Autobiography Maarten Schmidt

I was born in December 1929 in Groningen, The Netherlands. My parents were both from Berkhout, near Hoorn. They had known each other for many years when they were married in 1922. Father was a government accountant who eventually ended up heading the countries' accountants in The Hague. He died in 1977. Mother eventually moved to Roden near Groningen and died in 1991 at the age of 90. My brother Cees is retired after an academic career specializing in Middle Age Dutch.

We lived in Groningen till 1948. This included World War II, during which Holland was under German occupation for 5 years. The low flying Messerschmitts on May 10, 1940 heralded the beginning of years of fear and persecution. Our immediate family was lucky enough to escape the most serious consequences. Father experienced that accountants soon came under increasing pressure to work in Germany; some were eventually forced to go. Gradually a national underground resistance developed, which would attack German targets, leading to the execution of notables of the community in retaliation. Around 1943 all men of age 18-45 yrs were required to work, often digging defense ditches. Large numbers of men went undergound, or tried to get a medical exemption. Father and Cees eventually got the exemption, but not until after Cees was detained for falsifying one.

All during the war, a strict black-out was enforced. This made it possible to see the night sky even in the middle of a city. My father would often take me on a walk at night, unless there was an air alarm when Allied bombers would fly over, or sometimes bombard, the city of Groningen. These walks may well have played a role in awakening my interest in astronomy. This interest took a quantum jump when I visited my uncle Dik Schmidt in Bussum in the summer of 1942. He was an active amateur astronomer who observed occultations of stars by the Moon. He showed me the sky through his telescope on an upper floor of his pharmacy. I found a lens at my paternal grandfather's workshop in Berkhout and soon put my first little telescope together. To find out what I could see in the sky, I read many popular books on astronomy, including Flammarion's.

In late summer 1944 Allied troops had advanced into the southern part of Holland and expectations were high for a fast liberation of the country. The failed attempt by Montgomery to secure the bridge accross the Rhine in Arnhem brought the advance to an abrupt halt. In retaliation for a strike by railroad workers in support of Montgomery's battle, the Germans dismantled the entire railroad sys-

tem in Holland and sent the iron to Germany for the war effort. A shortage of food had already developed and with the lack of transport it became critical in the W. part of Holland. A famine resulted that took tens of thousands of lives.

In the E. part of the country, we managed to survive. While no bread, butter, meat, tires, fuel, etc. was available in the stores, curiously some materials could still be found. This allowed me and Jan Borgman to polish some mirrors for use in a telescope. We also visited the local observatory and met the young astronomer Adriaan Blaauw, who eventually became one of my dearest colleagues.

Finally, on April 13, 1945 Canadian troops had advanced to the S. side of Groningen signaling a battle that lasted several days. On the second day, we found ourselves in no-mans' land between the Canadians and the Germans, and directly in the firing line of the Germans. We spent much of the night on the kitchen floor in the back of the house - looking through the window we could see the sky, blood red as the center of Groningen was on fire. The liberation the next day was an unforgettable event. It took several more weeks for the war to end. Even before the German surrender, Swedish aircraft flew over W. Holland dropping large amounts of food on football fields.

I went back to high school in the summer of 1945, in order to catch up on more than a year of missed school attendance. In 1946, I entered Groningen University to study physics, mathematics and astronomy. Lucas Plaut was kind enough to let me help with observations he was doing at the Kapteyn Laboratory, next to the university building. Curiously, the observer was enabled to turn off certain rooftop advertisements - it required us to get on our bicycles to find the switch at the offending building. In the spring of 1949, at the annual conference attended by all astronomers and students in the country, Professor Jan Oort offered me the position of assistant at Leiden Observatory upon my graduation.

After a short stint at Leiden working for Professor Oosterhoff on the light curve of a variable star, I was called into military service. Holland was conducting a 'police action' against the Dutch East Indies, and it was expected that I would be sent out at the end of basic training. As luck would have it, the police action ended and Indonesia became independent. Not only that, but I was also one of about a dozen recruits who got no assignment after basic training. For several weeks I wrote weekend railroad tickets for my fellow soldiers, until we were granted a release after about two months.

When I returned to Leiden, I found that my assistantship had gone but I was happy enough to be back. Prof. Oort asked me to study the brightness behavior

of comets. He had just launched his theory that there existed a cloud of comets around the solar system reaching halfway to the nearest stars, now called the Oort cloud. I did a literature study of the brightness of comets, particularly at the largest observable distance from the sun as well at perihelium. I found that "new" comets that came in from the outer parts of the cloud showed a much slower increase in luminosity as they approached the sun than "old" comets that had been near the sun in the past. While this was going on, I was asked by Prof. Oort whether I was willing to go to Kenya to take part in the Leiden expedition.

The expedition was located on Timboroa Hill at 9600 ft. in the W. part of Kenya. It was designed to measure declinations of stars all over the sky from a location on the Earth' equator. The leader was G. van Herk, who was assisted by a lieutenant of the Dutch Navy. Since his three-year assignment was expiring, I was asked to replace him. I arrived by ship in Mombasa in early September 1950, and was met by Van Herk and his wife in Nairobi. It was truly an extraordinary change of life. The observatory was near the main road from Nakuru to Eldoret. The road deck was composed of red clay that would become very slippery in rainy weather - I became very adept at installing tire chains, often under trying conditions. The region was lightly populated, with farms some 5 or more miles apart.

Van Herk and I shared the observational work, each taking a half night. The program consisted of azimuth measurements alternatively of a rising star above the eastern horizon and a setting star in the west. The housing of the small telescope was pushed aside at night, so the observer was entirely in the open. Only a weak fence separated us from the savanna. When walking under a tree in these fields, we would check them for leopards. The scariest experience I had while observing, was when one night I heard the sound of something galloping toward me. I checked with a flashlight but found nothing. I did lose a couple of stars in the observations that night. The most moving experience occurred when on Christmas night I heard a number of Kikuyus singing carrols in the distance. Suddenly they were around me and started singing. It took me a while to find a gap in my program, and I could talk to them, in Swahili, and give them their reward.

The expedition was to end in November 1951. Our access road from the main highway had a number of steep parts where the wet weather caused much erosion. I spent a couple of weeks with the staff of Kikuyus hauling rocks to fortify the road, to ensure we would be able to get out. It worked and we loaded all our equipment in a railroad car at Timboroa station. I left early November and traveled via Kampala, Kigoma, Lake Tanganyika, Albertville, 5 days up the

Congo to Elizabethville. From there by train to Victoria Falls, Johannesburg, Pretoria, Cape Town, to London by boat, to arrive back in Holland on December 15.

After such an adventurous year, I had to get used to the routine of taking classes, living at sea level and adjusting to the Dutch climate. In terms of research, I became involved in observations with the 21 cm line of neutral hydrogen. It had been predicted by Hendrik van de Hulst at an "underwater" (in hiding) colloquium in 1944, and discovered at Harvard, Holland and Australia in 1951. Using the 21 cm line had the enormous advantage that it was not affected by absorption in dust clouds in the plane of the Milky Way galaxy. The line also allowed very accurate radial velocities to be measured. After an initial exploration of the line by Oort and Van de Hulst, Gart Westerhout and I were given the task of surveying the Northern part of our Galaxy, Gart doing the part outside the solar circle, and I taking the inside part.

The observations were carried out with a German Wurzburg radar mirror at Radio Kootwijk. To stay fixed on a particular field, the telescope had to be moved each 2.5 minutes both horizontally and vertically, by hand. This was done in the cabin which moved with the telescope and contained the radio receivers and recording equipment. These observations were mostly done in 1953-54. It took an enormous effort to reduce the observations and to interpret the results. I remember well when it was time to plot the results on a map of the Galaxy. I had derived distances and densities of hydrogen at 808 locations. It was a hot summer night, late with all the windows open, when I had finished writing the density at each location on the map, allowing me to draw isodensity contours. And here it came, the first plot showing the spiral structure in the inner parts of our Galaxy. To be the first one to see it was momentous, an experience that I was to have once more later in my career.

I was living at Leiden Observatory at Sterrewacht 2, together with Westerhout, Kwee-Kiem King and Huug van Woerden. In 1954, at an Observatory party organized by the ladies of the Observatory, I met Corrie Tom who was a kindergarten teacher at the Haanstra school. We were married in September 1955.

The 21 cm observations allowed a direct observation of the rotation curve of our Galaxy. I soon started to construct models of the mass distribution that could produce the rotation curve. Prof. Oort who had been a pioneer in this field was my thesis adviser. I had the office opposite his in the Oort house, allowing me easy access. Discussions with Oort were characterized by long silences while he was thinking; the outcome was always inspiring. The Ph.D. exam in early 1956

was very formal, in white tie, with a small invited audience. Part of the exam was about a dozen propositions, all outside the field of astronomy. One of them was about homing pigeons, another one about the need to grant the right of way to traffic on a roundabout. Following the ceremony-ending *hora est*, the exam committee stayed out a long time; curious, since granting the Ph.D. at this stage was a mere formality. Oosterhoff told me later that Oort had tried to award me a *cum laude*. The university had stopped that when Lorentz, who had not been awarded one, had gotten the Nobel Prize. I did not get it, but Lo Woltjer did one or two years later.

Prof. Oort wrote Walter Baade at the Mount Wilson Observatory about my work and I was offered a Carnegie Fellowship. In May 1956 we traveled by boat to New York City, where we stayed with John Seeger, a brother of Pete Seeger, in Manhattan. We drove across the U.S. visiting many observatories, including Harvard and Yerkes, where I gave colloquia. Soon after our arrival in Pasadena I started to observe at the Mt. Wilson 60-inch and 100-inch telescopes. I worked on the color-magnitude diagrams of star clusters, a field in which Allan Sandage had done pioneering work. This work gave me invaluable experience in the practical aspects of observing.

In a discussion with Sydney van den Berg at Leiden, he had inquired about gas density results from 21 cm work, wondering how long it would take star formation to exhaust the local supply of gas. I followed up on this in Pasadena and published scenarios in which I made an assumption how the rate of star formation would depend on the gas density. Forty years later it became clear that the assumed dependence is universally observed. The paper is now my second most cited work.

Upon returning to Leiden in 1958, I found myself in a rather low-level position at the Observatory. We now had two daughters, Elizabeth (Els) and Marijke, and in the tight market of post-war housing had to pay a high rent. Rudolph Minkowski inquired at the end of 1958 whether I was interested in returning. Soon, Jesse Greenstein made me an offer of a professorship at Caltech. Getting a waiver from U.S. legislation that imposed a waiting time of two years following my fellowship, took almost a year.

We emigrated in October 1959. While we crossed the Atlantic in a DC-7 at night, I remember how remarkable it was: giving up a position in the Dutch civil service for ten years with tenure, for one based on a letter from the President of Caltech. Needless to say, it worked out well. I started teaching classes, we bought a house and Anne was born within a year.

In 1961, I started my first observational work with the Palomar 200-inch telescope. My work on star formation had shown how the abundance of heavy elements would increase with cosmic time, but the situation with helium was unclear. My observations at various locations in the Andromeda galaxy showed no evidence of differences of the helium abundance. Gradually my interest started to turn to radio sources. Tom Matthews had been observing radio sources at Owens Valley to derive accurate positions for optical identification. Minkowski had been following up with optical spectroscopy to confirm and to obtain the redshift. Just before his retirement, he had found a record redshift of 0.46 for the source 3C 295. I took over his role and eventually published spectra and redshifts for some 30 radio galaxies.

Quite separately from this work, there had been a remarkable development in 1960. Allan Sandage and Matthews had identified the source 3C 48 as a star, rather than a galaxy. The star showed emission lines that could not be identified and showed light variations over months. Among the radio sources that Tom supplied me with in 1962, several were star-like in appearance but the optical spectra showed few or no emission lines. This situation persisted till the strong radio source 3C 273 took the stage. It had been occulted by the Moon several times and Cyril Hazard et al. had obtained very accurate positions in Australia. Matthews gave me their results in late 1962. The identification was a 13th mag star and a very faint jet-like feature. Convinced that the bright star could not be the radio source, I obtained its spectrum in December 1962. The spectra showed a number of broad emission lines.

Several weeks later, while writing an article for Nature about the object, I realized that four of the six emission lines showed a regular pattern of spacing and intensity. Soon I realized that it was the Balmer spectrum of hydrogen, redshifted by 16 percent. The same day Greenstein and I found that 3C 48 had a redshift of 37%. It was a totally unexpected development. How could a star exhibit a big redshift? It could be a cosmological redshift like that of galaxies, but that would make its luminosity a hundred times larger than the typical galaxy. Alternatively, the redshift could be gravitational but that was soon rejected on spectroscopic grounds. We adopted the cosmological redshift, fully aware that the light variation in 3C 48 required that the object have a diameter of less than a light year. This coupled with the extraordinary luminosity posed a major problem of interpretation for these quasars, that was only resolved in 1969 when Donald Lynden-Bell proposed that they were massive accreting black holes.

Within a year, Matthews and I had found a quasar with redshift 0.55, surpassing Minkowski's record. In 1965 I published five larger redshifts, including 3C 9 at

a redshift of 2.0. This opened up the possibility of exploring the history of the universe over the last 10 billion years. My observational work then concentrated on collecting well defined samples of quasars. In 1968 it was possible to show that the number of quasars steeply increased toward earlier cosmic times by a factor of around 100 at redshift 2.

Sandage showed in 1965 that objects with little or no radio radiation also could show the quasar phenomenon. My thesis student Richard Green set out to survey much of the N. sky for bright optical quasars. The resulting Palomar Green survey contained many exotic rare objects, and over 100 quasars. Eventually we used the PG and other surveys to show that the density evolution with redshift was dependent on the quasars' luminosity.

I was offered a number of directorships throughout my career. An interesting case was the directorship of Greenwich Observatory which became vacant in 1970. Traditionally, the director of Greenwich also carried the title of Astronomer Royal. There was a long interruption in the negotiations after which I was told that according to the Act of Settlement of 1701 a foreigner could not hold any office or place of trust from the Crown. It was ironic that after 270 years, an act of Parliament aimed at limiting the power of my countryman William III had a direct effect on me, too. Within months the Prime Minister's office announced that the title and the directorship were to be separated.

I became Chairman of the Division of Physics, Mathematics and Astronomy at Caltech in 1975. I was appointed as Director of the Hale Observatories in 1978. It was a cooperative venture between Carnegie and Caltech, with observatories at Mt. Wilson, Palomar and Las Campanas in Chile. It was a demanding position that took all my time and energy. The cooperation in allocating and assigning time on the many telescopes to the members of the staff worked well. There was, however, considerable friction between Carnegie and Caltech in planning for joint housing in Pasadena and in the appointment of members to the joint staff. This led me to propose in November 1979 that the two institutions run their astronomical facilities separately. The reactions to this proposal were very mixed. Half a year later it was adopted by the two administrations and I returned to academic life.

Soon I became involved in a collaboration with Jim Gunn and Don Schneider to find quasars using Gunn's multiple CCD camera. Initially we searched in individual fields but then used a transit method where the daily motion of the telescope was stopped and the sky recorded as it passed by. After some ten years of work we were able to show that the density evolution of quasars peaked at a

redshift of around 2.5 and then declined to at least a redshift of 4.

From 1986 I was involved in a collaboration with Günther Hasinger, Joachim Trümper and Riccardo Giacconi based on a X-ray survey with the *ROSAT* satellite launched in 1990. It eventually produced a well defined sample of quasars based on their X-ray fluxes. In an extensive investigation of all X-ray surveys available, we conluded that the luminous ones had a density evolution much like those of optical quasars, peaking at a redshift around 3. In contrast, quasars of lower luminosity peak at redshifts as low as 1. Thus it appears that the most massive black holes in the universe tend to form early, around 3 billion years after the Big Bang, and those of lower mass some 4 billion years later.

Since 1990 I have been working on gamma-ray bursts, based on observations with the *Compton GRO* satellite. Using the raw data, I constructed the GUSBAD catalog of gamma-ray bursts independently of other catalogs. The catalog gives complete data for every object listed and is suitable for statistical work, like deriving the luminosity function and density evolution of these objects.

In the summer of 2005, our family came out to Hawaii to celebrate our 50th anniversary. Our good friend Erik Hazelhoff Roelfzema (a.k.a. Soldier of Orange) gave the traditional Dutch speech for that occasion. At the urging of the children, we all went to Holland in 2007 to visit the places where Corrie and I had grown up, and where we had met and were married. We were able to visit our house in Groningen and my grandfather's farm in Berkhout.

Then, unexpectedly, in 2008 we traveled again, to Oslo. When my award of the Kavli Prize in Astrophysics was announced, I soon was under relentless pressure from every member of the family. So Els and Rick Evans, Marijke and Dave Kuhns, Anne, our grandchildren Andrew and Alyssa, Andrew's fiancee Katrina, and my brother Cees and Mien all joined us in attending the award ceremonies and banquet in Oslo, an unforgettable experience for all of us.