Società Astronomica G.V. Schiaparelli

Con le tenebre si apre l'abisso, e il cielo si popola di mondi e luci lontane . . .

Uno spettacolo immenso si manifesta ai nostri occhi. E per comprenderlo dobbiamo misurarlo . . .

Solo 180 anni fa sono state misurate le prime distanze delle stelle

Decine o centinaia di migliaia di miliardi di chilometri.


© Stéphane Guisard


All'inizio del '900 la Via Lattea e la nebulosa Andromeda splendono da altezze ancora inaccessibili
Daniel López
Observatorio del Teide, IAC

What are galaxies?
No one knew before 1900.
Very few people knew in 1920.
All astronomers knew after 1924.
(A. Sandage)

Galassia di Andromeda, fotografia del 1899

THE

REALM OF THE NEBULÆ

BY EDWIN HUBBLE

OF THE

MOUNT WILSON OBSERVATORY

CARNEGIE INSTITUTION OF WASHINGTON

OXFORD UNIVERSITY PRESS

LONDON: HUMPHREY MILFORD

1936

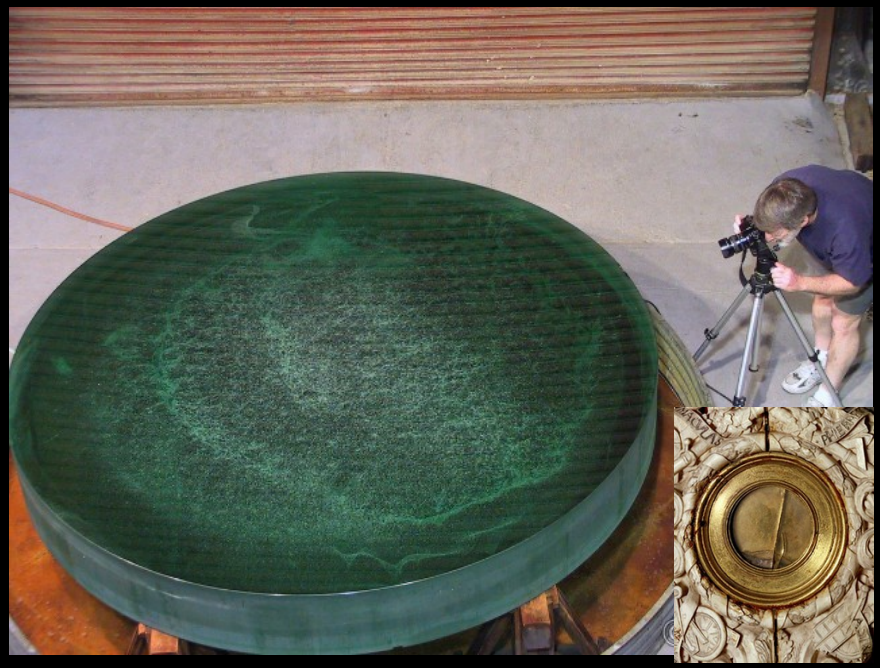
Edwin Powell Hubble

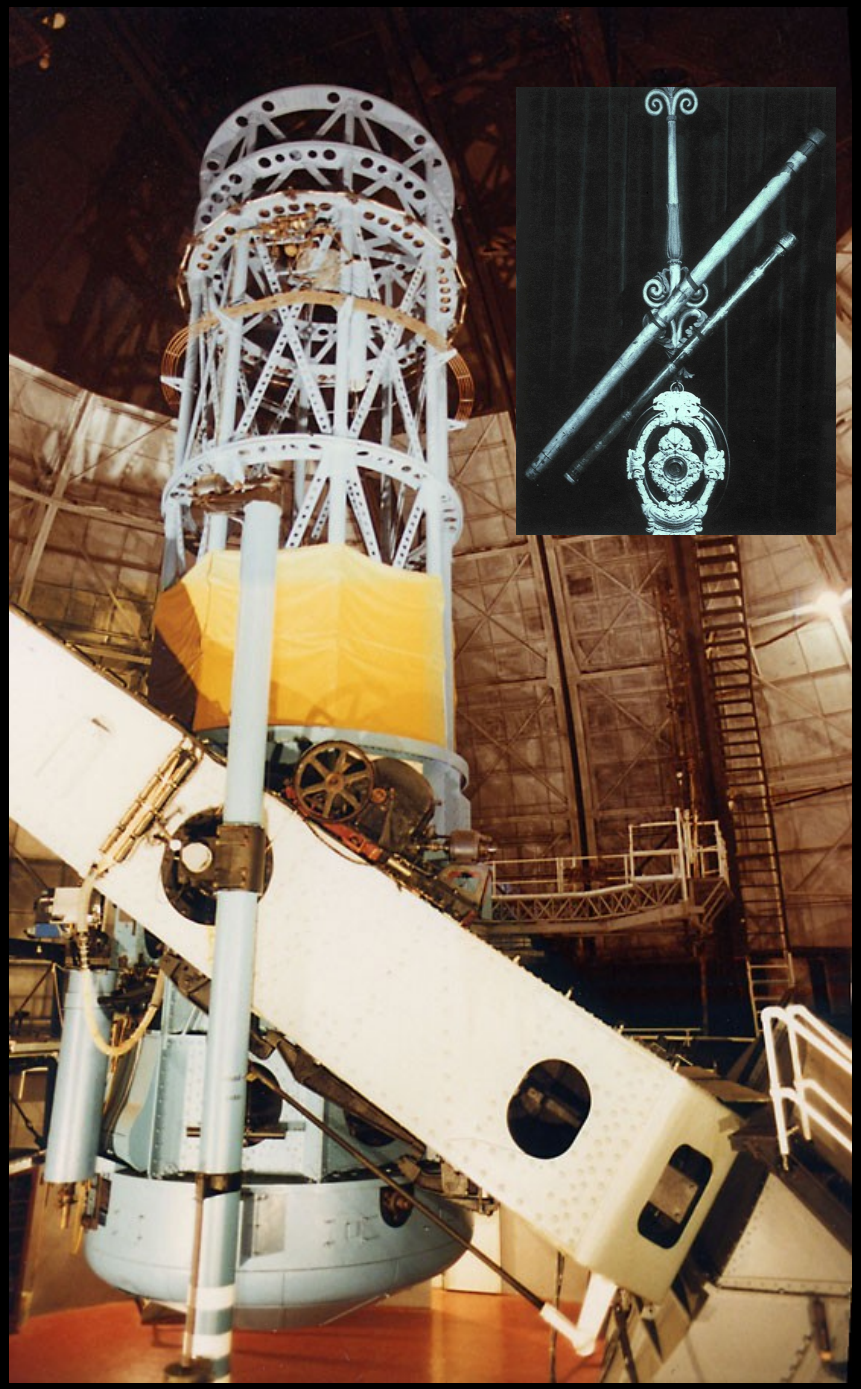
1889 - 1950

Edwin Hubble, e il Regno delle Galassie

Luca G Molinari
Varese, Villa Estense
23 ottobre 2009

Come Galilei nel 1609, Hubble nel 1924-29 ha rivoluzionato la nostra visione dell'universo



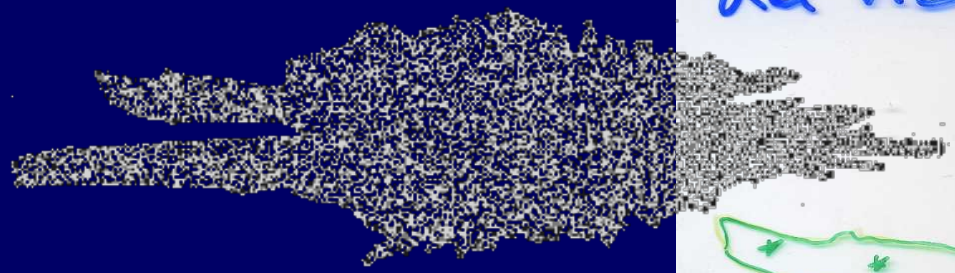


Quanto distano le galassie?

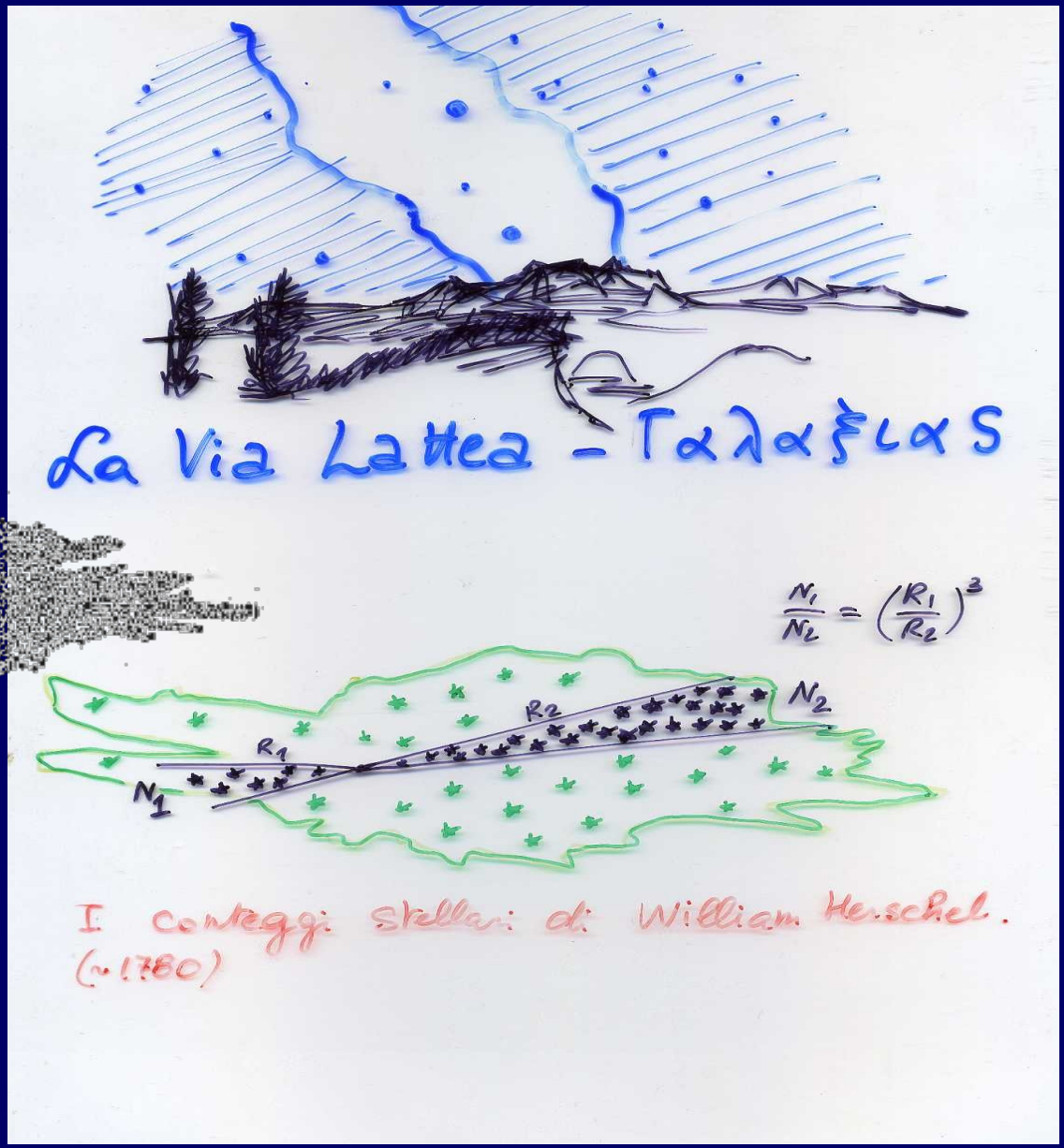
Perchè il cielo è buio?

William & John Herschel e Lord Rosse

William Herschel

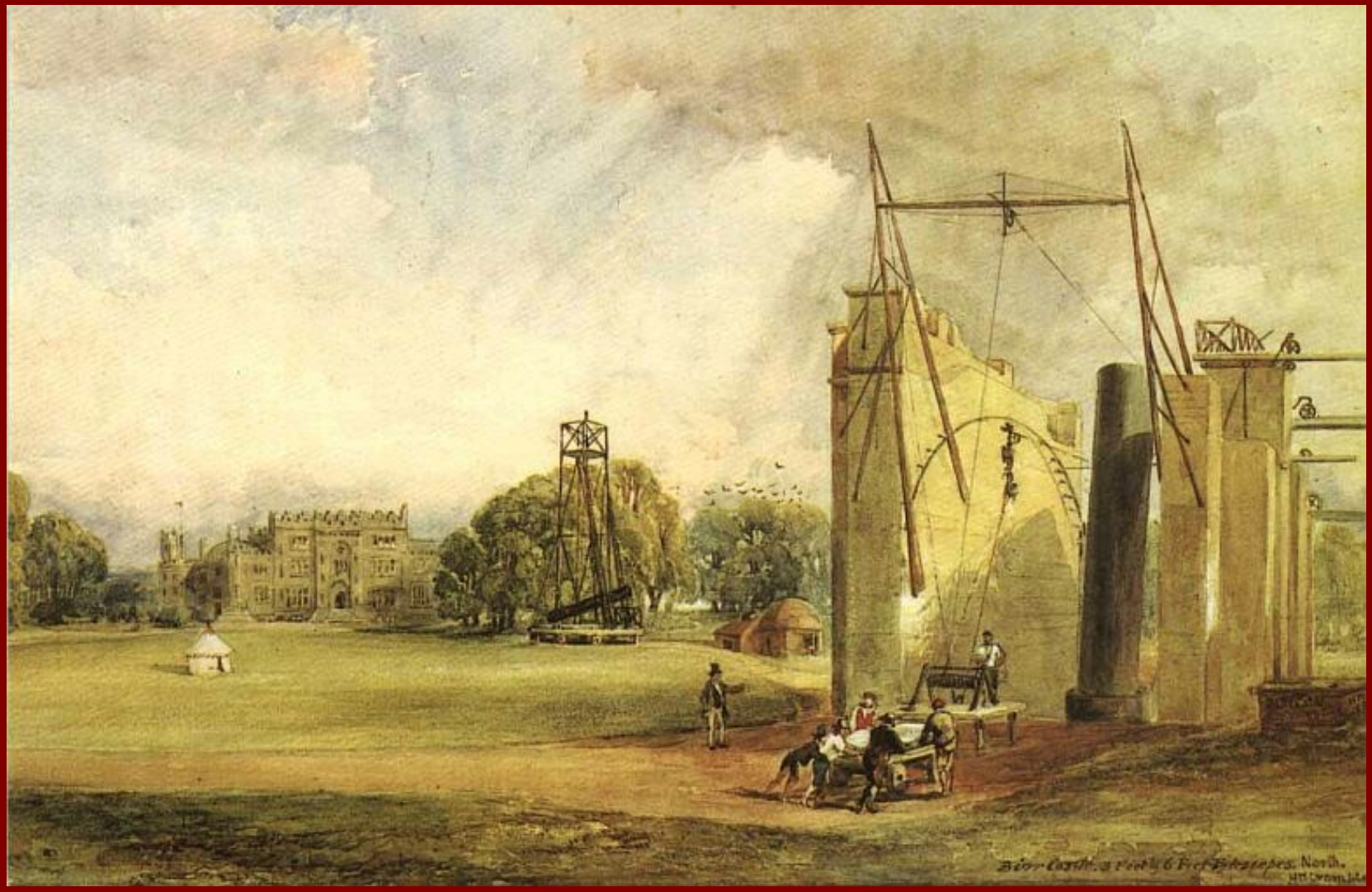


Il sistema solare si muove verso Ercole



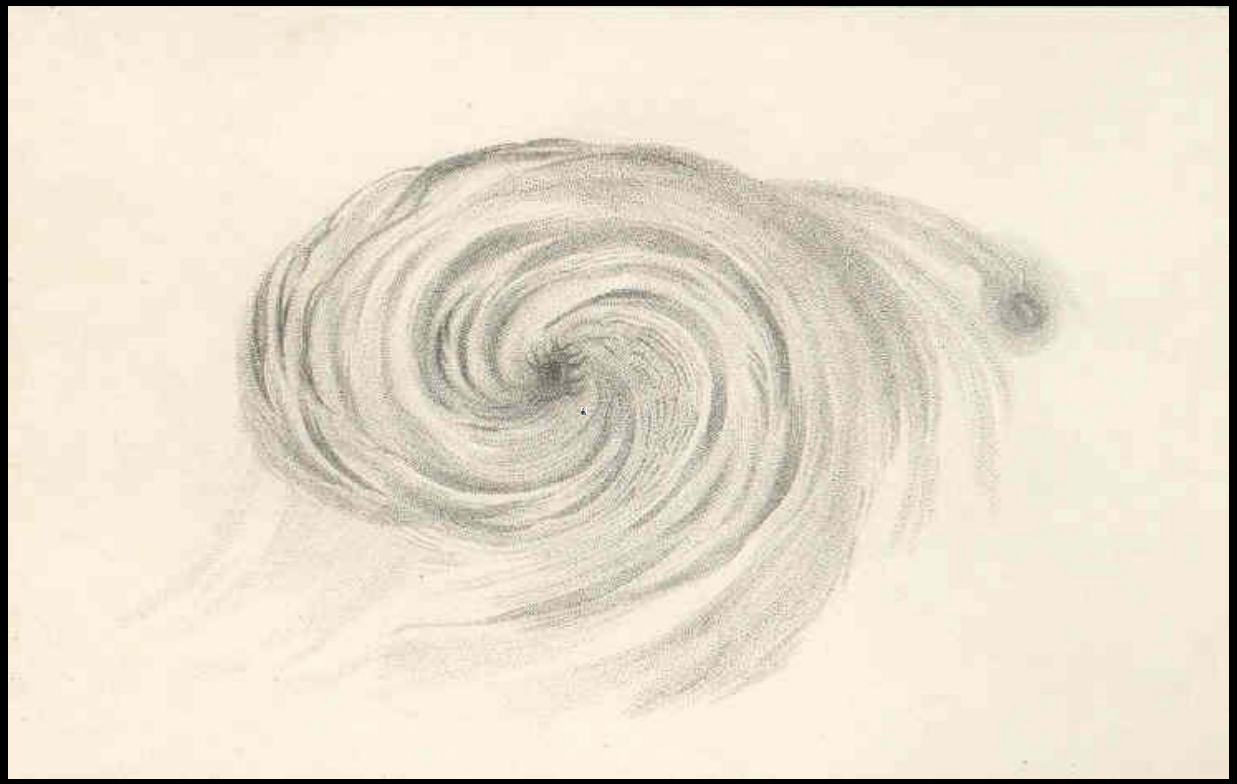
William H. e il figlio John osservarono migliaia di nebulose, di natura ignota.

Lord Rosse, e i telescopi da 3 e 6 piedi



The Leviathan of Parsonstown (1845)

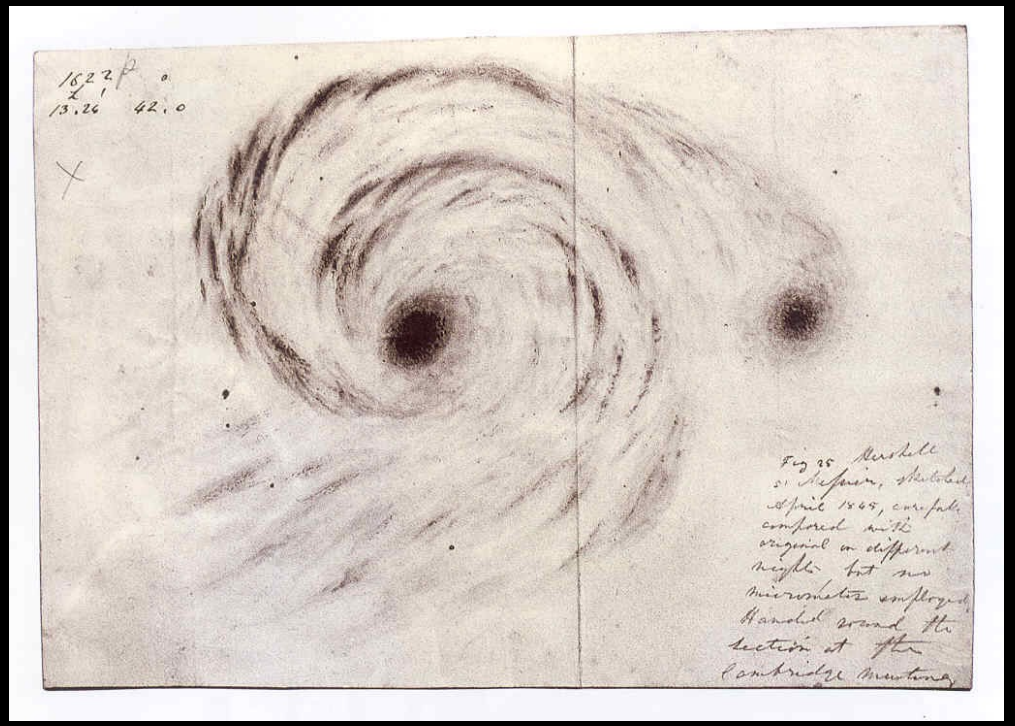
La struttura a spirale delle nebulae



Nebulosa Vortice (M51)

W. Herschel, E. Kant
universi – isole

P. S. Laplace
sistemi planetari
in formazione



Le variabili Cefeidi e la misura della Via Lattea

L’osservatorio di Harvard (1900)

Scanned at the American Institute of Physics

Il computer di Harvard

Henrietta Leavitt

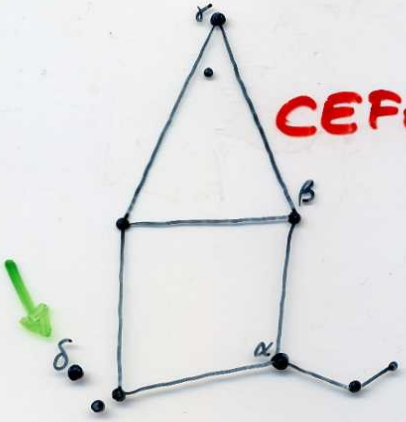
Scanned at the American
Institute of Physics

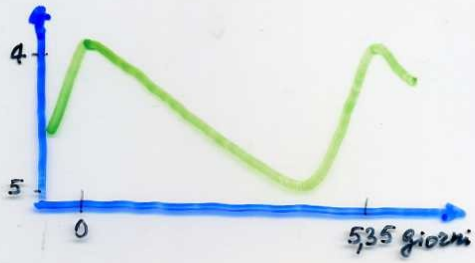
Fotometria della
sequenza polare

“1777 variables in the Magellanic Clouds”
Ann. Astr. Obs. Harv. (1908).

Seleziona 16 stelle variabili e osserva:
.. The brighter ones have longer periods.

LE VARIABILI CEFEIDI





L'indagine spettroscopica mostra che la stella è pulsante (da 31 a 35 raggi solari)

1912 Henrietta Leavitt, studiando le cefeidi nella Piccola Nube di Magellano, scopre la relazione PERIODO – LUMINOSITÀ.
Le più luminose hanno periodo più lungo

1918 Modello di Shapley della galassia.

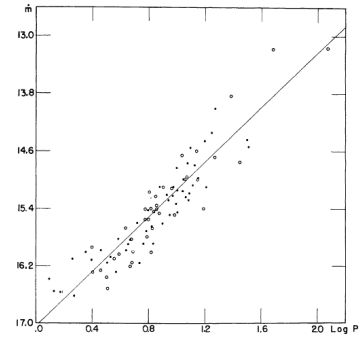


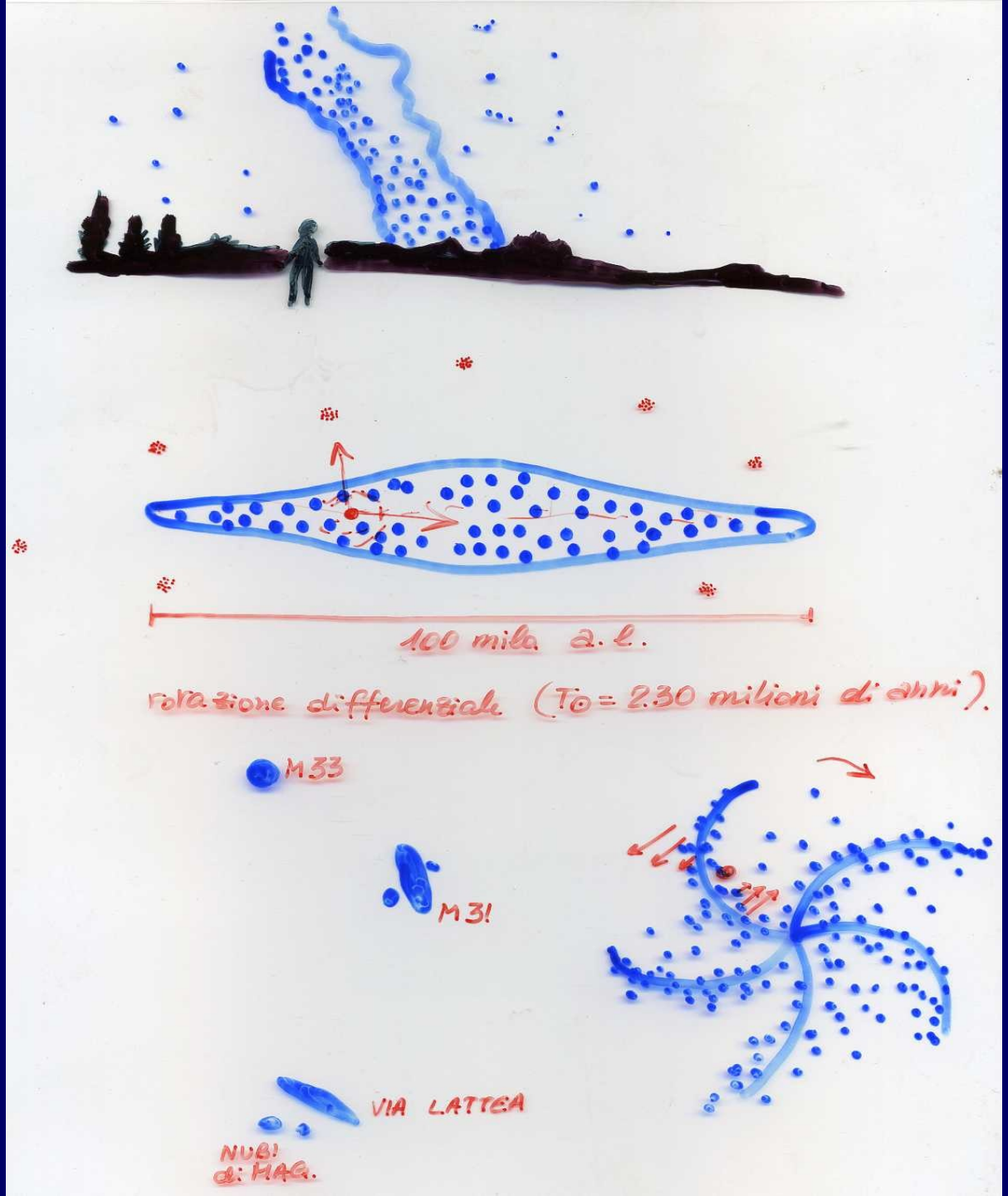
FIG. 4. Period-magnitude relation for the eighty-eight Cepheid variables. Open circles indicate variables in large Magellanic Cloud.

the mean is composed. The mean values for the two subdivisions are also given in table 3 and figure 3. For these three mean curves the pulse-indices are, respectively, 8.3, 10.6, and 5.3.

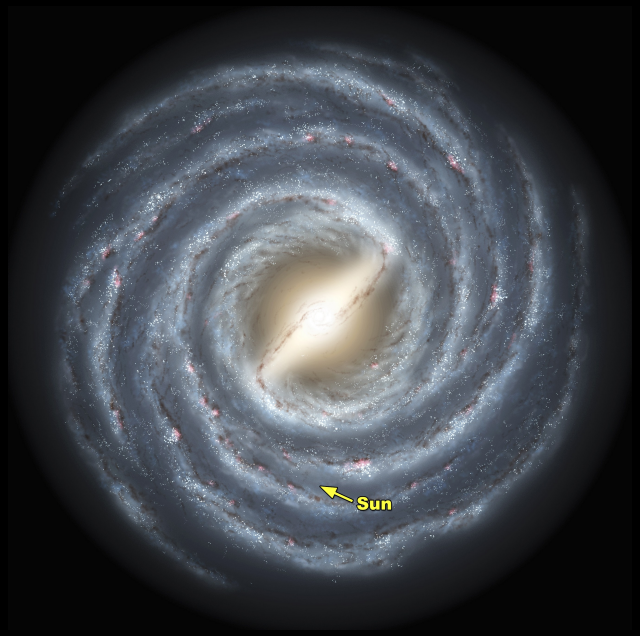
In the foregoing analysis, light curves from the two Magellanic Clouds were combined without an adjustment of the zero-points of the two systems of photographic magnitudes. Apparently it was not needed. That the two Clouds can be treated as at essentially the same distance is indicated in figure 4, which shows the period-luminosity relation based on all eighty-eight variables. The adopted distance modulus is 17.25 for both Clouds. The corresponding distance is approximately eighty thousand light years, if we adopt a value of 0.3 mag. as the correction for intervening space absorption.[4]

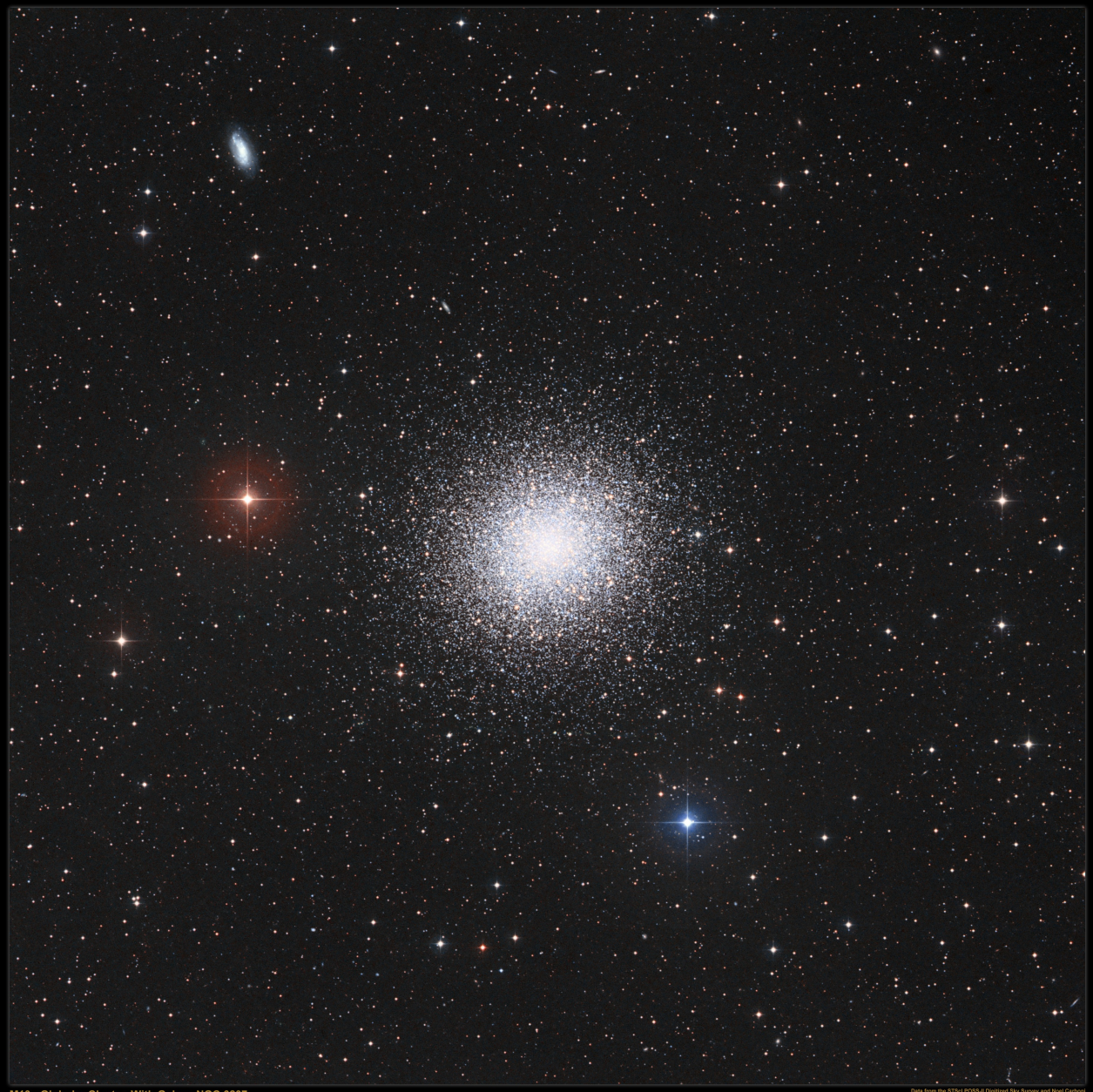
[4] Both in the tables and figures the median photographic magnitude of HV 2752 has been corrected by subtracting one magnitude to allow for light absorption by the 30 Doradus Nebula in which it is involved.

Le stelle cefeidi sono pietre miliari nel cielo



Shapley misurò la Via Lattea con le Cefeidi


Sun



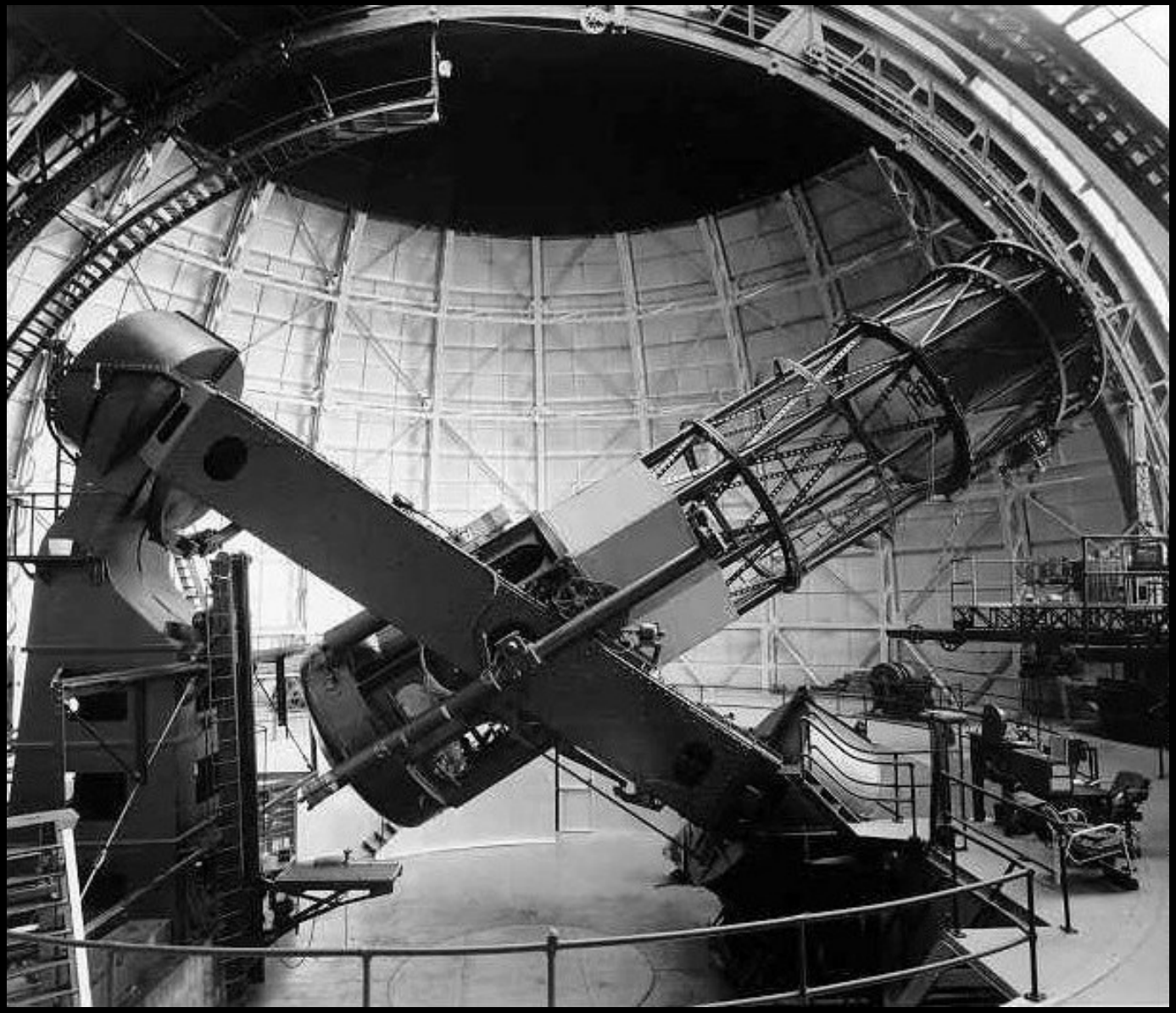
M13 - Globular Cluster, With Galaxy NGC 6207

Data from the STScI POSS-II Digitized Sky Survey and Noel Carboni
Composite Color Image Assembled by Noel Carboni

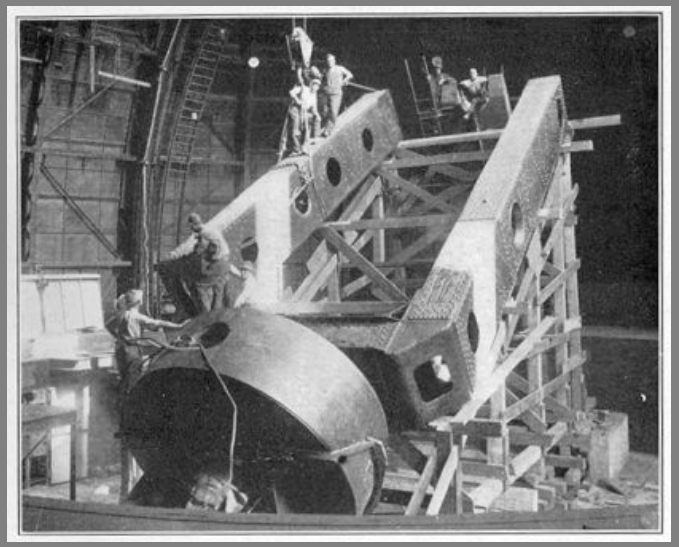
I grandi telescopi
La distanza delle galassie

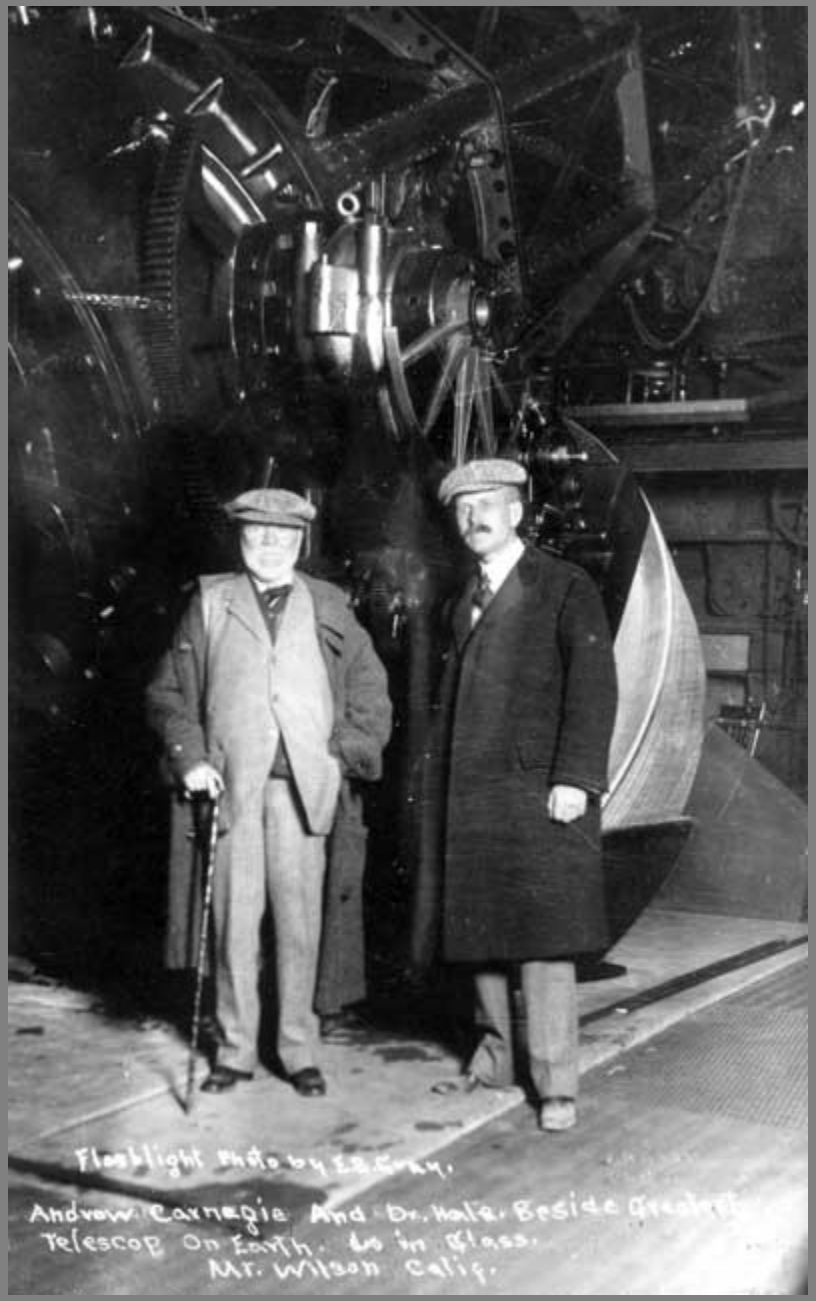
George E. Hale

Yerkes



Mount Wilson,100” Hooker telescope




Flashlight photo by E.E. Barnard.
Andrew Carnegie And Dr. Hale. Beside Greatest
Telescop On Earth. 60 in Glass.
Mt. Wilson Calif.

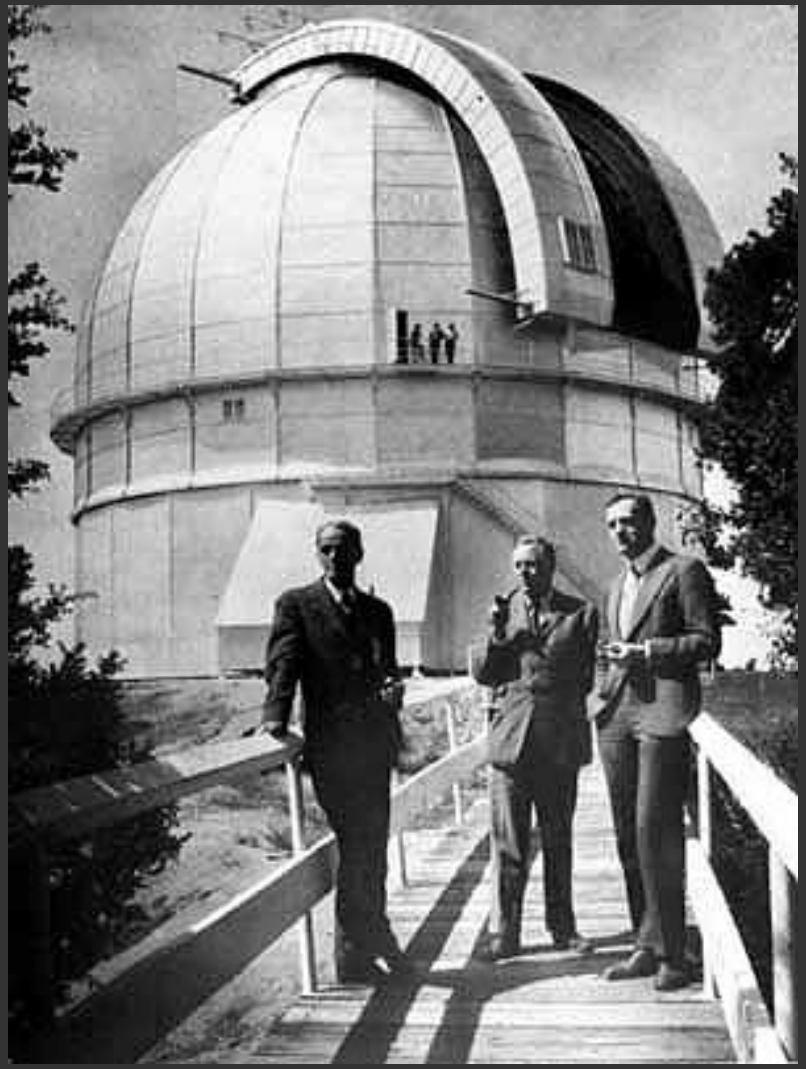
The great debate

National Acad. of Science, Washington 1920

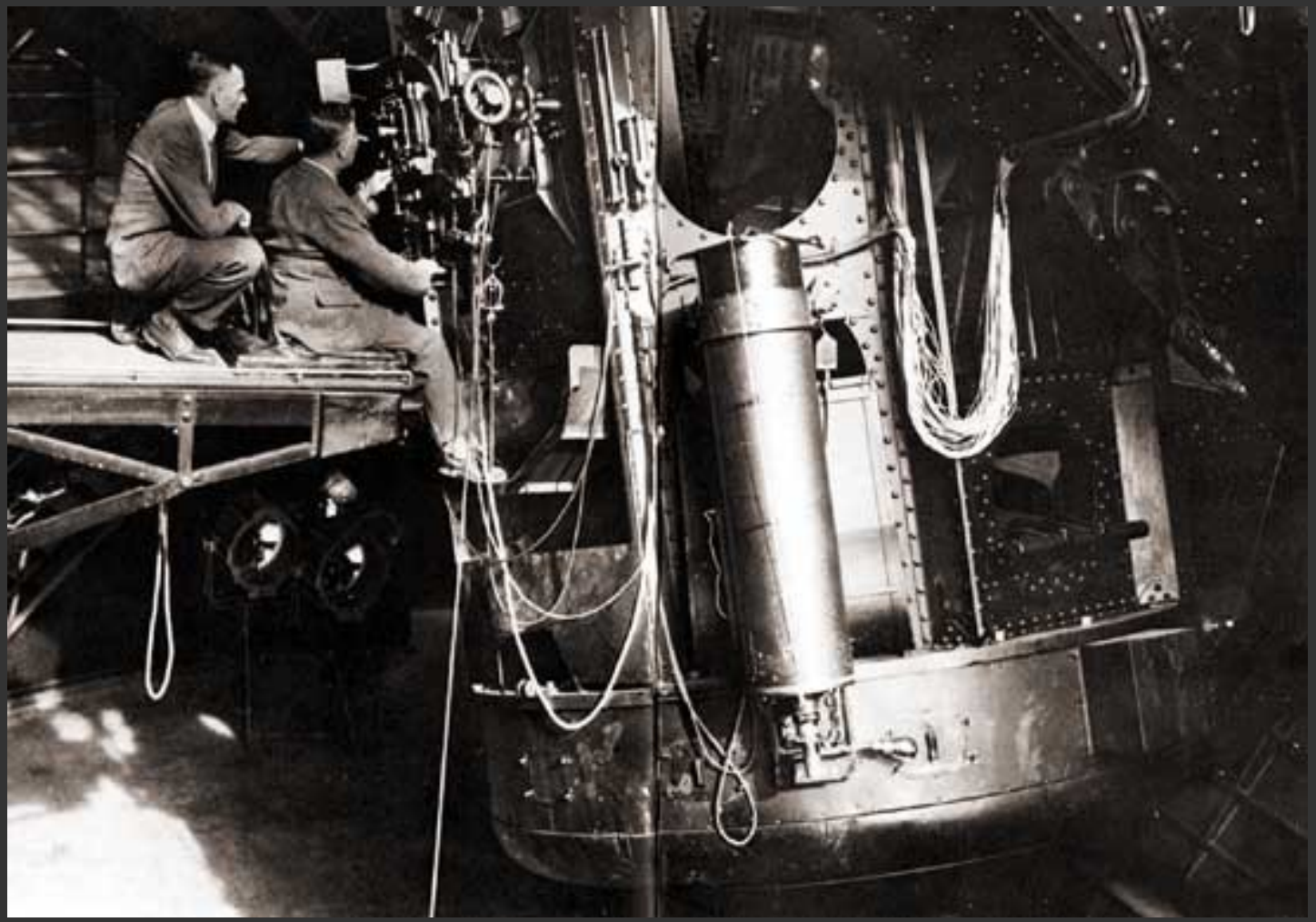
Herbert Curtis (Lick obs)
Le nebulae sono galassie

Harlow Shapley
Una sola Via Lattea

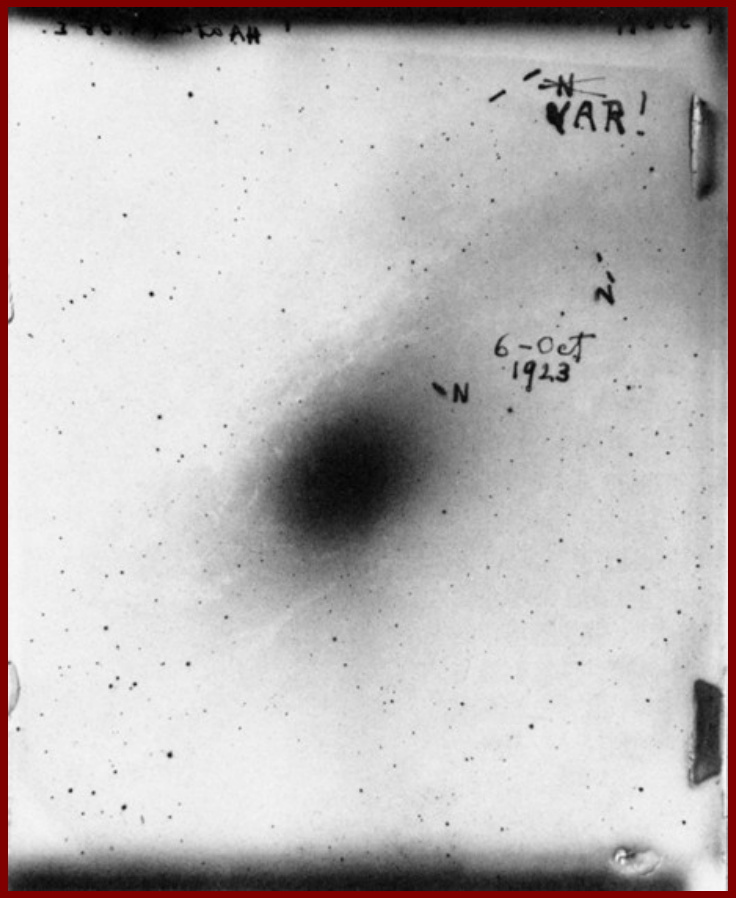
L’osservatorio di Monte Wilson

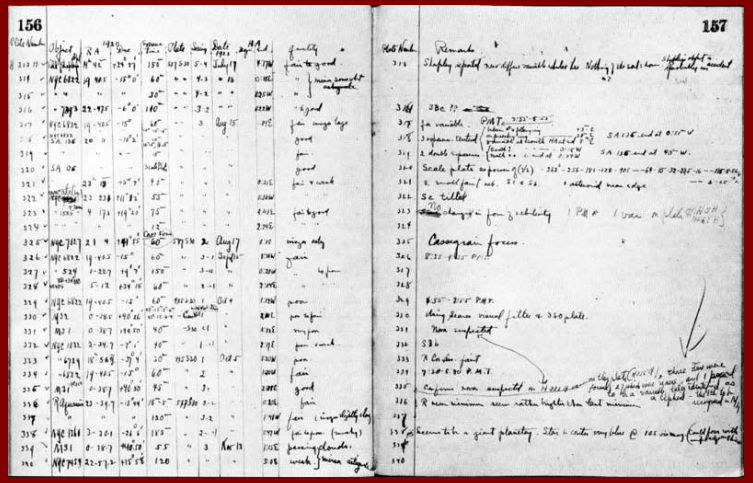


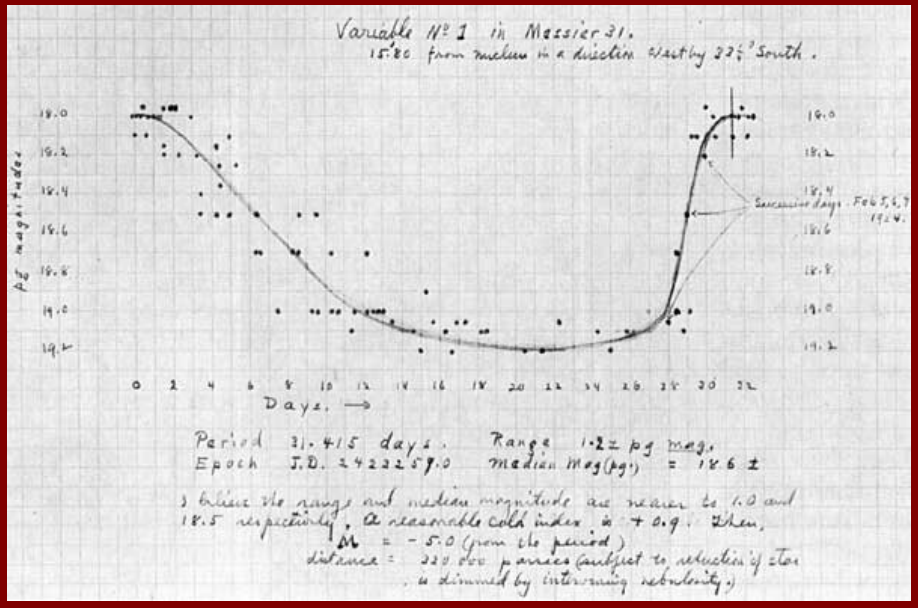
Edwin Hubble



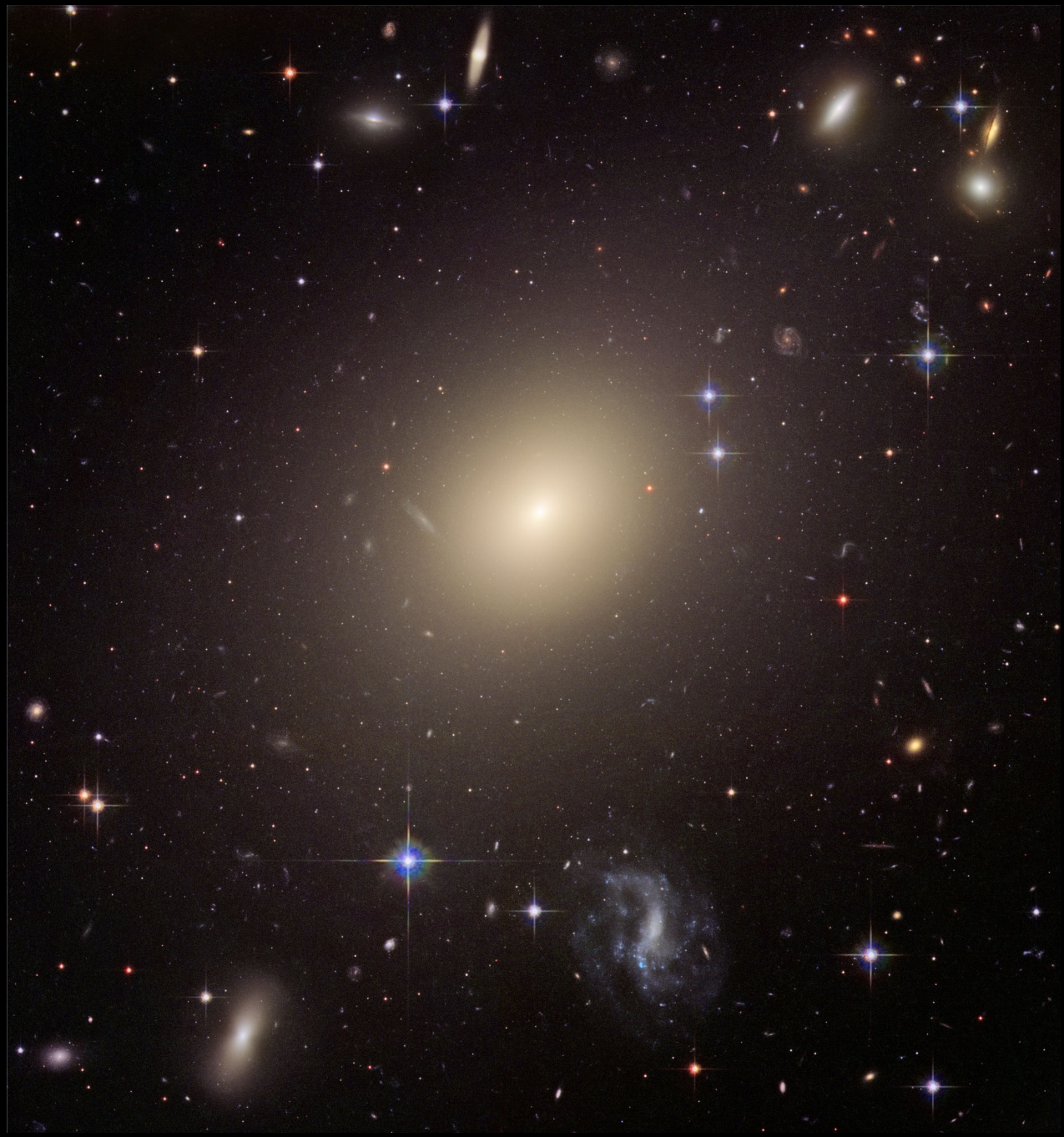
VAR! in M31

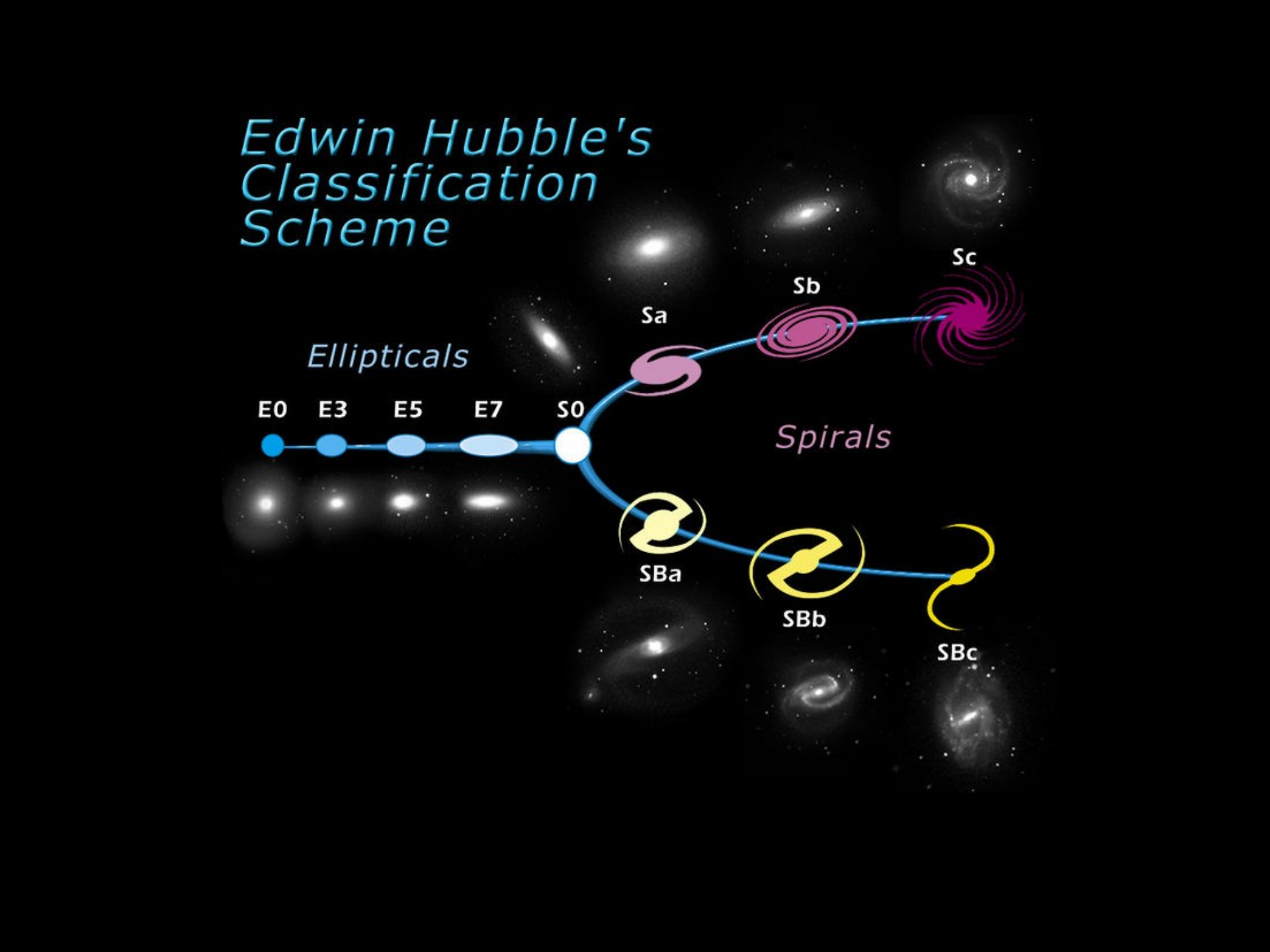

VAR!
N
N
6-Oct
1923


156
157


Variable No 1 in Messier 31.
15.80 from nucleus in a direction Westerly 22½° South.
Apparent magnitudes
Days. →
Period 31.415 days.
Epoch J.D. 2422259.0
Range 1.27 pg mags.
Median Mag(pg) = 18.6 ±
I believe the range and median magnitude are nearer to 1.0 and 18.5 respectively. A reasonable Cold index is + 0.9. Then,
M = -5.0 (from the period)
distance = 220 000 parsecs (subject to reduction if star is dimmed by intervening nebulosity.)

2,3 milioni di anni luce
(1 a.l. ~ 10mila miliardi di km)

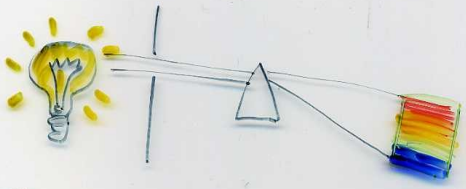



Edwin Hubble's Classification Scheme
Ellipticals
E0
E3
E5
E7
S0
Sa
Sb
Sc
Spirals
SBa
SBb
SBc

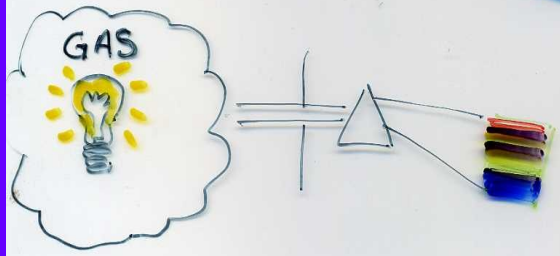
La legge di Hubble e l’espansione dell’universo

SPETTROSCOPIA

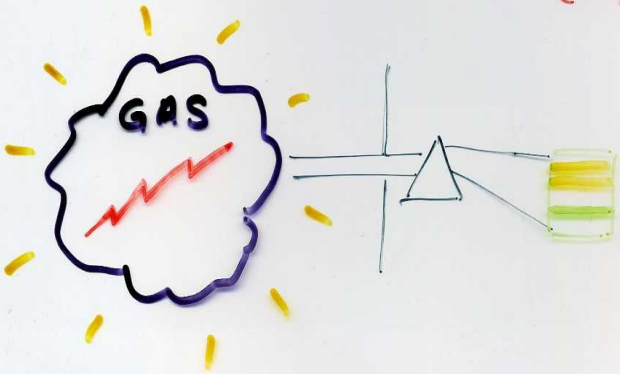
DISPERSIONE LUMINOSA:
dipendenza dell'indice di rifrazione (e quindi della velocità di propagazione in un materiale) dalla lunghezza d'onda.



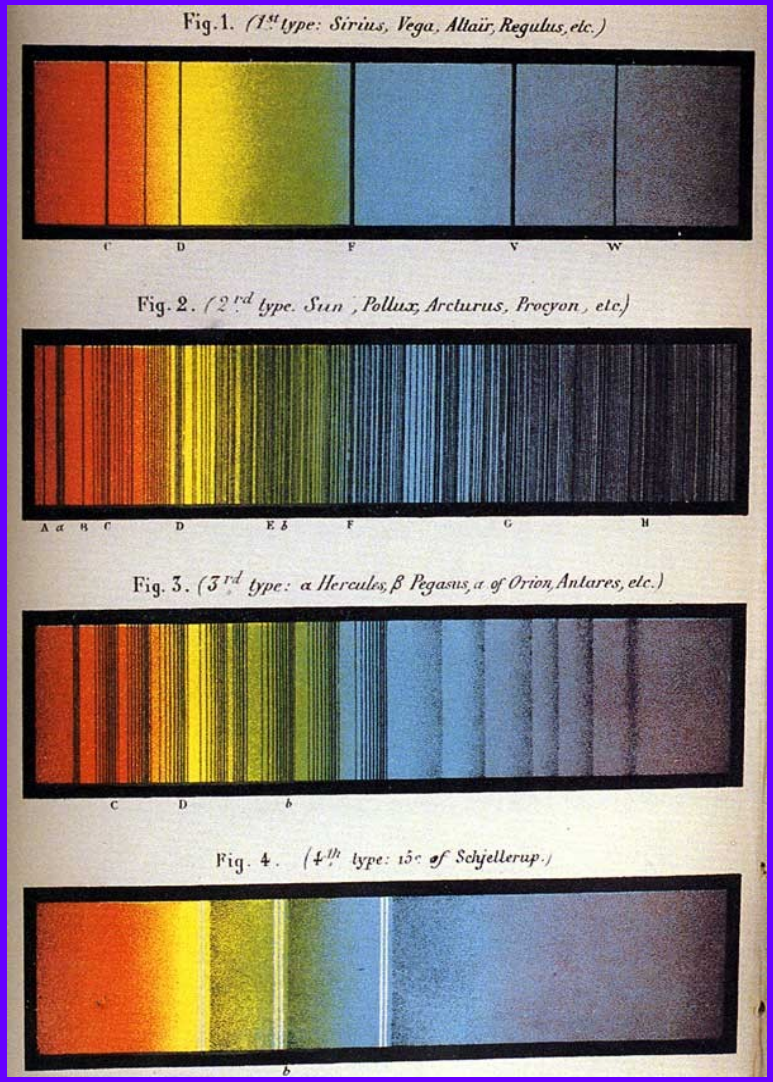
SPETTRO CONTINUO



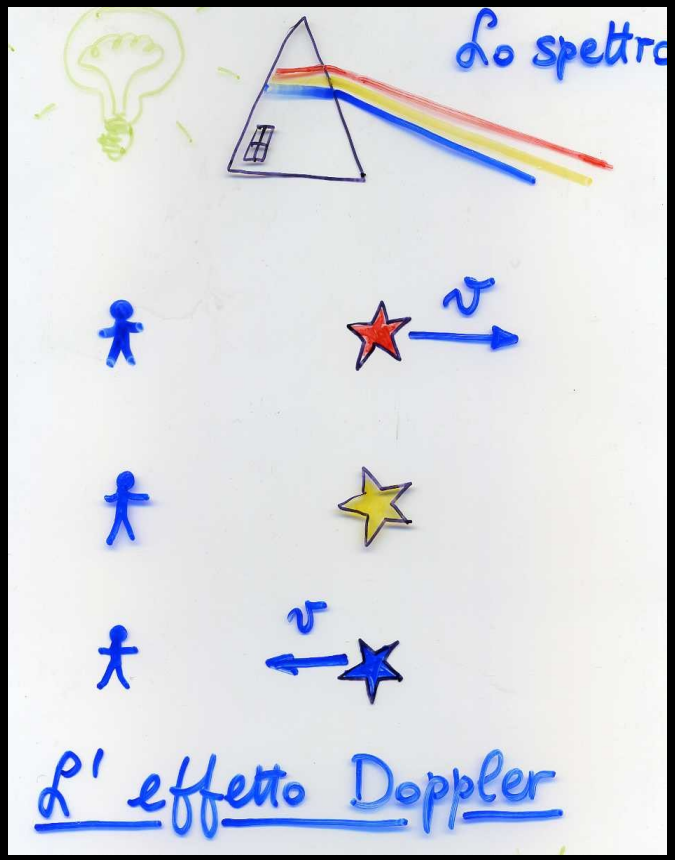
SPETTRO CONTINUO (della SORGENTE)
CON RIGHE di ASSORBIMENTO (da parte del gas)

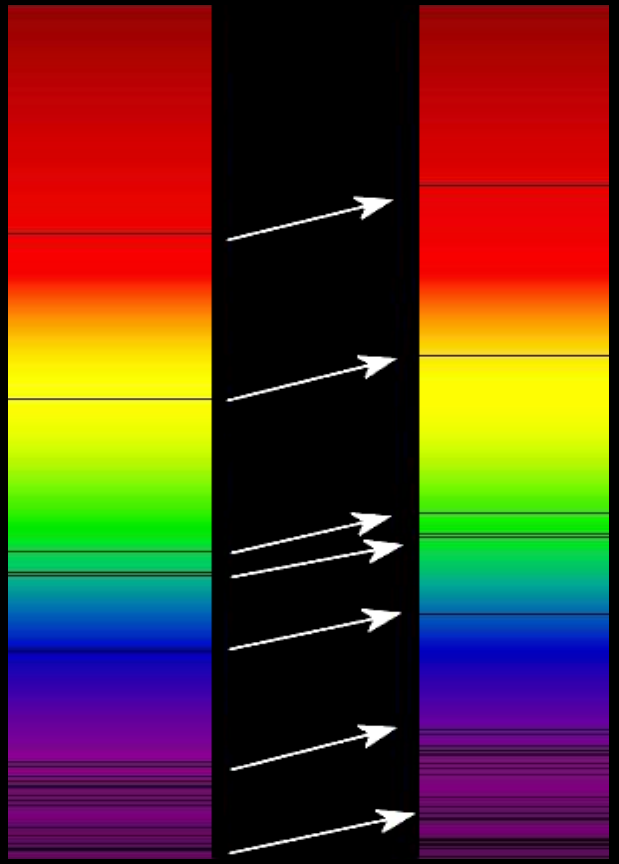


SPETTRO di EMISSIONE
(RIGHE LUMINOSE nelle stesse posizioni delle RIGHE scure di assorbimento!)



L’effetto Doppler





1914 - Vesto Slipher
REDSHIFT DELLE NEBULAE
Le nebulae si allontanano da noi con velocità fino a 2000 km/s

Humason & Hubble

LA LEGGE DI HUBBLE

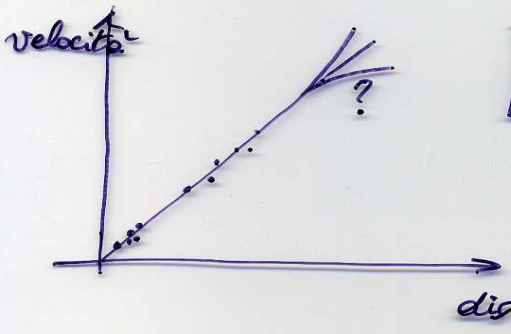
$V = H\,d$

Lo spostamento verso il rosso (redshift)

1910 – 1920 Slipher : effetto Doppler dovuto al moto del sistema solare.

1925 Cefeidi nelle spirali

1929 Edwin HUBBLE redshift di natura COSMOLOGICA



$V = H\,d$

legge di Hubble

1952 W Baade : due classi di cefeidi. $d \times 2{,}6$

$H = 15$ km/sec / 10^9 a.l.

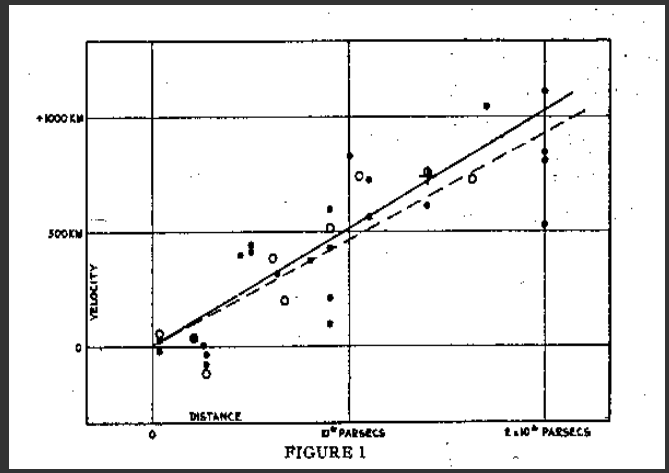
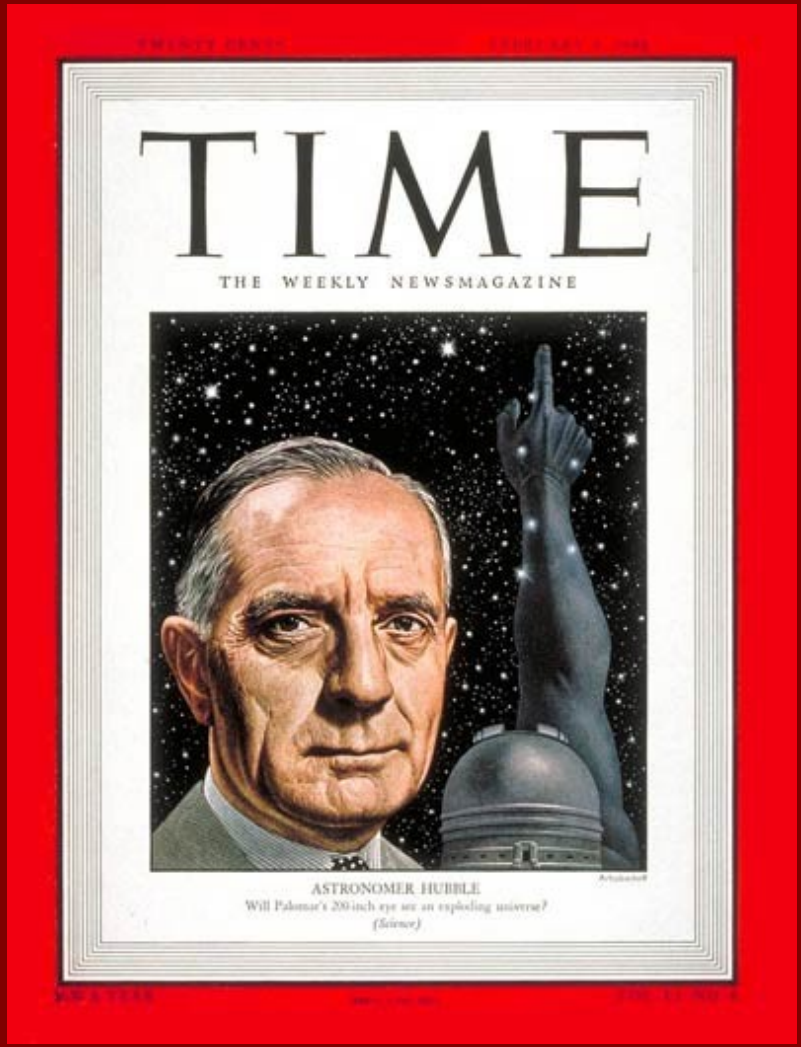


FIGURE 1

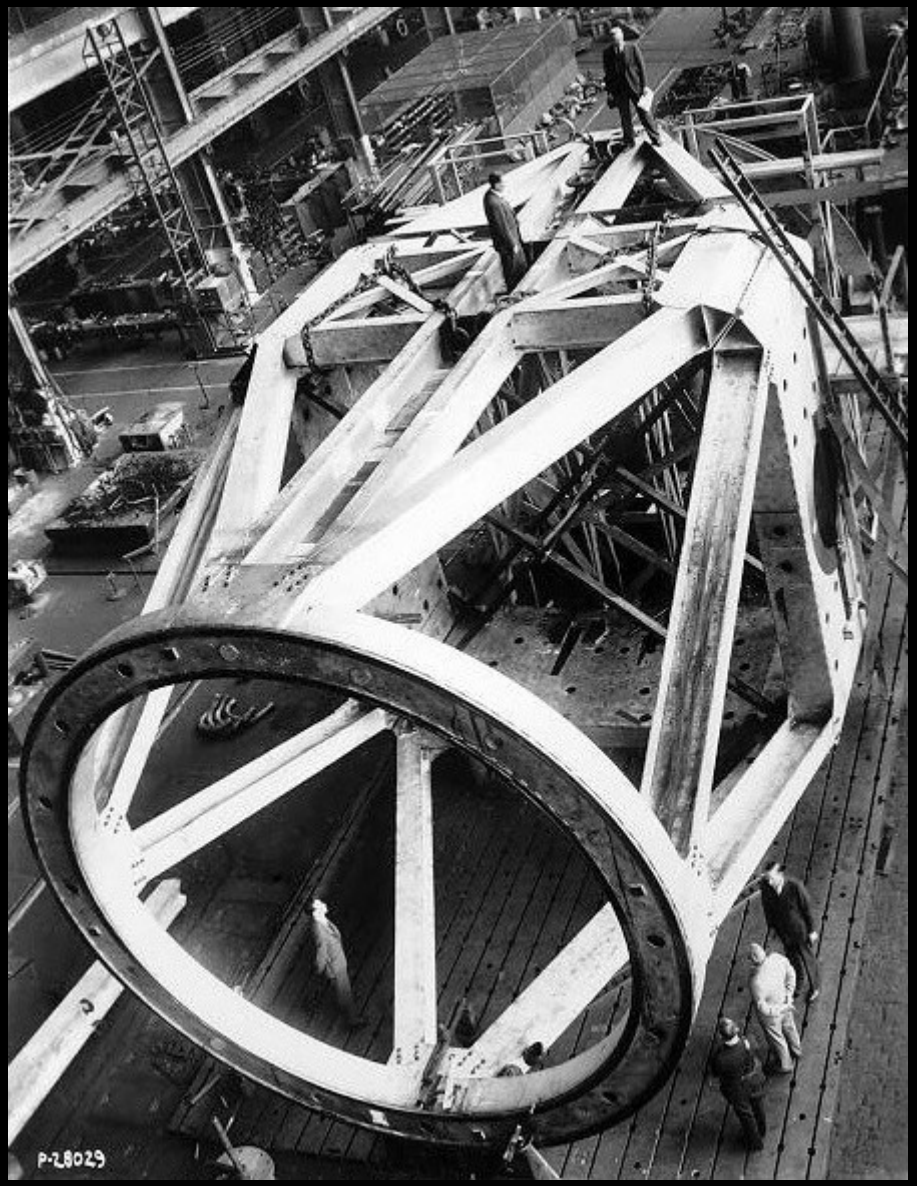
Youth who left Ozark mountain to study stars causes Einstein to change his mind

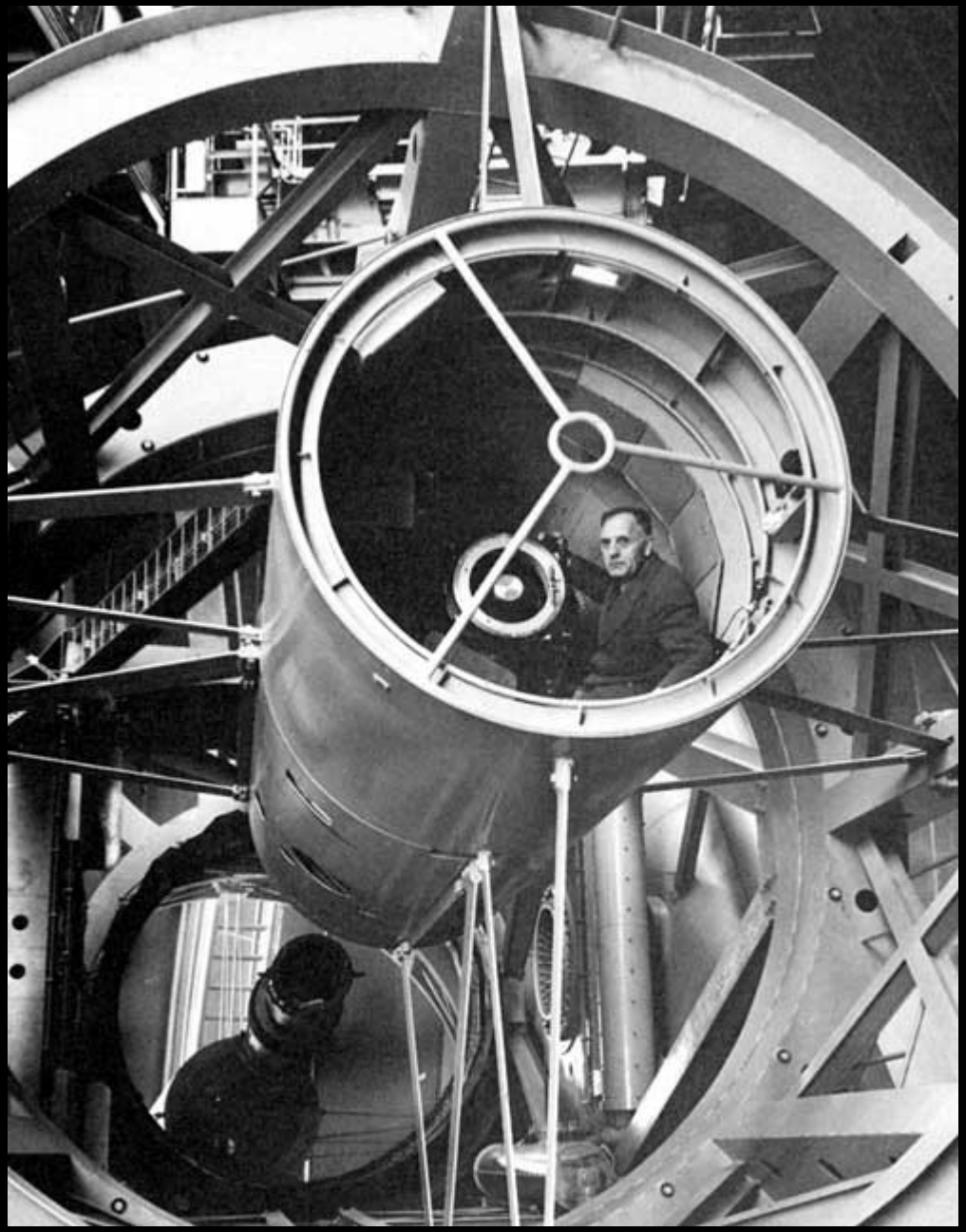


Dedication of Palomar 1948


Photo by
AVRES A. STEVAN


95B
85B


P-28029

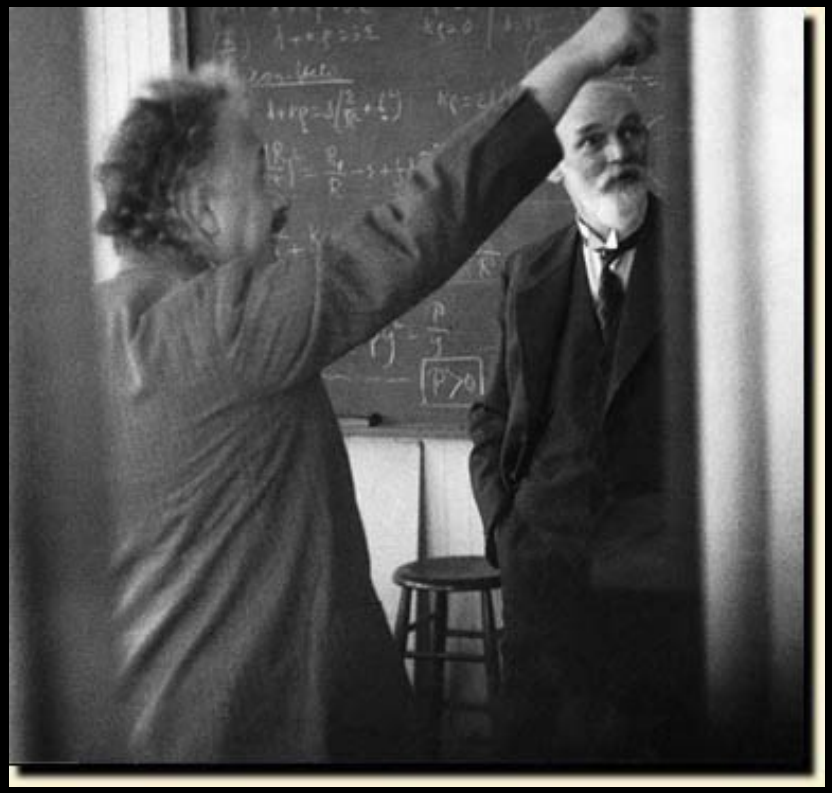


National Geographic and Palomar Obs. Sky Survey

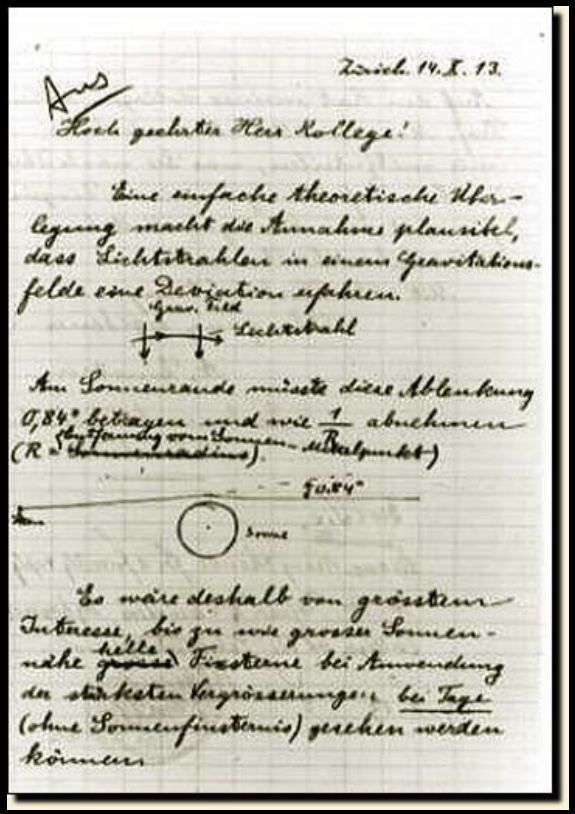
Allen Sandage

Teoria e osservazione: La Cosmologia

1915: Relatività Generale
(teoria della gravitazione)
La materia detta la geometria dello spazio, e la geometria dirige la materia.



Einstein e De Sitter



Zürich. 14. X. 13.

Hoch geehrter Herr Kollege!

Eine einfache theoretische Überlegung macht die Annahme plausibel, dass Lichtstrahlen in einem Gravitationsfelde eine Deviation erfahren.

Grav. Feld — Lichtstrahl

Am Sonnenrande müsste diese Ablenkung 0,84" betragen und wie $\frac{1}{r}$ abnehmen (r = Entfernung vom Sonnen-Mittelpunkt)

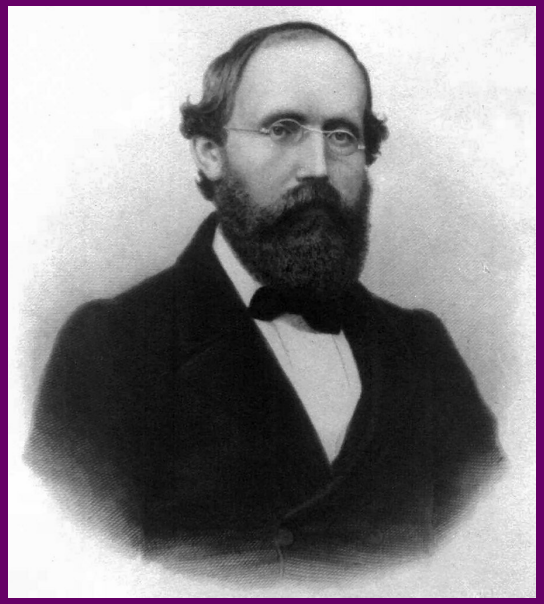
0,84"

Sonne

So wäre deshalb von grösstem Interesse, bis zu wie grosser Sonnennähe helle Fixsterne bei Anwendung der stärksten Vergrösserungen bei Tage (ohne Sonnenfinsternis) gesehen werden können.

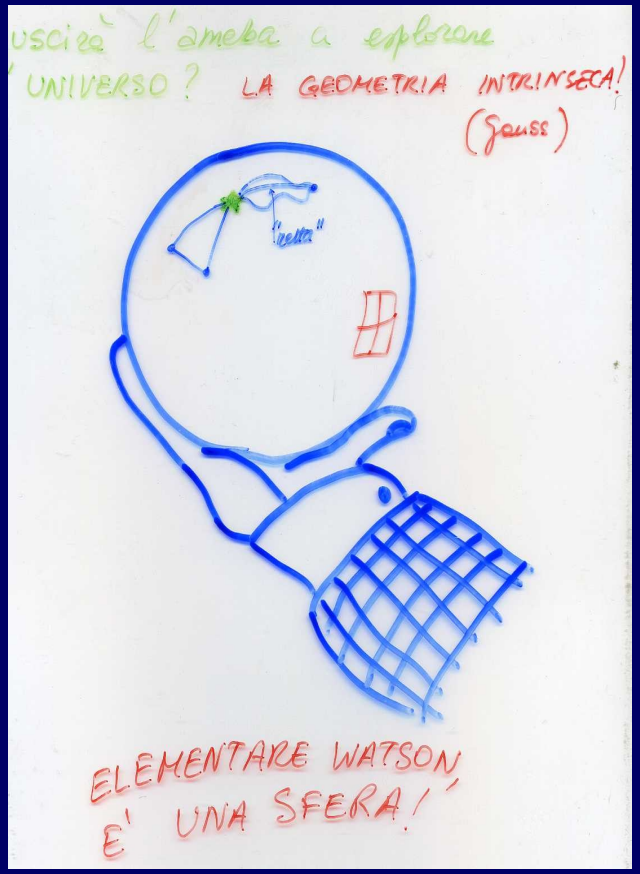
Le geometrie non euclidee
e la geometria intrinseca

Carl F. Gauss



Bernhard Riemann

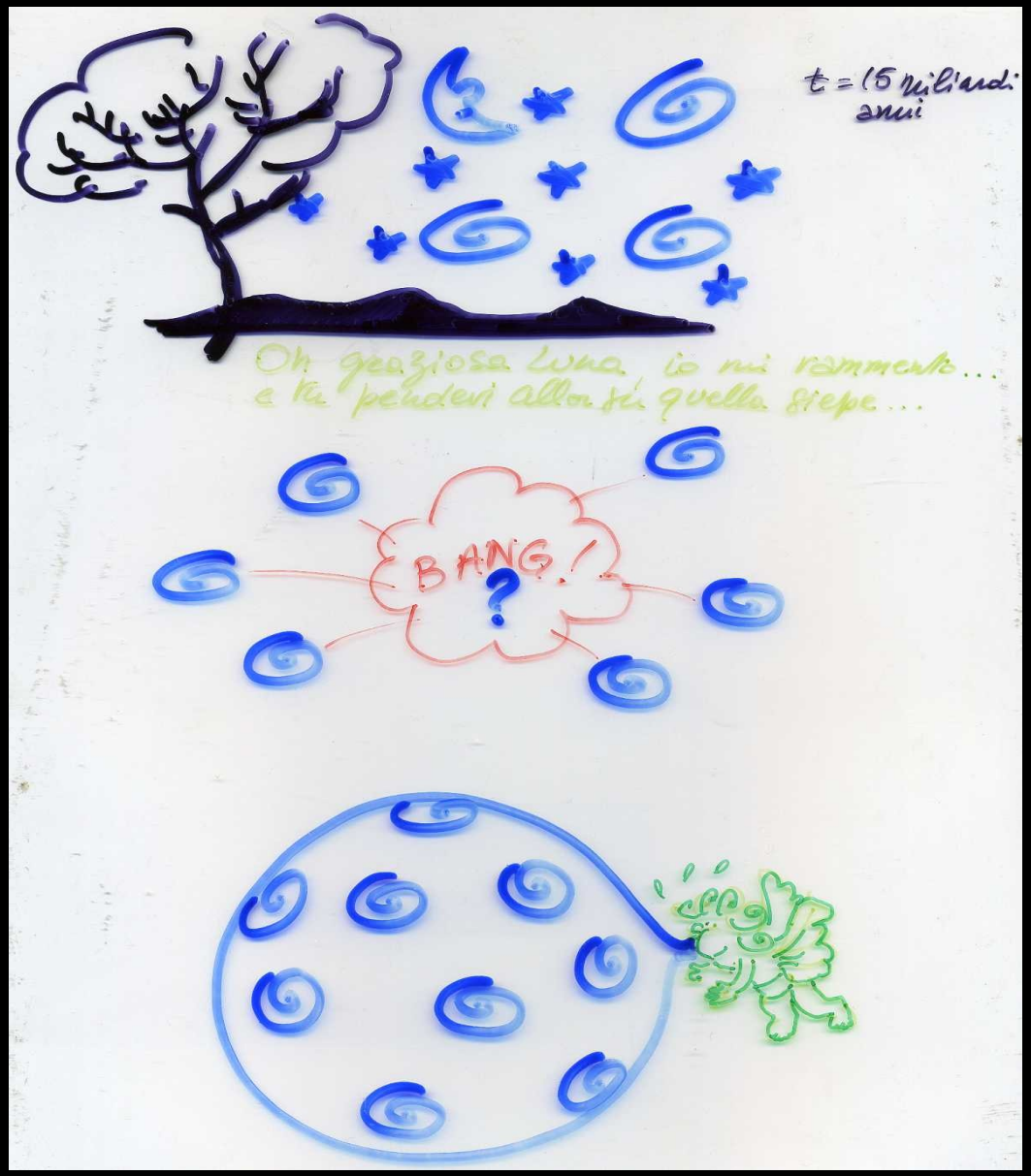
Tullio Levi Civita

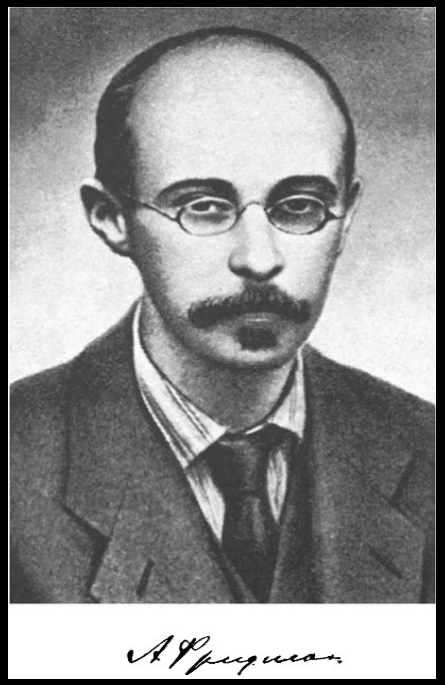

usciva l'ameba a esplorare
l'UNIVERSO? LA GEOMETRIA INTRINSECA!
(Gauss)
ELEMENTARE WATSON,
E' UNA SFERA!

Principio cosmologico:
l'universo appare, nello stesso tempo, uguale in tutte le direzioni e per qualunque osservatore

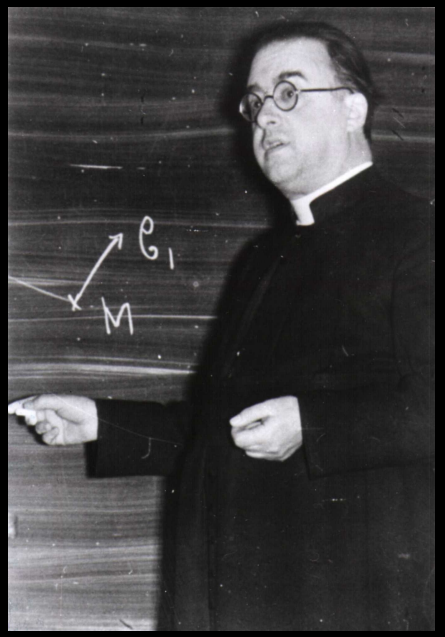
... the observable region is our sample of the universe. If the sample is fair, its observed characteristics will determine the physical nature of the universe as a whole.
(E. Hubble, The Realm of the Nebulae, 1936)

Le soluzioni di Friedman e Lemaitre

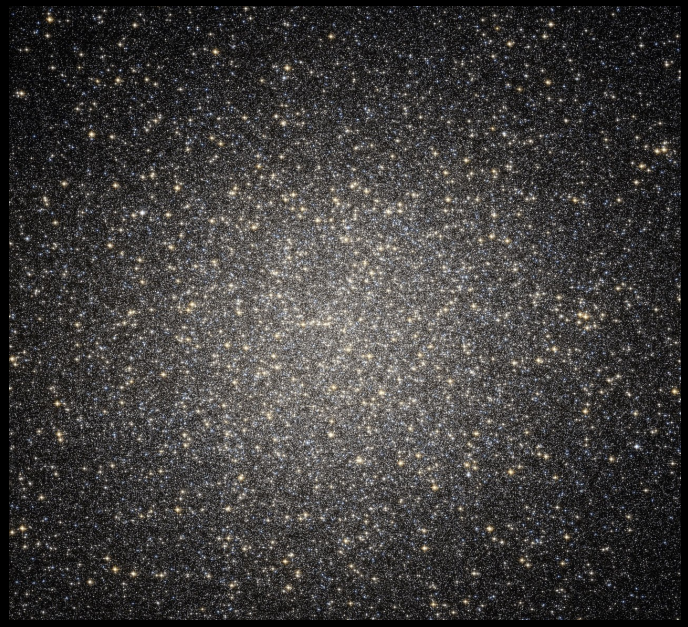




A. Friedman



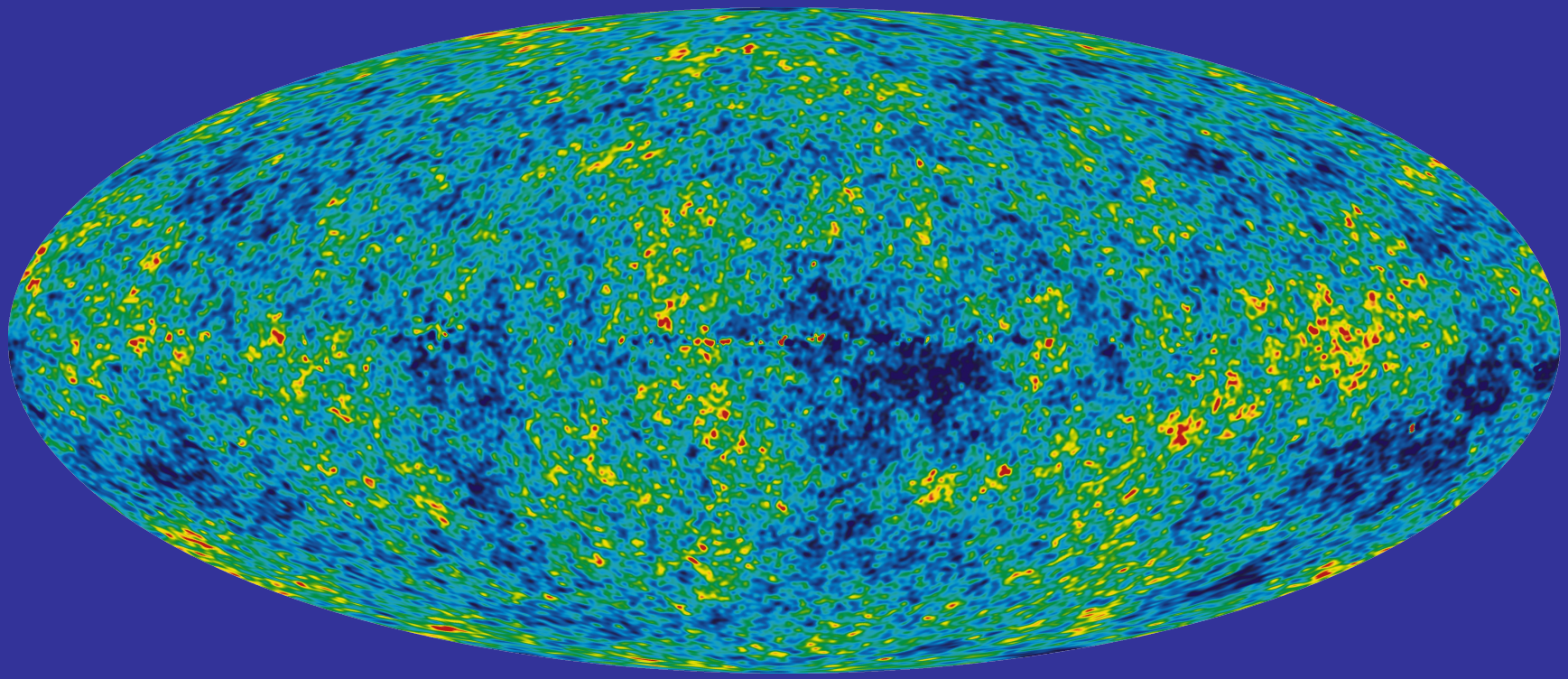
Radiazione fossile e rapporto H/He nelle stelle più antiche



Gamow

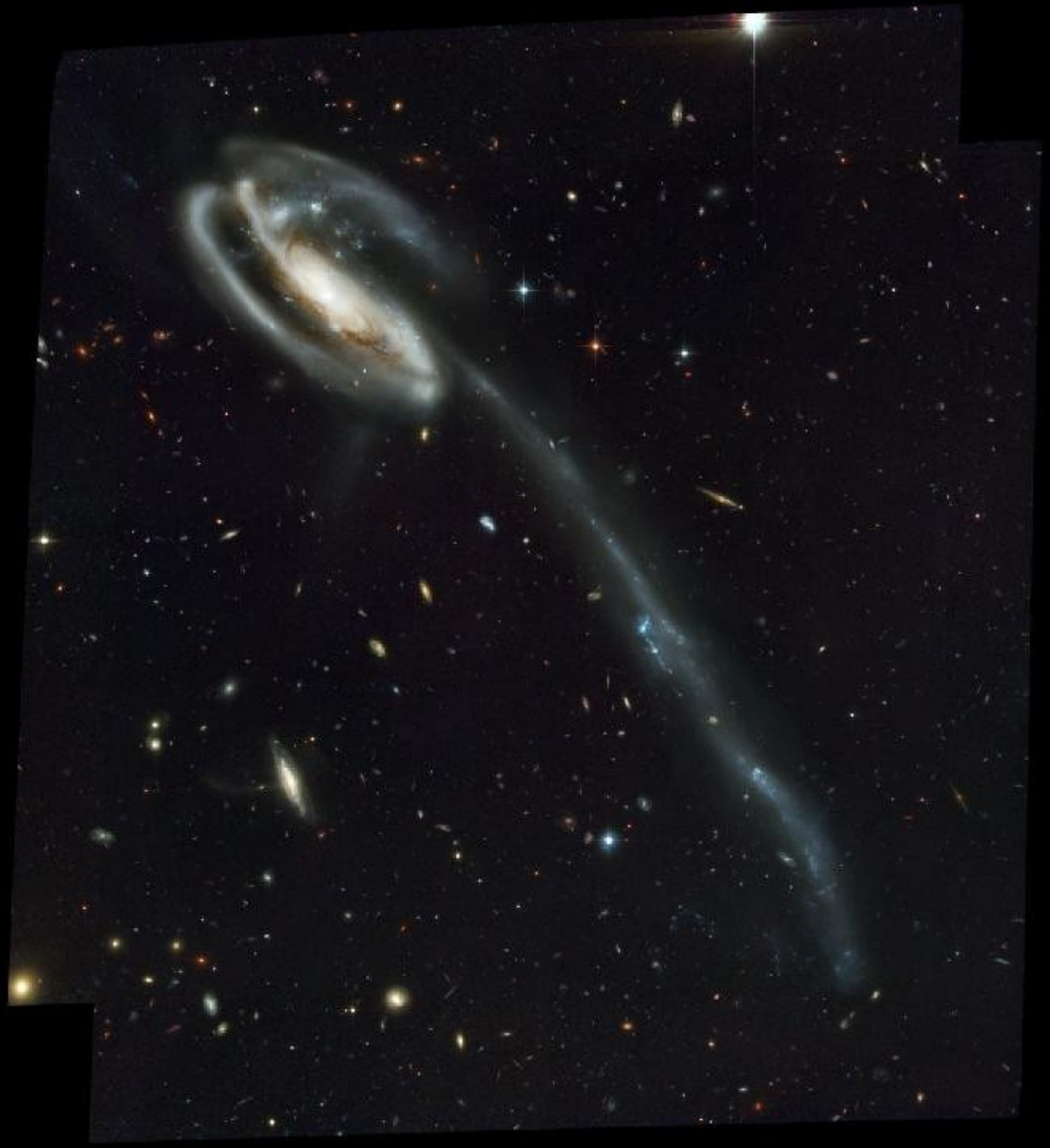
Il fondo cosmico di microonde a 3K

Cosmic Microwave Background



Hubble Space Telescope


Il Regno delle Galassie




Fine
?