Jan Hendrik Oort (1900–1992)

Master of the Galactic System

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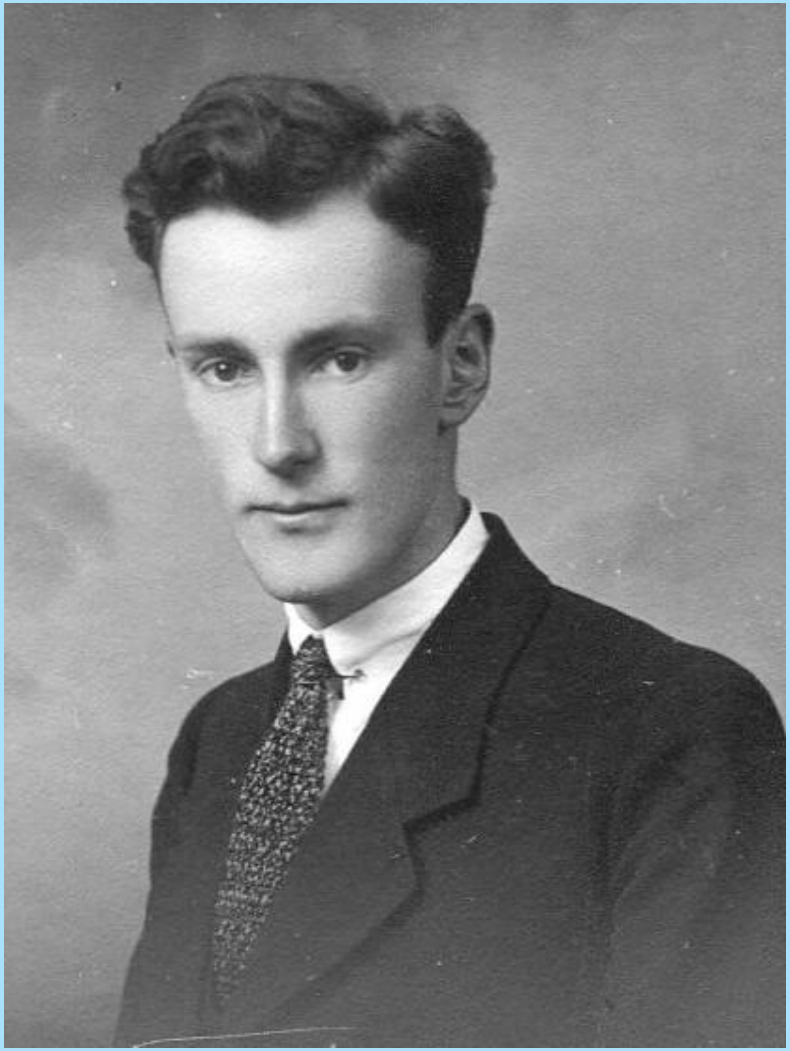
Introduction



- Oort grew up in Oegstgeest near Leiden.
- His father was a psychiatrist.
- But his ancestors from both sides were all clergymen.
- In 1917 Oort went to study physics or astronomy in Groningen because of the fame of Jacobus Kapteyn.
- Kapteyn's lectures made him quickly decide to become an astronomer.

J.C. Kapteyn (1851–1922) by Jan Veth, courtesy Jack Kapteyn.

Oort about Kapteyn (1981, Ann.Rev.):

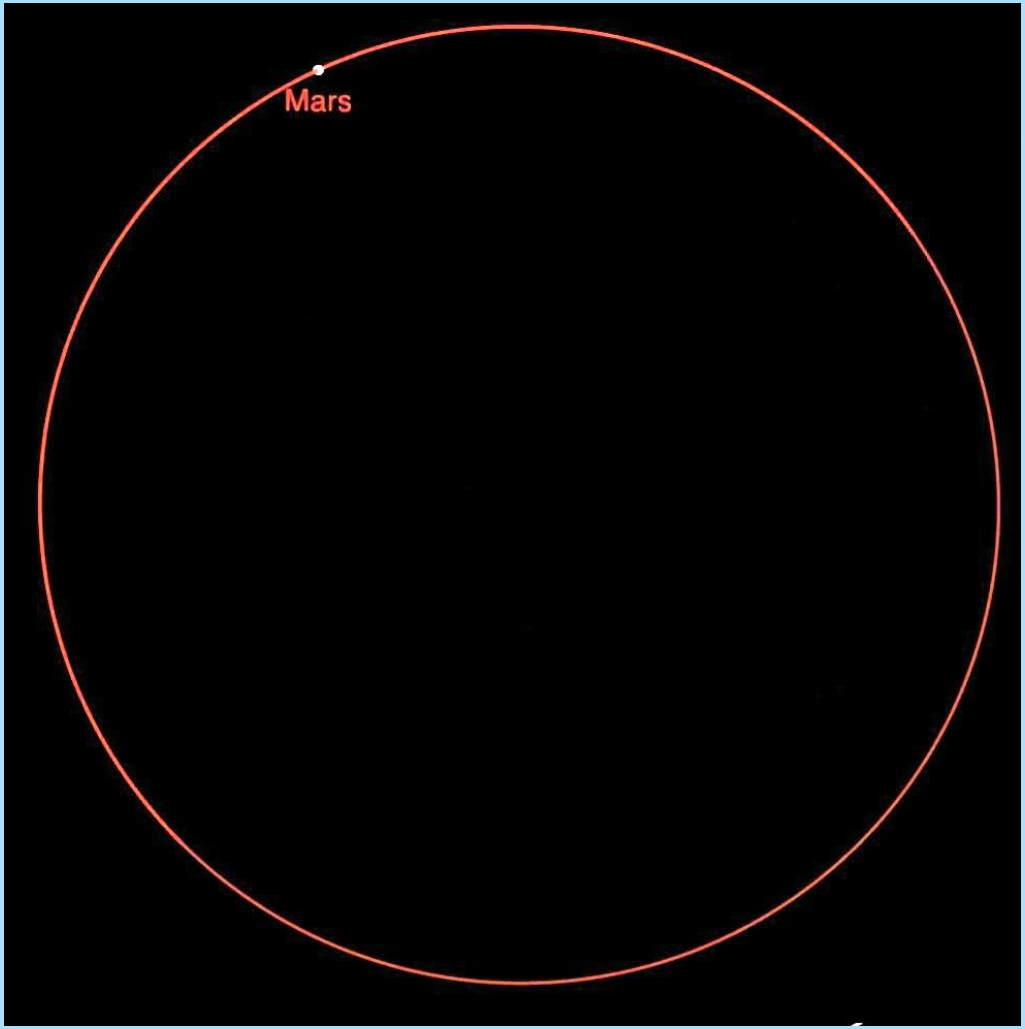
'Perhaps the most significant thing I learned – mainly, I believe, from Kapteyn's discussion of Kepler's method of studying nature – was to tie interpretations directly to observations, and be extremely wary of hypotheses and speculations.'

'Two things were always prominent: first the direct and continuous relation to observations, and secondly to always aspire to, as he said, 'look through things' and not be distracted from this clear starting point by vague considerations.'

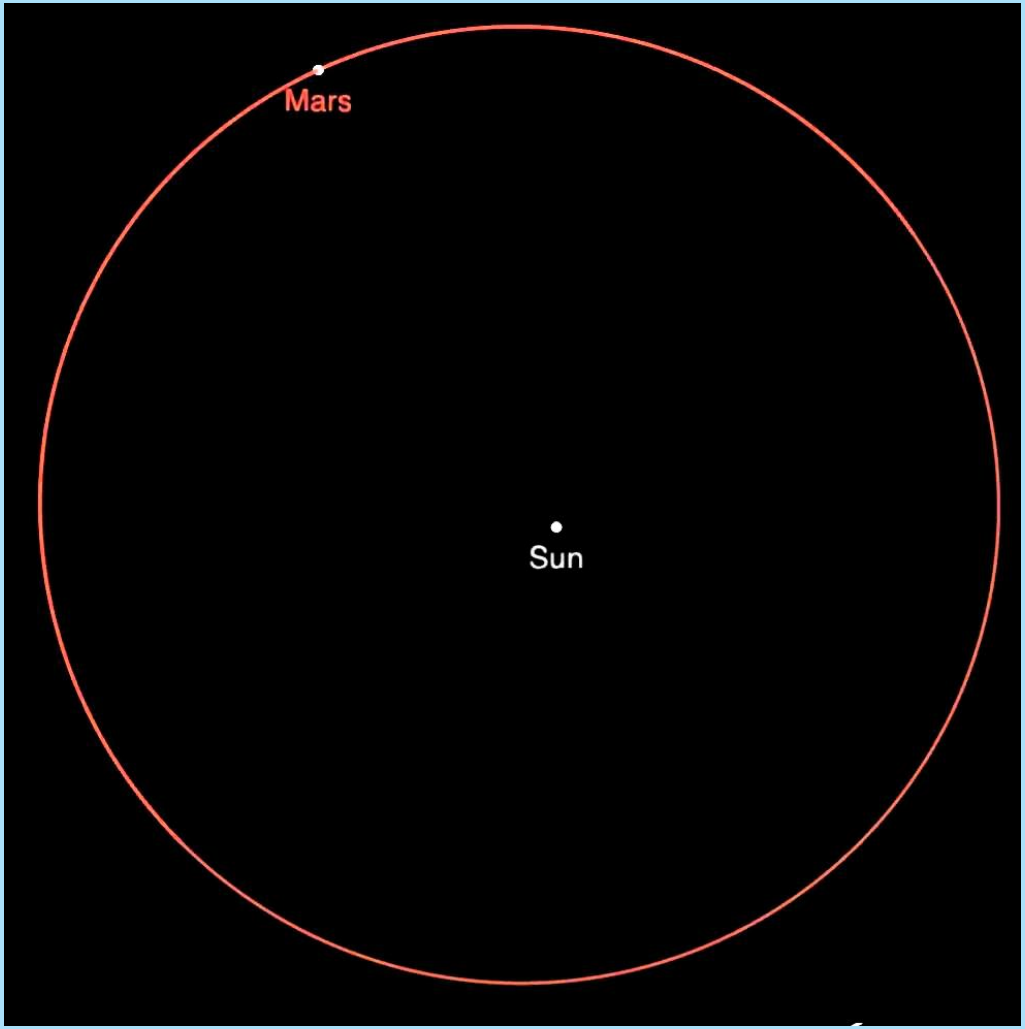
Oort, Kapteyn and Kepler

Johannes Kepler (1571–1630)

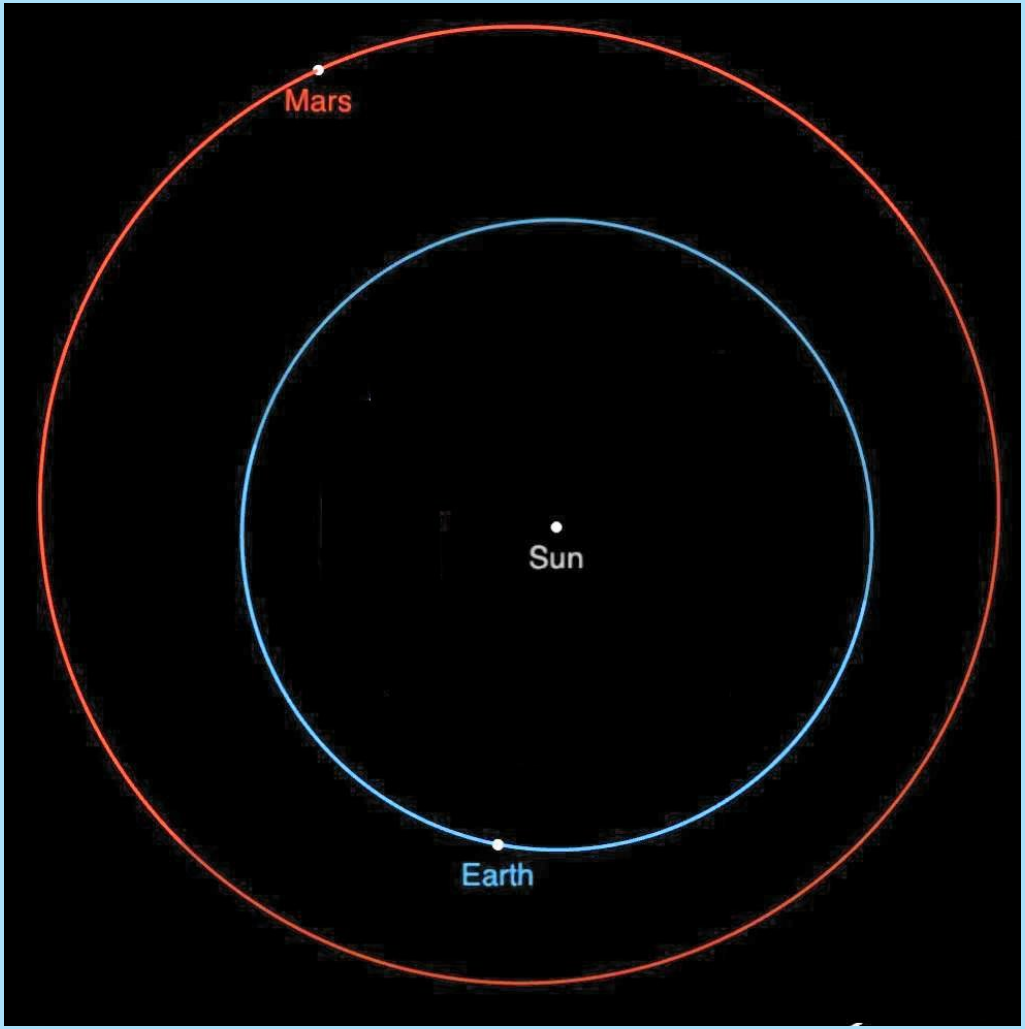
- What was Kepler's method of studying nature?
- What did Kapteyn cover in his lectures?
- The Oort Archives have Oorts notes from Kapteyn's lectures and for his own lectures.
- We have to go to the development of our understanding of the nature of the planetary orbits.



- Since Kepler we know that planets move in elliptical orbits with the Sun in one of the foci.
- This is Kepler's first law.
- Here is the elliptical orbit of Mars.

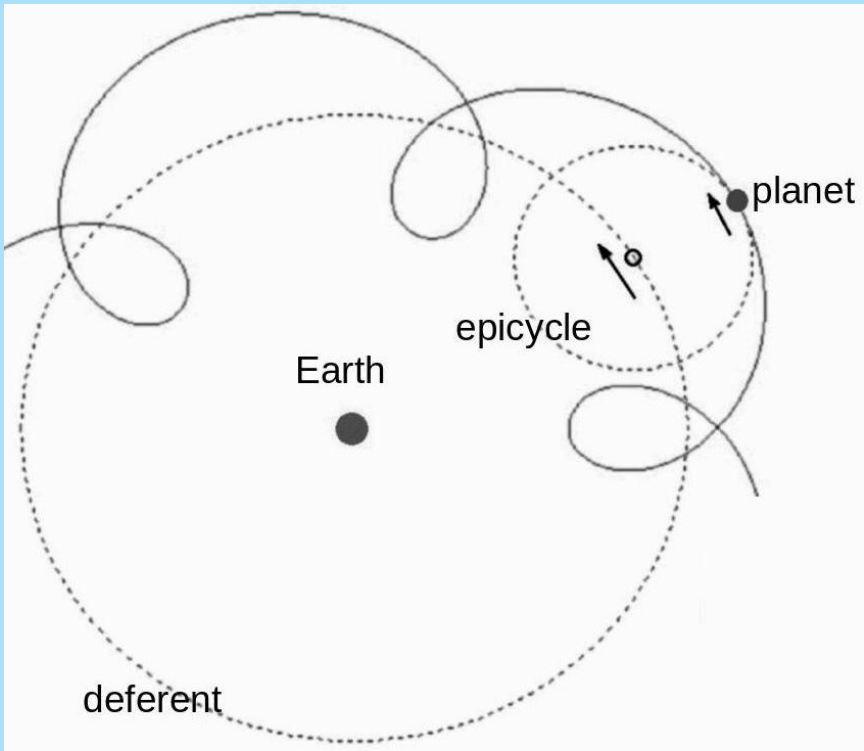


- Showing the position of the Sun shows the elliptical nature somewhat better.
- The planet moves faster when in perihelion (closest to the Sun) and slower in aphelion (farthest from it).
- This is Kepler's second law, or really conservation of angular momentum.

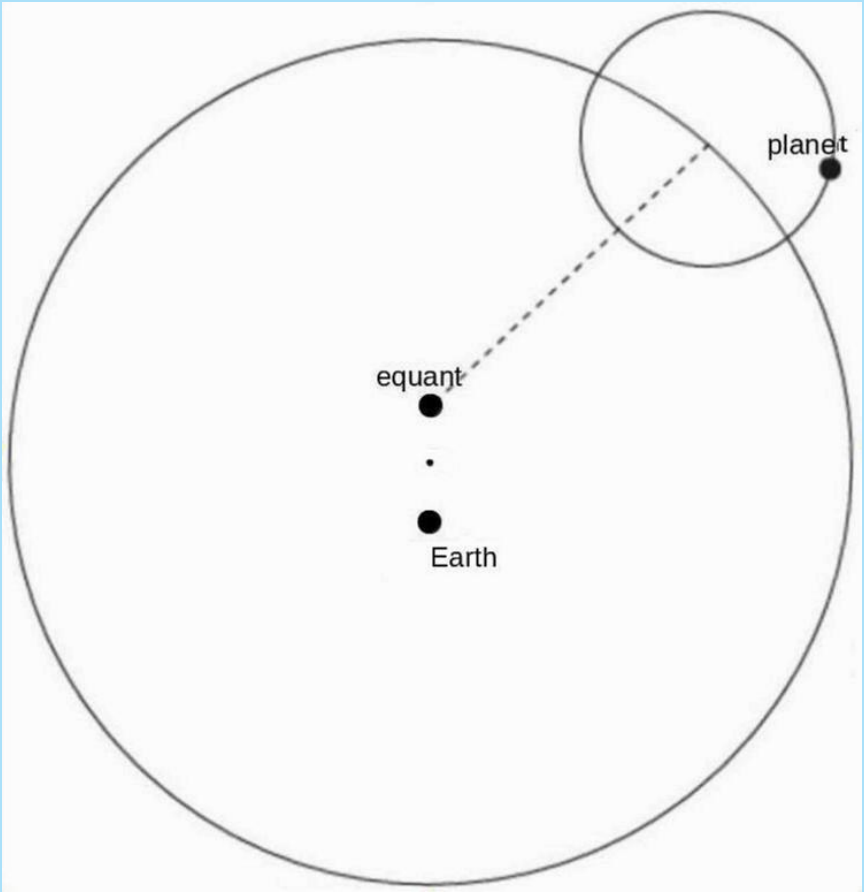


- Here the less elliptical orbit of the Earth has been added.
- How did Kepler arrive at his laws?
- This is the subject of Kapteyn's lectures (and Oort's and mine).
- We have to back to the geocentric model of Antiquity.

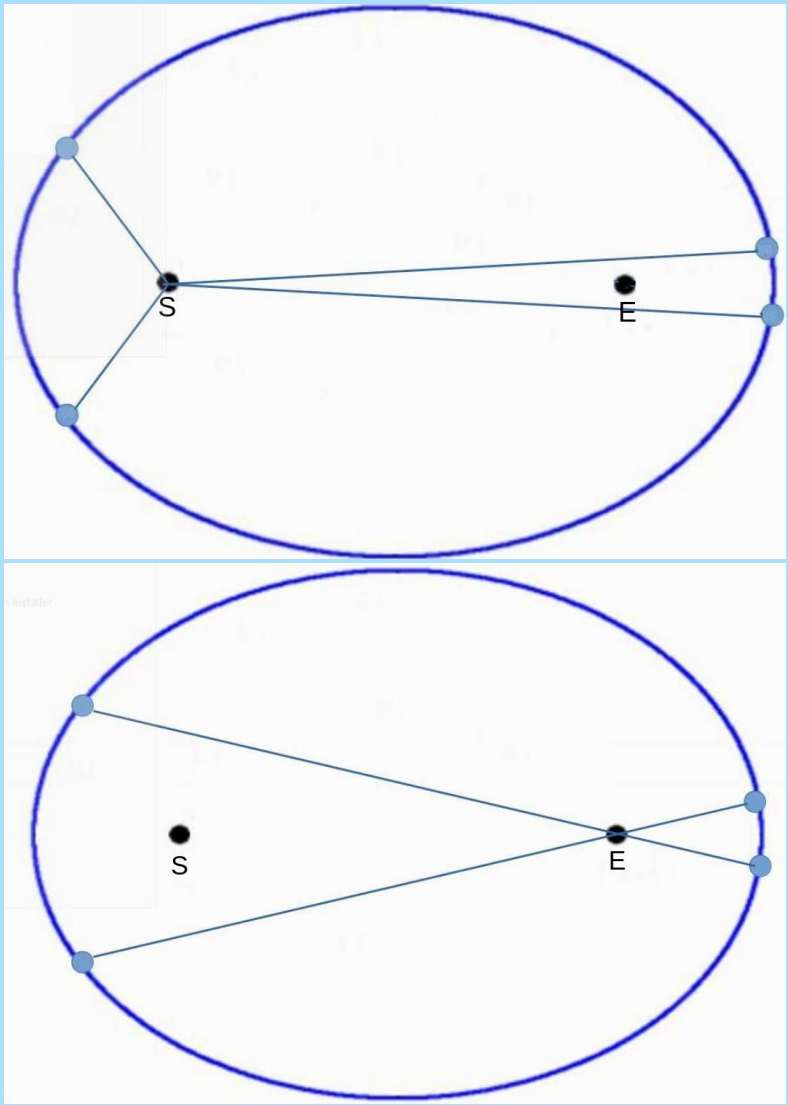
- The planets move in complicated orbits on the sky, because they are seen from a moving Earth.
- This maybe a loop or a Z-shape, due to slightly different planes of the orbits.
- This occurs around opposition.
- The problem was how to explain that.



- The paths of the planets were described by an epicycle with its center moving on a deferent centered on the Earth.
- For outer planets the deferent really is the orbit of the planet around the Sun and the epicycle that of the Earth.
- The problem was that following Plato and Aristotle the motions were required to be on pure circles with uniform velocity.
- This is bound to give problems because these are really ellipses with varying speeds.



- Ptolemy ($\pm$100–$\pm$170) corrected for the differences by putting the Earth off-center and letting the angular velocity be constant from the equant.
- This may have been acceptable practice at the time, but would in modern times it will be seen as fudging or cheating.
- Why did this work so well?

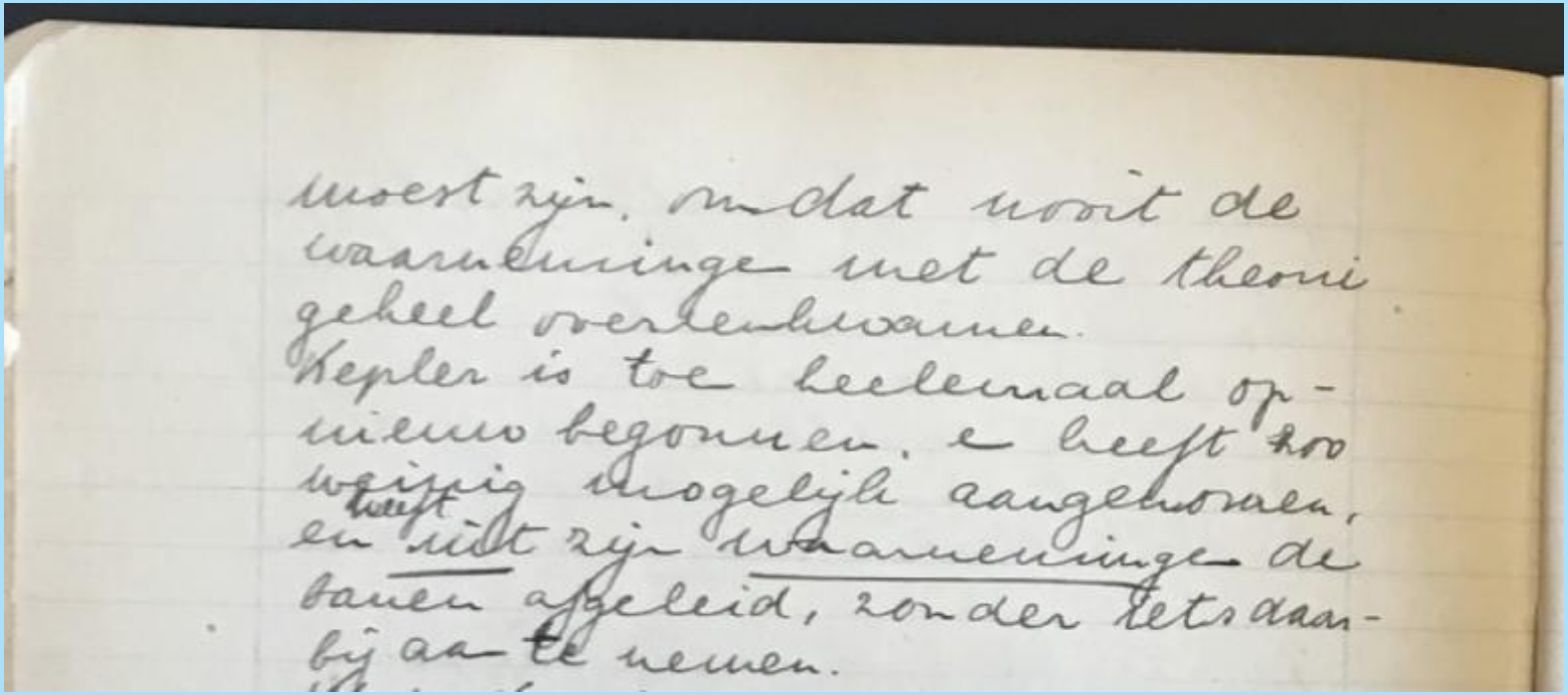


- The time interval between the two points left and the two points right is equal.
- (Top) From the Sun the areas of the two triangles are equal.
- (Bottom) From the empty focus angles are equal.
- So the angular velocity from the Sun varies.
- So the angular velocity from the empty focus is (almost) constant, just as Ptolemy's equant requires!

For astronomers:

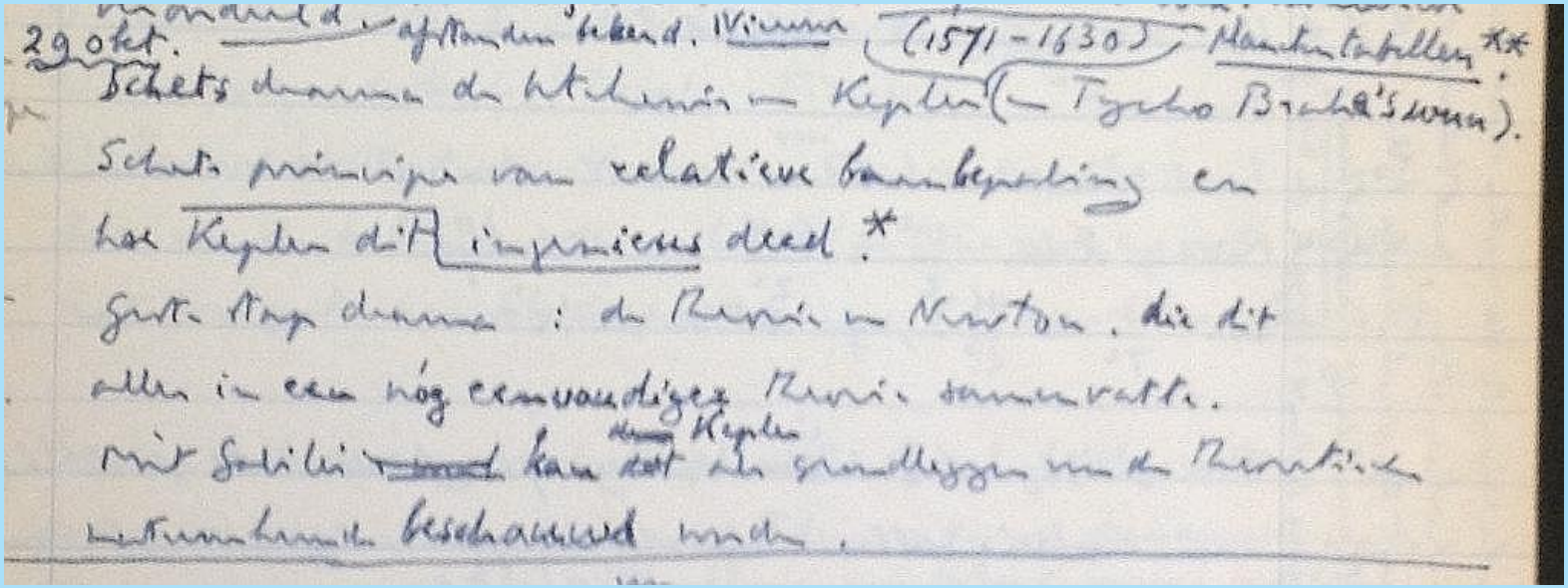
	Solar focus $\frac{d\nu}{dt} \propto \frac{\sqrt{1-e^2}}{(1-e\cos E)^2}$	empty focus $\frac{d\nu'}{dt} \propto \frac{\sqrt{1-e^2}}{1-e^2\cos^2 E}$
Earth (e=0.0167)	$\pm 3.4\%$	$\pm 0.014\%$
Mars (e=0.0934)	$^{+21.5}_{-16.3}\%$, $\pm 18.9\%$	$\pm 0.4\%$

- Tycho Brahe (1546–1601) measured the most accurate positions.
- Kepler had worked with him in Prague and used his data.
- He accepted the heliocentric model and thus variable orbital speeds.
- He tried various fits, including free equant positions.
- There remained an 8 arcmin discrepancy (1€ @ 10m).
- Too small for Ptolemy, but measurable for Brahe.



Oort's notes (1917) from Kapteyn's lectures.

'Kepler then started completely from scratch and made as few assumptions as possible, and deduced the orbits from his observations, without any hypotheses.'

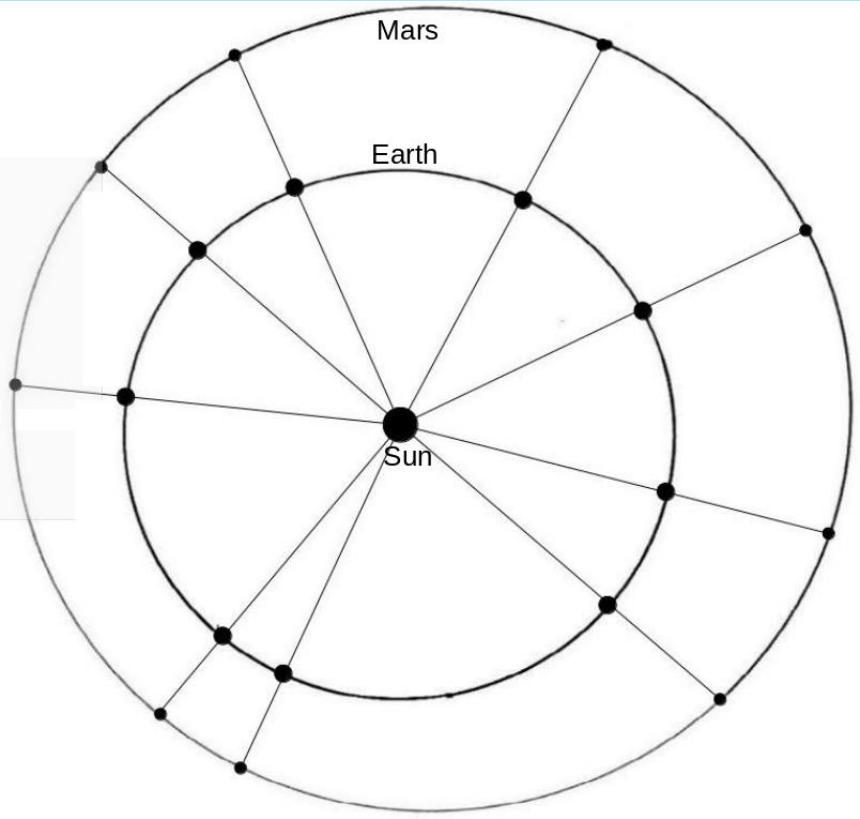


Oort's notes for his lectures on the planetary system (1964/5):
'Sketch the principles of determination of relative orbits and the ingenious manner in which Kepler did this.

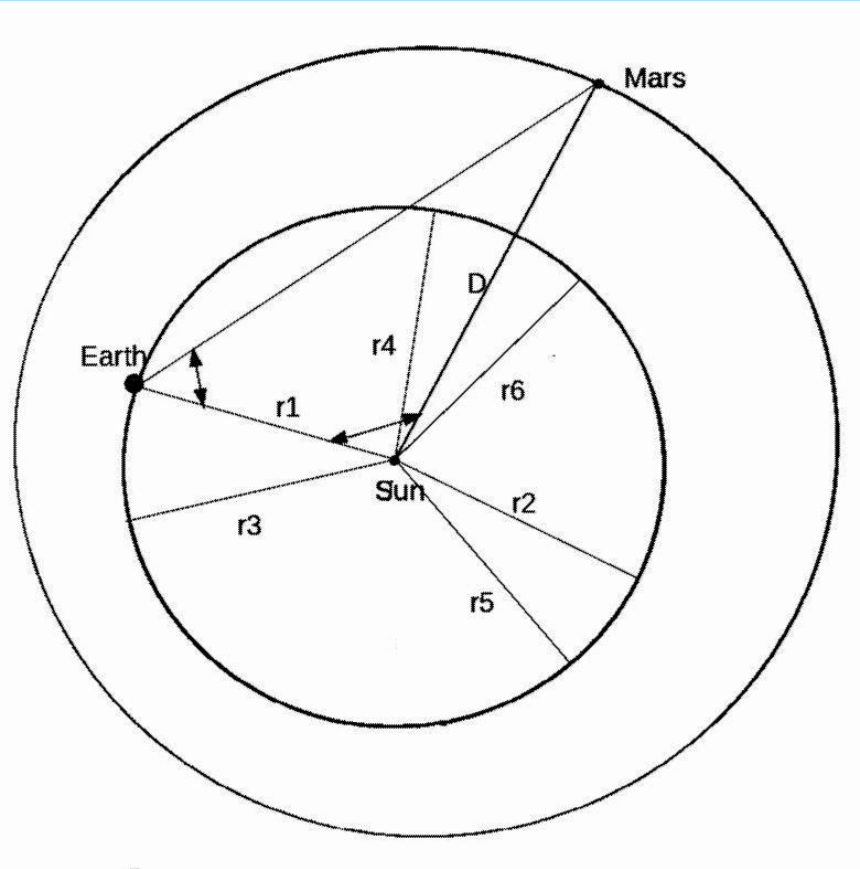
...

With Galileo, Kepler can be regarded as the founder of theoretical physics.'

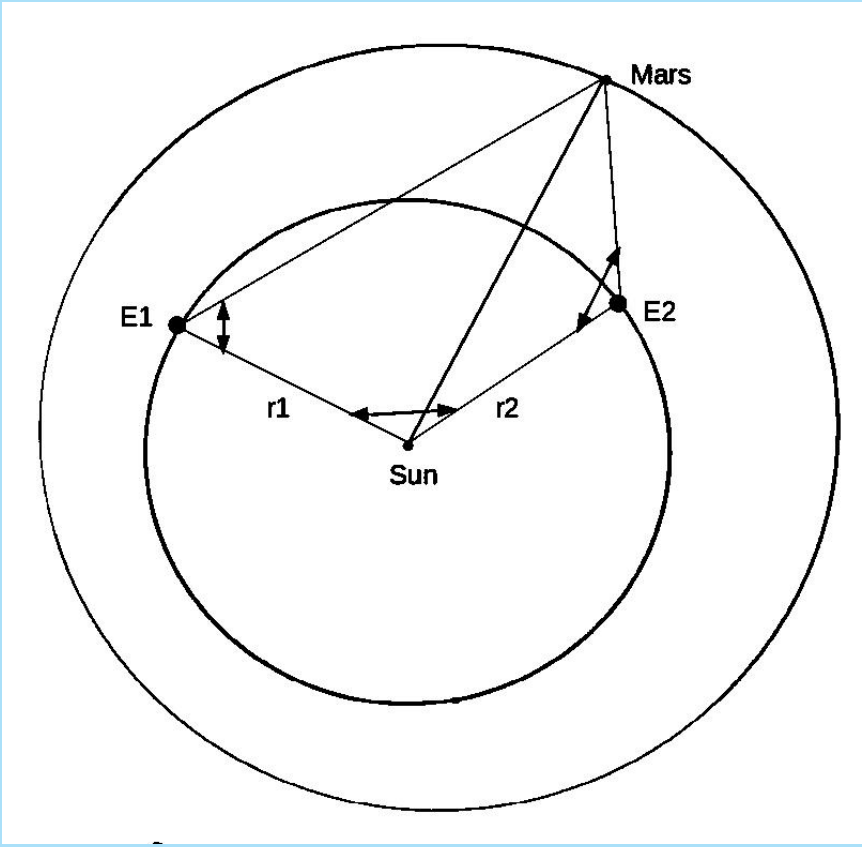
- So what was this ingenious manner in which Kepler did this?



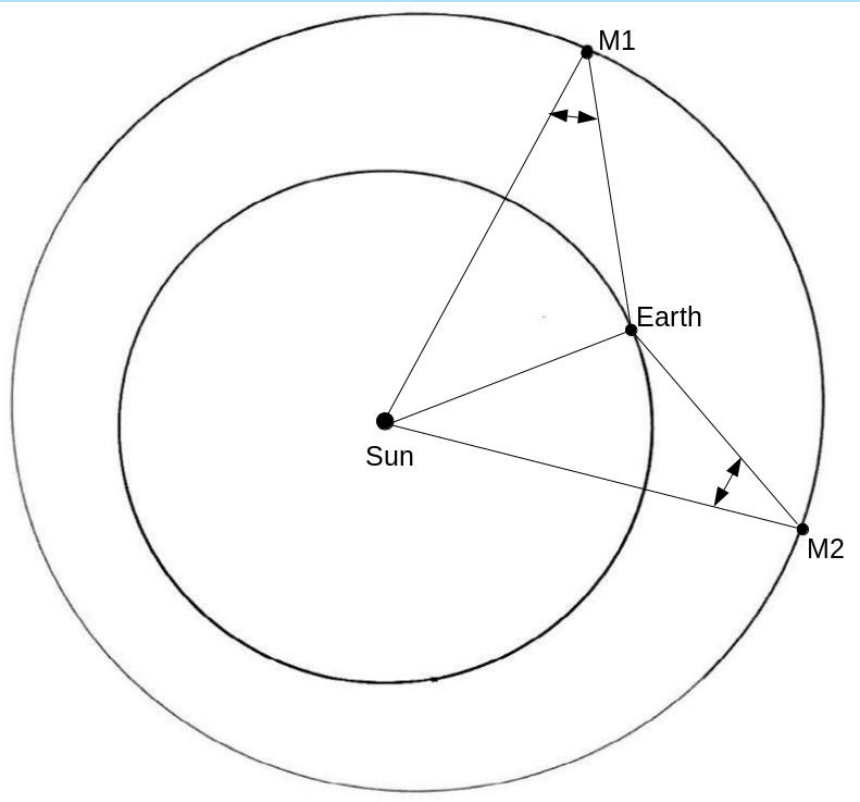
- Kepler started by collecting oppositions of Mars.
- The direction of the Sun w.r.t. stars gave the direction of the Earth from the Sun.
- So he knew many directions and times of Mars' orbit,
- This gave him the period of Mars (686.95 days).



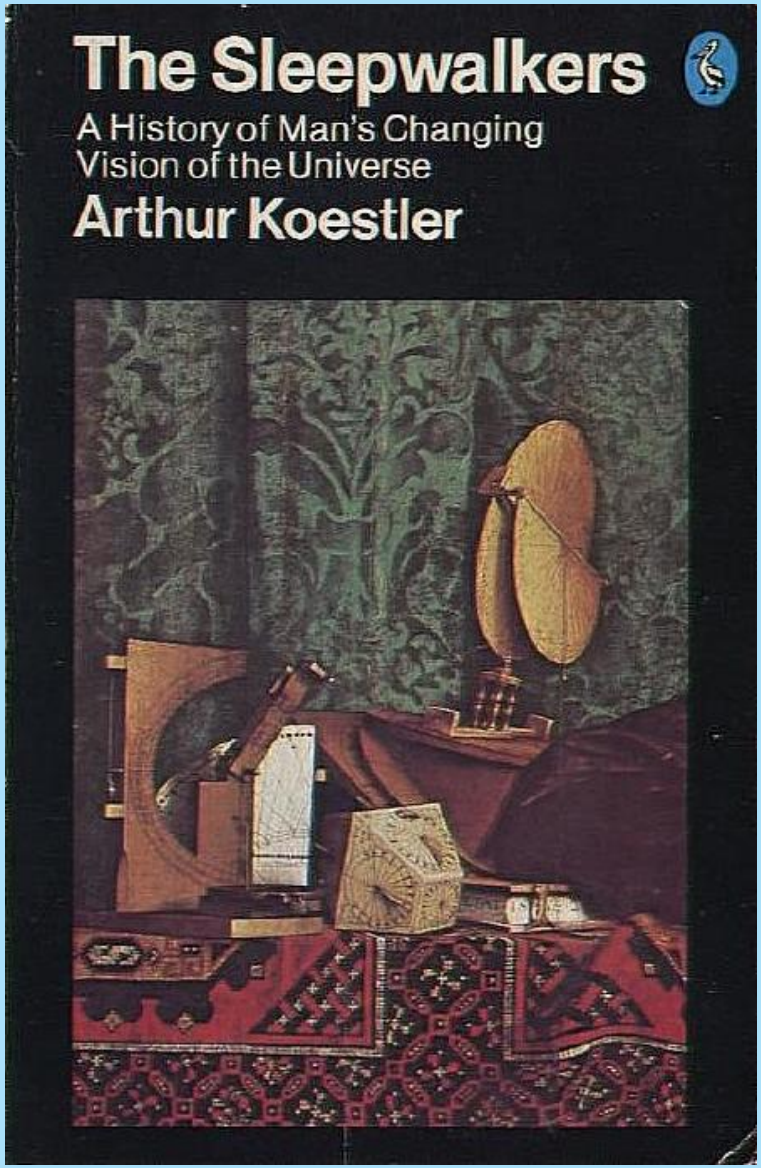
- He then selected dates at which Mars was in the same place in its orbit.
- Of the triangle Earth-Sun-Mars he knew now all angles.
- So he calculated $r1$ in terms of D.
- He repeated that for $r2$, $r3$, etc., and determined the shape of the orbit of the Earth.



- He then took two observations during which Mars was at the same place in its orbit and the Earth at E1 and E2.
- Since he now knew the Earth's orbit, he knew $r1$ and $r2$, and the angle between these two.
- And for both observations of Mars he knew the angles between the Sun to Mars.
- So he could draw the two lines from E1 and E2 to Mars and where they crossed was the position of Mars.

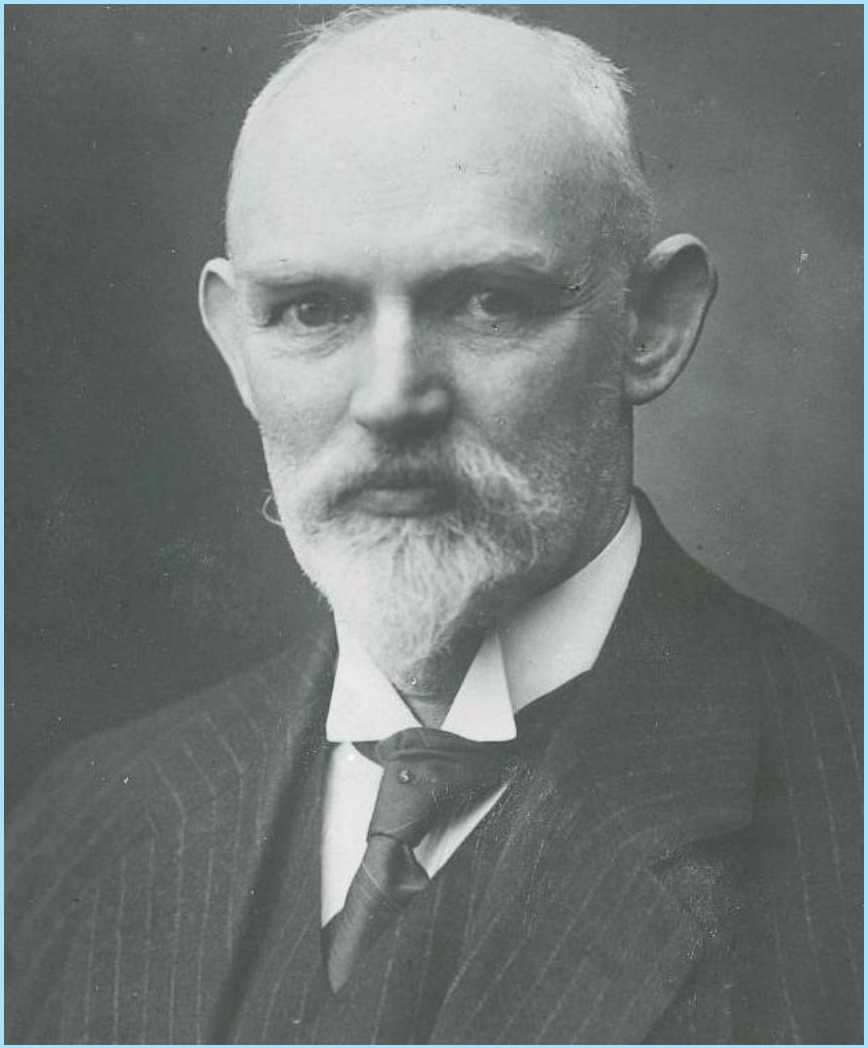


- Kepler then repeated this for many more such pairs and determined the orbit of Mars with respect to the orbit of the Earth.
- He then turned it around as if he were on Mars and selected instances where the Earth was at the same place in its orbit.
- In that way he found an improved orbit of the Earth and its linear velocity.



- Kepler dismissed all preconcieved conceptions and asked for the first time in almost two thousand years what the observations actually said about the planetary orbits.
- Arthur Koestler's (1905–1983) fascinating book describes all of this (and more).
- Apparently started as a biography of Kepler.
- I have given it as a present to all my students after defensing their thesis and obtaining their PhD degree.

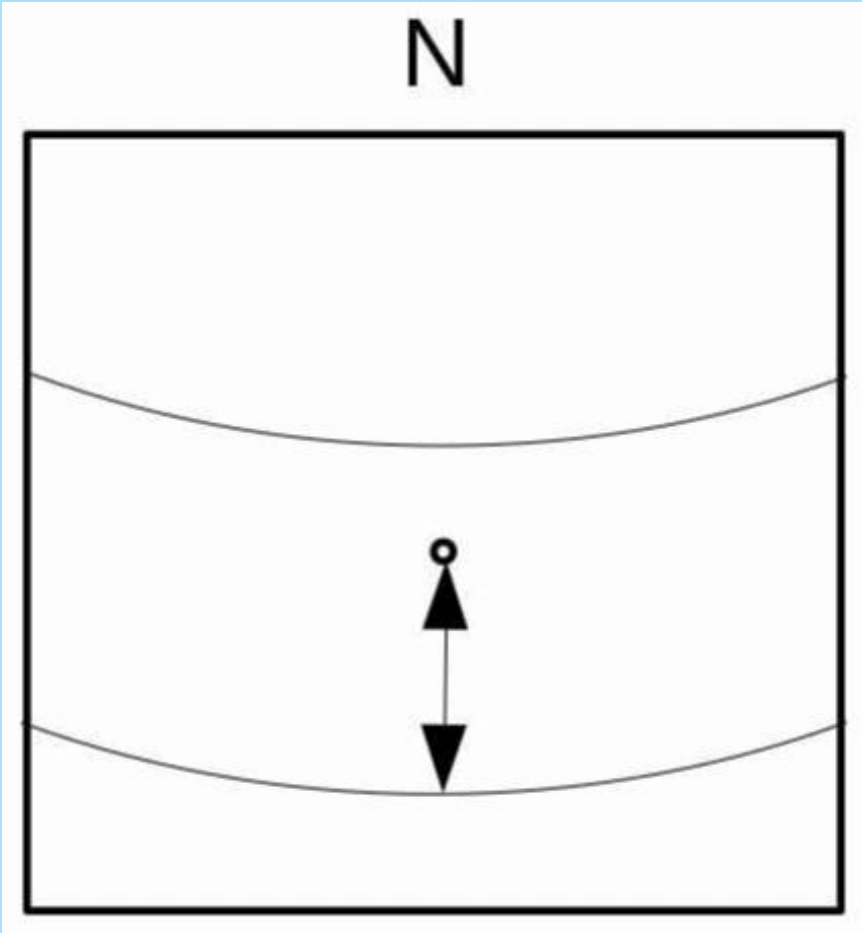
Oort as an observer



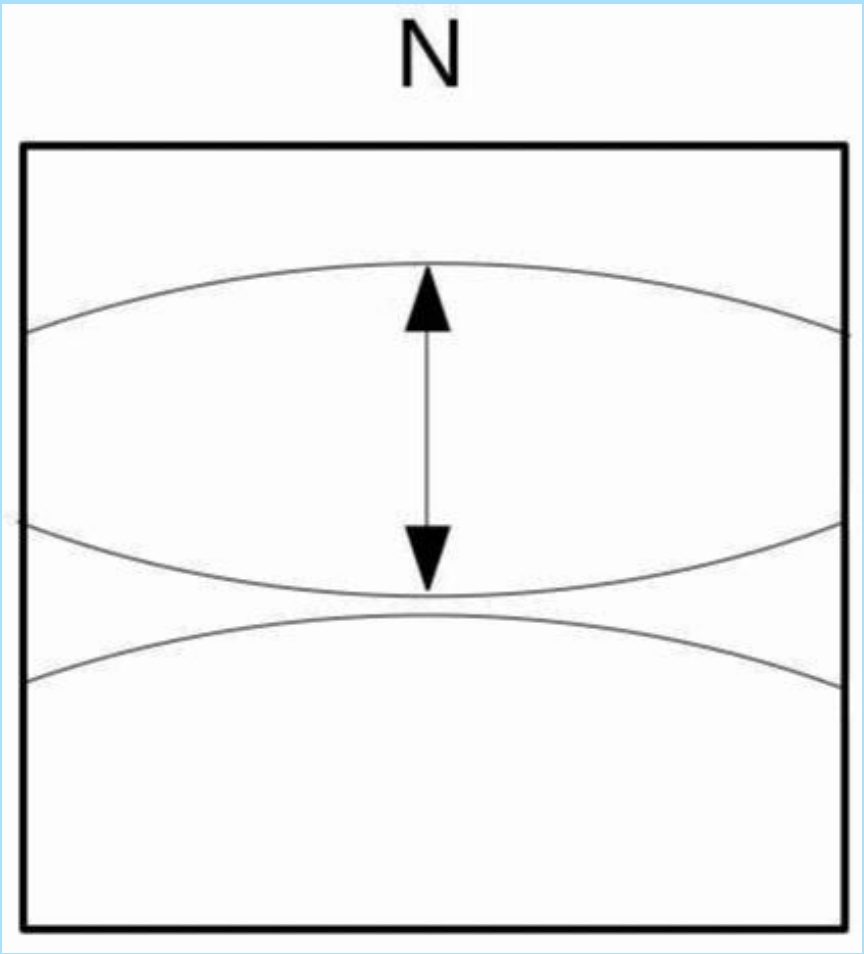
Yale Observatory

- Oort did his doctoral exam *cum laude* in 1921 and became assistent to Pieter van Rhijn at the Kapteyn Astronomical Laboratory.
- Willem de Sitter had reorganized Leiden Observatory, but could not get Antoon Pannekoek hired for the Astrometric Department.
- So he offered Oort a job in Leiden, but felt he needed observational (astrometric) experience first.

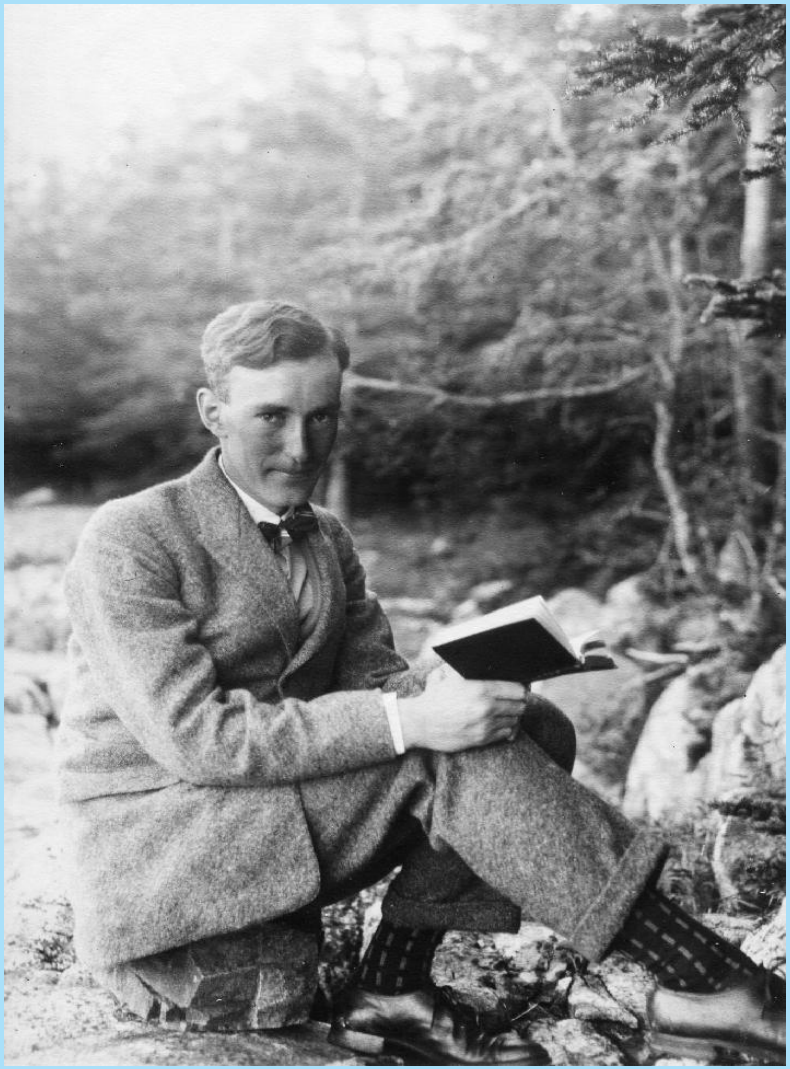
- De Sitter got Frank Schlesinger (1871–1943) to offer Oort a fellowship at Yale Observatory.
- Oort at Yale 1922 to 1924.
- The research was on latitude variations.
- Pole position important for star positions.
- The position of the pole on Earth changes semi-irregularly with amplitude about 10-15 m (corresponds to 0.3-0.5 arcsec or 1€ @ 10km).



- Use of a zenith telescope.
- Photograph star trails near zenith of stars of known declination.
- Requires accurate knowledge of position of the zenith.
- Geodesist Friedrich Helmert (Berlin) wrote in 1890 (Astron. Nachr.) that measurements were inconsistent.



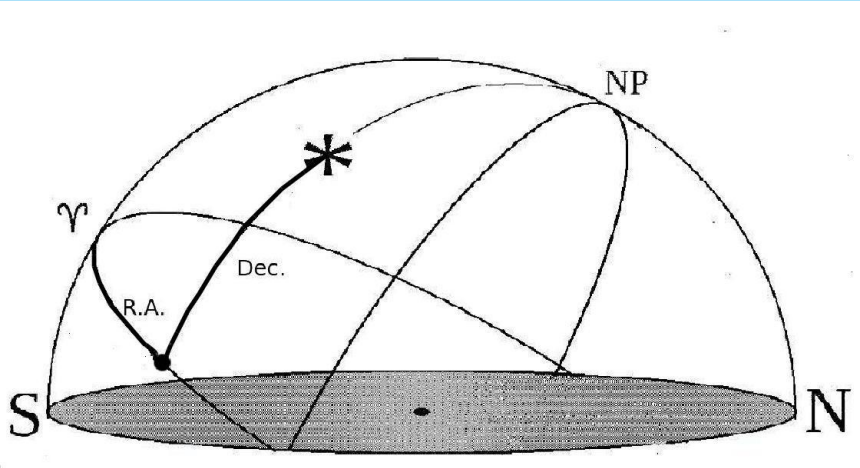
- Kapteyn read this and suggested to turn plateholder around halfway through the night.
- Kapteyn's letter published by Helmert in Aston. Nachr.
- Oort made such observations at Yale for two years with new zenith telescope.
- Lost time due to problems with objective lens.



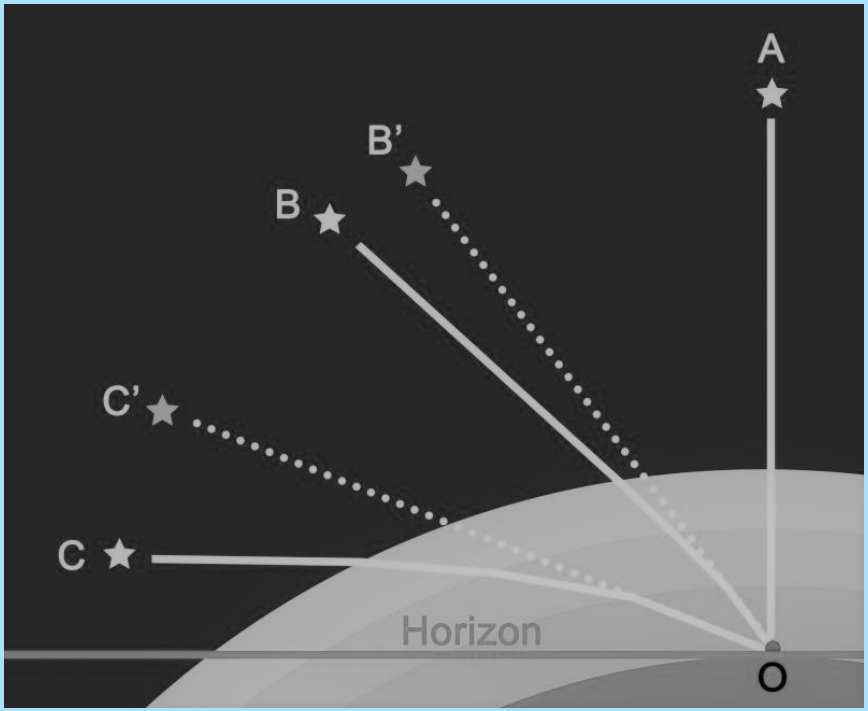
- Schlesinger wanted Oort to help with Yale southern telescope.
- Arranged Oort's military service in summer of 1923.
- But de Sitter could not wait and Oort moved to Leiden Observatory in 1924.
- Here he worked on astrometric problems and on his thesis work concerning stars of high velocity.
- Yale data eventually proved useless, because of plate movements in plate holder.

Kenya expeditions

- Oort started in Leiden September 1, 1924.
- De Sitter assigned him to some astrometric work before starting on a thesis.
- Concerned the problem of absolute declinations.

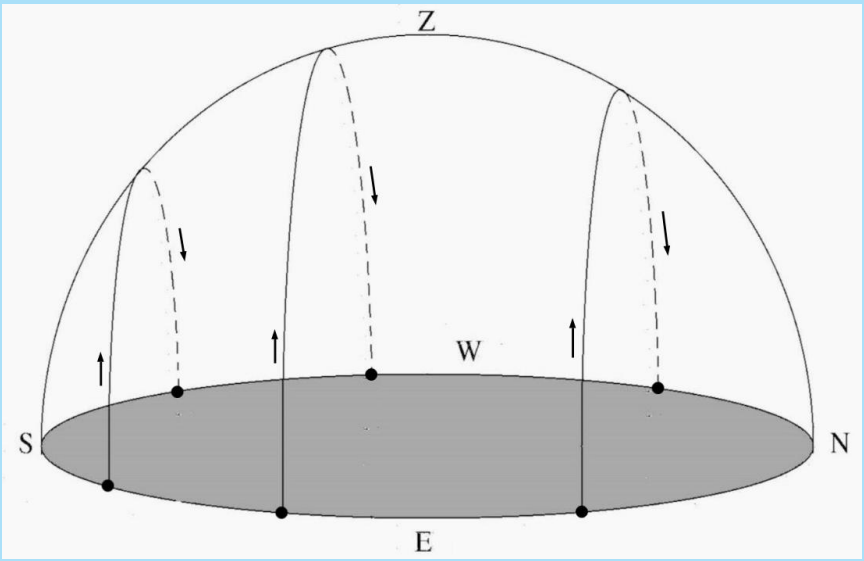


- Determination of declination is done by measuring altitude during meridian passage.



About 1 arcminute at 45°;
1€ @ 80m.

- Problems due to
  - Bending of telescope tube.
  - Atmospheric refraction.
- Kapteyn had looked into this also and suggested an observing strategy.
- Oort and de Sitter suggested three observatories, two at moderate latitudes to follow Kapteyns method and one near equator.



- Carl Sanders had worked in Portuguese Congo and eventually had a plantation in Matube (now Angola).
- He was an amateur astronomer and had worked out how to correct for small latitude of observer and observing at small altitude.
- Sanders had made many observations and Oort reduced these to a joint paper.
- His plantation had gone bankrupt; he sometimes worked for Leiden Observatory and joined in 1926.

Van Herk, Sanders and Hins in 1931, (Oosterhoff in the back).

- This gave rise to two expeditions to Kenya.
- The first one was executed by Coert Hins and Gijsbert van Herk and lasted from 1931 to 1933.
- Result unsatisfactory and a new expedition required.
- Oort took over responsibility from de Sitter when the latter died, but WWII interfered.

- The second expedition took place 1947 to 1951.
- Van Herk stayed all the time, Willem van Zadelhoff three years, Adriaan Blaauw half a year and Maarten Schmidt over a year.
- In the end eleven corrections (-15 to +20 arcsec) in eleven declination zones.
- Now are known to be quite accurate, but have been completely ignored.

Intermezzo on job offers

- Oort had two important job offers:
- Harvard 1928.
  Too much teaching, no formal relation with the Observatory and observing facilities.
- Columbia 1930.
  New department, no commitment for a telescope (60-70 inch reflector in the south).

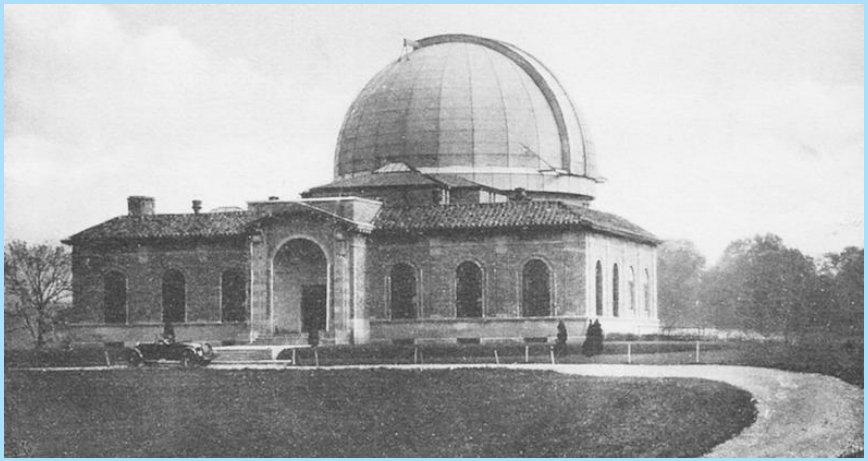
- But major factor was that Mieke Oort did not want to emigrate.

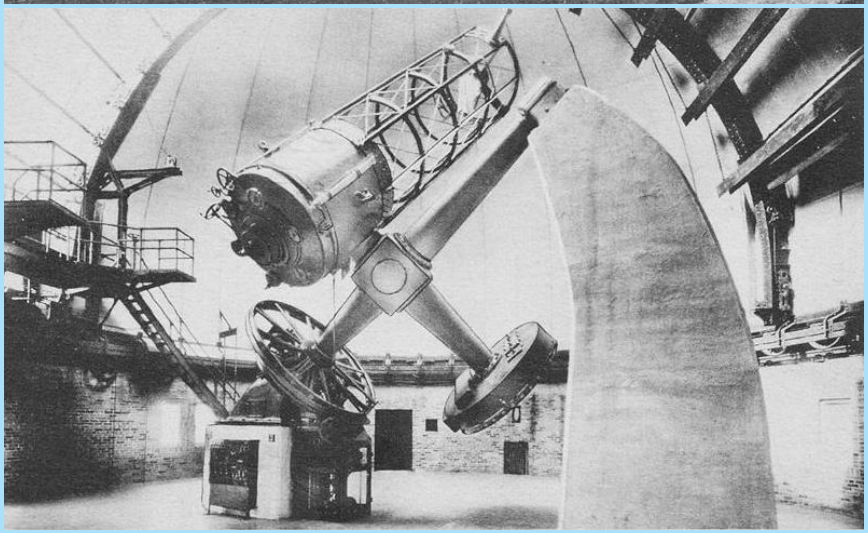
Harlan Stetson, director of Perkins.

Perkins Observatory

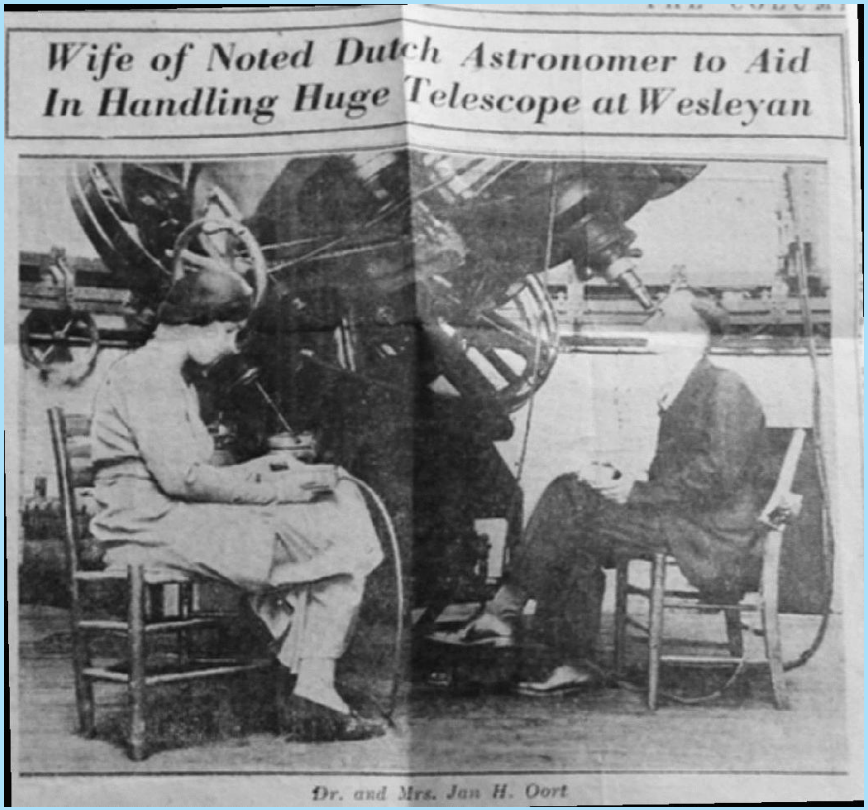
- Oort became interested in photometry of extragalactic nebulae.
- IAU General Assembly in Cambridge, Mass. (1932).
- Afterwards they went for a few months to Perkins Observatory.

- New 69-inch telescope in Delaware, Ohio.
- Largest telescope in USA, except for Mount Wilson 100-inch.





- Oort's aim was to obtain plates of galaxies for surface photometry.
- Oorts were in Delaware for three months.
- Oort taught at Ohio State University in nearby Columbus.
- Very poor weather (no surprise in Ohio), but did get some material though.
- Telescope later moved to Lowell Observatory (Flagstaff).

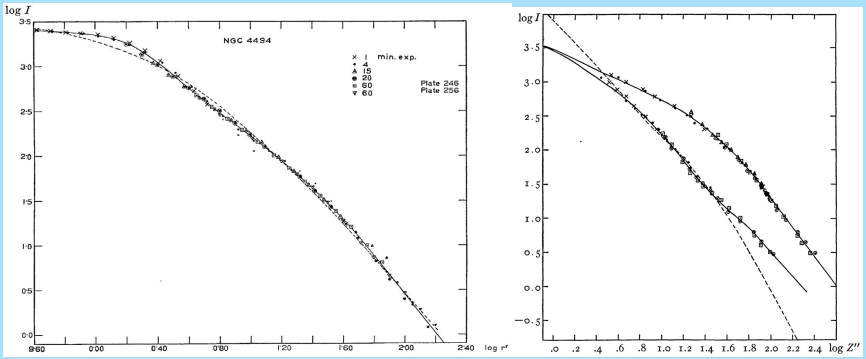


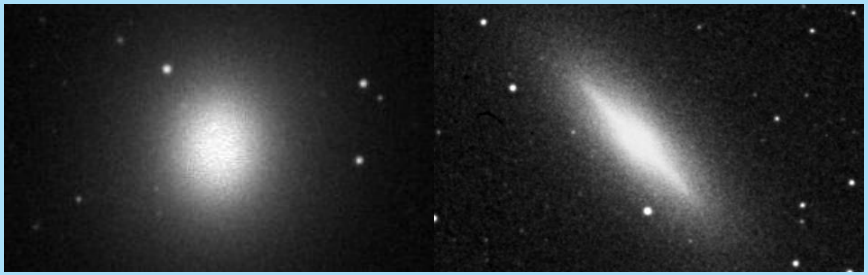
- Mieke Oort 'assisted' him.
- In the end plates proved unsuitable.
- Reason shift of mirror with hour angle.
- Pieter Oosterhoff, fellow at Mount Wilson, took some plates on 60-inch Telescope.
- Oort with help of Herman Kleibrink produced usefull data.

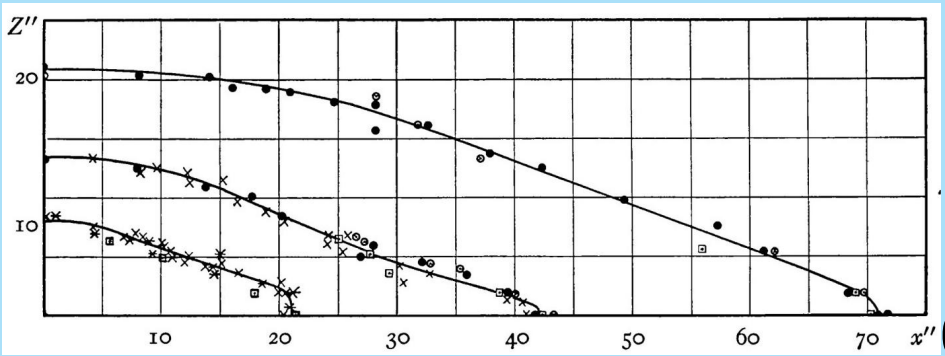
McDonald Observatory

Mount Wilson Observatory

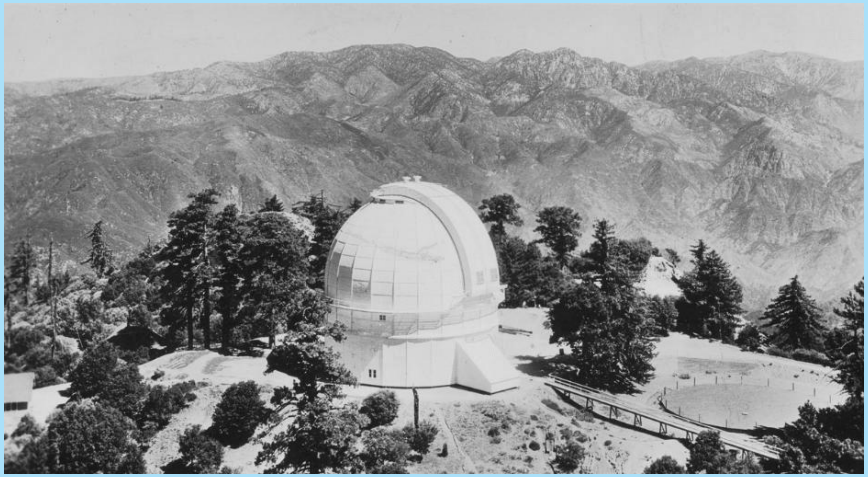
- In 1939 Oort tried again.
- Occasion was inauguration 82-inch telescope at McDonald Observatory in Texas.
- Oort was a prominent speaker at the symposium.
- Here Oort presented his famous 1940-paper on vertex deviation and galaxy dynamics.

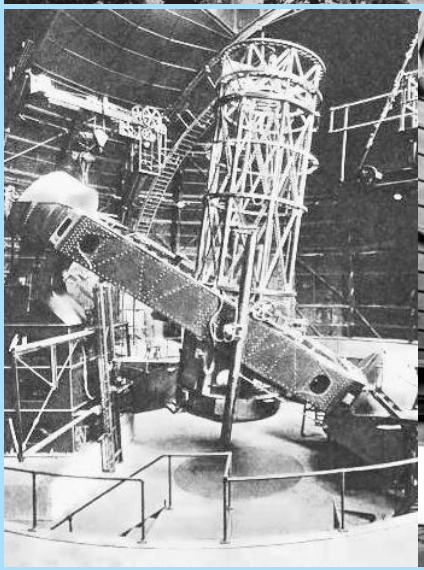






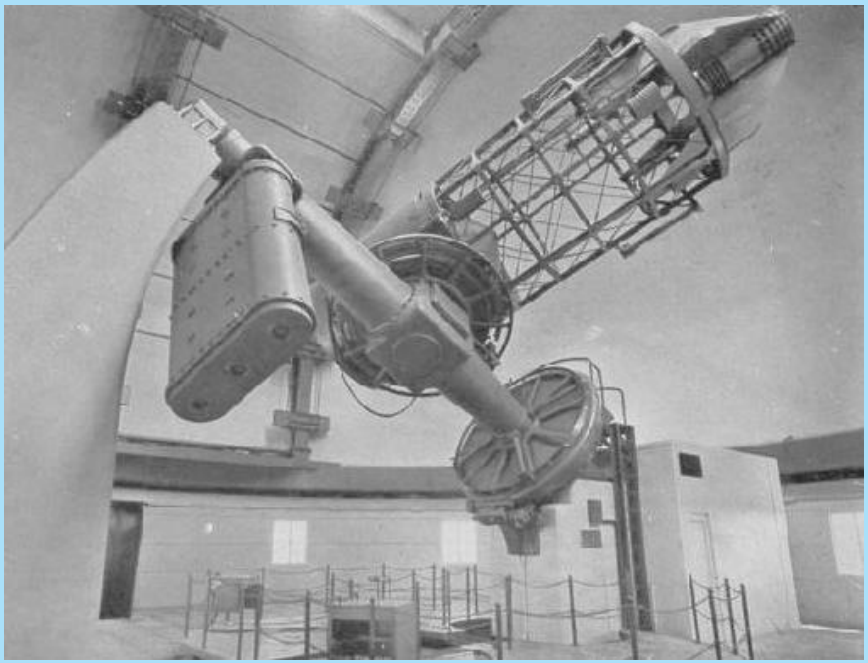
- Presented photometry of two systems from Oosterhoff's plates.
- Outlined deprojection analysis and dynamical studies of external galaxies.
- Applied to NGC 3115 with spectral data by Milton Humason.
- Inconsistent due to incorrect velocities.





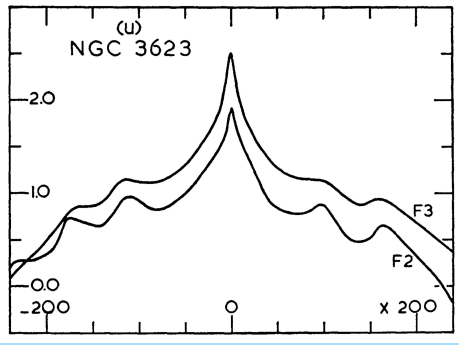
- Afterwards Oort went to Mount Wilson, where he observed with the 60-inch and 100-inch telescopes.
- He took 60 plates of 17 galaxies (with Oosterhoff's plates this gave a sample of 20).
- Calibration was through sensitometer spots and out-of-focus exposures in Kapteyn Selected Areas.
- Reduction delayed due to WWII.

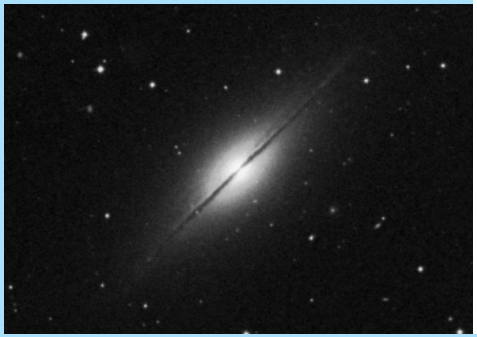
McDonald Observatory

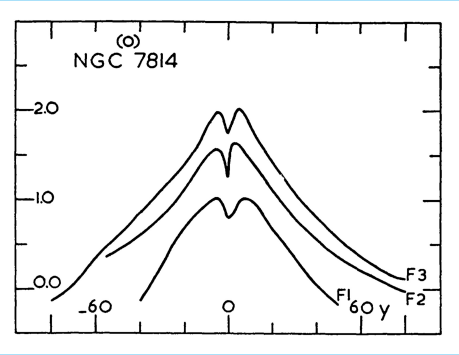


- Calibration ambiguous between spots and SA's.
- In 1947 Oort spent a few months at Yerkes near Chicago.
- He obtained observing time at McDonald 82-inch with William Hiltner to try photoelectric photometry.

- Oort first visited Pasadena and Palomar Mountain; was one of the first to look through the 200-inch.

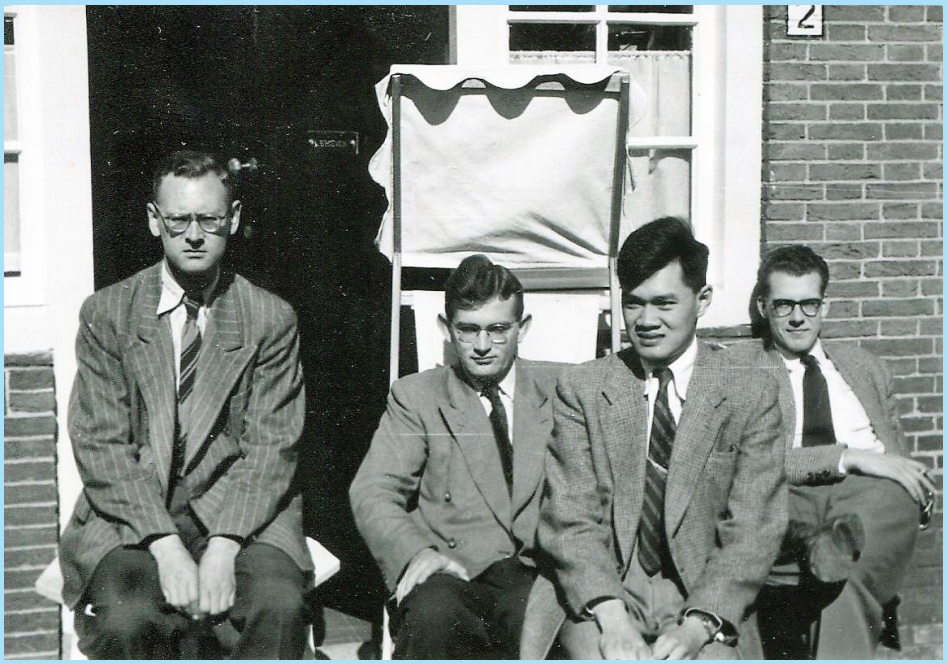






- Obtained photoelectric photometery of 7 galaxies.
- Data reduced by Kees van Houten; published in 1954.
- Proved out-of-focus SA stars as correct calibration.

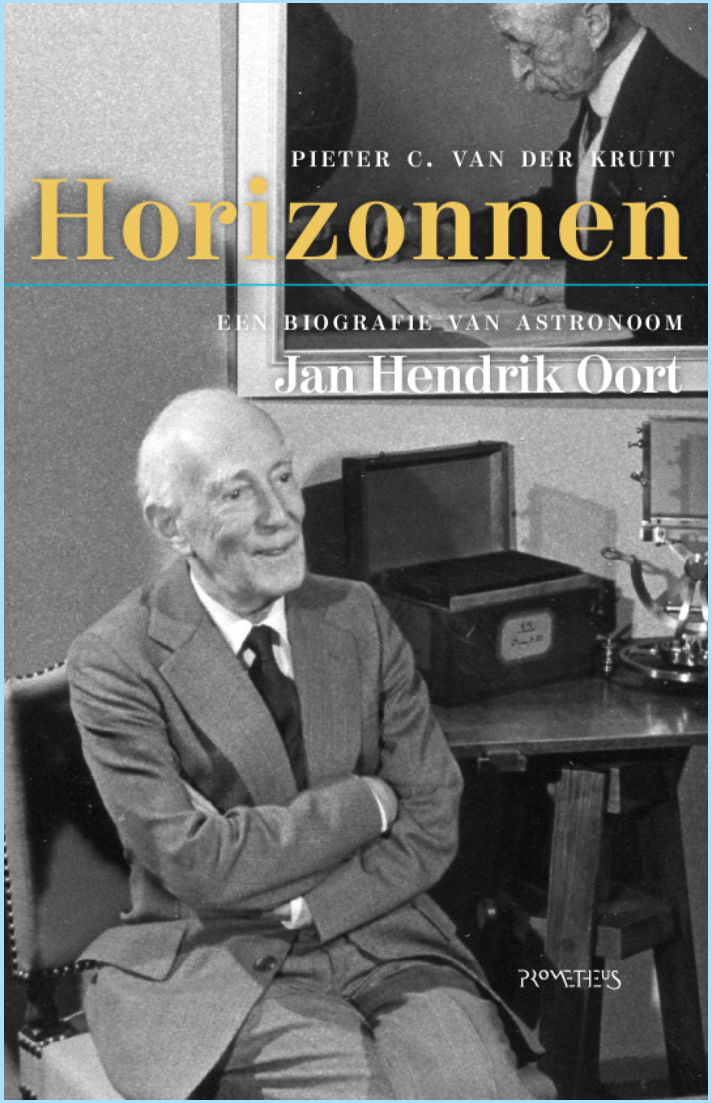
- This opened the way to reduction of plate material, which was taken up by van Houten (who also spenty some time at Yerkes and McDonald).



Kees van Houten, Gart Westerhout, King Kwee, Maarten Schmidt in 1953.

- In 1960 van Houten presented a PhD thesis with surface photometry of the twenty galaxies.
- Some of the very first two-dimensional surface brightness maps of a substantial sample of galaxies.

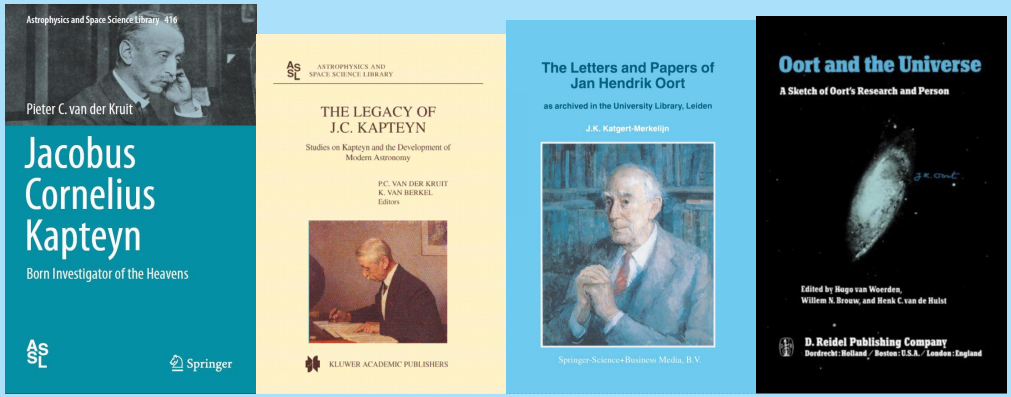
Horizons



- Dutch version for wider audience and with fewer details.
- Title of Oort's Kyoto lecture.
- Will appear with Prometheus end of the year or slightly later.


THAT'S ALL
Folks!

Boek presentatie



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- Born investigator of the Heavens
- Master of the Galactic System

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Jan Hendrik Oort
(1900 - 1992)

This Webpage accompanies a biography:

Jan Hendrik Oort:
Master of the Galactic System

by Pieter C. van der Kruit,

volume 459 in the Astrophysics and Space Science Library of Springer Publishers, (ISBN 978-3-030-17800-0). See also the product flyer.

The biography and this Website are dedicated to the memory of Professor Jacobus Cornelius Kapteyn (1851--1922), who Oort described as 'mijn inspireerenden leermeester' (my inspiring mentor), and who laid the foundation for the boom of Dutch astronomy in the twentieth century and --last but not least-- to my wife Corry for her love and support.

PREVIEW
The eBook version is available via the Springer site. It offers free previews of the Front Matter (titlepage, Preface, Acknowledgments, Table of Contents) and Back Matter (Appendices, References,

- Website: www.astro.rug.nl/JHOort.
- Publications about and especially by Oort.
- Links to ADS.
- Scans of H&D en Zenit articles.
- Public part of the Oort Archives ($\sim$ 23k out of $\sim$ 27k pages).

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This book is the first comprehensive and overdue biography of one of the giants of science in the twentieth century. Jan Hendrik Oort. His fundamental contributions had a lasting effect on the development of our insight and a profound influence on the international organization and cooperation in his area of science and on the efforts and contribution of his native country. This book aims at describing Oort's life and works in the context of the development of his branch of science and as a tribute to a great scientist in a broader sense. The astronomer Jan Hendrik Oort from the Netherlands was founder of studies of the structure and dynamics of the Milky Way Galaxy, initiator of radioastronomy and the European Southern Observatory, and an important contributor to many areas of astronomy, from the study of comets to the universe on the largest scales.

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