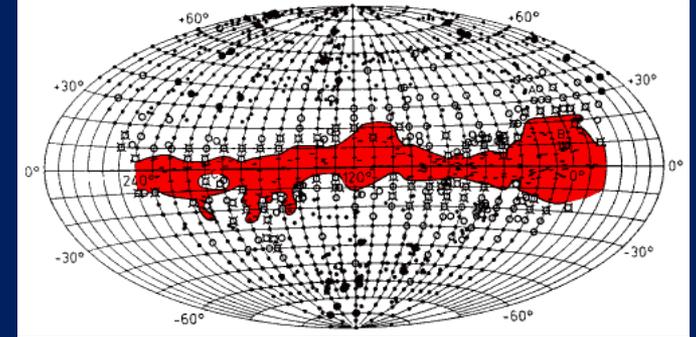


# The Great Debate. I.

## The background

Giulio Ragu in *Second Life*



In Real Life: Giuseppe Longo

University of Napoli Federico II, Italy

longo@na.infn.it

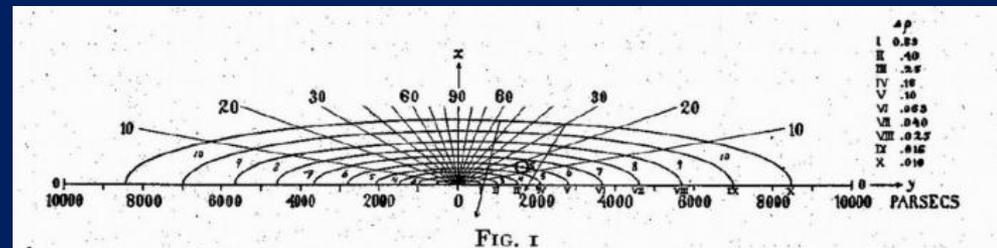
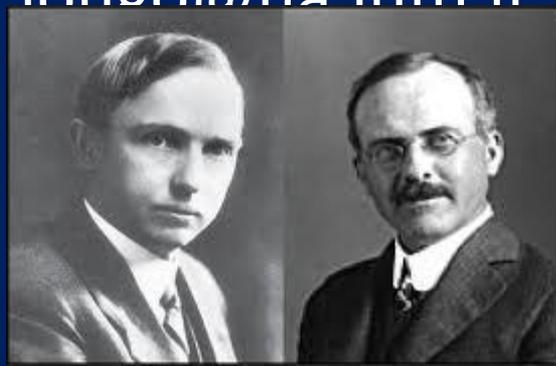
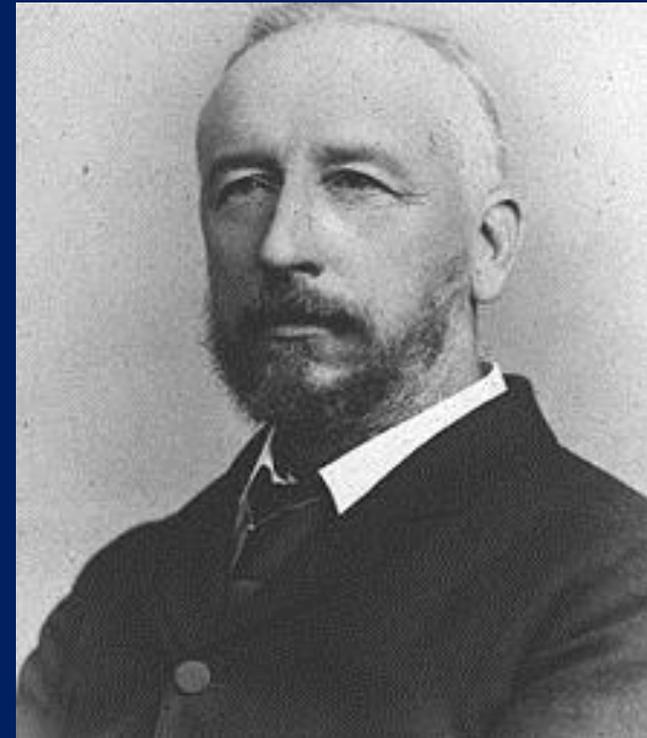


FIG. 1

## Sir David Gill (12 June 1843 – 24 January 1914)

- Scottish astronomer who is known for measuring astronomical distances, for astrophotography, and for geodesy. He spent much of his career in South Africa.
- Studied under J.C. Maxwell but after two years went to work in his father clock shop
- After a few years sells the business and begin to work in a private observatory
- In the 70's joins expedition to Mauritius and Ascension Island
- Becomes director of the Observatory at the Cape of Good Hope (South Africa)



# Richard Leach Maddox (1816 – 1902)

Photographer and physician.

In 1871 invents lightweight gelatin negative plates.

Collodion process invented in 1851 by Frederick Scott Archer required plates to be sensitized at the time of exposure, exposed while the emulsion was still moist, and processed immediately.

When he noticed that his health was being affected by the 'wet' collodion's ether vapor, he started looking for a substitute.

He suggested in 1871 that sensitizing chemicals cadmium bromide and silver nitrate should be coated on a glass plate in gelatin, a transparent substance used for making candies.

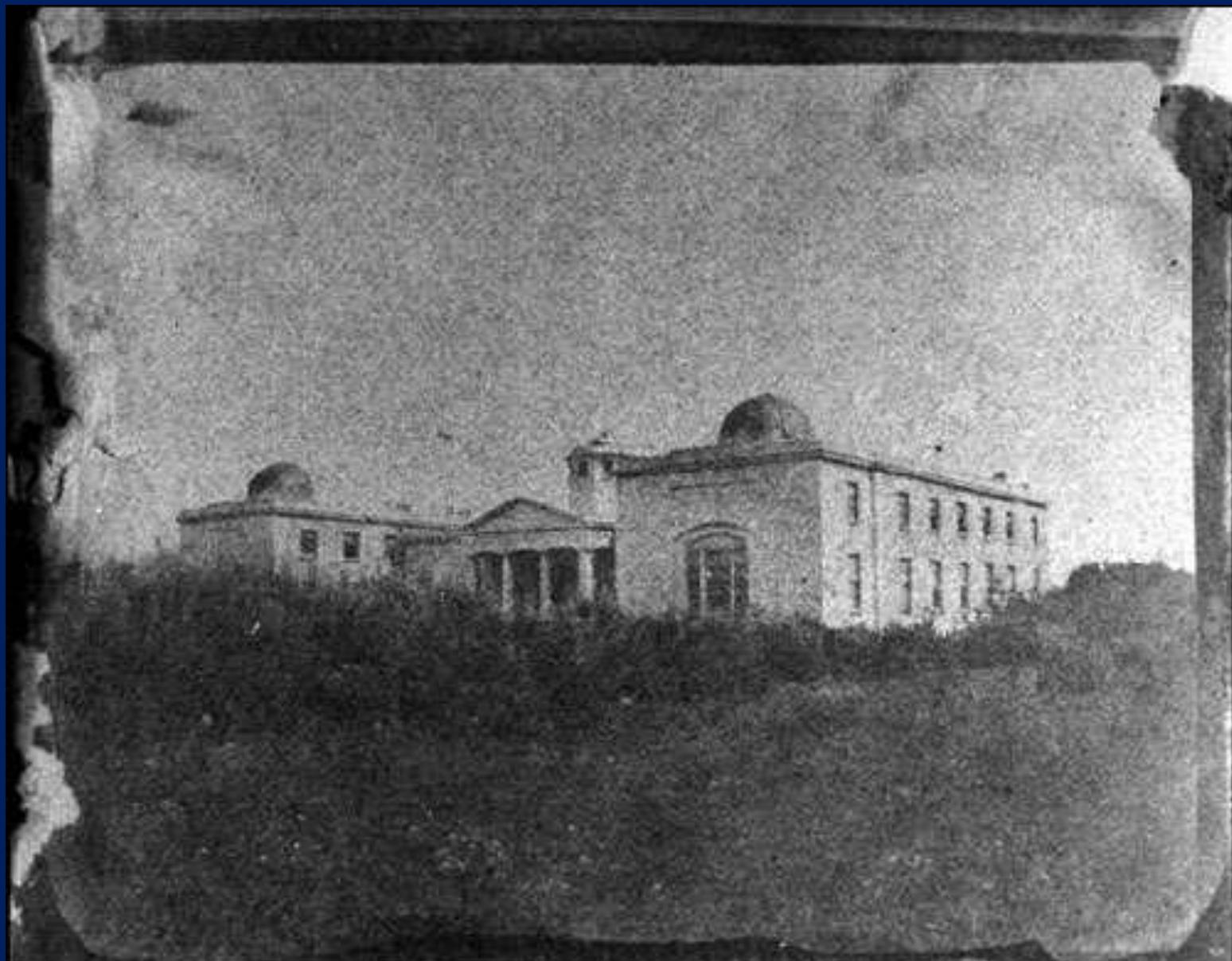
Advantages: commercial dry plates off the shelf, negatives did not need to be developed immediately, small cameras





Emerson Barnard

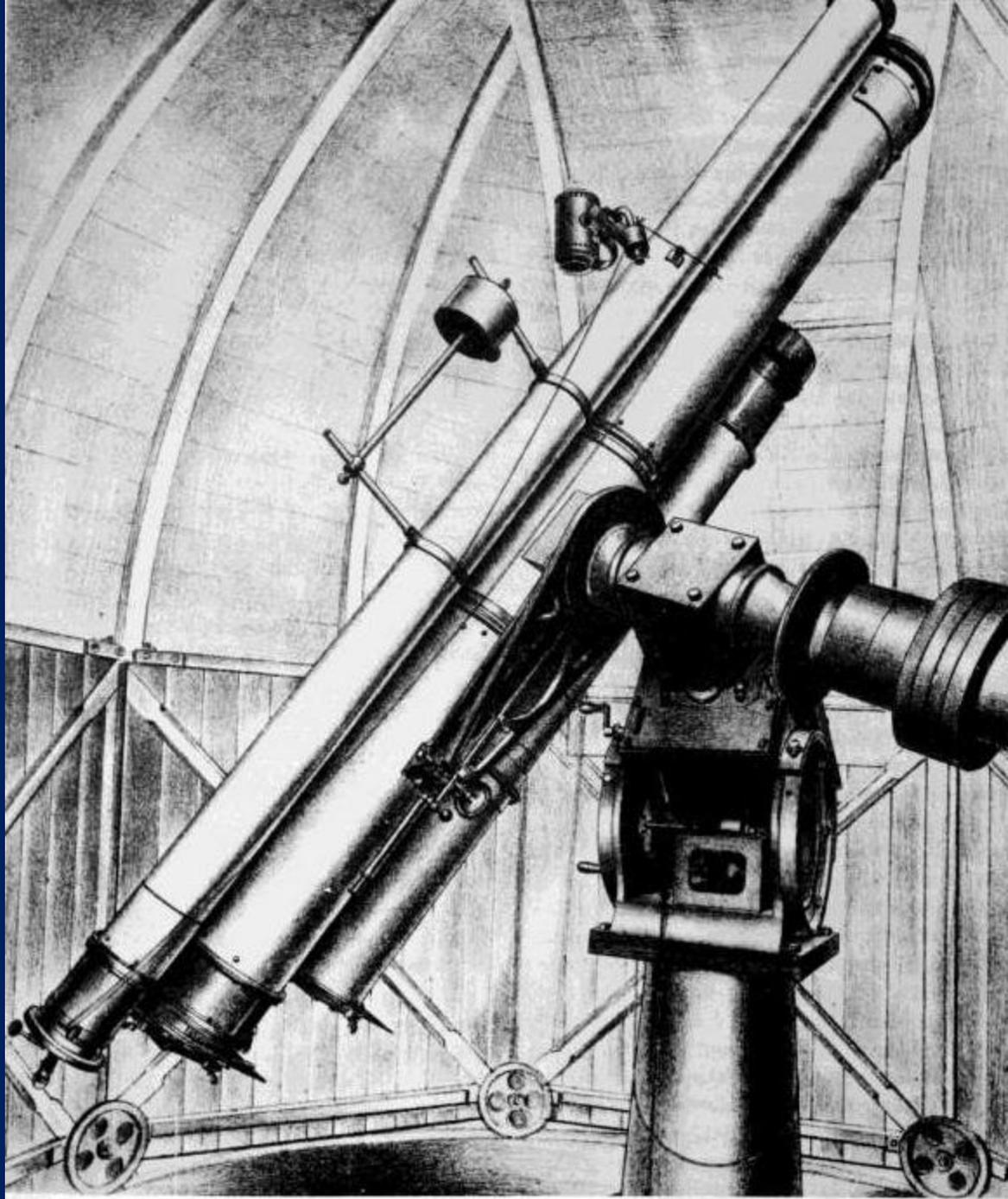
Dry emulsion plate of the Observatory at the Cape  
(date unknown)



**Gill** realised that the process could be used to create images of the stars and to more easily determine their relative positions and brightness.

This led to a massive project in collaboration with the Dutch astronomer J.C. Kapteyn,

The work was published as *Cape Photographic Durchmusterung* in 3 volumes between 1896 and 1900.



CAPE ASTROGRAPHIC ZONES.

VOL. I.

CATALOGUE OF RECTANGULAR CO-ORDINATES  
AND DIAMETERS OF STAR-IMAGES

DERIVED FROM PHOTOGRAPHIC

TAKES AT THE ROYAL OBSERVATORY, CAPE OF GOOD HOPE.

COMPOSED UNDER THE DIRECTION OF  
SIR DAVID GILL, K.C.B., LL.D., F.R.S., &c.,  
FARNSBOROUGH HOUSE, SOUTHAMPTON.

REVISED AND CORRECTED FOR THIS EDITION UNDER THE SUPERVISION OF  
S. S. HUGHES, M.A., F.R.S.,  
R.A.S. OBSERVATORY AT THE CAPE.

WITH A PREFACE BY SIR DAVID GILL.

ZONE -4 E.

Printed by Order of the Lords Commissioners of His Majesty's Treasury in plainness to  
His Majesty's Command.

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WILKINSON and WILKIN, Printers, at Stationers' Hall, Strand, W.C., and  
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R.M. WILKINSON, General Manager, at Stationers' Hall, Strand, W.C., and  
at the Royal Observatory, Greenwich.

At the Royal Observatory, Greenwich, and at the  
Royal Observatory, Cape of Good Hope, under the  
direction of S. S. HUGHES, M.A., F.R.S.

1875

[When Copyright Renewed]  
This Edition Sold.

Almost half million of stars  
(position and magnitudes)

Part of the **Carte du Ciel**  
project



## Jacobus Cornelius Kapteyn

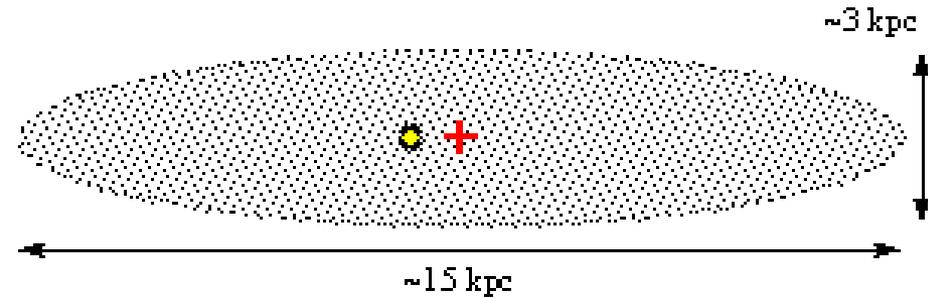
(1851, Barneveld - 1922,  
Gelderland)

In 1875, after having finished his thesis at the University of Utrecht went for three years at the Leiden Observatory, before becoming the first Professor of Astronomy and Theoretical Mechanics at the University [of](#) Groningen, where he remained until his retirement in 1921.

# Kapteyn's Milky Way (1922)

Kapteyn's star:  
Proper motion = 8 arcsec/year

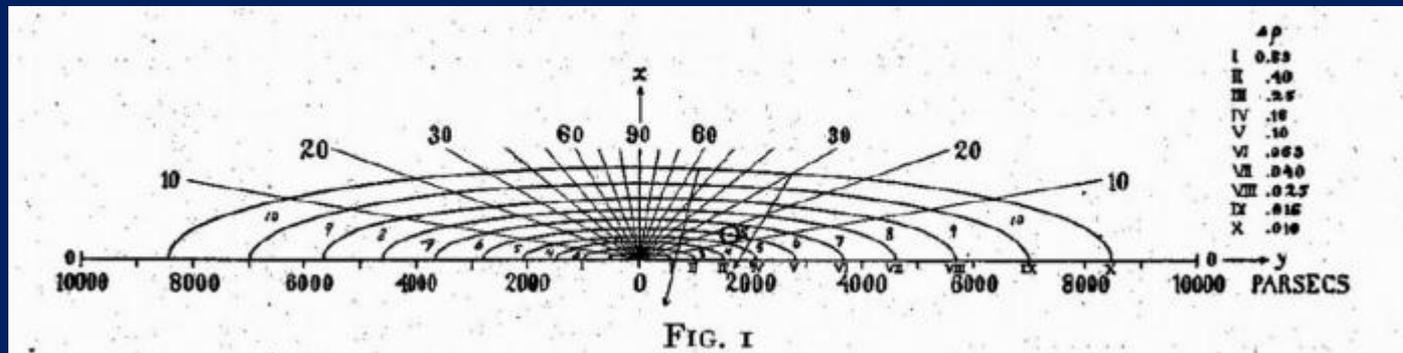
## Kapteyn Model (1922)



kpc = kiloparsec = 1000 pc

Kapteyn's star counts lead to a Milky Way of ca. 15 kpc x 3 Kpc

The Sun is very close to the center of the System



# William Herschel - 1796

342

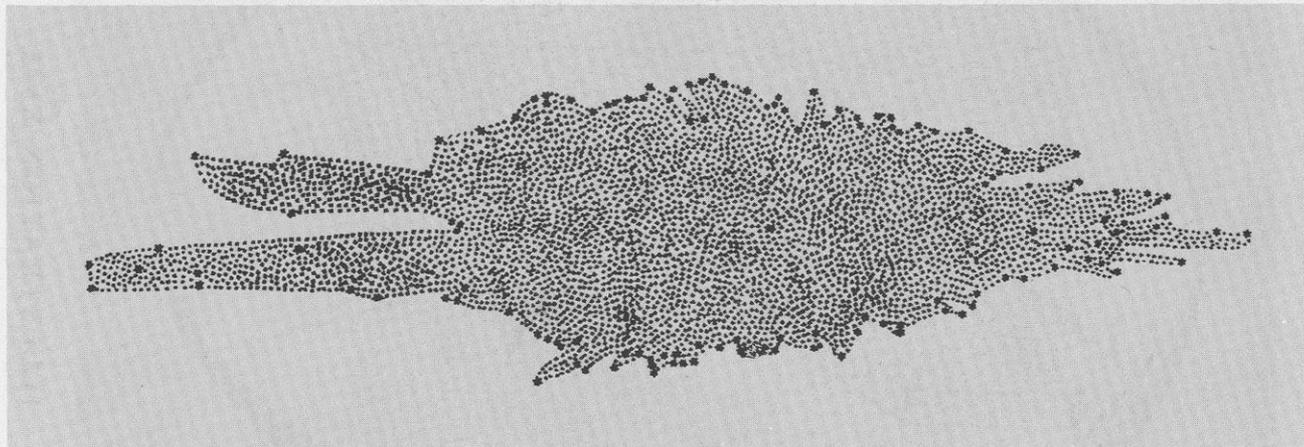


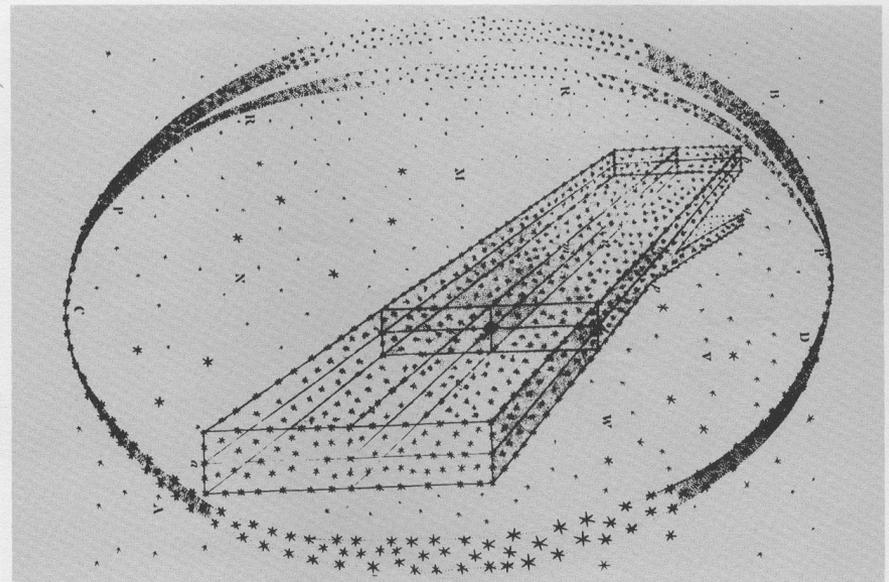
ILLUSTRATION XVIII

The Milky Way is a flattened disk with a ratio 1/5

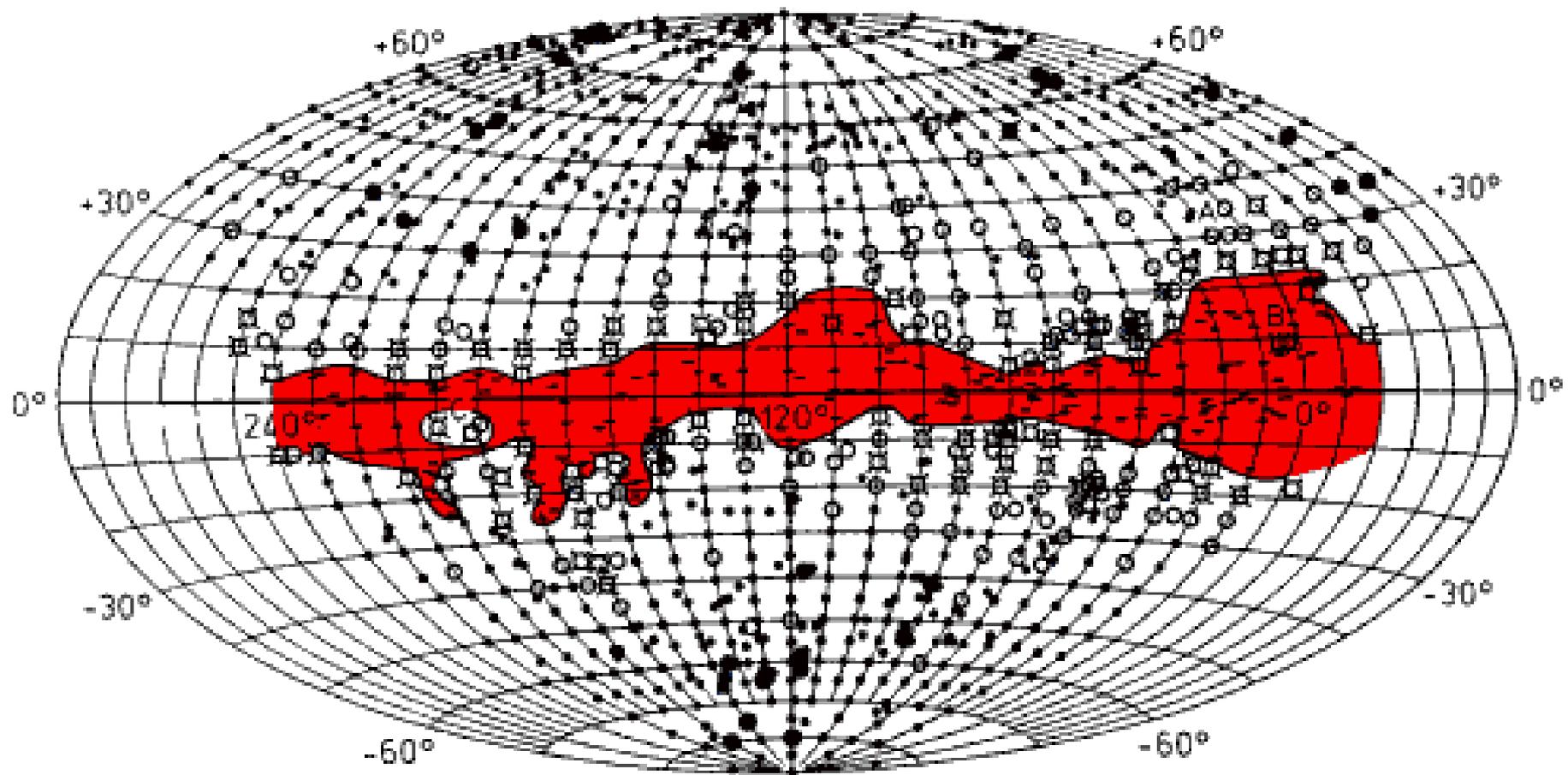
The Sun lies very close to the center of the system but Herschel warns that this is true only if the space between stars is empty

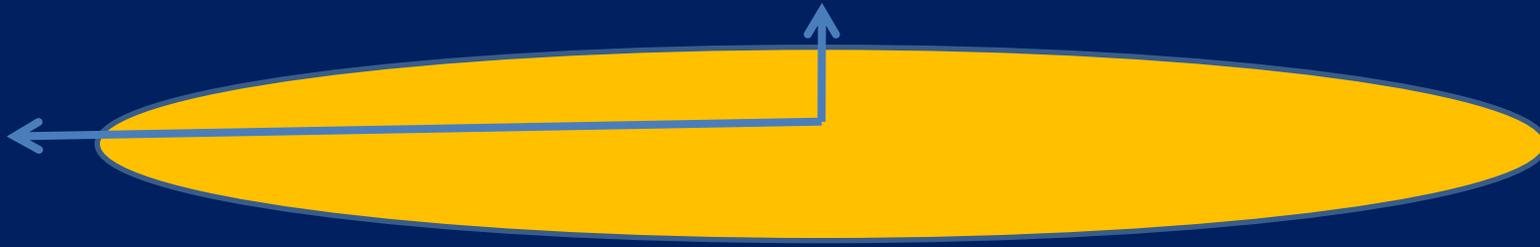
341

ILLUSTRATION XVII



# AVOIDANCE ZONE





WITHOUT absorption introduced by Interstellar Dust



WITH the absorption introduced by Interstellar Dust

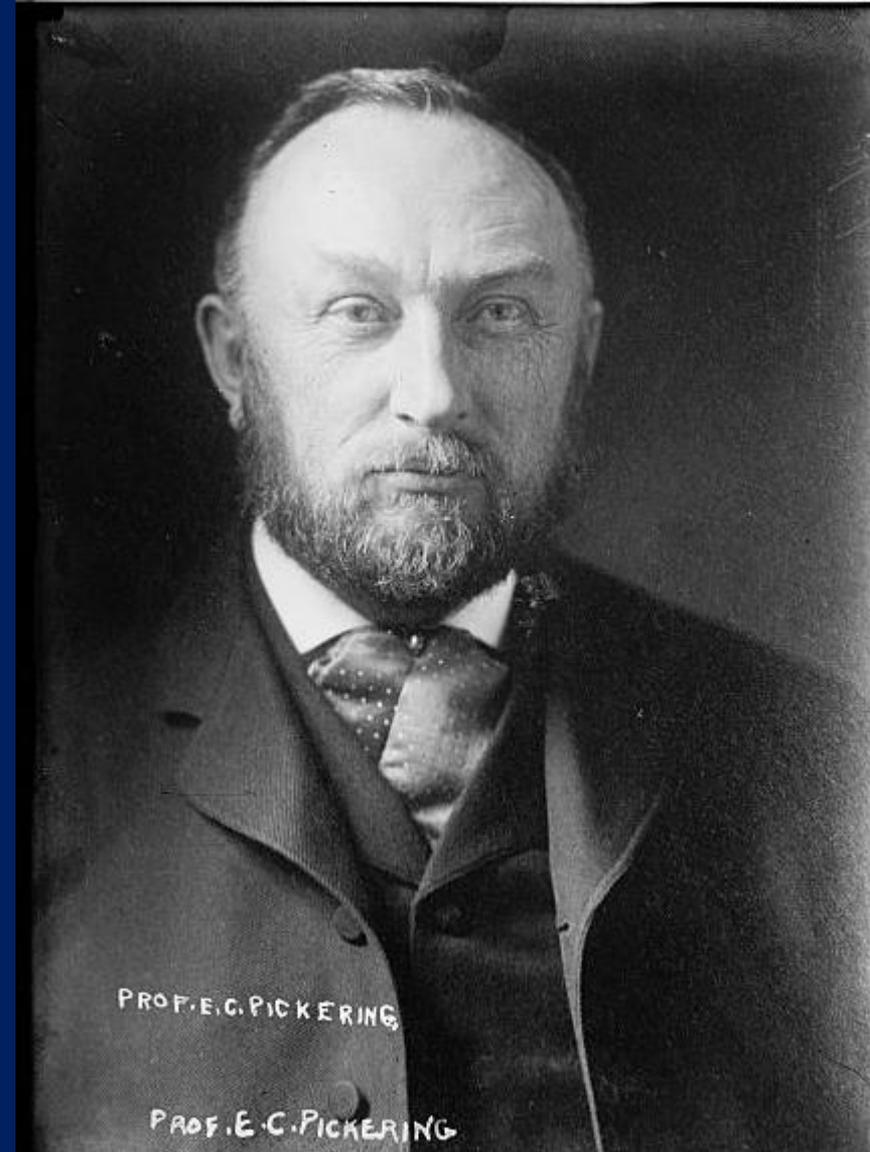
# Edward Charles Pickering (July 19, 1846–February 3, 1919)

Along with Carl Vogel, Pickering discovered the first spectroscopic binary stars. From 1877 to his death was director of the Harvard College Observatory

Pioneer of stellar photographic spectroscopy

Used women (“computers”) to reduce and analyse the plates

Annie Jump Cannon, Antonia Maury established the spectral classification system ...  
(e.g. O B A F G K M spectra)





Among the others:  
Williamina Fleming, Annie Jump Cannon, Henrietta Swan  
Leavitt and Antonia Maury

# Henrietta Swan Leavitt

(July 4, 1868 – December 12, 1921)

- In 1893 after graduating at Radcliffe, becomes a “computer” at Harvard College Observatory (working under E.C. Pickering) : counts stars on photographic plates (\$ 10.50-a-week) of the huge Harvard collection



- She notes thousands of variables in the Magellanic clouds and in 1908 publishes the results in the *Annals of the Astronomical Observatory of Harvard College*, noting that a few of the variables showed a pattern: brighter ones appeared to have longer periods.

1912

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 173.

PERIODS OF 25 VARIABLE STARS IN THE SMALL MAGELLANIC CLOUD.

The following statement regarding the periods of 25 variable stars in the Small Magellanic Cloud has been prepared by Miss Leavitt.

A Catalogue of 1777 variable stars in the two Magellanic Clouds is given in H.A. 60, No. 4. The measurement and discussion of these objects present problems of unusual difficulty, on account of the large area covered by the two regions, the extremely crowded distribution of the stars contained in



Scanned at the American Institute of Physics

- After further study, she confirmed in 1912 that the variable stars of greater intrinsic luminosity – actually Cepheid variables – did indeed have longer periods, and the relationship was quite strict, linear and predictable

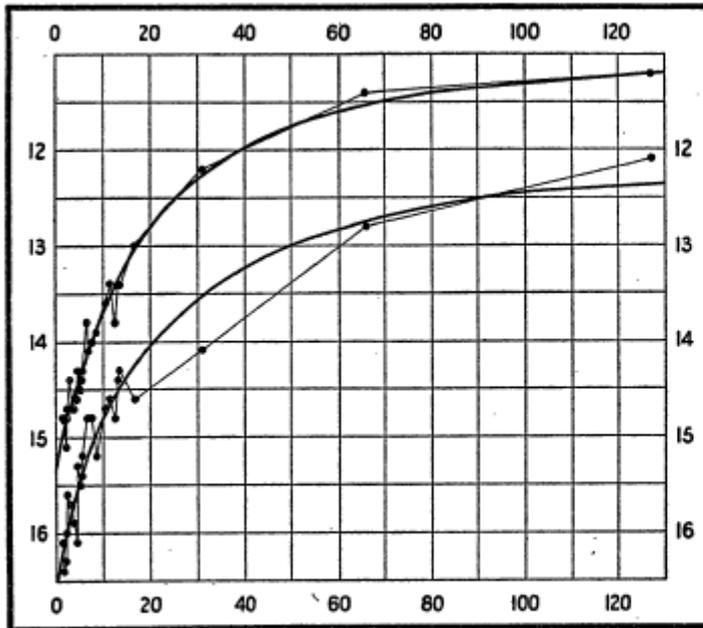


FIG. 1.

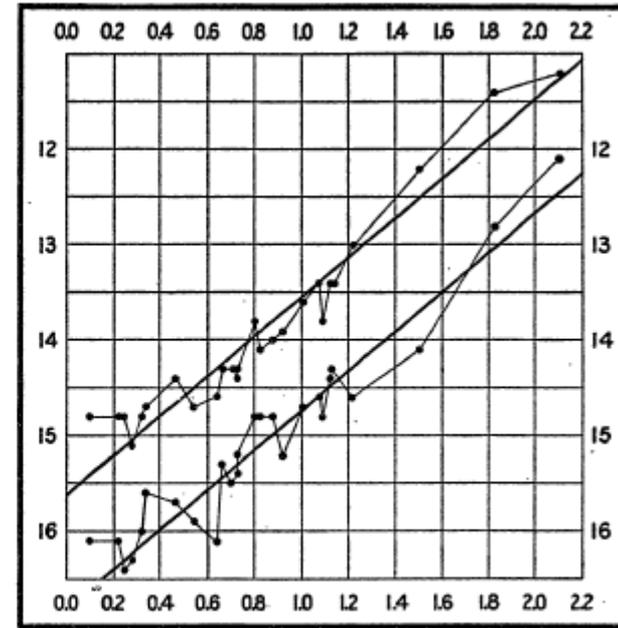


FIG. 2.

*“ Since the variables are probably at nearly the same distance from the Earth, their periods are apparently associated with their actual emission of light, as determined by their mass, density, and surface brightness”*

- Henrietta Leavitt had a quite difficult life, became deaf and died by cancer in 1922 after having been appointed leader of the Harvard Stellar Photometry Group
- In 1924 she was candidated to the Nobel prize by a committee who was unaware of her death
- In 1913 Ejnar Hertzsprung measure via trigonometric methods the parallax of several galactic cepheids and sets the zero point of the relationship between **Period and Luminosity**

# Heber Curtis

in 1917, George Ritchey at Mt. Wilson while taking long exposures of spiral nebulae to measure “proper motions and rotation”, finds a nova of apparent magnitude +15.

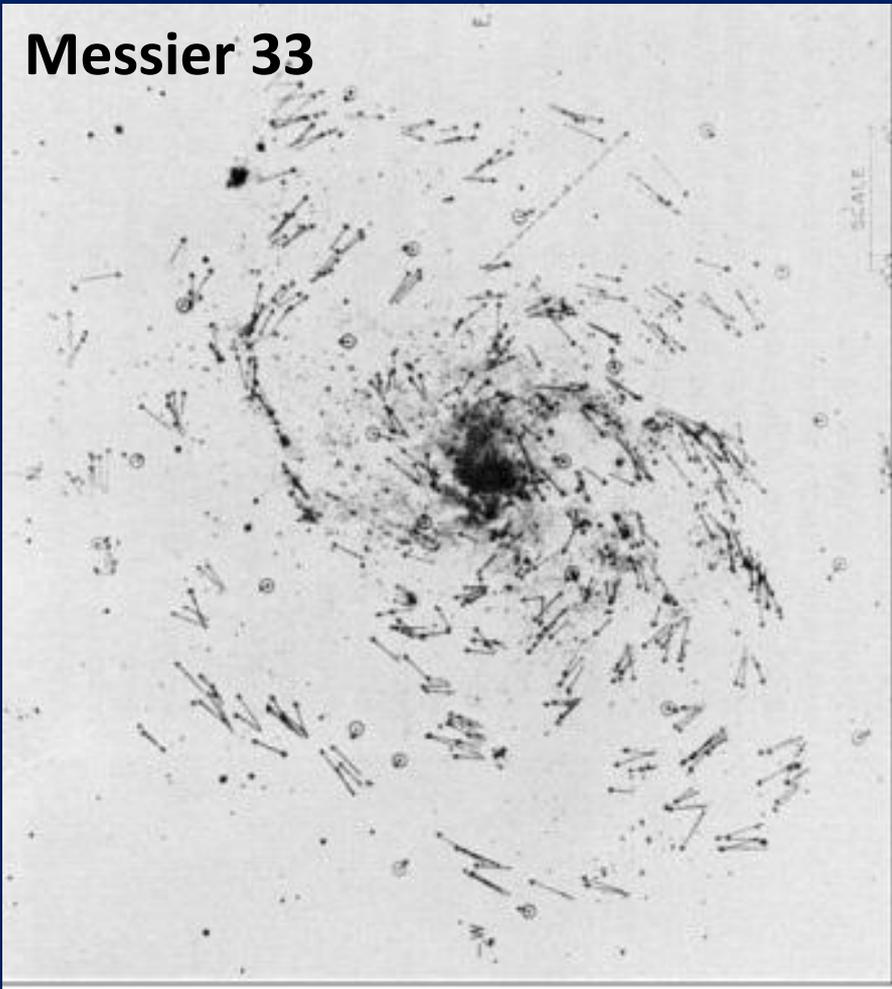
Soon other observatories were searching their plate collections and in 2 months, 11 more nova were discovered, many by Heber Curtis, who was also photographing spiral nebulae in a long term program to determine their proper motions, and thus get a handle on their direct distances.

Curtis found that there was an average difference of 10 magnitudes between galactic novae and those novae found in the spiral nebulae.

If this was the case, then if spiral novae were 10 magnitudes fainter, then they were 100 times further distant than galactic novae.



## Messier 33



## Adrian van Maanen

Student of Kapteyn

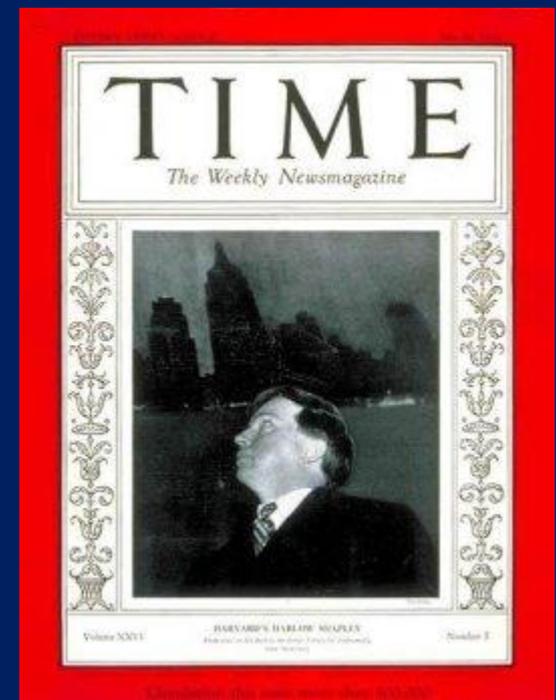
the Andromeda Galaxy parallax  $0.004 \pm 0.005''$  (250 pc).  
van Maanen's measurements were at the limit of detectable  
precision average rotational motion of spirals seemed to hover  
around 0.020 radians/yr, (1 radian =  $57.3^\circ$ ) indicating a complete  
rotation in less than 1,000 years.

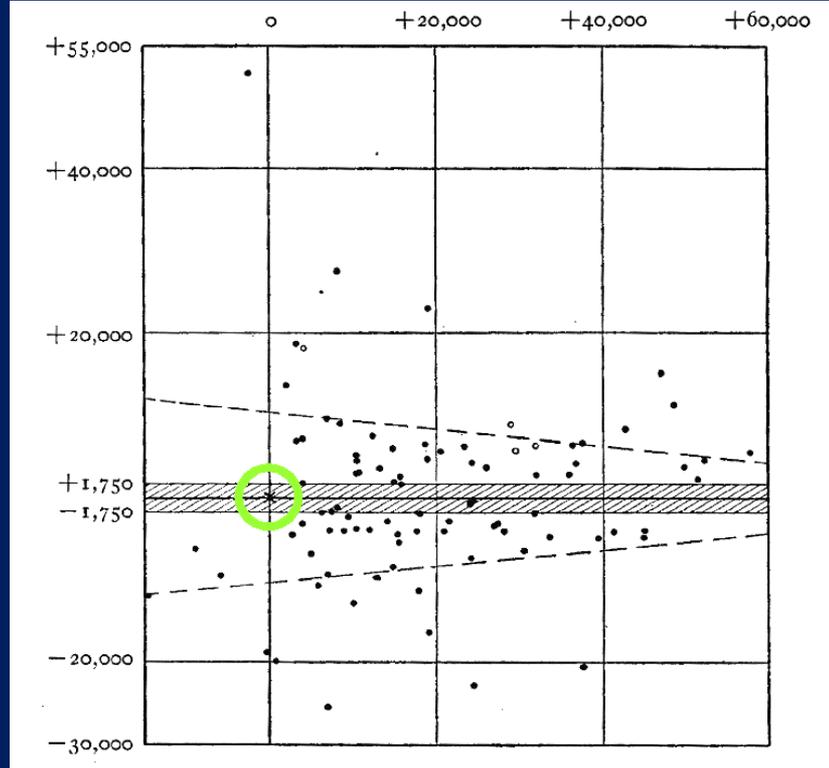
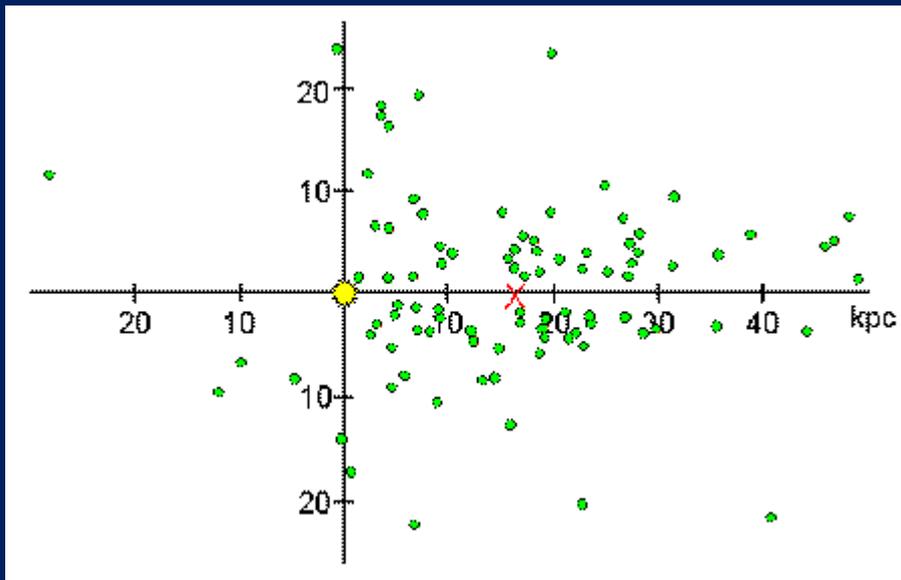
# Harlow Shapley (Nashville 1885-1972)

Drops school after the fifth-grade and becomes a reporter covering crime stories

Re enters school and finishes college in only two years (with honor) and in 1907 enters the University of Missouri to study journalism but, ***when he learned that the opening of the School of Journalism had been postponed for a year, he decided to study the first subject he came across in the course directory. Rejecting Archaeology, which Harlow later explained he couldn't pronounce, Harlow chose the next subject, Astronomy.***

Ph.D. fellowship at Princeton to measure the distance to Globular Clusters using the Period-Luminosity relationship....





# Situation in the 20's

The Universe is transparent.  
No absorption

Novae are still confused with  
Supernovae

No one knows what nebulae  
are, but...

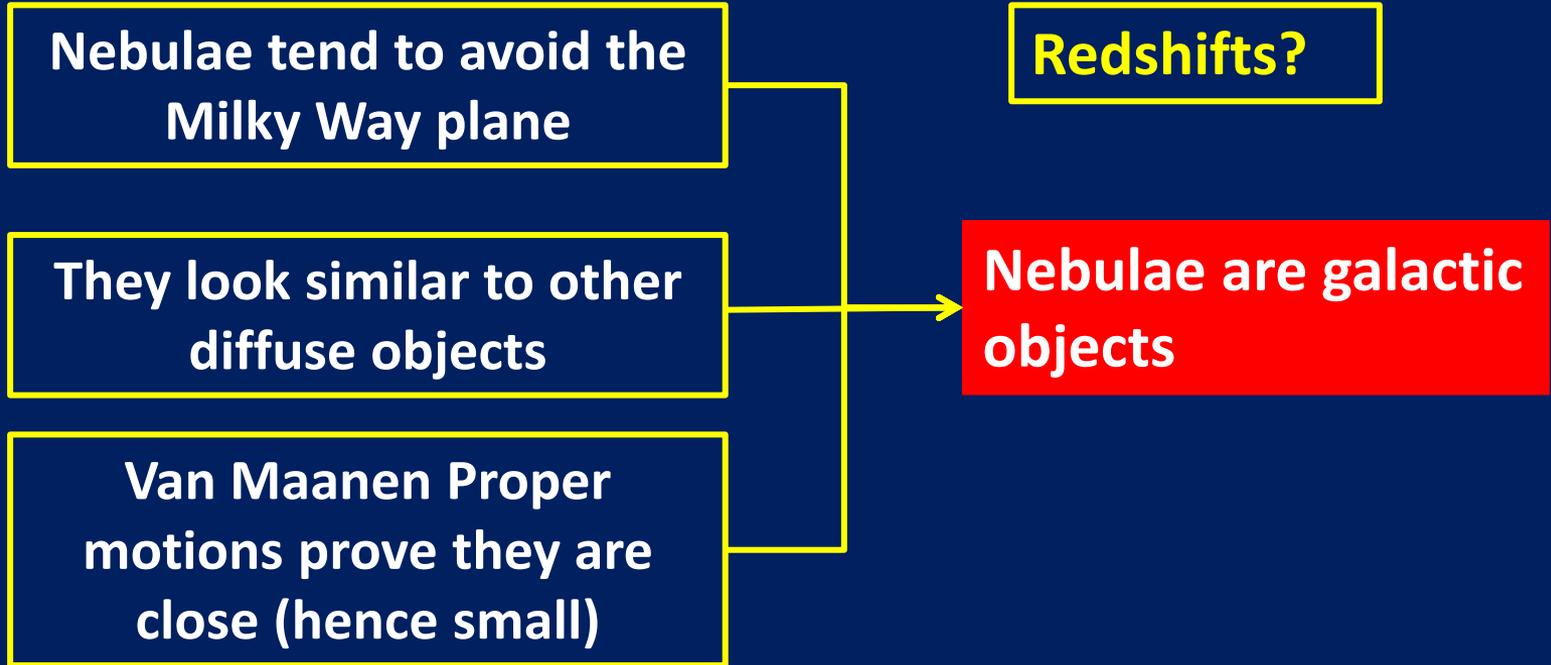
Nebulae tend to avoid the  
Milky Way plane

They look similar to other  
diffuse objects

Van Maanen Proper  
motions prove they are  
close (hence small)

Redshifts?

Nebulae are galactic  
objects



# Situation in the 20's – LARGE MILKY WAY

The Universe is transparent.  
No absorption

Novae are still confused with  
Supernovae

Milky Way is 30 Kp in  
diameter

Van Maanen is right

Milky Way is 30 Kp in  
diameter

Van Maanen is wrong

Nebulae are galactic  
objects

Nebulae are galactic  
objects

Letter of the 3 January by C. G. Abbot, the Home Secretary of the Academy, to G.E. Hale:

You mentioned the possibility of a sort of debate, either on the subject of the **island universe** or of **relativity**. From the way the English are rushing relativity in Nature and elsewhere it looks as if the subject would be done to death long before the meeting of the Academy, and perhaps your first proposal to try to get Campbell and Shapley to discuss the island universe would be more interesting.

I have a sort of fear, however, **that the people care so little about island universes**, notwithstanding their vast extent, that unless the speakers took pains to make the subject very engaging the thing would fall flat....

**Are there not other subjects-the cause of glacial periods, or some zoological or biological subject-which might make an interesting debate?"**

**As to relativity, I must confess that I would rather have a subject in which there would be a half dozen members of the Academy competent enough to understand at least a few words of what the speakers were saying if we had a symposium upon it.**

**I pray to God that the progress of science will send relativity to some region of space beyond the fourth dimension, from whence it may never return to plague us.**

**26 April 1920**

the Baird auditorium of the Smithsonian Museum of Natural History hosts the William Hallery Hale Lecture on “the distance Scale”

Takes place  
**“THE GREAT DEBATE”**

Harlow Shapley (Mt. Wilson)  
against  
Heber Curtis (Lick)

Two lectures in the morning and prolonged discussion in the evening



**To be continued**

| SHAPLEY                     | CURTIS   | WINNER  |
|-----------------------------|--|---------|
| Galaxy is large             | Galaxy is small  | Shapley |
| Nebulae are galactic        | Nebulae are extragalactic                                  | Curtis  |
| ARGUMENTS                   |  |         |
| Van Maanen is right         | Van Maanen is right  | wrong   |
| SN1885 puts Andromeda close | ?  | wrong   |
| $10^8$ ly are too much      | $10^8$ ly are too much                                     | wrong   |
| Redshifts due to expulsion  | Redshifts?   | Curtis  |
| ?                           | Novae are more frequent in Andromeda than in the Milky Way | Curtis  |
|                             |  |         |
|                             |  |         |