sky on photographic film over a circular area of almost 9° diameter, to map a large region around the Center of the Galaxy. He did this in red light (with a pan-chromatic film and a red filter), identifying areas with little extinction. At the Vosbergen Symposium Plaut estimated the time required to perform the blinking of plates and determination of light curves of RR Lyrae stars and other variables as "... something of the order of 15,000 hours or six man-years." At the start of the project four different fields were selected, three near the center in new coordinates (*l*, *b*) at (0°, +29°), (4°, +12°), and (0°, –10°) plus a field in a direction more or less perpendicular to this at (82°, +11°). Most observing was done for the first three fields when Plaut spent two extended periods in California in 1956 and 1959, and in between some plates were taken by other observers. The three-year time-span allowed the discovery of long-period variables. The fourth field was never completed.

The organization of the survey took much time and also irritation on the part of van Rhijn and Plaut. Much depended on Walter Baade, who was responsible for choosing the exact location of the fields and organizing access to the Palomar 48-inch Telescope with Ira Sprague Bowen (1898–1973), the Director of Mount Wilson and Palomar Observatories. In a letter to Jan Oort dated 4 May 1954 (in the Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149), Pieter van Rhijn complained (my translation):

> The correspondence between Baade and me has been as follows: Baade wrote me Oct. 13, 1953, that he himself was in favor of the plan to search for the variable stars in some fields in the plane perpendicular to the Milky Way with the Schmidt at Palomar, but that he still had to consult with Bowen about the execution of the plan, Also the possibility, that Plaut would cooperate in the execution of the plan at Mount Palomar, would be considered. In a short letter of Jan. 8, 1954, I asked Baade if he had already spoken to Bowen about the matter and if there was a reasonable chance, that the matter would go ahead. I repeated the same question on Feb. 9, '54. To date I have received no reply from Baade. The way Baade has handled this case has annoyed me. Surely the least he could have done was to answer me to my reasonable question of whether there was a good chance that the plan would be realized. Instead, he makes me wait six months and then asks you to tell me that he cannot give accurate dates for the work. Dates that I, you should note, had not even asked for. The sentence in which he says he was 'much amused by my writing' I will

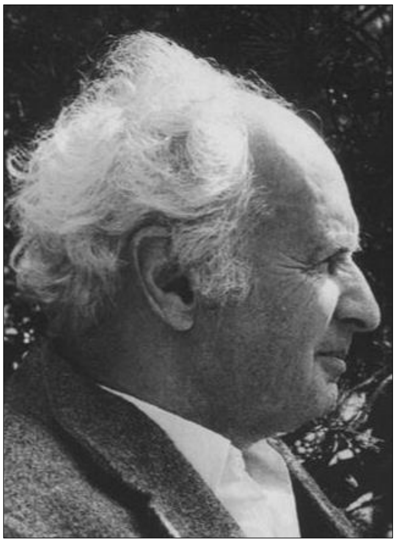


Figure 29: Lukas Plaut later in life. From the collection of Adriaan Blaauw (courtesy: Kapteyn Astronomical Institute).

> leave unmentioned. Such remarks will not promote good cooperation.

Oort wrote back two days later (same source, again my translation):

> Dear Piet,
>
> You should not take such statements from Baade too seriously, nor his non-answers to letters. I do not know at all what he was referring to in the phrase in question, but I find it hard to imagine that it would be worthwhile to get angry or annoyed about. After all, people often have strange manners of correspondence. If I wanted to be annoyed with Baade I would have jumped out of my skin last year before his visit here. He did not let me hear anything about his arrival for months, despite my repeated questions, and then finally wrote, after the date that had been firmly agreed upon had already passed, that he had come into conflict with other appointments and promises that he had made before and had forgotten again. And so on and so forth. We also have had more experiences like this. When he was here, it was most pleasant. We benefited enormously from his stay, also the students did, with whom he was very kind. This is to help you get over your annoyance, which is never pleasant or helpful.

It must have been quite difficult also to find finances for Plaut's necessary travel to Pasadena and Palomar Observatory. According to Plaut's acknowledgments in the publications resulting from the survey it involved originally the United States Educational Foundation in the Netherlands (Fulbright Travel Grant), Commission 38 of the International Astronomical Union, and the Netherlands Organization for the Advancement of Pure Research (ZWO). Later the Leids Kerkhoven–Bosscha Fund was added. The Kapteyn Laboratorium would have contributed also, but that (understandably) is not mentioned in the acknowledgments.

Almost 400 plates were taken in the photographic wavelength region plus about 90 in the photovisual to measure colors. In the course of the project a field called Baade's Window was added as a final part of the *Variable–Star Survey*. This field had been discovered also by Baade as part of his survey of the region around the Galactic Center and is a field very close (only four degrees) from the actual direction of the Center, (l, b) = (1°, –4°). It is in the brightest part of the Milky Way in this general direction and very uniform, suggesting very little extinction. It is centered on the globular cluster NGC 6522, which is at about 7.5 kpc along the line of sight, so in space close the Center of the Galaxy; the extinction is not zero, but about 'only' 2.5 magnitudes in photographic magnitudes according to Baade (1946). Baade had studied this window extensively with the Mount Wilson 100-inch telescope and discovered some 159 RR Lyraes (also known as cluster-type variables, because they occur in large numbers in globular clusters). Plaut reanalyzed these data, redetermining their periods and the photometric zero-points, using the 1-meter telescope by then available at the La Silla site of the European Southern Observatory. The results of the *Palomar–Groningen Variable–Star Survey* were published by Plaut in six papers, the last one appearing in 1973 (Plaut, 1973, which has references to the earlier papers). It was concluded in 1975 by Jan Oort and Lukas Plaut in a discussion of the whole project in terms of the distribution of RR Lyrae variables in the inner region and halo of the Galaxy and its implication for the distance to its Center and the rotation constants (Oort and Plaut, 1975).

The main effort in the program was to find the variable stars. The problem was the fact that blinking plates was tedious, tiring, slow and difficult to do consistently for anything more than a few hours at most. It was therefore time-consuming and requiring an experienced astronomer. It was known very well that completeness levels were poor except for the largest amplitudes. In general three methods had been in use that provided useful results, always involving two photographic plates recorded at different epochs with the same telescope and the same exposure time. These were the following: The first was direct blinking in a comparator or microscope, where the two plates were examined by rapidly switching the view between the two. The second method involved superimposing a negative of one of the plates on a positive of the other, so that the images of the non-variable stars were canceling. A third option was to examine the plates in a stereocomparator, which meant viewing two plates at the same time each with one eye. All these methods produced rather low completenesses, as could be judged from repeating the process later by the same or a different person. New variables then turned up, but also some were not rediscovered. Of course the chance of discovery depended also on the average magnitude of the star and magnitude difference between the two observations. Whichever method was used, searching for variable stars remained a tedious business.

The classical study in this issue is that by Hendrik van Gent (1933), who worked for a long time as the Leiden observer at the Unie Sterrewag in Johannesburg (Oort, 1947). Using a blink microscope, he found the chance of discovery on a single pair of Franklin-Adams plates around magnitude 13 or 14 and variations of 1 to 2 magnitudes to be usually below 10%. The actual value depended of course on the amplitude of the variation and the phase in the light curve. Astronomers used often ten or more pairs of plates, but even then the incompleteness can be still quite significant. In the famous Volume V of the compendium *Stars and Stellar Systems* Plaut (1965: Appendix I), summarized the completeness issue, and provided further details such as the dependence on type of variable. Obviously completeness in detecting variables was a major concern.

This had worried Plaut for a long time. At the suggestion of a young physicist in Groningen (Herman de Lang) he tried a new method by observing one plate in the blink comparator through blue and one through a red filter, such that non-variable stars were black while variable stars because of their differing dimension on the plates had a blue or red ring around them. He involved student Jan Borgman in this, which resulted in a short note (Plaut and Borgman, 1954), reporting that the method worked well, but also announcing they (this really was Borgman) were developing an electronic device for the purpose of identifying variable objects more completely and conveniently. Indeed Borgman designed and built an instrument for electronic discovery of variable stars in the framework of his PhD research. The thesis that resulted from this was defended in 1956 under Hendrik Brinkman and was titled *Electronic Scanning for Variable Stars* (see Borgman, 1956b). Brinkman was a Professor of Experimental Physics in Groningen. He worked in many areas of physics, and is particularly noted for founding the Nuclear Physics Accelerator Institute in Groningen.

The design was in principle straightforward. It made use of the principle of so-called flying-spot scanning developed for television. On a cathode ray tube, sitting on the floor in Figure 30, a rectangular grid or raster is formed on the screen, and a bright spot is formed moving across that grid. This spot is focused by an optical system from below onto the two photographic plates lying on the table. The optical system divides the light in two by a semi-transparent/semi-reflecting mirror. This system is positioned such that the same portions of the plates are covered by this grid. The light spot on the screen on the cathode ray tube results in two beams of light on the photographic emulsions, at any time illuminating the same position. As the spot moves across the raster on the screen of the cathode ray tube the corresponding spots on the photographic plates are illuminated simultaneously. Two photomultiplier tubes above the plates convert the light transmitted by the photographic emulsions into electrical impulses (a video signal). These signals are then subtracted electronically and the resulting signal is amplified and transferred to the grid of another cathode ray tube, whose dot is synchronous with the dot on the first tube. This then is displayed on the television screen on top. The image shows noise (resulting chiefly from the grains in the photographic emulsions) as a gray background level in positions where the two plates are the same, but show a white or black dot where a variable star is present. Figure 31 shows the results.

Plaut used the Borgman machine to measure the plates from the *Palomar–Groningen Variable–Star Survey*. The Borgman machine was essential for the project because it speeded up the blinking process substantially; with classical methods it would have been impossible within any reasonable time-scale. This was the first time the device was used extensively. He reported that it took 40 hours to search a plate pair (square of 14-inch sides or about 6.5°). The work was still strenuous and could not be done for more than 4 hours a day, so searching each pair had to be spread over at least 10 days. The detection probability for amplitudes in excess of 1.5 magnitudes was over 80%, and still of order 50% for 1 magnitude amplitude, at least for the first field. For the more crowded fields it was worse. As mentioned, Plaut blinked ten pairs of plates for each of the three fields. Altogether the three fields yielded about 1100 RR Lyraes, with 110 more from the reanalysis of Baade's Window, and on top of that determined magnitudes for all objects found on the total set of almost 500 plates. In addition the survey yielded similar numbers of long-period and other types of variable stars, including eclipsing binaries.

The estimation of brightnesses was done visually using the technique introduced by Friedrich Wilhelm August Argelander (1799–1875) and designated the 'Argelander step estimation method', in which a brighter and a fainter comparison star are used and it is estimated where the variable's brightness is positioned as a step value of the fraction of the magnitude difference between these stars. The fascinating history of these magnitude estimations from the Herschels to Argelander and beyond is summarized by John B. Hearshaw (1996: Chapter 2).

The *Palomar–Groningen Variable–Star Survey* was a major, long-term undertaking, extending well beyond van Rhijn's Directorate, actually even beyond that of his successor

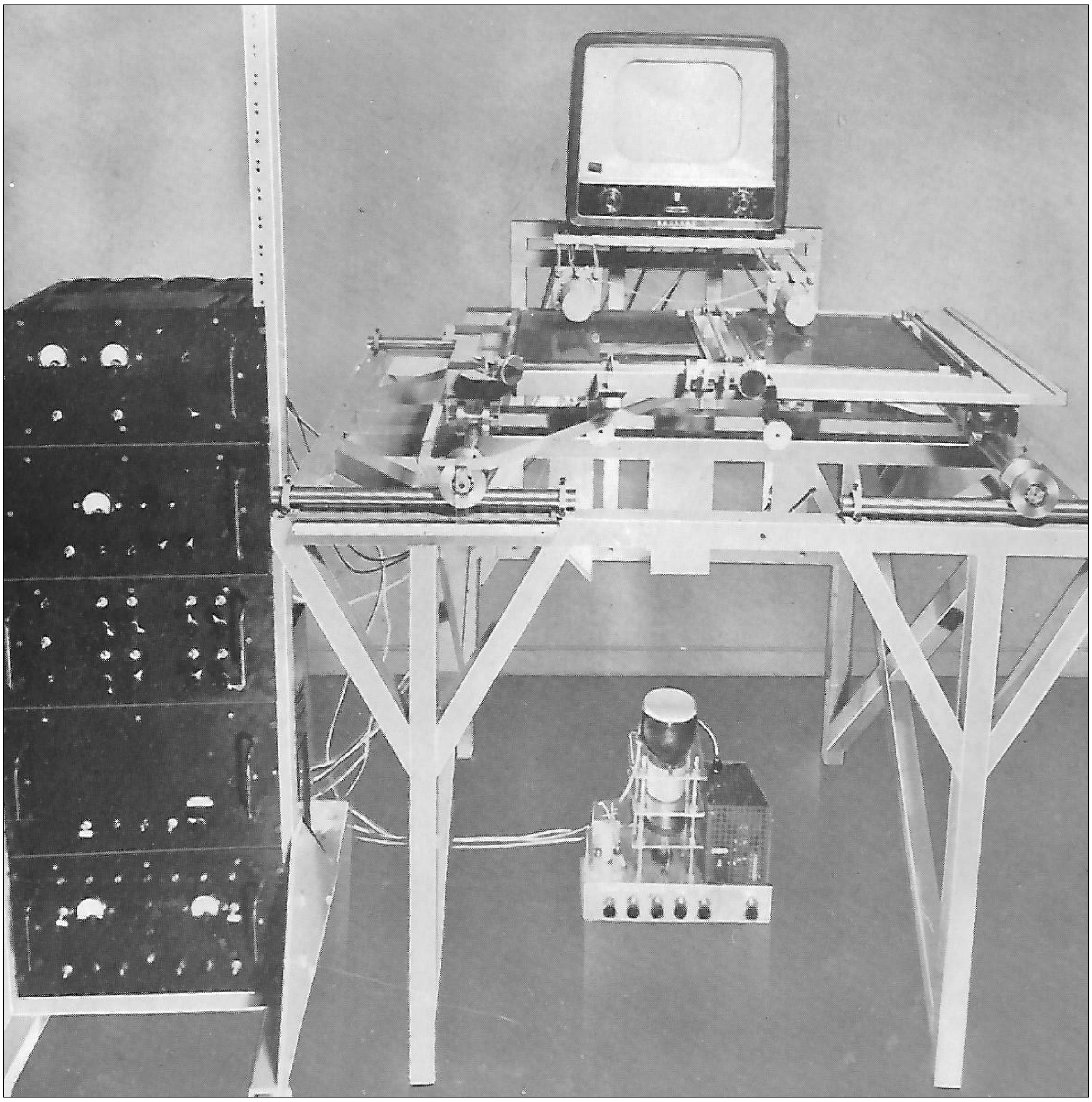


Figure 30 (above): The electronic instrument designed and constructed by Jan Borgman to identify variable stars by comparing a pair of photographic plates. See text for explanation. This work constituted his PhD thesis under Physics Professor Hendrik Brinkman (after Borgman, 1956b).

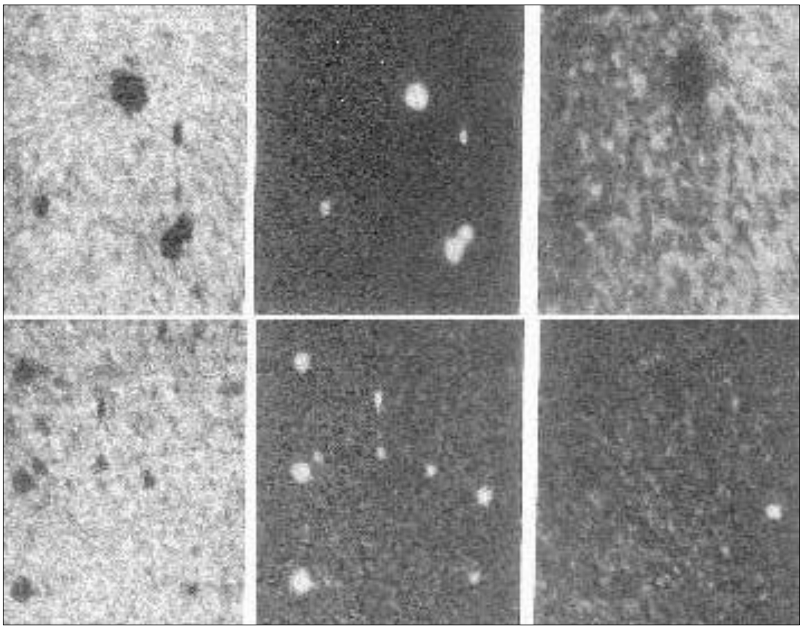


Figure 31 (right): The left panels show images of parts of plates obtained with the Palomar 48-inch Schmidt telescope. The middle panels show the same areas from a different plate but now with the video signal's phase reversed. The right panels show the difference signals. The variable star in the top panels changed from magnitude 12.1 to 13.5, and at the bottom from 17.9 to below the detection limit of 19. Adapted from Borgman's contribution to *In het voetspoor van Kapteyn* (Nederlandse Astronomen Club, 1956) (courtesy: Kapteyn Astronomical Institute).

Adriaan Blaauw. It dominated Plaut's research efforts for the rest of his academic career. The most important results, announced in the paper by Oort and Plaut (1975) was that the distance to the Galactic Center was 8.7 ± 0.6 kpc, and that the density distribution in the bulge and halo to about 5 kpc was almost spherical and varied approximately as R^{-3}. These constituted fundamental, very important results of a very long-term investment of time and effort by Lukas Plaut, but of course they did not generate a stream of press releases announcing a major astronomical breakthrough.

20 VAN RHIJN'S FINAL RESEARCH AND HIS SEVENTIETH BIRTHDAY

The final installment of the *Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung* appeared at the time of the Vosbergen Symposium (in the same year 1953), as did van Rhijn's paper with the first results of the spectrographic work with his telescope addressing the issue of the wavelength dependence of interstellar extinction. In the year before, 1952, finally the measurement of the Harvard plates for positions and magnitudes of stars in the *Selected Areas Special Plan* had been completed and published. It was presented as a separate publication by the Kapteyn's Laboratorium with van Rhijn as first author and Kapteyn posthumously as the only other author (Van Rhijn and Kapteyn, 1952). But other work was going on in Groningen—apart from the programs by Lukas Plaut on variable stars and by Jan Borgman on spectral energy distributions—in the framework of the *Plan of Selected Areas*, as can be seen from the IAU Commission 32 Reports.

In the 1955 Report there is a paragraph on collaborations between 'Alger and Groningen'. This involved proper motions near the Equator. The measurements of these had been performed at the Kapteyn Laboratorium and the plates had been taken at Alger (in Algeria). This institution had been established by l'Observatoire de Paris as l'Observatoire Astronomique de Bouzareah, so named after the suburb in Algers where it had been located. The Observatory had been involved in the *Carte du Ciel* Project, for which it had been assigned the equatorial zone. These plates served as first epoch plates. Their useful extent covered 30–80% of the 3.5° × 3.5° area of those of the *Spektral–Durchmusterung*, which served as second epoch plates. At Alger some special plates were taken to investigate possible systematic errors. The project has been described in some detail by Plaut in (Nederlandse Astronomen Club, 1956). First, relative proper motions were derived for 10,960 stars. These were made absolute using various fundamental catalogues for which there was an overlap for 850 stars. The results were published in 1955 and 1959 in two volumes of the *Publications and of the Kapteyn Astronomical Laboratory at Groningen*, the first part on the relative proper motions by van Rhijn and Plaut (1955) and the part on the absolute motions by Plaut (1959). This enormous volume of proper motions constituted another major investment of time. It is not clear what use has been made of it, since until recently these publications had not been included in ADS (see below).

The second project concerned also proper motions and was a collaboration with the Yale-Columbia Southern station. It was aimed at measuring proper motions of the stars in the zone of declination –15°. The first epoch plates date from around 1927 and the interval was twenty-four years, which meant that the probable error of the proper motion components was ±0.0022. The telescope was the 26-inch refractor originally erected in 1924 in Johannesburg under Frank Schlesinger (1871–1943), Director of Yale Observatory. Actually, when he was at Yale in 1922–1924, Jan Oort was briefly considered to be appointed the astronomer responsible for the setting up of the telescope. Oort went to Leiden instead, but Schlesinger's intervention had meant for Oort an earlier and shorter military service (see van der Kruit, 2019). In 1952 the telescope was moved to Mount Stromlo near Canberra, Australia, where it was destroyed in a bush fire in 2003. The proper motion survey was set up by Dirk Brouwer and Jan Schilt after they had become Directors of Yale and Columbia respectively, and they initiated the collaboration and orchestrated the move from Johannesburg to Canberra. The plates were measured in Groningen, but as far as I am aware the results were never published.

These two programs did constitute the final contributions from Groningen to the *Plan of Selected Areas*.

As indicated above, Borgman took over the program of determining the wavelength dependence of interstellar extinction with the Groningen telescope. As already described above, he published two more papers on this subject (Borgman, 1954; 1956a). As he stated in the Introduction in the second of these:

> The publication of these results concludes the present investigation; the material available for our instrument and method is almost exhausted and, moreover, it is considered that the present state of photo-

> electric techniques does no longer justify a photographic investigation of the absorption law.

So the paper by Borgman in 1956 marked the end of research with the Groningen telescope. The total outcome was three papers on wavelength dependence of extinction, when the technique was actually no longer state-of-the-art. Most likely, the telescope had also been used for student training (when there were students).

I will briefly summarize Borgman's further career. As we have seen, after completing the work with the Groningen telescope Borgman developed instrumentation to help identify variable stars for Plaut and the Palomar–Groningen Survey. He then moved on to photoelectric photometry, and was introduced to Yerkes and McDonald Observatories. This was undoubtedly through Adriaan Blaauw, who was Adjunct-Director at Yerkes under Gerard Kuiper as Director, and in 1957 became the new Director in Groningen. Borgman collaborated with Bill Morgan and Bengt Georg Daniel Strömgren (1908–1987) at Yerkes and McDonald Observatories and with Harold Lester Johnson (1921–1980) at Lowell Observatory, and observed extensively at McDonald and Lowell. Borgman developed a seven color narrow-band (width 5 to 10% of the wavelength) photometric system and designed a new d.c. amplifier (which was used to amplify the output photo-current of the 1P21 photomultiplier used in the photometers). With this seven color system he analyzed the spectra of OB-stars and attacked again the problem of the wavelength dependence of extinction. Eventually he became Director of the new Kapteyn Observatory at Roden (15 km SW of Groningen) and his career moved to infrared, ultra-violet and balloon and space astronomy and in the 1970s on to science administration. He became Dean of the Faculty of Mathematics and Natural Sciences, Rector Magnificus and Chairman of the Governing Board, all of Groningen University, before moving to Den Haag as Chairman of the Netherlands Organization for Scientific Research NWO and finally Brussels as first Chairman of the European Science and Technology Assembly of the European Commission.

In 1956 van Rhijn turned seventy, the age of retirement. There was a small event celebrating this milestone, honoring him for his accomplishments and major contributions. A special booklet was produced titled (in English translation): *In Kapteyn's Footsteps: Sketches of the Work Program of Dutch Astronomers, Offered by Friends and Colleagues to Prof. Dr P.J. van Rhijn on the Occasion of His Seventieth Birthday* (Nederlandse Astronomen Club, 1956). This was published by The Dutch Astronomers Club, and dated Groningen, 7 April 1956. Van Rhijn's birthday was on 24 March. The date 7 April 1956 was a Saturday, so it was offered at a Special Meeting of the NAC on that date held in Groningen. The contributions to the booklet do not look like written accounts of oral presentations, but rather short contributions written for the occasion.

It gives the impression of a sloppy, hastily prepared document (see Figure 32). It was produced using cheap offset printing, bound cheaply with a soft cover without any illustration. On the Contents page the entry has Bart Bok's name typed as 'B.J. Kok', and then corrected by over-typing the 'K' with a 'B'. There is no Introduction, and the editor or coordinator is not identified. There is a picture of van Rhijn in the front of the booklet (Figure 33), but without a caption. As indicated by the correspondence below, Lukas Plaut organized the meeting and collected the contributions for the booklet.

The title refers to an expression quite similar in Dutch and in English, meaning 'Following Someone's Example' or 'Going to Do Something Similar to What Someone Else has Done Before'. Maybe unintended, this points to a lack of originality; after all, in a literal sense, putting your feet on the same spot as another person means you are not breaking new ground. This choice for the title of what could have been a Festschrift is a rather minimal token of appreciation, just like the lack of any prominent obituary in international journals after van Rhijn's death.

There is a little more background in the Oort–Blaauw correspondence (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 161). On 21 February 1955 Oort mentioned that he had received a letter from Lukas Plaut (this is not present in the Oort Archives), and noted that he was uncertain what to do about this. It was a typed letter in Dutch, so what follow is my translation:

> From Plaut I received a letter these days, a copy of which you will find enclosed. I do not really know what to make of it. I think it is very difficult for the people he mentions to write something in 2 or 3 pages that would be of use to van Rhijn. That is why I think it would be more appropriate to offer his complete work in beautifully bound volumes, and perhaps also an album with photos and signatures of all the people who have just collaborated with him. Let me or Plaut hear what you think about this.

On 27 February 1955 Blaauw wrote to Oort

IN HET VOETSPOOR
VAN KAPTEYN

Schetsen uit het Werkprogramma van Nederlandse Sterrekundigen

aangeboden door vrienden en collega's aan

PROF. DR P. J. VAN RHIJN

ter gelegenheid van zijn zeventigste verjaardag

De Nederlandse Astronomen Club – Groningen, 7 april 1956

Figure 32: The title page (above) and table of contents (right) of the booklet *In het voetspoor van Kapteyn* presented to van Rhijn at his 70th birthday (Nederlandse Astronomen Club, 1956)(courtesy: Kapteyn Astronomical Institute).

On 27 February 1955 Blaauw wrote to Oort from Yerkes (handwritten in Dutch, my translation):

> I am as unenthusiastic as you are about Plaut's proposal concerning the tribute for van Rhijn. I seriously doubt that van Rhijn would care much for a collection of essays as proposed by Plaut, especially if we apparently do not think it is worthwhile to print them. I also doubt that I could get people like Ambartsumian and Baade to write such an unpublishable article.
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> I believe that the tribute should in any case have a rather intimate character and should be limited to those who have worked with van Rhijn. I would feel very much for an album with signatures and photographs and perhaps letters addressed to van Rhijn from these fellow workers. One could then indeed expand it with a nicely bound collection of van Rhijn's works, but I do not find that solution ideal. The collection cannot be complete, for how can the work on the Bergedorfer Spektral Durchmusterung be represented in it. And would van Rhijn really care enough? He will probably rarely look in it, since he has his notes in his much-used hand copies anyway. What do you think of the idea of having all those who received their doctorates from him write a short article about the current view of the subject of their dissertation? Such articles, which at the same time give a picture of the development of astronomy, might be of interest to

Figure 33: Photograph of van Rhijn as the frontispiece of the`Voetspoor' booklet of Figure 32. There is no caption or accompanying text (Nederlandse Astronomen Club, 1956) (courtesy: Kapteyn Astronomical Institute).

> a wider public and could be printed somewhere in Dutch or English. Writing this would not be any problem for most participants. Would the articles not be suitable material for Hemel en Dampkring, e.g. a special issue. That would reduce the costs.

Interestingly, they refer to him as 'van Rhijn' and not 'Piet' or 'Pieter', which if talking about a mutual good friend would be more logical (however, they refer to 'Plaut' rather than 'Lukas'). They used first names throughout their correspondence for most other colleagues. On 12 October Blaauw wrote (typed, and in English):

> I have been very busy lately and not given much thought to the Groningen succession. I just received Plaut's letter for a short article, which I shall write.

No further mention of the whole business occurs in subsequent letters between Oort and Blaauw. From this correspondence it appears that Lukas Plaut played a definite role in setting up the tribute on the occasion of van Rhijn's imminent retirement and invited people to contribute to a small publication with collected contributions by friends and colleagues. Plaut edited the booklet, and in his modesty felt it inappropriate that he should add an Introduction, or even mention his role.

The 13 contributors comprise van Rhijn's students Jan Schilt, Jan Oort, Bart Bok, Jean-Jacques Raimond, Peter van de Kamp, and Adriaan Blaauw, and also Jan Borgman. Dirk Brouwer was a Leiden PhD but collaborated in the *Plan of Selected Areas*. Lukas Plaut was a colleague and collaborator, Henk van de Hulst and Piet Oosterhoff were important colleagues from Leiden, while Herman Zanstra and Marcel Minnaert were Directors of the Astronomy Institutes in Amsterdam and Utrecht. All of them described their own work or that of their Institutions, usually, but not even always, concluding with a sentence or two of personal appreciation of van Rhijn, but nowhere is anything included like a summary of van Rhijn's contributions or a statement of the importance of his work. Those people who had emigrated to the USA and established themselves permanently there (Bok, Brouwer and van de Kamp) wrote in English, the rest in Dutch. It seems, altogether, not a volume intended for a wide audience.

The Oort Archives (Website accompanying van der Kruit, 2019, No. 149) contain a text of the speech Oort gave at the special NAC meeting, when the booklet was presented. He acknowledges Plaut's editorial work and regrets that he is not present. He describes the set-up as letting each contributor address what interested them at the time. Oort does review van Rhijn's work in some detail and notes (my translation):

> Prof. van Rhijn saw, as it were, a great task before him when he was appointed to the Groningen Laboratory, and he has been completely faithful to this task during the long period he has been attached to it. This commands admiration. It is clear from the scope of this work, but also from its nature. It is a task that only someone capable of self-sacrifice can accomplish.

And Oort finishes by saying

> Both you and I will be reminded on this occasion of a day when, I believe almost ten years ago, in more intimate circle, we also faced each other in much the same way. What I remember most about that day, Piet, is how beautifully your friend van der Leeuw, who died so much too soon, spoke to you then.
>
> Van der Leeuw then spoke to you. He more or less said that the main reason why he felt such a warm friendship for you was your aversion to making too much fuss and your simplicity, which springs from a deep-rooted sense of truth.
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> It is not only van der Leeuw who saw this in you. We all appreciate you for this.
>
> It is also because of this that today, instead of the frills of an official tribute, we only wanted to give you something of that which ultimately affects us most deeply: our own work.

It would have been fitting had Oort provided an introduction along these lines or an advance summary of this speech to include in the booklet.

In his final years before retirement, and actually also beyond, van Rhijn published three more papers in the *Publications of the Astronomical Laboratory at Groningen*, the final one even the last volume in that series. The institute publications in the Netherlands existed alongside the *Bulletin of the Astronomical Institutes of the Netherlands*, which had been founded as a national journal in 1921. *The Supplement Series* of the BAN was instituted in the 1960s, the first volume starting in 1966 and in anticipation the institute series had already been phased out by then. Between 1960 and 1966 there had been no need for a Supplement publication from Groningen, but eventually Plaut used the new series and published his measurements from the *Palomar–Groningen Survey* in the *Supplements of the BAN*.

Van Rhijn's final research was quite original and timely. It actually resulted also from the Vosbergen Symposium, where the local structure in the Galaxy was seen as an important and urgent subject of research. He started determining the space distribution of A0-stars near the Sun from low latitude *Selected Areas* and for higher latitudes for A0- to A5-stars, also in *Selected Areas*, but other sources as well as in cases, where the number of A0-stars in the Areas is too small (van Rhijjn, 1955). It was suggested at Vosbergen to use A0-stars because of their small spread in intrinsic luminosity. The spectral types were taken from *the Henri Draper Catalogue, Bergedorf(–Groningen–Harvard) Spektral–Durchmusterung* and the Potsdam southern equivalent, and the magnitudes were corrected for absorption from the color excesses, which could be determined since the spectral types were known. The densities then followed from the distribution of corrected apparent magnitudes and the luminosity function, which he assumed to be a Gaussian around a mean value with 0.5 magnitudes dispersion. Within 200 pc of the plane of the Galaxy he found that the A-star density correlated with the hydrogen density derived from the 21-cm surveys at Kootwijk by Leiden observers.

Next van Rhijn (1956) turned to K-giants, doing essentially the same thing. The percentages of giants among K-stars was taken to be the same as in various detailed studies in the literature. Using new determinations of the hydrogen densities derived in Leiden he found that for A-stars that were closer than 50 pc from the Galactic plane their density correlated with that of hydrogen, whereas for K-giants there was no evidence of such a correlation. Above 50 pc neither the A-star nor the K-star distributions correlated with that of the hydrogen. Typically for van Rhijn, there is no discussion of what this would mean for understanding Galactic structure or the presence of spiral arms.

Van Rhijn's (1960) final research paper appeared after his retirement, and concerned the ellipsoidal velocity distribution of the A stars as a function of the distance from the Galactic plane. He extended his study of A0 stars to A5 at low latitudes using proper motions to derive the distribution of their random motions, and from this the properties of the Schwarzschild distribution, the dispersions in the principal directions and the vertex deviation (see Section 8), at various distances from the plane of the Galaxy. Solving for the axes of the velocity ellipsoid for a sample of stars can be done from their distribution of proper motions (the components parallel and perpendicular to the Galactic Equator) using a method developed in 1948 in Leiden by Coert Hendrik Hins (1890–1951) and Adriaan Blaauw. Van Rhijn found the dispersion of the motions to increase with vertical distance, while their ratio's remained more or less constant. These and the vertex deviation of 26° were not unreasonable. He attributed the change in mean vertical velocities with height above the plane to a mixture of two components with different velocity dispersions. Although he investigated the possibility of a difference in spectral types among the two distributions and presented for this a table, but he failed to discuss this table and to draw any conclusions from it, nor did he discuss the implication for our understanding of the structure of the Galaxy. Note that this was published in 1960, when the concept of Stellar Populations was widely accepted and a discussion of the results in this context would have been highly appropriate. The two components had dispersions of about 10 and 25 km/sec (the smaller one contributing some 90%), so could in terms of the scheme of the Vatican Symposium of 1957 be interpreted as young population I and the (older) disk population (Blaauw and Elvius, 1965). In that context it would have been no surprise that A-stars, being relatively young, would overwhelmingly be part of the young Population I.

These three investigations, comprising van Rhijn's final research, stemmed from the Vosbergen Symposium. The results were interesting and provided new insight; yet, van Rhijn presented them without any real discussion on what the impact would be on our understanding of Galactic structure at a fundamental level. Unfortunately, their impact as revealed by citations cannot be evaluated with the ADS. During this research I discovered that the last six volumes of the *Publications of the Astronomical Laboratory at Groningen* were not included in ADS. It turned out that the scans were in the system, but for some reason the corresponding records were not created. I was promised this would be corrected.

21 VAN RHIJN'S SUCCESSOR

Van Rhijn's retirement would be at the end of of the 1955–1956 academic year. The University of Groningen had the choice between on the one hand continuing the Laboratorium and try and raise its prominence to what it had been in Kapteyn's days by appointing a prominent astronomer, or on the other, to close it and arrange for a Physics Professor to take care of Astronomy teaching as a task secondary to his main activities, or appoint an astronomer from Leiden (Utrecht and Amsterdam were possibly even too small in staff for this) to come on a part-time basis to teach. In the end they chose to pursue the first option. But it was clear that there was a need for not only a change in leadership but in addition a modernization of the way the laboratory was organized, and associated with that new investments and an increase in staff were required. The complete reliance on other observatories providing plates, to be measured and reduced in Groningen, was no longer a guarantee for success.

Van Rhijn was very concerned about the issue of his succession, and the future of his Laboratorium. Already on 24 November 1952 he wrote to Oort (from the Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149, my translation):

> Dear Jan,
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> I would like to write to you about a matter which has been occupying me for some time now and which also gives me concern, namely the future development of the Kapteyn Laboratorium.
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> As you know, the possibilities for work here are very limited, Kapteyn has tried to establish a proper possibility for scientific research in Groningen, which he has been refused. The only possibility, which I saw to change this, was the purchase of a second-hand mirror, which happened to be offered to me at the time. I have had the greatest difficulty in obtaining permission to install the instrument on the roof of the laboratory from money from private funds, that is how strongly 'Den Haag' [the Minister] was opposed to expansion. The instrument is very useful ... But the weather in Groningen is too bad for photometric work. A few years ago I applied to Z.W.O. for a spectrograph, which of course can be used even if the sky is not too clear. The application was turned down. And so we are still stuck with very limited possibilities of research. Many times I have received a refusal on a request to take plates and even if they were granted, the work of the Groningen laboratory was subordinated to that of the particular Observatory itself. It is not my intention to reproach anyone for this. But it does make research in Groningen very difficult.
>
> In a few years time I will have to resign and of course I am thinking about the future of the Kapteyn Laboratorium. It has been suggested a few times to close the laboratory as a financial cut-back measure. I would regret this very much, not only because the University of Groningen is already disadvantaged in several respects compared to Leiden and Utrecht, but also because a concentration of Astronomy does not seem to me to be in the best interest of the enterprise. Just think of the time of Bakhuyzen in Leiden, Nijland in Utrecht and Kapteyn in Groningen. Leiden and Utrecht were of little importance for the development of Astronomy at that time. Especially in such times the importance of an independent institute, which goes its own way, becomes apparent.
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> If, however, Groningen is to continue to exist, there will have to be other possibilities for research here in the future than there have been so far. But I have given this matter some thought and one obvious possibility is radio research. In the decisions to be made concerning this research I would ask you to consider the possibility that in the future the Groningen astronomers will wish to participate in this research. I would also be glad to attend the meetings of the Foundation, since the development of radio research in the Netherlands is, in my opinion, also very important for the future of the Kapteyn Laboratorium. What do you think of this?

Oort replied on 29 November 1952, saying among other things (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149; my translation):

> The starting point is who you will be able to get as your successor upon retirement. Should Blaauw by then be available for that, I would not be the least bit worried about the future prosperity of the lab.

He then went into a long argument as to why it was difficult to add another astronomer to the Board of the Foundation for Radioastronomy, in the end suggesting that

> ... you attend a meeting occasionally, when an issue in which you have a special interest is on the agenda? Another possibility would be to have somewhat alternating meetings to discuss the technical issues of the instruments and the like and meetings to discuss the general scientific side, which could then include a few more people.

The issue of Oort keeping van Rhijn off the Board of the Foundation for Radioastronomy is beyond the scope of this paper, but has been treated in detail by Astrid Elbers (2017) in her thorough study of the history of Dutch radio astronomy and need not be covered here. In the end the outcome was that van Rhijn joined the Board. On 14 September 1956, according to him a few days before his formal retirement, van Rhijn wrote to Oort, saying he was grateful the latter considered including others than Leiden astronomers join the Board of the Kerkhoven–Bosscha Fund, but he complained rather bitterly that he (and Kapteyn) had been denied an observatory with the argument that two (in Leiden and Utrecht) were enough, yet now a very expensive third one was being built (in

Dwingeloo) without involving the Groningen Director in this.

Returning to the future of Astronomy in Groningen, I will now quote from a letter that van Rhijn wrote to Oort on 15 December 1952 (Oort Archives, Website accompanying van der Kruit, 2019, Nr. 149; my translation). On the issue of appointing a successor or closing the Laboratorium, he described the position of the Faculty:

> In such a Faculty [covering the Natural Sciences] astronomy should, in the opinion of our Faculty, be represented. Astronomy is too important to leave the teaching of that subject to a lecturer who comes to Groningen once a fortnight from the west of the Netherlands.

This shows that there was a firm decision in Groningen to continue with a Professor and an Institute in Astronomy. He continued:

> If one develops the practice of astronomy at an institute to a very high degree compared to others, then there is a danger that the smaller institutes will be closed down as prosperity declines in the Netherlands. Thus in 1932 the plan was to close down the Observatory in Utrecht and the Kapteyn Laboratory was in those days also on a proposal to disappear. All the more reason not to make the difference in size and importance of the various institutes too great.
>
> It is undoubtedly true that a competent astronomer, appointed as my successor, will be able to bring the Kapteyn Laboratory to a favorable development. But it is precisely the question of how to make the appointment to Groningen plausible for this man, and to this end new possibilities for scientific work will have to be created here. Otherwise he will be grateful for the honor, but look for a job elsewhere.
>
> Sending a Groningen astronomer abroad to collect material could indeed partially solve the difficulties. The Kapteyn Laboratorium would have to have a workshop for the production of instruments and tools, which are not available at the observatory. If one does not have access to a workshop, it will be very difficult to undertake something new and one is dependent upon work of the same nature as is already done at that observatory. In this way one remains dependent upon the directors of other institutes. This remains a major obstacle, as I have painfully experienced on several occasions.

Van Rhijn added to the letter:

> P.S. I am convinced of Blaauw's abilities. His articles on the O-associations I have read. It is excellent work. It seems unlikely to me that he would be willing to come from Yerkes to Groningen in a few years time. If he feels somewhat at home in America he will stay there because of the greater possibilities for research.

So, Jan Oort had been involved from an early stage on. It was obvious that his favorite was Adriaan Blaauw. The problem was, of course, the latter's move to Yerkes Observatory. In the Oort Archives (Website accompanying van der Kruit, 2019, Nr 161) we can find some correspondence between Blaauw and Oort on this issue. On 8 March 1956 Blaauw wrote (handwritten, in Dutch) to Oort (my translation).

> Dear Jan,
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> As you will of course know, van Rhijn has indeed asked me, on behalf of the Groningen Faculty, to succeed him. I have already replied to him that I am seriously considering the offer, and have exchanged views with him about certain conditions which I believe must be met in any case. However, I have also made it clear that my decision will also depend on the future character of my position here, which, now that the first three-year period ends soon, will have to be reviewed in any case. On this last point I have not yet heard a decision. Nevertheless, I am resolved to make the decision within a few weeks whether or not I desire the Groningen position, at least in principle. Van Rhijn would like a speedy decision.
>
> I have already informed van Rhijn, among other things, that I believe that the special character of the laboratory as a place for processing material obtained elsewhere could be fruitfully maintained if the necessary arrangements were made so that regularly Groningen observers could personally collect the material elsewhere. This requires, among other things, a guarantee of a relatively high annual travel fund, and an expansion of the staff with at least one young and energetic astronomer.
>
> A subject to which van Rhijn alluded but which I do not yet clearly understand concerns the part that Groningen should play in radio astronomy. Van Rhijn did mention that Groningen has a seat on the board of the Radio Foundation, but I would like to be clear first of all of the view that you and Henk van de Hulst have on this. You may remember that we touched on this point during our conversation in Hamburg last summer, and my impression was that you were rather reserved about the participation of other institutes in the 21 cm work ... Would you write me what you think now of a possible Groningen share in Dutch research? Of course I would also like to hear your views on the Groningen research work in general.

He added that he will drop the plan to visit the Netherlands that summer partly in view of his possibly going to Groningen, but mainly because of a serious backlog of work. This apparently crossed a letter by Oort to Blaauw on 12 March in which Oort mentioned that he had already heard from Maarten Schmidt that Blaauw would not visit the Netherlands that summer, but invited him to come in the fall for a few months as lecturer on a temporary position.

When Oort received Blaauw's letter he answered immediately, on 14 March 1956 (my translation):

> Dear Adriaan,
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> ... I am glad that now Groningen has taken the first step and congratulate you with the fact that you have been placed as Number 1 on the list. I have not seen van Rhijn for a long time, it seems as if his already very limited appetite for travel has become even less lately.
>
> I don't have to tell you how much I would enjoy your coming to Groningen. There is not the slightest doubt in my mind that we would work together pleasantly and fruitfully in all the areas you would like. I hope that you feel the same way and that you would never feel that the larger Sterrewacht in Leiden is drawing too much in for itself. This is certainly not our ideal. It is our ideal to build a useful collaboration for all concerned. Groningen, Leiden, Dwingeloo, Hartebeestpoort and Pretoria could form a wonderful set of institutes for research of the Milky Way system, interstellar media and evolution.
>
> I meanwhile agree with you that making ample funds available for travel to America and South Africa and expanding the staff with a scientific staff member for Groningen are the necessary conditions for healthy development. In most cases this can at present be done incidentally through applications to Z.W.O. Although the acceptance of such requests will depend on the resources available at Z.W.O. and the number of other requests, in my experience if the request is well-founded we can almost count on it being accepted ...
>
> But now to the actual question. I can answer without reservation that there will certainly be very much room for Groningen to participate in the work of the radio observatory, at least if someone like you were to come and put it in good shape ...

As remarked above already, it is remarkable that both Blaauw and Oort kept referring to 'van Rhijn' without using his first name, while they used first names addressing each other, and in their correspondence used first names when referring to e.g. Henk van de Hulst or Pieter Oosterhoff (although in correspondence above they refer to 'Plaut' without using his first name). Both Oort and Blaauw had obtained their PhD's with van Rhijn as their 'promotor', but were senior now themselves. Oort addressed van Rhijn as 'Piet' when writing him, and Blaauw probably did the same.

The reference to 'Dwingeloo' of course is to the 25-meter Dwingeloo radio telescope, about to become operational, and 'Hartebeespoortdam' to the Leiden Southern Station. This latter facility resulted from the condition for Hertzsprung to accept his appointment in 1918 that there should be a southern telescope for his research. Willem de Sitter then had arranged access for Leiden to the facilities of the Unie Sterrewag in Johannesburg, including the Franklin-Adams Telescope (referred to as F.A. below). Later this was extended with the Rockefeller Telescope, a twin 40-cm astrograph, that Leiden had built from funds provided by the Rockefeller Foundation. After the War Oort had furthermore arranged funding from Leiden University for an additional 90-cm 'light-collector', which would become operational in Hartebeespoortdam near Pretoria in 1958. It was to be out-fitted with a five-channel photometer built by Théodore (Fjeda) Walraven (1916–2008). The Leiden station (and the Unie Sterrewag telescopes) were moved from Johannesburg to Hartebeespoortdam in 1957.

Oort followed his letter up on 16 April 1956 (my translation; 'Pieter' is Pieter Oosterhoff):

> In this connection I would like to write to you that during the NAC meeting in Groningen, where van Rhijn was honored, Borgman gave a lecture with demonstration on the electronic blink-machine. I was very impressed by the skill and complete mastery of the subject which he demonstrated. He has thought the problems through exceptionally well and also has great skill in putting things together so that they work effectively. He reminded me very much of Walraven in this respect, only he is much calmer and more balanced, If you could keep him in Groningen you would, I believe, have a worker of the very highest quality.
>
> Indeed I have written to the Groningen Faculty that we would also like to foster a collaboration at our Southern Station. Pieter and I have reviewed this after receiving your letter. We are of the opinion that there will be room enough to also have Groningen observers there at times, when we have both the light-collector and the Rockefeller there as well as part of the

> F.A. Moreover, Walraven is going to build another telescope for continuous observation of special variable stars ...
>
> Fee for the use of our instruments we would rather not want to ask. Only if you occasionally want to take over part of our time with the Radcliffe telescope would it be reasonable if Groningen would bear the cost.

However, on 20 April 1956 Adriaan Blaauw wrote (typed, in English):

> Dear Jan,
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> I have, after long hesitation, decided to decline the offered position at Groningen, It was a most difficult decision to make, and several times during the past two months I felt strongly inclined to go back to [the Netherlands]. But I was, after all, not really convinced that it would be worth discontinuing my present position and work, and transferring my family again, especially not because I believe there are other astronomers who may be interested in this position and do as good a job – and who at present work under less favorable circumstances than I do.

He must have had a particular person in mind, but did not specify who it was. Oort urged him to reconsider, or at least postpone a final decision, until after the summer when he might spend some time in Leiden and could visit Groningen. In a handwritten PS (to an otherwise missing letter to Oort on 29 May 1956), Blaauw mentioned that van Rhijn had asked him who he had had in mind and that he had told him it was Bruno van Albada.

Gale Bruno van Albada (1912–1972; for an obituary see Oort, 1973), uncle of at that time student Tjeerd van Albada in Groningen, had studied in Amsterdam and obtained a PhD under Pannekoek in 1945. The thesis was in Dutch but concerned pioneering methods of analysis of spectral lines to obtain chemical element abundances that would come to fruition only after electronic computer were used, and he worked on theories of the origin of the chemical elements. After a short stay in the USA van Albada moved to Indonesia in 1949 to become Director of the Bosscha Sterrenwacht, which he rebuilt into a working observatory under extremely difficult (Adriaan Blaauw would euphemistically say 'less favorable') circumstances.

From the correspondence between Oort and van Rhijn it can be learned that Oort suggested all activities in Groningen related to van Rhijn's succession should be postponed. Blaauw was to visit Leiden in the fall and Oort seemed hopeful he could persuade Adriaan Blaauw to visit Groningen and reconsider. It turned out, according to this exchange, that in addition to van Albada, Peter van de Kamp also was reconsidered an option. He was a student of van Rhijn and worked in the field he had always worked in, astrometry. Van Rhijn asked Oort his opinion of these two people without giving his own. Apparently he did not know van Albada very well. He wrote to Oort (7 May 1956, my translation):

> We have heard that he is stubborn and finds it difficult to accept the opinions of others. These traits would make it difficult to work with the Faculty.

Oort replied that he never had any problems with van Albada and if he had a difficult character that was "... more appearance than reality." He did think van de Kamp would certainly do good work, but Groningen needed someone with the "... enthusiasm and talent to start something new." Of the two he definitely preferred van Albada.

Blaauw in the meantime had also himself suggested to postpone any decision until September when he was to visit the Netherlands. As far as I am aware, van Albada and van de Kamp were never approached.

Through Oort's intervention (as seems the case according to the exchange of letters) Groningen University postponed the decision and decided not to approach van Albada, and await Blaauw's reconsideration. Eventually, but a few years later, Bruno van Albada felt forced to leave Indonesia in view of the growing discontent towards Dutchmen as former colonizing nationals. He moved to Amsterdam in 1958, where he became Director in 1959.

Blaauw indeed spent a few months in Leiden in the fall of 1956, eventually October and November, on a temporary appointment as a lecturer, arranged by Oort. The visit had the effect Oort had hoped for. On 10 December 1956 Adriaan Blaauw's wife Atie wrote to Oort that the day after his return Adriaan had fallen ill with what had been diagnosed in the meantime as jaundice and was unable to write himself (my translation):

> In principle A. has decided to accept the position, but he needs to write to Groningen about further details ...
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> Prof. van Rhijn does not yet know all this; A. has not talked to him about this. What do your think of this in principle?

Oort responded on 17 December that "Mieke and I are very much delighted."

Blaauw accepted the position in Groningen, but with some specially agreed on conditions. These were: a new staff position, travel fund for observing; and provision to build an observatory with a workshop to build instrumentation outside Groningen. Hugo van Woerden was appointed to the new staff position to start radio astronomy as part of the research effort. Jan Borgman and student Tjeerd van Albada did site surveying in the area around Groningen and found the village of Roden, 20 km to the southwest of Groningen, to be best in terms of darkness at night and accessibility. The Kapteyn Sterrenwacht was inaugurated there in 1965, with a 62-cm telescope.

On 1 September 1956 Adriaan Blaauw had become Adjunct-Director of Yerkes and McDonald Observatories, so his future in the USA seemed very bright. Yet, he decided to accept the Groningen Directorship. In 1984 Blaauw celebrated his 70th birthday, and on this occasion, in September 1984, the Dutch astronomical community organized a symposium to honor him. At that meeting, Hugo van Woerden, who was Blaauw's first PhD student and his first appointment at Groningen, gave an extensive overview of Blaauw's career (van Woerden, 2005), and I quote from this:

> Groningen had acquired world fame under Kapteyn in 1900-1920. But while van Rhijn, as successor to Kapteyn (1921–1956), had continued the latter's work with distinction ... the Kapteyn Laboratory had remained small and poorly equipped, and its research no longer drew much attention.
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> Within the Netherlands, astronomy was dominated by Leiden under Oort's directorship. Leiden Observatory was 'big' and famous; it had 3 full professors (Oort, Oosterhoff and van de Hulst), a tenured academic staff of about 10 plus a dozen or more graduate students; its personnel totaled about 40. Its pre-war fame due to de Sitter, Hertzsprung and Oort had been strongly enhanced by post-war developments, notably the 21-cm line studies of rotation and spiral structure of our Galaxy, but also research on interstellar matter, stellar associations, comets and variable stars. Utrecht, with Minnaert as professor, and Houtgast and de Jager as associate professors, was smaller but growing rapidly; it was famous for its solar work and developing in stellar astrophysics. Amsterdam, under Zanstra, was small but had many good students. Groningen, with van Rhijn retiring, had one staff member (Plaut), one scientific assistant (Borgman), 3 computing assistants, one draftsman, one junior technician, no secretary, and ... no students. Borgman's doctorate in 1956 had been the first in 10 years.

That is to say, no graduate students. In 1957 Tjeerd van Albada and Harm Habing entered their fourth and third year respectively as undergraduate students. Then,

> By early 1968, when Blaauw accepted the Scientific Directorship of ESO, the total number of people working in the Department amounted to about 40 — a growth by a factor of five in ten years.

Now the question is, what made Adriaan Blaauw accept the appointment at the Kapteyn Laboratorium? And why did he go to Yerkes in the first place? For this it is important to find out what kind of person he was. First note that Blaauw was a person who liked adventures, challenges and exploring new grounds. But he was also unconventional and could be annoyed and amused at the same time by bureaucracy. To illustrate this consider the following anecdote. In the central building at the University of Groningen (the Academy Building) many rooms are decorated with paintings of well-known (Emeritus) Professors, dressed in gown, jabot and sometimes barret (e.g. see Kapteyn in Figure 2). Now Blaauw was not regarded as an Emeritus Professor, as he had resigned in 1975 and therefore never retired from a Groningen Professorship. And the administrators adored bureaucracy, as they were careful not to set any precedents. After his retirement from Leiden Blaauw had been given the status of guest researcher in Groningen, because he lived nearby, but that would not qualify him to have his portrait added. It meant he also did not receive the announcements and invitations that other emeriti did. As were others, I was annoyed by this and thought it was thankless and unfair, and I appealed a few times to the upper officials, trying to use my weight as Director of the Kapteyn Institute or Dean of the Faculty of Mathematics and Natural Sciences, but all to no avail. Blaauw was on the one hand a bit piqued by this bureaucratic nitpicking, but foremost he was amused. We were unable to break this deadlock for a long time. With Adriaan's upcoming 90th birthday in 2004 we wanted to add a painting of him to the gallery in the Academy Building. In the end Rector Magnificus Simon Kuipers intervened and Blaauw was appointed for one year as an Honorary Professor so that he would qualify for the status of a Groningen Emeritus Professor after that and a painting of him was added. Typically for Adriaan Blaauw, he selected without hesitation by far the most unconventional painter of those that he could choose from. This was Adriana Engelina Maria (Janneke) Vieger. His portrait was displayed on the cover of the Institute's 2004 *Annual Report* (van der Kruit, 2005), and is shown here in Figure 34.

That Blaauw was also adventurous can be illustrated with his travels when a young staff member in Leiden. He has told on many occasions that he very much enjoyed his participation of the second Kenya expedition of the Sterrewacht Leiden. These two expeditions (in 1931–1933 and 1947–1951) aimed at measuring absolute declinations, that is to say free from corrections for flexure in the telescope and atmospheric refraction. The principle is that at the equator declinations can be measured as the angle along the horizon (azimuth) between the positions where a star did rise and set or between one of these and that of the north (Katgert-Merkelijn, 1991, or van der Kruit, 2019). Blaauw was at the Kenya site for five months in 1949–1950. His description of the extensive travel involved, full of detours through Africa, in his autobiographical contribution to the *Annual Review* (Blaauw, 2004) illustrates very well his adventurous character.

With this in mind we can understand that Blaauw gave up a permanent position in Leiden to accept a temporary one at Yerkes and McDonald with less pay. Of this he said in an unpublished interview with Jet Katgert-Merkelijn some time in the 1990s (my translation):

> But then you see, I did decide to take that job in America. Of course, that was also a decision of, um. Well, on the one hand it was quite nice in Leiden.
>
> On the other hand, I also had the feeling that others in Leiden also had, of a certain stabilized situation. Oort was the boss and there was, eh Oosterhoff, who directed things in that other building which we then called the 'Astro'. And then you had the feeling of 'Yes, you could sit here for another 20 or 25 years, but the world is so big and there's so much more interesting to look at, so, eh ... let's do that, so I just resigned as a lecturer then. And I accepted a temporary job at the University of Chicago at the Yerkes Observatory. In retrospect, actually a curious gamble. And I think few people at present would still do that, that you give up a permanent job for and that was also a job in America in which I was, I think, paid less than I was in Leiden, but there was apparently so much that feeling of either you stay here and then you're a bit walled in, although, walled in in a nice community, or you go and have another adventure. Well, that's what I did. Look, others have done it too of course, Gart Westerhout with the same feeling. And there have been others like that.

Adriaan Blaauw saw a lack of room to develop and start new initiatives in Leiden where Oort dominated and everything was set and determined by him.

The University of Chicago's Yerkes Observatory had been founded just across the state border from Illinois in Williams Bay, Wisconsin, by George Hale in 1897, where he erected the world's largest refracting telescope, with an objective of 40 inches aperture. Yerkes had become one of the leading centers in astronomy in the United States, especially under the Directorship of Otto Struve (1897–1963), a descendent of a long line of famous Russian von Struve astronomers from St. Petersburg (Otto dropped the 'von' when he became a USA citizen). Blaauw twice spent extensive periods at Yerkes, of nine and six months in 1947–1948 and 1952, respectively, and —as was the case with the Kenya trip—without his family. Figure 35 shows him with Jan Oort, Director Struve and later Director Gerard Kuiper in 1947.

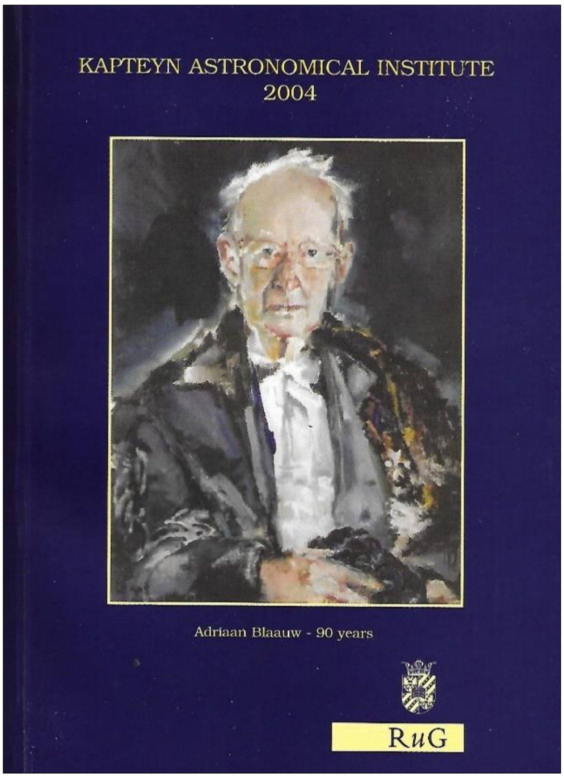

Figure 34: The cover of the *2004 Annual Report* of the Kapteyn Astronomical Institute (van der Kruit, 2005) with Adriaan Blaauw's painting by Janneke Viegens for the gallery in the Academy Building (courtesy: University of Groningen.

Yerkes employed some first rate astronomers, including in addition to Struve, Jesse Greenstein (after his work referred to above on the wavelength dependence of interstellar extinction he moved to the California Institute of Technology), Surahmanyan Chandrasekhar (1920–1995; for example, known from his work on white dwarfs and degeneration pressure); William (Bill) Morgan; William Albert Hiltner (1914–1991; another pioneer of photoelectric photometry); Bengt Strömgren (well-known for his work on the chemical composition of stars, and physics of the interstellar medium); and others. Yerkes was responsible for the op-

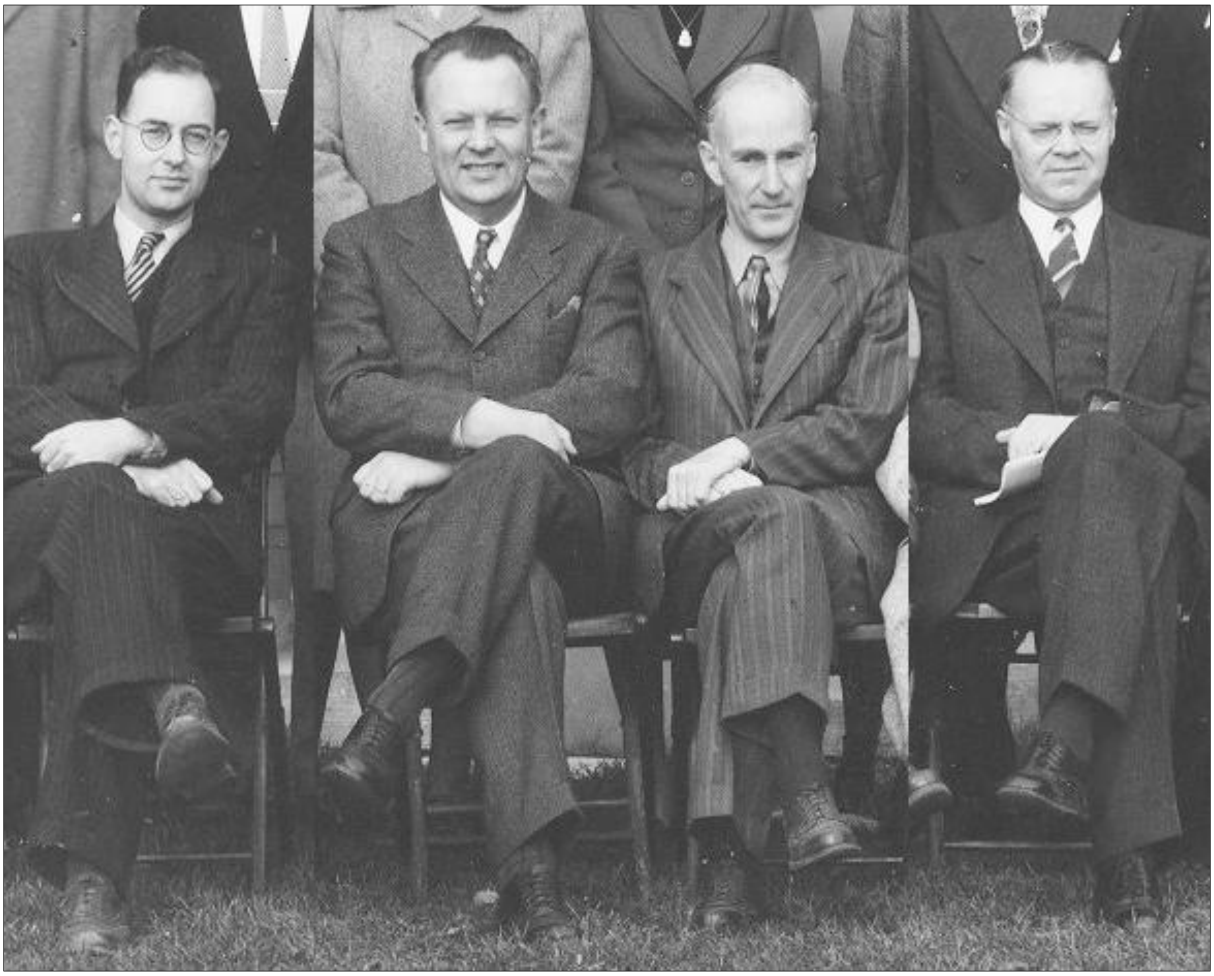

Figure 35: Adriaan Blaauw (left) at Yerkes Observatory with (from left to right) Gerard Kuiper, Jan Oort, and Otto Struve. These frames are cut from a group photograph of staff and visitors at Yerkes Observatory in 1947 (courtesy: Oort Archives).

operation of the 84-inch telescope at McDonald Observatory in Texas, one of the most productive American telescopes, and Yerkes astronomers had easy access to it. In 1947 Struve left for Berkeley and then Kuiper was Director until Strömgren was appointed in 1950; the latter stayed until 1957 when he went to Princeton, and Kuiper took over again. Blaauw had published important papers with Struve and Morgan.

Coming back to the Groningen appointment the question is: why then did Blaauw elect to leave the USA and become Director of a place that was in poor shape with little promise of flourishing again? By this time he was 43 years of age. This question was not covered in the Katgert-Merkelijn interview (which concerned Jan Oort primarily), but it was in the AIP interview. Here are some excerpts:

> So I said, 'Well, certainly I want to stay at Yerkes till somewhere in 1957.' ... It was to complete things I had been working on, and also because we were not quite sure that we wanted to go back to [the Netherlands]. We had gone to the United States, as I said, more or less as emigrants from [the Netherlands], and we liked it very much there. Where we lived at William's Bay was a very pleasant place and we had very nice friends there. The educational situation for the children was not bad ... I think we all felt that the possibilities for the future of children in [the Netherlands] were rather limited ..
>
> On the other hand, I felt attracted to the job in [the Netherlands], and there was a circumstance – the general situation at Yerkes that had developed at that time ... And while people have sometimes said that you can have at an opera only one prima donna, and a lot of good players, but you cannot have six prima donnas. It doesn't last for long, unless you have one person who very strongly keeps it together. And maybe one should say that there were all these prima donnas, but not one who kept the whole thing together strongly enough, by one common motivation, you see. I think one should look at it in that way. Maybe not the fact that there were frictions. There are frictions almost every-

where. I don't know of any observatory where there have not been frictions.

... the catalogue work [at the Kapteyn Laboratorium] had been practically finished by that time. On the other hand, radio astronomy was developing in [the Netherlands]. There was the Dwingeloo Radio Observatory that was dedicated in 1956. I was still away then. It really opened the future for participation in that work. So then when I went back to [the Netherlands], I said of course, 'Now, this place has to be, in a way, rebuilt, modernized, and we want to participate in the radio work.'

Blaauw saw it as a challenge and an opportunity to bring the laboratory in Groningen back to prominence, while at the same offering himself the possibility of gathering his own research group around him and leading it to become a significant factor in astronomy. The complex composition and balance between personalities on the Yerkes staff with many 'prima donna's' was not the environment he was looking for. You either strive to be a prima donna too, or you settle for being one of the smaller players. This was to some extent the same as working in Leiden under the dominance of Oort had been, which had made him leave Leiden. Groningen meant working next to Oort, not under him. And, of course a challenge and an adventure were opportunities never to let pass.

22 THE LABORATORIUM AFTER VAN RHIJN

At the end of the academic year 1955–1956 van Rhijn had been given honorable discharge since he had become 70 years of age earlier during that year. Like the appointment of Professors this was by Royal Decree. However, since he had no successor he was appointed, also by Royal Decree and on the same date of 30 July, on a temporary basis to be responsible for education in Astronomy. He remained listed in the *Yearbook* of the University (University of Groningen, 1877–1978) of 1956 as the Director of the Kapteyn Laboratorium. The next *Yearbook* mentions the appointment of Blaauw, but not the discharge of van Rhijn.

When Blaauw had taken over, van Rhijn (Figure 36) prepared his final research for publication, which constituted the final volume of the *Groningen Publications, Number 61* (van Rhijn, 1960). He died that same year, on 9 May 1960, at the age of 74. In the *Yearbook* of the University (University of Groningen, 1877–1978) for 1960 he is remembered in an *In Memoriam* by Adriaan Blaauw, of which I will quote a part (my translation).

When van Rhijn accepted his position in 1921 as Kapteyn's successor with a lecture on 'The Gravitation Problem', he consciously followed in his teacher's footsteps. He considered it his task to carry out the grand plan designed by Kapteyn. This plan envisaged an extensive investigation of the structure of the Galaxy. At the time of Kapteyn's resignation, important preparatory research had been completed; some highly significant results had already been obtained. However, only the foundations had been laid for the broad scope actually intended. A start had been made on international cooperation, with the aim of systematically collecting all kinds of observation data. Throughout his career, van Rhijn has been the driving force behind this '*Plan of Selected Areas*'. With enthusiasm and unyielding perseverance he managed to

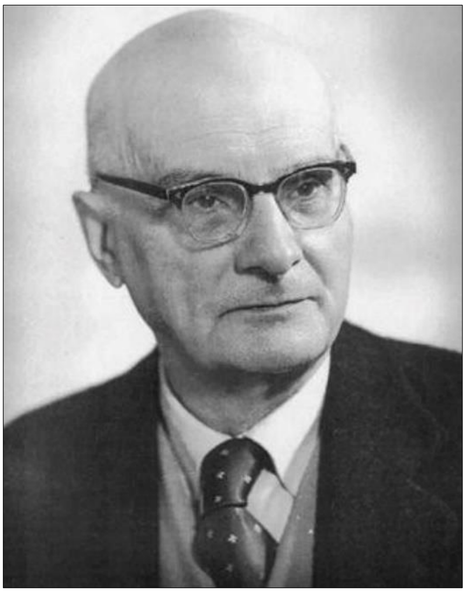

Figure 36: Pieter Johannes van Rhijn in 1957. From the collection of Adriaan Blaauw and Kapteyn Astronomical Institute.

obtain the cooperation of observatories all over the world and, what was certainly not the easiest thing, he managed to persuade almost all collaborators to complete their often time-consuming work. The arsenal of data thus created is a lasting monument to van Rhijn's efforts ...

Van Rhijn had a, for astronomy, large number of students. They can be found in important posts at observatories abroad – in Australia and in the United States – and in the Netherlands. In all their work the imprint of their teacher can be detected. Many of them – both students and colleagues – are now mourning the passing of a friend whose exemplary rectitude they admired. Because his thinking and his actions, both in his work and in his daily life, were dominated by sincerity and modesty, those who came into contact with him on a superficial level were under the impression that he barely cared about what was going on in the world around him. But those who knew him better know that he had a profound interest in and a sharp judgment of what was going on in the world. The War years were very difficult for van Rhijn: his rectorate ended under the German occupation and then he suffered from extended illness. With great willpower he resigned himself to the therapy that demanded so much patience in sanatorium and hospital. Fortunately, after the war, he was given many more years of fruitful scientific work.

Van Rhijn was averse to insincere honors. He could speak with glowing indignation about speeches at special occasions in which merits were exaggerated and shortcomings concealed. He lived in the deep awareness that there is a judgement of man and his work, higher and purer than that which can be pronounced by fellow men.

Figure 37: The tombstone on the graves of van Rhijn and his wife in the 'Selwerderhof' cemetery in Groningen (after 'Online begraafplaatsen', 2021).

After 28 years of marriage, Van Rhijn left behind his wife (who was twenty years younger) and their two children, who by now had grown up and were in their twenties. Regnera L.G.C. de Bie survived him by 37 years, and after she died in 1997 she was buried next to her husband in a cemetery in the north of the city of Groningen (see Figure 37).

It would carry us beyond the scope of this paper to go into the development of the Kapteyn Laboratorium under the Directorship of Blaauw in the same detail as done here for the long period of van Rhijn's leadership. Yet in order to contrast how it to some extent regained its prominence, a short summary of the first decade or so is appropriate. Adriaan Blaauw assumed his position in Groningen on 1 September 1957. He immediately started to expand the Laboratorium by hiring a young radio astronomer from Leiden, Hugo van Woerden (1926–2020). Van Woerden had studied Astronomy in Leiden and had been involved in the research with the Kootwijk radiotelescope, a refurbished German radar antenna of the Atlantikwall, a 7.5 meter 'Würzburg Riese' (van Woerden and Strom, 2006). In 1955 he had started a PhD protect that involved the 25-meter Dwingeloo radio telescope that subsequently had become operational in 1956. This work on the structure and motion in the interstellar gas in the Orion region was transferred to Groningen and resulted in the first PhD thesis completed and defended under Blaauw, in 1962.

Blaauw's next hire was Andreas Bernardus (André) Muller (1918–2006). He also came from Leiden after having obtained his PhD in 1953 with Oosterhoff as supervisor on a thesis on the variable star XZ Cygni, an RR Lyrae type variable star. He spent a few years at the Leiden Southern Station, as main observer in long-term photometric programs and oversaw the move of the Rockefeller Telescope from Johannesburg to Hartebeespoortdam. At the new site Walraven was busy erecting the Light-collector. Two Leiden astronomers in South Africa was too much of a luxury, and Muller and Walraven did not get along very well, so one of the two had to come back to the Netherlands. Blaauw recalls in his interview with Jet Katgert-Merkelijn (1997):

> Now, the developments in the project to found a large European Observatory in the south, for which Oort and Baade had taken the initiative had developed to the stage that there had been an 'ESO Committee' of which by then Oort was permanent President. With the limited funding that was provided by the members of the informal organization, site testing campaigns had been organized.

Blaauw was very much involved in all this and wanted to hire Muller to contribute (my translation):

> Well, André then was given a job in Groningen. I had convinced people to accept him, since the situation in Leiden was very poor. And then the developments in the framework of ESO demanded that someone would supervise things that developed and André with his experience in South Africa was the right person. And slowly he shifted from a job in Groningen to one at ESO. It all worked out well for him, but he and his family sacrificed a lot when he worked in Chile. That has been very difficult.'

The sequence of events was as follows. In the same year 1957, Oort in this capacity as President of the ESO Committee had approached the Ford Foundation for funding to proceed to found the European Southern Observatory ESO. This was successful in 1959. In that year Blaauw took up the role of Secretary of the ESO Committee and was keen on playing a major role in the setting up of this organization. In January 1964, four of the five countries (the Netherlands, Sweden, Germany and France) had signed and ratified a convention, the Ford funds became available. Belgium ratified only in 1967, a few months after Denmark had joined as the sixth member state. The appointment of André Muller in 1959 ensured a major involvement of the Kapteyn Laboratorium in ESO (Blaauw, 1991). Muller turned out to be instrumental for ESO; a well-written article was published by Richard West at the time of Muller's death, which describes his work and personality very well (West, 2006).

In 1961 a young student Martien de Vries was added to the staff of the Laboratorium to work with Muller and Blaauw on stellar photometry using the Leiden Southern Station. Unfortunately de Vries never finished his PhD thesis and after he participated in setting up the Kapteyn Observatory in Roden under Borgman he went on long-term sick leave and eventually was dismissed from the staff late in the 1970s.

In 1968 Tjeerd van Albada and Harm Habing obtained their Candidaats degrees (Bachelor). In respectively February 1962 and March 1963 they passed their Doctoraal exams (Masters) and started PhD research.

The radio group under van Woerden was extended in 1962 with the appointment of Swiss-born Ulrich J. Schwarz (1932–2018), who joined the Kapteyn Laboratory in 1962 to become its second radio astronomer. For an in memoriam see (Kapteyn Astronomical Institute, 2018b). He had studied Physics in Bern, but did spend a year (1957–1958) in Leiden working on radio astronomy and receivers (with American Charles Seeger) preparing for the Benelux Cross Antenna projects, see e.g. van der Kruit (2019; 2021b), where he had met Hugo van Woerden's sister Elisabeth, whom he married in 1961. After obtaining his PhD Van Woerden left for a two-year Fellowship at the Carnegie Institution at Mount Wilson and Palomar Observatories and Schwarz took over the coordination of the radio astronomical work in Groningen

And in 1960 a Professorship in Astrophysics was allocated to Groningen University, and after a long search this was filled in 1963 by Stuart Robert Pottasch (1932–2018; Kapteyn Astroonmical Institute, 2018a). He had studied at Harvard and Colorado and had been a Postgraduate Fellow at Leiden and a Postdoctoral Fellow at Utrecht and Paris before joining the Kapteyn Laboratorium. His field was stellar atmospheres and interstellar physics.

So within six years the Kapteyn Laboratorium had grown from three staff members (Blaauw, Plaut and Borgman) and no students to seven staff members (plus van Woerden, Muller, Schwarz and Pottasch) and (as it turned out) three students!

The growth was also reflected in the publications output. Most, but not all papers appeared in the *Bulletin of the Astronomical Institutes of the Netherlands* and extensive data in tabular form in the the *Publications of the Astronomical Laboratory at Groningen*, the latter having been terminated with van Rhijn's final publication and was replaced by the *Supplement Series* of the BAN, of which the first volume started in 1966. In 1969 both the main and supplements editions were terminated and incorporated into *Astronomy & Astrophysics*. Table 3 shows the number of papers in the BAN over the full period it appeared in five-year totals. The *Supplement Series* was published only during the final interval (1966–1969) and since of these papers an abstract was published in the main journal and in listings counted as an article, the numbers for the main journal have been corrected for this. The overall Groningen share is 5.3%, but there is a pronounced change from a few percent before 1955 under van Rhijn to 20% towards the end. It should be noted that up to WWII the numbers are significantly distorted by Ejnar Hertzsprung's publication record, who published large numbers of short (often single page) single author papers often on 'elements' (periods, amplitudes, etc.) of variable stars and other objects. In the period 1921–1942, he published 123 papers of the total number of 638 papers in the journal, which amounts to 19%. Keeping this in mind, even then the effect of the change of the Directorship from van Rhijn to Blaauw is very large. There was of course also the budget increase for travel. According to van Woerden (2005) it amounted to the sizable sum of 10,000 guilders per year, which in current times would be around 35,000€. It was probably used among other things to pay for part of Plaut's long stays at Palomar Observatory for the *Palomar–Groningen Variable–Star Survey* and Borgman's observing and research trips to McDonald, Lowell and Yerkes Observatories. It is very likely that this budget has been used also for some of the expenses related to the sight-testing activities for ESO in South Africa under André Muller.

The Groningen Laboratory did not contribute any further data sets to the *Plan of Select-*

Table 3: Number of papers in the *Bulletin of the Astronomical Institutes in the Netherlands* and its *Supplement Series* (BAN) and the share from the Kapteyn Laboratorium Groningen (RUG).

Years	BAN	RUG	%	Years	BAN	RUG	%
1921–1925	163	7	4	1946–1950	97	2	2
1926–1930	215	7	3	1951–1955	59	2	3
1931–1935	104	0	0	1956–1960	85	5	6
1936–1940	142	2	1	1961–1965	97	12	12
1941–1945	82	1	1	1966–1969	99	21	21
Main 1921–1969	1104	59	5	Suppl. 1966–1969	34	5	15

ed Areas after van Rhijn finished his research. With van Rhijn no longer present as the driving force it also disappeared from the research program of the Kapteyn Laboratorium, which badly needed a new focus and new inspiration.

It would carry too far to go into detail over the new research projects that were initiated under Blaauw. In addition to his own research, which concerned young stars, stellar associations, interstellar medium and star formation, the fields opened were Galactic structure using pulsating stars under Lukas Plaut, Galactic radio astronomy with the large Dwingeloo dish under Hugo van Woerden (van Woerden and Strom, 2007) and under Jan Borgman the founding of the Kapteyn Observatory in Roden with a 62-cm telescope and a well-equipped workshop to develop instrumentation, infrared photometry from balloons and ultraviolet photometry in the first Astronomical Netherlands Satellite ANS. It is fair to say that the prominent position the Kapteyn Laboratorium had under Kapteyn, and had to a major extent lost under van Rhijn, was largely recovered during Adriaan Blaauw's term as Director.

23 DISCUSSION

I want to start this discussion with a few numbers that illustrate the enormous amount of work that the Kapteyn Astronomical Laboratorium has devoted to provide fundamental data. Here are the numbers of stars of the Groningen shares for which positions and magnitudes have been derived in catalogues produced as part of the *Plan of Selected Areas*:

Harvard(–Groningen) Durchmusterung:	231,981
Mt. Wilson(–Groningen) Catalogue:	45,448
Durchmusterung of the Special Plan:	140,082
Bergedorf(–Groningen–Harvard)–Spektral Durchmusterung:	173,559

These total 591,070 position and brightness determinations were mainly performed between 1910 and 1950, so 40 years of work (not allowing for termination and slowing down of work during the Depression and WWII). Now the working week usually was 6 days and since 1919 the workweek was by law set at 45 hours. Allowing for closure during public holidays, we may take a year as 51 workweeks or 2295 working hours. With these assumptions this means that during working hours another star with measured coordinates and apparent magnitude was added to the data base on average every 9 to 10 minutes. And even less if allowance is made for times of fewer operating hours. This is an incredible accomplishment! Of course, at any one time a number of people were working on this.

Although remarkable it should be said that it is not unprecedented. For example, the initial version of the *Bonner Durchmusterung* was produced by Friedrich Argelander and his assistants between 1846 and 1863 (observations ran from 1853 to 1859, sometimes as many as 30 observations per minute; Charlier, 1921), and this resulted in a catalogue of the positions and apparent magnitudes of approximately 325,000 stars. And Annie J. Cannon classified some 350,000 stellar spectra for the *Henri Draper Catalogue* and extensions between about 1900 and 1940, with a reported peak frequency of about three per minute (She is an Astronomer Task Group, 2019)!

The production of positions and magnitudes started even earlier in Groningen with the *Cape Photographic Durchmusterung*, or *CPD*, which also concerned positions and magnitudes. This involved a total of 454,875 stars and was achieved in 12 years, so repeating the calculation with these numbers yields a rate of adding another star with measured and reduced coordinates and apparent magnitude to the set of completed measurements on average every 4 or 5 minutes for this period. This is even faster, but it should be realized that the *CPD* plates were measured with Kapteyn's very clever 'parallactic method'. In this method a small telescope was placed at a distance from the plate exactly the same as the focal distance of the telescope, so that in a correct orientation the two perpendicular angular distances of a star from the plate center that were read from dials on the axes of the small telescope were direct measurements of the differences in right ascension and declination of the star and the plate center.

The Kapteyn Laboratorium between 1888 and 1957 (the year of van Rhijn's retirement) measured 1.045,945 positions and magnitudes of stars in the context of the *Cape* and *Select-*

ed Areas Durchmusterungs. A quick scan of the Groningen Publications shows that in addition, over this period, there have been measurements of over 27,500 parallaxes (often of course upper limits) and/or proper motions from plates provided by Anders Donner at Helsingfors Observatorion, Ejnar Hertzsprung at Potsdam Observatorium, the Cape Royal Observatory, Radcliffe Observatory, l'Observatoire Bouzareah (Algers), and a number of other places. Of these, about 7800 were obtained in Kapteyn's time and the Algers collaboration accounted for the largest faction (41%). So between 1888 and 1957, the Kapteyn Laboratorium produced a new position/magnitude combination every 9 minutes during working hours and a proper motion and/or parallax every five-and-a-half hours.

After WWII there were identifications and magnitude measurements of thousands of variable stars during Lukas Plaut's research. This of course continued further in the latter's variable star survey on Palomar plates up to about 1970. When Kapteyn in 1885 wrote David Gill to take on the measurements for the *CPD*, which he estimated would be an effort of six or seven years, and a little later developed his concept of an astronomical laboratory, he could not have foreseen the enormous production this would lead to.

Before addressing the questions I formulated in the Introduction I quote Adriaan Blaauw, who has expressed himself more than others on van Rhijn's personality and style of research. In his interview with Jet Katgert-Merkelijn he said this about van Rhijn (my translation):

> Yes, he must have regretted seeing that the great development in the field of Galaxy research went a little bit past him. But at the same time, if you were to say, that was also kind of his own fault, you're right about that too. And I think he also sensed that a bit. But in his last years he had, I think, enough problems to deal with: his health, his family, and yes ... the cuts from the University and the staff ... He was a man who very conscientiously carried out a program, but with little .... what can I say? ... Not very inspired, I would say.

I will now return to the questions posed in the Introduction.

23.1 Was van Rhijn the Successor Kapteyn Had Wished For or Had He Preferred Someone Else?

We have no written statement or account by Kapteyn, but we can say a few things about this. It should be seen in a national context. He had been offered the Directorship of the Sterrewacht Leiden at the retirement of Gerardus van de Sande Bakhuyzen in 1908, which was untimely as at that time he started his Research Associate appointment with the Carnegie Institution. So he had pushed for his student Willem de Sitter for this. Against his advice Leiden had appointed Ernst van de Sande Bakhuyzen as Director and de Sitter to the Professorship. This first action was indeed a failure due to van de Sande Bakhuyzen's conservative nature and when in 1918 he unexpectedly died before retirement, de Sitter and Kapteyn had already considered a course of action, which resulted in a new structure with three departments with renowned leaders (like Hertzsprung). From this it is clear that Kapteyn must have viewed the future of Dutch Astronomy to be the much better staffed and equipped Sterrewacht in Leiden and not his much smaller Groningen establishment. It is also important to realize that in the proposal for his *Plan of Selected Areas*, Kapteyn had presented it in addition to the science as a means to secure the near future of the Laboratorium.

So, Kapteyn would have looked for someone who would be dedicated to executing the Plan, rather than someone who wished to start new initiatives before this Plan had been completed. Someone to follow 'in his footsteps', we may say. Van Rhijn was just that, and he must have been seen also by Kapteyn as the right person. He obviously expected a great future for Jan Oort, who studied with him, and recommended him strongly to de Sitter for a future job in Leiden (along with Jan Schilt, but with a preference for Oort). The conclusion would be that Kapteyn might have been content with van Rhijn taking over his position in Groningen. Van Rhijn had carried out, one would think to Kapteyn's satisfaction, the preparatory work for the star count analysis in 1920 (Kapteyn and van Rhijn, 1920a), which would lead to the Kapteyn Universe and was the basis for his 'first attempt' (Kapteyn, 1922).

23.2 What Future Might Kapteyn have had in Mind for His Laboratorium?

At the opening of his Astronomical Laboratorium, still on a temporary location, on 16 January 1896, Kapteyn said in his lecture (see van der Kruit, 2019: 228; my translation):

> ... we need to look at the work that needs to be carried out at a photographic observatory. It consists of two parts: 1st. The work of the photographer. His part ends with the completed photographic plate. 2nd. The work of the astronomer. His part starts with the completed photographic plate ...

> Eliminate the photographer and all you need is a building with some six rooms, for which no very special requirements exist. Still we cut out what seems to us the least vital, the lack of which would present an eminent advantage to most astronomers if they prefer research to teaching ... No laborious efforts on the part of the photographer, only concentration on the real astronomical work! What pleasure, what alleviation!

In his presentation of the *Plan of Selected Areas* he wrote in the Introduction:

> That such a plan was evolved at the Laboratory of Groningen is only natural.
>
> The nature of our astronomical institution makes our work dependent on that of other observatories. Every work of a practical nature undertaken here is of necessity a work of cooperation with another astronomer who possesses the means of having photographs of the sky taken ...
>
> At the same time, in pursuance of the same plan, I devoted all my leisure left, to the investigation of the structure of the stellar system by means of the data already available ... These labors have now come to that point, that they ought to enable me to make at last definite plans for the future work of the laboratory ...

Not only was the Plan a means of securing a future for the institution, but it also illustrated that to secure the collaboration of others required a vision in terms of a plan, the usefulness of which had to convince directors of observatories. In the 1896 lecture above, Kapteyn's assumption was that the observatories produced abundantly more plates than they were able to measure, reduce and analyze. The case of Anders Donner at Helsingfors was a clear example. Presenting a good proposal was sufficient to obtain the plates. As long as this situation prevailed the concept of an astronomical laboratory could survive.

However, in van Rhijn's days these assumptions started to fail. The work with the Mount Wilson telescopes by astronomers like Harlow Shapley, Edwin Hubble and Walter Baade was manifestly not intended to provide research material for others. Even in the collaboration for the *Mount Wilson(–Groningen) Catalogue*, Frederick Seares pursued his own part independently and published the catalogue without Groningen in its name (but with Kapteyn as co-author). In Kapteyn's day, observatories often collected data to produce catalogues for the general benefit, but those times were past in van Rhijn's era and would never return.

23.3 Was van Rhijn's Work Really So Unimaginative, and How Important has it Turned Out to Be?

I will start with the second part. This concerns van Rhijn's scientific research, not the efforts for the *Plan of Selected Areas*. It can be maintained, I believe, that van Rhijn's work on the Luminosity Function, the provision of tables of mean parallaxes of stars as a function of position, apparent magnitude, proper motion and spectral type, etc. were no more than continuing Kapteyn's approach. His research work on the distribution of stars in the plane of the Galaxy after corrections for average extinction, and that of distributions of stars at a line of sight at higher Galactic latitude for various spectral types in the 1930s were good pieces of research, but the papers failed to put the results in a larger context. The PhD theses produced under him were of good or high quality, especially the one by Broer Hiemstra, which was ingenious and original. So my assessment is that van Rhijn's scientific work in general was solid, but it was straightforward and did not follow a new, innovative strategy.

A useful illustration would be to compare van Rhijn's 1936 study, in which he investigated the distribution of stars in the plane of the Galaxy (van Rhijn, 1936), with Oort's 1938 study of the distribution of stars in the Galaxy in directions out of that plane (Oort, 1938). In van Rhijn's paper average extinctions per kiloparsec were derived and applied to Selected Areas near latitude zero. He ignored the effects of irregularities in the dust distribution and in the end found only a local result (of which he seemed not really convinced) that the Sun is located in a local cluster with a radius of the order 1 kpc and a drop in density by a factor almost two lower at the borders. Results from larger distances on the structure of the 'larger system' were ambiguous, uncertain and inconclusive. As was usually the case with van Rhijn papers, he failed to discuss the repercussions of his work for the larger picture of the structure of the Galaxy.

Oort's (1938) study contrasts with this in that he was interested in the larger view of the Sidereal System and attempted to supersede Kapteyn's 'first attempt' with an improved version with the inclusion of what had become known subsequently. In particular, his approach was to limit himself to high latitudes and at the lowest latitudes only to include those for which Hubble's galaxy counts allowed an estimate of the corrections involved. Furthermore, he stayed away from very low latitudes, because he then could no longer simplify the work by assuming that absorption took place in front of the bulk of the stars. This led to a first glimpse of how our Stellar System compared to external spiral galaxies:

> The structural features indicated are large-scale phenomena, extending on both sides of the Galactic plane to distances of 500 or 700 parsecs from this plane. The analogy between this structure and the spiral structure of strongly flattened extra-galactic systems is discussed, but the data are still too inaccurate and incomplete to permit any conclusion about the course of the eventual 'arms', except that the Sun should be between two arms. (Oort, 1938: 233).

Van Rhijn's work was not unimaginative and certainly not unimportant. But he did not take the wider view of how his work fitted in with the emerging picture of the Galaxy that we live in. Or at least he does not address this when presenting the results of his investigations. As it turned out, Adriaan Blaauw also took these same two papers to make a comparison between van Rhijn and Oort in his interview with Jet Kargert-Merkelijn (quoted earlier). He took a somewhat different approach and stressed another fundamental difference in conducting research (my translation):

> Look, van Rhijn's working method was, in a way, that of Kapteyn. You make a plan, you know those and those observational data are all here, this is the problem we want to solve and we are going to do that step and that step and you finish that way. But of course when you do that, it happens that at a certain moment you say: 'Hey, there is something I never thought of. Now I will just have to look at the matter again.' Well, that flexibility, he had very little of. A 'serendepity'-development did not fit in van Rhijn's schedule ...
>
> Van Rhijn's style of research can be characterized well by comparing two pieces of research that appeared in 1936 and 1938 ... Here you can see the different ways of approach: the somewhat rigid, systematic, programmatic one of van Rhijn and a more flexible one of Oort ...
>
> Well, there were two people, both of them had the task of 'we must do Milky Way research and take into account the interstellar matter.' They had the same data and then you see van Rhijn working according to a certain scheme, he says in advance, 'I am going to go with those reddening measurements, I am going to calculate the absorption per kiloparsec and then I will apply that ..' And Oort leaves things more open in the approach he will take. And at a certain moment he says: 'Well, I will leave the low latitudes for what they are, I can at least say something about the higher latitudes. Because I know how thick that layer is and I know that if I use up to a certain point, I can trust the star counts.

23.4 Was Kapteyn's Concept of an Astronomical Laboratory, an Observatory Without a Telescope, a Viable One?

It should be noted that this concept was not Kapteyn's preferred option; he was forced to accept it as the only way to get involved in forefront astronomical research. I have described this development of Kapteyn not obtaining his own observatory and telescope earlier (van der Kruit, 2019; 2021b), as a blessing in disguise. Had he been running his own observatory, he might have been prevented from conducting research, measuring plates or interpreting the results thereof to the extent that he was been able to. Add to this the fact that the material that he did receive to measure was far superior to what he could have obtained from an in-house observatory at Groningen.

The success formula worked for Kapteyn's lifetime, but would it hold up in the long run? In the first place it required a person like him to succeed him and that the world also would not change. As mentioned above, the eminent astronomers drawn to Pasadena to exploit the new Mount Wilson Observatory were not the kind who were satisfied to provide others with unique observational material; they wished to push astronomy forward themselves and take the credit for the progress. And this was not just limited to Mount Wilson, but probably was part of a much more fundamental international development. Blaauw's story of the 'damned van Rhijn program', as Harvard astronomers described the obligatory taking of plates that were to be sent to Groningen, illustrates this well.

Van Rhijn was aware of this and took steps to obtain his own telescope and did in fact have a viable observing plan for it. The delay due to the economic depression and WWII does not invalidate this point. But after the War the real world moved to a situation where observing facilities of top quality (or simply superior size) were not possible for the average university institute. Blaauw realized this and accepted the position of van Rhijn's successor only receiving guarantees of access to facilities (Dwingeloo, Hartebeespoortdam, foreign observatories) and funds to actually use these.

So, yes the 'observatory without a telescope' concept worked for the person Kapteyn was, in his time. The commitment to the *Plan* *of Selected Areas* worked for van Rhijn as a work plan to pursue, but without a road-map of how to exploit the data and synthesize a model of the structure of the Galaxy it produced little more than catalogues and data bases. Van Rhijn seemed to have been satisfied with that, but the future of the astronomical laboratory needed a change in tactics. Having funds to go observe elsewhere solved at least part of the issue under Blaauw. What remained was the problem of how to be awarded the necessary observing time, but collaborations helped to solve that (Plaut at Palomar, Borgman at Yerkes, McDonald, etc.) for the moment. The existence of a nationally funded foundation to run the Dwingeloo dish solved the radio astronomical needs. The initiative to build ESO would do the same in the optical.

So, is the concept of an astronomical laboratory still a viable one? Maybe paradoxically I would say: Yes, I would think so. After all, in a sense the current Kapteyn Astronomical Institute is not fundamentally different from the laboratory of Kapteyn's days. Astronomers obtain their data from elsewhere, often without the need to travel and observe personally. We sometimes indeed do travel to observe at observatories the Netherlands participates in such as on La Palma, La Silla or at Paranal, but in many cases we can use service observing, and this is increasingly an option. We use other facilities through collaborations with astronomers who have access to these facilities, in which we are not a stakeholder, such as in my case Palomar or Siding Spring, sometimes traveling there, sometimes not. In all cases material comes to Groningen for analysis much like the plates that reached Kapteyn and van Rhijn. Or we use space facilities, where data arrive at our doorstep. As a PhD student in Leiden in the 1960s I did not have to go to Dwingeloo for radio observations (although I did for the larger part of my observations)—I only had to fill in a form to 'order' observations. The same has been the normal *modus operandi* at Westerbork from the start in 1970. Obviously, satellites and observatories in space by definition are operated this way. Dedicated staff ensure efficient use of the telescope or satellite.

The problem van Rhijn faced was the reliance on other observatories to provide data without having the authority Kapteyn had. The concept failed if it relied entirely on the generosity of directors of observatories with telescopes, but with funding to arrange access to facilities it is a model working well in many places. In fact, going to the telescope oneself is seen more and more as a poor and inefficient use of manpower and budgets. Kapteyn could concentrate on research without having the burden of running an observatory. We still conduct our research that way.

23.5 What Precisely Caused the Kapteyn Laboratorium to Loose its Prominent Place in the International Context?

There was no single cause. One simple answer is that van Rhijn was not in the class of Kapteyn. Indeed, Kapteyn really was 'a difficult act to follow'. It would be difficult to rival the discovery of the Star Streams, the vision of the *Plan of Selected Areas*, and the two concepts of statistical astronomy and galactic dynamics that Kapteyn had developed. But there must have been more to it. Part of that was van Rhijn's attitude to give priority to data collecting in the context of the *Plan of Selected Areas* over analysis, in order to develop an overall picture of Galactic structure. And of course there was Leiden, which with no less than three world class leaders in Willem de Sitter, Ejnar Hertzsprung and Jan Oort could not be bettered by a single individual. And then there was the lack of funding, resulting partly through Groningen's remoteness from the seat of Government. This affected the whole of the University, but more so Astronomy, where additional funding of the Sterrewacht in Leiden was more opportune than the small-scale Laboratorium in distant Groningen.

On the other hand, one should remember that the Kapteyn Laboratorium and Pieter van Rhijn did not become insignificant when it came to global ranking in Astronomy.

23.6 How Important Was the *Plan of Selected Areas* for the Progress of Astronomy and Did It Ever Reach the Goals Kapteyn Had in Mind For It?

Astronomy profited from the coordinated approach in various ways. First, of course, the availability of a database in general. For photometry the existence of photometric sequences in the Selected Areas, sometimes to very faint magnitudes has been important, as discussed by Kinman (2000) in the Legacy Symposium. The existence of reasonably consistent and uniform catalogues of spectral types, color indices, proper motions and radial velocities must have been of value for many ongoing investigations.

Was this what Kapteyn had in mind? Not in the first place. His focus was an analysis to determine what we now call the structure and dynamics of the Galaxy, which he pioneered in his seminal 'first attempt' paper of 1922 (Kapteyn, 1922), in which he was the first to apply dynamics to observational information. The dynamics were studied extensively by, in particular, James Jeans, Arthur Eddington, Bertil Lindblad and Jan Oort, but not so much in van Rhijn's research establishment. But it seems fair to say that the ultimate goal of understanding Galactic structure was brought within reach by the data collected for the *Plan of Selected Areas*. On the other hand, the Plan did not fundamentally contributed to the discovery of extinction.

Kapteyn's original goal had been to use the data collected in the Plan to determine the distribution of stars in space, as a road-map for the future of his Laboratorium. In his presentation of the Plan, Kapteyn (1906) wrote in the Preface:

> As will be explained more fully in the introduction, the present plan was originally meant only as a working plan for the astronomical laboratory of Groningen. Having first determined on its main lines it was my task to try to convince astronomers, who were in a situation of executing the necessary plates and observations, of its urgency and thus win their cooperation.

And in the Introduction:

> In the following pages a plan is outlined, which may be realised by the cooperation of few astronomers in a, relatively speaking, moderate time.
>
> The aim of it is to bring together, as far as is possible with such an effort, all the elements that at the present time must seem most necessary for a successful attack on the sidereal problem, that is: the problem of the structure of the sidereal world.

What he had in mind was a final attack on this problem when all the data would be in, along the lines of his 'first attempt'. I have argued that Oort's (1938) paper in fact was just that, except that most of the data used were not yet in the final form.

This concerned the *Systematical Plan*. The *Special Plan*, I stress, adopted under pressure from Pickering, had a few goals that can be appreciated from his justification of the choice of the Special Areas in his presentation of the Plan. As far as I am aware, only the study of those few Areas that targeted the dark clouds was actually realized in Broer Hiemstra's thesis.

23.7 Did van Rhijn Get the Support He Deserved From His University and The Government?

The correspondence between van Rhijn and the Curators of Groningen University showed a healthy level of support for the Kapteyn Laboratorium. The problem was the bias, at least in the 1930s, from the Ministry for observational facilities in favor of Leiden and Utrecht and against Groningen. The statement that computers in Groningen should not expect to be paid at the same level as in Leiden is curious, to say the least. After all, the work was similar and the salary should not depend on the success or prominence of an institution at an international level, or the fame of the Professor in charge. It is much to van Rhijn's credit that he persevered in his attempts to obtain his own telescope.

A comment that should be added here is that van Rhijn's idea in the 1930s of addressing the important and urgent issue of the wavelength dependence of interstellar extinction by comparing similar stars with strong effects of reddening and insignificant amounts, was timely. The difficulty of obtaining the funding and the crippling effects of the economic depression and the War delayed the project by about two decades, so by that time photoelectric techniques had made photographic approaches obsolete. Nonetheless, the results obtained by van Rhijn and Borgman showed the program to be viable and capable of providing definitive answers. The lack of support from the Ministry in funding the telescope and its refusal to at least fund the dome was a major factor in the delay, and was therefore a major cause of van Rhijn missing this important opportunity.

23.8 How Influential Was van Rhijn and What Was His Role in the Prominence of Dutch Astronomy that Followed During the Twentieth Century?

Obviously, in the field of stellar and Galactic astronomy van Rhijs was overshadowed by de Sitter, Hertzsprung and Oort in Leiden, but probably not by Pannekoek in Amsterdam. The latter's legacy after all was in the area of astrophysics and stellar atmospheres. Minnaert in Utrecht was prominent in solar research. Van Rhijn kept Kapteyn's legacy alive, but the dominance of Dutch galactic and stellar astronomy in the twentieth century was a result of the work of the trio from Leiden and constitutes a major part of Kapteyn's legacy. Van Rhijn's influence on the development of Dutch astronomy was limited, but his coordination of the work on the Selected Areas remained important for astronomy as a whole.

That is not to say, van Rhijn did not contribute. He did produce—or at least supervised in the final stages—a number of excellent PhD theses and students, who later would occupy very prominent positions in the Netherlands and abroad, such as Jan Schilt, Jan Oort, Peter van de Kamp, Bart Bok and Adriaan Blaauw. In the same period there had been in Leiden Dirk Brouwer (with de Sitter), and Pieter Oosterhoff, Gerrit (Gerard) Kuiper and Adriaan Wesselink (with Hertzsprung). In this respect van Rhijn did extremely well, also compared to Leiden. Of course there have been more outstanding astronomers in the Dutch school, but these had their PhDs only after van Rhijn's active period: Oort's most prominent students Maarten Schmidt and Lodewijk Woltjer and van de Hulst's Gart Westerhout followed in 1956 and 1958. Utrecht with Marcel Minnaert contributed with Henk van de Hulst and Cees de Jager, and Pannekoek in Amsterdam with Bruno van Albada, but only after WWII. This selection is of course a subjective inventory and somewhat arbitrary, but does show that van Rhijn did contribute very significantly to the reputation of Dutch astronomy in the first half and a bit of the twentieth century.

23.9 What Made Adriaan Blaauw Accept His Appointment as van Rhijn's Successor?

I have argued that a significant factor was Adriaan Blaauw's appetite for adventure and challenges. This made him accept Oort's request to join the Kenya expedition and leave his secure tenured position in Leiden for an uncertain temporary one at Yerkes. But adventure or challenge was not enough. The advent of radio astronomy and the allocation, upon his request, of a new staff position and for funds to travel abroad and collect new observational material together made an effort to revive of Groningen Astronomy one with a reasonable chance of success. I suppose that had it failed Blaauw could easily have found another position elsewhere.

What also helped him to pursue the kind of career he desired was the attitude of his wife, who agreed to let him go away from his family for long periods, and her consent to move the family across the Atlantic twice in only a few years. Adriaan Blaauw was exactly what Groningen needed after van Rhijn.

Of course, the University of Groningen had been keen as well on attracting Blaauw, and even provided opportunities for growth of the Astronomy Laboratorium. I have not been able to find any written statement on this in the Archives to back this up, but I would think the University leaders and administrators were still sufficiently aware of Kapteyn's significance and his stature as one of the greatest scientists in the history of Groningen University, and they wanted to keep his legacy intact, even though the focus of Dutch astronomy had moved with Kapteyn's protégés, de Sitter, Hertzsprung and Oort, to Leiden.

24 CONCLUDING REMARKS

Pieter van Rhijn may not have been of the same caliber as Kapteyn (who could possibly blame him for that?), and his work and leadership may not have been highly imaginative, but still an enormous amount of important and useful work was done at the Laboratorium under his Directorship, and to the great benefit of astronomy. And an admirable number of extraordinary students wrote their theses under his supervision. He deserves much credit for keeping the *Plan of Selected Areas* alive and coordinating the enormous effort that was not likely to lead to much fame or praise for himself. Van Rhijn disliked travel and attending large meetings, and it also was his misfortune to have much of his Directorship coincide with the Great Depression, WWII and his own protracted suffering of tuberculosis, while the Minister denied him funding at the level he was prepared to supply for Leiden. Yet despite these unfavorable circumstances, in the end his modest and unassuming manner and efforts left the spirit and heritage of his inspiring predecessor intact until new leader of the Laboratorium could take over.

25 NOTES

1. Because it concerns names I will as much as possible keep the formal names of institutions and observatories in the language of their location, so Sterrenkundig Laboratorium Kapteyn or for short Kapteyn Laboratorium, the Sterrewacht Leiden, Bergedorfer Sternwarte, Helsingfors Observatorion, Mount Wilson Observatory, etc. But, since it would be impractical, I will refrain from applying this to universities, but I will not translate 'Rijks-universiteit Groningen' into the sometimes used 'State University of Groningen' (a correct translation would be 'National University', since the term 'State University' refers to universities funded by states in the USA rather than by a nation) but use the official University of Groningen.
2. I add in general for persons when they first appear in this text their full set of first names and the years of birth an death, but for those still alive I refrain from quoting their year of birth.
3. This is Lies de Bie, a younger sister of his wife, who and her preacher husband Foppe Oberman at the time were still in Java.

A copy this letter was kindly provided by Gert Jan van Rhijn.

4. Note that in Box 15.3 of van der Kruit (2015) the function *D*(*r*) has been erroneously omitted from the integrand of both equations.
5. See this reference also for some more remarkable coincidences related to the orientation of nearby galaxies and the position of the Sun in the disk of the Galaxy.
6. The term *Durchmusterung* comes from the two German words for 'through' and 'sampling'. In the *Bonner Durchmusterung* this refers to the fact that the telescope was pointed at the meridian and stars passing through the meridian were timed and their altitudes measured and magnitudes estimated (see Charlier, 1921). So, in a strict sense, the *CPD* is not even a *Durchmusterung*.
7. NASA/ADS (ui.adsabs.harvard.edu) provides some informaton in terms of numbers of citations and of reads as measures of usefulness or at least one aspect of this. Citations to other publications are reasonably complete in ADS since the mid-fifties, when journals started to collect references at the end of papers rather than in footnotes in the text, so that it was practical for ADS to collect them [see Section 14.6 of van der Kruit (2019) for some more details]. Reads, when the full fecord in the ADS has been downloaded by a user, are available since around the year 2000.
8. Holland is sometimes used as the name of the nation, although it really is only two of the western provinces of the Netherlands bordering the North Sea, where Amsterdam, Rotterdam and other cities thrived as centers of commerce and culture in the seventeenth century. The use of Holland instead of the Netherlands is much the same as the often-heard incorrect reference to Great Britain as England, and both should be avoided.
9. I have not been able to locate a copy of this speech that Adriaan Blaauw must have seen, to confirm this.
10. Van Rhijn used 'mean statistical parallax' in the title (note that ADS has omitted the 'mean'). Statistical parallax is different from secular parallax and this may be confusing to some readers. I use the following. Usually statistical parallax is that for a group or cluster of stars for which both proper motions and radial velocities are known, where then the average parallax is derived from comparing the scatter in the radial velocities to that in the proper motions. It is therefore fundamentally different from secular parallax from proper motions relative to the solar apex. Van Rhijn has in the titles of the (sub-)sections in the paper been careful to avoid confusion.
11. Oort of course did not call them that, but in his lectures introduced them as 'two constants of Galactic rotation', to which he would add 'which we will call A and B', hesitating a few moments as if to make up his mind what he would decide to call them.
12. In September 1922 Joan Voûte acted as leader of a joint Dutch–German solar eclipse expedition to Christmas Island to the south of Java (see Spencer Jones, 2022), for which the Friedrich–Wilhelms Universität in Berlin—now the von Humboldt–Universität—awarded him an honorary doctorate in 1923.
13. See the letter from Curators of the University to van Rhijn dated 27 April 1929 (no. 617) with copy of letter from Curators to the Minister of 10 April (no. 539) and of the reply of the Minister of 22 April (no. 1592, department H.O.); Van Rhijn's letter of 4 May 1929 to Curators and their message of 16 December 1929 (no. 2719) regarding the Minister's dismissive answer; Van Rhijn's letter of 3 March 1930 to the Curators and their reply of 17 July 1930 with copy of the Minister's letter of 14 July (no. 31621 dept. H.G.); all this correspondence in the van Rhijn Archives at the Kapteyn Laboratorium.
14. No. 1498 Department of H.O.
15. From a copy attached to the letter from the Curators to van Rhijn of 24 October 1929, no. 2429.
16. A useful currency conversion site is provided by the International Institute of Social History (2021).
17. In an interview remininiscing on Plaut in 2010, a few months before his death, Blaauw gives a much more balanced, although in details not fully accurate, account (vimeo.com/16073067).
18. On the occasion of its centennial the predicate Royal has been awarded. Contrary to my optimistic and hopeful expectation in van der Kruit (2019) the change in the name from a 'Club' to the more professional 'Society' unfortunately did not happen, at least not to the Dutch name. However the abbreviation NAC was changed into KNA, at least removing the confusion with the Astronomers Conference.
19. This is somewhat reminiscent of the story of the Board of the Foundation for Radio Radiation of the Sun and Milky Way that Oort had founded after WWII to promote

the construction of radio telescopes (see van der Kruit, 2019; 2021b), where for a national effort it would have seemed appropriate that the Directors of all the institutes interested in using such facilities would be Board members. Remarkably, van Rhijn was not invited to join the Board, although this was later corrected, after he protested.

26 ACKNOWLEDGMENTS

I thank my colleague astronomer Jan Willem Pel and historian Klaas van Berkel, for a critical reading of a draft of this paper and making many detailed and very useful comments and suggestions. David Baneke and Ton Schoot Uiterkamp also read the manuscript and made a number of important remarks. I am grateful to Kalevi Mattila of Helsinki Observatory for providing the information about the correspondence of Kapteyn with Donner on the issue of Kapteyn's succession. I am especially grateful to Gert Jan van Rhijn, grandson of van Rhijn's brother Maarten, who maintains the van Rhijn Website (Stichting Het Geslacht Van Rhijn, 2022), for good quality photographs and much extensive biographical information about Pieter van Rhijn. I am grateful to van Rhijn's daughter for providing important information through Gert Jan van Rhijn. I thank the staff of the Kapteyn Astronomical Institute, in particular the secretariat and computer group, for support and help and the Director, Professor Léon Koopmans, for hospitality extended to an Emeritus Professor as Guest Scientist.

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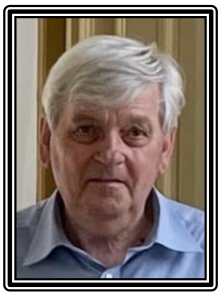

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His research concerns the structure and dynamics of disks in galaxies. He has published over 160 papers, more than half as lead or sole author, contributed substantially to over 20 more, and authored or edited eight books, among which are recent biographies of Jacobus Cornelius Kapteyn and Jan Hendrik Oort.

In Groningen he taught introductory astronomy and advanced level courses on the structure and dynamics of galaxies for many years, the latter also at a Saas-Fee winter school in Switzerland and in university curricula in Porto (Portugal), in Santiago (Chile) and in Beijing (China).

He is a former Director of the Kapteyn Astronomical Institute and has been a member and often chairman of numerous national and international boards and committees, notably President of Council of the European Southern Observatory and Chairman of the Board for the Atacama Large Millimeter Array (ALMA). In 2006 he received a Royal Decoration as Knight in the Order of the Netherlands Lion.