EXCITED STATES AND SPONTANEOUS TRANSITIONS:

ASTRONOMER, LECTURER, ADMINISTRATOR, BIOGRAPHER

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I didn't know I had it in me.
Marten Toonder (1912–2005),
by way of Olivier B. Bommel[1].

Abstract

This paper concentrates on my life as an astronomer performing observational and interpretative research, as a university staff member and professor teaching students elementary and advanced courses and supervising PhD students, as an administrator serving on boards and committees within the university of Groningen, at national and international level in organizations related to astronomy or science funding, and finally as an author of biographies and other publications related to the history of (Dutch) astronomy. A curriculum vitae with a complete list of appointments, administrative functions, publications and other relevant information is available through my homepage.

The emphasis is on my professional life and I do not describe my private life in any detail. I present a somewhat more detailed discussion of my ancestry and upbringing and its societal context to illustrate my background. I include anecdotes whenever appropriate. There are many more to tell, but that also would take too much space.

These various aspects in the subtitle of my career were often overlapping. A recurring theme is that the things I undertook were challenges. There is some chronology in the order they are presented. I was born in 1944. In 1962 I enrolled in the University of Leiden, where I passed my 'Candidaats' (roughly Bachelor) exam in 1966, after which I became involved in research. I defended my PhD thesis in 1971. After a Carnegie Fellowship at the Hale Observatories in Pasadena, California I was appointed at the University of Groningen in 1975. In addition to research and teaching more and more of my time went to administration. I have been involved in the latter somewhat more extensively than most of my colleagues, partly out of interest, partly out of a feeling of responsibility, but also for a significant part because it was challenging. I have been surprised, but also gratified that in the majority of boards and committees I eventually was asked to serve as chairman. After my formal retirement at age 65 in 2009, I was appointed honorary professor up to age 70. Teaching essentially ceased, but research and student supervision remained, as did a number of administrative functions. I had a long term interest in history in general and of astronomy in particular, but limited time forced my to devote not too much time to it. Since my formal retirement, and especially after I became emeritus in 2014, an increasing fraction of my efforts have been in that area.

Key words: History: Galaxy research – History: Extragalactic radioastronomy – History: Galaxy surface photometry – History: Astronomical facilities – History: Biographies

[1] 'Ik wist niet dat ik het in me had.' Marten Toonder (1912–2005), of whom I am a great fan. was a Dutch comic strip creator, appreciated not only for his drawing skills, but also for his unique linguistic ability. This is one of Toonder's many, widely used additions to Dutch expressions, used by one of the personalities he created.

1 Personal background

My ancestors lived in the general area around Rotterdam in the Netherlands. These days many Civil Registration archives have been digitized and it has been easy to find birth, marriage and death certificates of my ancestors up to my greatgreatgrandparents. This takes one up to early in the nineteenth century, when during the French occupation and rule (the Napoleonic times between 1799 and 1815) civil registration became mandatory. Before that one has to rely on church records.

The earliest person I have found among my ancestry is through my maternal grandfather to one Willem Janszn Diepenhorst (±1598–±1678), who was a beer tapper in Nieuwerkerk aan den IJssel. From my paternal side the earliest record I have found, also traces my last name as far back as possible, is of the marriage of Hermanus van der Kruijt and Pleuntje Brandenburg in September 1770, but that is about all I know about them. They had a daughter Kaatje (or Katherine) who was baptized in August 1773. She married one Leendert van der Most and had two children. However, he died in 1807, when Kaatje was almost 34 years of age. The burial of Leendert was paid for by some charity organization for the poor. Kaatje clearly was of very limited means and did not remarry, but in 1816 at age 42 she gave birth to a son, named Pieter van der Kruit. The birth certificate does not identify a father. Kaatje was characterized as a 'werkster' (cleaning lady, usually in private households of well-to-do citizens).

My male ancestors, in certificates of their marriages, and of birth and marriage of their children, were all described as ordinary worker or skilled laborer in employment. Often it was quoted as workman without specified profession. When specified, they usually had been bread-baker, blacksmith and carpenter. Three of them were at one time listed as skipper, shopkeeper and innkeeper, but always later as workman. It is unlikely they actually owned a business themselves; if so, they were not very successful in running it. Female ancestors sometimes had a profession at marriage but none when the children were born. Their professions listed were either cleaning lady, seamstress or maid.

My parental grandfather was listed as bread-baker and grandmother without employment at the same three occasions as above, and my maternal grandfather as blacksmith, bench worker and machine operator, and grandmother seamstress and unemployed. Education beyond elementary schooling was out of the question. On the paternal side the oldest males were alternatively called Pieter or Krijn/Krein; I broke with that tradition.

My father, Krijn van der Kruit (1912–1997), was a barber and my mother, Hermina van den Tol (1913–2002) before marriage a seamstress. My father grew up in Schiedam and my mother in Rotterdam. Schiedam is a town immediately to the west of Rotterdam. Schiedam being significantly smaller than Rotterdam, about 35,000 versus about 400,000 inhabitants at the times of my parents births (currently it is 80,000 and 650,000), gives rise to some supposed superiority among Rotterdammers over Schiedammers. One thing Schiedam can boast is that it had city rights earlier than Rotterdam (1275 versus 1340). Rotterdam is known for commerce and shipping, Schiedam was best known for harboring a number of producers of 'jenever', sometimes referred to as Dutch gin.

I was born on September 18, 1944 in Schiedam. My parents had been married in 1936 and remained childless for almost eight years. After me, in 1946, my younger brother

Fig. 1: This old photograph, presumably a postcard from the 1950s, shows the street where I lived until age 13. It was called 'Singel', so originally was a canal. The nearest shop of the three with awnings (where the car is parked – not ours; my father never owned a car and never even had a driver's license) is my father's barber shop. It has the barber sign on the facade on the second floor. We lived on the second floor of the next house on the right in the photograph, above a shop for stationary, office supplies and such merchandise. From my private archive, found on the Web with unknown credit.

was born. My birth coincided with Operation Market Garden, in which the Allied forces under Field Marshall Montgomery failed to break through the German lines at Arnhem ('A bridge too far'). The resulting winter and further months leading up to the German surrender in May 1945 were very hard for my parents, having hardly been able to feed me sufficiently, while my mother herself suffered from undernourishment too. A few weeks after my birth my father was taken to Germany for the *Arbeitseinsatz*. My parents survived the war, but were only reunited after the German defeat.

As I pointed out the oldest boys in my parental line were alternating Pieter and Krijn, so I was named Pieter like my grandfather. However, I was given a middle name Corijnus, a latinization of my father's name Krijn. Ironically Krijn is in fact derived from a Latin name, Quirinus, so my initials would have been P.Q. In September 1950 I entered primary school. Just before that I had suffered from a skull base fracture after being hit by a car when crossing the street where we lived without carefully checking the traffic (see Fig. 1). I recovered after six weeks in hospital and it did not leave me with any problematic consequences. During primary school, when I was about seven years of age, I contracted an, apparently relatively minor, case of poliomyelitis. It left me with a left leg 1.5 cm shorter than the right one, so that I use an additional centimeter of heel under my left shoe, and some deficiencies in operating my left hip, which misses some degrees of freedom.

It has not led to any major handicaps, just to some inconveniences such as lower back problems that got worse with age.

My paternal grandfather (Pieter van der Kruijt) was definitely my favorite grandparent. For a number of years as primary school pupil, I visited them almost every Saturday when school ended at lunch time. He used to greet me with the words: 'Pierre de la rue, Pierre de la vent'. It gave me the feeling that he had a lot of trust in me, and provideda sense of confidence. The second part ('de la vent') is strange; it is not good French, but then he did not speak French. I later found out that it referred to a song/chanson entitled 'Autant en emporte le vent' by one Pierre de la Rue (ca.1460–1518)[2]. Now my grandmother had an older brother who was a musician, probably organist, who worked as a music teacher and composer, and it is probable that he played it or made an arrangement on it.

Dutch society during much of the twentieth century was very much organized along the lines of what was called pillarization ('verzuiling' in Dutch). This refers to the segregation along religious and social/political lines. There were not only separate political parties based on religious beliefs (Roman Catholic, Dutch Reformed, Protestant) or political systems (Liberal, Socialist), it ran in many aspects through all of society. My primary school was a public school and next to it was a Roman-Catholic one, but with fences and hedges so the two populations did not mix. The 'public' school actually taught children according to Dutch Reformed principles, since this is the official State religion.

Many of my classmates were from households that were regular church-goers. They believed God was keeping a check on our behavior permanently and intervened in our daily life. Misfortune was a punishment for one's sins. They firmly believed in a life after death and a judgment on whether to spend this in heaven or hell. This was completely alien to me. My parents, and my grandparents, adhered to an organization that preached principles, which although accepting the Bible as a book of wisdom, denied any traditional, religious interpretation, taking the view that Jesus had been an ordinary human being preaching love and compassion and held the view that God could only be experienced through human relationships. It denied divine interventions, a life after life, the apocalypse, etc. The leader of the organization, Apostolisch Genootschap (Apostolic Society), felt it his responsibility to inspire others similarly as Jesus (if indeed a historical figure) had inspired his contemporaries. My classmates thought this was wrong and sometimes heretical or even blasphemous. I have remained associated with this organization and been actively involved in its activities, such as for many years directing the choir that sang during the Sunday morning 'service' and contributing to or leading these. It has evolved into a less centrally controlled organizational structure, describing itself now as combining aspects of Christian religion and humanism.

Primary school (Fig. 2) was no problem. My mother recalled that one of the school teachers remarked I was very bright and could easily go through technical university and become an engineer. In 1962 I entered a secondary school type called 'Hoogere Burgerschool' (higher citizen school, abbreviated HBS). This type had been introduced by Prime Minister Rudolph Thorbecke (1798–1872), founder of the liberal movement in the

[2] The lyrics go like this: *Autant en emporte le vent./ Qu'il n'a qu'un baiser seulement,/ combien qu'il soit donné de bouche,/ se le cœur ne donne la touche,/ ou y met son consentement./ Autant en emporte le vent*, which I translate as: *Gone with the wind./ If it's no more than a kiss,/ however often given with the mouth,/ but the heart is not touched/ or gives its assent,/ then it is all in vain.*

Fig. 2 Photograph of me at age about nine or ten in primary school. From my private archives.

Netherlands, in 1868 to provide appropriate education preparing boys for a career in commerce and industry. Most science teachers had PhDs. It had quickly become the preferred preparation for university studies in mathematics and natural sciences as a result of the excellent teaching. Gymnasium or grammar school remained the route to university in other academic studies. In my time the difference really was only the Greek and Latin in the gymnasium's curriculum, which took an extra year. I scored rather average marks in French, English and German and that route with in addition Greek and Latin would have been problematic for me. I later did regret missing the cultural background of such a classical schooling. When my final HBS exam was taken, partly written and partly oral, my scores for languages were mediocre; on a scale from one to ten I scored five (doubtful) for French language and literature and six (sufficient) for Dutch, English and German. But for mathematics I scored two eigths and two tens (merged into two nines), for dynamics (later absorbed into physics) a nine and for both physics and chemistry a perfect ten. Other scores were intermediate, sometimes based on school reports during the final year. My greatest triumph though was a nine for 'physical education' (sports), which had really taken an effort (I had been doing gymnastics at a club) for a boy that was not particularly athletic.

The HBS period also was of course that of my adolescence. My mother tells me that I was not particularly difficult, although I remember the periods of being very unsure of myself and somewhat depressed. There were two things that awakened my interest as a teenager: of course girls, but also science. The experience of falling in love was intense, but what was very remarkable was finding out, whether reciprocated or not, that these feelings after some time went away. More lasting was the fascination about the things we learned. I not only was captivated by natural science (although quite good at it, I did not find math very interesting), but also history was among my favorites. The insight towards the end of the school years that the valence of chemical elements, that we learned in chemistry lessons determined which molecules could be formed, could be explained using the shell structure of electron clouds around atomic nuclei, as we were taught in physics class, was fascinating. There were problems that were not so easy to solve. I particularly

remember was that I was never able to explain the mystery why my image in a mirror had left and right interchanged but up and down left intact.

At age about 13 or so I started reading books on various subjects that I found in the Schiedam public library among those for my age group. And during a two-week stay with an aunt and uncle I discovered that they possessed a small shelve of Dutch translations of Jules Verne's famous books, all of which I devoured during these days. I read books on almost everything I could find in the public library, but one on astronomy especially captivated me. It was a Dutch translation of *Astronomy for everyman* (Davidson, 1953). I read every book on astronomy the public library had. I memorized the names of the planets, their satellites, asteroids, constellations, etc. and collected in a notebook all numerical and other information on the universe I encountered. I wanted to know everything about the universe; it did not occur to me until later that many things were still unknown or simply not understood. When my fourteenth birthday approached I convinced my parents that if they gave me a small telescope I would not lose interest using it. And indeed they bought me as present, more expensive than they would otherwise be prepared to spend, a 4-cm telescope on a table tripod. I spent many clear evenings watching the moon, planets, star clusters, etc. and learned myself to identify the constellations. It was the summer after my final HBS exam in 1962 that I worked for six or seven weeks at some administration office to buy myself a 6-cm telescope on a full-size tripod (see Fig. 3).

It was obvious that with my capabilities and interests I would go to university to study physics or astronomy. This was of course very special for my parents. After all, they both were raised in lower class environments. My parental grandparents were determined that their two boys (my father had a younger brother) should advance in society beyond what they had accomplished and, quite unusual for an ordinary bread-baker, arranged for my father to have piano lessons (and his brother violin). This probably derived from my paternal grandmother. Her mother had died at age 42 two days after her birth. She had delivered twelve children before my grandmother, most of whom – including three girls that had been given the same name as my grandmother– had died in childhood. Five years later her father died also, leaving behind in addition to only two remaining adults the two younger children, a boy of sixteen and my grandmother of five years. These were raised by an aunt and uncle that were childless. The uncle also happened to be a baker, but he and his wife must have had a part in the adolescent boy, my father's uncle, becoming a music teacher. He had died at age 34 in 1911, before my father's birth. From my mother's side music lessons were not in the books as her parents had to raise three sons and three daughters. It is likely that my parental grandparents limited their offspring to two so that they could afford to give them more education than they would have had otherwise. This had to involve periodic abstinence, because there was little other birth control than that. After six years of primary school my father had one or two extra years of schooling in a voluntary program of extended elementary education; my mother has received some education for young girls on aspects of housekeeping.

It was a disappointment for my parents, particularly my father, that the profits from a barber shop were not sufficient to pay for music lessons for me and my brother. As an optional part of the HBS curriculum I did learn to play the recorder and later, when I

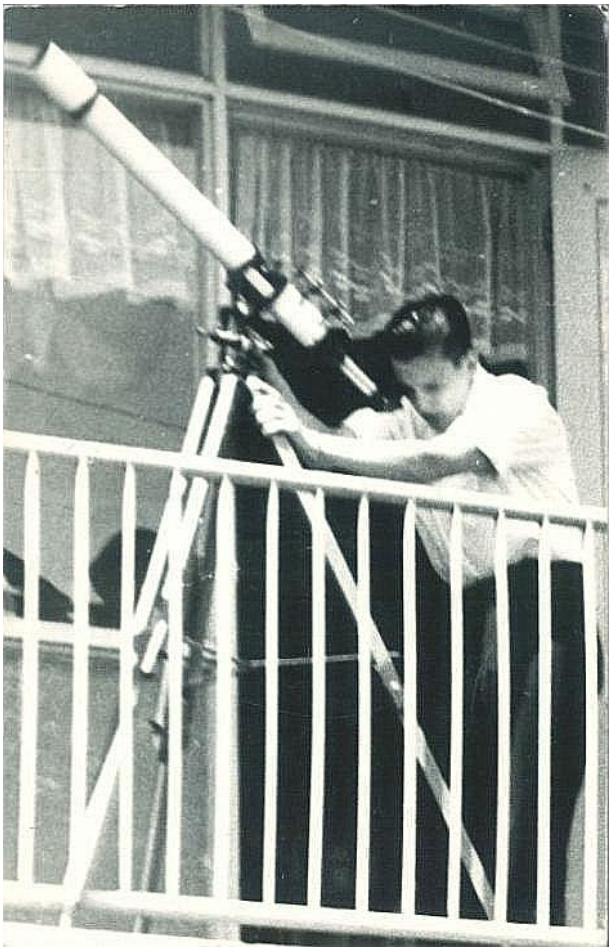


Fig. 3 Me and my 6-cm telescope at the balcony of my parents' apartment in Schiedam. I usually observed the sky from there at night, but because the part of the sky available was limited (it faced south-east and there was another balcony above ours) I sometimes went outside. Next to the apartment building's side with balconies was a recreational lawn and few street lights, so observing from there or the balcony was relatively free from city lights. From my private archives.

had my first own income, I took lessons to play the flute. I enjoyed that but must admit that I have not played for years.

My father was as far as I can ascertain from the earlier generations in his and my mother's ancestry, the first to be self-employed, starting a barbershop when he was around twenty. This kept my parents from getting married before the business had picked up sufficiently and by that time they had been engaged to marry for six years. The barbershop (see Fig. 1) was, of course, only for men; men had haircuts and shaves exclusively by males. Later my father extended his shop with a separate part for women in which he hired some female hairdressers. My mother started helping along and liked this, so she took the formal schooling and in her early forties obtained the diploma to work as a certified hairdresser.

My parents took the view that their two sons should advance in society. So they very much supported me enrolling in university. My brother was supported similarly; he became a primary school teacher, working many years as headmaster of a school. For me Leiden was the obvious choice because it was easily reached by train. To minimize the cost I stayed at first at my parent's house. After a little over two years I actually did move to a student room in Leiden. By that time I had a small grant from the government. Being a shop owner my father at first did not qualify for such support, later I was granted one for

about half my living costs, which my parents supplemented and I myself also by taking jobs during summer vacations. In those days government support came as a grant or as an interest-free advance (to be paid back later in ten years, curiously except when government employed). My results and progress were sufficient to qualify for a grant. Towards the end of my studies for the Doctorandus degree (roughly Master) I was employed part-time at Leiden Observatory to assist in supervising practical work for first year students, relieving my parents from further financial support.

I had preferred to go to Leiden anyway since this was the place where the Netherlands' most famous astronomer worked, Jan Hendrik Oort. Interestingly the director of my HBS, R. (Reynier) Oort, was a cousin of Jan Oort. This director had obtained a PhD in mathematics and taught a course on cosmography. This was an extremely dull subject and Oort a dull teacher, the course being restricted to celestial coordinate systems, time measurement, celestial orbits of sun, moon and planets, etc. No physics involved, nothing beyond the Solar System, very uninteresting. Based on intermediate classroom examinations and school reports the grade at my final exam was only an eight, reflecting my distaste of such matters that failed to give any insight in the structure of the universe.

2 Student in Leiden

The curriculum for the Candidaats (Bachelor) degree, which usually took four years or more, was mostly physics and mathematics, including exercise sessions in mathematics and laboratory work in physics. I did not dislike that, but certainly did not really enjoy it. The astronomy courses were very interesting and I looked forward to concentrating on astronomy in the phase after the Candidaats. In the first year there was a course in elementary astronomy and this took most of the academic year in the form of a two-hour lecture per week and an afternoon practical work at the Sterrewacht (Leiden Observatory). It was given by Pieter Oosterhoff, one of the three astronomy professors. It was an excellent course and Oosterhoff an inspiring lecturer. It covered all of astronomy and rather than being descriptive, concentrated always on the underlying physics. Later, when I became a staff member in Groningen and was assigned a similar course I used my notes as a guide towards my own lectures. It stimulated me very much and strengthened my determination to become an astronomer. Before enrolling in Leiden I had been uncertain about whether to become a physicist and have astronomy as a hobby, or to try to have a career in astronomy. Just before actually filling out the Leiden forms I decided to check the box 'Candidaats C: major astronomy, minors mathematics and physics'.

An example of Oosterhoff's exercises is the following. We were given a large (50 cm or so) square photograph of a globular cluster on which many of the brighter individual stars were seen, and a transparent sheet with a rectangular grid. We then counted stars in each grid-element. From this surface density distribution we located the center of the globular cluster and next the radial distribution. Assuming that the cluster was spherically symmetric the integral to go from space density to projected surface density was written down and inverted numerically from the outside inward. I was very much impressed about how powerful and straightforward this procedure was.

Fig. 4 Me as a student in Leiden. The location is the bridge over the Rapenburg in front of the Academy building. My bike, which can be seen in part, was a very simple, certainly according to current standards, one so as to be affordable; for example it had back-pedal brakes, no luxurious hand brakes, and certainly no gears, as was very common among students. From my private archives.

The second and third year we had 'caput' lecture courses. The subjects in my years were celestial mechanics by Henk van de Hulst and planetary system by Jan Oort. Van de Hulst lectured on the determination of solar system orbits from observations of sky positions and perturbation theory among planets from expanding the relevant equations into series. We performed in groups of two a numerical integration, in which an equal-mass binary star system in circular orbit was perturbed by a passing star of equal mass all moving in the same plane. I shared the numerical work (this was before the days of computers, so it was all done by hand, when possible using a slide ruler) with my year mate and later Groningen colleague Jan Willem Pel. Each pair of students was given different initial conditions. The restricted three-body problem with its Lagrange points was also treated in detail, as was that of boundaries (zero-velocity curves) of stellar orbits in the Galaxy as determined by Alex Ollongren in simulations using large computers, by writing equations of motion in elliptical coordinate systems. Especially the latter, which was related to the third-integral problem and a forerunner of Tim de Zeeuw's work on Stäckel potentials, I found extremely interesting.

The course by Oort on the planetary system was interesting too. Later, when I wrote a biography of Oort (van der Kruit, 2019, 2021b) and studied his archives I realized this course was modeled after Kapteyn's lectures that had so much captivated Oort that he became determined to become an astronomer. The crucial point was Kapteyn's treatment of Kepler's work in which the latter had discarded all that came before and went back to

basics, asking himself what the actual shape of the planetary orbits was in the first place and had found them from to be ellipses from observations.

During the first months in university I had to get used to the fact that I sometimes had to work very hard to understand some mathematical problem, while at the HBS it had been always clear without requiring any explanation from the teacher. Also there obviously were other students that more quickly than I grasped the material we were taught. This was not very helpful in boosting my self-confidence. However, this was repaired when I had to report for a day of inspection for military service. In the morning we had to go through physical and medical tests. University students were called away individually to report at the office of the 'commander', since these would be eligible to training as an officer. You were directed to sit in a large leather chair, which was very uncomfortable as this was during the medical examinations when one was only wearing underpants. At the end of the day I was unexpectedly called back into the commander's office. We had been required to do an IQ test and I had not only managed to answer all questions in the limited time available, but in addition given all the correct answers. During his years in his position he had seen this only on a small number of occasions. It meant, he told me, that my IQ was outside the range the test could measure and it had to be over 140. I felt that if indeed I were that smart, I should be able to complete academic studies and it became a challenge.

I did the Candidaats exam in May, 1966. This really was a formality since each lecture course ended with usually an oral or sometimes a written exam and each program of practical work with an overall grade. Within four years was relatively fast and I believe I was the first of the astronomy students of my year. I found some work through an office for student jobs at an insurance company for three months to handle claims from traffic accidents, so I could buy some new clothes and have some vacation (Fig. 4). In September I started the formal continuation for the Doctorandus (Master) degree. This meant being assigned some working space at the Sterrewacht (Observatory) and in addition to lecture courses a small and large research project (equivalent to a few months and to nine months to a full year of work) under the supervision of a staff member. The courses were three major ones in astronomy and one in physics, for which I did quantum mechanics, but for completeness I studied the lecture notes of a fellow student of the other choice classical mechanics. The three required astronomy courses were quite substantial; the first one I attended was on radio astronomy by Harry van der Laan, who had been appointed recently. This was timely as the Westerbork Synthesis Radio Telescope WSRT was under construction. Radio astronomers in Leiden used the 25-m radiotelescope at Dwingeloo, which concerned almost exclusively studies of our Galaxy. Many studies involved the neutral hydrogen 21-cm line, but others used the radio-continuum to map the spurs and other structure in the Galactic background or its polarization to study the magnetic field. Extragalactic radio astronomy was not really a focus, while the WSRT would be primarily suited for that work. Harry continued preparing Leiden astronomy for Westerbork by organizing working groups and literature reviews by and for students and staff members.

The room at the Sterrewacht, where once the meridian circle had been located (the room was still known as the meridian room) was the place where the staff and students

gathered at 11 am for morning coffee. There was a small billiards table and one for table tennis. Some people played billiards but nobody, or at most very few, could beat Oosterhoff. Some others played table tennis, usually doubles so that four could play at a time, or simply talked to each other. At lunch the same room was used. The three professors (Oort, Oosterhoff and van de Hulst) lived at the Sterrewacht. Van de Hulst and Oosterhoff had lunch at home, so winning a game on billiards was only possible at lunch time. Oort sometimes brought his lunch and joined us.

I first had a meeting with Oosterhoff, who asked in what kind of research I would be interested, so that he could assign me to a staff member to be involved in his research. I was excited about the prospect of working with the Dwingeloo dish. I was assigned to Willem (Wim) Rougoor. He had written a PhD thesis on neutral hydrogen gas near the Galactic center and its expanding features in 1964 and after a period at Caltech and Owens Valley Radio Observatory had returned to Leiden. He was starting up an observational program in Dwingeloo to map the hydrogen around the Galactic center but, contrary to his earlier work extending it to higher velocities and outside the Galactic plane (10° either side of the center in longitude and 5° in latitude; a corner of this rectangle never comes above the horizon in the Netherlands, so that was left out). Wim had been diagnosed to suffer from leukemia and underwent all sorts of experimental treatment. I only saw him while the project was being set up. Sadly, he died in 1967 at the age of only 36.

I first continued under Whitney Shane, who was working on a thesis on the Scutum arm region, also using Dwingeloo. However, Oort himself was very much interested in this work, so he took over the supervision. Oort's way of supervising was simple. At morning coffee he always had a minuscule scrap of paper with a few names scribbled on it in his even more minuscule handwriting of people he wanted to speak. Every now and then I was on this and he would come up to me and ask how it was going. I gave a short report and if it seemed interesting to show some results he proposed a date and time for me to report to his office. I still had serious doubts whether I would be capable of adding anything new and would be fit for a career in astronomy, but as long as Oort was interested it seemed I was not doing too bad. But the real test had still to come, when the observations would be reduced and would have to be analyzed.

The Dwingeloo radiotelescope was operated by three students, working in six hour shifts for periods of two weeks, and I tried to arrange to be one of these whenever my program was on. This popular arrangement had the added bonus of having free accommodation (which in winter saved you from heating your student room) and food, and in addition a quite reasonable fee. The specification of the observations was was extremely simple. I filled out a form, specifying a grid with extent and spacing in longitude and latitude and a range in frequency (radial velocity). The positional range surveyed was on a 1° grid with an additional grid at the centers of the grid elements and velocities were away from zero up to 250 or 300 km/sec positive and negative. The data were written on punched paper tape. There were three Creed punching machines, but since they were used very intensively they often broke down and had to be repaired all the time. All three were arranged to be in working order on Friday afternoon and this was usually good enough to get through the weekend. The tape had to be checked regularly, which was done by letting a short piece of tape move along through the Creed, and then the spacing of the

guiding ('sprocket') holes had to be verified with a ruler and the figures to be read from the punched holes and see if it agreed with the 'parity check' hole. Important also was to empty the waste basket in which the 'chads' (punched-out pieces of paper) were collected.

The reductions were performed in Leiden on the university's first computer, a single user Electrologica X-1. Before using it one had to turn it on with a on/off switch and manually set an address in a register. The output was a set of punched cards that had to be fed into a line-printer elsewhere. Reading the punched tape in Leiden was done with a special construction, in which the tape was always hanging down in a loop, which was checked to be fully extended by a photocell that could stop the reading process immediately, so as not to break the tape. Still there was always the danger the tape would get tangled or break. The computer room was on the top floor of a tall building; my colleague Renzo Sancisi and I at one occasion salvaged a tangled tape by throwing it out of the window and slowly and carefully winding it back up. Later in the project the university switched to a IBM machine causing much delays, because the necessary software took time to develop. In fact because of this a malfunctioning in Dwingeloo went undiscovered, so a significant number of observations had to be repeated.

The next lecture course I attended was by Oort on stellar dynamics. He used his recent chapter in the *Stars and Stellar Systems* compendium, volume V (Oort, 1965), and we all received a reprint. I have used it often as a source of reference. The course presented in detail his famous papers on the rotation of the Galaxy (Oort, 1927), K_z (Oort, 1932), the density distribution of stars in the Galaxy (Oort, 1938) and preliminary application of dynamics to early type galaxy NGC 3115 (Oort, 1940). Most of us found his derivation of the two-body relaxation time with quite significant approximations cuttig corners a bit too much, but Oort stressed it gave the correct answer within a factor of a few. He presented his unsuccessful efforts to get the dynamics of NGC 3115 right (the Minkowski rotation curve he used turned out incorrect; see Fig. 14.9 in van der Kruit, 2019) and concluded with his work on the Oort Cloud and the origin of comets (Oort, 1950).

Oort lectured with a rather soft voice, mostly facing the blackboard and with his back towards the students, while his chalk clicked on the board when 'improving' his drawings of circles and other sketches. The students clustered in the first rows of the lecture room to pick up what he said. Even though he used lecture notes, these were ones used before, sometimes from a different year than the ones used the previous week, with the result that he sometimes used different mathematical notations. He did not use textbooks, but referred to his *Bulletin of the Astronomical Institutes of the Netherlands* papers and the 1965 chapter he had distributed. In spite of all this his lectures were very inspiring and left me with the desire to work on the subject of dynamics of galaxies. My oral exam in June 1968 went well; later when writing his biography I found his notes on my performance. He had asked me to give the 'empirical estimate' of a cluster relaxation time, and I went into too much detail, deviating from his derivation, which he noted as 'did not know precisely'. The rest was either 'good' or '*vlot*' (meaning smooth or swift) and the final grade was 8 to 9, which was a high score compared to most others in the file, much better than I would have guessed at the time. In fact I definitely regarded myself as an average student. The note also ended by summarizing that I had completed van der Laan's course and would do interstellar matter with Henk van de Hulst in the fall.

This was part of an agreement he had made with me. In the fall of 1967 Oort had asked me to perform some calculations on his suggestion that the high-velocity clouds (HVCs), discovered in Dwingeloo, were manifestations of an inflow of pristine gas into the Galaxy. This would be my small research project. The HVCs were concentrated towards a complex at longitude 130°, latitude +40°, coming towards us at 100 to 130 km/sec. If this were an inflow, what would that mean for the velocity of the Galaxy w.r.t. the intergalactic medium and what more could be said about this?

For a more detailed description of the work, see section 13.4.4 in van der Kruit (2019). Oort had made one of his regular visits to the USA, I think among others to Princeton, where his younger son, meteorologist Bram, lived, but other places as well. According to the Oort Archives, I wrote to him in Pasadena at the Hale (Mount Wilson and Palomar) Observatories in December 1967 with intermediate results, but he did not reply to that. After his return I showed the final results, which impressed him a lot. It gave support to his idea of an intergalactic inflow. I calculated orbits of gas clouds assuming that the Galaxy was a point mass. There were two possible orbits ending up at the solar position, one direct and one first passing the Galactic plane so that part of it was blocked if this happened within the disk's extent. Assuming a dispersion in velocities in the flow this all resulted in a predicted distribution across the sky, which compared quite well with observations. At the time I did not regard this work very special, but rather straightforward and the approach obvious, but now I realize it showed some degree of originality. I wrote this up as a joint paper with Oort and, although he had it typed up and did some editing of it, it never was completed and published. I did the calculations during the winter of 1967/8, a major part of it on my slide ruler as student observer in Dwingeloo.

An interesting thing happened about that time. In February 1968 the discovery paper of the pulsars appeared in *Nature* (Hewish et al., 1968). I had an appointment with Oort on my research, and as I came to his office I found him extremely excited, since he had just received that issue of *Nature* and therefore just heard about the new phenomenon. Now Hewish et al. focused in their discussion on possible explanations particularly on oscillations of white dwarfs or neutron stars. Oort had apparent not found this explanation appealing. He had just convinced himself that a rapid rotation of a neutron star appeared to be not impossible in terms of angular momentum. The calculation he had made more or less went like this. A pulsar neutron star (say 2 $M_\odot$ and radius 15 km) with a rotation period of 1 second (about that of the first pulsar) has an amount of angular momentum of order one thousandth of that of the Sun. So this was entirely possible. He was extremely excited and told me all about the Crab Nebula research he had done and speculated that there would be a pulsar in it too. We spent little time on my research since he had a further appointment and we ran out of time.

Not long after this, sometime in April or May I think, Oort made me the offer to continue the Dwingeloo work as a PhD student. But I would then have to get my 'Doctoraal' in the fall of that same year 1968. That was problematic as I was not that far along yet, but I promised to work as hard as I could. I did the stellar dynamics exam, but I still needed another course. Van de Hulst would lecture next academic year on interstellar matter but that would be too late. The latter suggested I read some chapters of *Stars and Stellar Systems*, Volume VII on 'Nebulae and interstellar matter', which had just appeared. This

did not work well at the exam since without lectures I could not anticipate at all the kind of questions he would ask. I did not fail, but did also not perform too well. But is was sufficient to pass and I obtained the Doctorandus degree in November 1968.

3 PhD thesis and Westerbork

My large research project for the Doctoral exam had been the set of Dwingeloo observations near the Galactic center. It was not really completed at the time of my Doctoraal, but reductions were coming along. There really was no plan rather than look and see. So I proceeded reducing the data. When everything was done the most interesting thing I found was that there were two hydrogen clouds on either side of the Galactic center, roughly symmetric in longitude, latitude and radial velocity. One at about $(l, b, V) = (7, -2.5, -58)$ was new, while one at $(l, b, V) = (349, +3, +50)$ had been noted before. They would have masses of order a million $M_\odot$ if located near the center of the Galaxy (van der Kruit, 1970). The symmetry suggested to me an expulsion of matter in two opposite directions and Oort was very pleased with this. He and others had stressed that nuclei of galaxies might be the seats of violent events and moreover he had suggested that the expanding 3-kpc arm and its counterpart showed that this might have happened in our Galaxy too.

At the time spectroscopic studies of Seyfert galaxies (spiral galaxies with very bright, point-like nuclei) by Donald Osterbrock and others showed that in these clouds of similar masses were moving at 500 or more km/sec. I suggested that these clouds in our Galaxy might represent late stages of such a phenomenon, when they had moved out and slowed down. Oort thought this was an important conclusion. At one time (according to the Oort home guest register in the private parts of the Oort Archives, in April 1969) Osterbrock stayed with the Oorts, visiting to give a colloquium. Oort 'asked' (would I dare to refuse?) me to come to the Sterrewacht on Saturday morning (since about 1960 this was no longer usual office hours) to show my results. Don was very impressed and being an extremely nice man congratulated me profusely with the result.

When the results were written up (van der Kruit, 1970) Oort suggested that next 'I should make some calculations'. What kind of calculations he did not specify. I was at a loss, but after reflecting upon it I decided that I might calculate orbits of gas clouds expelled from the nucleus at an angle with the plane (so that the nuclear gas disk within 1 kpc would survive) that fell further out into the plane to see if they could form the 3-kpc arm expanding from the center at 53 km/sec and the opposite +135 km/sec arm. I made an appointment with Oort and explained what I had in mind. 'OK', I remember him saying, 'but don't forget the centrifugal force'. Bram van Leer helped me how to treat the braking of the clouds once they hit the gas in the plane and I constructed a rough mass model of the central parts along the lines Maarten Schmidt had done for the Galaxy as a whole. Leiden university at that time had an IBM mainframe and I taught myself programming in PL/1, a programming language IBM had developed. In the end I was able to present a model that explained the expanding arms by nuclear gas expulsion 12-13 million years ago. The asymmetry between the two sides resulted from a small difference

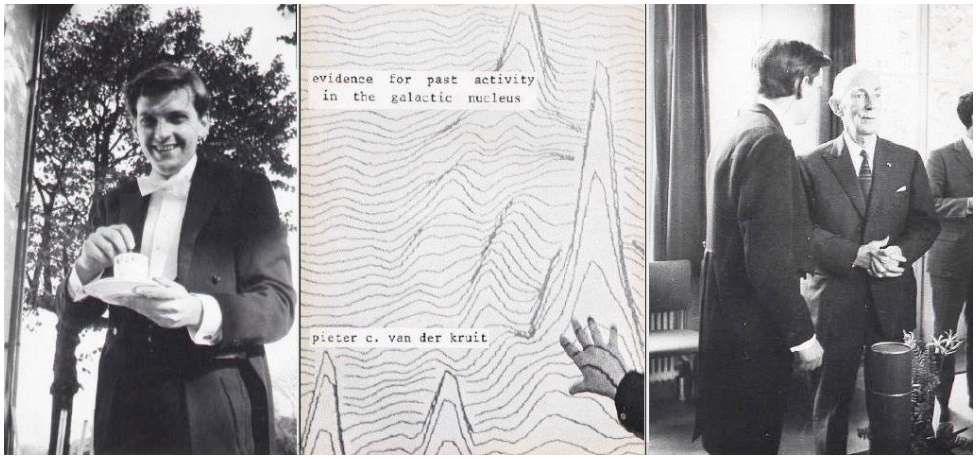


Fig. 5: In the middle the cover of my PhD thesis with myself dressed in tails before the defense on the left and with Oort at the reception afterwards on the right. The picture on the cover has been taken by Vincent Icke when I presented my WSRT observations of M51 (see Fig. 6) at a Young European Radio Astronomers Conference YERAC earlier in 1971 in Bonn, Germany. From my private archives.

in the angle of expulsion with the Galactic plane (van der Kruit, 1971a). Fellow PhD student Butler Burton's contour drawing program had saved me a lot of time.

Oort felt that my thesis would consist of the two papers. But by this time (spring 1970) I had spent not much more than a year and a half as a PhD student. The WSRT came online and Oort suggested I should be involved in the early science. But submitting a thesis would have meant that I would have to report for military service. I had had deferment up to the Doctoraal (one was allowed seven years for that) and starting late 1968 I was eligible for another four years for the PhD phase. So I had more than two years left. Oort suggested I should not hurry writing the second paper. He would tell the Minister of Defense the thesis work was going well, but was not complete yet.

The second paper (van der Kruit, 1971a) was published in August 1971 and I defended my thesis in October. In the Netherlands PhD theses are printed in a rather large number and distributed among colleagues, family members, friends and anyone interested. Partial financial support for this comes for astronomy PhD students from the Leids Kerkhoven-Bosscha Fund, which has been founded with an endowment from two tea planters in the Dutch East-Indies. It did and still does provide some support of the Bosscha Observatory in Lembang, but mostly it provides support to Dutch astronomers – of all institutes in spite of Leiden in the name –, such as for travel to conferences abroad and printing of theses. The University Library pays the extra costs for the copies they require. For the rest the PhD student has to save up money (or have generous parents), also for the reception after the defense and a dinner and/or party afterwards. My thesis consisted of reprints ordered from the journal, collected with a title page and some introductory pages, typed with an electronic typing machine, reproduced with the Sterrewacht's Xerox machine, stapled together and pasted into a separately printed cover (Fig. 5).

We astronomy PhDs could do things relatively cheaply by having the reception and party at the Sterrewacht. I had the dinner at the Sterrewacht as well with Vincent Icke's help. I recently found out to my relief that Oort had written in his diary:

> ... the Observatory, where in our [sic!] hall there are tables lighted by candles and a meal of cheese fondue. It is extraordinarily enjoyable. [...] I am given a beautiful vane for my schouw and Mieke a few bottles of sherry'.

It was held in the hall of their former home. Vincent had cut a wooden knob for the vane for Oort's sailing boat ('schouw' is the type) and I actually had also presented him with a bottle of vintage Scotch whiskey.

Some of us students were involved in early testing of the WSRT, working in shifts and sharing with three at a time two beds in a caravan on the site. Other persons involved in this included Peter Katgert, Jet Merkelijn, Roelf-Marten Duijn, Rudolf le Poole, Frank Israel. Somewhat later Peter and Jet got married and I acted as best man at their wedding. At some point we had problems with an interference signal that we could not identify. Radio interference was not unusual, but often related to television transmission (or radar but then it is a periodic pulse). As it happens there is a transmission tower in Smilde, a bit over 10 km to the west of the WSRT. This was known very well to me. It is about 10 km north of Dwingeloo and with the radiotelescope pointing to the south at the horizon to observe the Galactic center, the – if I remember correctly – second harmonic of the sound transmission signal of the Dutch second television channel came in through the backlobe (so leaking through the mesh) of the dish to spoil my observation in a narrow band at radial velocity +220 km/sec (Fig. 3 in van der Kruit, 1971a). In Westerbork Jet Merkelijn and I used one of the element telescopes to scan the horizon and saw the antenna pattern in the interference signal with a main direction to the southwest. It could not be the Smilde transmitter. Others took over and used two elements of the array to triangulate the source and visual inspection by driving out by car showed a radio transmission mast, which was unlisted, so military. When the Ministry of Defense was notified the frequency was quickly changed and the disturbing signal in Westerbork disappeared.

In the beginning the WSRT observed in radio continuum at 1415 MHz in a 4 MHz band, some 1000 km/sec from the 21 cm line. The line emission is very narrow-band, so serious contamination by line emission in the band, even if present at these velocities, was unlikely. When the first call for proposals came I immediately submitted one to observe most Seyfert galaxies to see if they had nuclear radio sources and a comparison sample of 'normal' spirals. This program was designate 'W2', 'W1' being a calibration project. The Seyferts were indeed brighter and I found a relation between radio and near-infrared emission in active nuclei up to quasars. Publication (van der Kruit, 1971b) was delayed so that the first WSRT paper would be by Oort, a *Nature* note on a non-detection of elliptical galaxy Maffei 1, which optically is hidden by the Milky Way (Oort, 1971).

Oort suggested I next should survey the major large spiral galaxies in the northern sky ('W2A'). When Don Mathewson from Mount Stromlo Observatory in Canberra, Australia came to Leiden for a sabbatical year, he was included in the project. His major interest was to measure polarization to study magnetic fields. In the end this was too faint to be measurable, but we did make quite an impact with the observations of the spiral galaxy M51(Mathewson, van der Kruit & Brouw, 1972). In those days all WSRT reduction took

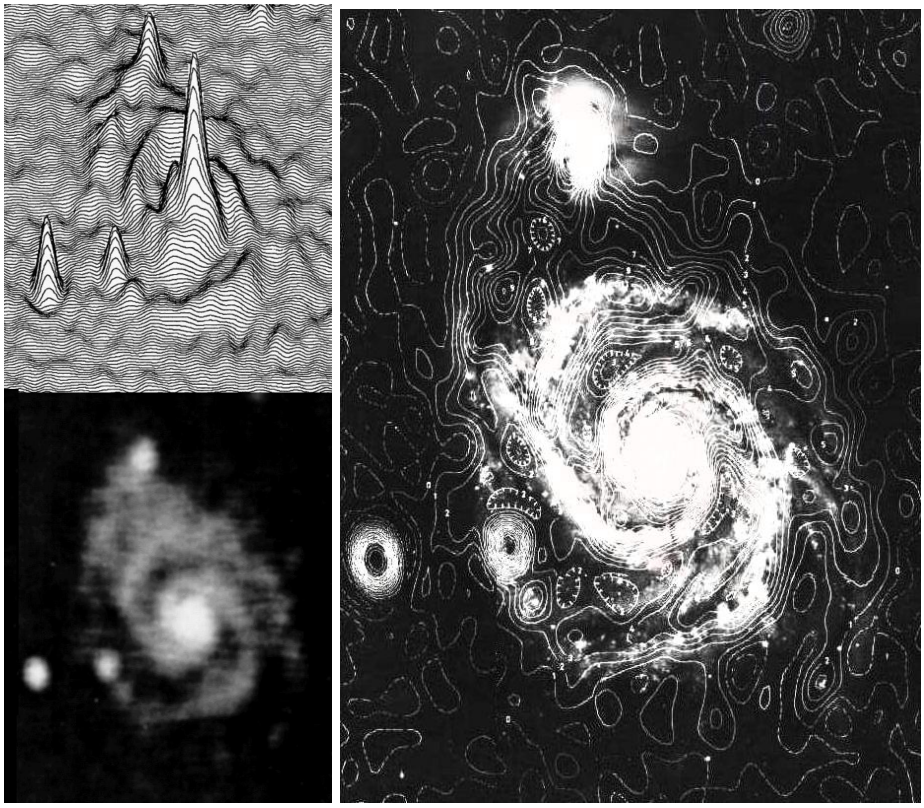


Fig. 6: Westerbork observations of the continuum radiation of the Whirlpool galaxy M51. On the top-left a so-called ruled surface plot and below that an intensity representation produced by Walter Jaffe on a cathode-ray tube. On the right brightness contours superposed onto an optical image. From Mathewson, van der Kruit & Brouw (1972).

place at the Central Computing Center at another location by dedicated staff. Plots and other results where brought in by coffee time and everyone would look at them. When someone had erred in specifying scales of plots (produced with ink-pens on paper) and the plot would have the size of a postage stamp, this was cause for much laughter. The first time we saw M51 was at coffee time in the form of the ruled surface plot in Fig. 6 (top-left), and everyone marveled at the spiral structure. It turned out to be convincing evidence for the density wave nature of spiral structure, at least in M51. The spiral pattern moving through the disk gives rise to shock fronts in the gas on the inside of the arms seen as dust lanes but also as enhanced radio emission.

When the paper on M51 was close to completion, Don Mathewson raised the possibility to publish the contour map superimposed on the optical image (right hand panel in Fig. 6) on a large scale as a fold-out. The editor of *Astronomy & Astrophysics* agreed on the condition that it be produced in Leiden and delivered to their printer in Gießen, Germany, some 450 km from Leiden. The Sterrewacht accepted and Frank Israel and I were designated to do the delivery. We could borrow the car of Peter and Jet Katgert and we set out in the morning. Driving on the German Autobahn we noticed suddenly that we were very low on gas. The next gas-station, as we soon found out, was 10 km down

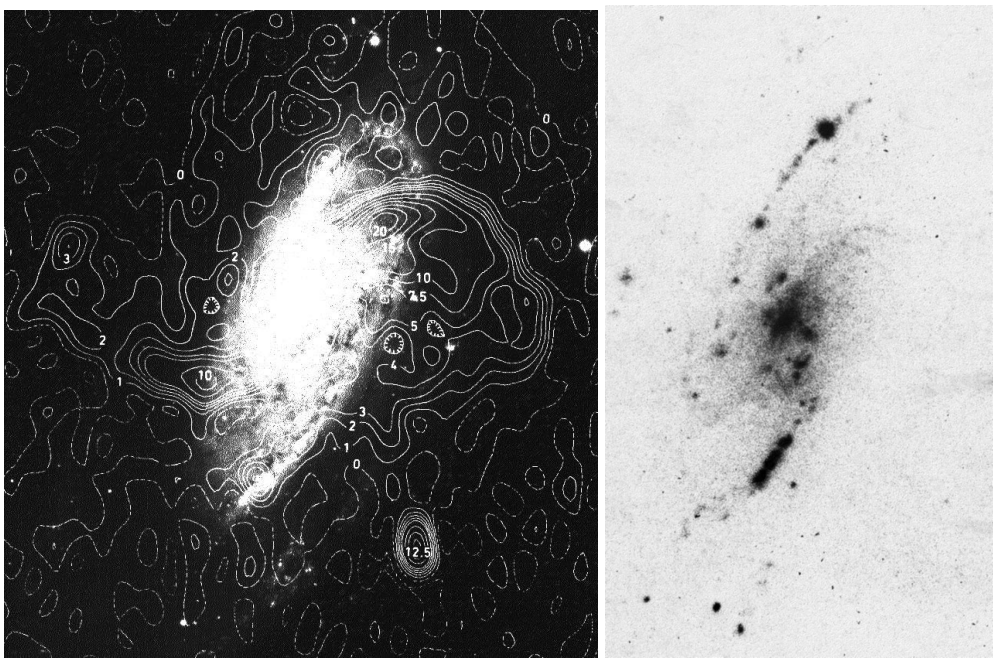


Fig. 7: NGC 4258. On the left an optical image with the radio continuum contours superimposed and on the right a photograph taken in the light of ionized hydrogen (Hα), taken by French observers and published some years before. From van der Kruit, Mathewson & Oort (1972).

the road. When we had about 2 km to go the engine stopped and as the driver that time I immediately hit the clutch. We were going up a hill, just made the top and rolled down to the gas station at the bottom. By the time we reached it we were crawling forward very slowly and I had to brake not come to a standstill ten meters or so too far. We delivered the fold-outs in good order. Not being able to find a suitable cheap hotel, we drove all the way back eventually in dense fog, arriving in Leiden early next morning. We only noticed as we stepped out of the car that the streets were slippery with frost.

Next, in NGC 4258 we found radio emission associated with two 'anomalous' arms running out radially from the center and visible in Hα (recombining hydrogen; see Fig. 7). We attributed this to nuclear activity and I used my thesis computer programs to calculate orbits of gas clouds expelled *in* the disk to back this up. Oort speculated that this was a way of regenerating spiral structure when a density wave had faded out (van der Kruit, Oort & Mathewson, 1972).

Without going into the details I note that my Westerbork work resulted in a few more papers, two on the Andromeda Nebula (one with Peter Katgert) and three on a significant sample of bright, nearby spiral galaxies. Another piece of work in which I participated was on 'head-tail' sources in the Perseus cluster and elsewhere, which were interpreted as trails, showing the orbit of the galaxy while ejecting relativistic plasma. My contribution was minor, but when the *Nature* paper (Miley et al., 1972) was published, I appeared on the Dutch national television news to comment on the discovery.

4 Carnegie Fellow

It had been customary in the Netherlands for young astronomers to spend some time abroad to obtain experience with other astronomical settings, techniques or research environments. This goes back to the days of Kapteyn (see van Berkel, 2000, in the 'Legacy' symposium on Kapteyn that he and I organized in 1999). During the expansion of the universities in the 1960s often young astronomers took very long to write their theses. Regulations stipulate that government employees (and therefore those at universities) cannot be given temporary contracts for more than four years, so many were on indefinite contracts before obtaining their PhDs. Most had had to report for military service, but with a permanent position to go back to that was no more than an unwelcome interruption. After obtaining the PhD degree, they did take a leave of absence to work abroad for some time. When I finished my PhD, new university positions had become scarce. Practice then became that after the PhD phase one would find a postdoc position, which at that time were generally for two years, and then apply for a position which could subsequently become permanent. Having been at a postdoc position abroad became a requirement for a prospect to be appointed permanently. I was one of the first in this new regime and my appointment in Leiden would end October 1, 1972, a year after my thesis defense.

However, then the problem of military service returned in 1971 after I had obtained my PhD, but Harry van der Laan urged the Ministry of Defense that I (and two others) should be extended our deferment because of being indispensable for the Westerbork operation since there were too few experienced others to take over. The prospects that this would be approved was good, so when my summons to report came I took no measures, such as terminating the lease on my apartment. When the Monday I was due came closer I became more nervous, and a week before the date a phone-call by Harry to the ministry provided no definite answer. Only on Thursday, when he called again, he was informed that the request would be honored. I was only notified formally by telegram, which was sent 5 minutes before the end of office hours on Friday afternoon and delivered at my address Saturday morning!

I had decided that after leaving Leiden I wanted to obtain experience in optical astronomy. I took up the idea to use optical emission lines to map velocity fields in the centers of spiral galaxies, especially ones where radio continuum indicated nuclear activity. So where could I go? Vera Rubin had been measuring galaxy rotation curves and was an expert in long-slit spectroscopy, so maybe finding a postdoc position with her might be an option. I knew that at the request of Oort, Maarten Schmidt had taken spectra of the anomalous arms in NGC 4258 at the Palomar 200-inch telescope. I had seen an advertisement for postdoctoral Carnegie Fellowships both at the Hale Observatories (which included Palomar Observatory) and Vera's Department of Terrestrial Magnetism in Washington, D.C. Oort thought applying for such a fellowship was a good idea and I submitted applications and asked Oort to send reference letters. And I asked Don Mathewson (now back in Australia) and Harry van der Laan to do likewise.

But should I look for other places to apply? Oort's secretary Dinie Ondei mentioned to me one morning at coffee time that Oort had sent the letters and that she thought that it would be very unlikely I would not get at least one of these fellowships. So, I took the

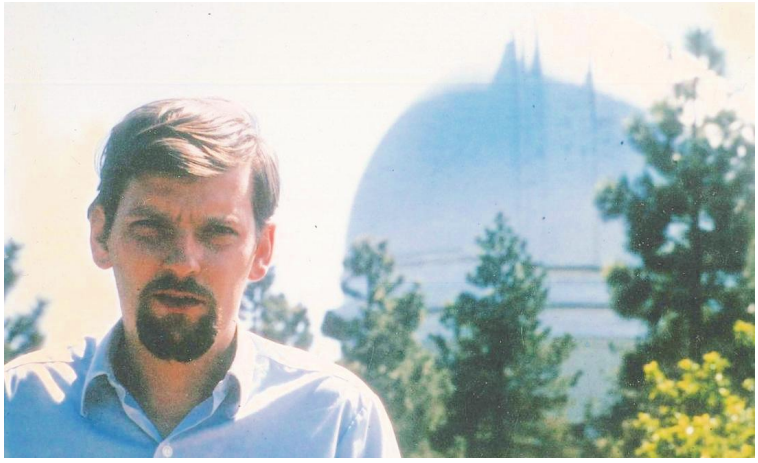


Fig. 8 Photograph of me as a Carnegie Fellow in front of the dome of the 200-inch Hale Telescope at Palomar Mountain. From my private archives.

risk and wrote no further applications. Some time later I was on Oort's scrap of paper at coffee time. He informed me that he had had a letter from Philip Abelson, president of the Carnegie Institution, saying that he had on his desk recommendations from both places to award me a Carnegie Fellowship. Which institution would Oort recommend or should I go to each for one year? Oort said he had written I should go to Pasadena, but the letter had not been sent yet. I agreed; Palomar was definitely the preferred place. I later was told that at the time Allan Sandage was spending some months at Mount Stromlo and Don Mathewson had convinced him to send a note back home to Horace Babcock, director at Hale Observatories, urging him to have me selected. I was offered a Carnegie Fellowship at Hale Observatories in the spring of 1972 to be taken up on October 1.

I moved to Pasadena in September 1972. This was my first trip to the USA. We (just before this I was married) spent a few days in New York and visited Vera Rubin in Washington and Butler Burton at the National Radio Astronomy Observatory (NRAO) in Charlottesville, Virginia on the way to California. I gave colloquia in both places. I arrived in Pasadena on September 30, just in time for the start of my fellowship.

My time at Hale Observatories was a great experience. I still had doubts about whether I was good enough to bring this period to a successful conclusion, and decided to look at it as another challenge. Hale Observatories is not on the campus of the California Institute of Technology (Caltech), but I did get Caltech faculty status and visited the Astronomy Department regularly. Both Hale Observatories and Caltech had excellent astronomers and postdocs and Caltech also PhD students, and I doubted I was in the same class. Every fellow had a 'sponsor', a sort of supervisor, on the staff. Mine was Leonard Searle and he talked to me every now and then, which always was enlightening. All I had to do at Hale Observatories was research; no meetings (a general staff meeting of an hour or so once per year), no teaching (I gave one lecture on density waves at Caltech in Alan Moffett's course), no other duties. I was introduced at Palomar Observatory to the 200-inch (the first optical telescope I ever used) and 48-inch Schmidt telescope by Halton ('Chip') Arp. I was allocated observing time on these telescopes and the brand new 60-inch. The latter was built with a long-slit spectrograph, so suited for my project. I used the Schmidt to search for NGC 4258-like galaxies, after checking on an exposure of NGC 4258 itself that the anomalous Hα arms were visible on Schmidt plates taken through an Hα interference

filter. I took quite a few plates (5 by 9 inch because of the size of the filter) in the Virgo cluster, but found no galaxy with Hα arms or similar features.

The bulk of my work was taking spectra in a few galaxies I had studied in Westerbork, both with the 200-inch and the 60-inch. For NGC 3310 and 4736 I used many position angles through the nucleus. Spectra taken on the 60-inch turned out usable only in bright parts of the galaxies, because the system was too inefficient; in the second year I ended up getting more 200-inch time. I used offsets to take spectra in NGC 4258 and Maarten Schmidt gave me his spectra of the anomalous arms. Spectra were recorded with high-contrast IIIa-J film pressed to the output screen of an image tube that amplified the signal. The film had to be 'baked' for many hours in nitrogen or forming gas at about 65°, so this had to be done during a previous run. The observing on the 200-inch could be done from the heated control room (on one occasion I had to use the very cold and uncomfortable Cassegrain cage). Guiding at the other telescopes had still to be done from the dome by keeping a star at the cross wires in a guiding telescope. In the winter and spring it would often freeze and with the telescope pointing relatively low in addition very windy, so this could be quite unpleasant. Completing a good night's work at the telescope, however, was very rewarding. Fig. 8 shows me with the 200-inch dome.

At one occasion I went up to the 200-inch prime focus cage to take an Hα exposure of NGC 4736. What an experience to go up on the elevator at the rim of the slit in the dome, seeing the valley far below and the stars above that felt much closer than the earth.

I shared my 200-inch time with Chip Arp, who used photometric conditions to photograph galaxies with supposed non-cosmological redshifts, looking for bridges or links with nearby, low redshift galaxies. I did not believe in this and we at first argued about that, but in the end let the subject rest. I liked Chip a lot, but I was on the other hand a bit apprehensive about the consequences for my relation with Allan Sandage. He and Chip were on very bad terms, because of the latter's stand on the supposed non-cosmological nature of some redshifts. When they were observing at the same time at Palomar, Allan took his meals in the 200-inch dome so as not to have to share the table with Chip in the 'Monastery'. Allan noticed I was not influenced by Chip's views and no problem arose. In fact I talked quite regularly and fruitfully with him in the Santa Barbara Street offices.

Poor weather was always a risk, especially in springtime when my galaxies were observable. The 200-inch dome had a pool room and one then tried to beat night-assistant Gary Tuton, which was very difficult. Only Maarten Schmidt was a match to him. Maybe Maarten had managed to beat Oosterhoff in billiards games when he was still in Leiden. I was reasonably lucky with the weather (how would my career have developed had I been much less blessed with clear skies?). Actually, when I was somewhat unlucky with weather at Palomar early during my final year, Leonard Searle generously donated a two-nights observing run on the 200-inch to me, so that I could complete my project.

I had observed NGC 3310 at the 200-inch in 1973, guiding from the operating room on a screen showing the image of the reflecting slit jaws. Guiding was done on features in the galaxy which were encircled with a marking pen with ink that could later be wiped off the screen. When returning to it in February 1974 (as usual sharing a run with Chip Arp), I noted immediately that a clear new feature had appeared (see Fig. 9). A supernova? I went over to the 48-inch, where my good friend François Schweizer was observing, who

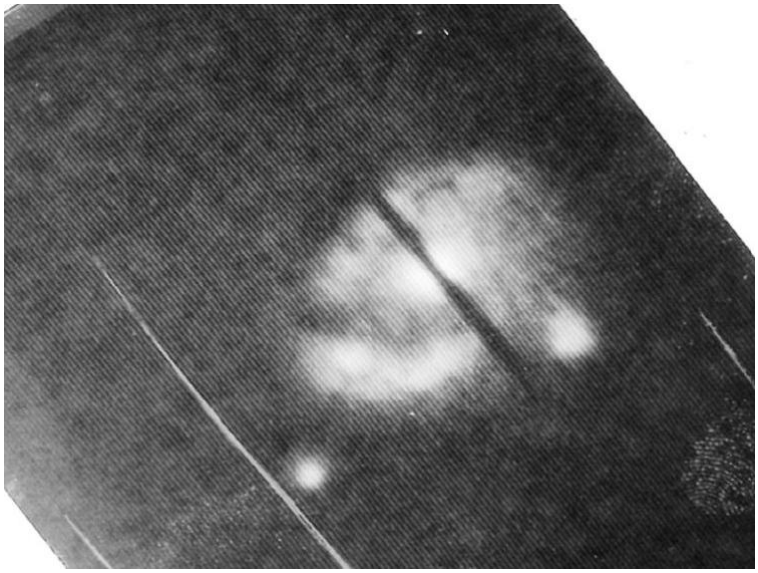


Fig. 9 'Discovery plate' of SN1974C in NGC 3310. This is a polaroid picture taken of the monitor screen in the control room of the 200-inch Hale Telescope viewing the reflecting slit jaws of the Cassegrain spectrograph. This was used for acquisition, monitoring and guiding. The picture has been rotated to have north at the top. The supernova is at the lower left, 16 arcsec from the nucleus. From my private archives.

took a short exposure plate that also showed it. We estimated it to be of magnitude 16.5 or so. The Caltech Astronomy Department sent a telegram to the Central Bureau for Astronomical Telegrams, which published it as IAU Circular No. 2641. The supernova was designated SN1974C. I also took a spectrum but my set-up had a small wavelength range around Hα and the nearby [NII] and [SII] lines. In spite of that Leonard Searle later identified it as probably of Type II, a few months up to half a year after maximum.

The main results of my Palomar work are in Fig. 10. For this and some other work I had been assigned 10 dark (moonless) nights on the 200-inch, which then was still the largest telescope in the western world and 15 on the 60-inch. There is quite a bit of overhead of rotating the spectrograph to the desired position angle, for which the telescope had to point to the zenith, acquiring the object, taking comparison spectra, etc. (and I lost about one third of the assigned time due to clouds and frustratingly some clear hours because of too high humidity). Most of these were in the spring when dark time is in very high demand. The final results were published as van der Kruit (1974b, 1976a,b). There were very few optical velocity fields determined in spirals and this constituted a significant new result. In NGC 4258 the velocities were as expected in our model with the anomalous arms having low rotation as expected if resulting from ejection from the nucleus, while the comparison in the anomalous arms of forbidden lines of oxygen and ionozed nitrogen and sulphur with the Balmer lines of hydrogen indicated collisional excitation, again as expected. In NGC 4736 the inner ring with a sharp outer boundary was expanding away from the nucleus and in NGC 3310 the pattern indicated exceptionally strong density wave streaming, possibly related to nuclear activity or it probably being a late stage of a galaxy merger.

The period of my postdoctoral fellowship was also one of getting to know many astronomers. There were weekly colloquia at Caltech and on Friday a joint astronomers lunch at the Atheneum, Caltech's faculty club. I was invited to give colloquia at various places visiting people, such as Woody Sullivan in Seattle, Bernie Burke at MIT, Stephen and Karen Strom at Kitt Peak, Sydney van den Bergh in Toronto. I also attended a work-

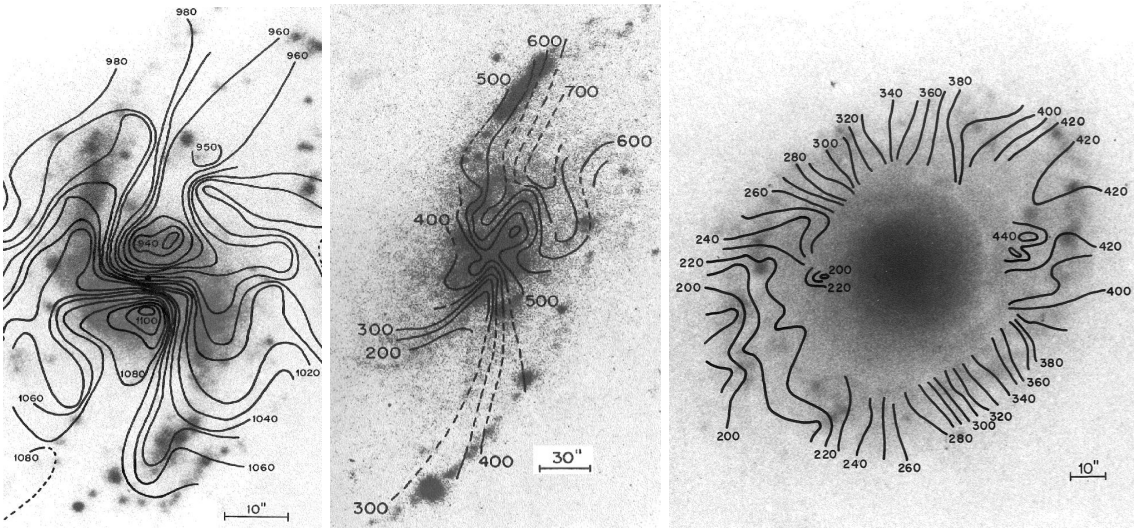


Fig. 10: Optical velocity fields observed at Palomar Observatory with the 200-inch and 60-inch telescopes using long-slit spectroscopy with iso-velocity curves superimposed on Hα pictures. From left to right NGC 3310, 4258 and 4736. The Hα picture of NGC 3310 is from Chip Arp, NGC 4258 from the literature, and that of NGC 4736 taken by myself at the 200-inch prime focus. From van der Kruit (1974b, 1976a,b).

shop on the Galactic center at NRAO in Charlottesville, organized by my later Groningen colleague Bob Sanders, who I had met earlier when he visited Leiden, a meeting of the American Astronomical Society in Las Cruces, New Mexico, and a symposium and the General Assembly of the IAU in Canberra and Sydney, Australia. In Canberra I for the first time met my later collaborator Ken Freeman. In the summer of 1974 I attended a two-week Summer Workshop in Aspen, Colorado, where I met many other well-known astronomers. We hiked in the afternoon and with Bob Sanders one afternoon we came to understand why one trail we tried out was called Lost Man's Trail.

In the second year I had to find employment for after the fellowship ended. My first priority would be returning to Leiden. But permanent jobs were limited and the only one available in Leiden went to support the field of interstellar matter. Hugo van Woerden had told me he would like me to come to Groningen. I applied, but the appointment was blocked. The wave of student protests of 1968 had resulted in significant changes in the way universities were run. Many things, in particular curricula, budgets and appointments of scientific staff were decided in councils that had elected representatives in which non-academics staff and students, who together had – at least in Groningen – two thirds of the members, formed a majority compared to the academic staff representatives. In the Council of the Sub-faculty Astronomy the students argued that appointing a Dutch astronomer from Leiden, even on a temporary appointment, would eventually lead to a permanent position (the boards had no say in career promotions) and therefore meant one position less left for Groningen students in the future. The non-scientific staff liked taking the side of the students so a proposal to appoint me was voted down.

In the mean time I did get other job offers, such as a postdoc position in Cambridge, UK, a year at Toronto, and a permanent position at the Max-Planck-Institut für Radioas-

tronomie in Bonn, the home institute of the new 100 meter Effelsberg radiotelescope. But there were signals from the Netherlands as well. The Dwingeloo Radio Observatory started a science group of astronomers, mostly instigated by Harry van der Laan. And a new vacancy would open in Groningen. So I held the offer from Bonn open for quite a number of months. When I felt a bit unsure if this was reasonable for me to keep them dangling, Leonard Searle told me not to worry. 'Institutes are there for you to use, not for them to use you', he said. In Groningen Hugo an Woerden talked to members of the Sub-faculty Council and this time the proposal was approved. At the same time the Board of the Foundation for Radioastronomy had decided to offer me a new position in Dwingeloo as research astronomer, but this was never communicated to me, since it was decided I should go to Groningen. I heard only later that this transpired and if asked to choose I would have made the same choice; still I would have preferred to decide myself. After a few years in Groningen I did get an offer from Harry van der Laan to move to Leiden. By that time I had bought a house in Groningen and moving to Leiden was financially very unwise, because mortgage interest rates in the late 1970s had become outrageously high, often over 10%. So I declined.

5 Surface photometry

On January 1, 1975 I started my appointment in Groningen. In the spring of 1977 it was turned into an indefinite appointment. My main research effort was finishing up the Palomar work described above, but also returning to WSRT radio continuum work, which was now possible at three frequencies, so that more could be said about the physical processes. Much ongoing work at the Kapteyn Laboratory was 21-cm line observations at Westerbork. This was possible through a temporary adaptation of the receiver system, mostly brought about by Groningen colleagues Ron Allen, Ron Ekers, Miller Goss and Renzo Sancisi. The WSRT receiver correlated each of the ten fixed telescopes with each of the two movable ones (so 20 baselines) and in each baseline each of the two perpendicular dipoles in each front-end with the two in the other one (so four correlations per baseline), resulting in 80 channels. These channels now had been re-figured to measure 8 velocity channels in 10 baselines, so quite a number of 12-hour observations were required to fully map a galaxy. First results were that the neutral hydrogen (HI) was more extended than light and that in edge-on galaxies the outer gas layer was warped. PhD student Albert Bosma was analyzing maps of a number of galaxies. It was suggested that I would supplement this by deep photographic plates for see how far out the stellar disk could be traced and by spectroscopy to determine the inner shape of the rotation curves where HI was often absent and the WSRT beam was too large to measure the exact shape.

I did obtain time in late March, early April 1976 at Palomar on the 48-inch Schmidt for deep exposures and on the 200-inch to obtain long-slit spectra. Albert Bosma came along. We obtained spectra in three of Albert's galaxies and one of my interest. We measured these in Pasadena and I analyzed this back in Groningen. On the 48-inch telescope we obtained deep, high-contrast (Kodak IIIa-J emulsion, also baked in forming gas at 65°) plates of eight galaxies. Five of these were in Albert's sample and three were edge-ons.

With the photographic department of the University in Groningen I spent quite some time developing methods for superposition printing to enhance the contrast, but no significant extension of the stellar disks were seen. In the edge-ons maybe a hint of warping was seen at the edges of the disks, in the same direction as Renzo Sancisi had observed in the gas.

This was a bit of an unsatisfactory situation because it all was not very quantitative. What was the upper limit on surface brightness in the regions where there was HI but no observable light? In the Netherlands there was (and is) each year an Astronomer's Conference of two to three days where most astronomy staff and students in the country would gather. One evening during the 1976 conference, I was talking to Rudolf le Poole. He was in the process of automating a two-dimensional measuring machine in Leiden, a David Mann Comparator, to measure star positions and estimate magnitudes. It would operate a one-dimensional array of 128 photo-diodes (a 'Reticon Array') that would move across the plate perpendicular to the array. This he would use for detailed and extensive study of the large globular cluster ω Centauri. In principle this might be a possible machine to 'scan' plates. We decided I would come to Leiden to try it out (Fig. 11).

I was not very familiar with photographic surface photometry. There were a few studies in the literature and I had talked a bit with François Schweizer at Hale Observatories, who after writing a PhD thesis under Ivan King in Berkeley had obtained a Carnegie Fellowship, overlapping a year with me. He had used in his PhD thesis the technique to search for the underlying density wave in the stellar disks in galaxies with well-defined spiral structure (Schweizer, 1976). Surface photometry of galaxies from photographic plates required much care. I think it was François who quoted Ivan King as saying (I paraphrase): 'Photographic surface photometry is difficult, but that doesn't mean you shouldn't attempt it; all you have to do is do it right'. With Rudolf's help, and local Leiden technical staff, I scanned a few plates in Leiden, took them on magnetic tape to Groningen. This was easy as the maps were written on the tape in the same format as the Westerbork data.

The output on the Leiden tapes was photographic density, a logarithmic scale in which zero means completely transparent when light is shone through, unity an attenuation of a factor ten, etc. To turn that into a brightness distribution you need the characteristic curve which relates the two. This is usually done by exposing after the sky exposure in a dark room near the edge of the plate a set of dots of known intensity ratio or a continuous wedge with decreasing intensity along it. This has to be done using about the same exposure time because of low-intensity reciprocity failure, the property of the photographic emulsion to become slower for faint light. But I had some plates taken as Carnegie Fellow that I wanted to use also, but these had no sensitometer spots. Now at Caltech John Kormendy, whom I knew as a PhD student, had measured the light profile of stellar images on 48-inch plates (Kormendy, 1973). So I thought I might use this on a bright star in the field for determining the characteristic curve, as John had intended its use. It would serve as a check on the method with the spots as well.

I would next determine the level of sky 'under the galaxy' in photographic density by a two-dimensional, second order polynomial background fit. The density of object + sky and of sky alone could then be turned into a surface brightness of the galaxy expressed in magnitudes fainter than sky. To find the absolute surface brightness one needed aperture

Fig. 11 Here I am positioning a 10×10-inch photographic plate from the Palomar 48-inch telescope on the plate holder of the Astroscan of Leiden Observatory. The instrument scanned predefined areas with square pixels of 30 microns (corresponding to 2 arcsec on the sky) on a side. From my private archives.

photometry from the literature, in practice the difference of two diaphragms to give an annular area because photographic plates were usually overexposed in the center. The photometry reached about 5 magnitudes below the dark night-sky surface brightness (or 1%). But first quite a bit of software had to be developed. However, since the format of WSRT maps was used, I could use existing display routines, such as for contour diagrams. Still developing, writing and testing of the necessary software took me an investment of time of more than half a year.

At that time Fortran was the common language for scientific programming, so that is what I taught myself. Fortran 66 had a number of inconvenient features and we used a precompiler called Sheltran. I called the set of programs ORACLE. It ran on the University's CDC Cyber-74 mainframe. The computer instructions in those days were in the form of punched cards (consisting of a Sheltran program and instructions for the operating system, including those to tell the operators to mount magnetic tapes) and one had go over to the Computing Center with these punched cards, read them into a card-reader and then be patient (in fact you returned to your office and did some other work). After a few hours the output would appear as a paper print in pigeon holes at the computing center. The individual 'jobs' at the computer were identified by a code consisting of 7 characters. The first three identified the user and usually were their initials, so 'PCK' in my case. The computer assigned in addition two figures and two letters to give each job a unique identification. The ultimate insult came on November 6, 1979, when my job (see Fig. 12) was designated PCK 00 IQ!

Actually, within the university the Kapteyn Astronomical Laboratory was a front runner in the use of electronic equipment. In the late seventies Ron Allen, Ron Ekers and others developed the Groningen Image Processing SYstem (GIPSY) for reduction of in particular Westerbork 21-line observations, using advanced display and imaging process-

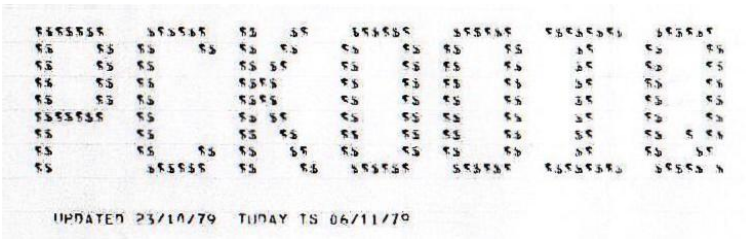


Fig. 12 The ultimate insult by the central computer of Groningen University (November 6, 1979). From my private archives.

ing techniques and equipment. The original system consisted of an image computer and display unit connected to small host computer. In the late 1970s we had one of the early text editing machines. It had a small screen displaying small green letters; we watched in awe how, as you inserted a few words, the rest of the text would shift and accommodate the addition. It was primitive in that it used two daisy wheel printers (one for Greek letters); to reduce the terrible noise they made, the workshop at the Kapteyn Observatory had built an enclosure to be used when printing. It is now amazing to realize that funds for such investments were available to the Kapteyn Astronomical Laboratory. The GIPSY system cost a multiple of 100k guilders and the text editing machine 70k as I remember (I was chair of the Laboratory's budget committee and gave my consent from Pasadena by telex). The conversion from late 1970s is: 1 guilder then had the same purchasing power as about 1.25 € now. Imagine spending 100k € on a text editor. Most of us started using email around 1985. We had a terminal in the Institute connected to a special computer in the Computer Center (a VAX from DEC) for this. It was connected to a network that connected such systems in Dutch universities run by a Foundation for Academic Computing Facilities (in Dutch SURF), connected to a European Academic Research Network (EARN) and similar networks around the world, such as BITNET in the USA. Addresses were complicated, so one used aliases, and each node that processed your email sent a message back it had done so, so that you could check the progress.

The results of my surface photometry (see Fig 13) were published as van der Kruit (1979) in the form of contour maps and radial surface brightness distributions. In NGC 5055 I found faint, extended light, that is now seen to be part of a structure of 'loops' around the system. I happened to have color information (in addition to the blue-sensitive IIIa-J emulsion, I had taken a plate with the redder-sensitive IIIa-F emulsion) and determined it to be red like coming from late-type stars in an older population.

The three edge-on galaxies in the sample gave two very surprising results. The cross-cuts perpendicular to the major axes showed that the width at half-maximum was rather independent of radial distance. Furthermore in the direction along the disk the light in the outer parts dropped off much faster than expected for a continuing exponential disk indicating relative sharp edges or 'truncations'.

As a follow-up of this work I proposed a major investment in what was named the *Palomar-Westerbork Survey of Northern Spiral Galaxies*, which aimed at providing for a set of galaxies Westerbork 21-cm line observations to determine distributions of HI gas and rotation curves, and Palomar 48-inch plates for surface photometry in three colors to determine distributions of surface brightness and color for the stars. For this I needed a collaborator in Pasadena, since as a visiting observer I would never get sufficient telescope

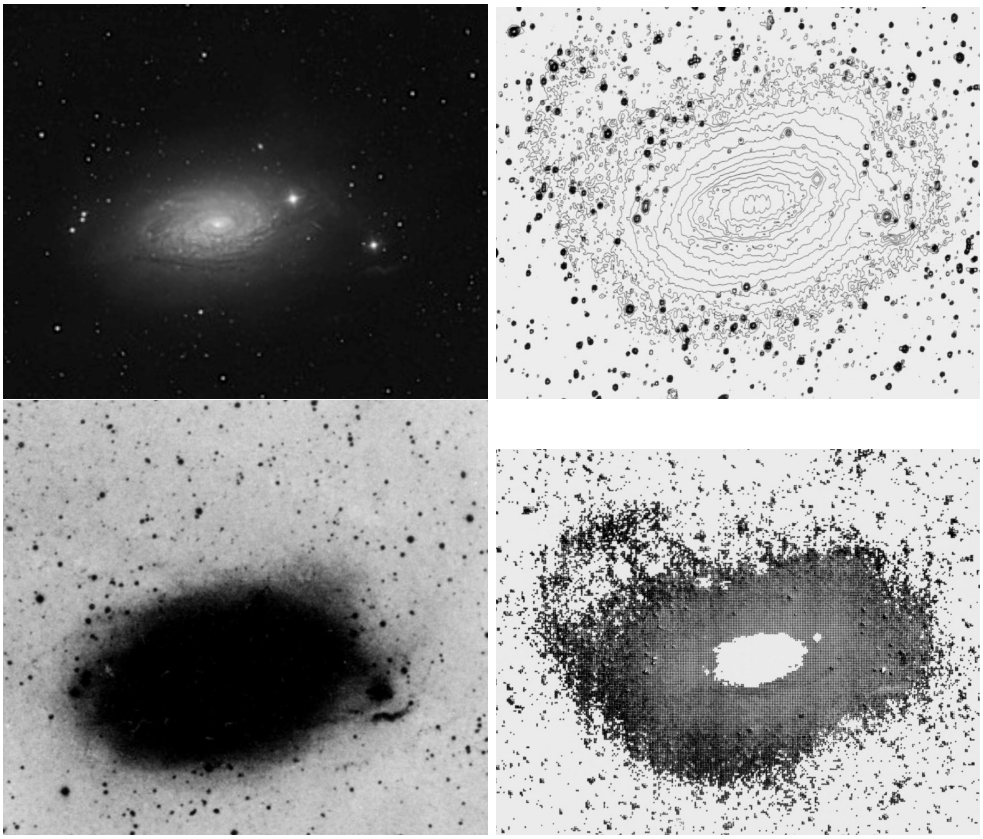


Fig. 13: Optical surface photometry of the spiral galaxy NGC 5055. Top-left: the optical image; bottom-left: deep print from my IIIa-J plate; top-right: contour representation of (actually two added) deep plates; bottom-right: color distribution (darker pixel means redder color). White is overexposed. From my private archives and van der Kruit (1979).

time at Palomar. I wrote Leonard Searle (Fig. 14) to see if he was interested. He thought about it for a while, and when we attended the enormously successful symposium on 'The Evolution of Galaxies and Stellar Populations', organized by Beatrice Tinsley at Yale University, New Haven, Connecticut in May 1977, he told me he had decided to go ahead. We applied for and were allocated a grant from the NATO Scientific Affairs Division for fostering collaboration of scientists between member states, so that over three years I could travel to Pasadena and Palomar twice per year and Leonard once per year to Groningen. We obtained the telescope time required at Palomar and at Westerbork and the project started. In the end the project was assigned 64 observing periods of 12 hours at Westerbork and 42 dark nights at the Palomar 48-inch Schmidt. The NATO stipend allowed me to do the bulk of the Palomar observing.

We together went to Palomar in February 1978 for the first run at the 48-inch Schmidt. The weather in California was atrocious. I had been on a short trip with a friend from Groningen, including two nights in Death Valley, where it rained all the time. The dome was never opened, but we at least finished one project, a bottle of Scotch that we had brought. The sun appeared when we were on our way back in Leonard's MG sport-scar

Fig. 14 Leonard Searle at his desk in Pasadena. He was British (English actually), fourteen years my senior, ending up in Princeton where he obtained a PhD. After periods at Toronto, Caltech and Canberra (Mount Stromlo) he became a staff member at the Mount Wilson and Palomar (Hale) Observatories, now Carnegie Observatories, of which he eventually became director until his retirement. He died in 2010 at age 79. Credit Carnegie Observatories; see obs.carnegiescience.edu/searle/searle.

just as we passed a sign 'Rainbow', a small village. Looking in the direction the sign pointed we saw a glorious rainbow.

Leonard paid his first visit to Groningen in June 1978. Before that we attended a conference in Liège, Belgium on 'The Elements and their Isotopes in the Universe'. This meeting was dedicated to Albrecht Unsöld, who himself gave an autobiographic introductory review (Unsöld, 1979). He mentioned that in 1939 he had obtained Coudé spectra at McDonald Observatory of the B0-star τ Scorpii, but was prevented from analyzing these data because the Second World War broke out and he had to report to the Luftwaffe and instead had been dropping bombs on London. But no problem, Unsöld told us, he returned to it and established the very large abundance of hydrogen in the Universe. Leonard, sitting next to me, froze at this story, telling me later that all memories of the terrible anguish returned that he experienced as a boy of nine or ten living in 1940 in a London suburb. 'So, he was one of those bastards!', he said.

During the week we spent hours talking about astronomy, observatories, astronomers, but also a great many other subjects, including WWII and we discovered we shared a strong interest in history, particularly of science and astronomy. In the train to Groningen Leonard was very much interested to see in the bridges at Nijmegen and Arnhem that played such an important role in the War. We became very good friends.

Together with my Groningen colleague Ron Allen, we obtained funds to hire a PhD student, Bart Wevers, who did the work for the actual survey. In the end the program encompassed 16 galaxies and resulted in Bart's PhD thesis in 1984 and a 158-page publication (Wevers, van der Kruit & Allen 1986). It constituted the first systematic set of surface brightness maps of spiral galaxies and has been cited almost 200 times and still receives one citation per year. It constituted at the time state-of-the-art surface photom-

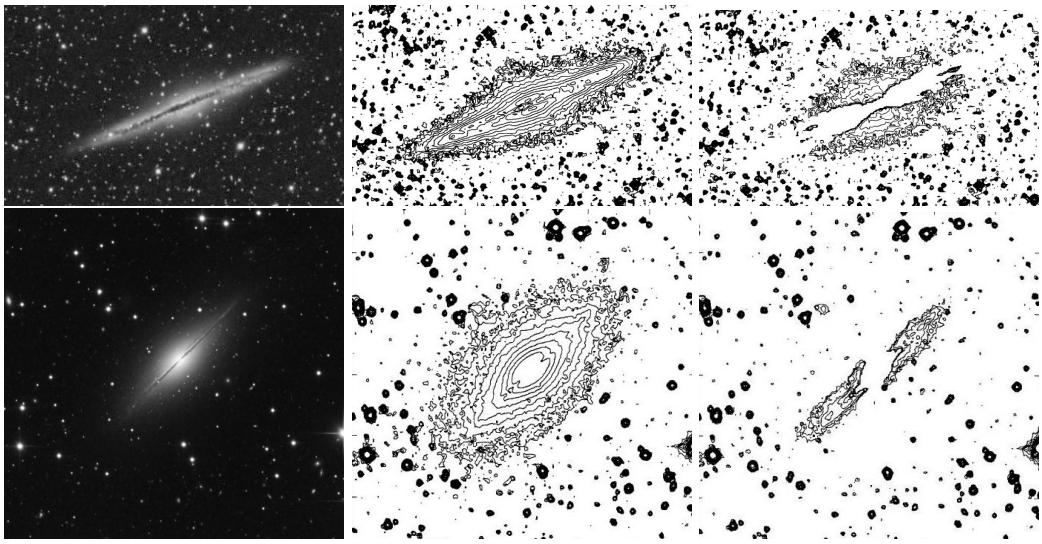
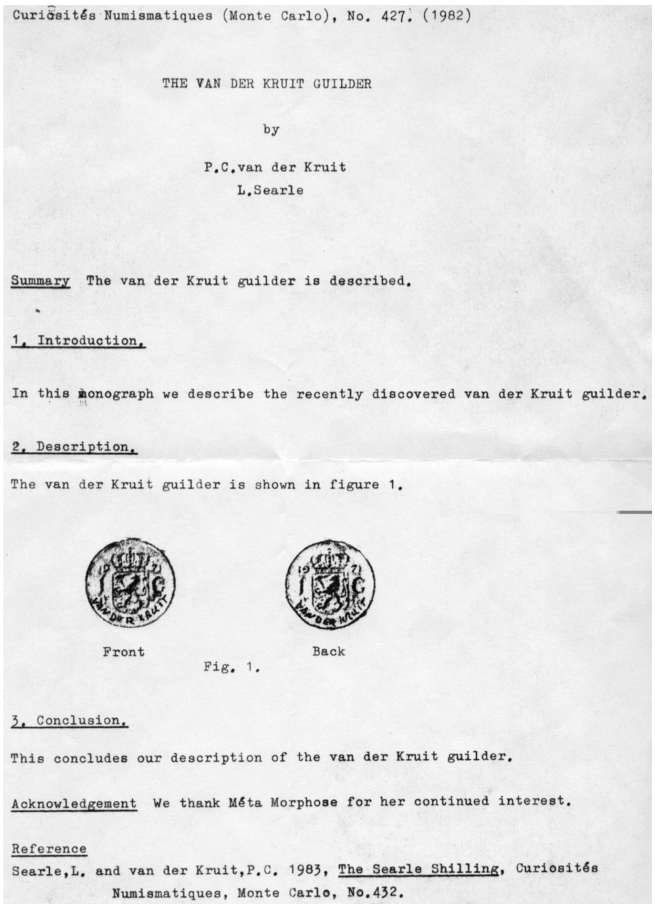


Fig. 15: Investigations of edge-on galaxies with Leonard Searle, in which the three-dimensional light distribution was studied. In NGC 891 (top) we modeled the disk with an exponential, constant thickness, truncated model, which we subsequently subtracted to reveal the bulge. In NGC 7814, we modeled the spheroid with a flattened, de Vaucouleurs R^{-4} surface brightness law and subtracted that to reveal the disk. From van der Kruit & Searle (1981b, 1982b).

etry and has now of course been superseded by work with 2-dimensional digital detector arrays, but the photometric accuracy has proved to be excellent. The only large preceding set of surface brightness distributions was due to Oort. He had started a program of photographic surface brightness measurements in the 1930s, first unsuccessfully at Perkins Observatory and then using plates obtained with the Mount Wilson 60- and 100-inch telescopes. This did take a very long time, partly as a result of the Second World War, partly because of calibration problems, which were only solved using photoelectric observations together with William Hiltner with the 84-inch telescope at McDonald Observatory. It finally resulted in Kees van Houten's PhD thesis, which contained 20 mostly early-type galaxies (van Houten, 1961). More photographic surface photometry existed of course, such as Schweizer's (1976) as mentioned, and by a group around Gérard de Vaucouleurs at Austin, Texas, but no other systematic sample was available.

Leonard Searle and I decided we would leave the main project to Bart and concentrate on edge-on galaxies, following up my findings in the initial work. We fitted the vertical distributions with that of an isothermal sheet with thickness (scale parameter) independent of galactocentric distance. The work resulted in a series of four papers (van der Kruit & Searle, 1981a,b, 1982a,b), the first of which presenting a model for the three-dimensional distribution of light in galactic disks. The referee of the first paper, who identified himself as Gérard de Vaucouleurs, predicted that it would become a classic. The four papers had me as first author, which Leonard felt should be justified by a footnote to the title of the fourth (see Fig. 16), which he wrote early one morning in Groningen still suffering from jetlag. The first paper indeed became a classic and the series highly cited.



Curiosités Numismatiques (Monte Carlo), No. 427. (1982)

THE VAN DER KRUIT GUILDER

by

P.C.van der Kruit
L.Searle

Summary The van der Kruit guilder is described.

1. Introduction.

In this monograph we describe the recently discovered van der Kruit guilder.

2. Description.

The van der Kruit guilder is shown in figure 1.

Front Back

Fig. 1.

3. Conclusion.

This concludes our description of the van der Kruit guilder.

Acknowledgement We thank Méta Morphose for her continued interest.

Reference

Searle,L. and van der Kruit,P.C. 1983, The Searle Shilling, Curiosités Numismatiques, Monte Carlo, No.432.

Fig. 16 The title of the fourth paper in the series on edge-on galaxies (van der Kruit & Searle, 1982b) had a footnote that read: *The order of the authors' names in this series of papers has been decided in each case by tossing a coin. The coin used for this purpose is fully described in a forthcoming monograph 'The van der Kruitguilder' by P.C. van der Kruit and L. Searle to be published in the series 'Curiosités Numismatiques', Monte Carlo.* The ensuing requests for a preprint of that publication caused me to produce this 'article'. From my private archives.

I had always been interested in how our Galaxy compared to others and it therefore would be interesting to obtain surface photometry of the Milky Way. Our Galaxy is also seen edge-on and a similar analysis could give insight into this question. An unexpected possibility appeared when one day in 1984 or 1985 I was in our library reading the latest issue of *Sky & Telescope*. There was an article in this, in which surface brightness contours of the Milky Way were shown! It turned out that these had been obtained with the Pioneer 10 spacecraft. The reason for observing this had been to study the zodiacal light, which needed correction for the Milky Way background light. Researchers had arranged for the Pioneer 10 and 11 to scan the sky on the way to Jupiter once beyond the asteroid belt, where Solar System dust and zodiacal light were essentially absent. The researchers had no real interest in the integrated starlight; it was a nuisance and their only purpose was to determine the corrections required to get rid of it. I wrote to the author of the *Sky & Telescope* article and after some time received a thick envelope with a stack of computer printouts, listing the almost full sky surface brightness of the background starlight in two colors (see Fig. 17 for the contour maps I generated from that). I decided to analyze that using the star count simulator of Bahcall and Soneira (1980), that had recently become available, based on their Galaxy model, but of which I of course could twiddle the knobs (the parameters). With little effort I turned the export Fortran program into one that calculated surface brightness by summing the star counts.

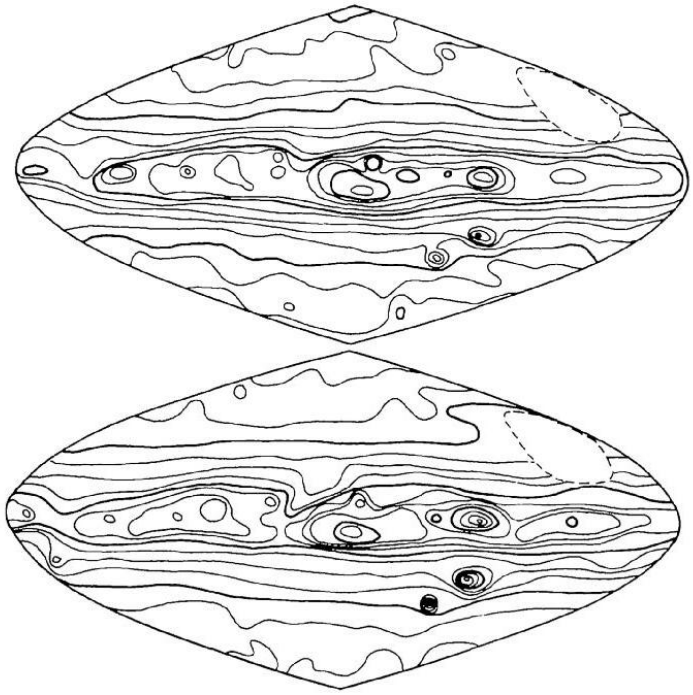


Fig. 17 Full-sky surface brightness distribution of the Galaxy after removal of stars with $m < 6.5$, from Pioneer 10 in the red (top) and blue. The angular resolution is 8°. The direction towards the Galactic center is in the middle of the pictures and the north pole at the top. Galactic longitude increases towards the left. The contour unit is 0.25 mag arcsec^{-2}; the faintest thick one in the upper part corresponds to about 24 V-mag arcsec^{-2} and in the lower part to about 24 B-mag arcsec^{-2}. The missing part is the direction towards the sun as seen from Jupiter around Pioneer 10 encounter. Note the Magellanic Clouds on the lower right. From van der Kruit (1984).

The most interesting outcome (van der Kruit, 1986) was that the Galaxy has a longer radial disk scalelength (e-folding) than previously adopted, namely of 4.5-5.5 kpc. Actually for a spiral galaxy of the rotation velocity it has of about 220 km/sec, 4.5 kpc (my preferred value) is a much more reasonable value than the often used 2.5 kpc. Our Galaxy would only be a little bit smaller than the Andromeda Nebula (M31). This had an interesting consequence related to the then intense debate on the value of the Hubble constant H of the expansion of the universe, which would be either around 100 or around 50 km sec^{-1} Mpc^{-1}. I determined scalelengths of spirals in the Virgo Cluster from extensive (published but not analyzed) surface photometry by Japanese workers. This showed that if the Galaxy and M31 would be similar in size (scalelength) to the largest spirals in the Virgo Cluster, H would be 50-70 km sec^{-1} Mpc^{-1}. If 100, our Galaxy and M31, the two large spirals in the Local Group, would be larger than any other spiral up to and including the Virgo Cluster. The argument could have been made with only M31. Together with the apparent contradiction that for the large value of H the chemical elements would be older than the universe, this provided strong support for the lower value, much to the delight of Allan Sandage (as he wrote me).

With the computer model I could also generate star counts based on my value of the disk scalelength. I used these for some historical purposes in the same paper (van der Kruit, 1986). First I used this to generate star counts to compare to those of Kapteyn and van Rhijn (e.g. van Rhijn, 1929). This showed that at photographic magnitude 10 or so their magnitude scales start to go wrong and are too bright, eventually by as much as half to three quarters of a magnitude at the limit of 18.5 on their scale (see Fig. 10 in van der Kruit, 1986). Also I used the model to answer the question to how faint a magnitude limit did William Herschel perform his star 'gauges' to produce his famous

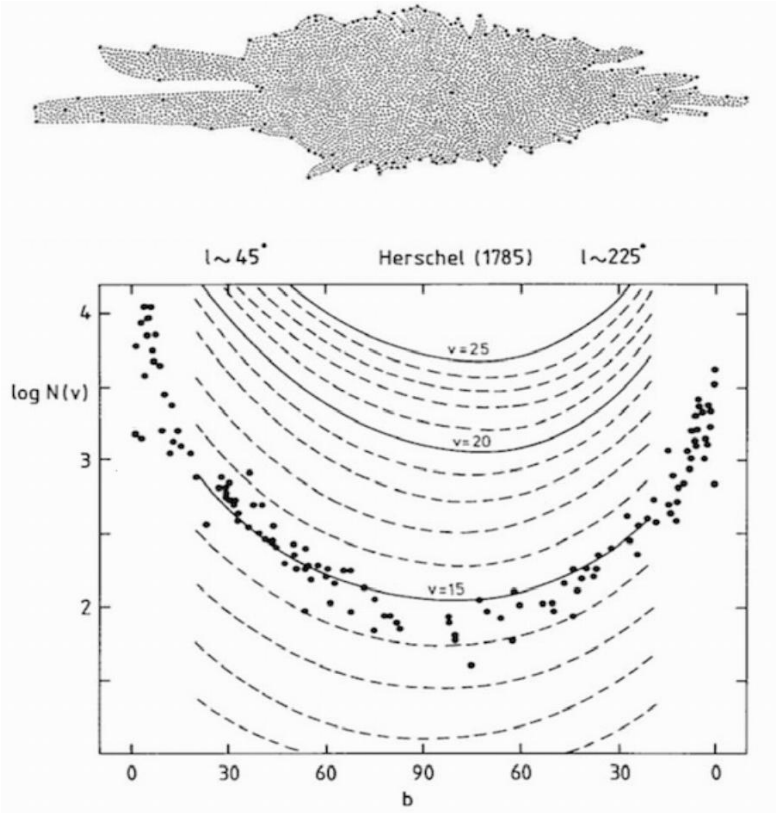


Fig. 18 Top: Herschel's crosscut through the Galaxy based on star counts using his 20-foot telescope along a great circle. From his description (it is traced out from Slough by the horizon when τ Ceti culminates) it can be derived that this great circle cuts the Galactic plane at longitudes about 45° and 225°, and misses the Galactic poles by about 5°. Bottom: The dots are Herschel's counts, derived from measuring the radii in the crosscut (the 'rays' of his 'star gauges') in units of his distance to Sirius and using his description converted to stars in his 15 arcmin field of view and hence to cumulative counts per square degree. The lines are the number N(v) of stars to limiting visual magnitude v from my modeling of the Galaxy. From Herschel (1785) and van der Kruit (1986).

crosscut through the Galaxy (Herschel, 1785)? The conclusion (Fig. 18) is that Herschel counted down to about magnitude 15. From the properties of his 20-foot telescope and various other considerations I concluded that Herschel would have found roughly the same had he expressed his 'extent of telescopic vision' this way.

I had a note from Tom Gehrels, in his native Dutch, expressing his surprise and delight that the Pioneer data in which he had had a major involvement, had proved to be so useful for a purpose he had never imagined.

6 Galaxy disk dynamics

My work had shown that the 'dark matter' indicated by flat rotation curves of spiral galaxies indeed was not accompanied by starlight at least to very faint levels (Bosma & van der Kruit, 1979). This dark matter could in principle reside in an extended disk, but, it was generally believed that there were massive dark halos, particularly because these could stabilize disks, where numerical simulations had shown them to be unstable unless having very large velocity dispersions in their central parts. It therefore would be interesting the make sure the dark matter indeed was in a more or less spherical halo. This can de done by determining the disk surface density in the outer parts of the galaxy from the disk thickness and the vertical velocity dispersion (like Oort, 1932). It is not

straightforward, since the thickness can be measured when the galaxy is edge-on and the vertical velocity dispersion when face-on. Measuring stellar velocity dispersions was very difficult, to say the least. But there is the HI. So I set out to obtain Westerbork 21-cm line measurements to determine the velocity dispersion of the gas. It was known in the Galaxy that this was of the order of 10 km/sec. I chose systems that are at most a few degrees from face-on, as judged from their integrated profiles, so that there were no significant changes of the mean motions across the beamsize of the radio telescope. Together with Seth Shostak, I observed three systems in Westerbork (van der Kruit & Shostak, 1984). The result was that everywhere the dispersion was 8 to 10 km/sec. NGC 628 (or M74) was large enough to distinguish spiral arms and interarm regions (Shostak & van der Kruit, 1984), showing the larger value to apply to the spiral arms. The random motions of the HI are very likely isotropic due to cloud collisions. Using this and the 21-cm observations of the edge-on galaxy NGC 891 by Renzo Sancisi and Ron Allen, I was able to show that the HI layer became thicker with galactocentric distance in such a way that the radial mass distribution had to have the same dependence as that of the light (Sancisi & Allen, 1979; van der Kruit, 1981). Within the optical extent of the disk no more than half the mass could reside in the disk and therefore the dark matter had to have a more spherical distribution.

The direct way would be to measure the stellar velocity dispersion and use statistical ratios between stellar scale parameters. But measuring that in a spiral disk was rather challenging. I discussed that with Ken Freeman and we decided it was worth a try. We arranged that I would spend a sabbatical year at Mount Stromlo Observatory and in August 1982 I moved my family (by then I had two daughters and a son) to Canberra, Australia. Ken and I first tried long integrations on the 74-inch telescope at Mount Stromlo, showing the approach to be feasible. The measurement of the shape of stellar absorption lines in the faint galaxy light was possible using devices such as Alec Boksenberg's Image Photon Counting System (IPCS), in which photon events were detected electronically, intensified by a very large factor, which were then detected, centroided and accumulated in a memory. At Mount Stromlo a system called Photon Counting Array (PSA) had been developed where the detection of the intensified signal was done with a charge coupled device CCD, rather than a television tube. We obtained two nights on the 3.9 m Anglo-Australian Telescope at Siding Spring Observatory. Fortunately these were clear and we used them to observe two galaxies. The detector there was a Boksenberg IPCS, in which – contrary to the PSA where the counts are read out at the end – one observes the data accumulating on a small screen. It is weird to 'see' individual photons arrive from a distant galaxy. At the end of my year we observed an edge-on galaxy with the Stromlo 74-inch for 8 nights, accumulating an exposure time of 29.3 hours (Bottema, van der Kruit & Freeman, 1987)!

The AAT observations (van der Kruit & Freeman, 1986) showed that in a face-on galaxy the vertical velocity dispersion of stars fell off with twice the scalelength of the optical light. With the constant thickness of disks this is predicted to be the case if the total mass is distributed like the light, and thus the mass-to-light ratio constant. In edge-on systems one has to disentangle the line-of-sight integration, but this gives the tangential velocity dispersion and the asymmetric drift (the lagging behind of the stellar rotation). It also threw light on the stability of disks. Gravity makes matter clump when fluctuations in

Fig. 19 In 2003 I was appointed one of the first three distinguished professors named after a famous scientist of the choice of the appointee. On the photograph on the left Serge Daan, Niko Tinbergen distinguished professor of behavioral biology, in the middle Ben Feringa, Jacobus H. van 't Hoff distinguished professor of synthetic organic chemistry, and myself, Jacobus C. Kapteyn distinguished professor of astronomy. Ben went on to share the 2016 Nobel Prize in Chemistry. From my private archives.

density arise. In galaxy disks a local stability can be maintained by the random motions on small scales and the shear from differential rotation on large scales. A disk is stable when there is no gap between these two regimes and that is expressed in a parameter Q first derived by Alar Toomre (1964). This could now be measured and we showed that disks seemed marginally stable ($Q \sim 1-2$) according to this parameter at all radii. An approximately constant Q with radius could serve as the explanation for the roughly constant thickness Leonard and I had found.

My further work on galaxy disks included surface photometry extension to the near infrared, HI velocity dispersion and layer thickness, stellar disk truncations and stellar kinematics. It was the subject of PhD theses of my students some in collaboration with Ken Freeman, in particular Roelof Bottema, Roelof de Jong, Johan Knapen, Richard de Grijs, Michiel Kregel and Stephan Peters. I have been intrigued by the very sharp edges or truncations of galaxy disks often seen when we view them edge-on. My work in the 1990s and 2000s, some of it with my PhD students, established their presence more securely and I have shown quite convincingly that warps in the gaseous layer start very close to these truncations, suggesting they are not just truncations in the stellar distribution, but also in the distribution of total mass. My work and that of collaborators on disks of galaxies was reviewed in an extensive article in the *Annual Review of Astronomy & Astrophysics* by Ken and myself (van der Kruit & Freeman, 2011). My research has been very much in the tradition of my thesis supervisor Jan Oort, but also of Oort's 'inspiring teacher' and the founder of my Institute, Jacobus C. Kapteyn.

This overview of my scientific work is incomplete. I should point out that I kept collaborating with my colleague Ron Allen after he left Groningen in 1985, when after a spell at the University of Illinois in Champaign-Urbana he settled at the Space Telescope Science Institute at Baltimore, on subjects related to dust absorption and interstellar molecular hydrogen. The theses of my PhD students Benne Holwerda, Jonathan Heiner and Peter Kamphuis resulted from working with Ron, and my association with STScI in that of

Fig. 20: Some of my PhD students during the symposium *Island Universes* in 2005 on the island of Terschelling, marking my appointment as Jacobus C. Kapteyn distinguished professor. From the left Benne Holwerda, Richard de Grijs, Erwin de Blok (although first of all a student of Thijs van der Hulst), myself, Roelof de Jong, Jonathan Heiner, Eline Tolstoy, Johan Knapen.

Eline Tolstoy. For a number of years I was blessed to have the opportunity to spend a few weeks each year in Canberra with Ken Freeman and in Baltimore with Ron Allen. I have been very sad when Ron died in August 2020.

I had been elected a member of the International Astronomical Union at the Sydney 1973 General Assembly. The director of Hale Observatories, Horace Babcock, had proposed me and to pay for my expenses he arranged that I would be the recipient of the first Dr. Knut Lundmark Award, established by his widow to advance a young astronomer 'in the meta-galactic field'. I became a member of three IAU commissions, among which Commission 28 on 'Galaxies', one of the largest of the IAU. To my surprise I appeared in 1979 on the proposed list of candidates for its Organizing Committee. And I was elected. Even more to my surprise, the next time, in 1982, I was nominated (Vera Rubin was Vice-president and the next President and must have had a hand in this) and elected Vice-president and therefore served as President from 1985 to 1988.

In 2003 the University of Groningen instituted the concept of named professors, a special appointment for what they called their 'coryphees', starting with three in my Faculty. I was selected as one of these first three (see Fig. 19). In addition to a bonus added to my salary this entailed a grant of € 50,000 annually until my retirement to spend on research as I saw fit. I saved some of this for after my retirement in 2009. I chose the professorship to be named after Jacobus Cornelius Kapteyn. To celebrate this a number of my PhD students (Fig. 20) organized in July 2005 a well-attended, full-week symposium at the island of Terschelling. The proceedings, *Island Universes*, were edited by Roelof de Jong (de Jong, 2006). At my retirement I was appointed honorary Kapteyn Professor until

my 70-th birthday in 2014 (but without the annual grant). Since then I am emeritus Jacobus C. Kapteyn distinguished professor. To be selected named professor has been a tremendous honor.

7 Teaching

My appointment in Groningen per January 1, 1975 was on a vacancy that had resulted from the retirement of Lukas Plaut (for more on him see van der Kruit, 2022). I was expected to take over the lecture course 'Sterrenkunde I', an introductory astronomy course for first year students with majors mathematics, physics or astronomy. Most of these attended (for astronomy majors is was obligatory) and sometimes a chemistry major also. Usually there were around 60 or 70 students. I modeled the lectures according to the ones I had attended as first year student in Leiden that Pieter Oosterhoff gave. It ran for 13 weeks for two hours oral lectures per week and two hours practical work. For the latter I was given an advanced astronomy student as assistant. I had essentially no experience teaching and had never developed didactic skills and at first it must have been at best mediocre, but I immediately started liking to teach such a course.

In the beginning the lecturing was in the old-fashioned manner of talking while writing on the blackboard, but I soon started using an overhead projector. I kept improving the course and my performance was rated highly in student evaluations. I have given this lecture course in various forms up to my retirement with only two interruptions during and after my sabbatical year at Mount Stromlo and when in the 1990s I was Dean of the Faculty. The last three years before my retirement an overhaul of the curriculum limited the course to only seven two-hour lectures. After a few years I produced a syllabus and provided students copies of my overhead viewgraphs, first handwritten but when it became available produced in the Slides package of LaTeX. When beamers became fashionable I reworked the presentation to the LaTeX Beamer package. The presentations are still on my homepage in the 'Courses' sub-page together with my other lecture courses.

I concentrated on the physics behind the subjects, whenever appropriate giving insight by simplified derivations. To set the scene I started by estimating the flattening of the Earth approximating it as a fluid in equilibrium. This I actually took from Oort's lecture course on the Planetary System I had attended in Leiden. This illustrated how an approximate derivation could produce a reasonable estimate while elucidating the physical mechanism. It also helped students understand that an integral is more than a mathematical trick, and in fact a powerful tool in scientific research. When time still permitted I ended the course by two special lectures. One was the Search for Extraterrestrial Intelligence (SETI), in which I made the point that the chance for success was completely unknown, but that this was precisely the reason to go ahead with it. The Drake Equation is in my view no more than a misleading way of expressing our ignorance, the mathematical expression suggesting to a general audience that a reliable estimate could be made of the distance to the nearest intelligent (radio emitting) civilization. In my view the answer derived with it depended entirely on just one thing: what one wanted it to be. The other lecture, called 'Why the sky is dark at night', was on Olbers' Paradox,

Fig. 21 This shows me in the lecture room of the Kapteyn Astronomical Institute teaching an introductory astronomy course. This photograph has been taken a few years before my formal retirement. At that time the course was taken by astronomy majors only. The subject at this photograph is degeneration pressure and estimates of the masses, diameters and densities of white dwarfs and neutron stars. From my private archive.

using Edward Harrison's (1974) thermodynamic approach. The paradox showed that an apparently simple observation (it is dark at night) could with a critical reflection lead to a profound conclusion (the Universe has a finite age).

The course (see Fig. 21) was concluded with a written exam, and for those that failed or missed the opportunity with an oral examination. When I had graded my last group of students in 2009 and had informed them of the grades by email, one student thanked me by reply email and gave his father's regards. The latter had followed my course as a student. In my records I found that the son had scored half a point better than his father. It also happened to me several times that at some happening, or in the street or a shop, someone walked up to me and told me that often years earlier he or she had attended this course and had excellent memories of it.

The advanced course I gave for many years was on the structure and later also the dynamics of galaxies. This was in smaller groups (ten to fifteen) in a two-year cycle in which the courses for advanced astronomy students were given. Based on this course I have lectured also outside of Groningen. For example, it was the basis of my share in a 'Saas-Fee' Winterschool in Switzerland, *The Milky Way as a galaxy*, that I gave in March of 1989 together with Ivan King and Gerry Gilmore. It was held in ski resort Leysin. I knew the organizer, Gustav Tammann, quite well. We lectured in the morning and late afternoon, leaving a few hours after lunch for skiing. I did bring my skis. Twice Gustav took me on a skiing trip, which as a Dutchman is not a wise thing to do with a Swiss. Gustav skied with an open jacket wearing a white shirt and tie under it. He effortlessly skied down a few hundred meters, stopped, lit a cigarette and waited for me to catch up with him, which with my limited skiing experience would take a while. Gustav being a very courteous and extremely nice person, always giving people far more credit than they deserved, complimented me profusely with my skiing skills. I suggested that if he ever would visit Groningen I would take him out skating, but this never came about.

Ivan King had taken the initiative to turn the customary book based on the winterschool, which was traditionally a set of three monographs, into a textbook. The Swiss

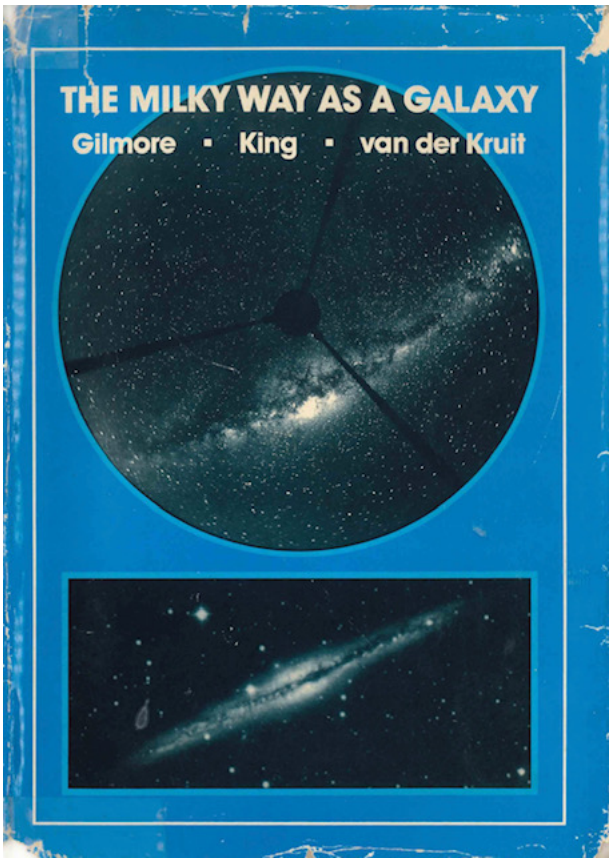


Fig. 22 The cover of my own slightly battered copy of the textbook Ivan King, Gerry Gilmore and I published on the 'Saas-Fee' course (Gilmore, King & van der Kruit, 1990) that we gave in 1989. This is the American version that only was available in Europe after enough copies of the usual soft-cover version published by the Swiss Astronomical Society had been sold. The book is now available in pdf-format as separate chapters in the SAO/NASA Astrophysics Data System (ADS; full set at www.astro.rug.nl/∼vdkruit/jea3/homepage/MWGal.pdf). From my private archives.

used the proceeds of the book to finance the winterschools and agreed to this under the condition that they would have the sole rights to market the book in Europe until they had recovered their expenses. The book (Fig. 22) was set up as a textbook with the contributions as chapters in a logical order (Gilmore, King and van der Kruit, 1990). We used the typesetting systems TEX (only after this book was published I started using the set of TEX-macros called LATEX) to arrive at a common lay-out, and agreed on common terminology and mathematical notations. We had been using email for a number of years (Gerry and I had been in regular contact by email for some time, for example when we organized a three-months stay for me at the Institute of Astronomy in Cambridge in 1987). The textbook was a success; to my gratitude I have on quite a few occasions been approached by young, American astronomers at conferences telling me they 'grew up' with the book and complimented me with my chapters.

In addition I gave a similar course as the one in Groningen on structure and/or dynamics of galaxies in one form or the other at a number of places, among others for a number of years at the invitation of Teresa Lago at the University of Porto, Portugal, and at ESO-Vitacura in Santiago, Chile, when I was a visiting scientist there, and at the invitation of Richard de Grijs at the Graduate University of the Chinese Academy of Science and of Peking University in Beijing, China. These courses ended with a written exam. One of my favorite problems was the following: 'Given the absolute magnitude of the Sun and the number of arcsec in a radian, convert 1 solar luminosity per square parsec ($L_\odot$ pc^{-2})

into magnitudes per square arcsec'. This problem is experienced by candidates as not straightforward to solve (I have experienced professional astronomers struggling with it) and the correct answer has generally been found by only half to two-thirds of my students, except in the Beijing course where it was correctly solved by the full 100%.

8 Administration

Months after I arrived in Groningen I was asked to be the representative of the astronomy scientific personnel on the Council of the Faculty of Mathematics and Natural Sciences and a member of the Council of the Sub-faculty of Astronomy. The councils had quite extensive powers, including the appointments of scientific staff, approving budgets and most educational matters. The boards were advised by budget and education committees. It did not take long before I chaired both committees in the Sub-faculty of Astronomy. This has been a recurring situation: in a large majority of boards or committees that I became a member of I would, often soon, sometimes later, end up as chairman.

As I described above the Law on the Reform of the Structure of Academic Administration (WUB1970) was approved by the Dutch government in 1970. It was a unique law in that it was a temporary one that would hold until the summer of 1976 and after evaluation be replaced by a permanent one. Eventually the evaluation was delayed and a permanent law was put into force only in 1986. There were three features that were important for my involvements. First, the sub-faculties disappeared, the basic level was the 'vakgroep' (professional group), usually an organizational unit around one or more professors of a specialization within a discipline. In Groningen the option to split up the Faculty of Mathematics and Natural Sciences into separate faculties per discipline was rejected, but is was felt that there should be something in between the professional groups and the large Faculty. By rules and regulations departments were instituted that were quite similar to the sub-faculties. Secondly, the personnel (the distinction scientific and non-scientific was abolished) would have at least half the seats in councils and boards and the students the rest. Appointments of scientific staff was left to the professional groups. The departments could not have a board since they were not part of the law, so there were 'commissions' formed with the same delegated powers and duties. Finally research institutes could be formed, which if approved ensured longtime funding. Astronomy became a department after successfully opposing a merging with physics and be a minority partner within a department, and one professional group to minimize the administrative workload. Eventually it was recognized as a research institute. It had been the Kapteyn Astronomical Laboratory since 1921 (and later extended with a Kapteyn Observatory in nearby Roden) and in 1994 these together became the Kapteyn Astronomical Institute.

I have been a member of the Faculty Council up to 1982, when I went to Australia on a sabbatical year (northern hemisphere academic year 1982-83) also for a year of the Board of the Faculty. As long as we were a sub-faculty Stuart Pottasch had assumed the role of Dean, while when we became a department the role of chair was taken up by Ron Allen. In 1983, after returning from Australia, I deliberately slowed down any effort to become involved again quickly in administration. When in 1985 Ron Allen left Groningen, Hugo

van Woerden took over the chairmanship of the Department. I accepted the position of his deputy and succeeded him upon his retirement in 1991. It was in this term of mine that we were recognized as a research institute and the chairman of the department became the director of the institute. Altogether I have been chairman of the department or director of the institute for over ten years.

I pause here to reflect on the question why one would want to do administration in the first place. The obvious reply would be to say that it has to be done and each faculty member should accept a share of it. But there is more to it. My research career, especially in the early phases, has profited from having access to world class observing facilities, the Westerbork radio telescope when it was new and only just operational, and the Palomar 200-inch, still the largest, well functioning optical telescope in the world. There was an extensive infrastructure in place, where I could receive first class training. The next generation deserves to be provided with excellent education and facilities as well.

Furthermore there has always been an element of challenge. Can we make sure things are optimally functioning within available funds? Can we keep facilities up to date and competitive? What new initiatives should be taken? Providing for a next generation is not only a service, it is also a challenge. Whenever I was asked for a new committee, council, board, etc. I always experienced it as a sort of adventure. When I was asked for or selected in a position of leadership, the same held, but in addition there was the challenge to see if I possessed the right qualities, authority, tact, insight, persuasiveness, or whatever to took to bring it to a good end. Being in a position of power never was important as a goal; being in a position to get something done was a challenge. And I like challenges.

On the other hand, administration is not always fun; often it is frustrating and unrewarding, and sometimes outright dull and thankless work. It does take away time for research, so I always tried to keep some involvement in astronomical research and have one or at most two PhD students. I know colleagues that claim they are not good in administration, and much better in research, and use that as an excuse to let others do the work of providing environments for them to do their research. I always felt this had a touch of arrogance and often unjustified superiority.

Around 1980 the Netherlands had started negotiations to take a share in the Isaac Newton Group of Telescopes (ING) at the Roque de Los Muchachos Observatory on La Palma, Canary Islands. The first contacts on this had been between Harry van der Laan and Francis Graham Smith during the 1979 IAU General Assembly in Montreal and not much later a delegation of Dutch astronomers, of which I was part, met a UK delegation at the Royal Greenwich Observatory (RGO). Graham Smith was director of RGO and Astronomer Royal. My presence was related to the fact that I was one of the few Dutch astronomers with experience in extragalactic optical astronomy on large telescopes. The starting point, agreed by Harry and Francis, was that the Netherlands would take a 20% share, which was reasonable in view of the relative sizes of the communities, but also in terms of the number of nights per year and the funding we might hope to raise.

The Dutch research council or science foundation that would fund the UK/NL collaboration dates back to the late 1940s and was originally called the Netherlands Organization for Pure Research, abbreviated ZWO. It funded from the beginning radioastronomy

Fig. 23 My PhD thesis supervisor Jan Hendrik Oort and myself at the reception after I had delivered my inaugural lecture in January 1988, having been appointed full professor half a year earlier at the university of Groningen. From my private archives.

through the Foundation Radio Radiation from Sun and Milky Way (SRZM), founded in 1949 by Jan Oort, who chaired the board until his retirement. SRZM operated the radio facilities, first in Kootwijk, later Dwingeloo and Westerbork. To enable the participation in La Palma (which we referred to as UK/NL) a further foundation was created, Foundation for Research in Astronomy or ASTRON, that in addition started a grants program. The provision of manpower and instrumentation (optical, but also millimeter for the James Clerk Maxwell Telescope, JCMT, that was part of the La Palma agreement, but which on Dutch initiative went to Mauna Kea, Hawaii) went through SRZM. From 1975 onward Harry van der Laan chaired the board of SRZM. In 1985 Harry had arranged that I chaired the Dutch working group that coordinated the UK/NL efforts. But when Harry would be appointed Director General of ESO, to my complete surprise, I was asked to become chair of SRZM. I had not even been a board member, although as chairman of the Westerbork Program Committee I had been invited to parts of the board meetings. I took up this position on October 1, 1987.

A few months before that, per June 1, 1987, I was appointed full professor in Groningen. The final trigger for that had been a deep review of all of Dutch astronomy the year before, related to the extra funding from ZWO for UK/NL. This ASTRON Foreign Evaluation Committee AFEC, chaired by a Ivan King and containing a few other very high power astronomers, had rated Dutch astronomy as among the top three worldwide together with the USA and the UK. But it also provided confidential letters to each institute, the Groningen one containing the strong recommendation that I be promoted to full professor. So, here I was; a full professor at the relatively young age of 42 (see Fig. 23) and a few months later, just 43, chairman of SRZM, one of the most important positions in Dutch astronomy. A year later ZWO dropped the 'Pure' in its name and became NWO, while the two foundations merged to form a new ASTRON and I became its chairman (old ASTRON chairman Max Kuperus, a solar physicist from Utrecht, was adamant that I should take that role). As a result I became vice-chair of the governing body of the UK/NL

La Palma effort (and later for a term the chair), the Joint Steering Committee (JSC). When the JCMT became a separate effort, I left membership of the corresponding board to persons more experienced in millimeter wave astronomy.

In the Netherlands national coordination among astronomers had for a long time been quite intense. Leading astronomers met a few times per year in an informal body named Netherlands Committee Astronomy (NCA). This consisted of the chairs of the university astronomy departments, chairs and directors of ASTRON and the similar Foundation for Space Research in the Netherlands SRON, astronomical members of national or international governing bodies. This body did (and under a different name still does) among others produce a decadal strategic plan to agree on priorities and convince the government to fund these. Although discussions often develop along lines of conflicting priorities and choices, in the end always a consensus emerges. The issue of the 1980s was that the ASTRON budget had been raised for a period of ten years to pay the UK back for our share in the collaboration. This we called the 'hump' which we hoped would become a permanent increase. In the end we succeeded, helped by the very positive AFEC report. I have, almost uninterrupted, been a member of the NCA between 1987 and 2012, often in two or more different capacities, most of the time as vice-chairman or chairman.

During my ASTRON chairmanship (mainly through the efforts of others) a major upgrade of the WSRT was pursued, the William Herschel Telescope (WHT) at La Palma and the JCMT in Hawaii became operational, Very Long Baseline Interferometry was incorporated in the Dwingeloo Observatory, participation in a square-kilometer low-frequency radio telescope and a large millimeter array were made priorities. One definite initiative of me was a second AFEC in 1995 (chaired by Jerry Ostriker, who had been a member of the previous AFEC), which confirmed the AFEC I conclusions, but noted that other European countries had evolved to similar levels as the UK and the Netherlands. Another initiative I took was a complete overhaul of the organizational structure of ASTRON, moving from a collegiate directorate of heads of departments to one in which leadership was more professional with a well-determined management structure and lines of authority with a general director at the top. Harvey Butcher was appointed at that position.

During my ASTRON term I was invited to international advisory bodies such as the Astronomy Working Group of ESA, where advise on the selection of ESA missions was prepared, and selection and audit commissions of the European Commission concerning science funding in the Framework Programs. I was particularly active in the programs in which access to large facilities was funded. One of the nice collaterals of this was that in the framework of an audit of large facilities for environmental research I visited Ny-Ålesund in Spitsbergen (Svalbard) at latitude 78°5. There are no astronomy facilities among the extensive research facilities at Svalbard; the radio telescope located there is participating in European VLBI, but was not used for astronomy but only available for geodetic purposes using quasars to monitor the drift of the island.

I remained chair of ASTRON for over eight years until the end of 1995. In 1994 I was approached for the position of Dean of the Faculty of Mathematics and Natural Sciences. This involved mathematics, computer science, astronomy, physics, chemistry, environmental science, biology and pharmacy. One reason for accepting was the challenge; would I be able to do that? This was the time of extremely low influx of first-year exact

Fig. 24: Here I am acting as Rector Magnificus during a PhD thesis defense ceremony in the Faculty of Mathematics and Natural Sciences during my term as Dean of that Faculty. According to the office of the Faculty I did this 251 times. Left: preparatory consultation, right: in front of the Faculty room. From my private archives.

science students. One year we had only 9 first-year students in mathematics, which is way below what society needs. Physics and chemistry were low too, but astronomy stayed at the 'normal' level of 10 to 15. On the other hand, biology and pharmacy grew enormously. Relocating personnel was no option, funds only to some extent. Another problem was in the workshops of the physics and chemistry departments, which had just merged. The resulting workshop was much too large, also because of-the-shelf purchases became more the rule than the exception. A major reorganization was unavoidable, involving loss of jobs and of people. This I have found difficult emotionally; I am quite stress resistant, but telling people they were no longer needed and their presence was no longer appreciated has given me sleepless nights. In the end it worked out with a minimum of pain.

At that time all students received a stipend from the government for the duration of the curriculum plus one year. For all studies the curriculum was first set at four years, but the technical universities had succeeded in having five years approved backed by a strong lobby from industry. In natural sciences the factual curriculum was also five years. A major problem occurred in 1995 when the Minister decided to limit the support to students to the formal curriculum duration. I chaired a national committee whose report convinced the Minister and Parliament to increase this to five years for all natural sciences (see Commissie Vijfde Jaar Bèta Studies, 1997; with Executive Summary in English).

There were other important issues, but that would carry us too far. One of the things I enjoyed was chairing the PhD thesis defense ceremonies (Fig. 24). It made me aware of and appreciate the large amount of diverse, interesting and high quality research that was going on. The opposition during the defense consists of professors knowledgeable in the subject and is chaired by the Rector Magnificus. In practice the rector is not available and I made it a point to act in this capacity as much as possible. Usually this was three in a

row during Friday afternoon and in the end as Dean I had chaired 251 of such ceremonies. Another initiative of mine was to institute visiting professorships. The astronomy one became the Blaauw chair, where an international high profile astronomer visits a few weeks, interacts with postdocs and graduate students and delivers a Blaauw Lecture for a general audience. The first was Michael Feast in 1999.

My final months were devoted to the implementation of yet another law overhauling the governing structure of universities that came into force in September 1997. This law reversed the democratization process, in particular taking the right to determine budgets away from councils with personnel and student representation. It is still in place.

After my term of three years I decided not to accept an extension. There was a significant level of déjà vue in the job, but most importantly I missed teaching students and making them eager to learn about astronomy and the universe, and supervising them to produce good science. Getting back into research was a challenge also. Finding a successor proved to be not easy and I ended up doing another four months. With the start of 1998 I returned to the Kapteyn Astronomical Institute. I was surprised to note how many students we had that I had never met. In fact, I saw them looking at me wondering who that fellow could possibly be. Tjeerd van Albada had taken the directorship, but wanted me to relieve him from that burden. I took over in the fall, first making use of the possibility offered by the Faculty to spend some time elsewhere which became a month at Mount Stromlo Observatory to renew research programs with Ken Freeman and a month Space Telescope Science Institute for the same with Ron Allen.

In 1991 the concept of Research Schools was introduced by the Minister of Education, Culture and Science[3] to coordinate and stimulate training of young scientists by bringing excellent research groups from different universities together. It was envisaged that excellent schools would receive extra funding. After some skirmishes in the NCA it was decided that astronomy should opt for one national school, bringing all the university institutes together. The name would be NOVA which is the Dutch acronym for Netherlands Research-school For Astronomy. There were four astronomical institutes in the Netherlands, at Amsterdam, Groningen, Leiden and Utrecht, and a small one at Nijmegen. Leiden was the largest, Groningen somewhat smaller and Amsterdam and Utrecht somewhat smaller still. We always maintained that the quality was quite similar, but now one university had to be chosen as the legal representative, which was in the concept of the Minister the leading and most prominent of the set. In Groningen the Dean of the Faculty, a physical chemist, and the Governing Board had decided that they would primarily go for local schools. Not by accident this left only the Dean's own Materials Science Center MSC. The Kapteyn Astronomical Institute could participate in NOVA but Groningen could not be legal representative. After some months of deadlock Leiden became legal representative, but it would rotate every five years, and Leiden also contributed the director, Tim de Zeeuw. Tim and Ed van den Heuvel from Amsterdam wrote the proposal. NOVA was recognized as one of the first national research schools.

[3] I have always had difficulty with that name. You can argue about the order, but science in my view is part of culture. At the time I was a university student (and actually quite some time before that) the Ministry had the much more appropriate name of Education, Arts and Sciences.

In 1997 the Minister organized a competition for substantial extra funding over a ten-year period. Of the one hundred or so research schools in a first round of this 'Bonus Incentives Scheme' about a quarter or so took part and six were selected with NOVA as number one and received Mfl 46 (≈ M€ 21) over 10 years! The Groningen MSC was selected also. NOVA came through the mid-term review after five years with flying colors and ended again as number one when renewal of the six selected schools after ten years was in order. I was in the meantime chairman of the NOVA Board (and the NCA) and Groningen was legal representative. In 2010 both NOVA and the Zernike Institute for Advanced Materials (as the MSC was now called) were designated 'exemplary', so higher than the other remaining four. Up to the present time the extra funding is continuing. It is used for both training of young astronomers as well as for participation in instrumentation; NOVA has made it possible for example for the Netherlands to participate in the instruments program of ESO. This was and is vital for our future. The university of Utrecht decided in 2012 to discontinue their astronomy department after 370 years of excellent teaching and research. This, in my view unwise, decision has not lead to any adverse effects, as the Radboud University in Nijmegen has taken over most staff members (a few went to Amsterdam or Leiden) and that is now one of the four thriving centers of astronomy that make up NOVA.

In 1998 NWO went through a major restructuring and formed new Area Boards, which were in particular responsible for the grants programs that were growing. I was no longer dean, so it was felt that the membership on behalf of astronomy in that for the exact sciences (mathematics, computer science, physics and astronomy) was a natural thing for me to do. It was a nice experience, particularly since the group felt some responsibility for the whole rather than just their own discipline. My term ended in 2003. In 2006 the astronomer on the Area Board (now without physics) and the members of the advisory committee on astronomy resigned collectively, because an atmosphere of negative bias against astronomy had developed, in particular in the office that supported the board, but to some extent in the board itself also. This left NWO without any formal communication channel to the astronomical community. The only option was that I, as chairman of both the NCA and the NOVA Board, would try to mend the situation. I made an appointment with the NWO Board and took Tim de Zeeuw, director of NOVA, along. This turned out a very constructive meeting and things eventually went back to normal. But to build up renewed trust and confidence I took another term at the Area Board. It resulted in much goodwill and credit for me with the NWO Board. So, when I had my valedictory lecture and 'Challenges' symposium in 2009, the chairman of NWO, physicist Jos Engelen, came all the way to Groningen to attend and at the reception he presented me a silver lapel pin with the NWO logo. I was very moved by this token of appreciation and have worn it whenever I had to do with NWO – at least until they adopted a new logo.

9 HST, La Palma, ESO, ALMA

The mid-1980s, coinciding with me reaching the age of forty, were sort of a turning point. I had established myself as an expert on galactic disks, my ideas for research were turned

into projects for PhD students (who were the ones going out to telescopes for observing sessions, while being at the telescope was one of the highlights of being an astronomer), and I became more and more involved in international advisory committees. The one that I particularly enjoyed was on Space Telescope, as it was still called then, key-programs, trying to establish what were the highest priorities in its use. Sometimes phrased as 'If it failed after a year, what should we have been using it for?'. This involved a few meetings in the USA, mostly at the new STScI in Baltimore. In my panel (concerning galaxies and the universe) there were three candidates for this. Two eventually got recognized as 'Key Programs' and had priority in early cycles. One was measuring the Hubble constant, and through this the age of the universe, which was difficult to ignore as Space Telescope was sold in the USA for this, and the other deep exposures to look for anything new and unexpected. I pushed for stellar population in nearby galaxies, but it lost out in the end.

I was asked to take part in the Time Assigning Committee (TAC) for Cycle 1. This was all very secretive. Proposals had covers with no information and we were instructed to keep them at the office, immediately close the covers if someone entered and lock them in a desk drawer when leaving. No list of names of the panel members was published, no group photograph was taken. I was a member of the panel on galaxies and the universe (excluding AGN and quasars), and because the chairman Jay Gallagher had to leave halfway through the week, I was made vice-chair and attended the 'super-TAC' chaired by Lyman Spitzer where everything was put together. Altogether I have been on seven of the first sixteen HST TACs, once as member-at-large and the rest as panel chair.

I was among the early observers at La Palma. In September 1984 I obtained a few nights on the 2.5 meter Isaac Newton Telescope (INT) to try to measure stellar kinematics in one of the edge-on galaxies I had studied with Leonard Searle, NGC 891. The INT had been moved from RGO at Herstmonceux Castle near Hastings to La Palma and the mount had been adapted for the different geographical latitude. This did not work very well yet; the tracking of the telescope was problematic and there was a significant (a number of arcsec) 'wobble'. For my work this did not matter, since for sensitivity I had to average over similar areas along the slit anyhow. I arrived at the observatory with a taxi that had picked me up at La Palma Airport (at sea level); I was told this was the only taxi driver on the island that was prepared to drive up his car over what for the most part was an unpaved dirt road to the observatory at 2400 meters altitude (the staff used four-wheel-drive vehicles). The last part we were in the clouds and I was dropped off in heavy mist. There was nobody around, but I saw the faint outlines of a building which I identified from a sign attached to it as the INT dome. I went inside using an open door and groped around until I found a light switch. However, throwing the switch produced no light. I decided to call out: 'Anybody there?'. Finally a voice behind a flashlight came from a distance: 'Who is there?'. 'The observer', I answered. A roaring laughter greeted me: 'There is no observing here!'. This was Keith Tritton, head of the ING at the time. They just had one of their not very infrequent power failures. Actually the telescope worked reasonably well. I was assisted by Edwin Valentijn, at the time seconded to La Palma from Groningen. The Netherlands was to contribute manpower to the operations, some was in the form of technical personnel seconded from Dwingeloo, and from Groningen for some years we contributed a postdoc on a five-year contract of which half was to be spent

as support astronomer at La Palma. Edwin was the first of these. We did get useful data and Edwin actually obtained some more later, which resulted in a very useful result with my PhD student Roelof Bottema (Bottema, van der Kruit & Valentijn, 1991).

I had not observed at the European Southern Observatory (ESO) in Chile. The 3.6 meter Telescope had been operational since 1975, but had no suitable instruments for me to use. In the late 1970s I had been on an *ad hoc* advisory group to Director General Lodewijk Woltjer, advising him to provide a long slit spectrograph with a suitable electronic detector, but this had not come about. In early 1984 a 2.2 meter telescope had been installed on La Silla on indefinite loan from the Max Planck Gesellschaft, and this had a spectrograph with a reasonably long slit operated with a CCD as detector. I obtained observing time on it and went to Chile as one of the early observers.

This was a long trip; KLM provided a flight from Amsterdam to Santiago, but this required a fueling stop at Lisbon before flying to Rio de Janeiro, and then further stops at São Paulo or Montevideo and Buenos Aires, arriving in Santiago at 2 am. The Pinochet regime had a curfew in effect except for taxi's from the airport, but it felt quite uneasy to travel through the dark, spooky streets with regularly trucks full of soldiers with rifles. The taxi driver awaited me at the airport with a sign with my last name on it, but he was surprised that it concerned a single person while he had expected three. But I arrived at the ESO Guesthouse finding someone awake to let me in. During the night I woke up a few times from what seemed thunderstorms, but at breakfast I was told these were bombs aimed at sabotaging power installations.

The flight in a small airplane to the ESO airstrip near La Silla was interesting to say the least. At one time we flew directly at a ridge with insufficient height, relying on a thermal upward lift that just made us clear the ridge. Lo Woltjer has at one time told me that he constantly worried about possible problems and crashes – and even loss of life – during these trips transporting ESO personnel and observers a few times each week. The telescope worked fine but using the detector was problematic and I obtained no usable data. For the return trip to Amsterdam ESO had provided me with the departure fee, required to leave the country, in Chilean currency, but the customs officer refused to accept that and demanded US dollars for more than twice the amount. I gave in. This was a short run and there had been no time to arrange the usual diplomatic visa; the next time I came for observing this was arranged and I left without any problem.

As chair of SRZM I became automatically vice-chairman of the UK/NL Joint Steering Committee (JSC), a position I held until I resigned from it at the end of 1997, except for a three-year term as chairman. Interaction was particularly frequent with Alec Boksenberg, the director of RGO. The WHT was coming online with its first suite of instruments, the INT instrumentation extended, personnel issues arose regularly concerning the staff seconded to La Palma. Alec and I went along well; I was flattered that in a speech at my farewell to the JSC he thanked me for 'correcting our English', which was a definite overstatement. There was always the problem of matching the budgets. When we had some extra funds the UK had to cut, when we were denied an indexation for inflation the UK got one, the exchange rate between Pounds and Guilders worked by definition positively for only one of the two and with the Peseta was usually a disadvantage to both. My dealings with the UK were at the level of the research council. The Brits liked to overhaul

Fig. 25 The UK/NL Joint Steering Committee for the Isaac Newton Group of Telescopes at the Roque de los Muchachos Observatory on La Palma in front of the dome of the William Herschel Telescope in 1994. From left to right Mike Bode, Rod Davies, Gerry Gilmore, Alec Boksenberg, Harvey Butcher, myself, Rowena Sirey, Mr. Lindgren (SERC). From my private archives.

these regularly; it started out with the Science Research Council (SRC), became Science and Engineering (SERC) soon and then Particle Physics and Astronomy (PPARC). But I ended up developing an excellent working relationship with Ian Corbett who became in charge of that, and his deputy Rowena Sirey. The JSC met regularly at La Palma, to which I traveled with Hette Weijma from NWO. Hette held a chemistry PhD and was a senior administrator supporting the directorate of NWO; he always attended SRZM and ASTRON Board meetings and for many years also the JSC. It was helpful, as he was always up to date on affairs in which he advised the NWO Board. The other advantage of him attending the JSC was that he could circumvent usual bureaucracy so that we flew business class. 'Piet, we travel like gentlemen', he used to say when we had taken our seats at Amsterdam Schiphol Airport. Fig. 25 shows the JSC at La Palma some time in the 1990s when time pressure had prevented Ian Corbett and Hette Weijma from attending.

My involvement with ESO before 2000 was two-fold. From 1983 to 1987 I was the Dutch delegate to the Observing Programmes Committee, that advised the Director General on the selection of proposals for observing time. At that time there simply was one astronomer from each member state plus one from the ESO scientific staff. It met twice a year for three days with Director General Lodewijk Woltjer present most of the time. The other involvement had to do with the Space Telescope European Coordinating Facility, operated at ESO jointly with ESA. In 1986 a User's Committee was formed and I was asked to

chair it. Since HST was not launched yet it became a sort of visiting committee. In conjunction I was appointed a member of ESA's Space Telescope Advisory Team. Both committees advised on problems related to the delay of Hubble because of the Challenger disaster. Probably because of this involvement I was between 1995 and 2001 one of the two ESA members of the Institute Visiting Committee of STScI in Baltimore. The other ESA member was Catherine Cesarsky, with whom I was to have major dealings later.

In 2000 I became the Dutch astronomy delegate to ESO Council. I had been part of the Netherlands delegation in 1999 at the dedication of the Very Large Telescope (VLT) at Paranal Observatory, and visited the site where ALMA, the Atacama Large Millimeter (and sub-millimeter) Array, would be constructed. It was the first time a party like this visited the site at 5 km altitude and for safety an ambulance came along. It went well (unlike my later visits, I did not even have to use any of the oxygen we were given), although we returned somewhat quicker than planned because Per Olaf Lindblad from Sweden started to suffer from signs (severe headaches) of altitude sickness. On that occasion I talked extensively with Jan Bezemer, the diplomatic delegate for the Netherlands to ESO Council and he wanted me to be the next astronomical member. He was a colorful person, who smoked cigarettes and liked a drink. On the flight from Amsterdam to München he usually managed to have two wines and one cognac. Yet he did never seem to be affected by alcohol. At the ALMA site he lit a cigarette, but at that height it simply extinguished by lack of oxygen if not drawn on. Jan was a geologist by training, had worked at the ministry for Education, Culture and Science for many years and been a longtime Council delegate for ESO (and for CERN). He has been very important, arranging increases of budgets with the Minister whenever desired, usually stressing the important role the Netherlands had played and still was playing in ESO. At one time he remarked in feigned despair (outside a formal meeting) referring to discussions on OWL (the case study for a 100-meter OverWhelmingly Large telescope, which eventually would lead to the ELT): 'Astronomers are only satisfied when they have built a telescope on every molehill!'. Had we decided we literally wanted this he would probably have supported it.

My summary here of that period, when I ended up being President of ESO Council and chairman of the ALMA Board will be brief. I have written an extensive account (van der Kruit, 2006) that is available on my homepage.

At my first meeting of ESO Council in December 2000, I was elected Vice-president and designated head of the group that would negotiate with the U.K. on the 'in-kind' contribution to the accession fee to join ESO. Interestingly, my opposite number turned out to be Ian Corbett! The largest part of in-kind contributions was the 4-meter Visible & Infrared Survey Telescope for Astronomy (VISTA), but at a price. We felt it had to be optimized for the near-infrared (there was already an optical survey telescope being built at Paranal; the 2.5- meter VLT Survey Telescope (VST) in collaboration with Capodimonte Observatory, Naples), so VISTA had to come with a silver coating plant for mirrors up to 4 meters. In the near infrared coating with silver is more effective than aluminum, because in the infrared the reflectivity of silver is much better. Some in the UK that had conceived VISTA must have had to swallow hard, because we had to insist it would become an ESO telescope, operated and archived by ESO according to ESO standards and exploited by the full ESO community. All of this required further funds to be invested by the UK. In

the end part of what the UK had intended in-kind remained in-cash, to be paid over a ten-year period. Council felt I had done well, having negotiated a rather good deal for ESO.

In December 2002 a new President of Council had to be elected and I was proposed and duly elected. The UK had joined by then, but we started negotiations with Finland, and somewhat later with Spain. There were major problems with the growing membership, like the necessity to revise the voting procedures in Council and Finance Committee, so that no financial decisions could be taken without any of the large member states being in favor. Also the levels of contribution, which are based on the respective NNI's (Net National Income) had to be revised, because there originally had been a cap so that the larger countries would not contribute out of proportion. Whenever there was a new member state (Council always decided its contribution would be added so that the total budget increased) this gave immediately rise to an increase of the contributions from the large countries because they would have to contribute the same percentage of a larger total budget. There also was an urgent need to redefine the advisory committee member structure, where the older principle was that that each member state had a member on all committees regardless of expertise. Expertise and manageable size of committees were to be more important than representation. This was all effected.

When I became President another Dutch astronomical delegate was required and I proposed the director of NOVA, Tim de Zeeuw. The Minister agreed. In 2004, after long discussions in a special *ad hoc* working group of Council that I had instituted, a strategy plan was adopted unanimously, which I regard as a major accomplish of Council during my presidency. Ralph Bender chaired this working group and Tim was an important member. With the extension of ESO with the UK and the adoption of a share in ALMA, a clear long term strategy for the next two or three decades was needed. The full text of the 2004 resolution on ESO strategy is available at European Southern Observatory (2004). In brief, ESO Council accepted the principles: • ESO's highest priority strategic goal must be the retention of European astronomical leadership and excellence, • the completion of ALMA is assured, • the VLT will continue to receive effective operational support and regular upgrading, • the unique capabilities of the VLTI will be exploited, • the construction of an Extremely Large Telescope on a competitive time scale will be considered. The last point paved the way for the ELT.

An unexpected problem arose when Portugal did not pay its contribution for two years in a row. This was resolved only after Portugal had its voting rights in Council, Finance Committee and other bodies revoked. This required a unanimous Council decision and to spare the Portuguese delegation from extreme embarrassment, when the resolution was put to a vote, I asked for votes against and abstentions and when none came skipped asking for votes in favor, but concluded that the resolution had been adopted. Portugal eventually payed all outstanding amounts plus interest.

Council meetings were very formal. Science was seldom addressed and delegates often had the habit of addressing each other formally ('the delegate from this or that country', sometimes even with the adjective 'honorable') and me as 'Mister President'. I started using first names, and in the end even the most formal delegates followed me in this. A diplomatic delegate from one of the smaller member states would however still say when

Fig. 26 Some members and attendees of an ALMA Board meeting in Chile, in November 2004, visiting the Valley of the Moon near San Pedro de Atacama to watch one of the beautiful sunsets from there. From left to right: front row Catherine Cesarsky, Lewis Knee, myself, Jim Hesser, Helen Lo, Fred Lo; back row Richard Wade, Bob Dickman, unidentified, Massimo Tarenghi. From my private archives.

he was given the floor: 'Thank you, Mister President', then adding after a short pause 'Thank you, Piet'. To add some amusement I started using funny (at least that is what I felt) quotes in my customary speeches at the Council dinners. Some of these are in an appendix in van der Kruit (2006).

Another restructuring I introduced was the following. Council met every six months. There had been a custom of having in between so-called Committee of Council meetings, which were in principle attended only by the diplomatic delegates (each member state has two, usually one a diplomat and the other an astronomer). No decisions could be taken at these meetings. I took the initiative to make these meetings with in principle all delegates to have exchange of information and a major brainstorming session, all again without allowing any formal agenda items or decisions. To enhance the informal setting these were held away from ESO headquarters. I was very happy that the position of Head of Administration of ESO was taken by Ian Corbett, so that contrary to previous occasions we were actually on the same side. The collaboration with Catherine Cesarsky and Ian Corbett has been enormously fruitful and pleasant.

A major effort of ESO concerned ALMA. When I became president in January 2003 the decision to build the bilateral ALMA had just been taken. The Japanese government had not agreed to be part and the agreement was only between North America and Europe (Spain participated but through ESO). I had not been involved in that. Yet because the agreement had specified that the first chair would come from Europe, I became such by default at the first ALMA Board meeting in Washington in February 2003. The Vice-chairman was Bob Dickman from the US National Science Foundation NSF, and our roles would switch in two years. It was intense with telecon meetings every month of the full board, preceded by one with an advisory European ALMA Board, and every four months a face-to-face meeting of these bodies. Each year one of these was in Chili, where we did visit the high site, at least if one passed a short medical examination. We did sometimes do a bit of sightseeing early in the evening watching sunset before dinner (Fig. 26).

Some enormous tasks lay ahead now that the construction phase had started. Collaborations were not smooth in the beginning. It was noticeable that the US had difficulty

adapting to the role of equal rather than majority partner, which they had in practice been in most, if not all, large scientific collaborations. Sticky issues like the choice of the ALMA logo, which should not look too much like the one of ESO, the location of the Santiago ALMA offices, which at the ESO Vitacura premises would have the same address as ESO, were examples that were eventually solved, but management, employment and operation cultures were more difficult to integrate. After a stormy ALMA Board meeting in Santiago in November 2003, we had a very nice celebration marking the start of construction with a groundbreaking ceremony (Fig. 27). At the same time the ALMA logo was unveiled. This was held at the location where the Observing Support Facility OSF at 2,900 meters altitude would be. We also visited the site of the telescope itself at 5,000 meters, where by that time the location of the telescope stations were marked.

The bilateral project consisted of sixty-four 12-meter antennae, but if Japan would join they were expected to contribute a short baseline 'compact' array of twelve 7-meter antennae and four 12-meter 'zero-spacing' or 'total power' ones. At the VLA-site at Socorro, New Mexico three 12-meter antennae were constructed, each led by the three eventual partners. The idea of the North-American and European partners was that testing would lead to a preferred design which would be adopted for the 64 bilateral antennae. Using a mix was considered detrimental to the performance, because the antenna patterns were different and that would result in difficulties with calibration and software. Not surprisingly, it turned out that the projected budget was extremely tight. And it was adamant that Japan would join, because their contribution would be vital to the project. In addition to the compact array and cash they would add three more frequency channels and a new design correlator, first for the compact array but possibly as a second generation one for the full array. Negotiations were difficult, management structure differences had to be overcome and mutual trust to be built up. During a few-day-long session in Tokyo we did achieve progress, although halfway through the meeting it looked very bleak (at one time the two delegations had lunch at separate tables).

In 2005 when the testing of the prototype antennae had been completed and both bilateral ones had passed all tests, came the problem of choosing between the two (Japan would deliver their own design). The tendering showed that the costs would be very significantly higher than projected, in particular because of rises in the prices of steel and oil (used for production of various materials) and it became clear that we could not afford 64 antennae. Even with 50 antennae the budget would have to rise and it was not certain at all that the US Congress and ESO Council and Ministries in the member states were prepared to agree to that. The whole project seemed in jeopardy, since it was not obvious that the scientific requirements could be met with fewer antennae. A long and difficult (and I found worrisome because of conflicts of interest and lobbying activities of the industries involved) process lead to the purchase of 50 antennae, 25 of both types by the bi-lateral partners each. The increase in costs for ESO were partly recovered from the accession of Spain for which I had headed the negotiating team on ESO's side.

Needless to say, all my administrative duties took quite some time and especially for ESO involved a large amount of travel. I quickly reached the highest level of KLM frequent travel status. Briefly on a personal level: my children grew up to independence later in the 1990s and I went through a divorce. In 2003 I remarried. Late in 2005, as I was nearing

Fig. 27: Groundbreaking ceremony at the location of the Observing Support Facility, at 2900 meters altitude, of ALMA on November 6, 2003 (left). The hard rock had been prepared by pulverizing a part of the top layer to make a little bit of digging possible. From left to right, myself, Wayne Van Citters, NSF Division of Astronomical Sciences, and Massimo Tarenghi, director of ALMA. On the right the ALMA logo that was unveiled on the same occasion. From ESO and private archives.

Fig. 28 Catherine Cesarsky and I at the ALMA site the day after the inauguration ceremony in 2013. I am clutching a bottle with oxygen with mouthpiece to help breathe at this altitude of 5 km. From my private archives.

the end of my term at ESO it was discovered that I had a birth defect in my aortic valve, which urgently needed replacement by an artificial one, requiring open-heart surgery. This put me out of action for the final three months of my presidency when the ALMA project went through an independent cost review in Garmisch-Partenkirchen. This went well as I was told while recovering from surgery.

My farewell *in absentia* (because of heart surgery) in December 2005 to ESO Council was not final. In 2006 the search in Council for a successor to Catherine Cesarsky as Director General resulted in a shortlist of three persons, one of which was Tim de Zeeuw. He had to resign from Council and the Minister urged me to return as delegate for the duration of the selection. There was a sentiment that selecting a Dutchman for the fourth

time (after Adriaan Blaauw, Lodewijk Woltjer and Harry van der Laan) would be a bit much and in the end Rolf Kudritzki, from Germany but working in Hawaii, was selected as first choice with Tim as second, with upon our insistence the understanding that he would automatically be considered next would no agreement on the terms with Rolf be reached. Rolf in the end decided to remain in Hawaii and, in spite of a last-minute attempt (that was blocked) to bring selection back to Council, Tim was appointed. The accession of Spain took some time to be concluded by parliamentary ratification and the celebration with a Council meeting in Barcelona was scheduled for June 2007. Since I had been involved in all this the Minister agreed I would remain on Council until then. It was great to attend the Barcelona meeting and welcome Spain as part of ESO.

The dedication of ALMA and the Llano de Chajnantor Observatory took place on March 13, 2013, and as previous chairman of the Board and President of Council I was invited as special guest of honor by ESO. The ceremony took place again, as in the case of the groundbreaking, at the OSF location and we saw on large monitors how all the antennae, that all pointed in different directions, moved and were directed to the same point on the sky, the center of the Galaxy. To me, this moment was very emotional. The next day we went up to the 'high site', where we now saw the plateau covered with white antennae. Catherine Cesarsky and I (Fig. 28) rejoiced in seeing the project completed and reminisced that there had been a time when we seriously felt it would all be called off. My final view of ALMA was at some distance just before the descent to San Pedro began (Fig. 29). Looking across the plane at 5 km altitude with a major installation in place filled me with gratitude to have been part of it.

10 History of astronomy

My interest in history in general and that in astronomy in particular goes back to early age. I enjoyed history in secondary school (HBS) and as a teenager my interest in astronomy included reading books on its history and biographies of great astronomers like Copernicus, Kepler, Galilei, etc., but also of physicists. I am not blessed with an excellent memory, which reflects in my very average performance in languages at the HBS. I tend to memorize things that I find interesting much easier, which may be an explanation that I scored reasonably well in history. I did and still do enjoy reading historical novels and biographies in general. I am a fan of James Michener's novels that describe the history of a place, region or nation by setting it chronologically through the centuries. One of my favorite books on astronomy is Arthur Koestner's 'The sleepwalkers'. The criticism by Owen Gingerich (2004) is entirely justified, yet I found the book very inspirational and as a matter of fact I have presented my PhD students, from the first one onward, with a copy of it after they defended their theses. Maybe they share some of my fascination for the history of our profession.

Time restrictions prevented me from researching historical questions; what I did was restricted to writing historical introductions to papers, such as on the development of radio studies of nearby galaxies (van der Kruit & Allen, 1976), spectroscopic studies of galaxy kinematics (van der Kruit & Allen 1978), gravitational instability and galactic

Fig. 29: My final view of ALMA sitting in the middle of the Llano de Chajnantor at 5 km altitude. The top is an enlargement of the central part of the lower photograph. From my private collection.

disks (van der Kruit & Freeman, 1986, 2011), and of course the Kapteyn/van Rhijn and Herschel magnitudes described above. When the Netherlands was to host the 1994 General Assembly of the IAU, of which as director of the Kapteyn Astronomical Institute I was a member of the National Committee, I noted that this coincided with the 50-th anniversary of Baade's seminal paper, in which he introduced the concept of Stellar Populations (Baade, 1944). Over beers with Gerry Gilmore one evening in Leiden during a multiple-day meeting he agreed to co-propose an official IAU Symposium in Den Haag on the subject. When I drafted a program I included a half-day session on the history of the subject. IAU Symposium Nr. 164 (van der Kruit & Gilmore, 1995) had four invited reviews by Owen Gingerich, Don Osterbrock, Nancy Roman and Adriaan Blaauw. I think this was a success. In fact the whole symposium was a success; Kluwer informed me that never had the proceedings of an IAU Symposium been sold out so quickly. The historical session will have contributed to that. At Springer's request the proceedings were reprinted, with updates, as a complete volume of the journal *Astrophysics and Space Science* in 1999.

In 1999 the University of Groningen celebrated its 375th anniversary and the Governing Board decided to hold a few 'Legacy symposia', dedicated to famous Groningen professors. Klaas van Berkel, professor of history and expert on the history of Groningen university, proposed that Jacobus Kapteyn was an obvious candidate. He and John North, professor of history of philosophy and the exact sciences, contacted the Kapteyn Astronomical Institute. I took the organization upon me. The symposium, 'The legacy of J.C. Kapteyn. Studies on Kapteyn and the development of modern astronomy', was held on June 9-11,

Fig. 30 Part of one of the stained glass windows in the main auditorium of the University of Groningen, that depicts Kapteyn holding a Jacob's staff, an ancient instrument to visually measure distances between stars on the sky. Photograph taken by Elmer Spaargaren during the one-day symposium 'Challenges' in 2009.

1999. The program included many experts on the history of astronomy. The proceedings (van der Kruit & van Berkel, 2000) was a first comprehensive publication on Kapteyn, about whom no learned biography was ever written. Blaauw, and a few attendants of the symposium, suggested that after retirement I should write a Kapteyn biography. In the years after that Adriaan sometimes gently reminded me of this.

In 2009 I reached the age of 65, which meant (mandatory) retirement. Tradition is to present a valedictory lecture, and the Kapteyn Astronomical Institute proposed to make it part of a one-day symposium. Now, I had since 1998 been chairman of the Board of the Royal Natural Sciences Society, abbreviated in Dutch KNG, which was founded in 1801, and of which the most important of its various activities is to organize monthly lectures by natural or medical scientists for its members and guests. I actually resigned from the chair only in 2020. It should be mentioned that for many years Kapteyn had been a prominent board member and organizer of the KNG, and in the building it owns in the center of Groningen the room where the KNG Board meets is named Kapteyn Hall in his honor (not to be confused with the Kapteyn Room in our institute, where his books, desk etc. are kept). And there is an annual Kapteyn Lecture by a prominent national or international celebrity, such as Nobel laureates Brian Schmidt and Ben Feringa. The KNG decided to co-organize this one-day symposium. I drew up the program myself and proposed the title (see 'Challenges' sub-page on my homepage). It was meant for a general audience and was held in the main auditorium of the university. This is decorated

Fig. 31: My longtime collaborators Ron Allen (left) and Ken Freeman, presenting their contributions at my retirement symposium 'Challenges' in 2009. Photographs by Elmer Spaargaren.

with a number of large stained glass windows, of which one has an image of Kapteyn (Fig. 30). Two of my former PhD students Richard de Grijs and Roelof de Jong, and my two longtime collaborators Ron Allen and Ken Freeman (Fig. 31) spoke of their current research and various colleagues in the Netherlands presented the new large observing facilities we are involved in. Former PhD student Eline Tolstoy introduced the speakers. For the valedictory lecture at the end of the day I chose as title: 'It all started with Kapteyn' (van der Kruit, 2009). It addressed among others the role Kapteyn had played to lay the foundations for the tremendous boom Dutch astronomy experienced in the twentieth century. A possible biography of Kapteyn was still hanging in the air.

After my lecture the Rector Magnificus Frans Zwarts presented me with the Academy Plaque for distinguished service to the University, and the Faculty of Mathematics and Natural Sciences offered an official painting of me in academic attire to be donated to the university (see Fig. 32). The university displays in the central Academy Building a collection of such paintings. The Faculty donated mine because they wanted all their deans and named professors represented.

Writing a biography of Kapteyn requires the necessary skills and I did not know if I was up to it. In November/December of 2010, while on a visit to Ken Freeman and Mount Stromlo Observatory finalizing the manuscript for van der Kruit & Freeman (2011), I translated, as a first exercise, the biography Kapteyn's daughter Henriette wrote of her father (Hertzsprung-Kapteyn, 1928). It gave me sufficient confidence to go ahead and I wrote an email from Canberra to Adriaan telling him. Alas, this was a few days before his death and he never read it. I dedicated the academic biography (van der Kruit, 2015) to him and my wife (Fig. 33). The 700-page book was published in the Springer Astrophysics and Space Science Library and intended for a professional, academic audience. After it had been published I was urged to provide a version that would be more accessible to a wider audience (say of the level Scientific American readers). I rewrote the story with

Fig. 32 On the occasion of my formal retirement the Faculty of Mathematics and Natural Sciences had commissioned this painting to be donated to the University of Groningen to be part of the collection of professors that decorates the central Academy Building. The painter is Johannes Kleiker. It was presented after my valedictory lecture in 2009. I am wearing my Royal Decoration that I received on the occasion of the Queen's (Beatrix) birthday in 2006. It is Knight in the Order of the Lion of the Netherlands (for a description of the system of Dutch Royal decorations, see Kanselarij der Nederlandse Orden, 2022). From my private archives.

such an audience in mind. I did this in Dutch because I wanted to reach an as large as possible audience in the Netherlands. It has not been as successful as I had hoped.

The biography of Jan Hendrik Oort (van der Kruit, 2019) resulted from urging by a few of my colleagues and in a sense is a quite natural and logical sequel to the Kapteyn book. It was also followed up by a Dutch version for a wider audience. It attracted a somewhat larger readership. At the request of non-Dutch speaking colleagues, who were interested but found the academic versions far from affordable, I translated the two wider audience books into English for the Springer Biographies series (van er Kruit, 2021a,b). I understand that these more affordable version attract a reasonably large audience. Both biographies are accompanied by dedicated Websites with much information, particularly links to publications, English translations of articles in Dutch and electronic access to almost all archival material.

There are things that have intrigued me while researching for these biographies and on two matters I have written papers that have appeared in this journal. One was a subject I had neglected in the Kapteyn biography and that is the story of his honorary doctors, particularly Karl Schwarzschild and Annie Cannon (van der Kruit, 2021c). The other is the decline in the prominence of the Kapteyn Astronomical Laboratory under Kapteyn's successor Pieter J. van Rhijn. This resulted in an almost one hundred page paper (van der Kruit, 2022b). It served as background to a small bi-lingual book on the occasion of the centenary of Kapteyn's death in June 2022 on the history of the Kapteyn Astronomical Institute (van der Kruit, 2022a). It may be logical to describe next the revival under

Fig. 33 Adriaan Blaauw, myself and my wife Corry during the reception after the one-day symposium 'Challenges' and my valedictory lecture in October 2009. Photograph taken by Elmer Spaargaren.

Blaauw in a biography of him. I have indeed been urged to complete my biographies series that way, but I have not been convinced I am the right person to do that.

11 Concluding remarks

My career as an astronomer, lecturer, administrator and biographer has at all times been full of challenges; I seldom started anything convinced I would be able to bring it to a good end. Challenges are things you accept while being unsure about the outcome. It always came as a surprise to realize at the end that I had pulled it off.

I could have done or be involved in more research projects, or have more PhD students, or be in any function for a longer time. I did not plan my career beforehand, carefully predetermining a perfect balance between these aspects. In many cases I simply pursued things that came my way if I found them challenging, worthwhile and interesting. It would have been great if there had been more hours in a day (as long as there were not fewer days in a life to make up for it). Every aspect has had its moments of déjà vue or routine. That is unavoidable, but I can say without reservation that my professional live has been fulfilling and I enjoyed almost every minute of it. Referring to the title of this paper I can definitely state that it all was exciting and making often transitions between research, teaching, administration and history has been rewarding

I conclude with a story Jan Oort told at an after-dinner speech when he was about my present age: 'A traveler passed through some isolated village and saw an old man sitting in front of his house. 'Have you been here all your life? ', he asked the old man. To which the fellow replied: 'Not yet'.

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individuals takes too much space; I simply thank all who one way of the other, throughout my life, have provided love, friendship, support and encouragement, especially when I took on yet another challenge.

12 References

Allen, R.J., Ekers, R.D, & Terlouw, J.P., 1985. *The Groningen Image Processing System.* In: Data Analysis in Astronomy, Proceedings of the 1st Workshop held in Erice, Italy, 1984. Edited by V. Di Gesù, L. Scarsi, P. Crane, J.H. Friedman, & S. Levialdi. New York: Plenum Press, 271-304.

Baade, W., 1944. *The resolution of Messier 32, NGC 205, and the central region of the Andromeda Nebula.* Astrophysical Journal, 100, 137-146.

Bahcall, J.N. & Soneira, R.M., 1980, *The universe at faint magnitudes. I. Models for the Galaxy and the predicted star counts.* Astrophysical Journal, Supplement Series, 44, 73-110.

Bosma, A. & van der Kruit, P.C., 1979. *The local mass-to-light ratio in spiral galaxies.* Astronomy and Astrophysics, 79, 281-286.

Bottema, R., van der Kruit, P.C. & Freeman, K. C., 1987. *The stellar velocity dispersion in the disk of the spiral galaxy NGC 5170.* Astronomy and Astrophysics, 178, 77-90.

Bottema, R., van der Kruit, P.C. & Valentijn, A.E., 1992. *The stellar velocity dispersion of the edge-on spiral galaxy NGC 891.* Astronomy and Astrophysics, 247, 357-367.

Commissie Vijfde Jaar Bèta Studies, 1997. *Vijf Jaar voor Bèta's: De noodzaak van een vijfjarig curriculum voor de bèta-opleidingen aan de algemene universiteiten.* Rijks-universiteit Groningen, ISBN 90-367-0753-6.

Davidson, M., editor, 1953. *Astronomy for everyman.* Dutton & Co. New York, in 1956 vertaald en bewerkt door H. Hubenet en G. Tieman als *Astronomie voor iedereen*, Thieme, Zutphen.

de Jong, R.S. (editor), 2006. *Island Universes,: Structure and evolution of disk galaxies*, Springer, ISBN 978-9-0481-7398-3.

European Southern Observatory, 2004. *ESO Council Resolution on Scientific Strategy.* www.eso.org/sci/publications/reports/cou-991rev.pdf.

Gilmore, G., King, I.R. & van der Kruit, P.C., 1990. *The Milky Way as a galaxy.* 19th Saas-fee course, Mill Valley, University Science Books, ISBN 0-935702-62-8, per individual chapter available on ADS. I collected the full set at www.astro.rug.nl/∼vdkruit/jea3/homepage/MWGal.pdf.

Gingerich, O, 2004. *The book nobody read: Chasing the revolutions of Nicolaus Copernicus.* Walker & Co, ISBN 978-0-8027-1415-2.

Harrison, E.R., 1974. *Why the sky is dark at night.* Physics Today, 27, 30-36.

Herschel, W., 1785, *On the construction of the heavens.* Philosophical Transactions of the Royal Society of London, 75, 213-266.

Hertzsprung-Kapteyn, H., 1928. *J.C. Kapteyn; Zijn leven en werken.* Groningen, Wolters (electronic version available at www.dbnl.org/tekst/hert042jcka01_01/; for more information and my English translation see www.astro.rug.nl/JCKapteyn/HHKbiog.html).

Hewish, A., Bell, S. J. , Scott, P. F. & Collins, R. A., 1968. *Observation of a rapidly pulsating radio source.* Nature, 217, 709-713.

Kanselarij der Nederlandse Orden, 2022. *Decorations and honours.* www.royalhonoursanddecorations.nl/decorations-and-honours.

Koestner, A., 1959. *The sleepwalkers: A history of man's changing vision of the Universe.* Hutchinson (UK), MacMillan (USA). Reprinted by Penguin Books, 1980, ISBN 978-0-1401-9246-9.

Kormendy, J., 1973. *Calibration of direct photographs using brightness profiles of field stars.* Astronomical Journal, 78, 255-262.

Mathewson, D.S., van der Kruit, P.C. & Brouw, W.N., 1972. *A high resolution radio continuum survey of M51 and NGC 5195 at 1415 MHz.* Astronomy and Astrophysics, 17, 468-486.

Miley, G.K., Perola, G.C., van der Kruit. P.C. & van der Laan, H., 1972. *Active galaxies with radio trails in clusters.* Nature, 237, 269-272.

Oort, J.H., 1927. *Observational evidence confirming Lindblad's hypothesis of a rotation of the Galactic System.* Bulletin of the Astronomical Institutes of the Netherlands, 3, 275–282.

Oort. J.H., 1932. *The force exerted by the stellar system in the direction perpendicular to the Galactic plane and some related problems.* Bulletin of the Astronomical Institutes of the Netherlands, 6, 249–287.

Oort, J.H., 1938. *Absorption and density distribution in the Galactic System.* Bulletin of the Astronomical Institutes of the Netherlands, 8, 233–264.

Oort, J.H., 1940. *Some problems concerning the structure and dynamics of the Galactic System and the elliptical nebulae NGC3115 and 4494.* Astrophysical Journal, 91, 273–306.

Oort, J.H. 1950, *The structure of the cloud of comets surrounding the Solar System and a hypothesis concerning its origin.* Bulletin of the Astronomical Institutes of the Netherlands, 11, 91–110.

Oort, J.H., 1971. *Absence of radio emission from Maffei I.* Nature, 230, 103–105.

Sancisi, R. & Allen, R.J., 1979. *Neutral hydrogen observations of the edge-on disk galaxy NGC 891.* Astronomy and Astrophysics, 74, 73-84.

Schweizer, F., 1976. *Photometric studies of spiral structure. I. The disks and arms of six SbI and ScI galaxies.* Astrophysical Journal Supplement Series, 31, 313-332.

Shostak, G.S. & van der Kruit, 1986. *Studies of nearly face-on spiral galaxies. II. HI synthesis observations and optical surface photometry of NGC 628.* Astronomy and Astrophysics, 132, 20-32.

Toomre, A., 1964. *On the gravitational stability of a disk of stars.* Astrophysical Journal, 139, 1217-1238.

van Berkel, K., 2000, *Growing astronomers for export: Dutch astronomers in the United States before World War II.* in van der Kruit & van Berkel (2000), 151-174.

van der Kruit, P.C., 1970. *Evidence for a possible expulsion of gas from the Galactic nucleus.* Astronomy and Astrophysics, 4, 462-481.

van der Kruit, P.C., 1971a. *Attempt to explain the motions of the gas in the central region of the Galaxy by explosive events in its nucleus.* Astronomy and Astrophysics, 13, 405-425.

van der Kruit, P.C., 1971b, *Observations of core sources in Seyfert and normal galaxies with the Westerbork Synthesis Radio Telescope at 1415 MHz.* Astronomy and Astrophysics, 15, 110-122.

van der Kruit, P.C., 1974a. *The motions in the central region of NGC 4736: Evidence for an expanding ring.* Astrophysical Journal, 188, 3-17.

van der Kruit, P.C., 1974b. *The velocity field of NGC 4258.* Astrophysical Journal, 192, 1-19.

van der Kruit, P.C., 1976a. *The peculiar spiral galaxy NGC 3310: II. The velocity field of the ionized gas.* Astronomy and Astrophysics, 49, 161-171.

van der Kruit, P.C., 1976b. *The velocity field in the inner part of NGC 4736.* Astronomy and Astrophysics, 52, 85-92.

van der Kruit, P.C., 1979. *Optical surface photometry of eight spiral galaxies studied in Westerbork.* Astronomy and Astrophysics Supplement Series, 38, 15-38.

van der Kruit, P.C., 1981. *The thickness of the hydrogen layer and the three-dimensional mass distribution in NGC 891.* Astronomy and Astrophysics, 99, 298-304.

van der Kruit, P.C., 1986 *Surface photometry of edge-on spiral galaxies: V. The distribution of luminosity in the disk of the Galaxy derived from the Pioneer 10 background experiment.* Astronomy and Astrophysics, 157, 230-244.

van der Kruit, P.C., 2006. *Five-and-a-half years in ESO Council.* www.astro.rug.nl/∼vdkruit/President.html.

van der Kruit, P.C., 2009. *It all started with Kapteyn.* www.astro.rug.nl/∼vdkruit/jea3/homepage/address65.pdf.

van der Kruit, P.C., 2015. *Jacobus Cornelius Kapteyn: Born investigator of the Heavens.* Springer, ISBN 978-3-319-10875-9, accompanying Webpage www.astro.rug.nl/JCKapteyn.

van der Kruit, P.C., 2019. *Jan Hendrik Oort: Master of the Galactic System,*. Springer, ISBN 978-3-319-10875-9, accompanying Webpage www.astro.rug.nl/JHOort.

van der Kruit, P.C., 2021a. *Pioneer of Galactic Astronomy: A biography of Jacobus Cornelius Kapteyn*. Springer Publishers. ISBN 978-3-030-55422-4.

van der Kruit, P.C., 2021b. *Master of Galactic Astronomy: A biography of Jan Hendrik Oort*, Springer, ISBN 978-3-030-55547-4.

van der Kruit, P.C., 2021c. *Karl Schwarzschild, Annie J. Cannon and Cornelis Easton: PhDs Honoris Causa of Jacobus C. Kapteyn*. Journal for Astronomical History and Heritage, 24, 521–543.

van der Kruit, P.C., 2022a. *J.C. Kapteyn and his Astronomical Laboratory a century later*, Kapteyn Astronomical Institute, ISBN 978-90-903-6008-9, www.astro.rug.nl/∼vdkruit/JCK100.pdf.

van der Kruit, P.C., 2022b. *Pieter Johannes van Rhijn, Kapteyn's Astronomical Laboratory and the Plan of Selected Areas*. Journal of Astronomical History and Heritage, 25, 341-438.

van der Kruit, P.C. & Freeman, K.C., 1986. *Stellar kinematics and the stability of disks in spiral galaxies*. Astrophysical Journal, 303, 556-572.

van der Kruit, P.C. & Freeman, K.C., 2011. *Galaxy disks*. Annual Review of Astronomy and Astrophysics, 49, 301-371.

van der Kruit, P.C. & Gilmore, G., 1994. *Stellar Populations*. Proceedings of the 164th Symposium of the International Astronomical Union, Dordrecht, Kluwer, ISBN 978-94-011-0125-7.

van der Kruit, P.C., Mathewson, D.S. & Oort, J.H., 1972. *The radio emission of NGC 4258 and the possible origin of spiral structure*. Astronomy and Astrophysics, 21, 169-184.

van der Kruit, P.C. & Searle, L., 1981a. *Surface photometry of edge-on spiral galaxies. I - A model for the three-dimensional distribution of light in galactic disks*. Astronomy and Astrophysics, 95, 105-115.

van der Kruit, P.C. & Searle, L., 1981b. *Surface photometry of edge-on spiral galaxies. II - The distribution of light and colour in the disk and spheroid of NGC 891*. Astronomy and Astrophysics, 95, 116-126.

van der Kruit, P.C. & Searle, L., 1982a. *Surface photometry of edge-on spiral galaxies. III - Properties of the three-dimensional distribution of light and mass in disks of spiral galaxies*. Astronomy and Astrophysics,110, 61-78

van der Kruit, P.C. & Searle, L., 1982b. *Surface photometry of edge-on spiral galaxies. IV - The distribution of light, colour, and mass in the disk and spheroid of NGC 7814*. Astronomy and Astrophysics, 110, 79-94.

van der Kruit, P.C. & Shostak, G.S., 1984. *Studies of nearly face-on spiral galaxies. III. HI synthesis observations of NGC 1058 and the mass distribution in galactic disks*. Astronomy and Astrophysics, 134, 258-267.

van der Kruit, P.C. & van Berkel, K., 2000. *The Legacy of J.C. Kapteyn: Studies on Kapteyn and the development of modern Astronomy*, Dordrecht, Kluwer, ISBN 978-94-010-9864-9.

van Houten, C.J., 1961. *Surface photometry of extragalactic nebulae*. Bulletin of the Astronomical Institutes of the Netherlands, 16, 1-69.

Wevers, B.M.H.R., van der Kruit, P.C. & Allen, R.J., 1986. *The Palomar-Westerbork survey of northern spiral galaxies*. Astronomy and Astrophysics, Suppl. Ser., 66, 505-662.

Unsöld, A., 1969. *Introduction: A fifty years retrospect*. In: 'The elements and their isotopes in the universe', 7-21.