

26-06-2014

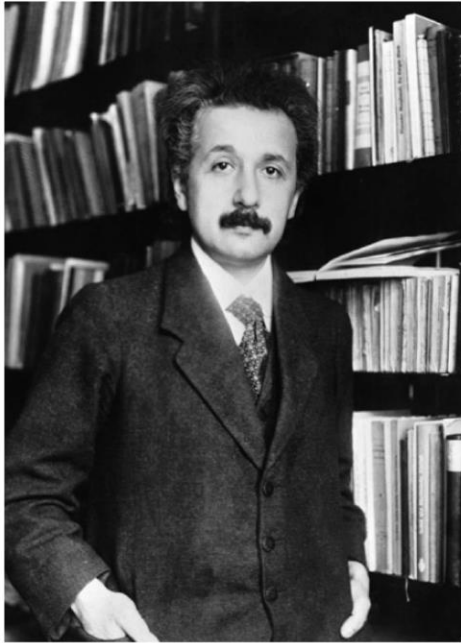
# VAR!

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Mecánica estadística 2014

Charla 1-Expansión del universo

1916



1916.

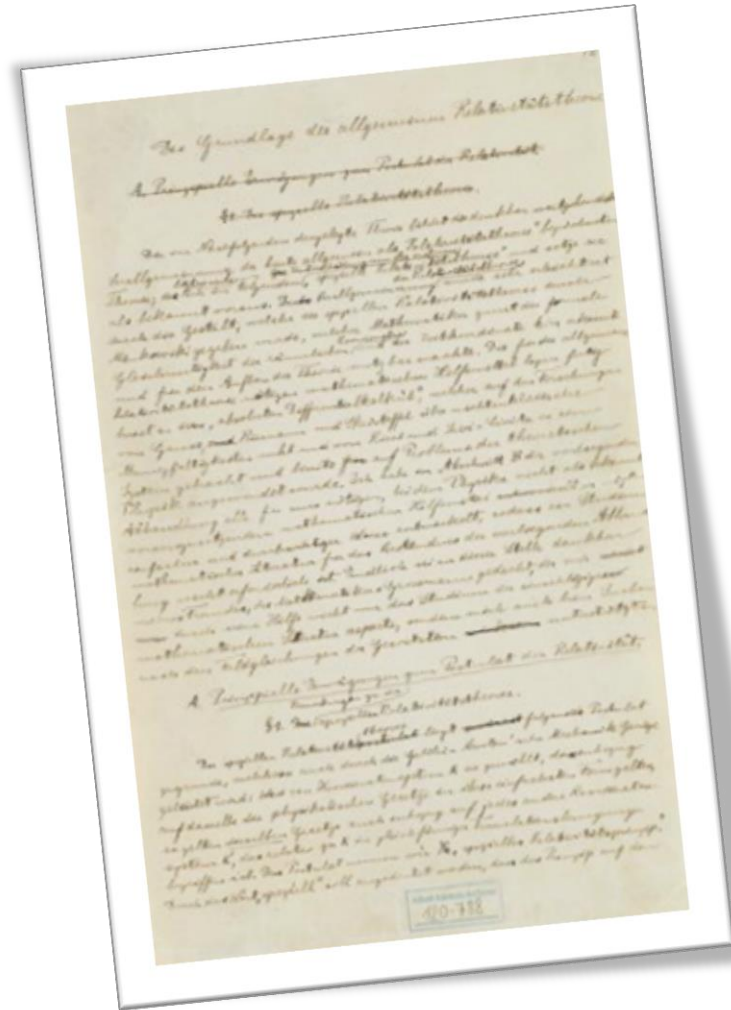
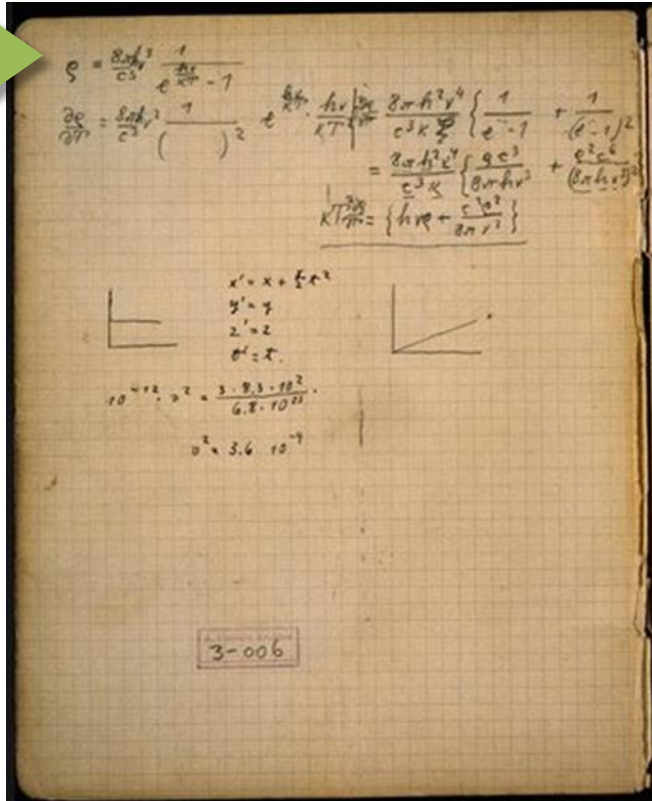
№ 7.

ANNALEN DER PHYSIK.  
VIERTE FOLGE. BAND 49.

1. Die Grundlage  
der allgemeinen Relativitätstheorie;  
von A. Einstein.

Die im nachfolgenden dargelegte Theorie bildet die denkbar weitgehendste Verallgemeinerung der heute allgemein als „Relativitätstheorie“ bezeichneten Theorie; die letztere nenne ich im folgenden zur Unterscheidung von der ersteren „spezielle Relativitätstheorie“ und setze sie als bekannt voraus. Die Verallgemeinerung der Relativitätstheorie wurde sehr erleichtert durch die Gestalt, welche der speziellen Relativitätstheorie durch Minkowski gegeben wurde, welcher Mathematiker zuerst die formale Gleichwertigkeit der räumlichen Koordinaten und der Zeitkoordinate klar erkannte und für den Aufbau der Theorie nutzbar machte. Die für die allgemeine Relativitätstheorie nötigen mathematischen Hilfsmittel lagen fertig bereit in dem „absoluten Differentialkalkül“, welcher auf den Forschungen von Gauss, Riemann und Christoffel über nichteuklidische Mannigfaltigkeiten ruht und von Ricci und Levi-Civita in ein System gebracht und bereits auf Probleme der theoretischen Physik angewendet wurde. Ich habe im Abschnitt B der vorliegenden Abhandlung alle für uns nötigen, bei dem Physiker nicht als bekannt vorauszusetzenden mathematischen Hilfsmittel in möglichst einfacher und durchsichtiger Weise entwickelt, so daß ein Studium mathematischer Literatur für das Verständnis der vorliegenden Abhandlung nicht erforderlich ist. Endlich sei an dieser Stelle dankbar meines Freundes, des Mathematikers Grossmann, gedacht, der mir durch seine Hilfe nicht nur das Studium der einschlägigen mathematischen Literatur ersparte, sondern mich auch beim Suchen nach den Feldgleichungen der Gravitation unterstützte.

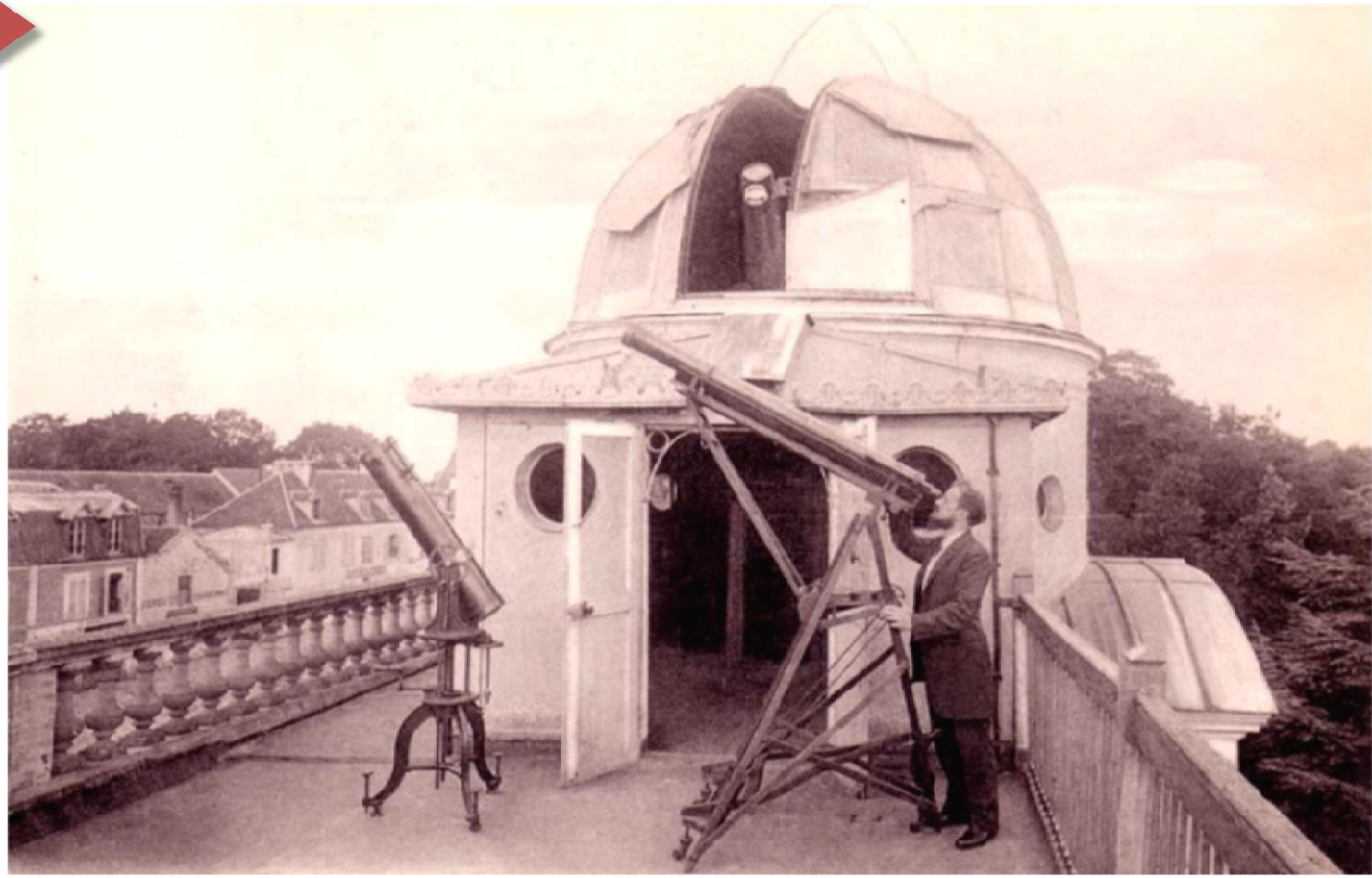
1916



<http://teoria-de-la-relatividad.blogspot.com.ar/2009/03/apendice-iv-el-manuscrito-original-de.html>

<http://www.alberteinstein.info/>

1916





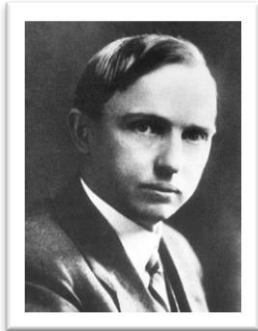
1920

# ▶ El gran debate



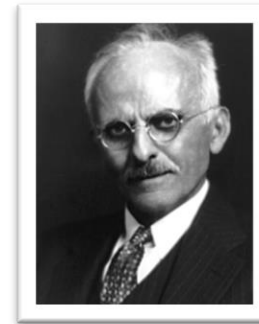
1920

## ▶ El gran debate



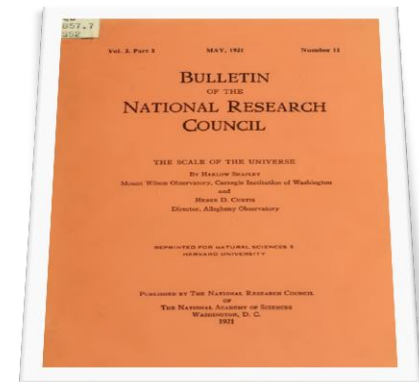
▶ Harlow Shapley

- La Vía Láctea comprendía la totalidad del universo.
- Las galaxias como Andrómeda y las nebulosas espirales pertenecían a la Vía Láctea.
- Si Andrómeda no fuese una parte de la Vía Láctea, entonces se hallaría a una distancia de unos 108 años-luz.



▶ Heber Curtis

- Andrómeda y las otras nebulosas eran galaxias independientes o "universos-isla".
- Mostró que había más novas en Andrómeda que en la Vía Láctea.



 <http://fcaglp.fcaglp.unlp.edu.ar/~egiorgi/cumulos/historica/debate.htm>

<https://archive.org/details/scaleofuniverse00shap>

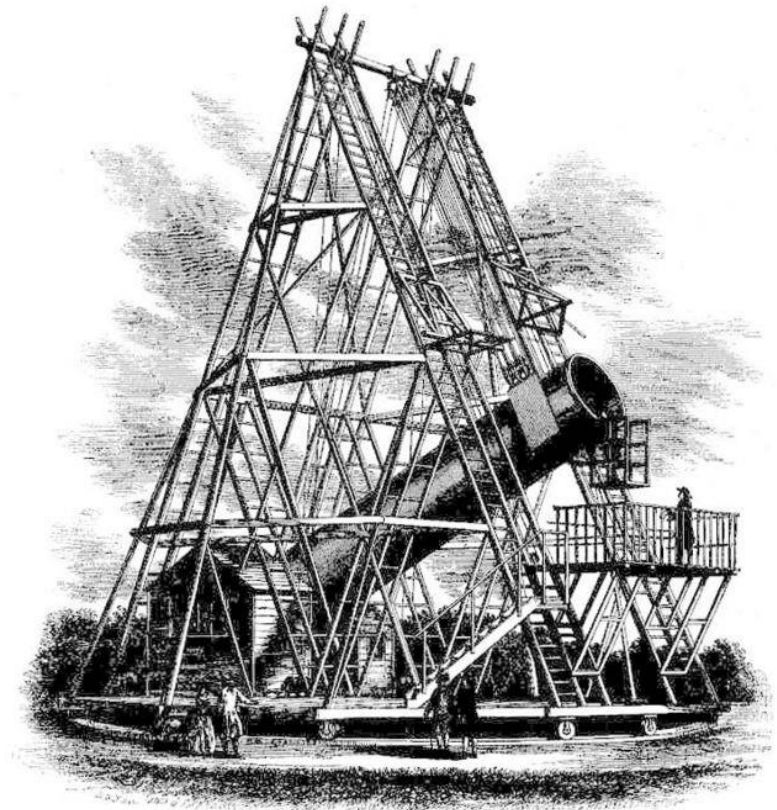
1789



William Herschel

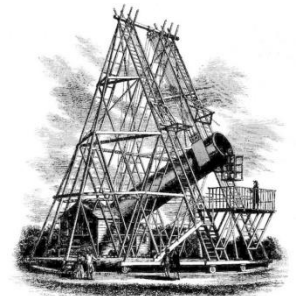
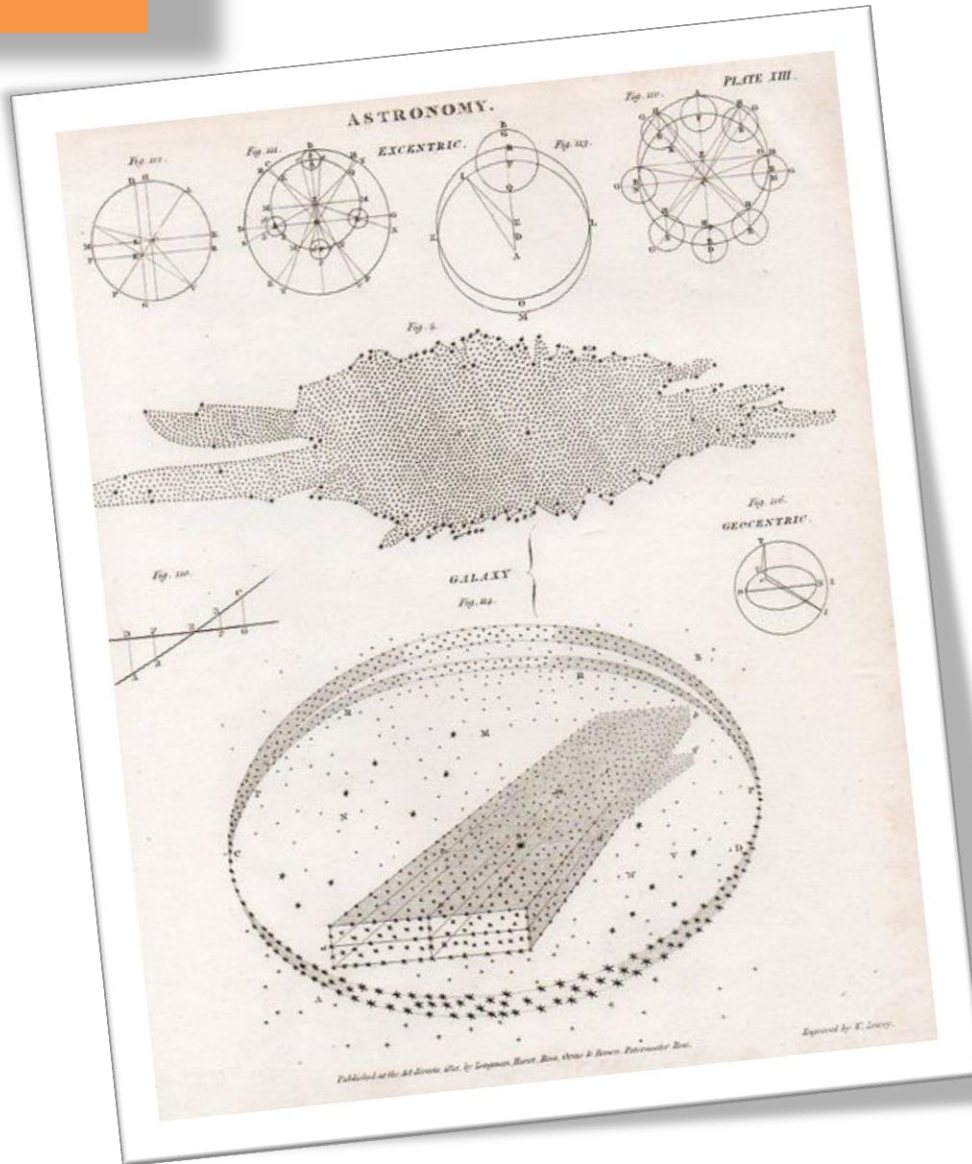
Realizó un conteo de estrellas en el campo de vista de su telescopio. Cuando terminó el proyecto, 20 años después, había contado mas de 90.000 estrellas en 2400 áreas de muestra. Durante estas observaciones descubrió muchos objetos interesantes como cúmulos, nebulosas, estrellas variables y estrellas dobles.

Telescopio reflector  
espejo de 1,98 m de diámetro.





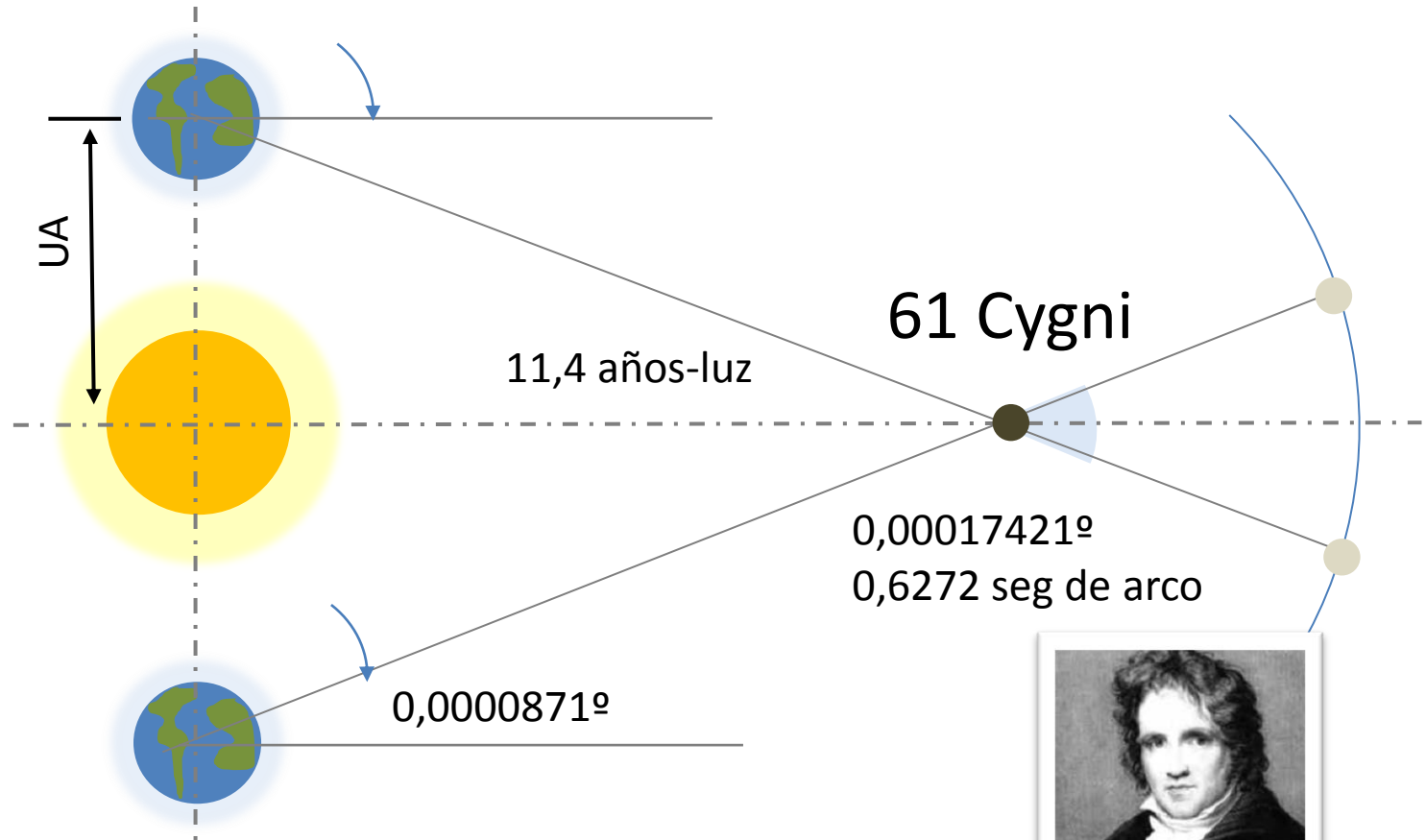
1789



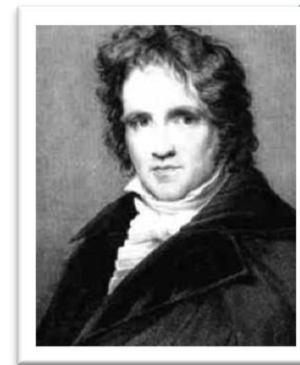


1838

# ▶ Paralaje estelar



**1 pársec** = 206.265 ua = 3,2616 años luz =  $3,0857 \times 10^{16}$  m



Friedrich Bessel

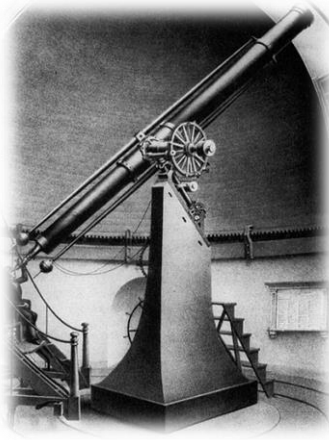


1877

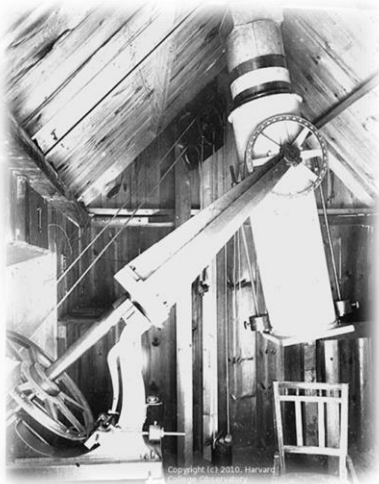


Edward Pickering

# ▶ Catálogo Draper



El gran refractor  
38 cm de lente  
Harvard



Telescopio reflector  
8 pulgadas diámetro espejo  
Arequipa Perú



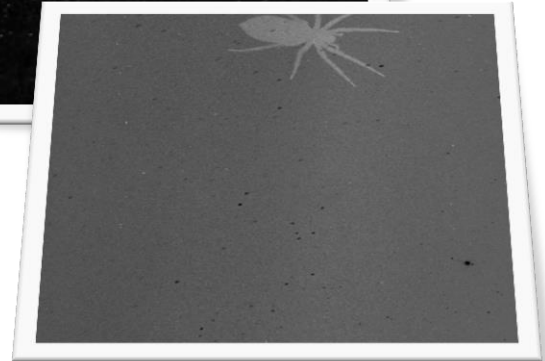
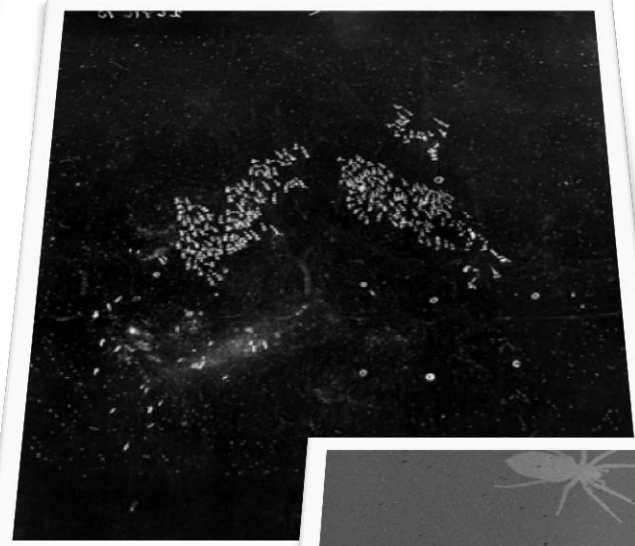
1877

## ▶ El harem de Pickering



- A lo largo de casi 6 décadas, se analizaron más de 500000 placas fotográficas, catalogando cerca de 10 millones de estrellas.
- El primer catálogo publicado en 1890 contenía la clasificación de 10000 estrellas.

1877



<http://www.cfa.harvard.edu/hco/plates.html>



# 2014

The screenshot shows the Galaxy Zoo website interface. At the top left, it states "Galaxy Zoo is a Zooniverse project." and "Our Projects" section lists 12 projects in astronomy, climatology, biology, and humanities. A login section on the top right includes fields for "username" and "password", and buttons for "Login" and "Sign Up". The main navigation menu includes "CLASSIFY", "STORY", "SCIENCE", "GALAXY ZOO" (highlighted in yellow), "DISCUSS", "PROFILE", and "LANGUAGE". The central banner features the headline "Few have witnessed what you're about to see" and a sub-headline "Experience a privileged glimpse of the distant universe as observed by the SDSS, the Hubble Space Telescope, and UKIRT". Below this is a "GALAXY ZOO QUARTZ" logo and a call to action: "We are trying something new! Come help us understand a very specific type of galaxy and experience science from start to end. [Take part](#)". The "Classify Galaxies" section explains the goal: "To understand how galaxies formed we need your help to classify them according to their shapes. If you're quick, you may even be the first person to see the galaxies you're asked to classify." and includes a "Begin Classifying" button. A large image of a spiral galaxy is shown. At the bottom, there are two columns: "How Do Galaxies Form?" and "History of Galaxy Zoo".



Galaxyzoo.org

Clasificar 1 millón de galaxias del telescopio Hubble



<http://www.galaxyzoo.org/>

# 1904



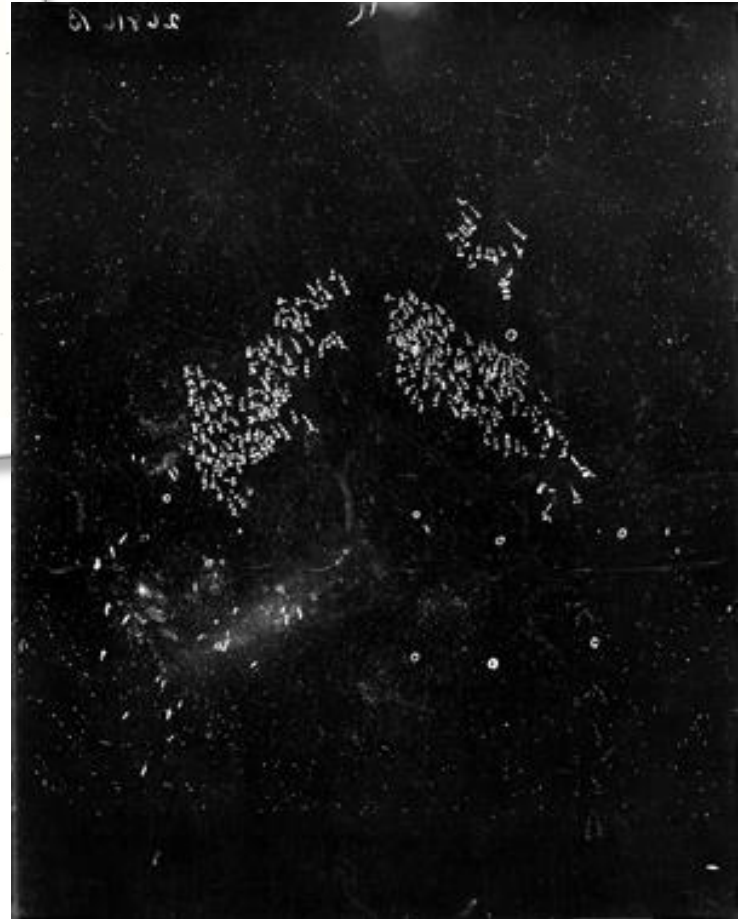
▶ Henrietta Leavitt

ANNALS OF HARVARD COLLEGE OBSERVATORY. VOL. LX. No. IV.

## 1777 VARIABLES IN THE MAGELLANIC CLOUDS. By HENRIETTA S. LEAVITT.

In the spring of 1904, a comparison of two photographs of the Small Magellanic Cloud, taken with the 24-inch Bruce Telescope, led to the discovery of a number of faint variable stars. As the region appeared to be interesting, other plates were examined, and although the quality of most of these was below the usual high standard of excellence of the later plates, 57 new variables were found, and announced in Circular 79. In order to furnish material for determining their periods, a series of sixteen plates, having exposures of from two to four hours, was taken with the Bruce Telescope the following autumn. When they arrived at Cambridge, in January, 1905, a comparison of one of them with an early plate led immediately to the discovery of an extraordinary number of new variable stars. It was found also, that plates, taken within two or three days of each other, could be compared with equally interesting results, showing that the periods of many of the variables are short. The number thus discovered, up to the present time, is 969. Adding to these 23 previously known, the total number of variables on 18 photographs taken with the Large Magellanic Cloud has also been examined on 18 photographs taken with the 24-inch Bruce Telescope, and 808 new variables have been found, of which 152 were announced in Circular 82. As much time will be required for the discussion of these variables, the provisional catalogues given below have been prepared.

The labor of determining the precise right ascensions and declinations of nearly eighteen hundred variables and several hundred comparison stars would be very great, and as many of the objects are faint, the resulting positions could not readily be used in locating them. Accordingly, their rectangular coordinates have been employed. A reticule was prepared by making a photographic enlargement of a glass plate ruled accurately in squares, a millimetre on a side. The resulting plate measured 14 x 17 inches, the size of the Bruce plates, and was covered with squares measuring a centimetre on a side. Great care was taken to have the scale uniform in all parts of this plate, which was designed to furnish a standard reticule, not only for the Magellanic



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 Leitch in a Catalogue of 1777 variable stars in the Small Magellanic Cloud.

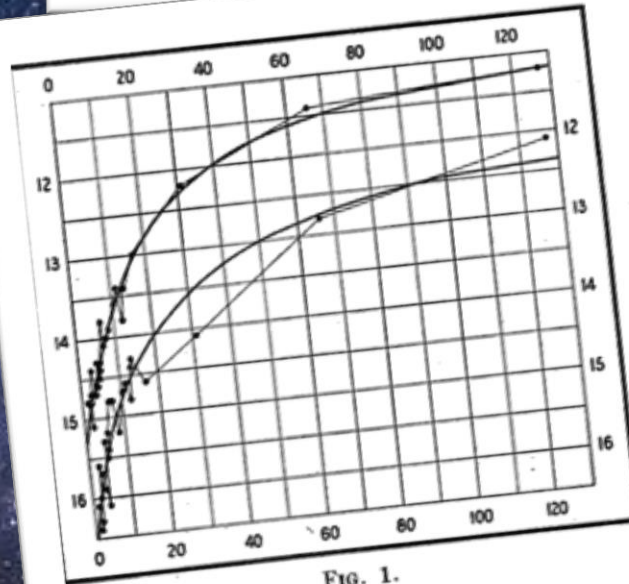


FIG. 1.

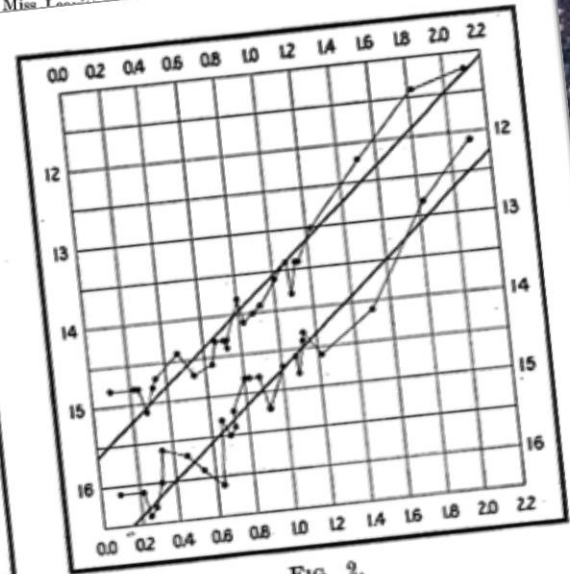


FIG. 2.



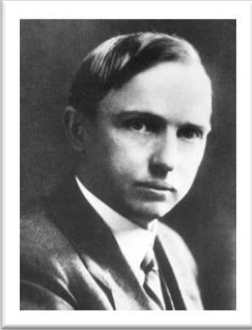
1912



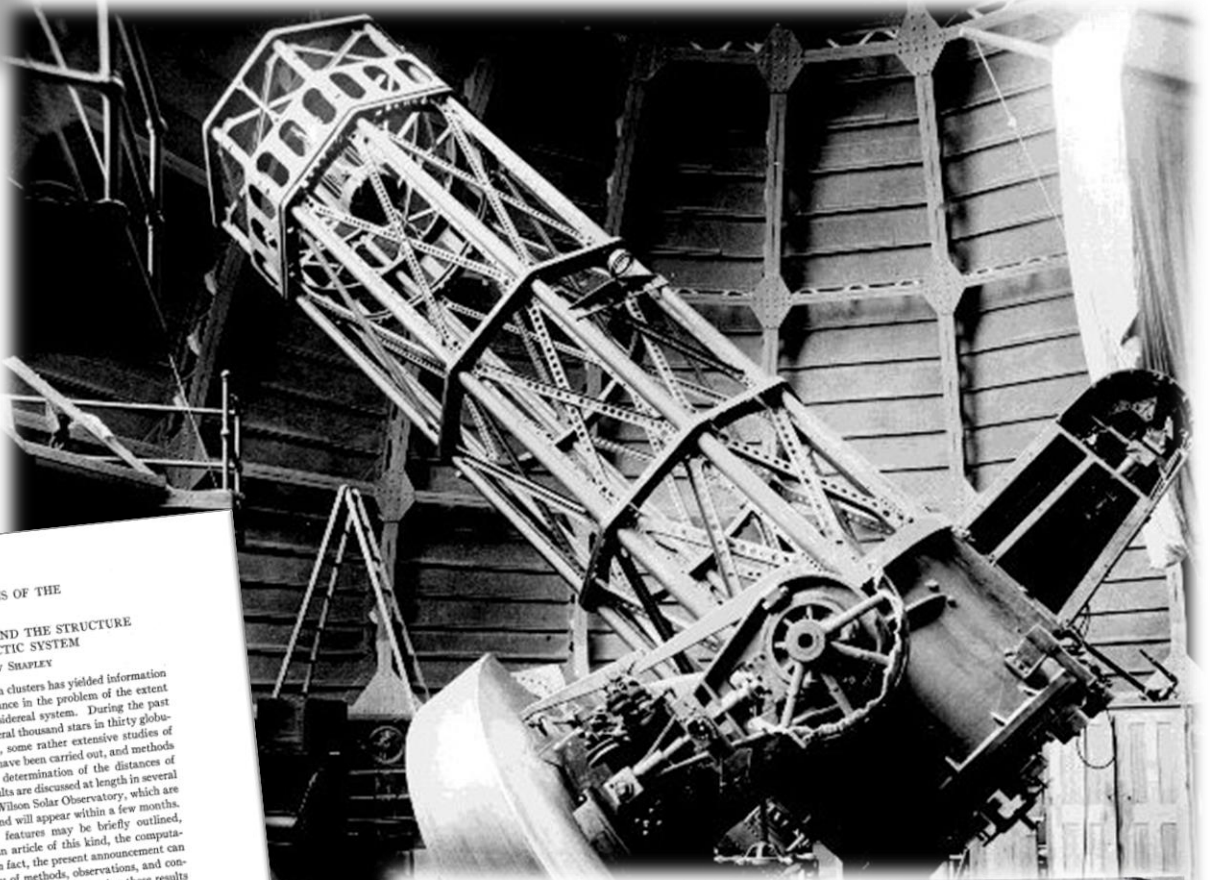
Se denominan CEFÉIDAS por el nombre del prototipo de esta clase, la estrella Delta Cephei, la cuarta en orden de brillo de la constelación de Cefeo



# 1917



▶ Harlow Shapley



42 PUBLICATIONS OF THE  
GLOBULAR CLUSTERS AND THE STRUCTURE  
OF THE GALACTIC SYSTEM  
BY HARLOW SHAPLEY

The continuation of my work on clusters has yielded information that seems to have some significance in the problem of the extent and arrangement of the general sidereal system. During the past two years the magnitudes of several thousand stars in thirty globular clusters have been measured, some rather extensive studies of variable stars and open clusters have been carried out, and methods have been investigated for the determination of the distances of clusters and variables. The results are discussed at length in several contributions from the Mount Wilson Solar Observatory, which are now in process of publication and will appear within a few months. Meanwhile the more striking features may be briefly outlined, omitting, as is necessary for an article of this kind, the computations and numerical tables. In fact, the present announcement can be little more than a summary of methods, observations, and conclusions, and indulgence must be asked for presenting these results in advance of the observational material upon which they are based. The accompanying diagrams, however, may partially serve in the place of tabular data.

A. METHODS OF DETERMINING THE DISTANCES OF GLOBULAR CLUSTERS

1. The parallaxes of stellar systems that are too remote for direct trigonometrical measurement are best determined from the luminosities of the individual stars they contain. To give such a method accuracy, we must first find stars both near the Sun and in the distant systems having intrinsic luminosities which, within allowable uncertainties, are comparable, and in the second place we must be able to derive the absolute magnitudes of such stars near the Sun. To estimate provisionally the distances of the *Persaeus* cluster and the Small Magellanic Cloud, Kapteyn has used the B-type stars, for which the differences in real brightness are not great and for which the absolute magnitudes are determined with considerable certainty from proper motion data. Hertzsprung, on the other hand, has resorted to the use of Cepheid variables to estimate the parallax of the Small Magellanic Cloud, basing

12 MAY 29 1921 BOSTON SUNDAY ADVERTISER—New Eng

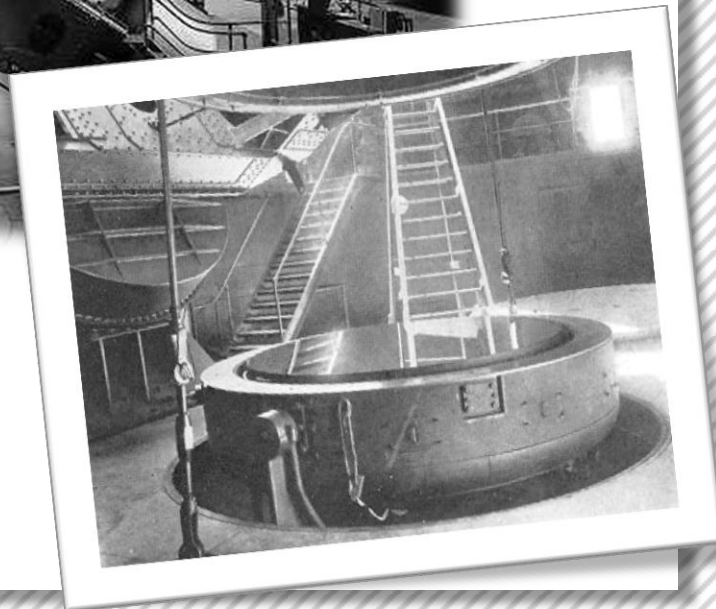
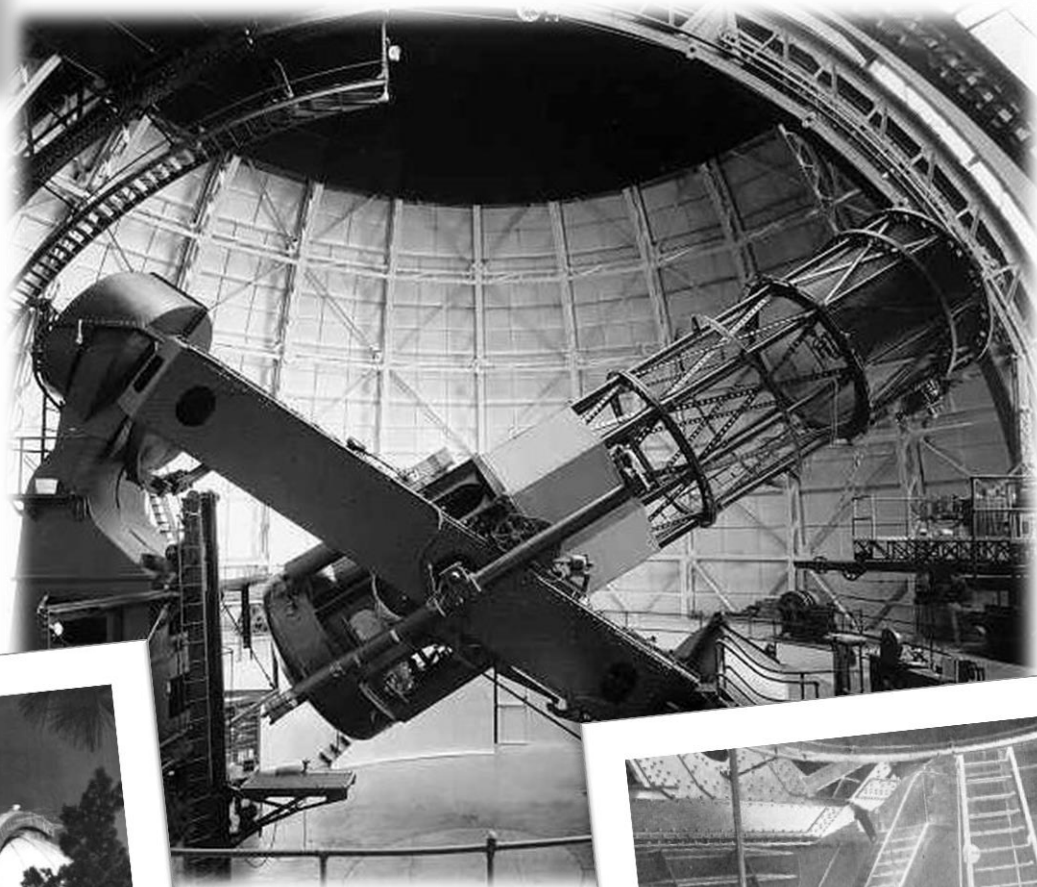
## UNIVERSE THOUSAND TIMES BIGGER, HARVARD ASTRONOMER DISCOVERS

The diagram shows a horizontal scale of the universe. On the left, a dashed oval is labeled 'REGION OF FAINT STARS IN TAURUS AND AURIGA'. In the center, a small circle with an 'x' is labeled 'SOLAR DOMAIN'. To its right, a larger circle is labeled '300 TRILLION MILES' and '60,000 LIGHT YEARS'. On the far right, a large dashed oval is labeled 'REGION OF GREAT STAR CLOUDS IN SAGITTARIUS'. A large 'C' is placed at the end of the scale.

1920



▶ Edwin Hubble

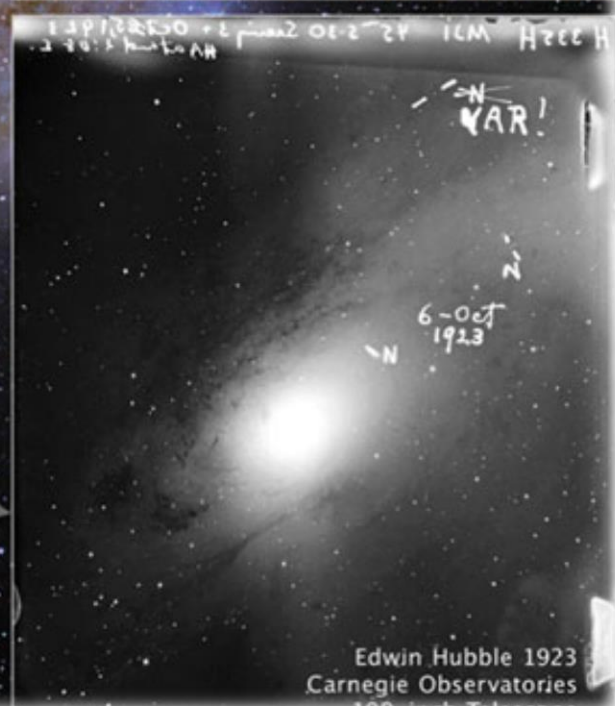




1923



Photo: B. Gendler



Edwin Hubble 1923  
Carnegie Observatories  
100-inch Telescope

# 1923

156										157													
Plate No.	Object	RA	Dec	Exposure Time	Plate Size	Date	Mag	HA	Quality	Plate No.	Remarks	Plate No.	Object	RA	Dec	Exposure Time	Plate Size	Date	Mag	Quality			
312	NPC 6822	19 42	-15 37	150	175x175	July 17	11.7	1923	fair to good	313	Slightly repaired near diffraction circles but nothing else out of line	313	NPC 6822	19 40.5	-15 0	60	175x175	July 18	11.8	0.18E	fair		
315	"	"	"	30	"	"	9.2	"	0.25W	"	main smooth	314	"	"	"	30	"	"	9.2	"	0.25W	fair	
316	"	"	"	110	"	"	3.2	"	0.25W	"	good	315	"	"	"	110	"	"	3.2	"	0.25W	fair	
317	NPC 6822	19 40.5	-15 0	28	"	Aug 15	"	"	0.1E	316	fa. mag. large	317	NPC 6822	19 40.5	-15 0	28	"	"	"	"	"	0.1E	good
318	SA 126	20 0	-15 2	100	"	"	"	"	"	318	good	318	SA 126	20 0	-15 2	100	"	"	"	"	"	"	good
319	"	"	"	100	"	"	"	"	"	319	fa.	319	"	"	"	100	"	"	"	"	"	fa.	
320	SA 06	"	"	100	"	"	"	"	"	320	good	320	SA 06	"	"	100	"	"	"	"	"	good	
321	"	23 0	-15 2	90	"	"	"	"	0.1E	321	fa. & weak	321	"	23 0	-15 2	90	"	"	"	"	0.1E	fa. & weak	
322	"	23 23.8	-15 2	55	"	"	"	"	0.25W	322	"	322	"	23 23.8	-15 2	55	"	"	"	"	0.25W	"	
323	"	4 17.3	-14 20	75	"	"	"	"	0.1E	323	fa. & good	323	"	4 17.3	-14 20	75	"	"	"	"	0.1E	fa. & good	
324	"	"	"	12	"	"	"	"	0.25W	324	"	324	"	"	"	12	"	"	"	"	0.25W	"	
325	NPC 7117	21 4	-14 15	60	175x175	Aug 17	11.0	1923	mag. only	325	Cassiopeia focus	325	NPC 7117	21 4	-14 15	60	175x175	Aug 17	11.0	1923	mag. only		
326	NPC 6822	19 40.5	-15 0	60	"	Sept 10	"	"	0.25W	326	fa.	326	NPC 6822	19 40.5	-15 0	60	"	Sept 10	"	"	0.25W	fa.	
327	"	1-22.7	-14 7	150	"	"	3-4	"	0.25W	327	fa.	327	"	1-22.7	-14 7	150	"	"	"	0.25W	fa.		
328	"	5-12	-13 15	60	"	"	2-1	"	0.1E	328	"	328	"	5-12	-13 15	60	"	"	"	0.1E	"		
329	NPC 6822	19 40.5	-15 0	60	175x175	Oct 4	"	"	0.1E	329	poor	329	NPC 6822	19 40.5	-15 0	60	175x175	Oct 4	"	"	0.1E	poor	
330	NPC 7117	0-28.5	-14 26	100	"	"	"	"	0.1E	330	poor	330	NPC 7117	0-28.5	-14 26	100	"	"	"	"	0.1E	poor	
331	M 31	0-28.7	-14 20	40	175x175	"	"	"	0.1E	331	poor	331	M 31	0-28.7	-14 20	40	175x175	"	"	"	0.1E	poor	
332	NPC 1022	2-24.7	-7 1	90	"	"	1-1	"	0.1E	332	poor	332	NPC 1022	2-24.7	-7 1	90	"	"	"	1-1	"	0.1E	poor
333	"	15-56.8	-7 4	50	175x175	Oct 5	"	"	0.1E	333	poor	333	"	15-56.8	-7 4	50	175x175	Oct 5	"	"	0.1E	poor	
334	"	19 40.5	-15 0	60	"	"	2	"	0.1E	334	fa.	334	"	19 40.5	-15 0	60	"	"	"	0.1E	fa.		
335	M 31	0-28.7	-14 20	45	"	"	3	"	0.1E	335	good	335	M 31	0-28.7	-14 20	45	"	"	"	0.1E	good		
336	"	23-29.7	-15 54	150	175x175	"	"	"	0.1E	336	fa.	336	"	23-29.7	-15 54	150	175x175	"	"	"	0.1E	fa.	
337	"	"	"	120	"	"	3-2	"	0.1E	337	fa. (irregularly)	337	"	"	"	120	"	"	3-2	"	0.1E	fa. (irregularly)	
338	NPC 1161	3-20.1	-26 6	180	"	"	2-1	"	0.1E	338	fa. (poor)	338	NPC 1161	3-20.1	-26 6	180	"	"	2-1	"	0.1E	fa. (poor)	
339	M 31	0-28.7	-14 20	55	"	Nov 13	"	"	0.1E	339	poor	339	M 31	0-28.7	-14 20	55	"	Nov 13	"	"	0.1E	poor	
340	NPC 7117	22-57.2	-15 58	120	"	"	"	"	0.1E	340	weak	340	NPC 7117	22-57.2	-15 58	120	"	"	"	"	0.1E	weak	

Remarks:

313 Slightly repaired near diffraction circles but nothing else out of line

314 main smooth

316 good

317 fa. mag. large

318 good

319 fa.

320 good

321 fa. & weak

322

323 fa. & good

324

325 mag. only

326 fa.

327 fa.

328

329 poor

330 poor

331 poor

332 poor

333 poor

334 fa.

335 good

336 fa.

337 fa. (irregularly)

338 fa. (poor)

339 poor

340 weak

314 30c??

317 fa. variable. P.M.T. 7:55-8:00

318 Japan centered (taken at following) SA 126 end at 0:15 W

319 2 double exposures (each 0.1 sec) SA 126 end at 40 W

320 Scale plate exposure (1/2) 322-255-191-128-211-68-85-32-225-6-115-0-154

321 2 small faint (mag. 5.1 & 5.2) obtained near edge

322 Se tilted

323 changed for 3 visibility P.M.T. 1:50 on plate (H.S.H.)

324

325 Cassiopeia focus

326 8:35-1:15 P.M.T.

327

328

329 8:50-2:05 P.M.T.

330 long leaves visual filter & 350 plate.

331 None suspected

332

333 R Cas. faint

334 7:20-8:30 P.M.T.

335 Cas. none suspected on 112224

336 R Cas. none seen rather bright than last maximum a clipped

337

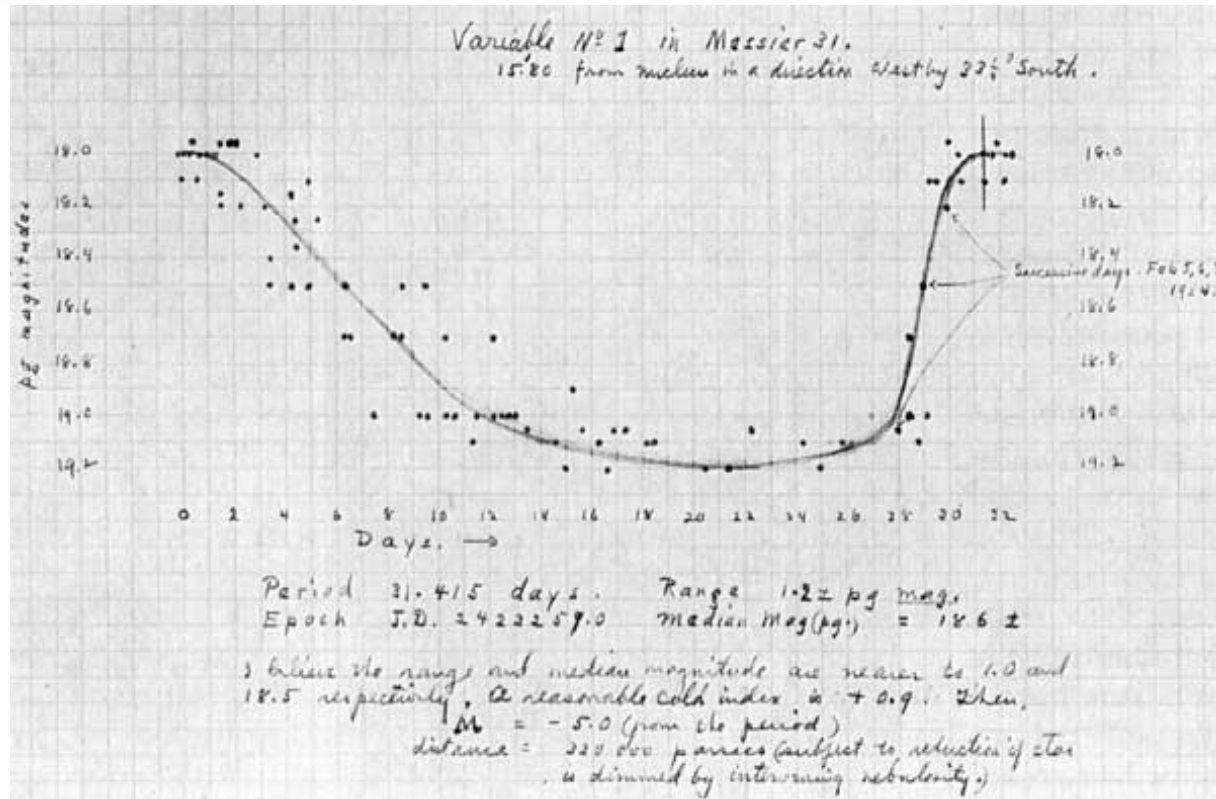
338 seems to be a giant planet. Star & center very blue @ 105 microns (could form with)

339

340



# 1923



► distancia=220000 parsec=717552 años-luz

1929

A RELATION BETWEEN DISTANCE AND RADIAL VELOCITY  
AMONG EXTRA-GALACTIC NEBULAE

BY EDWIN HUBBLE

MOUNT WILSON OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

Communicated January 17, 1929

Determinations of the motion of the sun with respect to the extra-galactic nebulae have involved a  $K$  term of several hundred kilometers which appears to be variable. Explanations of this paradox have been sought in a correlation between apparent radial velocities and distances, but so far the results have not been convincing. The present paper is a re-examination of the question, based on only those nebular distances re-examined and believed to be fairly reliable.

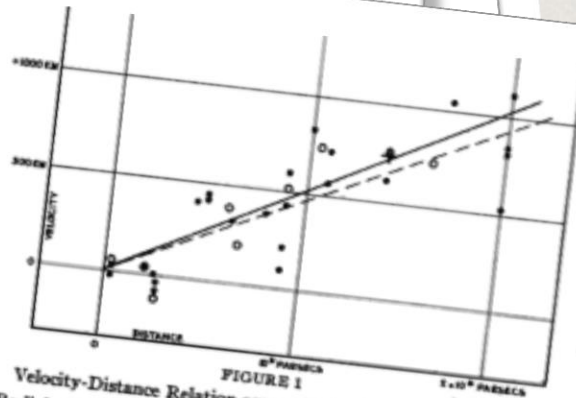
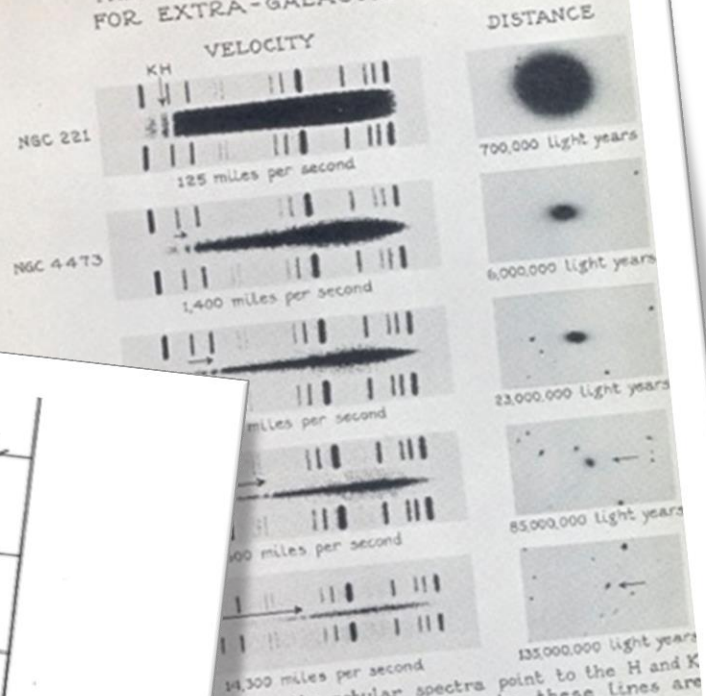


FIGURE 1  
Velocity-Distance Relation among Extra-Galactic Nebulae.  
Radial velocities, corrected for solar motion, are plotted against distances estimated from involved stars and mean luminosities of nebulae in a cluster. The black discs and full line represent the solution for solar motion using the nebulae individually; the circles and broken line represent the solution combining the nebulae into groups; the cross represents the mean velocity corresponding to the mean distance of 22 nebulae whose distances could not be estimated individually.

THE VELOCITY-DISTANCE RELATION  
FOR EXTRA-GALACTIC NEBULAE

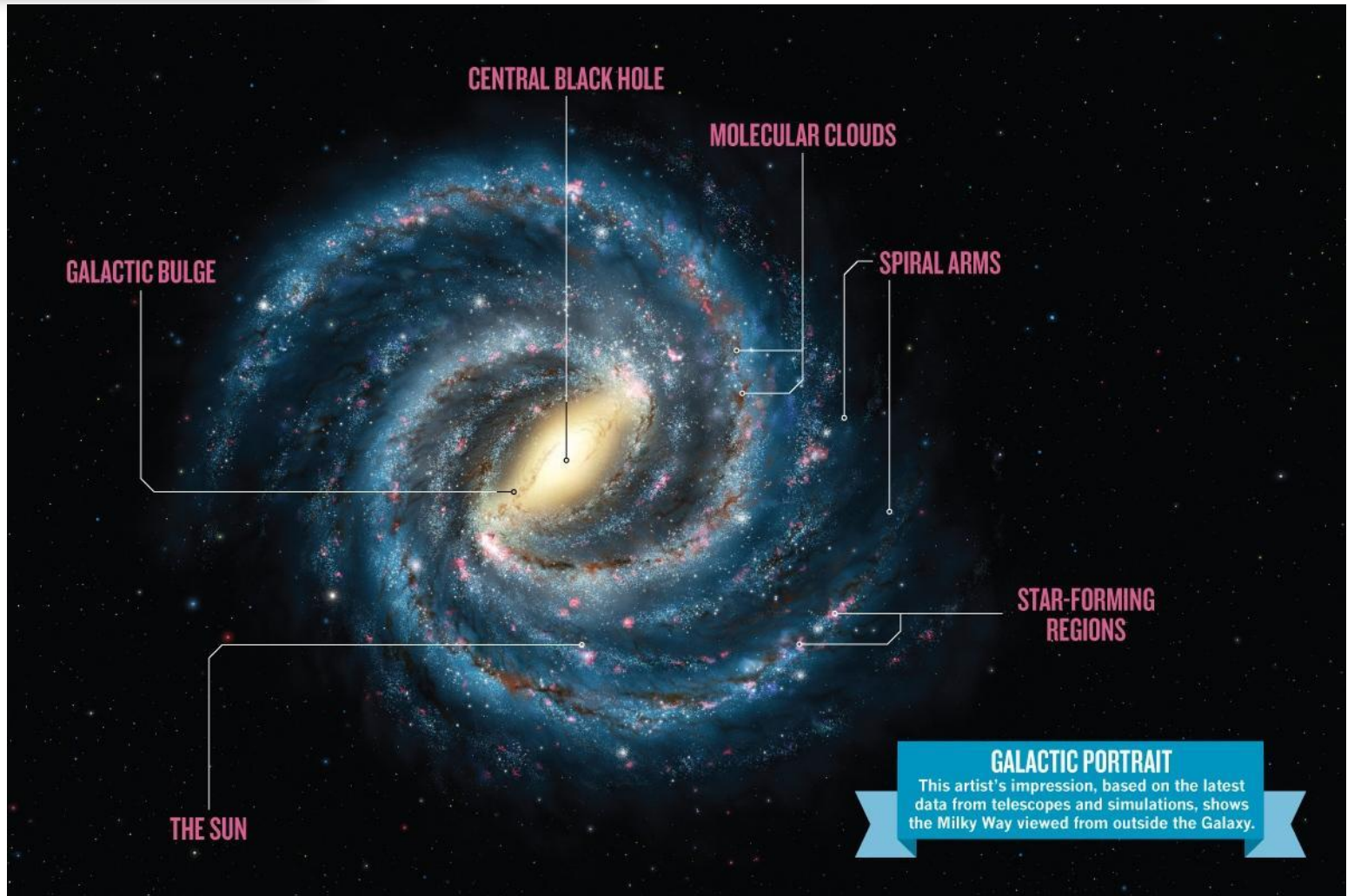


... above the nebular spectra point to the H and K  
... and show the amounts these lines are  
... toward the red end of the spectra. The com-  
... spectra are of helium.  
... photographs (on the same scale and with approxi-  
... same exposure times) illustrate the decrease in  
... brightness with increasing velocity or red-shift.  
... 473 is a member of the Virgo cluster and NGC 379  
... member of a group of nebulae in Pisces.



Hubble, E. (1929). "A relation between distance and radial velocity among extra-galactic nebulae". Proceedings of the National Academy of Sciences 15 (3): 168-73.

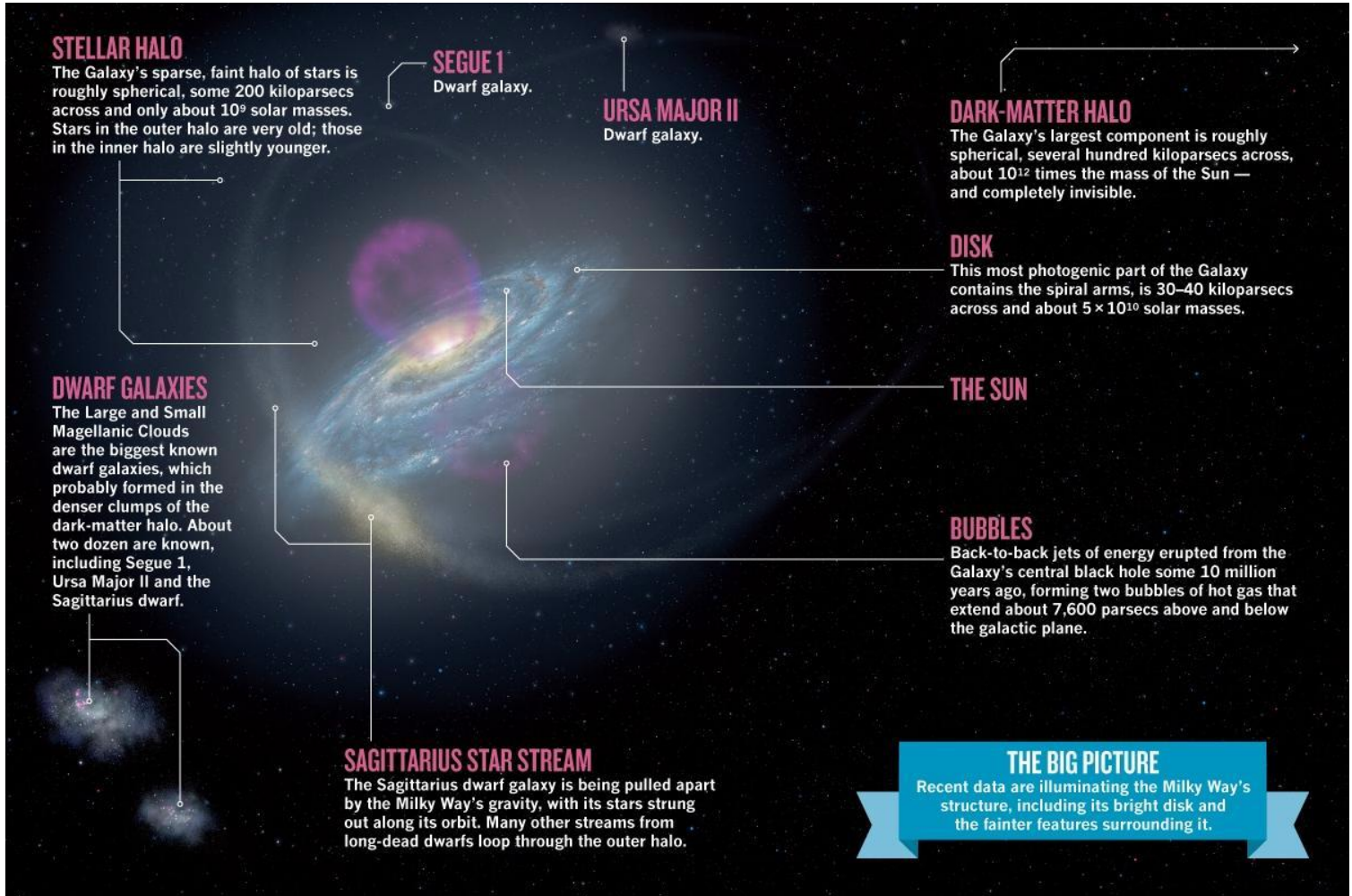
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Ann Finkbeiner. Galaxy formation: The new Milky Way. A fresh look at our Galaxy points to a chaotic past and a violent end," News Feature, Nature 490: 24–27 (04 October 2012)



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