The Born Investigator of the Heavens

Jacobus Cornelius Kapteyn (1851–1922)

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Kaiser-Kapteyn day, Leiden, June 18, 2022

The Born Investigator of the Heavens

Simon Newcomb, *The Stars: A study of the Universe*[1] (1901).

'This work of Kapteyn offers a remarkable example of the spirit which animates the born investigator of the heavens. Although the work was officially that of the British Government, the years of toil devoted to it were, as the writer understands, expended without other compensation than the consciousness of making a noble contribution to knowledge, and the appreciation of his fellow astronomers of this and future generations.'

[1] Footnote on page 49.

Short biography

- Kapteyn was born on January 19, 1851 in the municipality of Barneveld.
- In the middle of the 'Bible Belt'.
- His parents were Gerrit Jacobus Kapteyn (1812–1879) and Elisabeth Cornelia Koomans (1814–1896).
- They ran a boarding school for boys.

- He was the tenth child of fifteen.
- Family reunion around 1877 (40th wedding anniversary?).

- Kapteyn was educated at the boarding school of his parents.
- He always complained of a lack of attention by his parents.
- He enrolled at the University of Utrecht in 1868 to study mathematics and physics.

ONDERZOEK

DER

TRILLENDE PLATTE VLIEZEN.

Akademisch Proefschrift

TER VERKRIJGING VAN DEN GRAAD VAN

DOCTOR IN DE WIS- EN NATUURKUNDE,

AAN DE HOOGESCHOOL TE UTRECHT,

NA MACHTIGING VAN DEN RECTOR MAGNIFICUS

D^R. C. H. C. GRINWIS,

GEWOON HOOGLEERAAR IN DE FACULTEIT DER WIS- EN NATUURKUNDE,

MET TOESTEMMING VAN DEN ACADEMISCHEN SENAAT

EN

VOLGENS BESLUIT VAN DE FACULTEIT DER WIS- EN NATUURKUNDE,

TE VERDEDIGEN

Op Donderdag, 24 Juni 1875, des namiddags ten 7 ure,

DOOR

JACOBUS CORNELIUS KAPTEYN,

GEBOREN TE BARNEVELD.

BARNEVELD,
P. ANDREÆ MENGER.
1875.

- He studied with C.H.D. Buys Ballot and C.H.C. Grinwis.
- And obtained his PhD in 1875 under Grinwis.
- The title was 'A study of vibrating, flat membranes'.

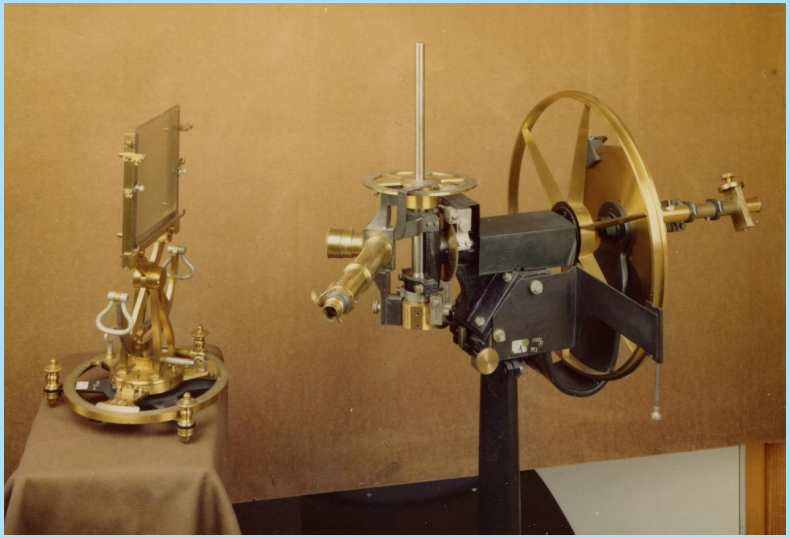
- In 1875 he was appointed observator at Leiden Observatory.
- The director was Hendricus G. van de Sande Bakhuyzen.
- The Observatory was mainly involved in positional astronomy.

- In 1877 he was appointed Professor of astronomy and theoretical mechanics at the University of Groningen.

- The chair was a result of the Law on Higher Education of 1876.
- He took up his chair in 1878.
- He married Catharina Elisabeth Kalshoven (1855–1945) on July 16, 1879.

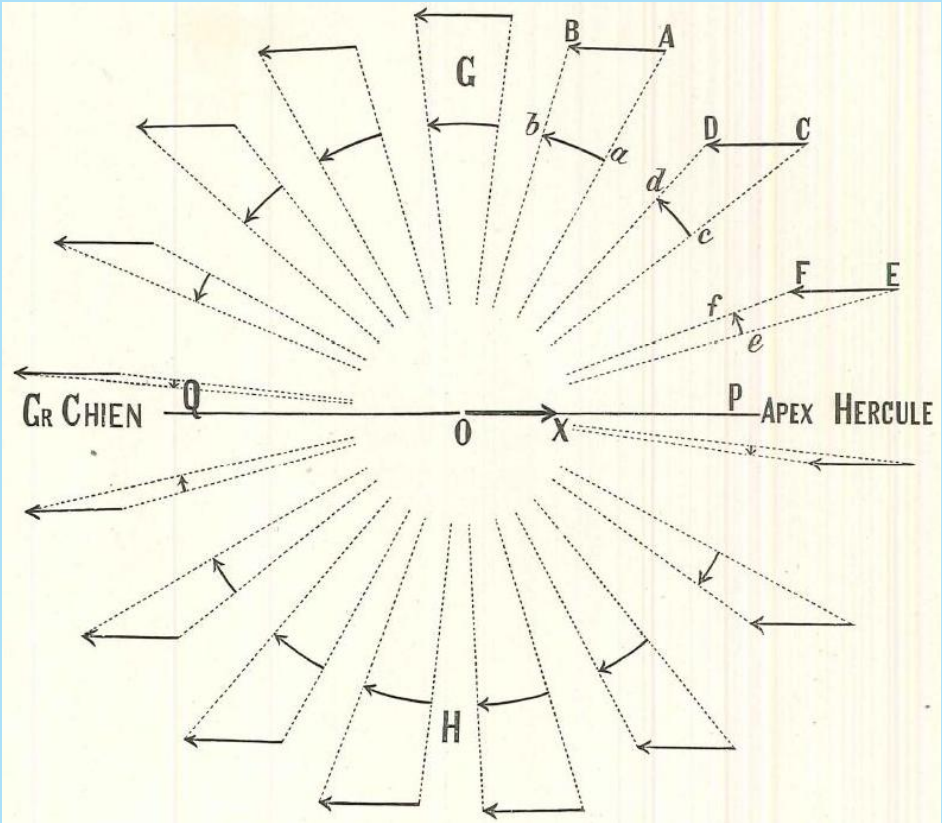
- In spite of many efforts he failed to obtain his own observatory.

- He heard about the efforts of David Gill at the Royal Observatory at Cape of Good Hope to produce a photographic Durchmusterung.
- He offered to measure Gill's plates and produce the star positions and magnitudes.
- The Cape Photographic Durchmusterung was published in three volumes in 1896, 1897 and 1900.

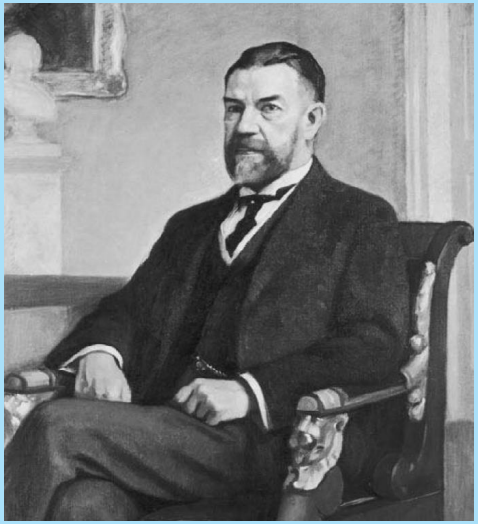


- He devised the parallactic method and measured the positions and magnitudes of 454,875 stars.
- He was given two small rooms in the laboratory of G. Heymans, professor of psychology and philosophy.

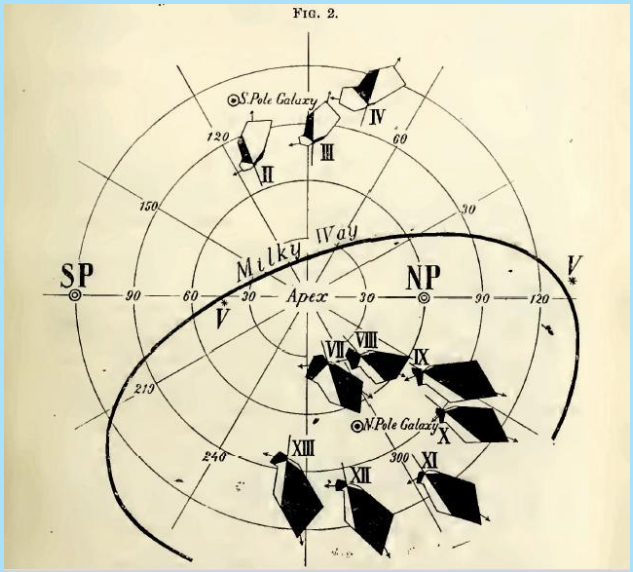
- Kapteyn devoted his carreer to the problem of the Construction of the Heavens or the Structure of the Sidereal System.
- He gave up measurement of direct trigonometric parallaxes.
- He used proper motions.



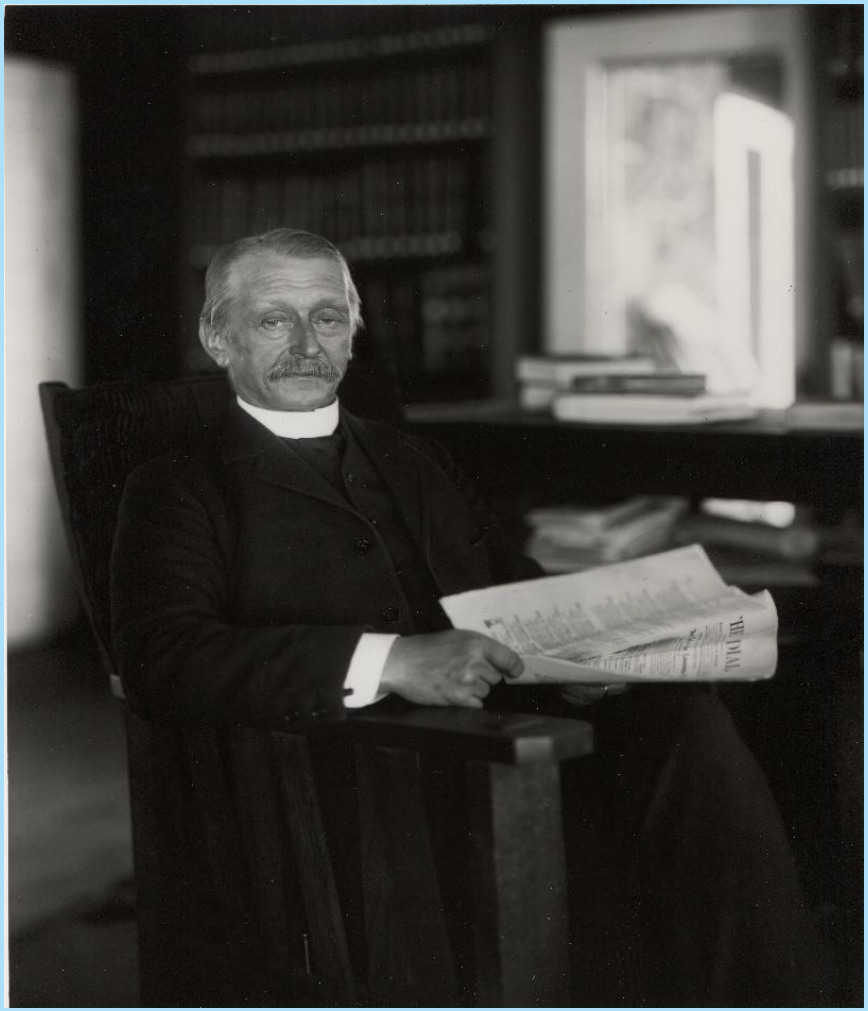
- Space motion of the Sun towards Apex in Hercules.
- Used for secular parallaxes.
- Kapteyn made the assumptions that
  - Luminosity curve everywhere the same.
  - Stellar motions in space have no prefered direction.
  - No insterstellar absorption.



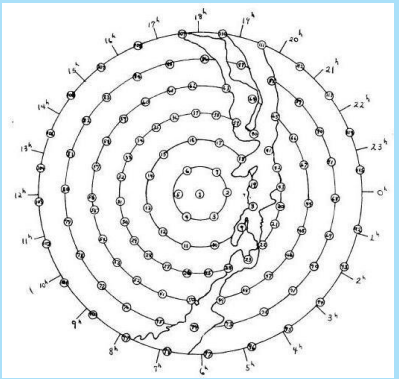
- Anders Donner from Helsingfors provided him with many plates for both proper motions and parallax determinations.
- He had met Donner at the meeting of the Carte du Ciel in Paris in 1887.

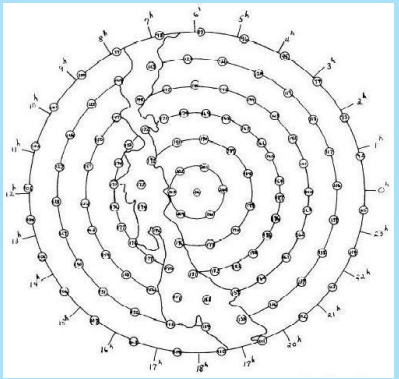


- However, Kapteyn discovered the Two Star Streams, showing two preferred directions.
- He first presented that at a Congress during the 1904 Louisiana Purchase Exposition.

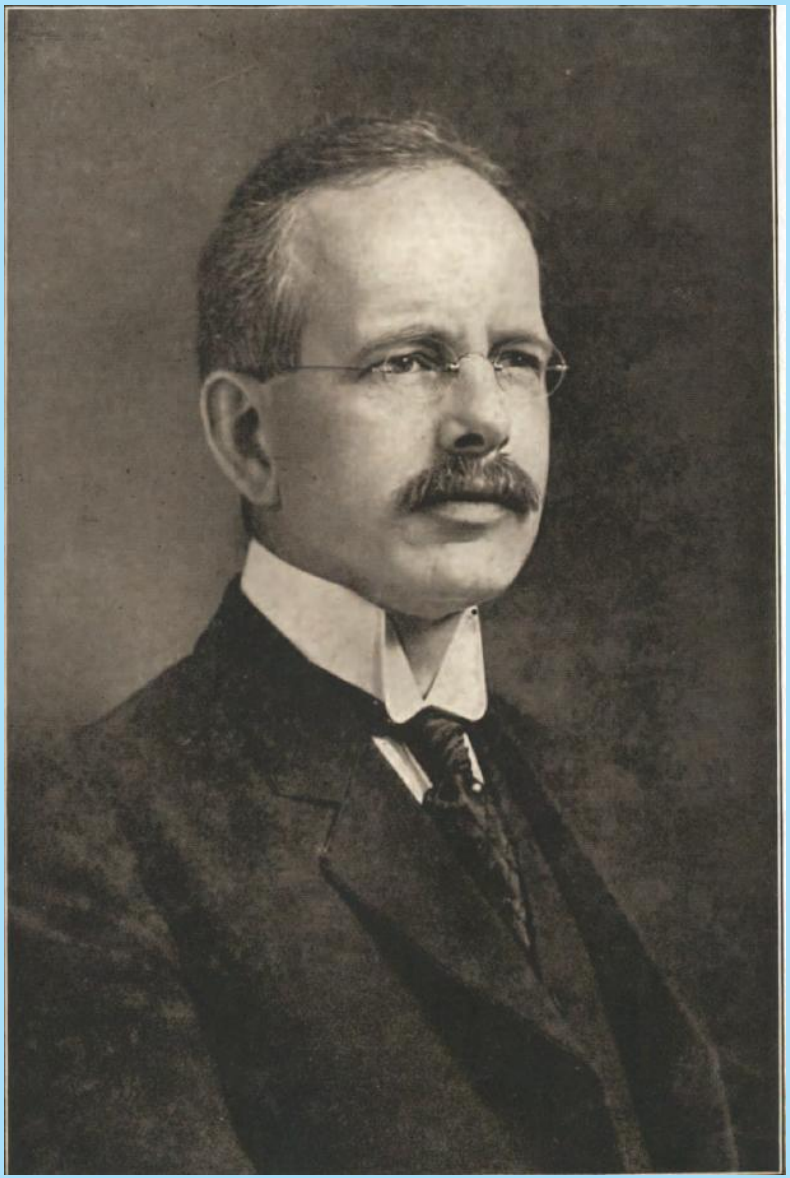


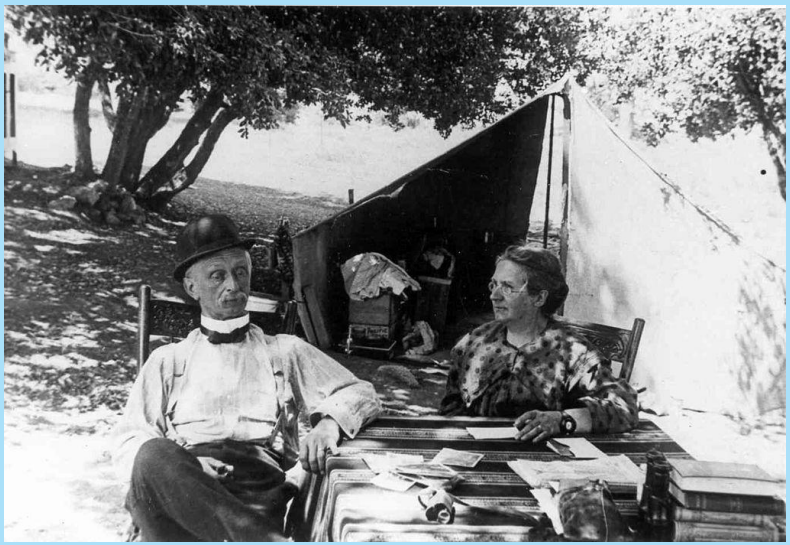
- The concept of Star Streams was quickly confirmed, a.o. by Arthur Eddington.
- Karl Schwarzschild proposed that the explanantion was an anisotropic velocity ellipsoid.
- But the stellar composition of the two Streams was very different.
- The Streams had to be taken into account in the study of the distribution of stars in space.



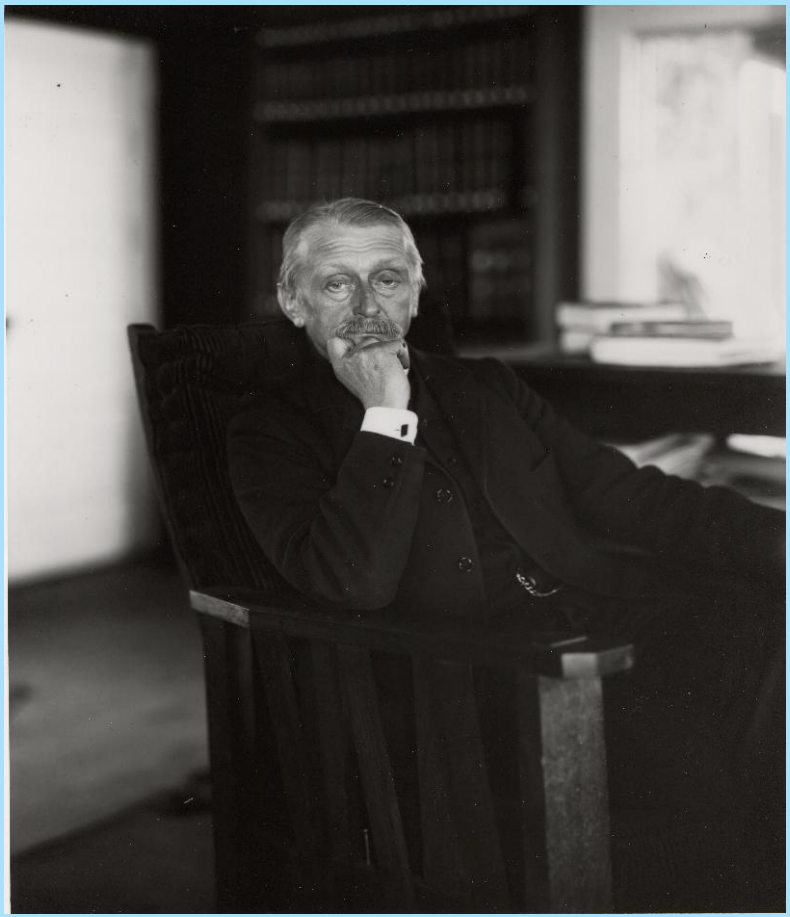


- He devised the Plan of Selected Areas after discussion with many colleagues.
- Eventually it became 220 areas in the 'Systematic Plan' (+46 in the 'Special Plan').
- All measurable properties of stars should be determined.





- In St. Louis he met George E. Hale of the Mount Wilson Observatory
- Kapteyn was appointed staff associate for three months/year.
- He went to Mt. Wilson each year from 1908 to 1914.

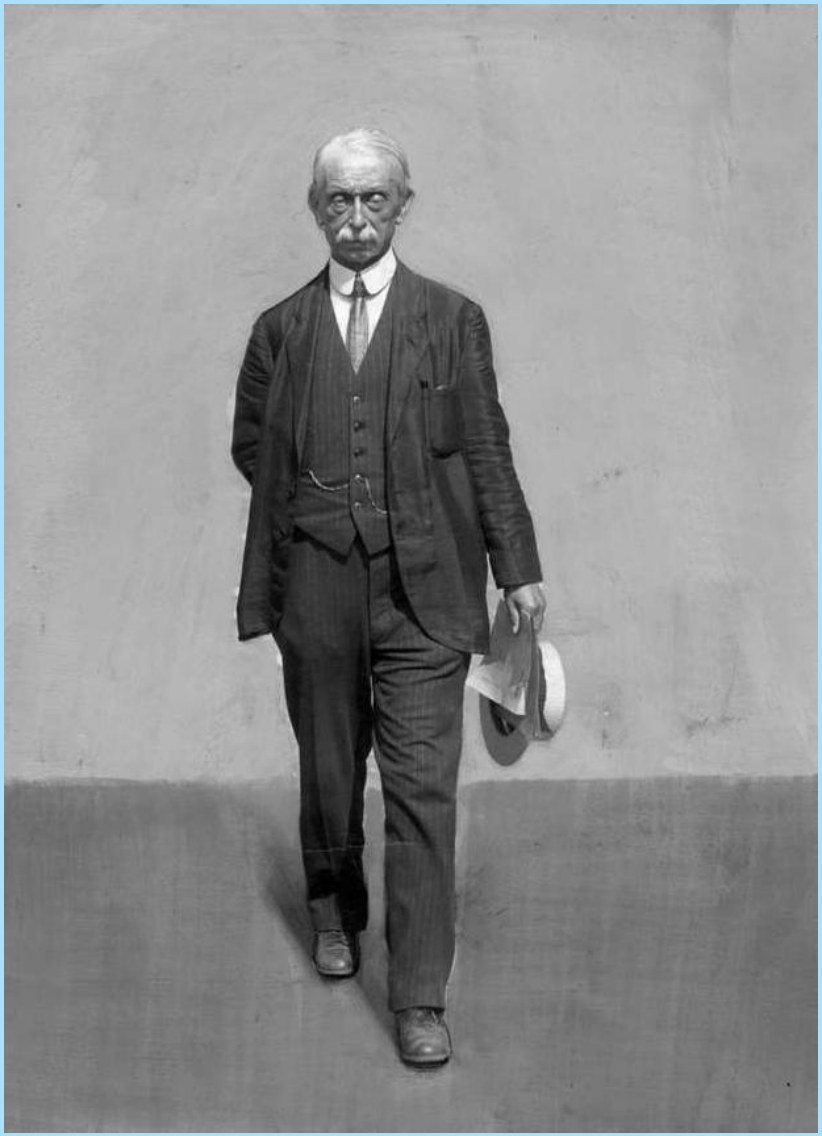


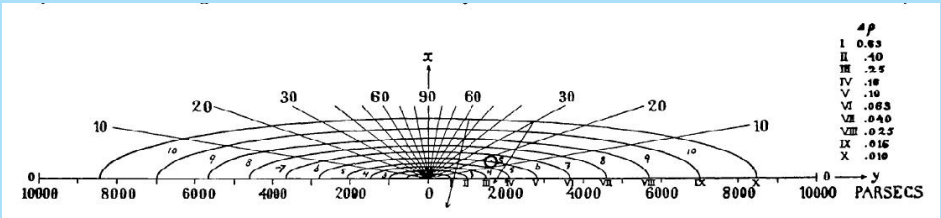
- Hale adopted the Plan as the prime program for his new Mount Wilson 60-inch.
- The star counts in the Selected Areas project did come along well.
  - Harvard-Groningen with Pickering (1918/23/24): all sky down to mag. 16 .
  - Mt. Wilson-Groningen with Seares (1930): north down to mag. 19.
- Contributions of 28 observatories in 11 countries.

JACOBUS CORNELIUS KAPTEYN

(Fotografie door ALBERT KAPTEYN)

- The problem Kapteyn worried about very much was that of extinction or absorption by interstellar dust.
- He deduced it would produce reddening and found (1909) a reasonable ~ 0.3 mag/kpc (also van Rhijn's PhD thesis).
- Could be due to correlation color-absolute magnitude.
- Shapley showed (1916) space was transparent towards M13.





- In the end he produced the Kapteyn Universe, which had the Sun close to the center.
- He did derive a correct vertical distribution.
- Using velocities he laid the foundations for studies of galactic dynamics.
- First determination of local mass density.

- Kapteyn introduced the concept of the astronomical laboratory.
- As quoted by Willem de Sitter:
  - This was listed by Baillaud, first IAU president in Rome in 1922 as one of the three most important recent developments.
  - The other two were astronomical photography and giant telescopes.
- But rather overinterpreted.

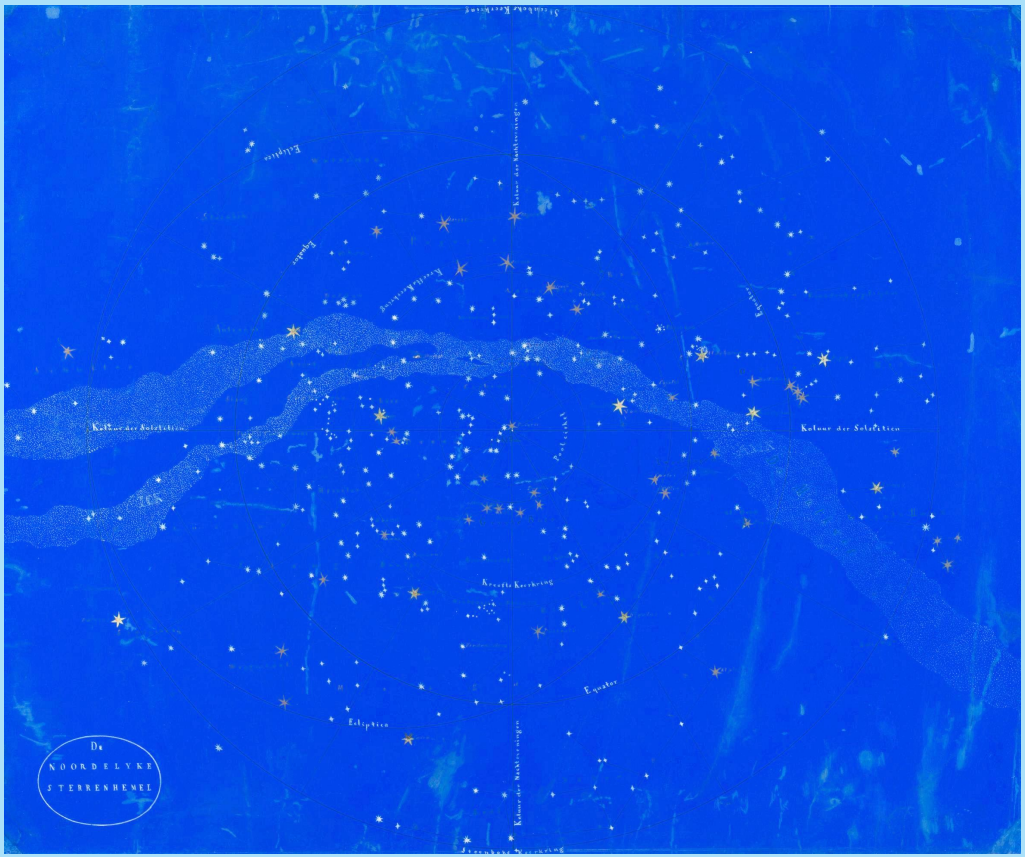
- After retirement, Kapteyn became parttime adjunct-director in Leiden.
- The Kapteyns first stayed with their daughter in Amsterdam and bought a house in Hilversum.

- Kapteyn never lived there; after a prolonged illness he died in Amsterdam on **June 18, 1922**.

Born investigator of the heavens?

Accidental astronomer?

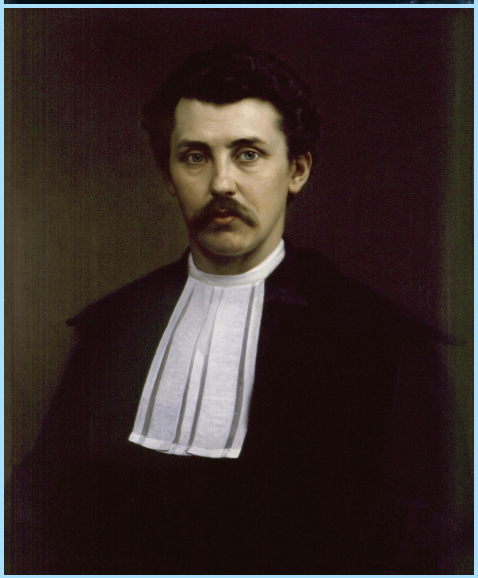
- It is usually stated that Kapteyn by accident entered astronomy.



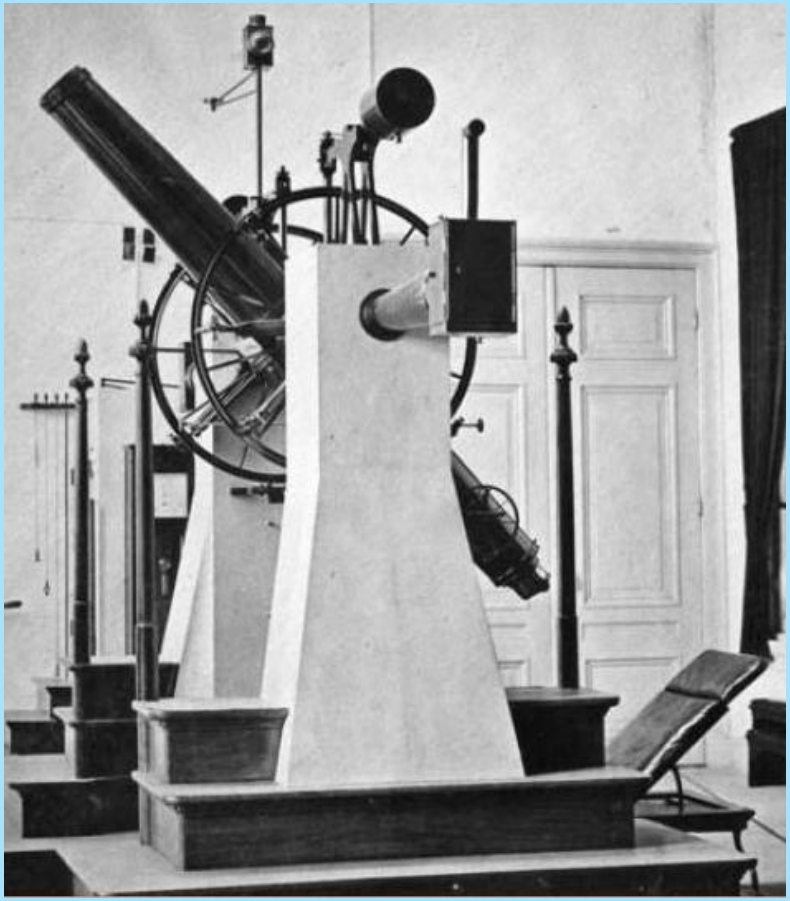
- But there is evidence that Kapteyn as a child already had a special interest in astronomy.
- As a boy of 14 he made a starmap after his older sister had given him a star globe.
- HHK says:

- *'When his father noted how seriously he studied the stars, he bought a large telescope for him, that was erected in the attic room and with which he very diligently observed the stars.'*

- Various sources, including a brochure of the boarding school, mention that 'Benno' had an 'observatory'.



- Buys Ballot was first responsible for astronomy teaching and supervised one astronomical thesis (1871).
- In 1856 J.A.C. Oudemans was appointed, but he left to Dutch Indies (as geographer) in 1857.
- Eventually M. Hoek was appointed for astronomy teaching (1859).
- He was mostly interested in ether experiments and had no PhD students.
- He also had a poor health and died in 1873.
- Oudemans came back as professor of astronomy in 1875.



- So, Kapteyn had no option for an astronomy thesis in Utrecht.
- How did he get appointed in Leiden?
- The 'Sterrewacht' had H.G. van de Sande Bakhuyzen as director, and K.W. Valentiner and E.F. van de Sande Bakhuyzen as 'observator'.
- In 1875 Valentiner became director in Mannheim, creating a vacancy in Leiden.
- Van de Sande Bakhuyzen proposed that his brother become first and J.C. Kapteyn second observator.

- There is an unusual exchange of letters *directly* between the Minister and van de Sande Bakhuyzen.
- September 21, 1875. The Minister suggests that maybe Dr. W. Gleuns should be considered as well for the position.
- After all, Gleuns had been involved in calculations for van de Sande Bakhuyzen and was looking for a job.
- Father Gleuns was a mathematician, teacher in secondary schools in Groningen and author of many books for schools.
- September 22, 1875. Van de Sande Bakhuyzen writes back immediately.
- Draft unreadable, but original in National Archives.
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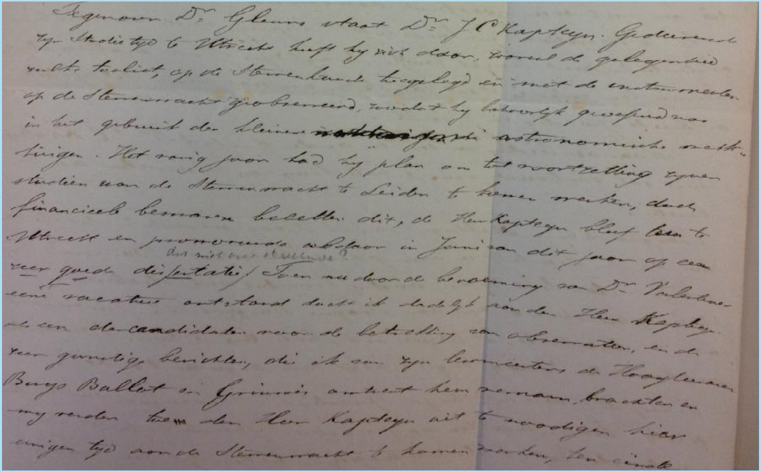
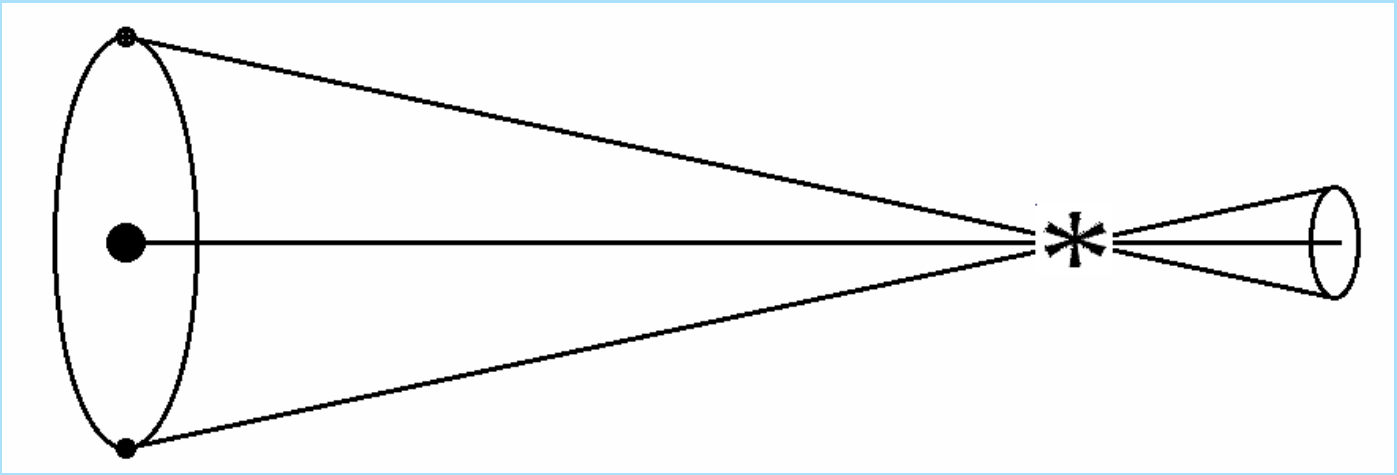

Tegenover Dr. Gleuns staat Dr. J.C. Kapteyn. Gedurende
zijn studietijd te Utrecht heeft hij zich, doordien, toen al de gelegenheid
zulks toeliet, op de Sterrenkunde toegelegd en met de instrumenten
op de Sterrenwacht geobserveerd, zoodat hij behoorlijk geoefend is
in het gebruik der kleinere [illegible] astronomische werk-
tuigen. Het vorig jaar had hij plan om tot voortzetting zijner
studiën aan de Sterrenwacht te Leiden te komen werken, doch
financieele bezwaren beletten dit, de Heer Kapteyn bleef dus te
Utrecht en promoveerde aldaar in Junij van dit jaar op een
dus niet over sterrenkunde?
zeer goede dissertatie. Toen nu door de benoeming van Dr. Valentiner
eene vacature ontstond dacht ik dadelijk aan den Heer Kapteyn
als een der candidaten voor de betrekking van observator, en de
zeer gunstige berichten, die ik van zijne leermeesters de Hoogleeraren
Buys Ballot en Grinwis omtrent hem vernam, brachten er
mij toe om den Heer Kapteyn uit te noodigen hier
eenigen tijd aan de Sterrenwacht te komen werken, ten einde

- Van de Sande Bakhuyzen strongly opposed Gleuns as being a mathematician with no affiliation to astronomy.
- From September 22, 1875 letter:
  - *'Vis-a-vis Dr. Gleuns we have Dr. Kapteyn. During his studies in Utrecht he has, as much as opportunities allowed, devoted himself to astronomy and has observed with instruments at the observatory so that he obtained consideable familiarity with the use of astronomical apparatus. Last year he took up the plan to continue his studies at the Observatory in Leiden, but financial considerations prevented this. Mr. Kapteyn did stay in Utrecht and obtained his degree there in June of this year with a very good thesis.'*
- So, Kapteyn had earlier contacted van de Sande Bakhuyzen and even tried to do an astronomical PhD thesis in Leiden.

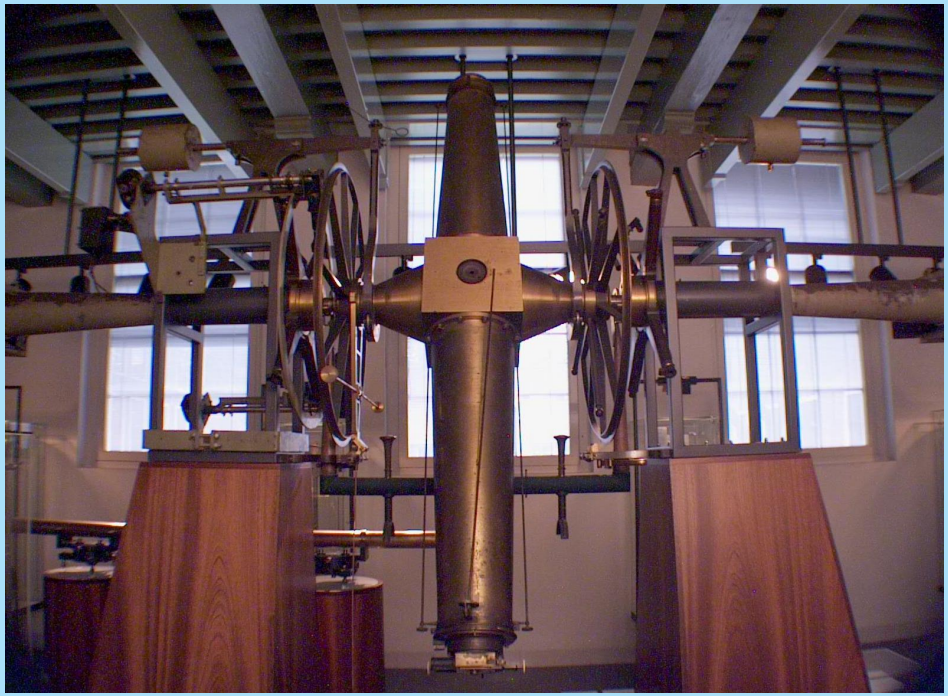
- Van de Sande Bakhuyzen continues:
  - *'When the appointment of Dr. Valentiner created a vacancy, I immediately thought of Mr. Kapteyn as one of the candidates for the position of observator and the very positive words I received from his professors Buys Ballot and Grinwis about him made me decide to invite Mr. Kapteyn to work at the Observatory in order to decide to what extent he was a suitable candidate for the position of observator. Mr. Kapteyn accepted this offer and worked here for about 3 months, during which time he has completely confirmed the favorable expectations I initially had of him. Although he is not yet familiar with all the observing techniques he will have to perform, he has shown not the be second to any more experienced astronomer.'*
- Van de Sande Bakhuyzen had invited Kapteyn to come to Leiden for a trial period.

- Kapteyn had an interest in astronomy from a young age onward.
- Kapteyn did as much astronomy as possible in Utrecht, but could not do a PhD thesis there.
- Kapteyn tried to move to Leiden to do a thesis, but was prohibited by finances.
- Van de Sande Bakhuyzen thought of Kapteyn, when Valentiner left.
- Kapteyn actually worked on trial basis in Leiden for a few months.
- Kapteyn certainly did not enter astronomy 'by accident'.

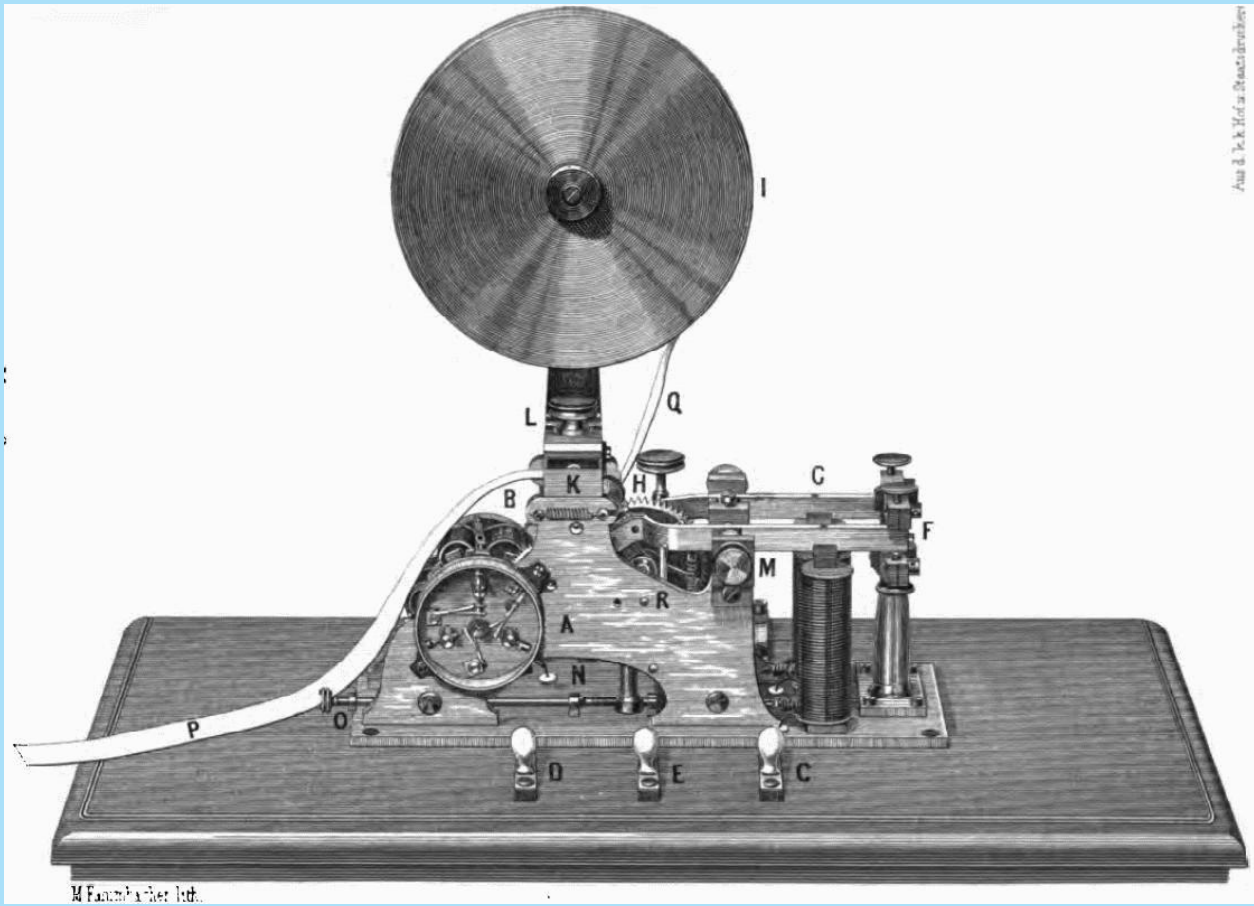
Trigoniometric parallaxes.



- Kapteyn started a program to measure annual parallaxes by differential meridian timing measurements.
- This was felt to be too difficult.
- If parallax is 0.1 arcsec and its declination 50°, then parallax corresponds to time difference of 0.02 seconds of time.



- So you need extremely accurate timings.
- Only possible with many repeated measurements.
- He selected 15 stars with high proper motion that may be not too distant, and observed these with the meridian circle of Leiden Observatory in academic vacations.



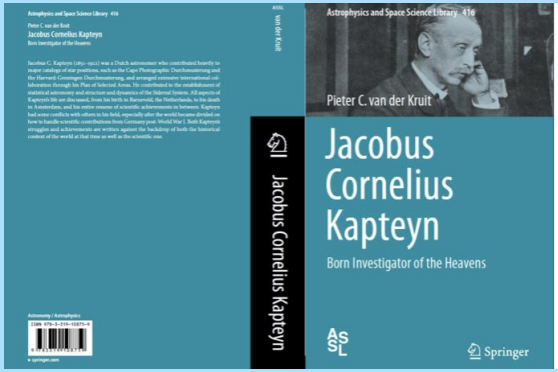
- Kapteyn used a 'Registrir-Apparat' or strip recorder on the Leiden meridian circle (during academic vacations).
- Results published in Astronomische Nachtichten (preliminary) in 1889 and in Annalen van de Sterrewacht te Leiden in 1891.

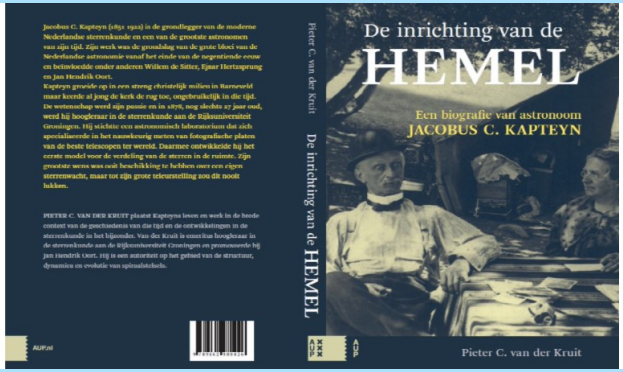
Star	$p_{\rm Kapteyn}$ milli-arcsec	HD	$p_{\rm modern}$ milli-arcsec	Remarks
BB VII 81 (pr.)	74 ± 27	79210	172.06 ± 6.31	Flare star; binary
		79211	156.45 ± 8.58	Flare star; binary
θ Ursa. Maj.	52 ± 26	82328	74.19 ± 0.16	Spectroscopic binary
BB VII 85	64 ± 22	84031	54.89 ± 0.92	Variable star
20 Leon. Min.	62 ± 29	86728	66.46 ± 0.32	High proper-motion star
BB VII 89	176 ± 24	88230	205.21 ± 0.34	Flare star
BB VII 94	101 ± 26	90508	43.65 ± 0.43	High proper-motion star
BB VII 95	38 ± 27	91347	26.48 ± 0.59	High proper-motion star
Lal. 20670	-6 ± 28	92855	26.84 ± 0.50	Star in double system
BB VII 104	428 ± 30	95735	392.64 ± 0.67	Flare star
BB VII 105	168 ± 27	–	206.27 ± 1.00	High proper-motion star
BB VII 110	30 ± 27	101177	43.01 ± 0.73	Spectroscopic binary
BB VII 111	16 ± 32	102158	20.29 ± 0.70	Star in double system
BB VII 112	139 ± 26	103095	109.99 ± 0.41	High proper-motion star
BB VII 114	-28 ± 42	104556	17.5 ± 0.51	High proper-motion star
BB VII 119	56 ± 34	105631	40.77 ± 0.66	High proper-motion star

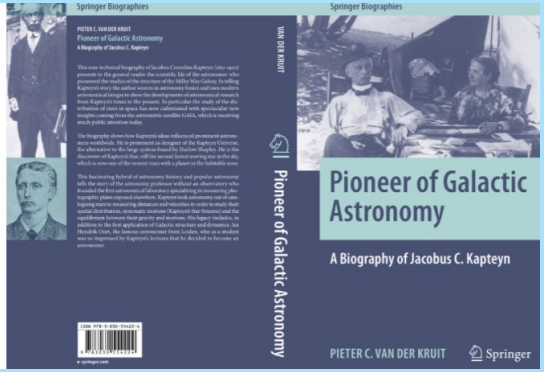
This really is very, very good!!

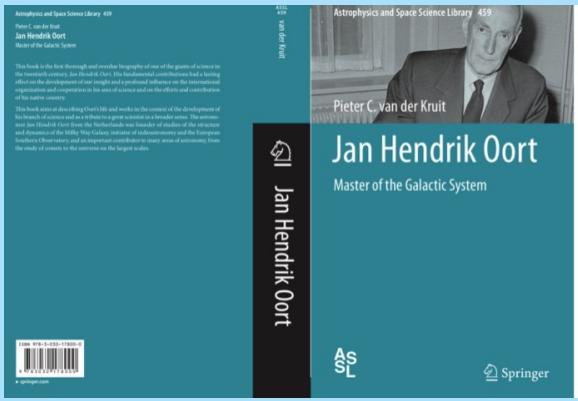
Further reading:

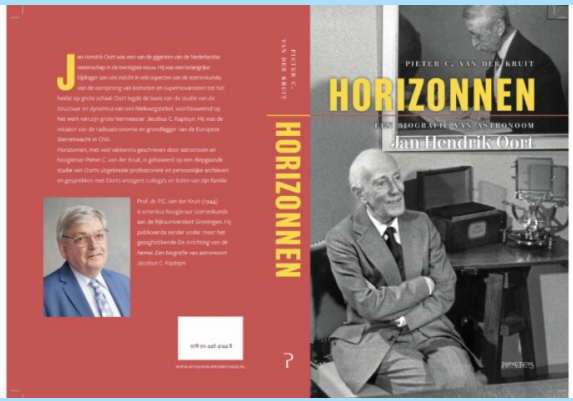
The result of my studies of Kapteyn in the end led to six books ....

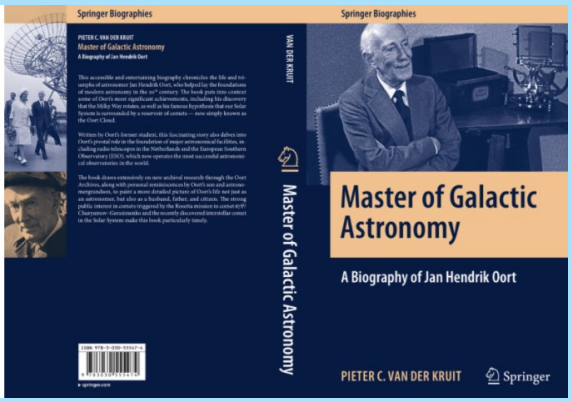




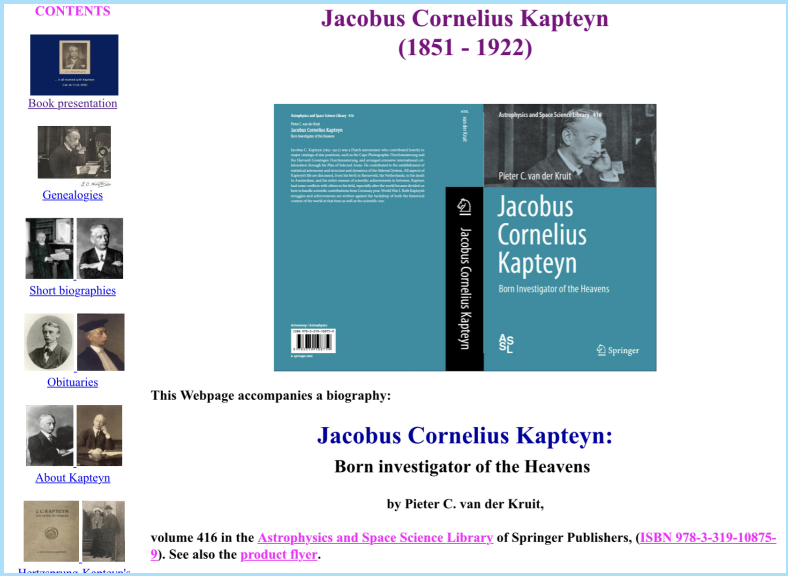








... and to two Websites.



www.astro.rug.nl/JCKapteyn & www.astro.rug.nl/JHOort

That's all folks