IT ALL STARTED WITH KAPTEYN

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Address at the mini-symposium 'CHALLENGES'
(www.astro.rug.nl/∼vdkruit/Challenges.html)
on October 12, 2009
on the occasion of his 65-th birthday and formal retirement.

[with a few notes added in 2020]

University of Groningen

Fig. 1: *The painting of J.C. Kapteyn by Jan Veth (1918) that resides in the Kapteyn Room at the Kapteyn Astronomical Institute in the Zernike Building.*

Meneer de Rector Magnificus, waarde toehoorders, dames en heren,

Today's fascinating presentations have been entirely in English; not surprisingly, as English is the *lingua franca* of science in general and of astronomy in particular. This has not always been so; in fact, Jacobus C. Kapteyn has been one of the first to develop this Anglo-Saxon orientation and I will come back to this below in some more detail. As you hopefully will see, there is much more that started with Kapteyn.

Although I am starting this address in English, I will actually use Dutch for some parts of it. After all, that has been the practice of my daily work: research was conducted almost all the time in English, teaching mostly in Dutch but when necessary in English and for management and administration it depended on whether it concerned local or national matters or was in an international context. I will adapt the language I use along roughly the same lines.

Dit is geen afscheidscollege; het is geen afscheid en het is ook geen college. En u hoeft ook geen tentamen te doen. Vroeger waren er aan de Rijks-universiteit Groningen afscheidscolleges op de dinsdag met de scheidende professor in toga. Dat dit in die vorm is afgeschaft, zal wel te maken hebben met het feit, dat de dinsdagmiddagen ook worden gebruikt voor oraties en alleen daardoor al waren overschreven. Ik heb even overwogen u in toga toe te spreken (en de rector had mij daar al schoorvoetend toestemming voor gegeven), maar ik heb besloten dat toch maar niet te doen. Toch heeft een formeel afscheidscollege of -rede wel wat. Ik was een paar weken geleden nog bij een afscheidsrede aan de Universiteit van Amsterdam, waar hoogleraren, ook van elders, een cortège vormen gekleed in de toga van hun universiteit. De scheidende hoogleraar was Karel Gaemers, jaargenoot van mij in Leiden. Alhoewel Karel natuurkunde studeerde (en ik sterrenkunde) volgden wij met name in het eerste jaar dezelfde colleges, werkcolleges en practica en bovendien waren wij beiden spoorstudenten; hij uit Den Haag en ik uit Schiedam. Zo'n cortège met hoogleraren in toga had van mij vandaag ook best wel gemogen, alhoewel we misschien de term 'afscheid' in afscheidsrede zouden moeten vervangen door iets anders.

Als het geen afscheidscollege is, wat is het dan wel? Ik zie het als een rede, waarbij de universiteit mij de mogelijkheid biedt om de overgang van hoogleraar in bezoldigde aanstelling bij het bereiken van de pensioengerechtigde leeftijd naar onbezoldigd dienstverband te markeren. Ik ben zeer vereerd dat dit de vorm heeft gekregen van een benoeming als *hoogleraar honorair*. Dat ik daarbij de vernoemde Jacobus C. Kapteyn leerstoel in de sterrenkunde mag blijven bezetten is nog meer een eer en Kapteyn (zie Figs. 1 en 3) zal dan ook een prominente rol spelen in deze voordracht.

So, what will I discuss today? I will not give some grand display of thoughts and advice on the future of astronomy, scientific research policy, university education, academic life in a broader sense or international coordination. For sure, I have been involved in all those matters, but I will not use this opportunity to bore you with my preferences and prejudices. Instead, I will first give you some background on the remark that I made above that *'it all started with Kapteyn'*. This statement comes from the Dutch-American astronomer Bart J. Bok, a Ph.D. student of Pieter van Rhijn,

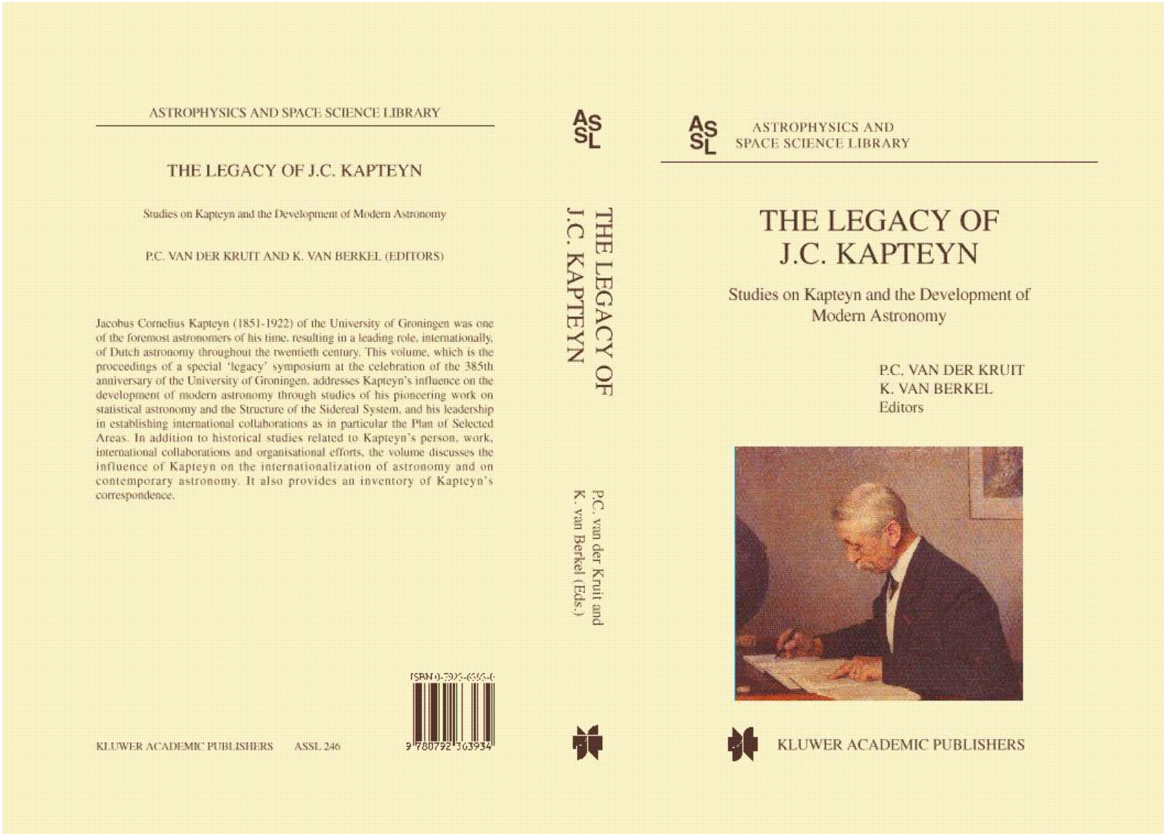

Fig. 2: *The cover of the proceedings of the 1999 'Legacy Symposium' about Kapteyn.*

Kapteyn's successor at Groningen. To be precise, Bok said: *'So the rise of Dutch astronomy was entirely Kapteyn, and pupils inspired* [by him].'[1] I feel –as Kapteyn professor of astronomy– that it is appropriate that I explain for those of you who may not be fully aware of it, what the accomplishments and significance of this remarkable scientist are. In the second part I will explain with a few examples why I found my academic career challenging and exciting. I will do this with an audience of non-astronomers in mind.

I feel urged to spend some of my time this afternoon on Kapteyn for more than one reason. I did and do work at, and was for more than ten years director of, the Kapteyn Astronomical Institute. But in particular, as I will come back to later, my research has been in hindsight much among the lines of Kapteyn's. So, when in 2003 the Board of the Faculty of Mathematics and Natural Sciences nominated me together with Serge

[1]The actual statements Bok made in an interview with David DeVorkin in 1978 were: *..in astronomy, I think we all derived from Kapteyn. It all starts with Kapteyn. Oort was Kapteyn's student. I was Oort's student. I was van Rhijn's student; van Rhijn was Kapteyn's. Pannekoek was a great friend of Kapteyn's. So the rise of Dutch astronomy was entirely Kapteyn, and pupils inspired* [by him]. From David DeVorkin's contribution to the *Legacy* volume on Kapteyn (see below).

Daan and Ben Feringa to become the first three named professors of Groningen University and the Governing Board (College van Bestuur) of the University of Groningen appointed us as such, I had no doubt who I would want my distinguished chair to be named after.

1 Jacobus Cornelius Kapteyn (1851–1922)

In 1999, when Groningen University celebrated its 385^{th} anniversary, the College van Bestuur proposed to organise a few so-called 'Legacy' symposia around important scientists that had worked at the University. Historian Klaas van Berkel, who unfortunately is not here today because of a sabbatical leave, proposed Kapteyn as an obvious possibility. I took up that challenge and eventually I ended up spending quite some time on organising the symposium and subsequently on the editing of the proceedings: *'The Legacy of J.C. Kapteyn: Studies on Kapteyn and the Development of Modern Astronomy*[2] (see Fig. 2). This excursion into history as a scientific enterprise was, as a non-historian, a real challenge! In the end we managed to bring together in Groningen most of the leading historians of astronomy and the conference and the book had some very positive reviews.

Kapteyn's first Ph.D. student Willem de Sitter (later director of the Sterrewacht Leiden and well-remembered in the Einstein-de Sitter model for the Universe) and the historian Johan Huizinga had been planning to write a biography of Kapteyn[3]. In the end, the biography was never written. Unfortunately, all of Kapteyn's private papers, except for his important correspondence with David Gill in Capetown, has been lost. It presumably was collected by de Sitter and Huizinga and was apparently being shipped to Indonesia by Aernout de Sitter (Willem's son), who became director of the Lembang Observatory and might have contemplated to work on a biography. It probably was still in Rotterdam harbor when the bombing of May 1940 took place. As part of the Legacy project we found financial support to employ Petra van der Heijden from Leiden, who is conducting research into the history of astronomy, to visit many archives around the world and collect copies of letters Kapteyn wrote and of drafts for letters to him. Adriaan Blaauw has subsequently catalogued and organised all this material. A thorough biography of Kapteyn remains to be be written; some participants at our 1999 meeting actually suggested I do that after my retirement. Maybe I will, possibly not. We do have in any case the biography Kapteyn's daughter Henriëtte wrote not long after his death, the contributions to the Legacy symposium and an archive of his papers that is as complete as possible.

Kapteyn died on June 18, 1922 at the age of 71, a month after the first meeting of the International Astronomical Union (I.A.U.) in Rome [subordinate clause deleted].

[2]P.C. van der Kruit and K. van Berkel (editors): *The Legacy of J.C. Kapteyn: Kapteyn and the Development of Modern Astronomy*, Kluwer, xviii + 382pp., ISBN 0-7923-6393-0 (2000).

[3]They actually asked for input from colleagues in a letter in the Journal *Observatory* in 1925.

Fig. 3: *Left: Photograph of Kapteyn taken at Mount Wilson Observatory in 1908. Right: The painting of J.C. Kapteyn in the Senate Room of Groningen University, presented to him at the occassion of his 70-th birthday.*

The founding president was the French astronomer Benjamin Baillaud, who mentioned in his opening speech what he felt were the three most important developments that in his fifty years of active scientific research had revolutionised astronomy. Even now (almost a century later), two of these readily come to mind, namely the invention of the photographic plate and the construction of giant telescopes, culminating at that time in the enormous 100-inch telescope on Mount Wilson near Los Angeles that had just been opened.[4] The third revolution that Baillaud mentioned was Kapteyn's 'Astronomical Laboratory' at Groningen.[5]

Why astronomical *laboratory*? Well, Kapteyn was appointed at Groningen University in 1878 as a result of a law that stipulated that all three state-funded universities should have a chair in astronomy. But the University and the Government failed to provide him with an observatory, in spite of the many requests he put in and the

[4] A month ago this historic observatory narrowly escaped being wiped out by wildfires. That would have been tragic in the International Year of Astronomy, 400 years after the invention of the telescope.

[5] The original text of this address is not available to me, but I paraphrase this from how it has been reported in Willem de Sitter's obituary of Kapteyn in *Hemel & Dampkring*, vol. 20, pp. 93–111, 1923. [I have since seen the original, and I must say de Sitter has exaggerated it quite a bit when he quoted this.

Fig. 4: *The building of the Astronomical Laboratory 'Kapteyn' in the Broerstraat, slightly to the west of and behind the central university building. The astronomers moved out of it in 1970 and it has been destroyed in a fire in the eighties.*

promises that were given. I quote Klaas van Berkel from our Legacy volume[6]: *'When he started his career around 1875, all Dutch astronomers more or less worked on their own. The observatories in Leiden and Utrecht were involved in a somewhat unpleasant competition, and together they blocked the development of an observatory in Groningen. Kapteyn therefore was almost forced to go abroad and to get elsewhere what he was unable to get in his own country'.* Kapteyn was interested in intrinsic properties of stars and their distributions in space. Thus what he needed for his research was star-counts: the observed distributions of stars on the sky as a function of their apparent brightnesses. David Gill in Capetown had been impressed by the possibilities photographic plates offered to make catalogues of stars. This involved special instruments, enormous amounts of very careful measurements and efforts of (human) computers, but in spite of that Kapteyn offered to turn Gill's photographic survey of the southern skies into the *Cape Photographic Durchmusterung* (by the way, note that such a sensus was known by the German expression *'Durchmusterung'*). This took him 12 years! In this way Kapteyn's *'observatory without a telescope'* (as he described it himself)

[6]Klaas van Berkel, *Growing Astronomers for Export: Dutch Astronomers in the United States before World War II*, pp. 151–174.

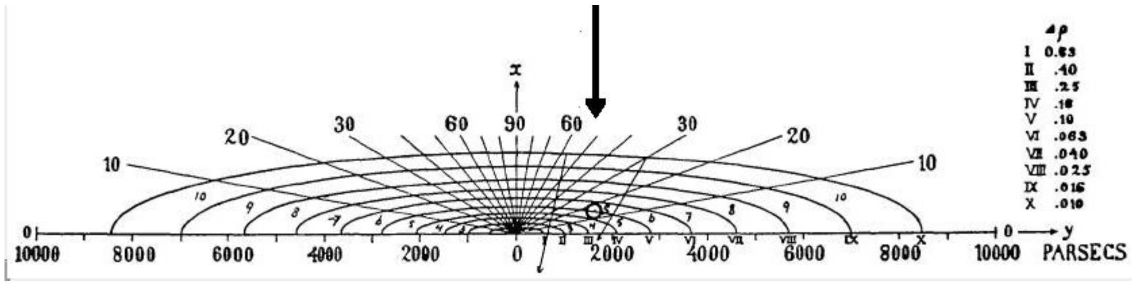

Fig. 5: *Kapteyn's Universe: the model of the distribution of stars in the Sidereal System. In this crosscut lines indicate surfaces of equal space density of stars. Note the position of the Sun (indicated by the arrow), which is only slightly off-center. [In reality it has been drawn a factor of three too far from the center according to what Kapteyn assumed this to be.]*

originated. Kapteyn later became associated with George Ellery Hale of the Mount Wilson Observatory in Pasadena near Los Angeles, that owned the largest telecopes of the time, and he actually for a number of years spend half his time at Mount Wilson. He organised an even more extensive and ambitious worldwide project, the *'Plan of Selected Areas'*, in which all major observatories around the world were recruited to provide photographic, photometric and spectroscopic data, which would, coordinated by Kapteyn and his Laboratory, result in a definitive sensus of representative samples of the stars in the sky. Eventually, Groningen University provided Kapteyn with a building for his laboratory (see Fig. 4)[7], but it took until 1931 until his successor Pieter van Rhijn could start operations of a 55-centimeter telescope on top of this building at the Broerstraat.[8]

Surely, Kapteyn did not just organise astronomy or construct catalogues. His research was original and highly regarded. He mapped the distribution of stars in space, and determined their patterns of motions. All from data obtained elsewhere. In 1904 he found that the system of stars in space consisted of two separate groups with their own collective motions. This became known as Kapteyn's two Star Streams. Later it was found that this effect results from anisotropies in the random motions of the common stars in the solar neighborhood. His statistical work eventually resulted in his *'Kapteyn Universe'*, illustrated in Fig. 5, after he developed all the mathematical and statistical tools necessary to go from observed distributions of stars on the sky at various apparent brightnesses to the statistical distribution of the intrinsic luminosities

[7]Wessel Krul has provided an excellent description of Kapteyn's life in Groningen in the Legacy volume: *Kapteyn and Groningen, A Portrait*, pp. 53–77.

[8]The telescope has been removed in 1959. Between 1965 and 1996 the University operated the Kapteyn Observatory in Roden with a 40-cm telescope. Recently, since 2008, Groningen University again has its own observatory, the *Blaauw Observatory* with the 40cm *Gratama Telescope*, on top of the Bernoulliborgh in the Zernike Complex. This is aimed primarily at outreach and education of the general public. See www.rug.nl/sterrenkunde/sterrenwacht/index.

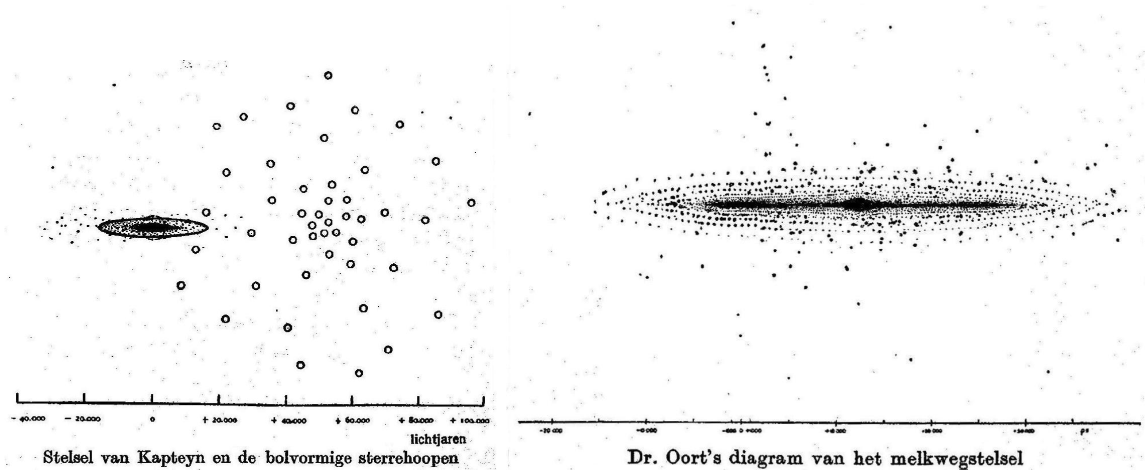

Fig. 6: *Left: Kapteyn's Universe and Shapley's system of globular clusters. Right: Oort's early view of the Milky Way Galaxy. (From de Sitter, 'Kosmos', 1934, van Stockum & Zoon, Den Haag; both figures were credited to 'Dr. Oort'.)*

of stars and their three-dimensional spatial distribution. The Kapteyn Universe was highly flattened with the Sun rather close to the center (see Fig. 5).

Next he used this as a very early example of observational galactic dynamics to estimate the mass density in the solar neighborhood from hydrostatic equilibrium[9]. The way this works, is that one finds for a set of stars the distribution perpendicular to the symmetry plane in space and from that an average *height* above that plane, and from the motions of these stars in space the average vertical *velocity*. In an equilibrium situation these should be related; e.g. if the density is higher the gravitational field is stronger, and for a fixed vertical velocity the mean vertical displacement a star can attain is less, and vice versa. This was an important step towards an understanding of the physical structure of the Universe (or in modern terms the Galaxy) and is a basis for the stellar dynamics that Jan Hendrik Oort developed.

Kapteyn's Universe is remarkably accurate in the vertical direction, but horizontally it is seriously in error, the Sun erroneously being very close to the center. This is a consequence of the neglect by Kapteyn of the effects of obscuring dust between the stars. This dust is concentrated towards the plane of the Milky Way and therefore affects only the horizontal distribution in Fig. 5. Harlow Shapley discovered that the system of so-called Globular Clusters was much more extended than Kapteyn's system. Not long after Kapteyn's death the view of our Galaxy changed dramatically, when it was realized that this was due to Kapteyn's neglect of interstellar absorption. Kapteyn only saw the local part of what we now call the disk of the Galaxy (see Fig. 6). Especially in the U.S. many uninformed and uncritical astronomers have come to associate Kapteyn

[9] *First attempt at a theory of the arrangement and motion of the Sidereal System*, Astrophysical Journal, vol. 55, pp. 302, 1922.

only with his neglect of interstellar absorption and his resulting incorrect description of the Galaxy. I quote Owen Gingerich at the Legacy symposium[10]: *'For American college students studying introductory astronomy, the chances are about even that they will encounter the name of Kapteyn. The distinguished astronomer of Groningen is mentioned in seven of ten recent textbooks that I examined, always associated with the Kapteyn Universe, and invariably as a foil for Shapley's larger and more modern conception of the Milky Way Galaxy.'* This def.initely does not give full justice to Kapteyn's accomplishments.

Actually, Kapteyn has written various papers in the *Astrophysical Journal*, the leading U.S. professional astronomical journal, looking for effects of interstellar absorption. In 1909 he wrote: *'If the absorption and scattering of light by meteoric material is really sensible, then there can be no reasonable doubt but that the violet end of the spectrum must be more strongly affected than the less refrangable rays.'* He predicted (!) what we now call interstellar reddening or selective absorption as the signature for dust in interstellar space, making more distant stars appear redder as well as dimmer as a result. Unfortunately, he could not find convincing evidence for its presence. Formal determinations were positive [but he worried about systematically selecting intrinsically redder stars with increasing diatcance]

As a sideline for my astronomical colleagues I note that another property used almost daily by astronomers also can be traced back to Kapteyn and that is *'absolute magnitude'*. Astronomers designate the apparent brightness of stars on the sky as their 'magnitude'. Of course a star is fainter, if it is intrinsically less luminous or if it is more distant. In his work on the construction of a model of the stars in space, Kapteyn needed their intrinsic luminosity. Now he used as a unit for distance that corresponding to a parallax of 0.1 arcsec. That means that from that distance the radius of the orbit of the Earth around the Sun is seen as an angle of 0.1 arcsec and conversely we see that reflected in the annual motion on the sky of such a star as a result of the Earth's orbit (see Fig. 7). Kapteyn did not use a name for this standard distance, but defined the property absolute magnitude as the magnitude the star would have in the sky if it had a parallax of 0.1 arcsec. When H.H. Turner defined the *'parsec'* in 1913 as the distance for which the parallax is 1 arcsec, Kapteyn's standard distance for the absolute magnitude became 10 parsec. Kapteyn felt, according to a letter to George Ellery Hale, that he should redefine the distance for the absolute magnitude to be the apparent magnitude at a distance of 1 parsec, but his original definition (at 10 parsec) was adopted by the International Astronomical Union during its first meeting in 1922.

I now come back to Kapteyn's Aglo-Saxon orientation and his role in the development of English as the lingua franca of astronomy. The following is mostly taken from the chapter of Klaas van Berkel in the Legacy book[11], who described it much more

[10] O. Gingerich, *Kapteyn, Shapley and their Universes*, pp. 191–212.

[11] Klaas van Berkel, *Growing Astronomers for Export: Dutch Astronomers in the United States before World War II*, pp. 151–174.

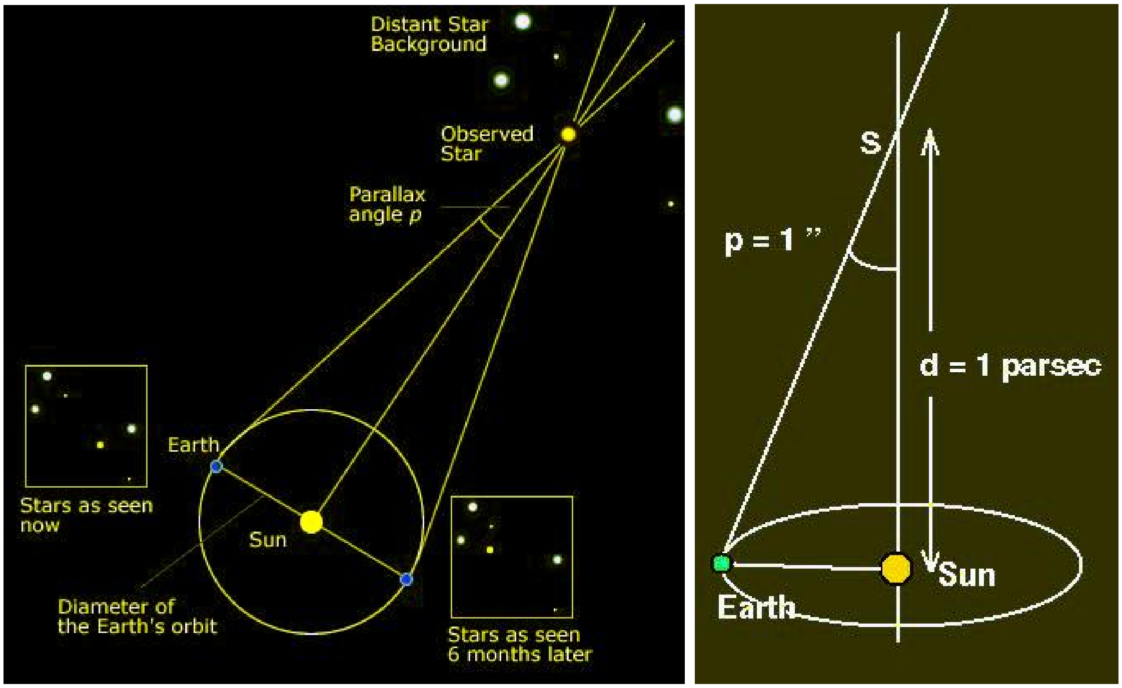

Fig. 7: *The parallax of a star is the semi-major axis of the ellipse that a star traces on the sky as a result of the motion of the Earth around the Sun. When it is 1 arcsec, the distance is said to be 1 parsec (pc), which is a little more than 3 lightyears or* 3×10^{13} *kilometers.*

succinctly than I will ever be able to. I quote: *‘Compared to the attitudes at other institutions in the Netherlands it is remarkable that Kapteyn was so strongly orientated towards the English-speaking world. Both his cooperation with David Gill at Cape Town and with George Ellery Hale at Mount Wilson testify to his Anglo-Saxon orientation. Leiden and Utrecht were much more directed towards the European continent, as was Dutch science in general. In those days, Germany offered the model for the Dutch academic world in almost every respect, from university organization to professional career planning, while French was still considered to be the most important language for international scientific communication. England of course was important too, but the large international congresses all took place on the Continent, where English was a language of secondary importance. The major society in astronomy, the Astronomische Gesellschaft, was German, [...]. American science, with some exceptions, was not considered to be of equal rank. Only after the Louisiana Purchase Exposition and its accompanying congresses were held in 1904 did Europa take full notice of what was going on in the U.S. [...] for the two Dutch representatives at the scientific congress at St. Louis, Kapteyn and the botanist Hugo de Vries, this direct confrontation with American science proved to be crucial in their career. [...] For Kapteyn, [...] the new opportunities offered to his astronomical research proved to be beneficial for Dutch astronomy as a*

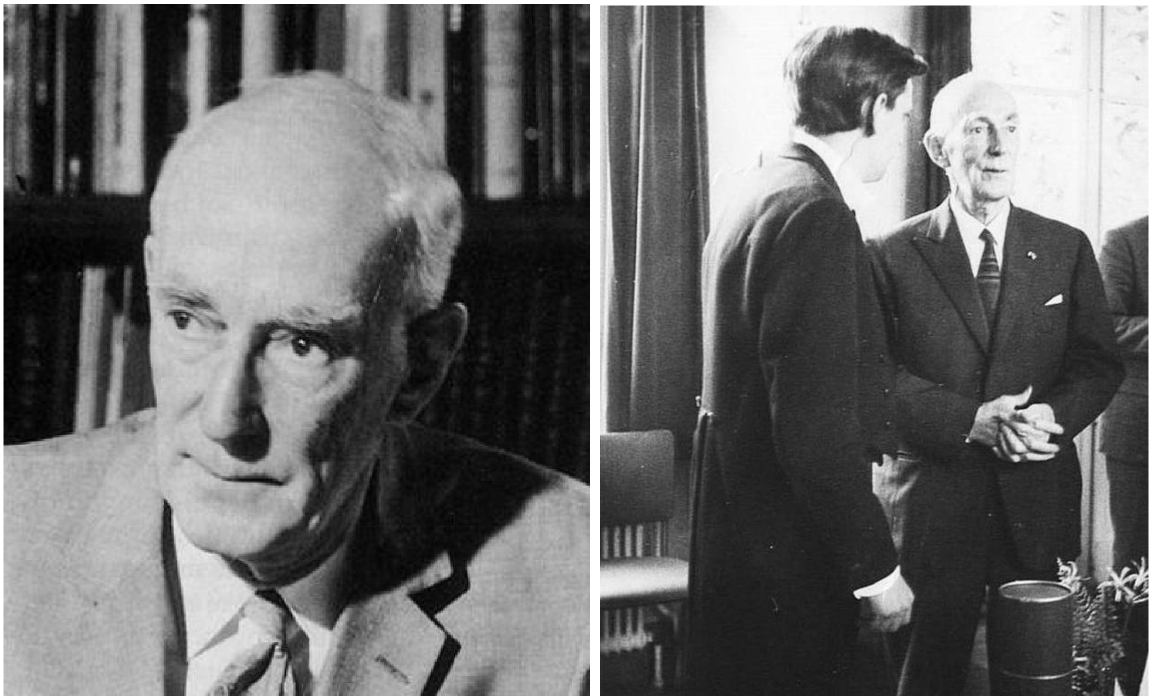

Fig. 8: *Left: Prof. dr. Jan Hendrik Oort (1900 – 1992). Right: Oort and myself after my Ph.D. defense in 1971.*

whole. It was also mainly due to his influence that English quickly became the language in which Dutch astronomers presented their results to an international audience. Part of this program of internationalization was doing research abroad. Kapteyn himself returned to the U.S. each year from 1908 to 1915 as a much honored research associate of Hale at Mount Wilson. But internationalization for Kapteyn also meant sending his students abroad, to Gill in South Africa or to Hale, E.B. Frost and others in the U.S.'

So, is this the basis for the long standing requirement for astronomers in the Netherlands, that it is essential to have some experience at an research institute or university abroad for a career as an academic staff member? No permanent position at a university without a postdoctoral period abroad first. In any case, it started a tradition of young astronomers moving for some time to the New World, often even staying there, described by David DeVorkin as the *'Dutch pipeline'*[12].

My Ph.D. supervisor was Jan Hendrik Oort (see Fig. 8). Oort came to Groningen in 1917 undecided to major in physics or in astronomy, but his choice for Groningen was based on Kapteyn's presence there. He was quickly inspired by Kapteyn to become an astronomer.[13] He regarded himself always as a student of Kapteyn and referred to

[12]In the Legacy volume: David DeVorkin, *Internationalism, Kapteyn and the Dutch Pipeline*, pp. 129–150.

[13]See Oort's article *'Some notes on my life as an astronomer'* in Annual Reviews of Astronomy and

Pieter Corijnus **van der Kruit**: Schiedam, September 18, 1944
Student of J.H. Oort; Ph.D. thesis: *Evidence for past activity in the Galactic nucleus*, University of Leiden, October 6, 1971
I am professor of astronomy at the University of Groningen since 1987 (and Jacobus C. Kapteyn honorary professor since 2003) and I have been director of the Kapteyn Astronomical Institute 1991 - 1994 and 1998 - 2005.

Jan Hendrik **Oort**: Franeker, April 28, 1900 -- Leiden, November 5, 1992
Student of P.J. van Rhijn; Ph.D. thesis: *The stars of high velocity*, University of Groningen, 1 May 1926
Oort was professor of astronomy at the University of Leiden from 1935 to 1970 and director of Leiden Observatory 1946 - 1970. He won the Bruce Medal in 1942. Famous Ph.D. students of Oort are Maarten Schmidt (1956) and Lodewijk Woltjer (1957).

Pieter Johannes **Van Rhijn**: Gouda, March 24, 1886 -- Groningen, May 9, 1960
Student of J.C. Kapteyn; Ph.D. thesis: *Derivation of the change of colour with distance and apparent magnitude together with a new determination of the mean parallaxes of the stars with given magnitude and proper motion*, University of Groningen, July 9, 1915
Van Rhijn was professor of astronomy at the University of Groningen and director of the Astronomical Laboratory "Kapteyn" from 1921 to 1956. Other Ph.D. students of van Rhijn include Bart Bok (1932) and Adriaan Blaauw (1946).

Jacobus Cornelius **Kapteyn**: Barneveld, January 19, 1851 -- Amsterdam, June 18, 1922
Student of C.H.C. Grinwis; Ph.D. thesis: *Onderzoek der trillende platte vliezen* (*Study of vibrating flat membranes*), University of Utrecht, June 24, 1875
Kapteyn was the founder of the Astronomical Laboratory at the University of Groningen, where he was professor of astronomy and theoretical mechanics from 1878 to 1921. He received the Bruce Medal in 1913. Willem de Sitter (1901) was also a student of Kapteyn.

Fig. 9: *The first part of my academic genealogy. Jacobus Kapteyn was the supervisor of the supervisor (Pieter van Rhijn) of my supervisor (Jan Oort). A complete version is available via my homepage at www.astro.rug.nl/∼vdkruit/boomstam.html.*

him in his Ph.D. thesis as *'mijn inspireerenden leermeester'*[14], although Kapteyn had passed away by the time Oort obtained his degree and in fact Pieter van Rhijn was his Ph.D. supervisor. It is well-known that it was Oort who took the next major steps in Galactic astronomy by discovering (with Bertil Lindblad in Sweden) the rotation of the Galaxy around a center that coincided with that of the system of Globular Clusters, and subsequently the application of the basics of stellar dynamics, leading to a theory of the relation between the density in space and the distribution of velocities of the stars. It also led to a more thorough treatment of Kapteyn's analysis of the gravitational force perpendicular to the Galactic plane.

Some time ago my former Ph.D. student Roelof de Jong made his (and my) academic genealogy, Ph.D. supervisor of your supervisor, etc., going back to Johann Samuel König who studied with the Bernoulli's in Basle. I extended this by relaxing the requirement that actually a Ph.D. thesis had to be written or even a formal Ph.D. degree awarded, merely requiring that the person studied extensively with his professor. Such an excercise is facilitated enormously by the availability of the Math-

Astrophysics, vol. 19, pp. 1-5 (1981).

[14] *'My inspiring teacher'*

ematics Genealogy Project (genealogy.math.ndsu.nodak.edu), which actually contains many physicists and chemists. In my extension (see Fig. 9[15] for the first part) it includes von Leibnitz and ends back in time with Philippe Müller, who as a professor at Leipzig early in the seventeenth century, was one of the first supporters of Kepler's description of planetary orbits. Actually, his student Jacob Bartsch worked as an assistent to Kepler and married his daughter. This is interesting and gratifying as I am a great admirer of Johannes Kepler. Of course, this does not really reflect on me personally; after all it applies to all Dutch astronomers that have Kapteyn in their academic genealogy; and that is a fair fraction of the astronomical community in the Netherlands.

As I will discuss below in some more detail, my work on the distributions of stars and their kinematics in stellar disks in external galaxies, has been strongly influenced and is much in the tradition of Kapteyn and Oort. I have been fortunate to be able to contribute also to the coordination in astronomy at a national and international level. Although accomplishments of Kapteyn and Oort in these matters are enormously more far-reaching then mine, my contributions are along similar lines. My evaluation of Kapteyn's attitude is that he would have given more weight to national priorities than local ones, while Oort seems to me to have been the opposite. I for myself rate the joint interests of Dutch astronomy above the local Groningen ones (I think my record as a 'bestuurder' supports this) and I think that in that sense I have in fact been more like Kapteyn than Oort.

2 Challenges

The topic of today's mini-symposium has been 'Challenges' and we have seen many new and exciting opportunities for the near and not-so-near future. I will not add to that any further, but will devote the second half of this address to describing some of the challenges I encountered during my career and I will draw examples from teaching, research and administration. I start with teaching (in Dutch).

2.1 Teaching

Toen ik in 1975 in Groningen begon, werd ik gevraagd het eerstejaars college *'Sterrenkunde I'* te verzorgen. Destijds werd dit naast de sterrenkunde studenten ook nog gevolgd door de meeste studenten met hoofdvakken wiskunde en natuurkunde. Ik heb dat college in een of andere vorm met een paar onderbrekingen gegeven tot het afgelopen academisch jaar, toen het *'Sterren(en melkweg)stelsels'* heette (zie Fig. 10). Volgens het collegerooster heette het 'Sterrenstelsels', maar ik houd niet van die term

[15] Dutch speakers will note that the html-file is called 'boomstam'; this is because usually a stamboom starts with the earliest member and then works towards the present. The 'boomstam' in Fig. 9 is organized the other way around.

en noem die objecten melkwegstelsels. Immers ze bevatten veel meer dan alleen sterren en het interstellair gas en stof en de donkere materie hebben een grote invoed op hun evolutie. Verder kun je geen college over melkwegstelsels geven als je niet eerst de vorming, structuur en evolutie van sterren zelf behandelt.[16] Ik heb het bij elkaar zo'n vijfentwintig keer gegeven. Daarnaast heb ik (soms in een twee-jarige cyclus) zoiets van 15 keer een inleidend college over melkwegstelsels voor gevorderde studenten (met wisselende nadruk op structuur, evolutie of dynamica) gegeven.[17] Ook geef ik de laatste jaren zo'n college in een cursus van een week voor Master studenten aan de universiteit van Porto, Portugal.

Mijn uitdaging in onderwijs is altijd geweest om te laten zien hoe fascinerend wetenschap is. Natuurlijk gaat het in het onderwijs om het bijbrengen van kennis, begrip en vaardigheden. Maar enthousiasmeren is een minstens even belangrijk deel van de opdracht van een docent. Ik ben daar, dacht ik, redelijk ik geslaagd, gezien de over het algemeen positieve beoordelingen en recentelijk een paar keer spontaan applaus na het laatste college. Zoiets doet je goed! Ik heb bij het inleidend college met name getracht te laten zien, dat je met heel fundamentele beschouwingen belangrijk fysisch inzicht kunt krijgen. Voor de niet-astronomen onder u illustreer ik dit hier om te laten zien wat ik hiermee bedoel. Dus toch een beetje college.

Van sterren kunnen we drie dingen relatief eenvoudig meten: de massa, de lichtkracht (totaal uitgestraalde hoeveelheid licht en dus de energieproductie) en de temperatuur aan het oppervlak. Reeds rond 1910 vonden Ejnar Herzsprung[18] en Henry Norris Russell gevonden, dat als je lichtkracht en oppervlakte temperatuur tegen elkaar uitzet de meeste sterren op een band in het diagram liggen (zie Fig. 11, links). Dat heet de Hoofdreeks en die loopt van linksboven naar rechtsonder (de overige sterren zijn late stadia). We weten nu dat al de sterren op die hoofdreeks net als onze Zon energie produceren in hun binnensten door via kernreakties waterstof om te zetten in helium. De band blijkt ook een ordening naar massa te zijn (zie Fig. 11, rechts). Uit beschouwing van de beschikbare waterstof voor de kernfusie en de energie productie kun je uitrekenen dat zware sterren veel korter over deze fase doen dan lichte sterren. Onze zon is middelmatig (en ligt ook halverwege de Hoofdreeks) en blijft daar van de orde van 10 miljard jaar (waarvan dan bijna de helft inmiddels is verstreken). Sterren linksboven zijn zwaarder, heter en helderder. Bijvoorbeeld een ster tien keer zo zwaar als de zon is ongeveer drie keer zo heet aan het oppervlak, maar duizenden keer zo helder. Door deze enorme productie van energie en 'verbruik van brandstof' leven deze sterren slechts van de orde van miljoenen jaren. Rechtsonder is het juist andersom en daar staan hele lichte, koele, zwakke sterren die wel tientallen keren zo oud kunnen worden als het heelal nu is. Waar komt deze simpele ordening vandaan? Deze vraag

[16] De presentaties van mijn colleges staan op mijn homepage. Voor dit college zie: www.astro.rug.nl/∼vdkruit/#Sterren(en melkweg)stelsels.

[17] Zie www.astro.rug.nl/∼vdkruit/#Structure of galaxies en www.astro.rug.nl/∼vdkruit/#Dynamics of galaxies.

[18] Later heeft Herzsprung vele jaren in Leiden gewerkt en was er van 1935 tot 1944 directeur. Hij is ook enige tijd getrouwd geweest met Kapteyns dochter Henriëtte.

Fig. 10: *In this recent picture I am teaching my last lecture series. It was an introductory course on stars and galaxies. When this picture was taken I had just explained that at very high densities there is a so-called degeneration pressure as a joint result of electrons or neutrons having to obey both Heisenberg's uncertainty principle and Fermi's exclusion principle. I then estimate what the radii and densities are of white dwarfs and neutron stars (www.astro.rug.nl/∼vdkruit/jea3/homepage/galaxies04.pdf). Foto van Mariëlle Zwaanenburg van het Facultair onderwijsbureau, FWN.*

inzichtelijk trachten te beantwoorden is een uitdaging, die onderwijs een fascinerende en dankbare activiteit maakt.

Elke ster is net als onze Zon in evenwicht. De Zon bestaat miljarden jaren en is niet ingrijpend veranderd in die periode (weten we ook uit de geologie). Dat betekent, dat overal in de Zon en elke ster het 'gewicht' door de gravitatie van de bovenstaande kolom gecompenseerd moet worden. Anders ontstaan er stromingen van de materie. Dit gebeurt door de gasdruk (en niet zoals ik wel heb horen beweren door niet-astronomen door stralingsdruk). Ook is er in elk volumetje in de ster evenwicht tussen de energie die er geabsorbeerd wordt en de energie die wordt uitgestraald. Anders neemt de energie in dat volume toe en dan is er natuurlijk geen evenwicht. Er is natuurlijk wel transport van energie van binnen naar buiten, maar dat komt door de geometrie (de ster is bolvormig) en daardoor wordt er altijd net een beetje meer energie naar buiten

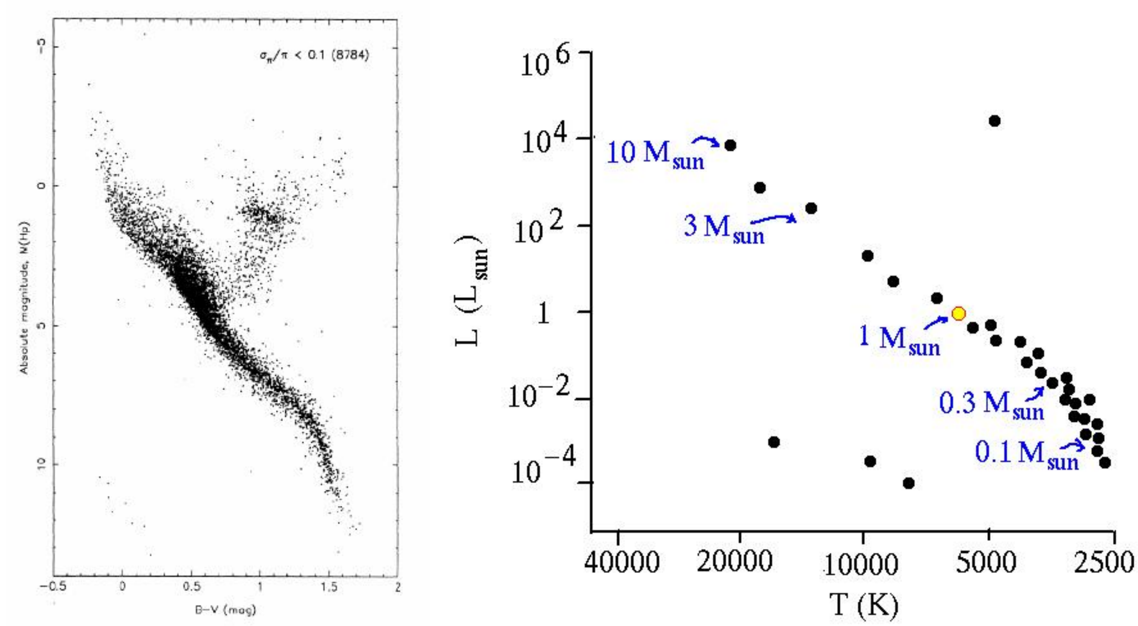

Fig. 11: *Stars as the Sun are all 'burning' hydrogen into helium in their inner parts. In this 'Herzsprung-Russell diagram' they are situated on the so-called 'Main Sequence' from upper-left to lower-right. There is a relation between luminosity (vertical axis), temperature at the surface (horizontal axis) and mass. The observed diagram at the left has been obtained with the HIPPARCOS satellite. It is customary to plot cool surface temperatures towards the right.*

gestraald dan naar binnen. Deze twee condities heten respectievelijk hydrostatisch en stralingstransport evenwicht. Tenslotte bestaat een ster uit gas en dus moet de ideale gaswet (ook wel bekend als de Wet van Boyle-Gay-Lussac) gelden, die de relatie tussen de druk, de dichtheid en de temperatuur beschrijft. Deze drie principes blijken dan alles te zijn dat je nodig hebt om de systematiek in het Herzsprung-Russel diagram kwalitatief te begrijpen!

Voor de affectionado's. Natuurlijk kun je die drie condities als wiskundige vergelijkingen schrijven. Namelijk:[19]

$$-\frac{1}{\rho}\frac{dP}{dr} = \frac{GM(r)}{r^2} \quad (1)$$

$$L_{\rm r} = -4\pi r^2 \frac{4ac}{3}\frac{T^3}{\kappa\rho}\frac{dT}{dr} \quad (2)$$

$$P = nkT = \frac{k}{\mu}\rho T \quad (3)$$

[19]Zie www.astro.rug.nl/∼vdkruit/jea3/homepage/galaxies03.pdf.

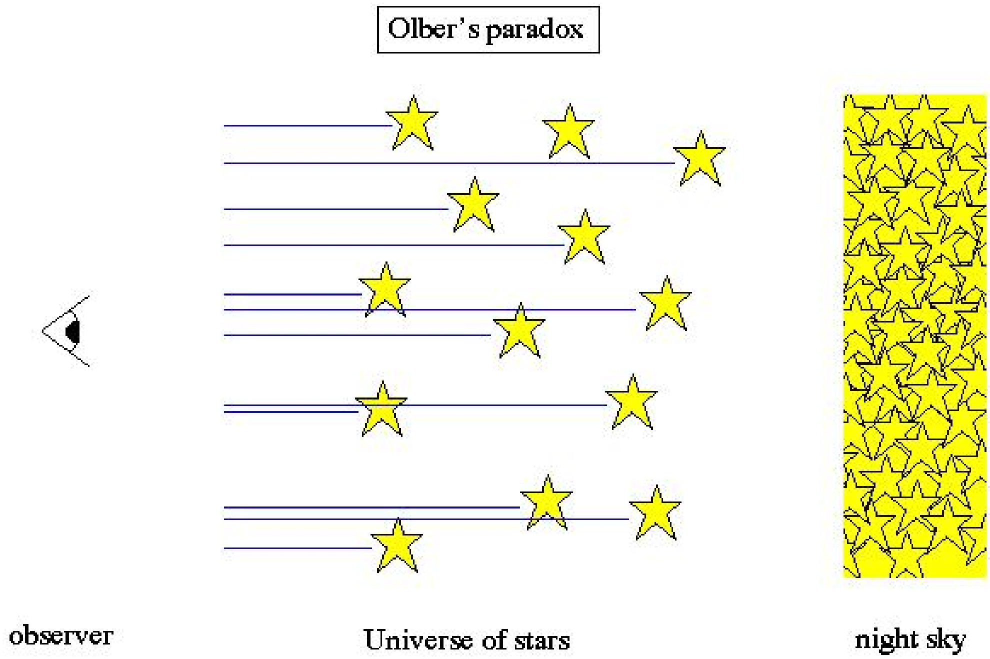

Fig. 12: *If the Universe is infinite in size and if everywhere the density of stars is the same, every line-of-sight will eventually end on the surface of a star. The sky would then have the same surface brightness as that of the Sun as we see it (but don't try to look at the Sun directly). So, why is the sky dark at night?*

Als je nu alleen met evenredigheden werkt (en dus even alle gedetailleerde fysica weglaat en aanneemt dat alle sterren daarin vergelijkbaar zijn) kun je dit herleiden tot

$$L \propto T_{\rm opp}^6 \quad ; \quad L \propto M^3 \quad ; \quad \tau \propto M^{-2}$$

Voilá! In uitstekende benadering respectievelijk de hoofdreeks in het HR-diagram, de massa-lichtkracht relatie en de afhankelijkheid van levensduur van een ster van haar massa. Natuurlijk is het veel en veel moeilijker om de precieze structuur van sterren uit te rekenen, maar kwalitatief volgen de relaties tussen massa, oppervlakte temperatuur en lichtkracht uit fundamentele fysische beschouwingen en principes.

Ik heb mijn eerstejaars collegereeksen bijna altijd besloten met een 'toegift' in de vorm van een uur college over de vraag *'Waarom is het 's nachts donker?'*[20]. Dit lijkt een overbodige vraag waarvan het antwoord wel zeer voor de hand ligt, maar die blijkt toch verstrekkende achtergronden te hebben. Het wordt de moeilijke vraag, waarvan het stellen veel meer inzicht biedt dan het geven van het gemakkelijke antwoord: *'omdat de zon dan onder is'*. Dat deze vraag verre van triviaal is werd al door Johannes

[20]Voor de bijbehorende presentatie zie www.astro.rug.nl/~vdkruit/jea3/homepage/galaxies07.pdf.

Kepler ingezien en het heet inmiddels 'Olbers Paradox' (zie Fig. 12). Neem aan, dat het heelal oneindig groot is en uniform gevuld met sterren. Elke gezichtslijn eindigt uiteindelijk op het oppervlak van een ster en dus zou de hemel overal dezelfde oppervlakte helderheid moeten hebben als de zon! De oplossing van de paradox blijkt te zijn, dat het (expanderende) heelal een eindige leeftijd heeft. Het is 's nachts donker omdat het heelal een begin heeft gehad!

2.2 Research

Back to research and to English. I did my Ph.D. thesis with Oort on a study of the central regions of our Galaxy. It consisted of two parts; the first was an observational study with the Dwingeloo radio telescope using the 21-cm line of neutral hydrogen. It concerned the mapping of hydrogen gas in a region around the Galactic Center to search for gas clouds that could have been ejected by the nucleus in directions out of the plane of the disk. It started in 1966 as a 'groot onderzoek' under the supervision of Dr. Wim Rougoor, but Wim soon after that died of leukemia at the tragically young age of 36 years. I continued the project by myself. After my 'doctoraal examen' in 1968, the data collection was complete and its reduction with the new IBM 160/50 computer of Leiden University, using programs developed by Wim Brouw and others, well underway. Oort suggested that I continue this work, but now as research for a Ph.D. thesis. We did indeed discover such gas clouds apparently expelled by the nucleus of the Galaxy in opposite directions. Could that be the cause of the expansions that were found in the central parts of the Galaxy *in* the disk by early Dwingeloo observers like Hugo van Woerden and Wim Rougoor? Oort suggested that *'ik er maar iets aan moest gaan rekenen'*[21]. So the second part of my thesis concerned a computer study in which I calculated orbits of such gas clouds and their interaction with the gas already present in the disk, and found ways in which expulsions of gas clouds could have given rise to the observed expanding motions in the central regions of the Galaxy. I completed that only a year and a half into my Ph.D. research period and I could have submitted my thesis. However, Oort suggested that we tell the Minister of Defense that I needed the full three years that I was entitled to in order to postpone military service, and that I should work with the then newly operational Westerbork Synthesis Radio Telescope on the radio continuum emission of spiral galaxies.

So I got my degree in 1971. Harry van der Laan succeeded in keeping me out of the army for another year (he had claimed I was 'essential' for the exploitation of Westerbork). But then staying in Leiden was no longer an option and I had to move abroad as a postdoc in 1972. My choice was to go the the U.S.A. and work with large optical telescopes. I felt that progress on the structure of spiral galaxies required information at various wavelengths and it was important, and a challenge, to get experience in optical astronomy. I was very lucky, undoubtedly as a result of a very positive letter of reference that Oort must have written, to obtain a prestigious

[21] *'Maybe you should do some calculations on this problem.'*

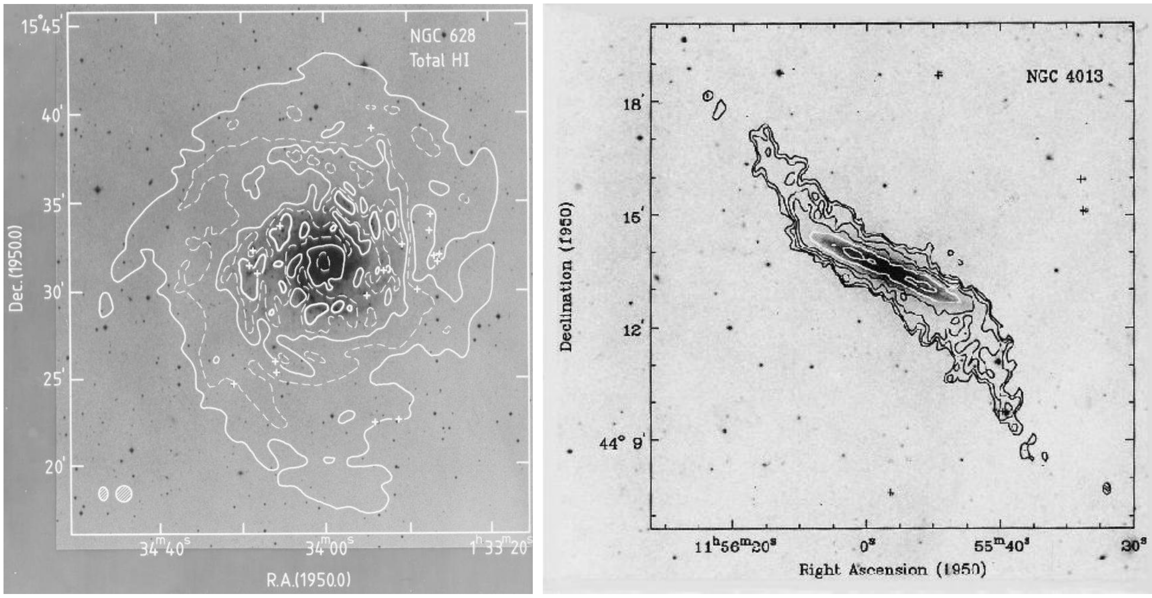

Fig. 13: *Left: Distribution of neutral hydrogen in a face-on galaxy (NGC 628). It is much more extended than that of the stars. Right: Distribution of neutral hydrogen in an edge-on galaxy (NGC 4013). The gas 'warps' severely away from the central plane of the stellar disk.*

Carnegie Fellowhip from the Carnegie Institution of Washington to work at the the Hale Observatories (earlier the Mount Wilson and Palomar Observatories) in Pasadena, California.

After I came to Groningen per 1 January 1975, I was very much interested in the new Westerbork developments, in particular the possibilities offered by observing the 21-cm line of neutral hydrogen in spiral galaxies. That would make it possible not only to study the distribution of interstellar gas, but also its velocities. The gas was found to extend much further than the stars (see Fig. 13, left, for a more recent example), while the rotation of the gas indicated that there must be enormous amounts of invisible matter. This dark matter makes up most of the mass in a galaxy, but up to the present day we don't know what it is. Albert Bosma was doing an extensive survey for his thesis. Furthermore, Renzo Sancisi had found that in edge-on systems the gas layer warped in the outer parts away from the central plane (Fig. 13, right, again a more recent observation). We were interested to see if there was starlight at very faint levels associated with this outer material in spirals. To that end I did obtain time on the 48-inch Schmidt telescope back at Palomar (Fig. 14, left) to take very deep photographic exposures. This is a telescope especially constructed for photographing the sky and is in effect a giant camera. For this people used (then) relatively new, special high-contrast emulsions and increased the contrast even more by taking a number of such plates and 'stacking' them on top of each other in order to see faint structures. I

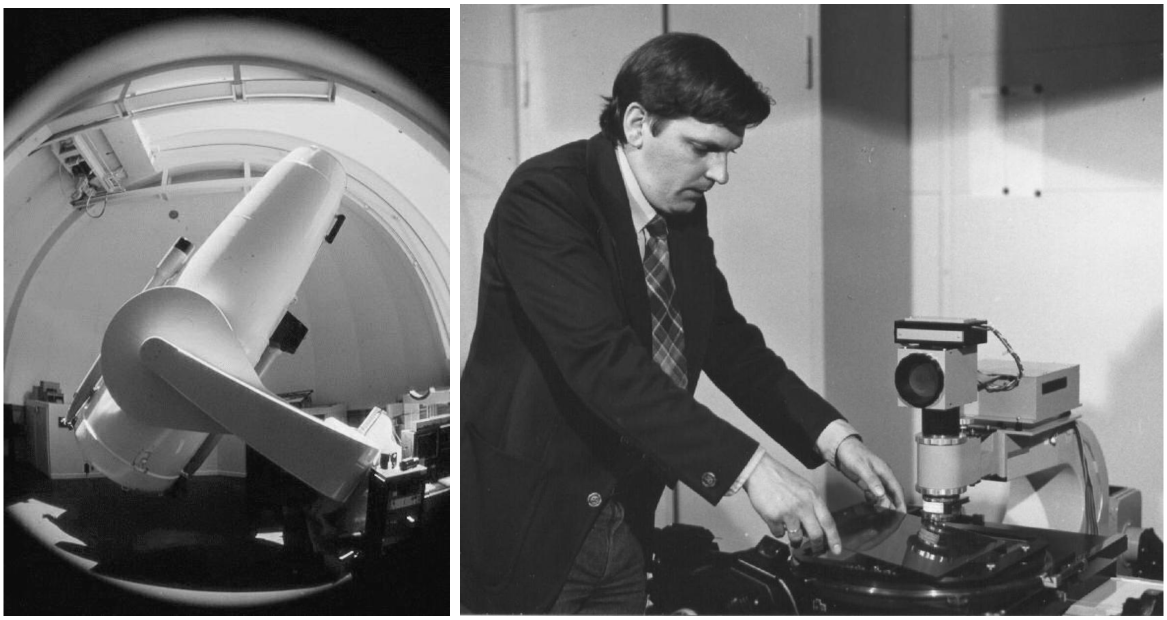

Fig. 14: *Left: The 48-inch Schmidt telescope at Palomar Mountain, California, that I used for making photographic exposures of galaxies. It is essentially a very large camera with an opening of 48 inches (a little over 120 cm) diameter. Right: The ASTROSCAN measuring machine at the Sterrewacht Leiden. This could be used to carefully and accurately measure the photographic density with 30 micron pixels (in my application) over regions of a few centimeters (corresponding in my application to some tens of minutes of arc) from photographic plates. That took of the order of an hour or so. The results were written on a magnetic tape and transported to Groningen for further processing. This photograph shows me positioning a photographic (glass) plate on the plateholder.*

spent many hours lying under the telescope in freezing weather conditions to 'guide' the telescope and keep it exactly pointed to the same position in the sky. In addition, to improve the sensitivity, plates had to be prepared in a special way ('baking' them for hours in an oxygen-free and hydrogen- and nitrogen-rich environment) and later carefully developed in an absolutely dark room.

I found no indication of any starlight at large distances from the centers of these galaxies and we wondered if indeed the gas at these positions did not make any stars. That was of course qualitative and I wondered what the actual upper limit was on the amount of material in the form of stars. That would involve measuring how opaque the photographic plates had become (this is called the 'photographic density') and finding a way to relate that to the amount of light emitted. Now there were at that time efforts to build machines that could automatically scan photographic plates, measuring the photographic density in small pixels over extended areas.[22] However, getting

[22]The term *pixel* from 'picture element' is often used today, especially after the advent of digital

reliable results was very difficult, and very little two-dimensional work of this kind had been done. Examples of this did exist, such as a Ph.D. thesis study by François Schweizer, a Swiss astronomer who obtained his degree in Berkeley and who came to Pasadena as Carnegie Fellow a year later than I. François, who became a very good friend in Pasadena, had looked for extended spiral structure in the disks of spirals (for astronomers: he was looking for the underlying density waves in the old disk population). His thesis supervisor Ivan King once stated (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.'*

At one of the annual 'astronomen conferenties' Rudolf le Poole told me that an older plate-measuring machine in Leiden was being turned into an automated device (the Astroscan) and that it could, at least in principle, be used for photographic surface photometry. I decided to give it a try. I realised that it might very well take a year or so and then it still could turn out to be impossible or unreliable. However, I had a tenured position in the mean time and there were no such things to worry about as citation impacts and other bibliometric scores, 'Vernieuwingsimpuls', 'Bèta's in Banen', or any other competition to finance one's research. It was a bit of a gamble, but certainly a major challenge; if it worked it would pay off very well and we would really learn something new. For many weeks my routine was to leave early on Tuesday morning for Leiden, experiment long hours with the Astroscan (Fig. 14, right) and return on Thursday evening to Groningen. It took a long time before it worked in such a way that I felt I might trust the results.

Next I had to develop the methods to reduce those data and write a complete package of reduction programs for the mainframe computer in Groningen (which was a CDC Cyber-74). The input in those days was in the form of punched cards (consisting of a Fortran program and instructions for the operating system, including those to 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 (we did a lot of walking those days). 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, so I would find my print-out under the letter P. 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. 15) was designated PCK 00 IQ!

In the end I spent more than a year on this effort, but it did pay off. It was possible to get reliable surface photometry to faint levels. The project led eventually to the larger survey in the Ph.D. thesis of Bart Wevers, a project with Ron Allen in Groningen and Leonard Searle in Pasadena, in which we for the first time combined 21-cm studies of a sample of spiral galaxies with optical surface photometry, including

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photography; it did actually exist much earlier in areas involving image processing.

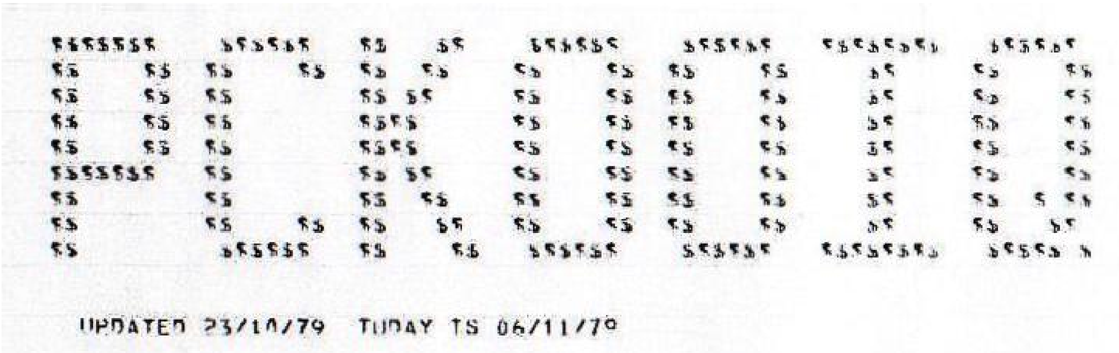

Fig. 15: *The ultimate insult by the central computer of Groningen University (November 6, 1979).*

colors. This we called the Palomar-Westerbork survey and it was a major observational effort, involving 64 observing periods of 12 hours at Westerbork and 42 dark nights (around New Moon) at the Palomar 48-inch Schmidt. It is still cited regularly. As it turned out, it was also the precursor of the Ph.D. thesis that Roelof de Jong wrote in the nineties using electronic CCD-detectors and extending it to the near infrared. This work has been a breakthrough in the studies of structure and evolution of stellar disks in galaxies.

I also included some edge-on galaxies in the sample, such as the two in Fig. 16. This proved to a gold-mine, since has led to the first general model of the three-dimensional distribution of stars in disks of external galaxies. The series of papers I wrote with Leonard Searle on this have become classics (as was actually predicted by the referee of the first two papers, Gerard de Vaucouleurs). The follow-up with Ken Freeman (both in edge-on and more face-on systems) to measure the motions of the stars in such disks and study the dynamics has likewise opened a new field. We could put a limit on the mass in disks and study the question of their stability. This work has led eventually to the Ph.D. theses of Roelof Bottema, Richard de Grijs and Michiel Kregel.

Looking back at these research undertakings I most vividly remember the excitement when a reliable observational result could be obtained. Doing surface photometry from photographic plates was at the limits of what could be done. It is now a much more standard procedure using CCD-detectors, but it was a major, tedious effort in the eighties. Some years ago a colleague remarked at a conference that I attended, that (I paraphrase) *'the old photographic surface photometry in the literature is not reliable, except when it has been done by Piet and his co-workers'*. That is a bit of an exaggeration, but also a big compliment that I cherish. Also, the work with Ken Freeman on the first measurements of stellar kinematics in disks (during my sabbatical at Stromlo in 1982/83) was only barely possible. We observed two galaxies on the 3.9-m Anglo-Australian telescope at Siding Spring Observatory in Australia (one of the largest telescopes in the world at that time), but had to effectively expose for a full night on a single galaxy. We even took an effectively 29.3 hour exposure in the

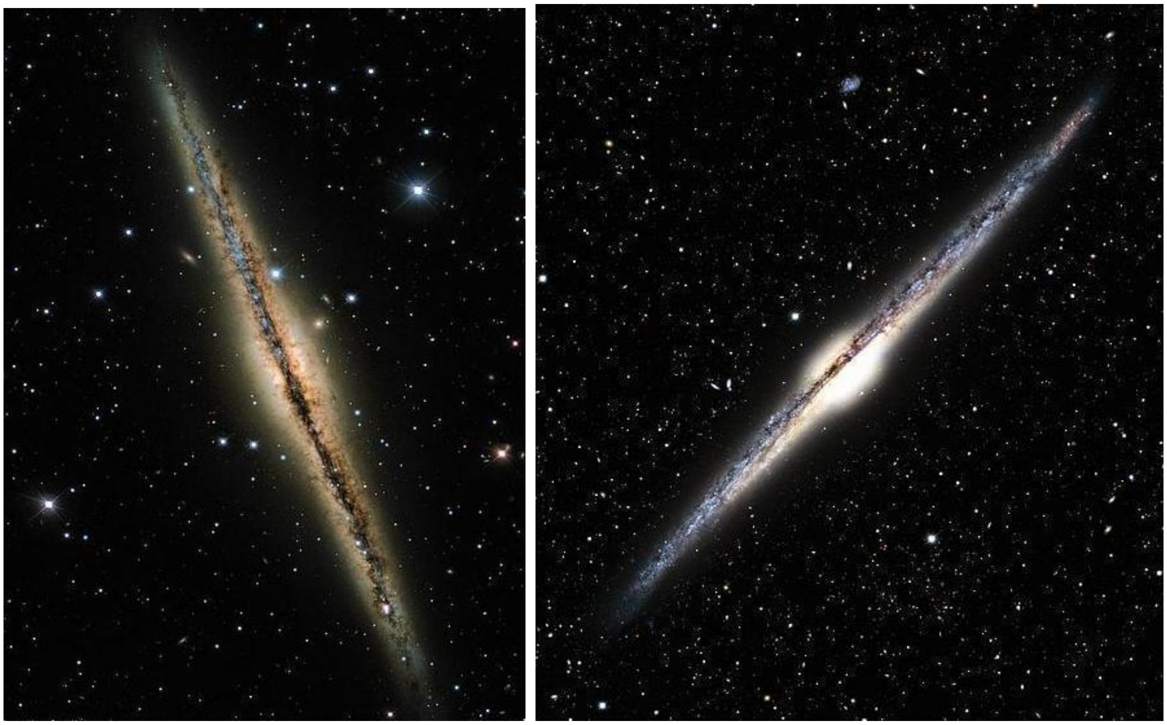

Fig. 16: *Two ede-on spirals that I studied extensively. The one on the left is known as NGC 891 and the one on the right NGC 4565. I have claimed in the literature that the one on the left is a very close twin to our own Galaxy. These beautiful pictures have been taken with the Canada-France-Hawaii Telescope on Mauna Kea, Hawaii.*

course of a whole week with the Mount Stromlo 74-inch, one of the telescopes tragically destroyed in the January 2003 bushfires.

Finding the three-dimensional distribution of stars in spiral disks and studying their dynamics is in a sense a natural continuation of the work that Kapteyn started in our Galaxy and involved stellar dynamical applications of the foundations of Oort. My work on the disk of our Galaxy using the detailed mapping of the Milky Way surface brightness distribution by the Pioneer 10 spacecraft from beyond the asteroid belt on its way to Jupiter, was a very gratifying result and is in effect a modern version of Kapteyn's studies. My professional life as a scientist has been rewarding in more than one aspect, but I am particularly grateful that the way it developed was such that it has been much in the tradition of both Jan Oort and Jacobus Kapteyn.

2.3 Administration

Ik heb relatief veel bestuurlijk en leidinggevend werk gedaan. Al snel nadat ik Groningen aankwam, werd ik lid van de Faculteitsraad Wiskunde en Natuurwetenschappen en de Subfaculteitsraad Sterrenkunde. Binnen de subfaculteit werd ik na niet lange tijd voorzitter van de begrotingscommissie en van de onderwijscommissie en in 1981 werd ik lid van het Faculteitsbestuur. Ik heb dat niet echt gezocht; het kwam op mijn pad en ik vond dat ik mijn steentje moest bijdragen. Maar ik heb het ook telkens weer een uitdaging gevonden. Alhoewel er bij bestuurlijk werk in sommmige opzichten ook van een hoog 'déjà vu' gehalte sprake kan zijn. Toen ik in 1987 benoemd werd tot hoogleraar, werd ik bijna tegelijkertijd voorzitter van het bestuur van de ZWO[23] Stichting Radiostraling van Zon en Melkweg (RZM), die verantwoordelijk was voor de operaties van de radiosterrenwachten in Dwingeloo en Westerbork. ZWO werd niet lang daarna NWO[24] en RZM fuseerde met de andere astronomische stichting en werd de Stichting Astronomisch Onderzoek in Nederland (ASTRON), waardoor de verantwoordelijkheid voor de projectsubsidies en de Brits-Nederlandse samenwerking op La Palma en Hawaii erbij kwamen. Overigens is het ironisch dat bij de reorganisatie van NWO in 1998 ASTRON langs exact dezelfde snijlijn weer uit elkaar is gehaald. Ik ben totaal ruim acht jaar voorzitter van ASTRON en RZM geweest.

Ik heb 10 jaar het Kapteyn Instituut geleid[25], onderbroken door een kleine drie-en-een half jaar als decaan van de Faculteit der Wiskunde en Natuurwetenschappen. Nationaal ben ik lid en voorzitter geweest van het Nederlands Comité Astronomie (NCA; het nationaal overlegorgaan van de sterrenkunde) en van het bestuur van de Nederlandse Onderzoekschool voor Astronomie (NOVA). En ik ben bij elkaar zeven jaar (en heb nog een jaar voor het eind van mijn huidige termijn) lid geweest van het Gebiedsbestuur Exacte Wetenschappen van NWO.

On the international scene I have chaired and vice-chaired for over twelve years the 'Board' of the UK-Netherlands optical telescopes on La Palma, Canary Islands[26] and I have been for more than six years involved with the Council of the European Southern Observatory (ESO), which among others owns the Paranal Observatory in Chile with the Very Large Telescope VLT. Of this body I have been vice-president for two years and president for three years. This has been very rewarding. I contributed among others to the negotiations for the assession of the UK, Finland and Spain to ESO and I was involved in the decision and first years of construction of the Atacama Large Millimeter Array (ALMA), being built at 5000 meters altitude in Chile. When it was formally still a bilateral European-North American project, I chaired the ALMA Board for two years and vice-chaired it for one year, and played an important part in the negotiations with Japan to join to make it a tri-partite undertaking. And I oversaw discussions in Council that led to a resolution that resolved that the next major project for ESO would be a large optical telescope, having become in the mean time the 42-meter(!) European Extremely Large Telescope E-ELT, that is in a design

[23]Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onderzoek.

[24]Nederlandse Organisatie voor Wetenschappelijk Onderzoek.

[25]Eerst als voorzitter van de Afdeling Sterrenkunde toen in de universitaire structuur bestuur en beheer strikt gescheiden waren en later als wetenschappelijk directeur van het Kapteyn Instituut toen in 1997 de wet 'Modernisering Universitaire Bestuurstructuur' (MUB) de scheiding legde tussen onderwijs en onderzoek.

[26]This was called the 'Joint Steering Committee for the Isaac Newton Group of Telescopes' at the Observatorio del Roque de los Muchachos.

study.

Ik heb besturen altijd uitdagend, maar ook bevredigend gevonden. Vandaar dat ik nog steeds de besturen voorzit van organisaties als het Koninklijk Natuurkundig Genootschap (KNG), het Groninger Universiteits Fonds (GUF), het Leids Kerkhoven-Bosscha Fonds (LKBF) en het Studiefonds J.C. Kapteyn. Dit is liefdewerk oud papier, maar geeft veel voldoening.

Uitdagingen hebben ook een aspekt van *'Hoe krijg ik dat nu weer voor elkaar?'* en ik wil mijn resterende ruimte gebruiken om een geval in herinnering te brengen, dat dat aspekt heel duidelijk had, maar ook laat zien dat bestuurlijke activiteiten interessant en dankbaar kunnen zijn. Het laat ook zien, dat je af en toe ook een beetje geluk moet hebben. Dat betreft de kwestie van het vijfde studiejaar voor bèta studenten. Hoe zat dat? Begin jaren negentig was de cursusduur van academische studies 4 jaar. Dat gaat terug naar de invoering van de twee-fasen structuur in de jaren tachtig, waarbij de eerste fase bestond uit een één-jarig propadeuse gedeelte en een drie-jarige doctoraal fase. De tweede fase werd uiteindelijk een vierjarig promotie traject. De studiefinanciering (basisbeurs) voor de eerste fase duurde oorsponkelijk maximaal 6, maar werd al snel maximaal 5 jaar.

Ondanks dat er een 4-jarige studieduur gold, werkten we in de wiskunde en natuurwetenschappen in de praktijk met een 5-jarig curriculum om de studie voldoende inhoud en gewicht te geven; de gemiddelde studieduur was vijf-en-een-half jaar. Dus studenten gebruikten in de praktijk de maximale studiefinanciering van 5 jaar. Het curriculum was destijds opgebouwd uit studiepunten; elk studiepunt is een werkweek van veertig studie-uren. Een volledig studiejaar bestaat uit 42 studieweken en hoort dus 42 studiepunten op te leveren en de student wordt geacht daarvoor 1680 uur inzet per jaar te verwezenlijken. Het curriculum omvatte dus formeel voor de gehele eerste fase per definitie 168 studiepunten, te halen in 168 weken. Maar in de praktijk waren daar voor de bèta studies 5 jaar voor nodig; visitatie-commissies pleitten er dus allang voor de studie formeel 5 jaar (en dus 210 studiepunten) te maken. Sinds 1996 waren de ingenieursopleidingen door een succesvolle lobby van de technische universiteiten (gesteund door de industrie) inderdaad erkend als vijf-jarig en omvatten dus wel formeel 210 studiepunten.

De algemene universiteiten kampten natuurlijk met een laag studie rendement. Het echte probleem ontstond toen minister Ritzen in 1996 de duur van de studiefinanciering terugbracht tot de lengte van de cursusduur. Plotseling zouden bèta studenten slechts 4 jaar studiefinanciering krijgen voor een curriculum dat formeel 4, maar effectief 5 jaar vergde. Terugbrengen van het curriculum naar 4 jaar werd gezien als bedreigend voor het niveau van de afgestudeerden en hun internationale concurrentie positie, en was daardoor onaanvaardbaar. Verder kwam er dan een eveneens onaanvaardbaar verschil in opleidingsniveau tussen de doctorandi en ingenieurs in de wiskunde en natuurwetenschappen.

De nieuwe regeling voor de studiefinanciering zou ingaan voor de eerstejaars van het studiejaar 1996/97, die dus in 2000/01 geen studiefinanciering meer zouden kunnen krij-

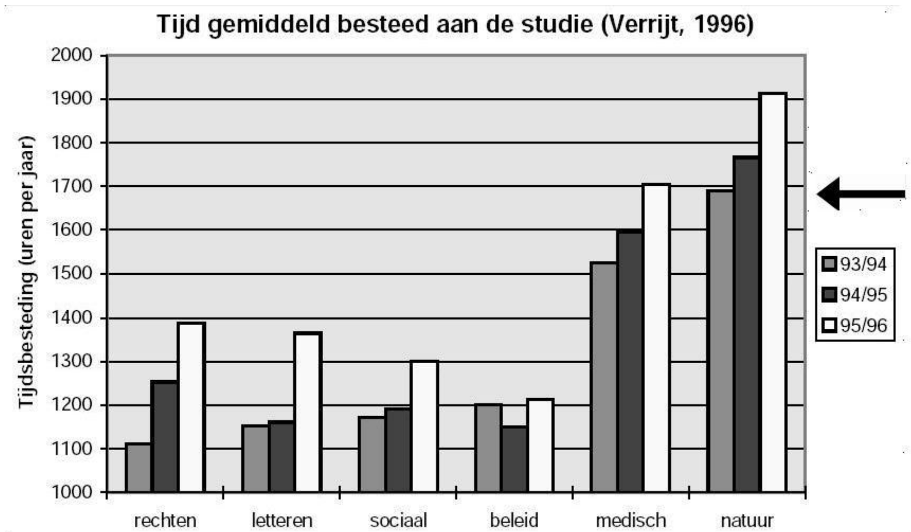

Fig. 17: *The number of hours per year that students spent on their studies for three academic years in the mid-nineties. The ministerial norm is 42 weeks of 40 hours, or 1680 hours. From left to right 'law', 'arts and humanities', 'social sciences', 'management sciences', 'medical sciences' and 'natural sciences'. From a study by Verrijt (1996) based on questionaires at the Catholic University Nijmegen (now Radboud University).*

gen. Na enige voorbereidende besprekingen kwam een overeenkomst tot stand tussen de zes algemene universiteiten[27] (en ons College van Bestuur onder leiding van Eric Bleumink speelde daar een belangrijke rol in), die beklonken werd op een vergadering van de Rectores Magnifici op 11 april 1996. Als decaan van de Faculteit Wiskunde en Natuurwetenschappen begeleidde ik onze Rector Magnificus Folkert van der Woude[28]. De universiteiten besloten voorlopig *zelf* de studiefinanciering van het vijfde jaar van aankomende studenten voor hun rekening te nemen en tegelijk een commissie in te stellen die een rapport zou moeten produceren waardoor de Minister overtuigd zou worden van de noodzaak van het vijfde studiejaar voor bèta's en een wetswijziging tot die strekking zou indienen. Ons Gronings College, en ik als decaan met hen, pleitte er sterk voor ook de biologie daar volledig in op te nemen; dat was niet triviaal want het maakte die tijdelijke financiering veel duurder. Voor de RUG ging het om een verschil tussen een half en één miljoen gulden per studiejaar. Uiteindelijk is de biologie alleen door de RUG in die financieringsregeling opgenomen, maar wel werd de biologie meegenomen in de opdracht voor de commissie en in het rapport werd wel sterk voor een vijfde-studiejaar ook voor biologen gepleit. Ik bewonder de besluitvaardigheid van ons College om zich zo sterk te maken voor de biologie en ook de takt het gehele pakket door de Universiteits-raad te loodsen.

[27]Dit zijn de klassieke universiteiten van Amsterdam, Groningen, Leiden en Utrecht, plus de Vrije Universiteit Amsterdam en de Katholieke Universiteit Nijmegen, nu Radboud Universiteit.

[28]Folkert kan helaas door ernstige problemen met zijn gezondheid hier vanmiddag niet zijn.

Tijdens genoemde vergadering van de rectores kwam de vraag wie die commissie zou moeten trekken en voorzitten. Niemand bood zich aan en na wat stilte sprak de Rector van de Leidse universiteit, de theoloog Lammert Leertouwer, de voor mij omineuse woorden: *'Dan pleeg ik een overval; ik vind dat decaan van der Kruit uit Groningen daar aan de overkant van de tafel dat moet doen.'* Later bleek dat dat niet uit de lucht kwam vallen; want toen ik hem na afloop sprak, bleek hij diverse details van mijn academische achtergrond te weten. Dat was dus zo'n uitdaging waarvan je in eerste instantie geen idee hebt hoe je het moet aanpakken en of het je ooit wel zal lukken dat tot een goed einde te brengen.

Om kort te gaan: De commissie presenteerde een jaar later een uitgebreid rapport, dat uiteindelijk heeft geleid tot de erkenning van het 5-jarige bèta curriculum[29]. De doorslag gaf de vinding dat de bèta studies inderdaad een inzet vereisten van zeker 210 studiepunten en beduidend meer dan 168. Cruciaal daarbij was de uitkomst van een onderzoek aan de Katholieke Universiteit Nijmegen (nu de Radboud Universiteit) op grond van jaarlijkse enquetes van studenten bij herinschrijving over hun studie-inzet het jaar daarvoor (zie Fig. 17). Bèta studenten besteedden (verleden tijd; het is meer dan 15 jaar geleden en hoe het tegenwoordig is, weet ik niet) ruim 5 jaar lang meer dan 1680 uur per jaar aan hun studie. Het bestaan van deze studie was een onverwachte meevaller, waarvan we enorm profiteerden; zonder dit was het een stuk lastiger geweest. Overigens was biologie ook weer punt van discussie toen het voorstel naar de Tweede Kamer ging, maar heeft het wel gered. Toen we het rapport met Minister Ritzen bespraken vroeg hij mij hoe voorkomen kon worden dat zo'n erkenning als een olievlek zich over de faculteiten zou verspreiden en in korte tijd alle studies 5 jaar zouden zijn. Mijn antwoord was verwijzing naar dit onderzoek, omdat daaruit bleek dat –althans toen– studenten uit andere dan de bèta en medische studierichtingen niet hun voorgeschreven 1680 uur per jaar haalden.

Zou ik weer zoveel bestuurlijk werk doen als ik nog aan het begin van mijn academiche carrière zou staan? Ik denk van wel. Het is waar dat ik erdoor minder publicaties heb geschreven en minder promovendi heb gehad. Maar het was de uitdaging en vooral het resultaat dubbel en dwars waard. Het is ook altijd een uitdaging om de organisatie, die ik heb voorgezeten, in goede toestand (en in goede handen) achter te laten en dat gevoel heb ik altijd gehad. En wat is er mis mee om de condities te scheppen om het voor jongeren mogelijk te maken zich aan onderzoek te wijden als anderen dat voor jou deden toen je zelf nog jong was? Ik blijf nog even lid van het Gebiedsbestuur Exacte Wetenschappen van NWO en ik ga nog even niet weg als voorzitter van het Groninger Universiteits Fonds en het Koninklijk Natuurkundig Genootschap.

3 In closing

Ik sluit nu af.

[29]Zie www.astro.rug.nl/∼vdkruit/jea3/homepage/rapport5.pdf.

During today's proceedings we heard a lot about new facilities that are being build or planned for astronomical research. I am very excited about them and eager to find out what new things we will learn about the open questions on the origin of structure in the Universe, the formation of the first stars and of galaxies, the nature of dark matter and dark energy, the formation of stars and planets and the incidence of life in the Universe. I am reminded of a story Jan Oort told when he gave the after-dinner speech at a conference in Cambridge in 1976. It goes as follows. 'A traveller came though a small village somewhere in the countryside and noticed an old man sitting in front of his house. The traveller asked the old man: *'Have you been here all your life?'* The old man replied: *'Not yet!'*.'

It is interesting that when you read the scientific justifications of those new facilities, you will find considerable overlap between the questions they will be used to address. That is no surprise; a comprehensive understanding of the Universe requires a concerted effort at all wavelengths domains we have at our disposal. Trying to answer those questions is the reason why we do astronomy and make all these investments and it is a privilege to be an astronomer and dedicate my professional life to it. For those who would ask *'But what is the use of astronomy and why are we making all these investments?'* I point out, as many astronomers do, that this question is not fundamentally different from questions as *'What is the use of a painting, of an opera, or of a poem?'*.

I want to close with a few words of thanks.

Ik dank in de eerste plaats het Kapteyn Instituut en het Koninklijk Natuurkundig Genootschap voor de organisatie van dit mini-symposium: Peter, Thijs, Lou, Albert Jan, Gineke, Jackie, Hennie, Hans en alle anderen. And many thanks to the speakers for their beautiful presentations and to Eline for acting as chair. And the audience for attending, especially those of you who have been here since 9 o'clock this morning. En ik dank de organisaties, die dit financieel hebben gesteund.

Ik ben het College van Bestuur zeer erkentelijk voor de eervolle benoeming voor 5 jaar, reeds per 1 september ingegaan, als hoogleraar-honorair en het behoud van de Jacobus C. Kapteyn leerstoel. Dan dank ik mijn promovendi voor de fantastische samenwerking en natuurlijk ook mijn andere collega's van het Kapteyn Instituut (nu en toen – wetenschappelijke staf, ondersteunend en beheerspersoneel, postdoc of promovendus). Het was en is een voorrecht met jullie een instituut te vormen. En alle studenten, die mijn colleges volgden en die ik daarbij mocht inspireren. Special thanks to my collaborators in research projects throughout the world and throughout the years. In particular Ron Allen and Ken Freeman. Ron, bedankt voor de vele jaren van samenwerking en vriendschap en niet te vergeten de gastvrijheid in Baltimore. And Ken, it was always great to visit Canberra and to work with you. We also have become good friends. What can I say but 'thanks, mate!' Ik dank allen in de Nederlandse astronomische gemeenschap, in besturen en andere gremia van de FWN, RUG, ASTRON, NCA, NOVA, NWO, EW, OCW, ESO, ALMA, IAU, SRON, GUF, KNG, LKBF, VSNU, etc. voor vele jaren van gezamenlijke inzet, constructieve samenwerking en het in mij gestelde vertrouwen, in de meeste gevallen ook gedurende perioden als voorzitter van die gremia. En niet te vergeten dank aan allen die het werk van die lichamen administratief en beleidsmatig ondersteunden.

En tenslotte dank ik mijn goede vrienden en al degenen, die mij door de jaren heen nabij zijn geweest. Ik denk met name aan het gezin, waarin ik ben opgegroeid, waarvan mijn broer nog over is (samen met mijn schoonzuster nu wonend in Nieuw-Zeeland). Mijn ouders zijn er niet meer en ik ben zeer vereerd met de aanwezigheid vanmiddag van mijn enige resterende oom en tante. En ik denk daarbij ook aan mijn kinderen. Tenslotte gaat een wel heel speciale dank naar Corry, mijn maatje van alweer zeven-en-een-half jaar.

Ik heb gezegd.

De Faculteit der Wiskunde en Natuurwetenschappen heeft me ter gelegenheid van mijn 65-e verjaardag bij het *'Challenges'* symposium en deze rede een geschilderd portret aangeboden. Dit zal worden opgehangen in de Faculteitskamer Wiskunde en Natuurwetenschappen in het Academiegebouw. Het is een portret in de traditionele stijl met toga en koninklijke onderscheiding.

Het portret is geschilderd door *Jannes Kleiker*[30] en is gereproduceerd op de tegenoverliggende pagina.

Ik ben bijzonder vereerd en dankbaar voor dit uitzonderlijke geschenk.

The Faculty of Mathematics and Natural Sciences presented me at the occassion of my 65-th birthday at the *'Challenges'* symposium and this address with a painted portrait. This will be placed in the portrait gallery in the Faculty Room Mathematics and Natural Sciences in the central building of the University. It is in the traditional style with academic gown and royal decoration.

The portrait was painted by *Jannes Kleiker*[31] and is reproduced on the opposite page.

I am extremely honored and grateful for this extraordinary gift.

[30] Zie www.janneskleiker.nl/.
[31] See www.janneskleiker.nl/.


JKleiker
2009