The born investigator of the Heavens
Jacobus C. Kapteyn (1851–1922)

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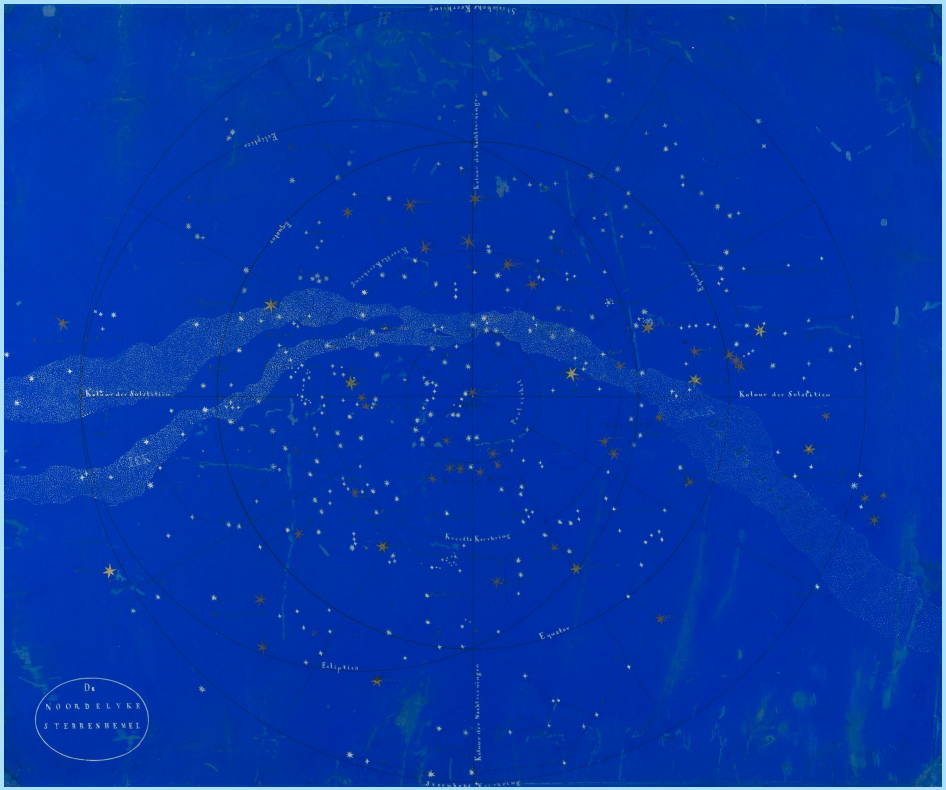
Groningen, Kapteyn Commemoration, June 17, 2022

Star catalogues

Jacobus Cornelius Kapteyn
(Jan. 19, 1851 – June 18, 1922)

- Simon Newcomb called him the Born investigator of the Heavens.
- His mission was to determine the distribution of stars in space and study what William Herschel had called the Construction of the Heavens.
- In modern terms this is the structure and dynamics of the Galaxy.



Kapteyn's star map

- Produced as teenager (14 years).
- Northern hemisphere.
- magnitude 1 gold paper, magnitude 2 silver paper, magnitude 3 white paint.
- Pogson scale. Factor $\sqrt[5]{100} = 2.512$ per maginitude.

Planetarium

1. Show the sky on June 17, 2022. Start at midnight. Only stars brighter than magnitude 4 (as can be seen from the city of Groningen). Highlight the constellations and bright stars and note Bootes (Antares), Lyra (Vega), Scorpius, etc.

2. Let time run (diurnal motion) until sunrise and we see Venus, Mars, Jupiter, Saturn rise. Stop briefly.

3. Continue diurnal motion until next midnight and stop. Now show stars down to magnitude 6. Show Milky Way.

4. Start diurnal motion again. Show the meridian to illustrate positional measurements by meridian passage.

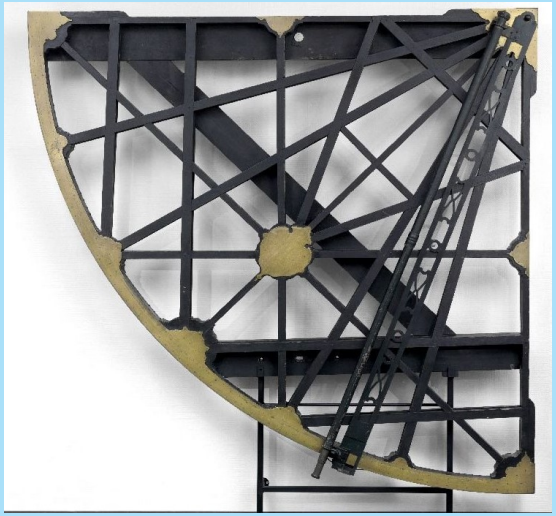
Star counts - all sky

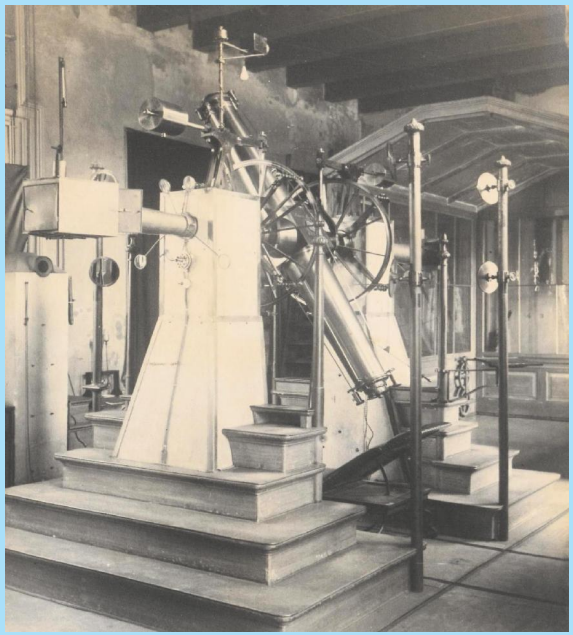
Down to	
mag. 4:	550
mag. 6:	5,050
mag. 9:	350,000
mag 14:	15,000,000
mag 19:	440,000,000

Star positions first naked eye with sextant or quadrant.

For example Snellius (1580-1626), Leiden

Johannes (1611-1682) and Elisabeth (1647-1693) Hevelius, Danzig.





Some early catalogues:

Name	Years	Limit	Stars
Bonner Durchmusterung	1852-1868	9.5	324,198
Südlicher Bonner Durchmusterung	1875-1886	10.0	133,659

But no comparable catalogue of the southern sky.

Planetarium

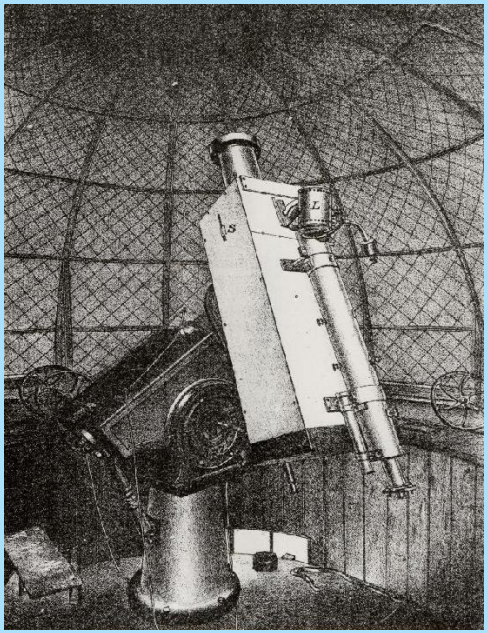
5. Go back to June 17, 2022, midnight, show stars to mag. 6. Show the sky down to magnitude 9.

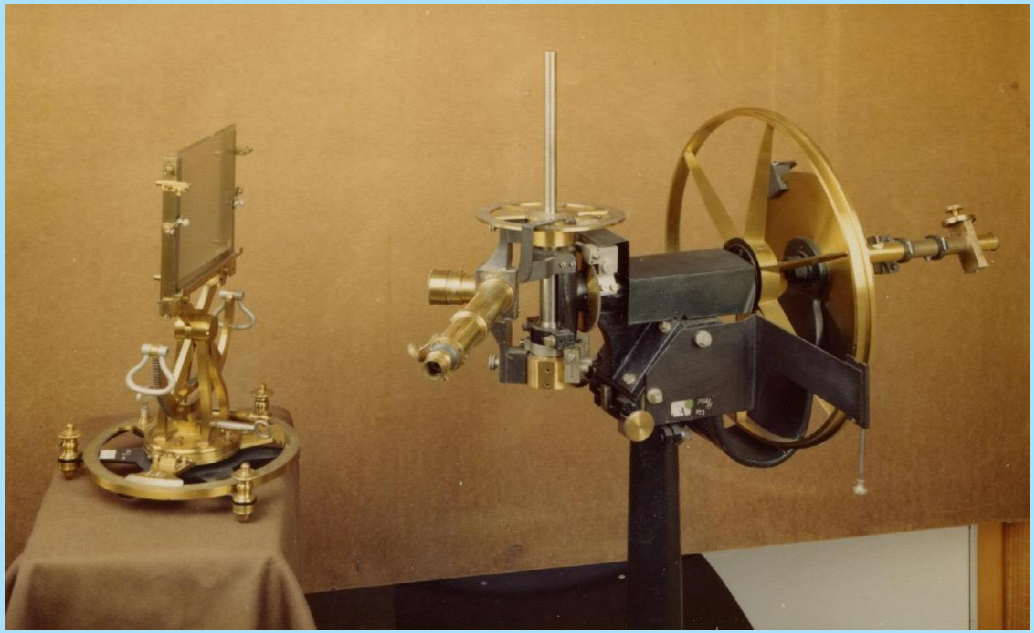
6. Go back to magnitude 6. Move to Cape Town (34° S, 18° E is good enough). Show Southern Cross and pointers.

7. Now turn around to face north. Bootes, Lyra, etc. will re-appear but 'upside down'.

8. Switch on diurnal motion until sunrise, goes opposite direction, night lasts much longer.

- David Gill of the Royal Cape Observatory had decided to produce a southern catalogue.
- Used photographic plates with a special telescope.
- Lured Kapteyn into offering to measure the plates in Groningen.





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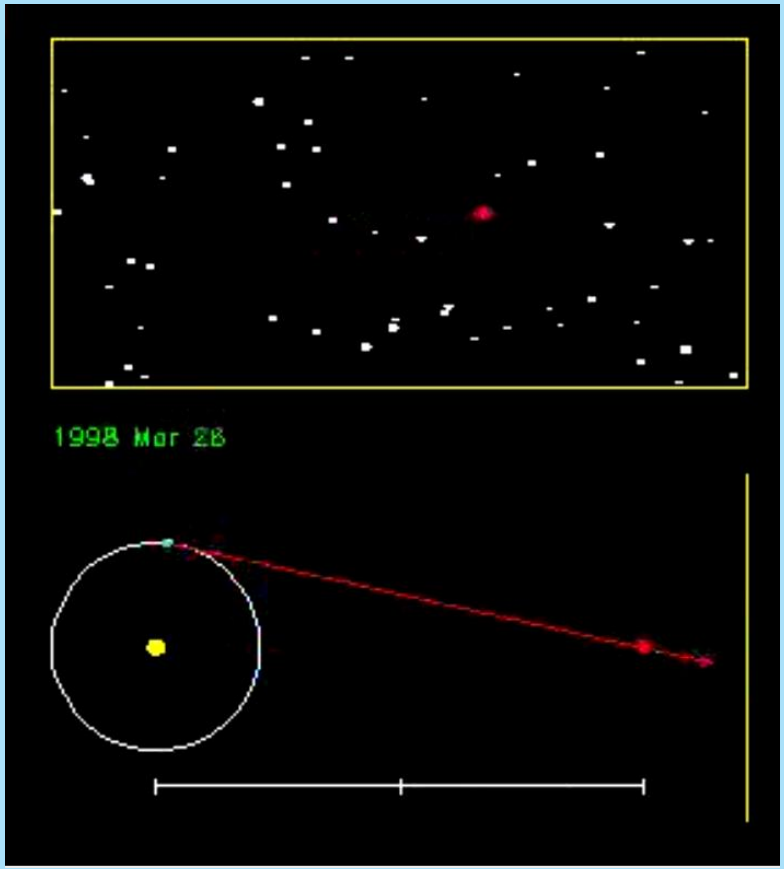
Cape Photographic Durchmusterung	1886-1900	9.2	454,875

Distances, parallax and proper motions

Annual parallax

Nearby stars show a reflection of the annual motion of the Earth around the Sun compared to more distant background stars.



Annual parallax in space and on the sky

Annual parallax

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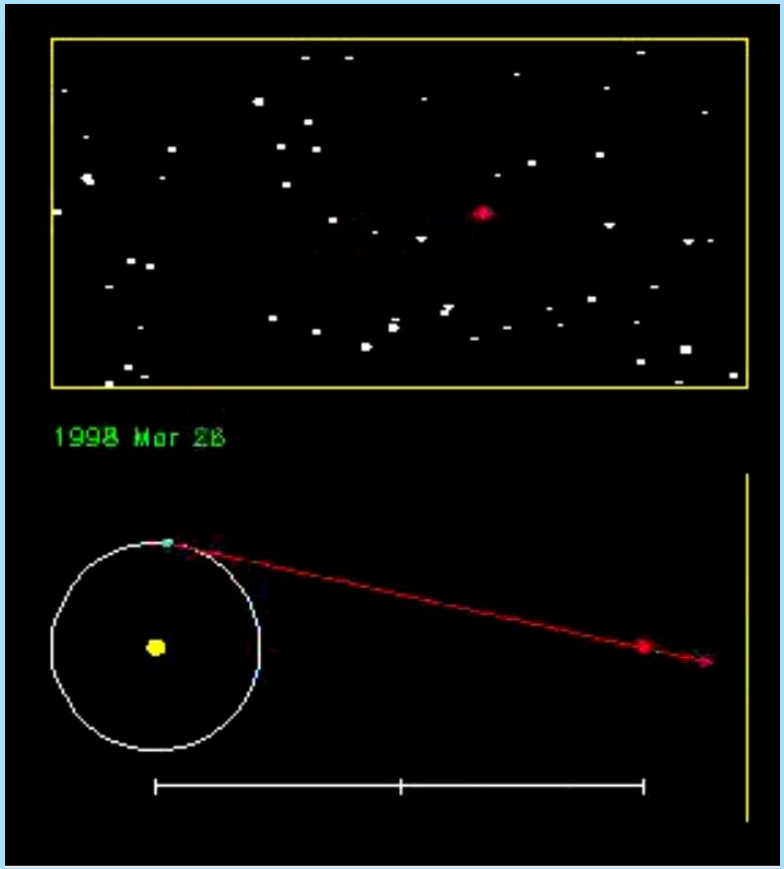
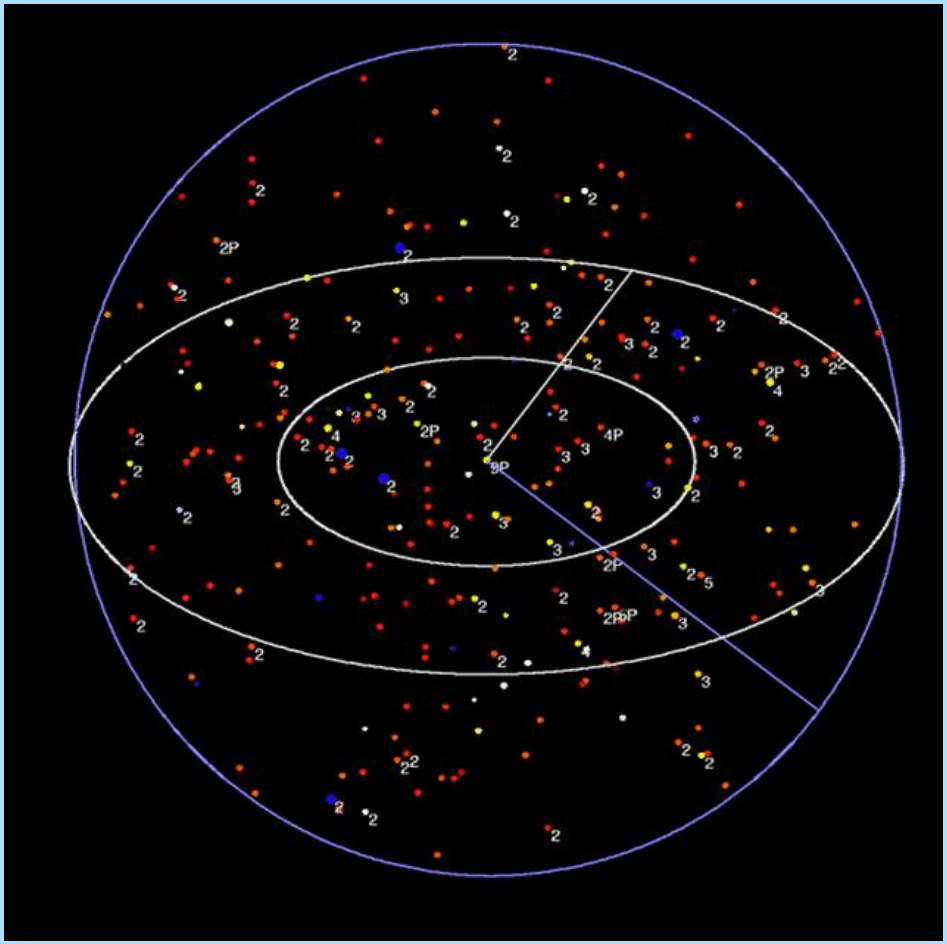


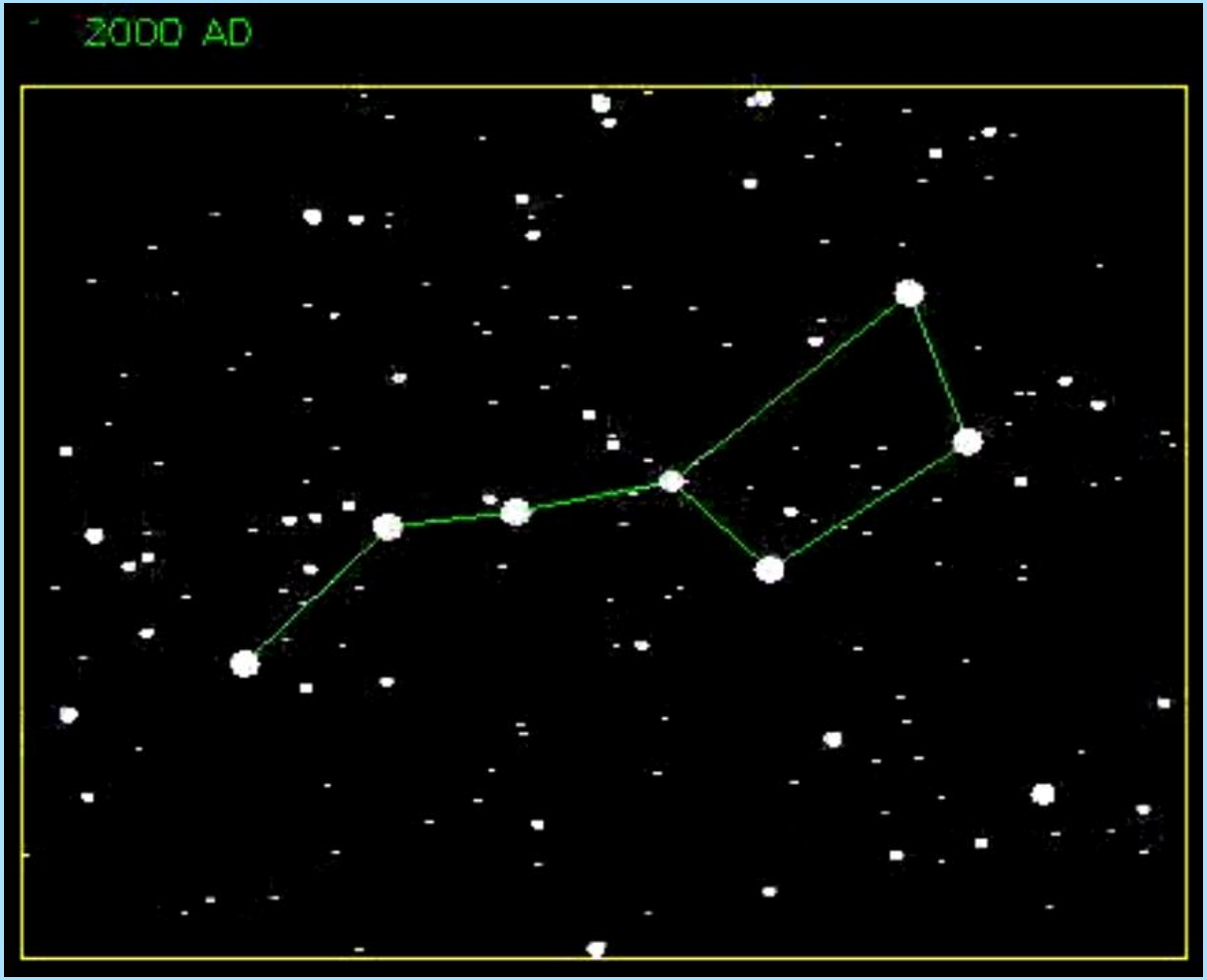
Annual parallax in space and on the sky

- Even for the nearest star, α Centauri, the resulting ellipse has a semi-major axis of less than a second of arc.
- A second of arc is a Euro at 4.95 km.
- Hipparcos parallax accuracy is about $\sim 0''.002$. GAIA about factor 10 better.
- There are only 271 stars systems for which the parallax $> 0''.1$.



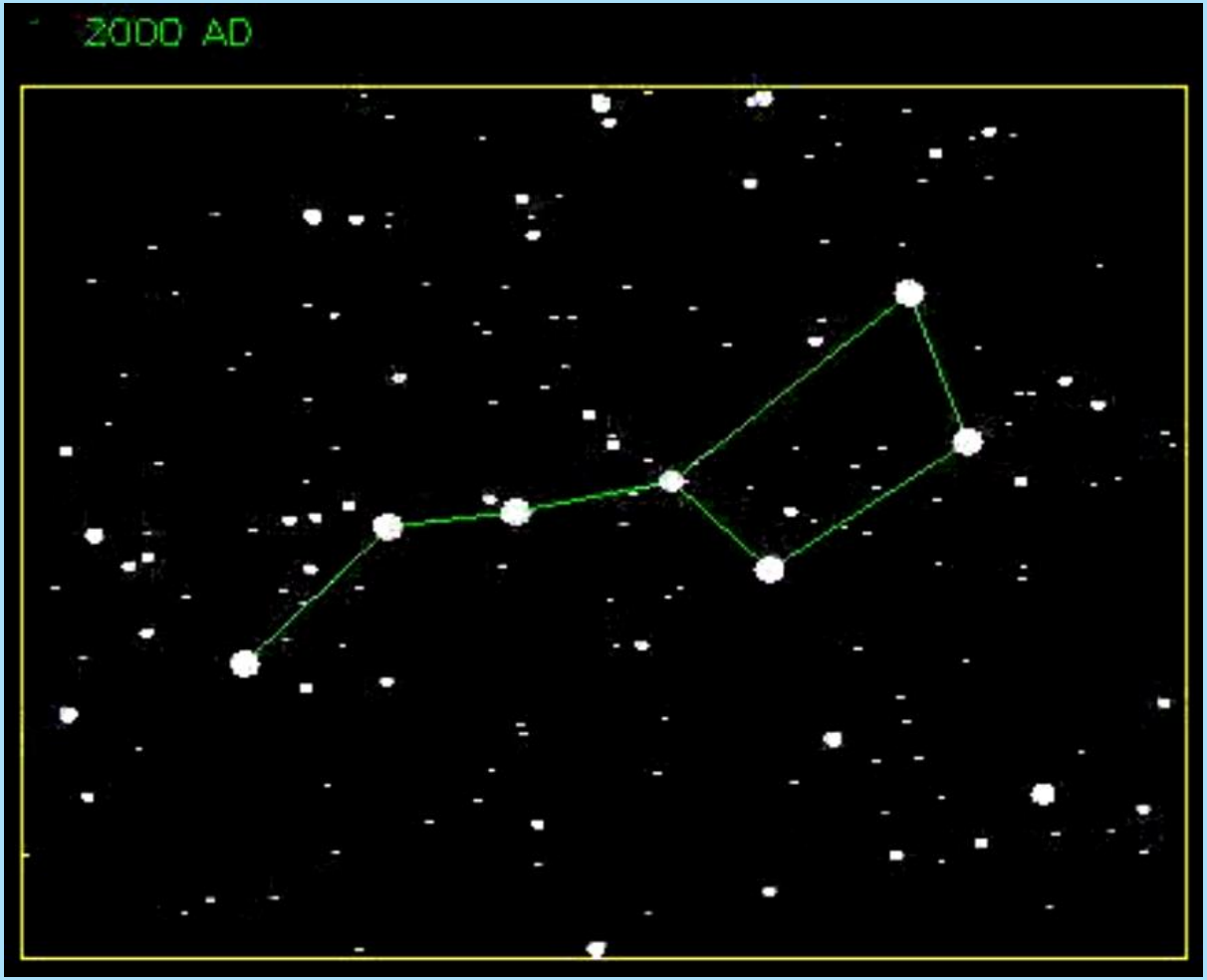
Stars are generally too distant to measure distances.

Proper motion



Big Dipper from 100,000 BCE to 100,000 CE.

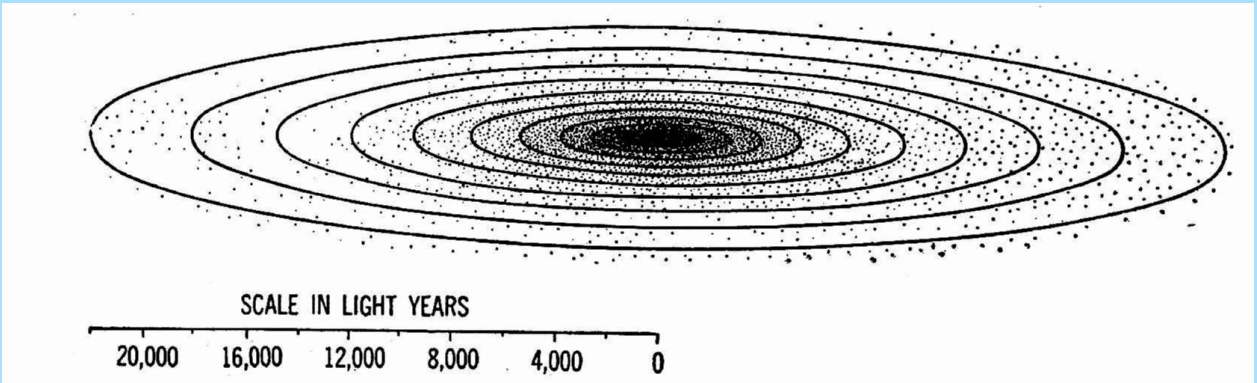
Proper motion

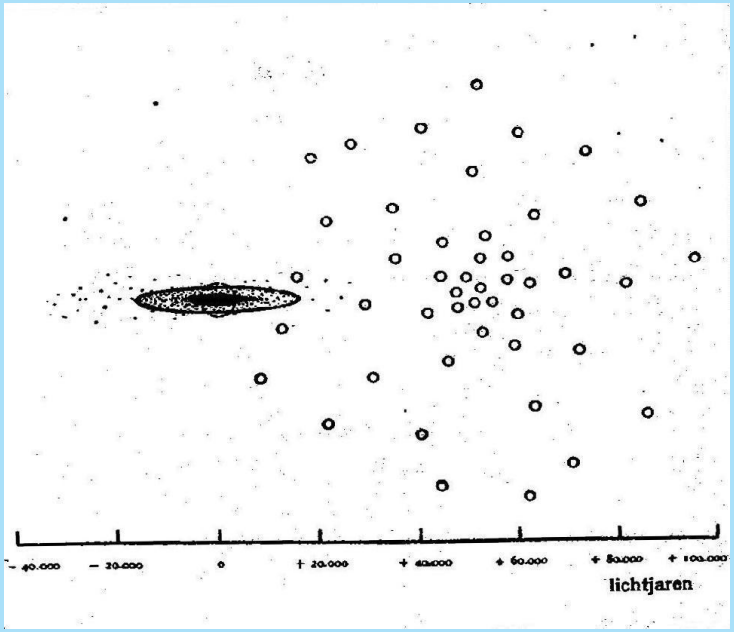


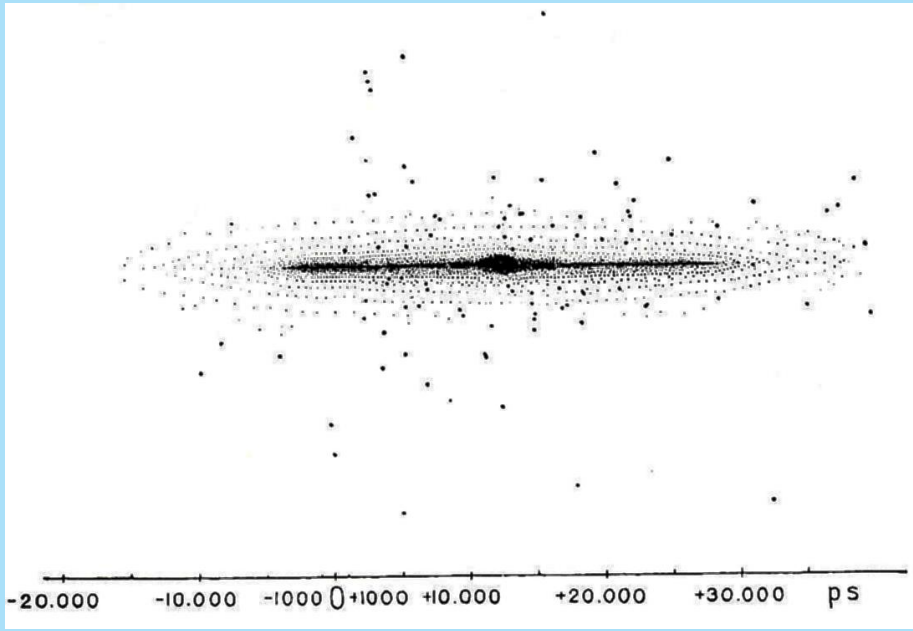
Big Dipper from 100,000 BCE to 100,000 CE.

Secular parallax

- The Sun moves with respect to other stars (20 km/s towards Apex near Vega and away from Antapex near Sirius).
- This can also be used to estimate distances statistically if motions are random and isotropic.
- This can be used to study the distribution of the stars in space.







- The model was wrong in the plane, excellent vertically.
- Oort and others found the correct solution.
- Kapteyn sometimes ridiculed for neglecting interstellar absorption.
- Also for strong opposition to banning Germany, etc. from international scientific organizations after WWI.

Kapteyn's contributions

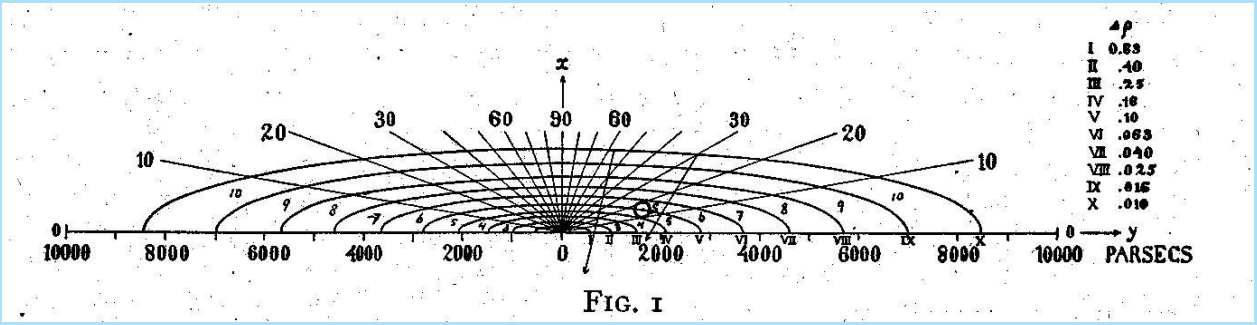
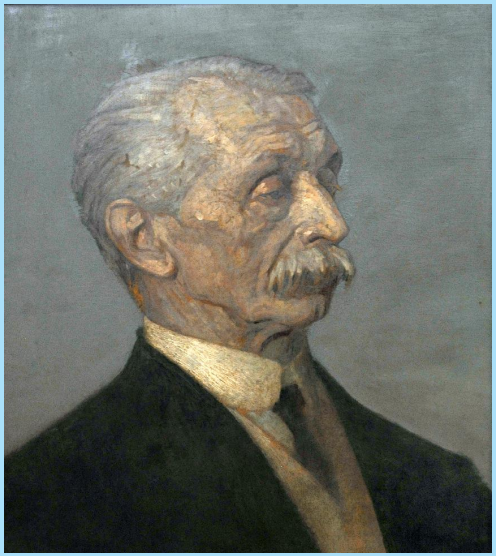
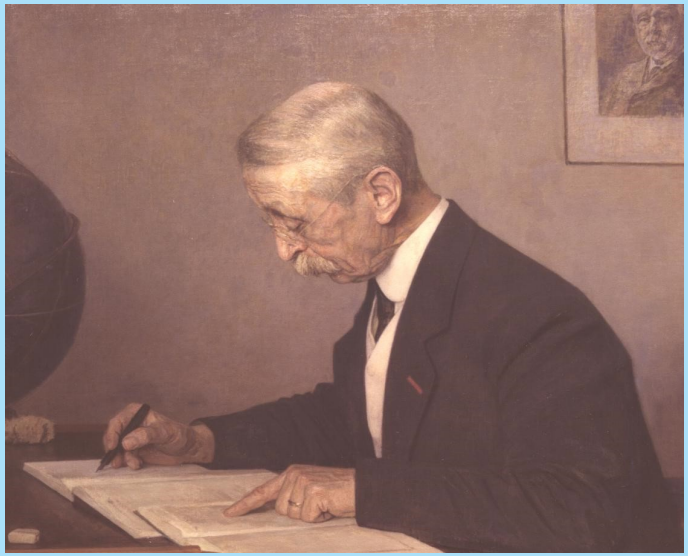


FIG. 1

- Cape Photographic Durchmusterung.
- Star Streams.
- Plan of Selected Areas.
- Interstellar extinction.
- First model for distribution of stars in space ('Kapteyn Universe').
- Incorporated dynamics.
- Was an inspiring teacher (Jan Hendrik Oort).

This made Kapteyn by far the most prominent astronomer in the Netherlands in his time and one of the very few worldwide.


Three paintings by Jan Veth?

That's all folks