Determinación de parámetros estelares

Determinación de parámetros estelares

Distancias

(Distance Ladder)

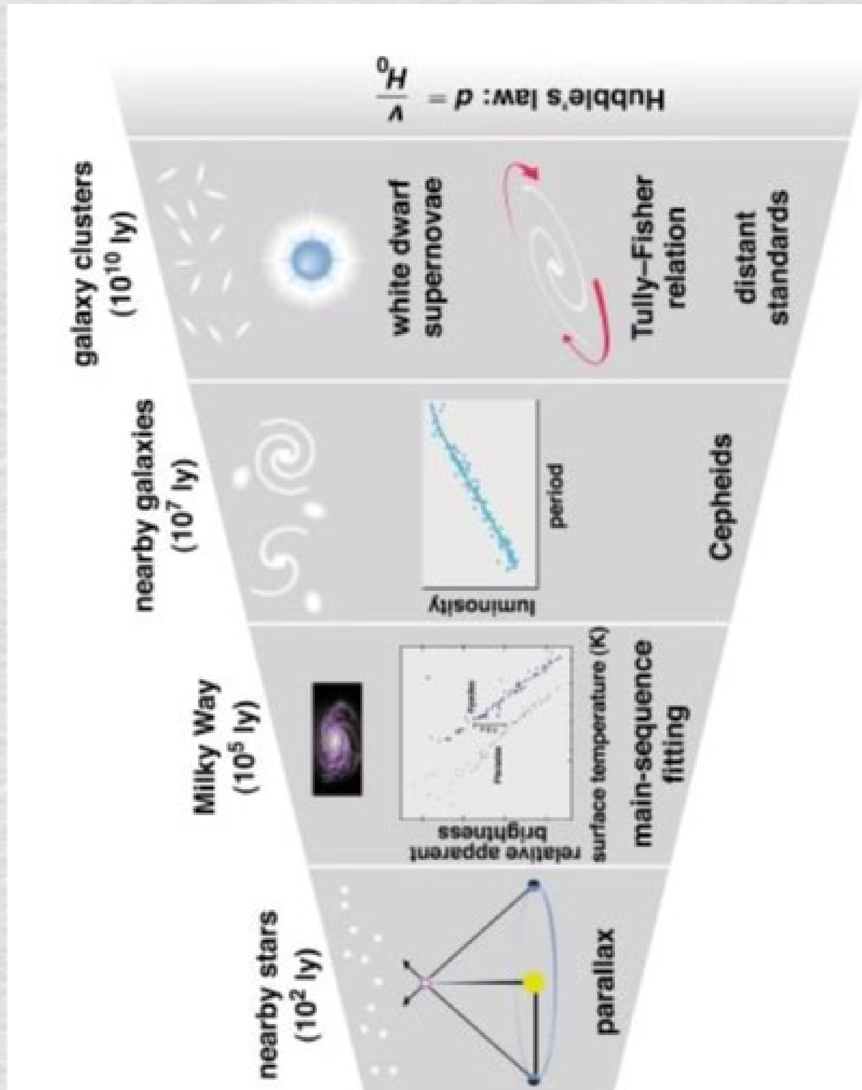
Determinación de parámetros estelares

Determinación de distancias

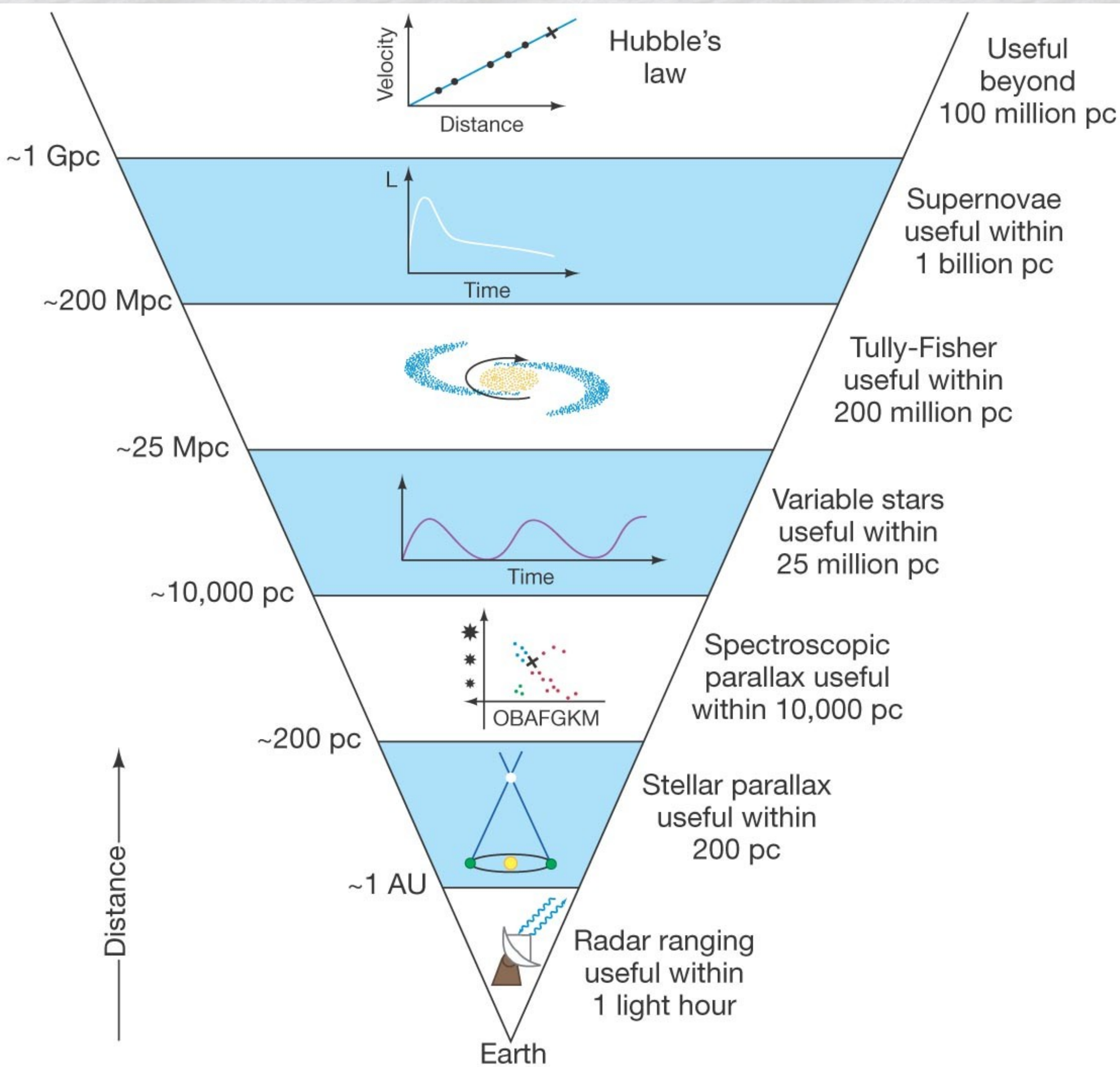
Existen diversos métodos:

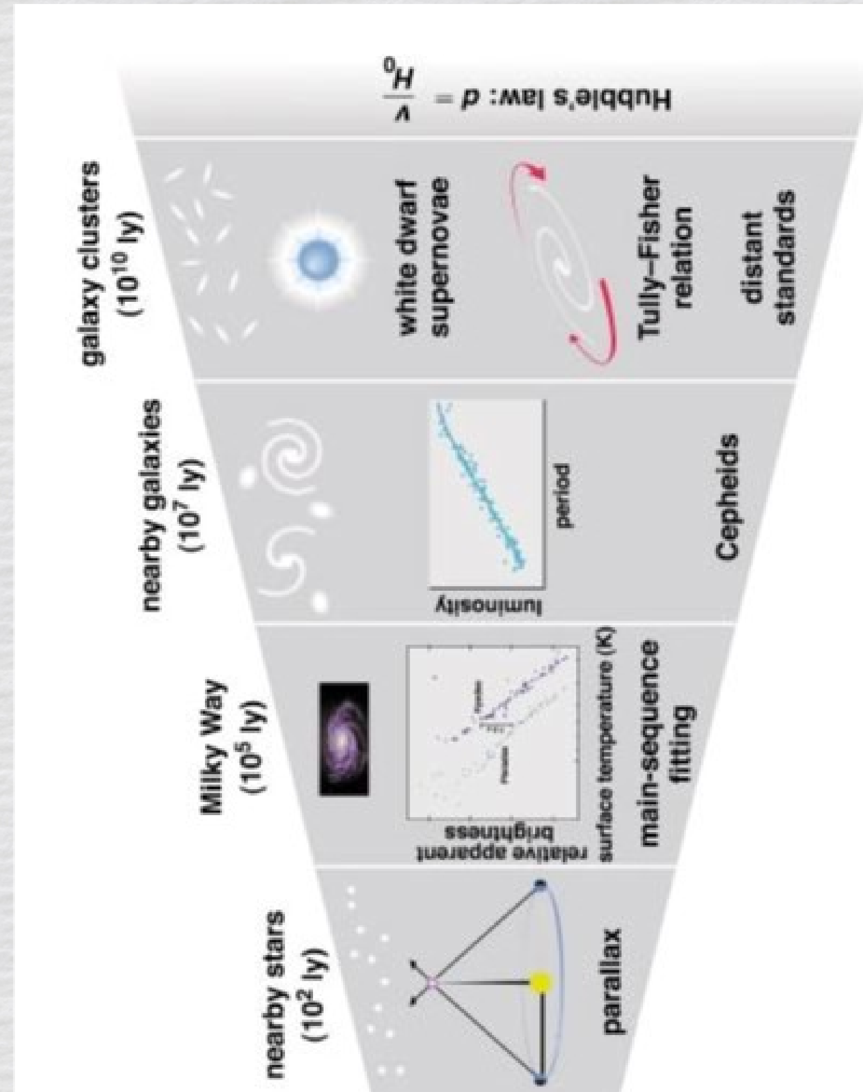
- Rango de validez y limitaciones.
- Geométricos, estadísticos, dinámicos, espectroscópicos, fotométricos,...
- A mayor distancia → menor precisión.
- Confrontar las distancias obtenidas por ellos.

Determinación de distancias



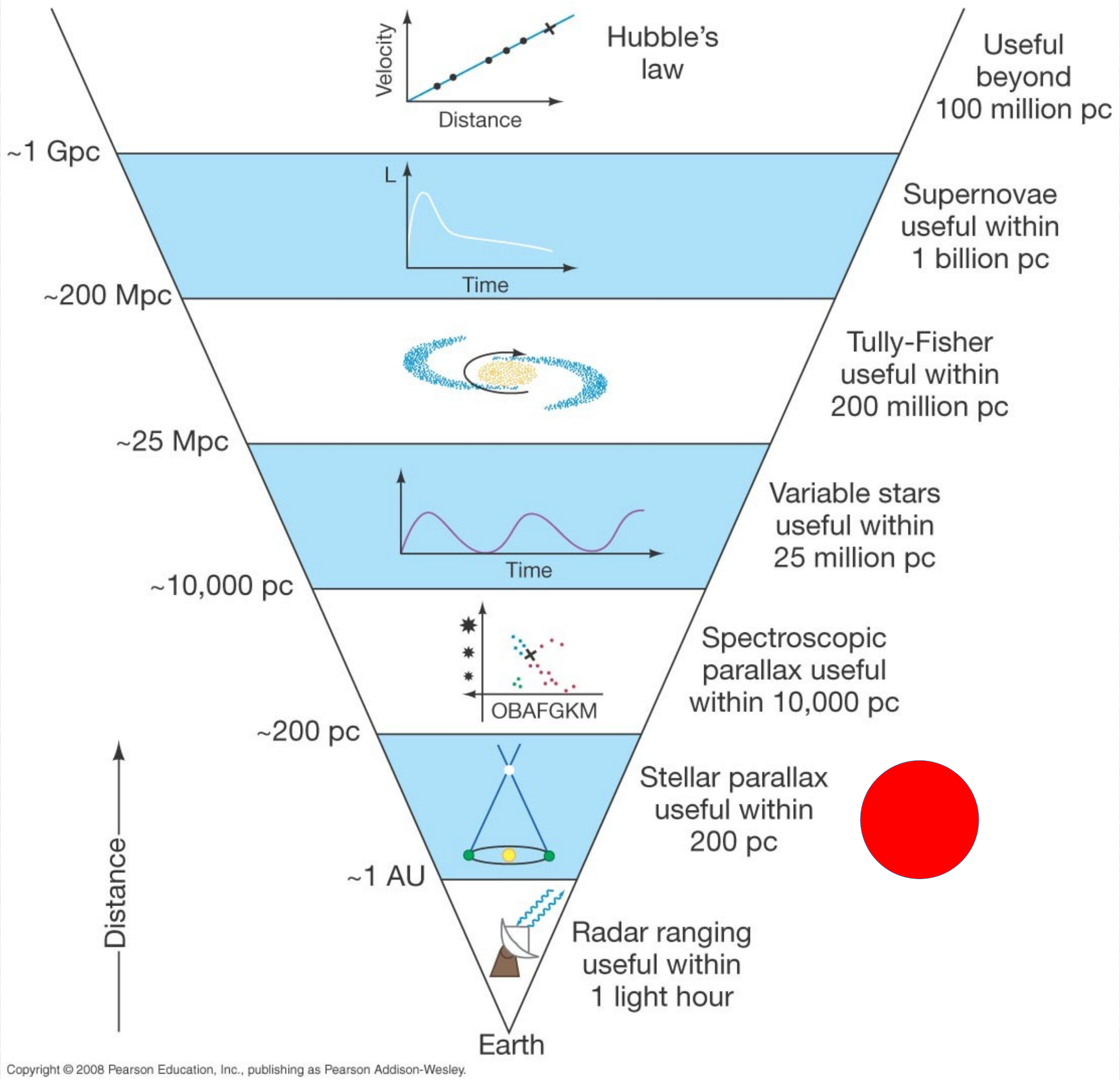
Determinación de distancias





1 pc = 3.26 ly
1 pc = 206.265 AU

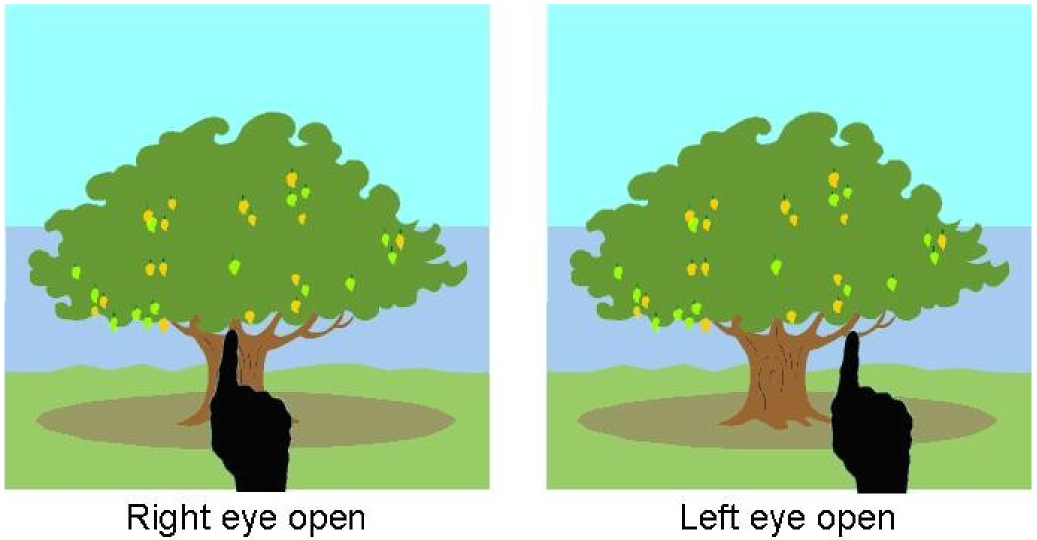
MW Diam ~ 100.000 ly
Solar syst ~ 2 ly – 200.000 AU
LMC ~ 160.000 ly – 50 kpc

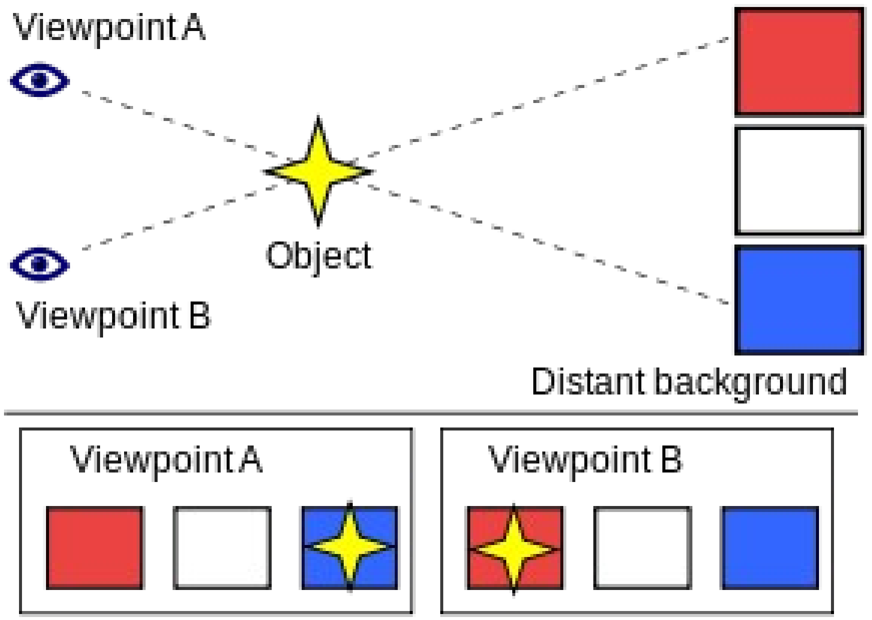

Velocity
Distance
Hubble's law
Useful beyond 100 million pc
~1 Gpc
L
Time
Supernovae useful within 1 billion pc
~200 Mpc
Tully-Fisher useful within 200 million pc
~25 Mpc
Time
Variable stars useful within 25 million pc
~10,000 pc
OBAFGKM
Spectroscopic parallax useful within 10,000 pc
~200 pc
Stellar parallax useful within 200 pc
~1 AU
Radar ranging useful within 1 light hour
Distance
Earth

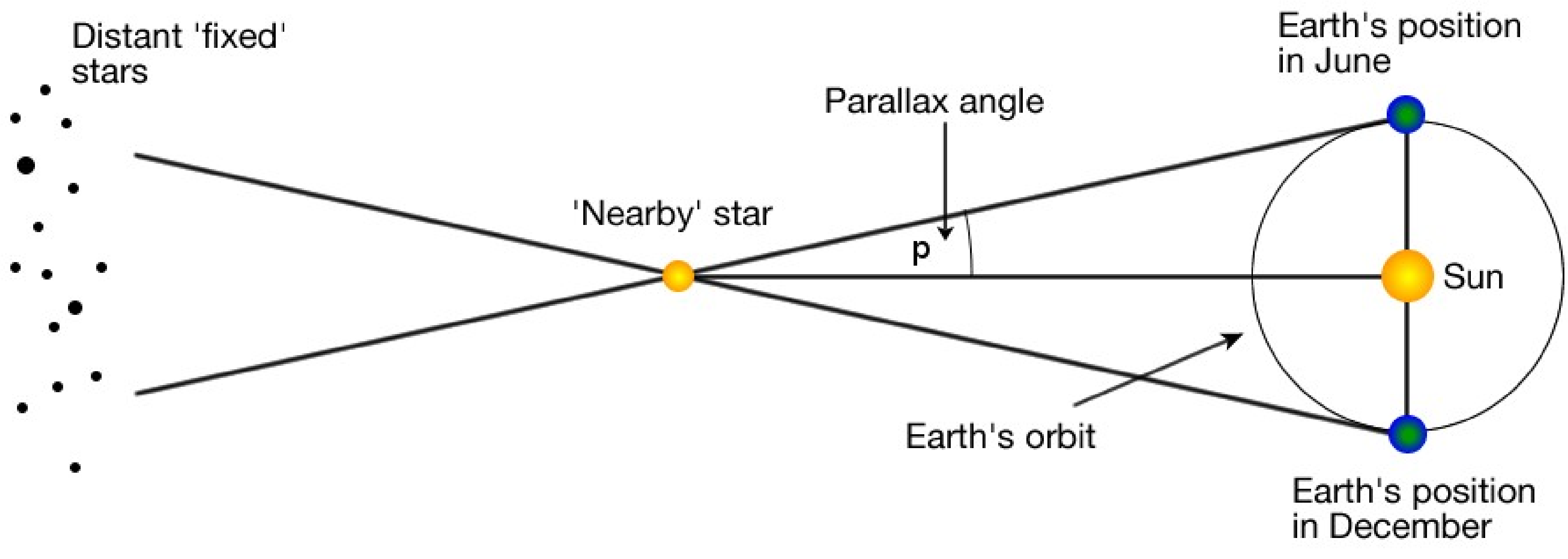
Determinación de distancias

Métodos directos: paralaje trigonométrica

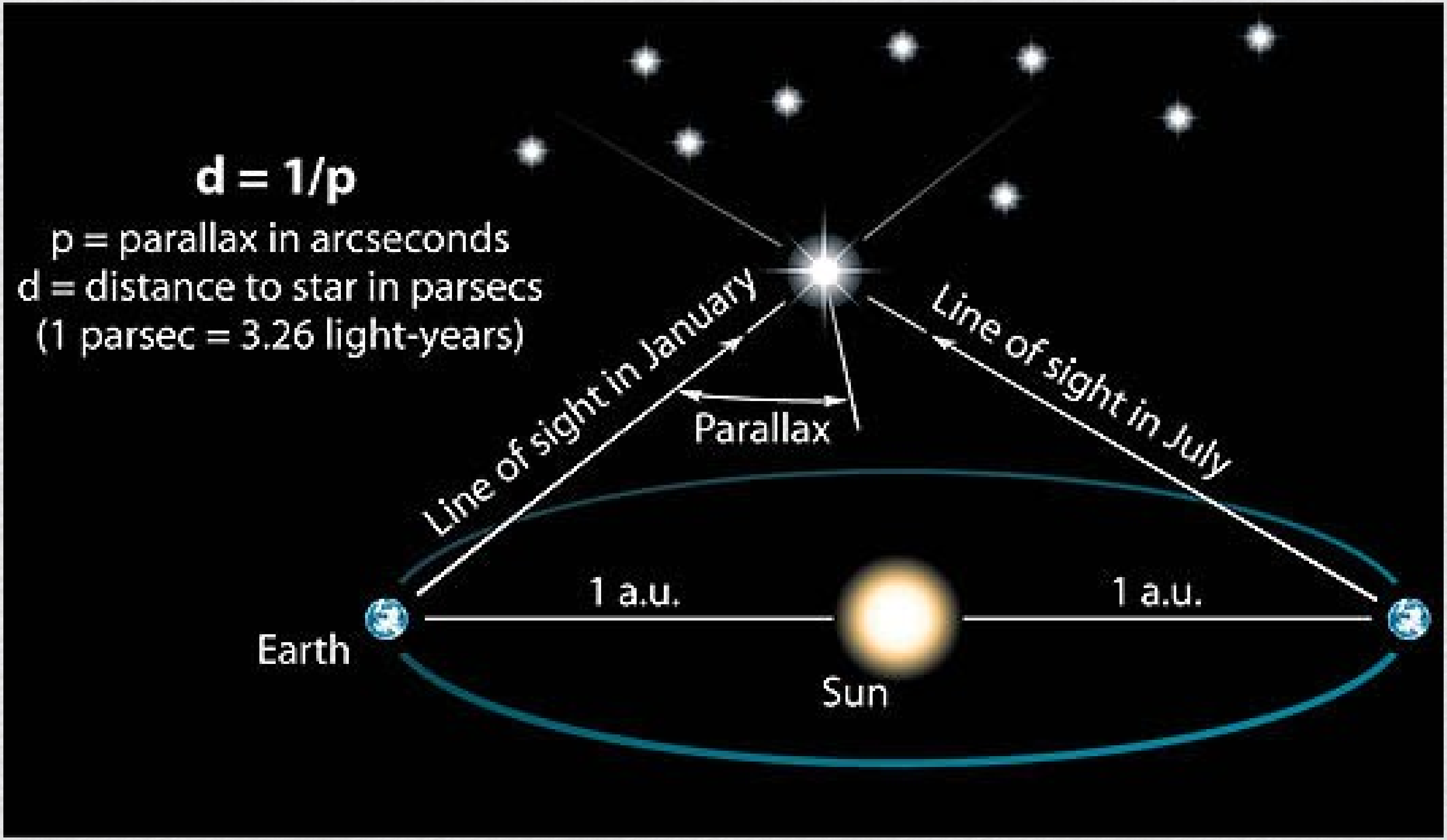
Paralaje trigonométrica



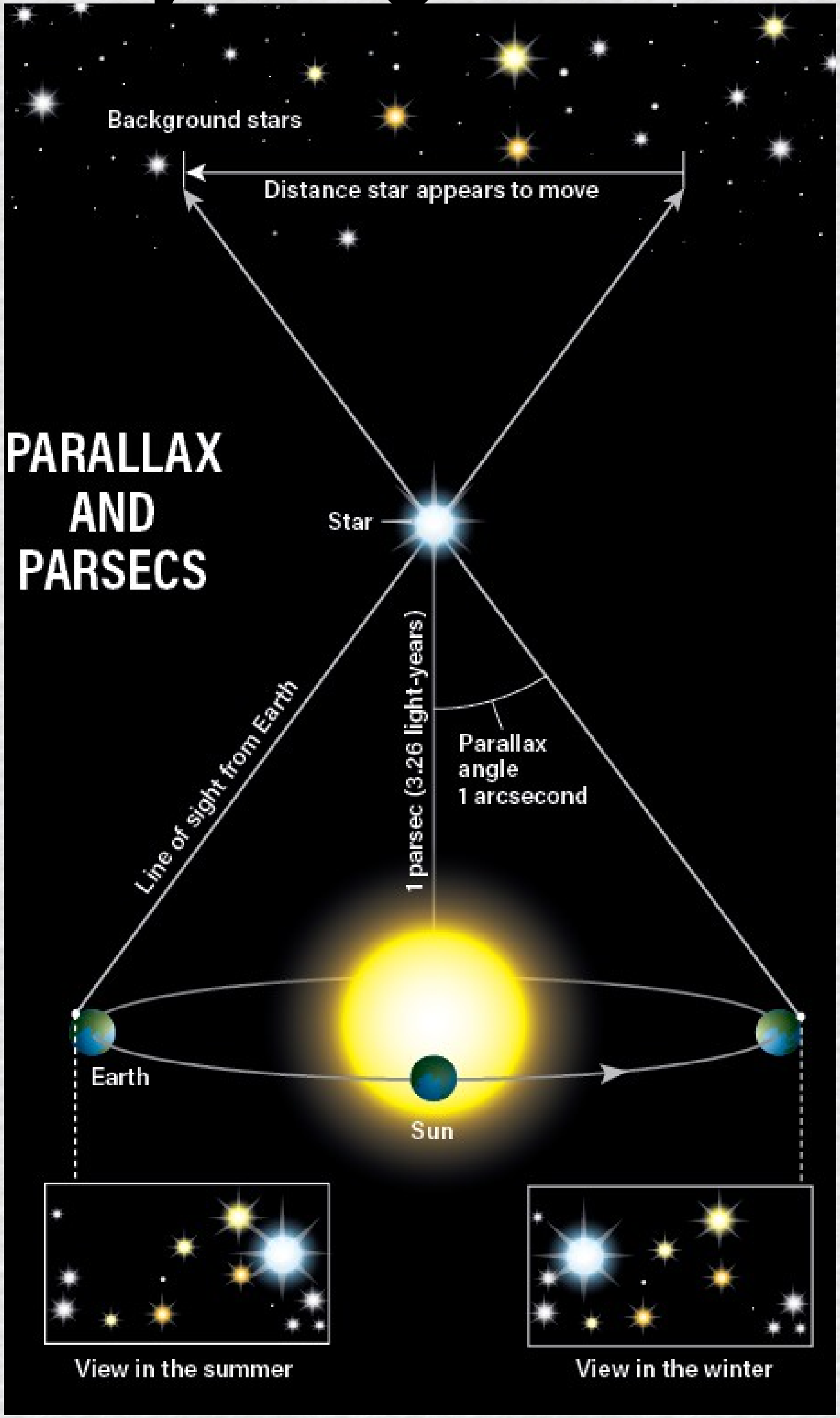




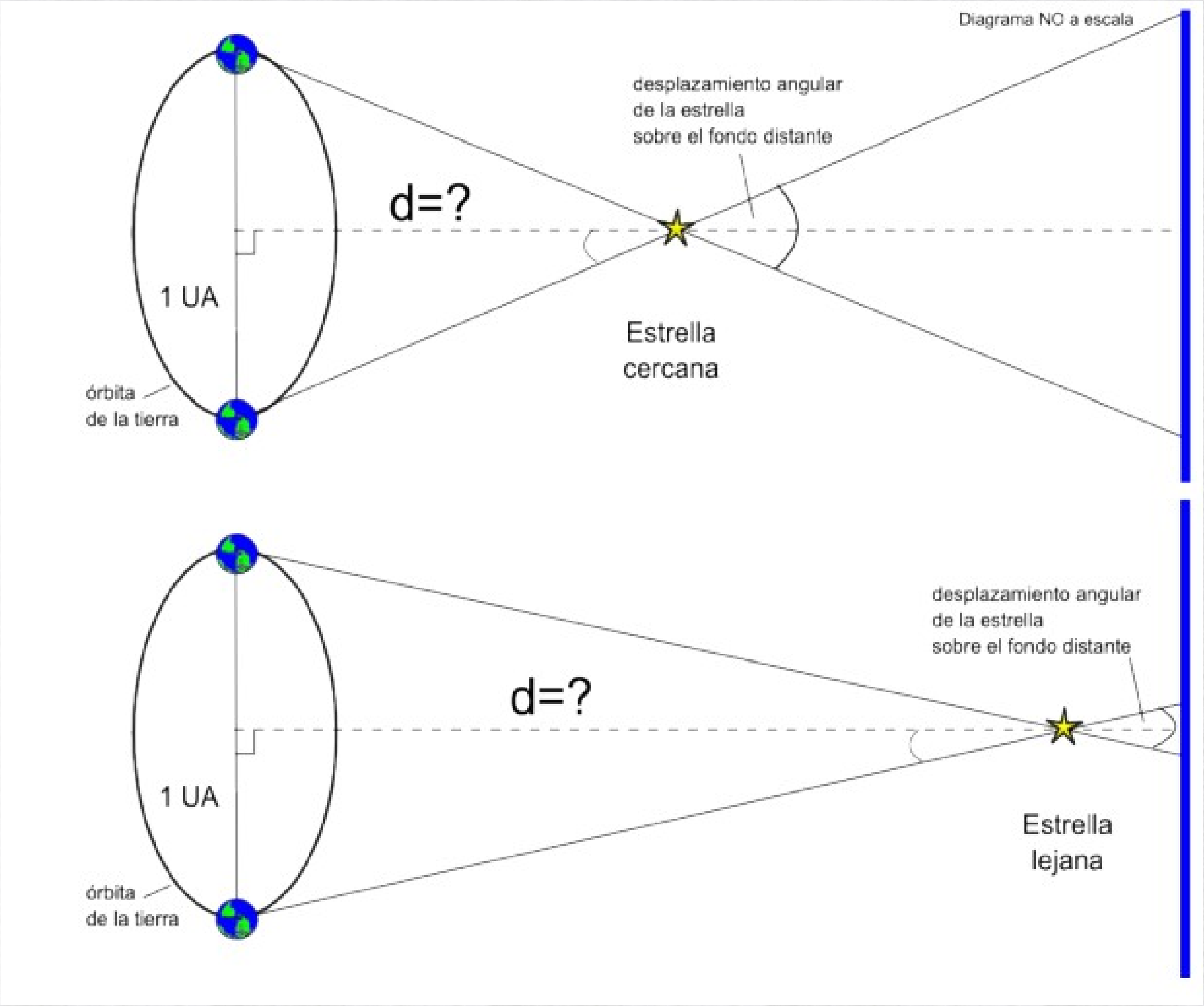
Paralaje trigonométrica



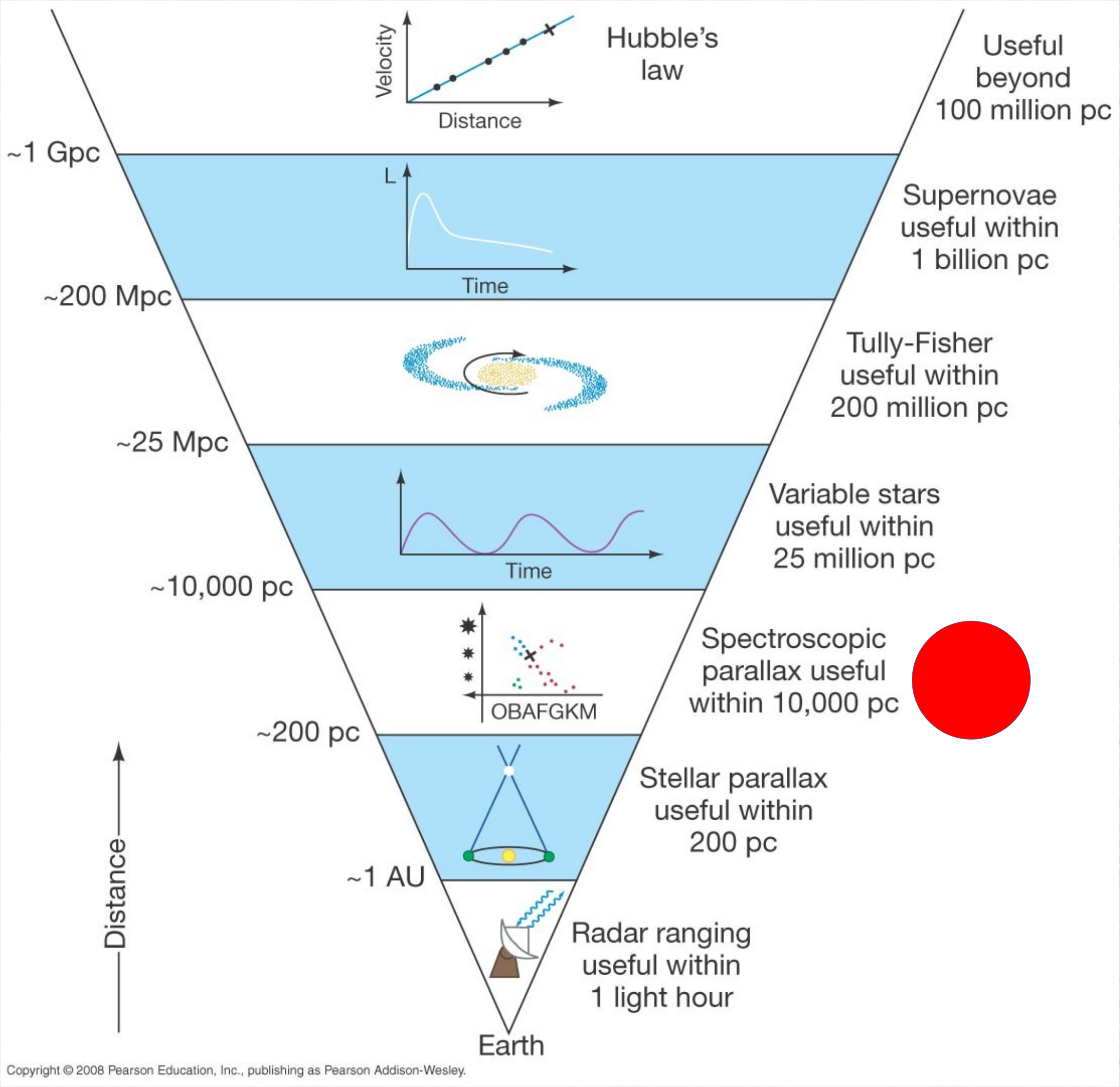
Paralaje trigonométrica



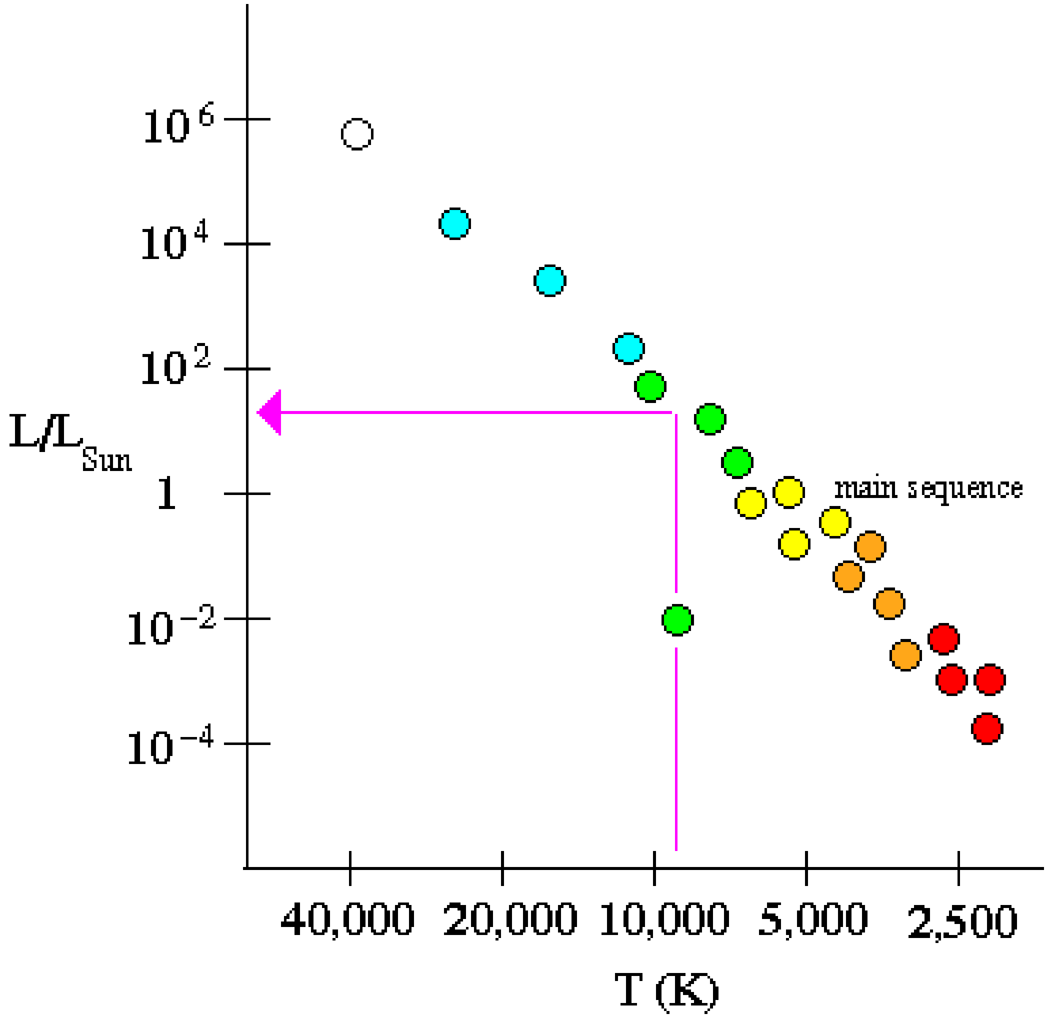
Paralaje trigonométrica



Determinacion de distancias

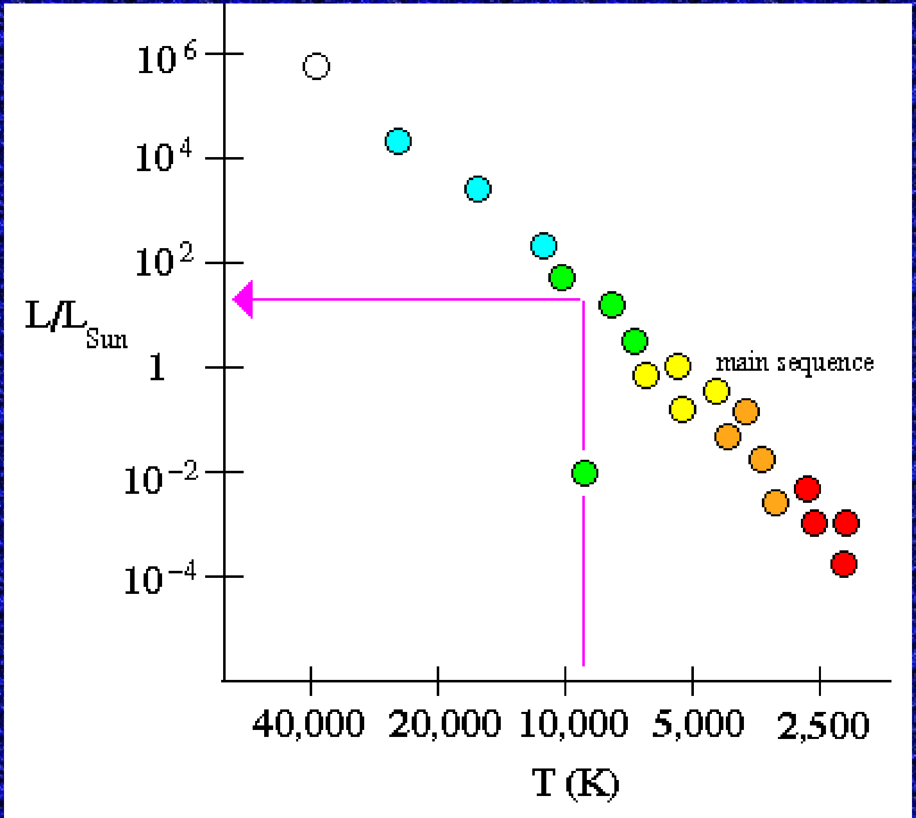


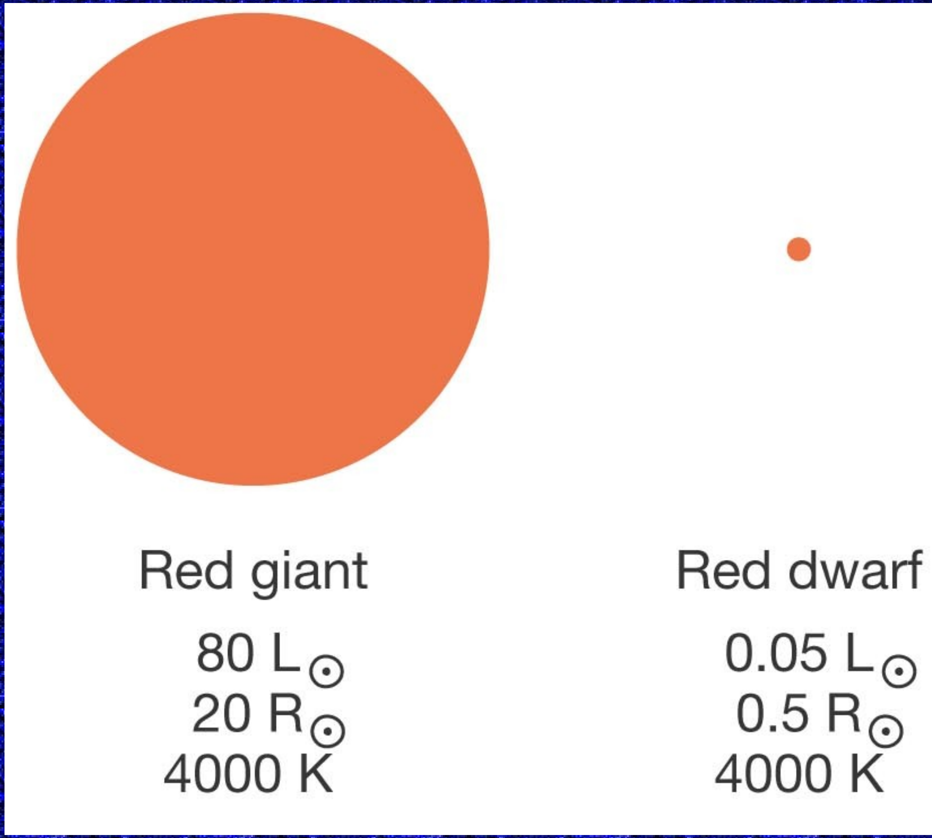
Paralaje espectroscópica



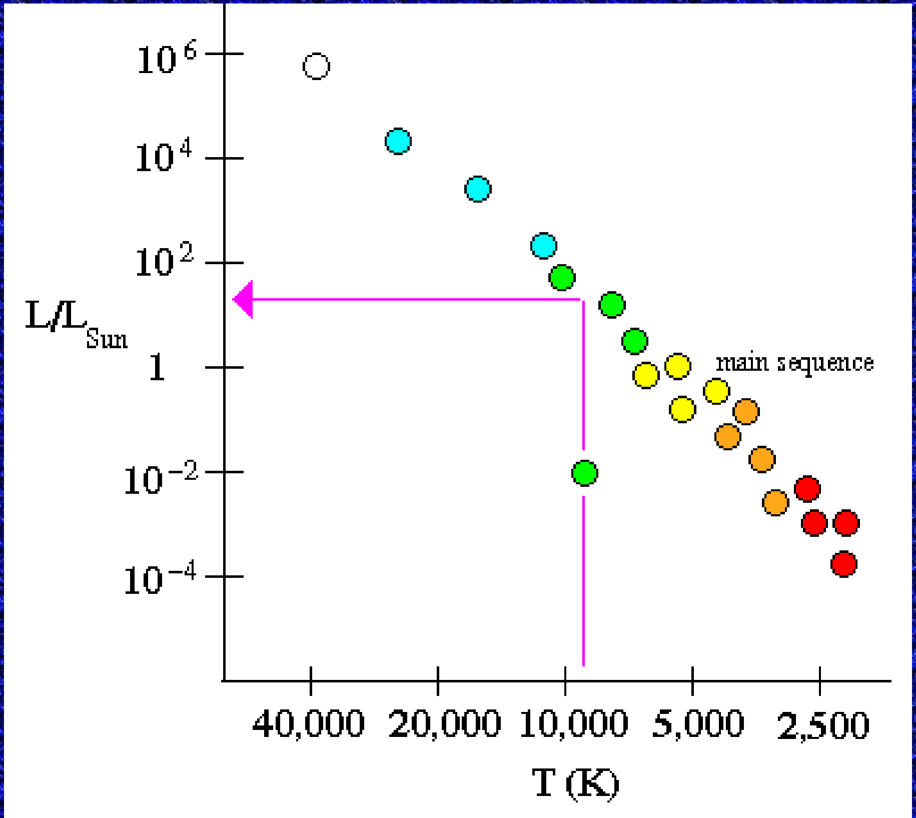
the true brightness of a star can be found if the color is known by matching the star to the main sequence. Knowledge of the observed brightness plus the true brightness derives the distance to the star.

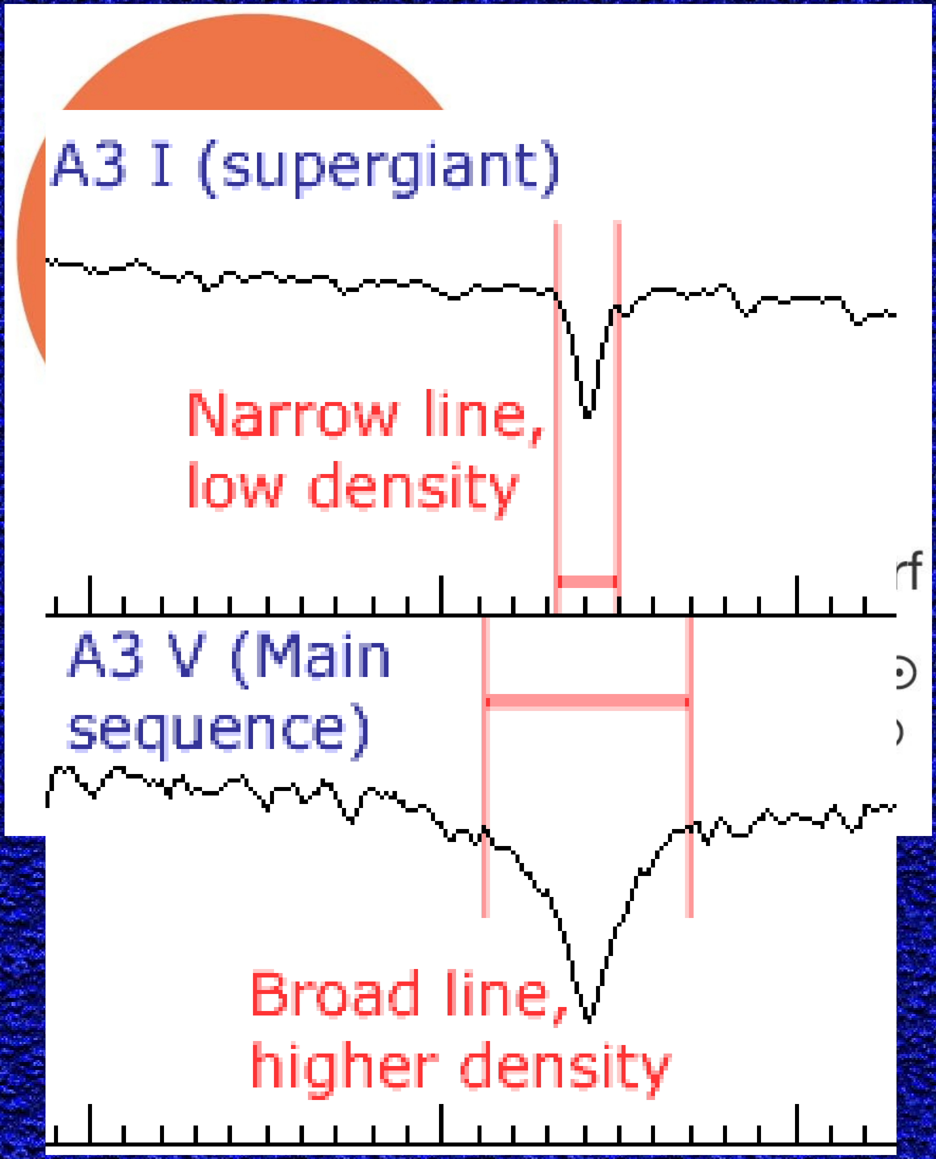
Paralaje espectroscópica

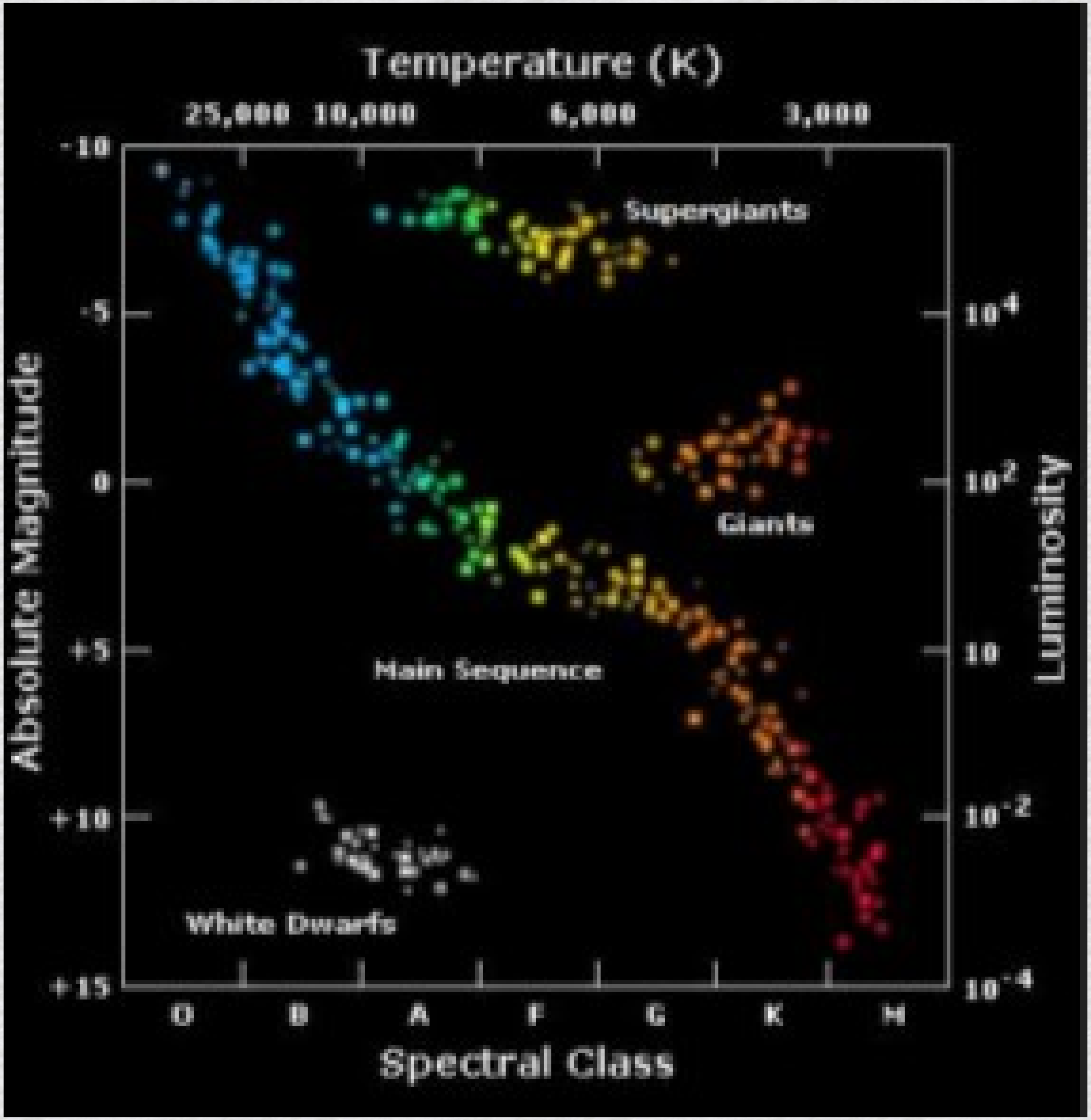




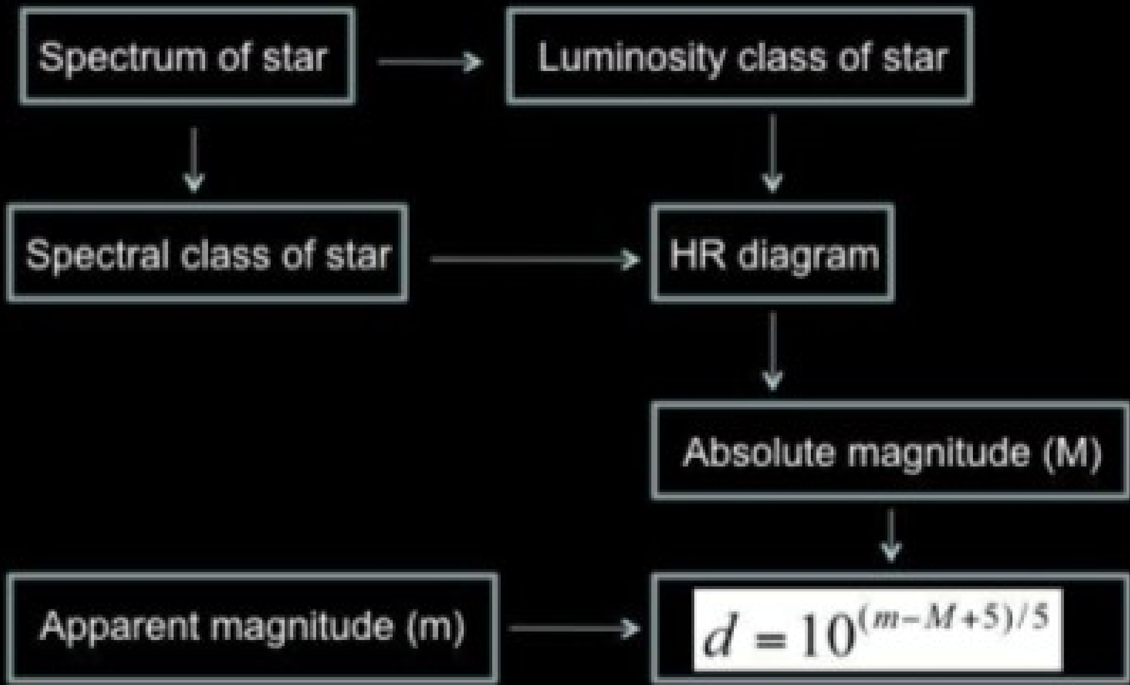
Paralaje espectroscópica



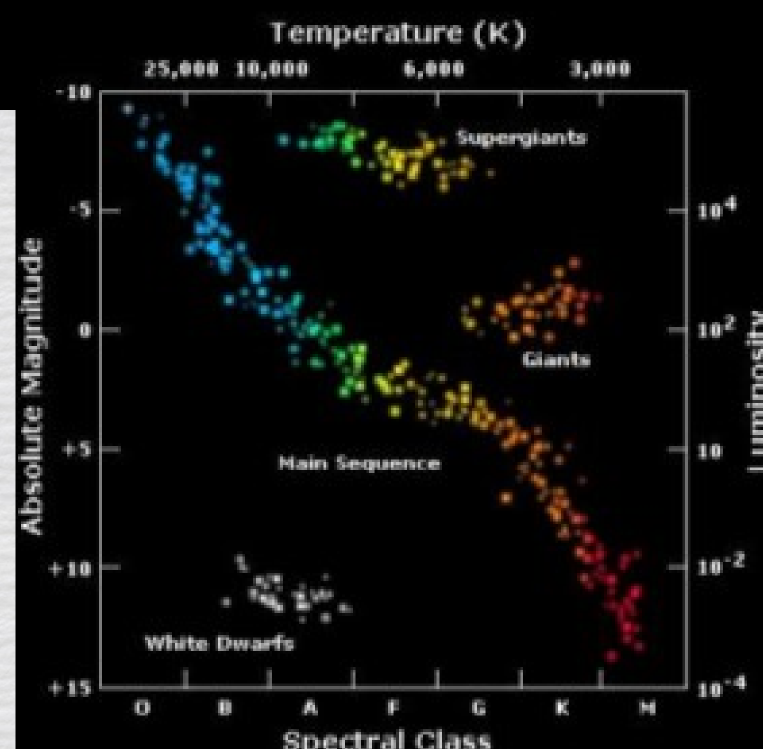



Temperature (K)
25,000 10,000 6,000 3,000
Supergiants
Giants
Main Sequence
White Dwarfs
Absolute Magnitude
-10
-5
0
+5
+10
+15
Luminosity
10^4
10^2
10
10^{-2}
10^{-4}
O B A F G K M
Spectral Class

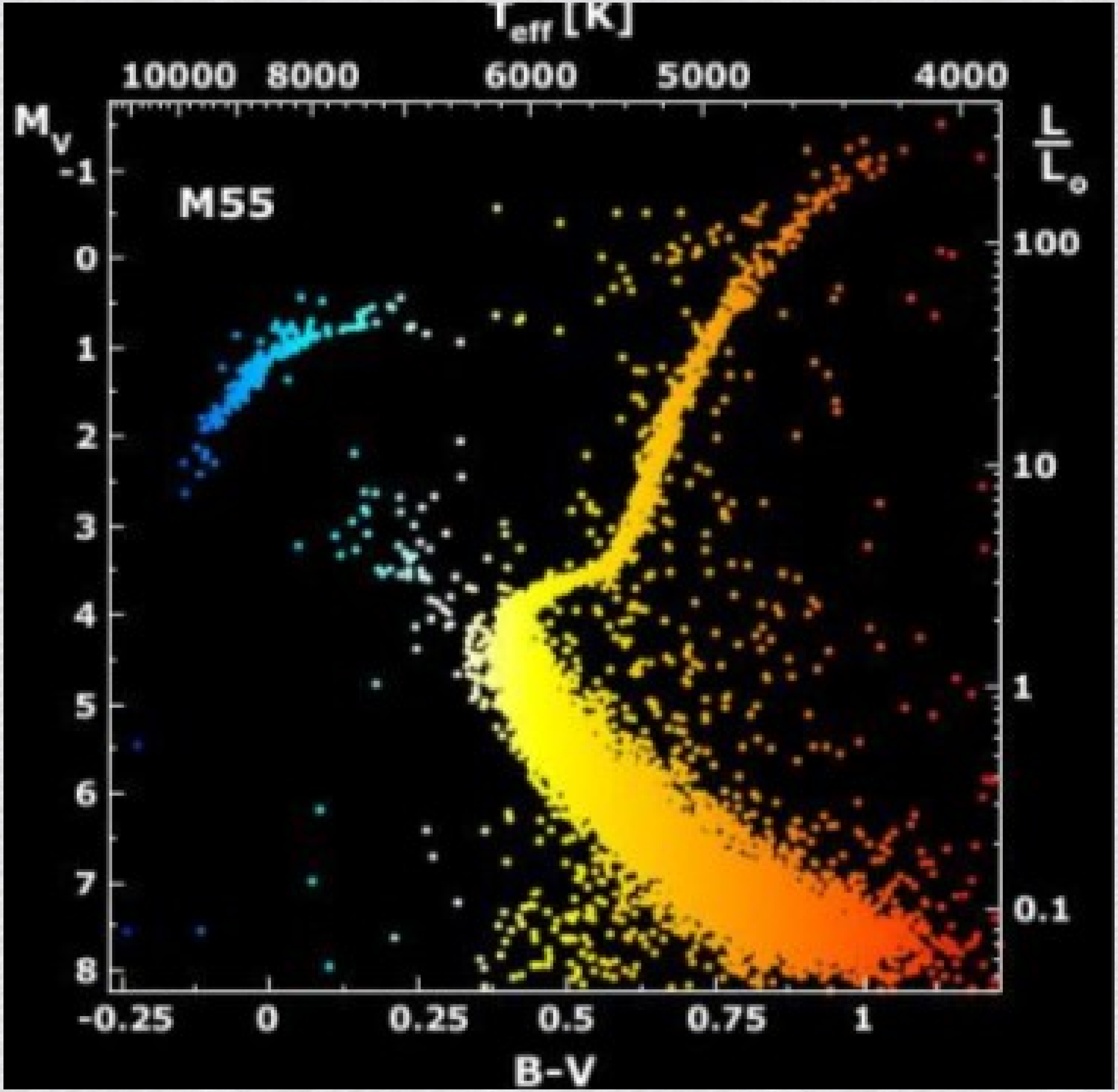
Spectroscopic Parallax is a method of determining distances to stars summarized with the following flowchart:



where d is distance in parsecs

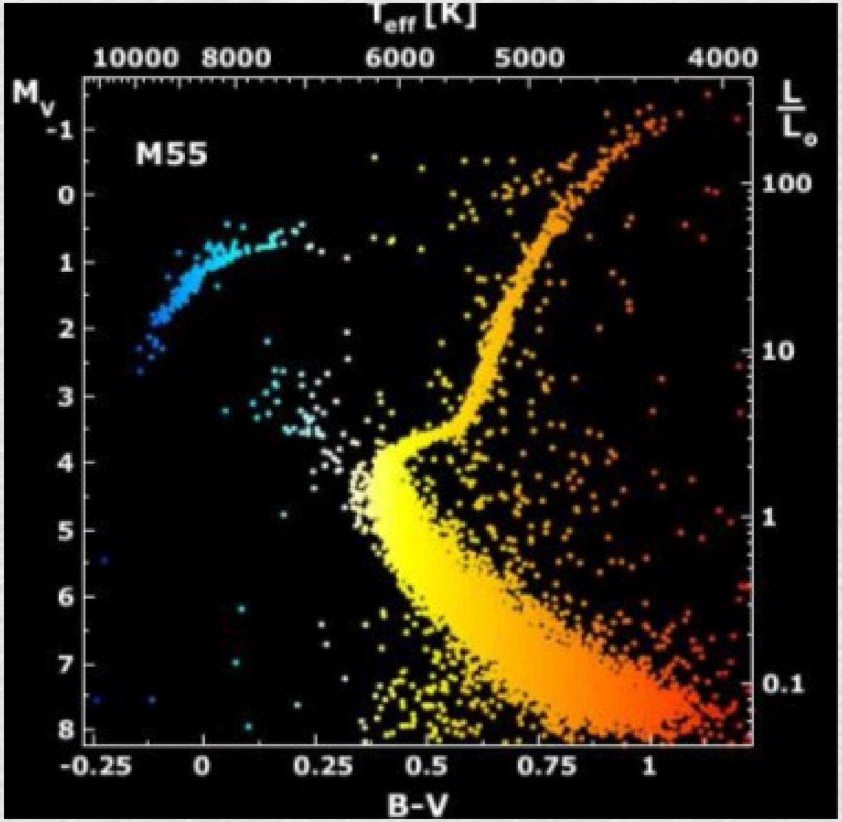


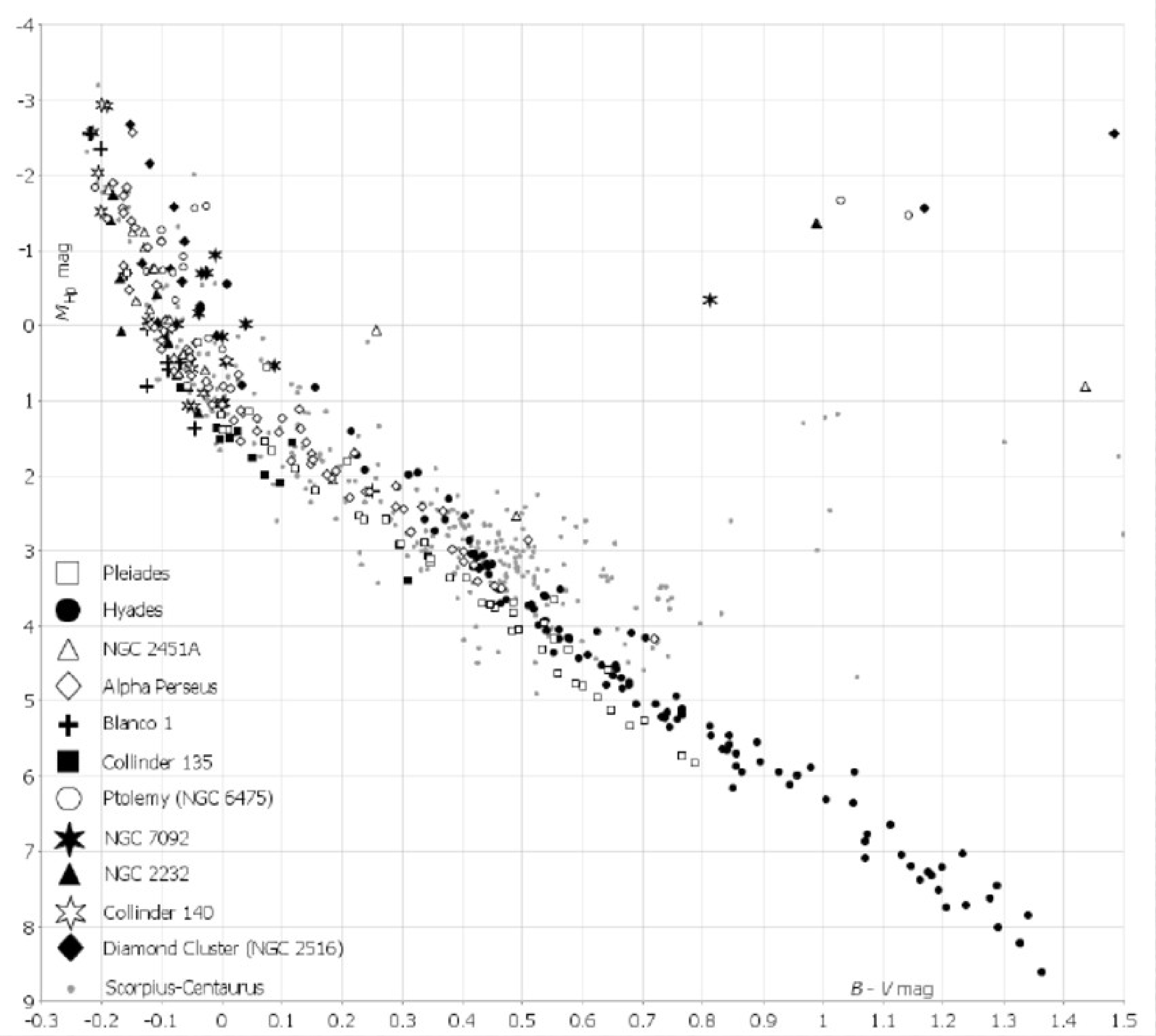
DCM: CA y CG



T_{eff} [K]
10000 8000 6000 5000 4000
M_V
M55
-1
0
1
2
3
4
5
6
7
8
$\frac{L}{L_\odot}$
100
10
1
0.1
-0.25 0 0.25 0.5 0.75 1
B-V

DCM: CA y CG


Teff [K]
10000 8000 6000 5000 4000
Mv
M55
L/Lo
100
10
1
0.1
-1 0 1 2 3 4 5 6 7 8
-0.25 0 0.25 0.5 0.75 1
B-V


M_Hp mag
B - V mag
Pleiades
Hyades
NGC 2451A
Alpha Perseus
Blanco 1
Collinder 135
Ptolemy (NGC 6475)
NGC 7092
NGC 2232
Collinder 140
Diamond Cluster (NGC 2516)
Scorpius-Centaurus
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9
-0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5

DCM: CA y CG

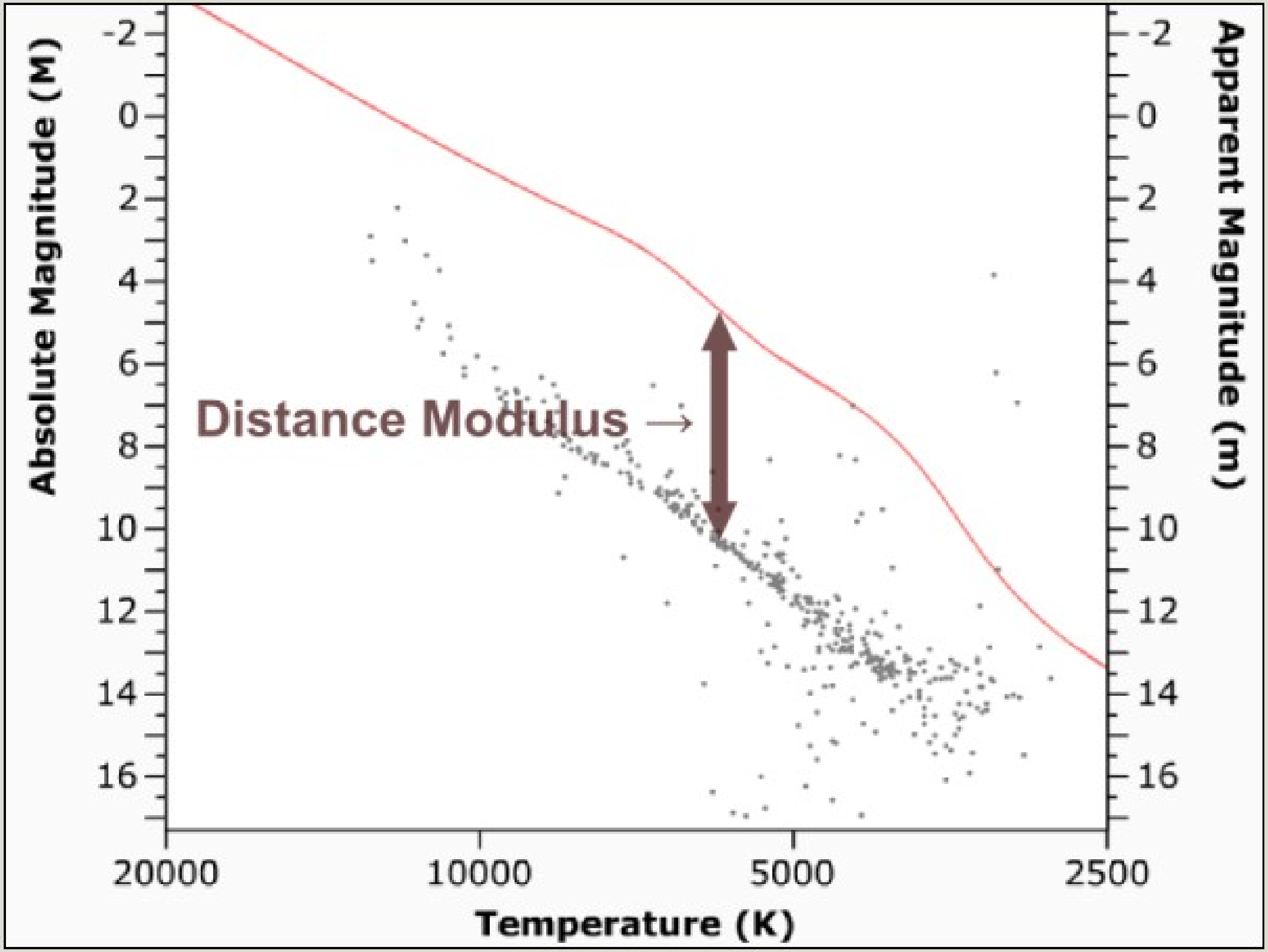
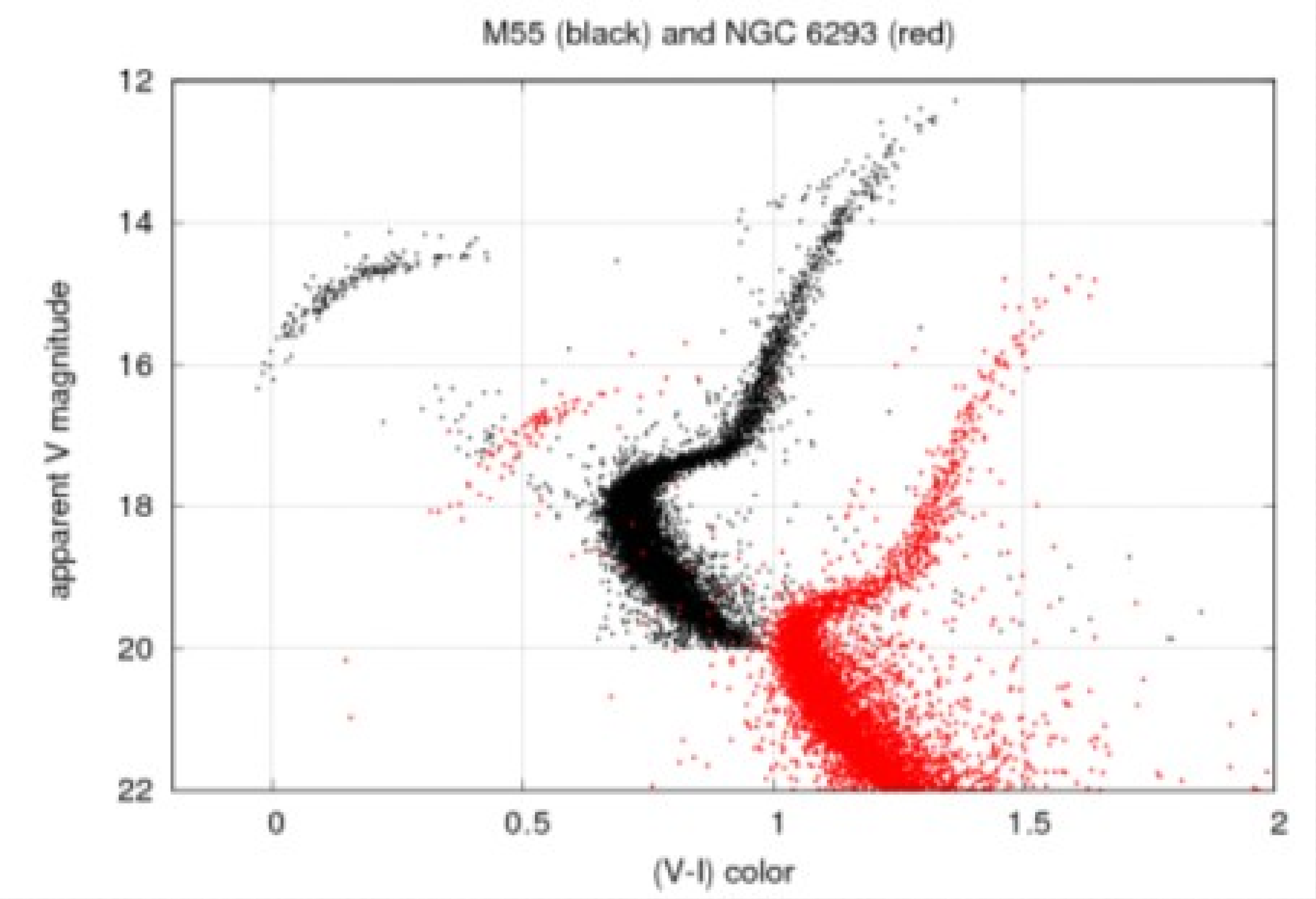
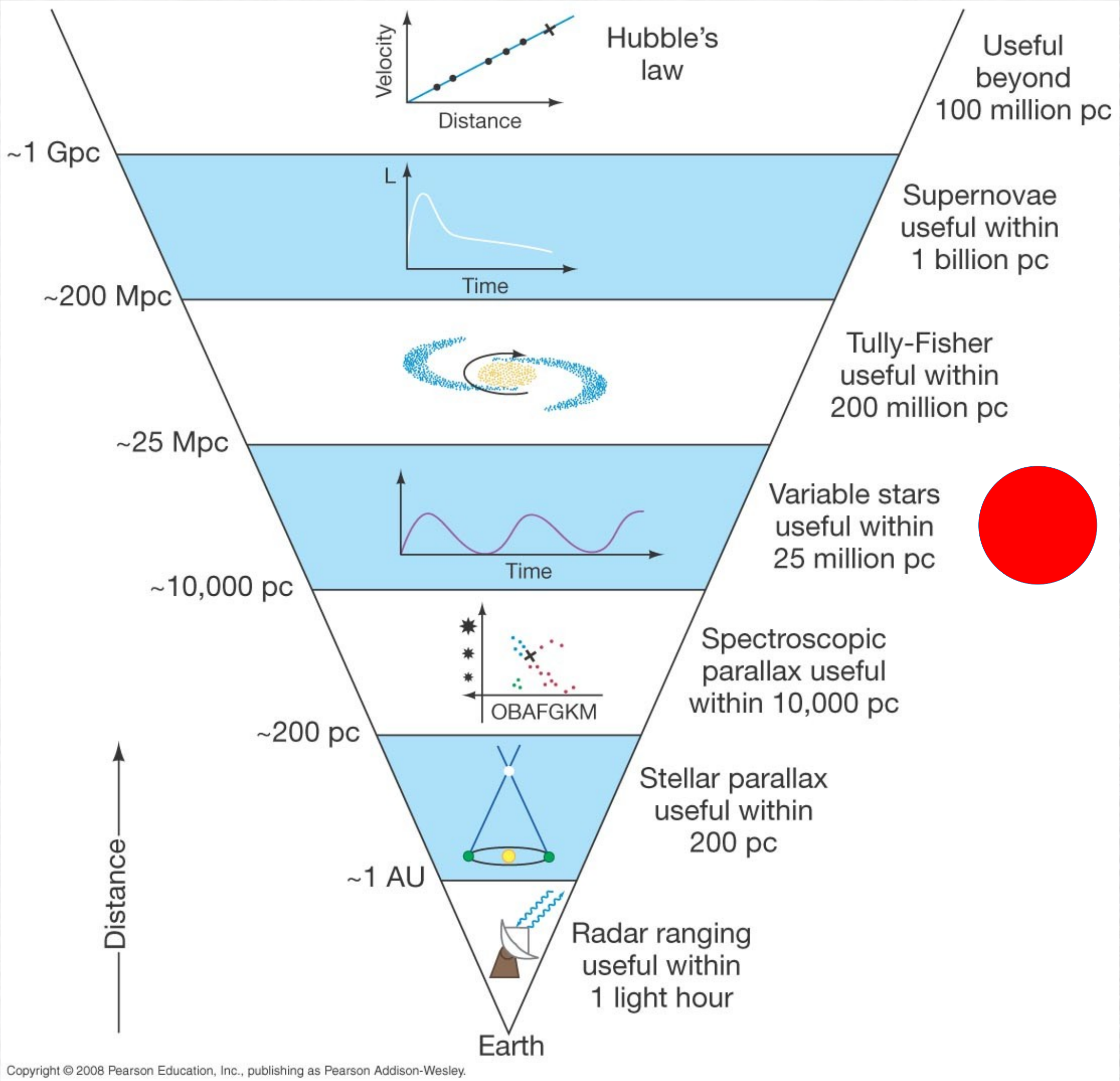


Figure 1: The difference between the apparent magnitude of the cluster and the absolute magnitude of the main sequeunce line is the distance modulus used in the main sequence fitting technique.

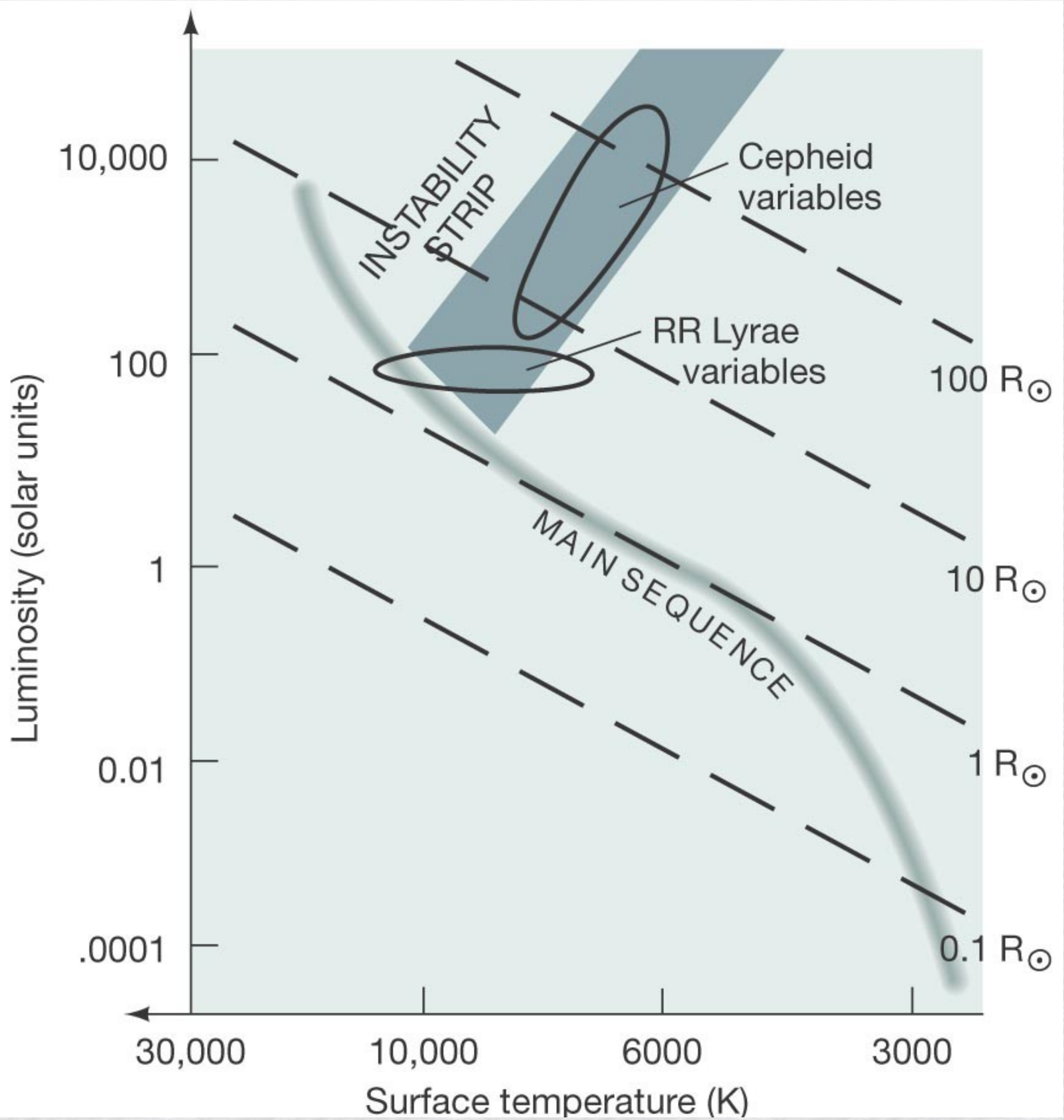
DCM: CA y CG


M55 (black) and NGC 6293 (red)
apparent V magnitude
12
14
16
18
20
22
0
0.5
1
1.5
2
(V-I) color

Determinacion de distancias



Variables y distancias ...



Variables y distancias ...

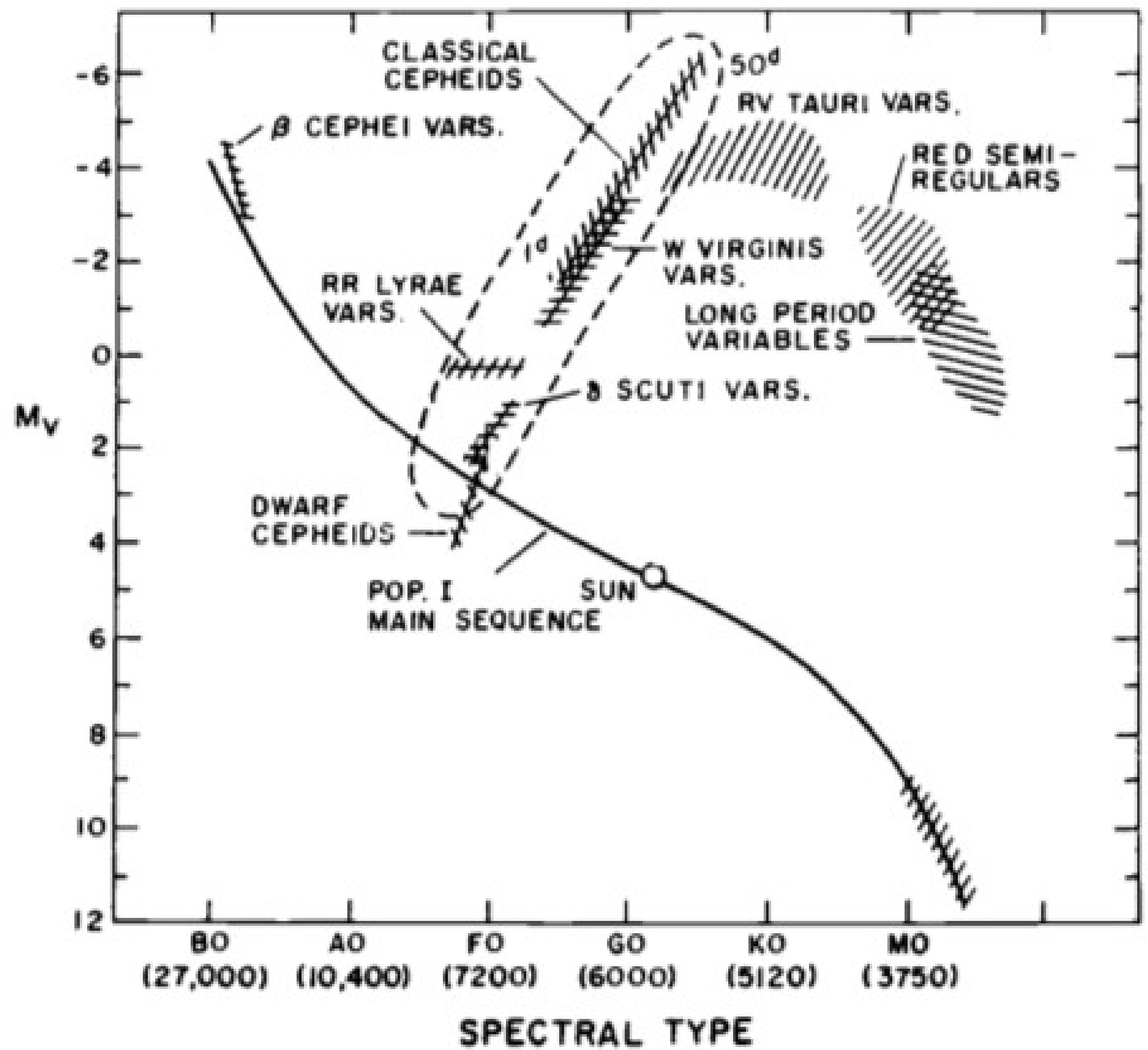
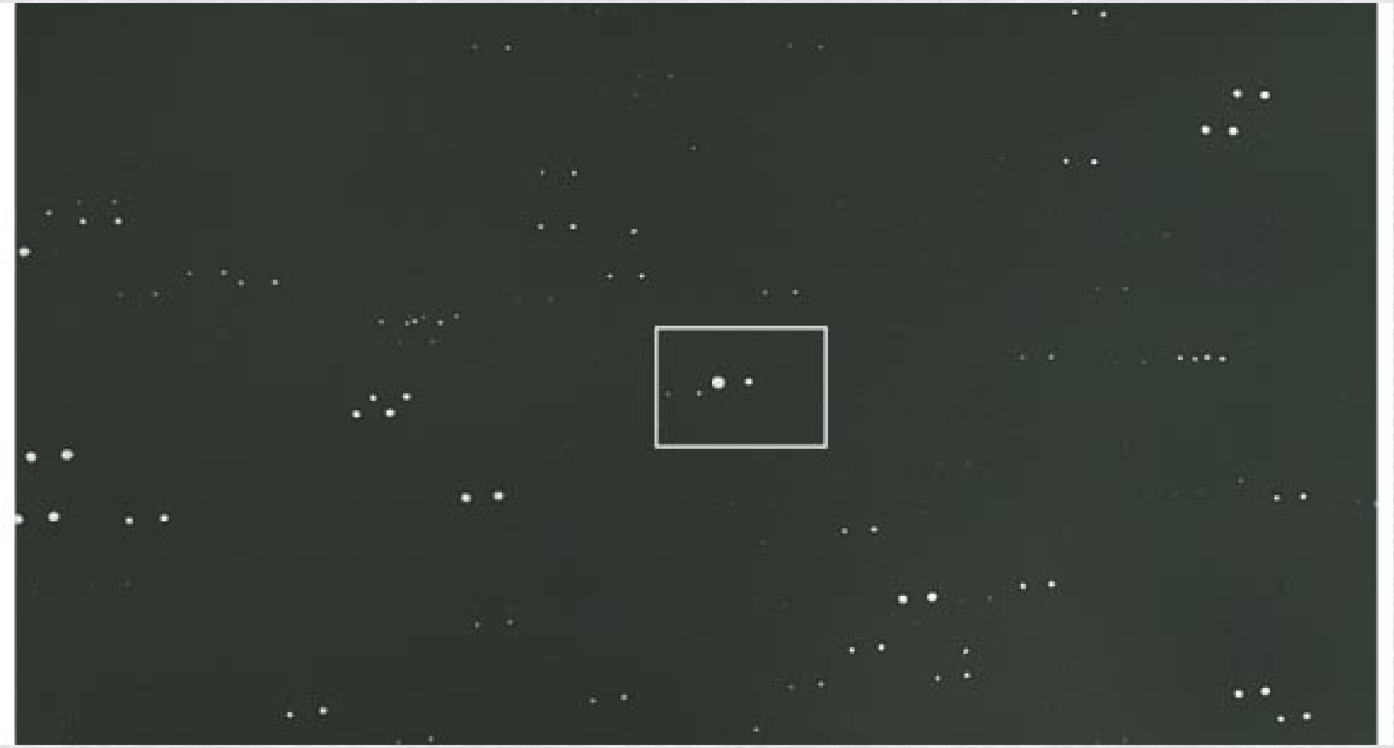
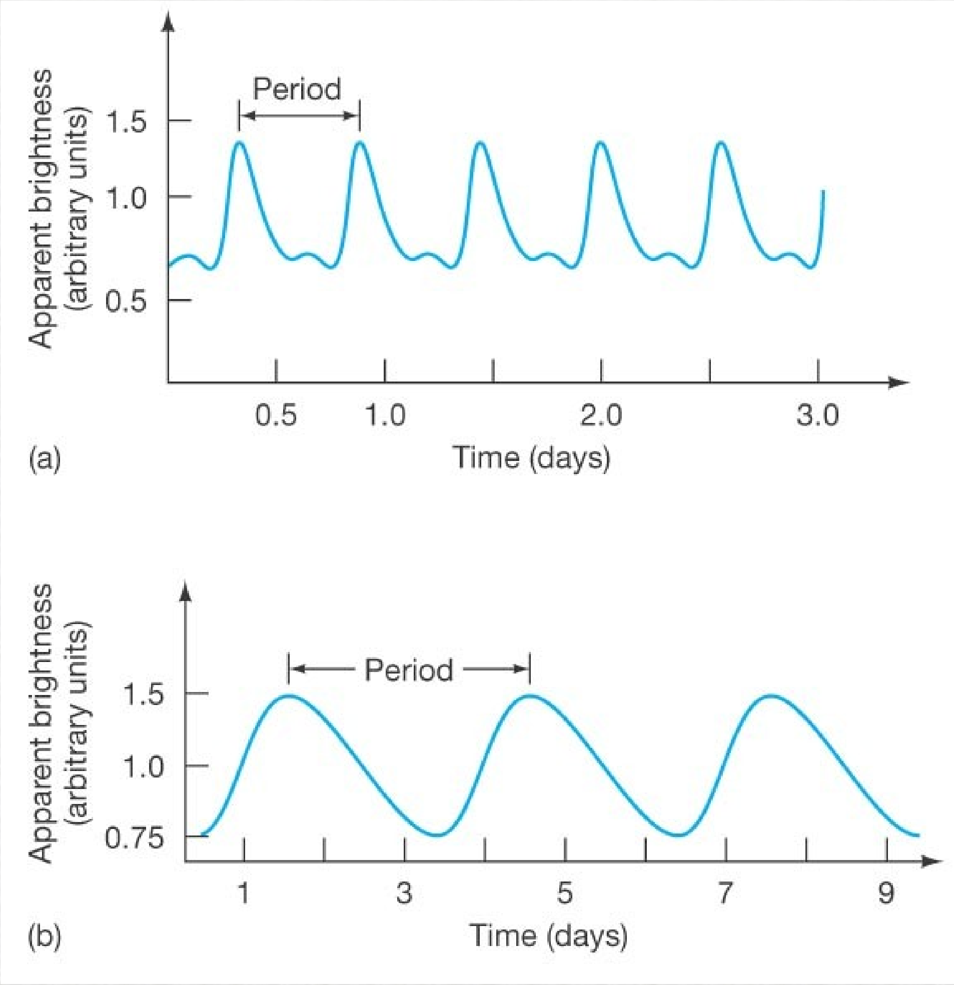


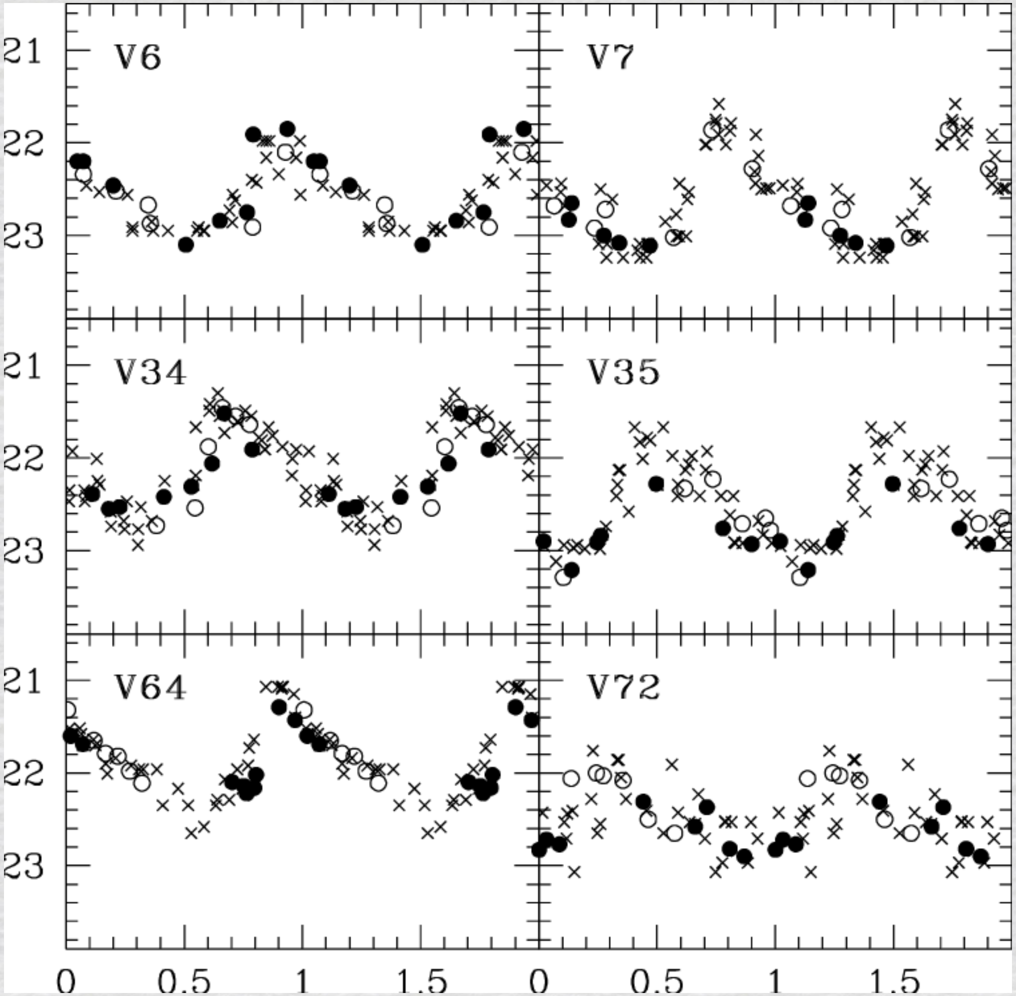
Fig. 16.3. The positions of the different kinds of pulsating stars in the color magnitude diagram are shown. The main groups of pulsating stars fall along a diagonal sequence, the so-called Cepheid instability strip. The long period Mira variables, the irregularly variable RV Tauri stars and, surprisingly, also the β Cephei stars, fall essentially along a constant luminosity strip close to the top of the diagram. The pulsation mechanisms for all these latter stars are not yet understood. (Adapted from Cox 1980).

Cefeidas
(P = días-semanas; TE: F-G; CL: I)



Cefeidas
(P = días-semanas; TE: F-G; CL: I)





Cefeidas

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 them, the faintness of the variables, and the shortness of their periods. As

The facts known with regard to these 25 variables suggest many other questions with regard to distribution, relations to star clusters and nebulae, differences in the forms of the light curves, and the extreme range of the length of the periods. It is hoped that a systematic study of the light changes of all the variables, nearly two thousand in number, in the two Magellanic Clouds may soon be undertaken at this Observatory.

EDWARD C. PICKERING.

MARCH 3, 1912.

http://adsabs.harvard.edu/full/1912HarCi.173....1L

Cefeidas

HARVARD COLLEGE OBSERVATORY.

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http://adsabs.harvard.edu/full/1912HarCi.173....1L

Cefeidas

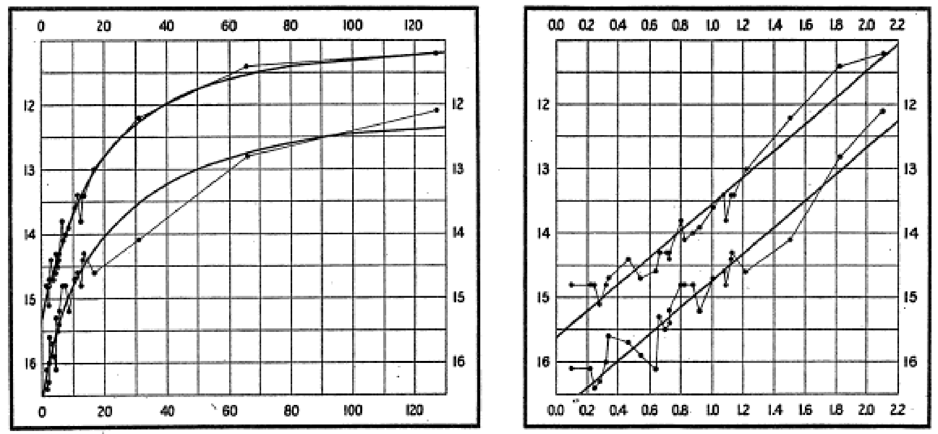


FIG. 1. FIG. 2.

Gráficas originales del artículo de Henrietta S. Leavitt. En las ordenadas la magnitud aparente de las veinticinco cefeidas estudiadas. En la abcisa sus periodos. En la segunda gráfica el periodo es expresado en logaritmo. La curva superior corresponde al máximo de la curva de luz, y la otra al mínimo.

Cefeidas

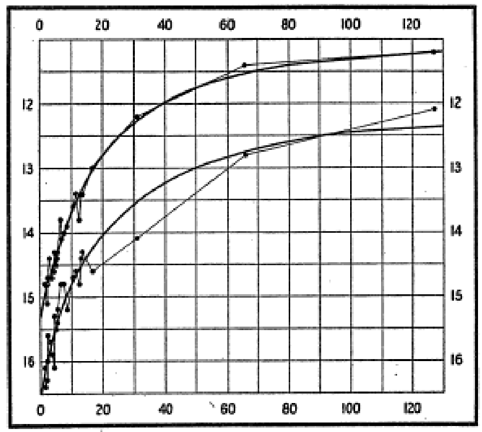


Fig. 1.

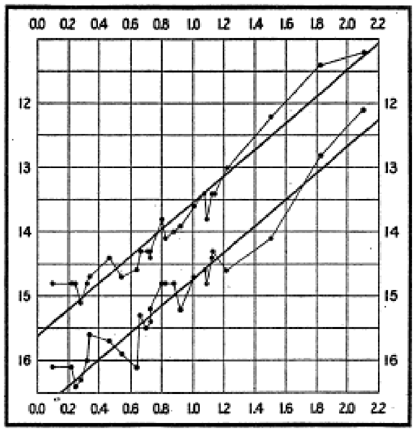
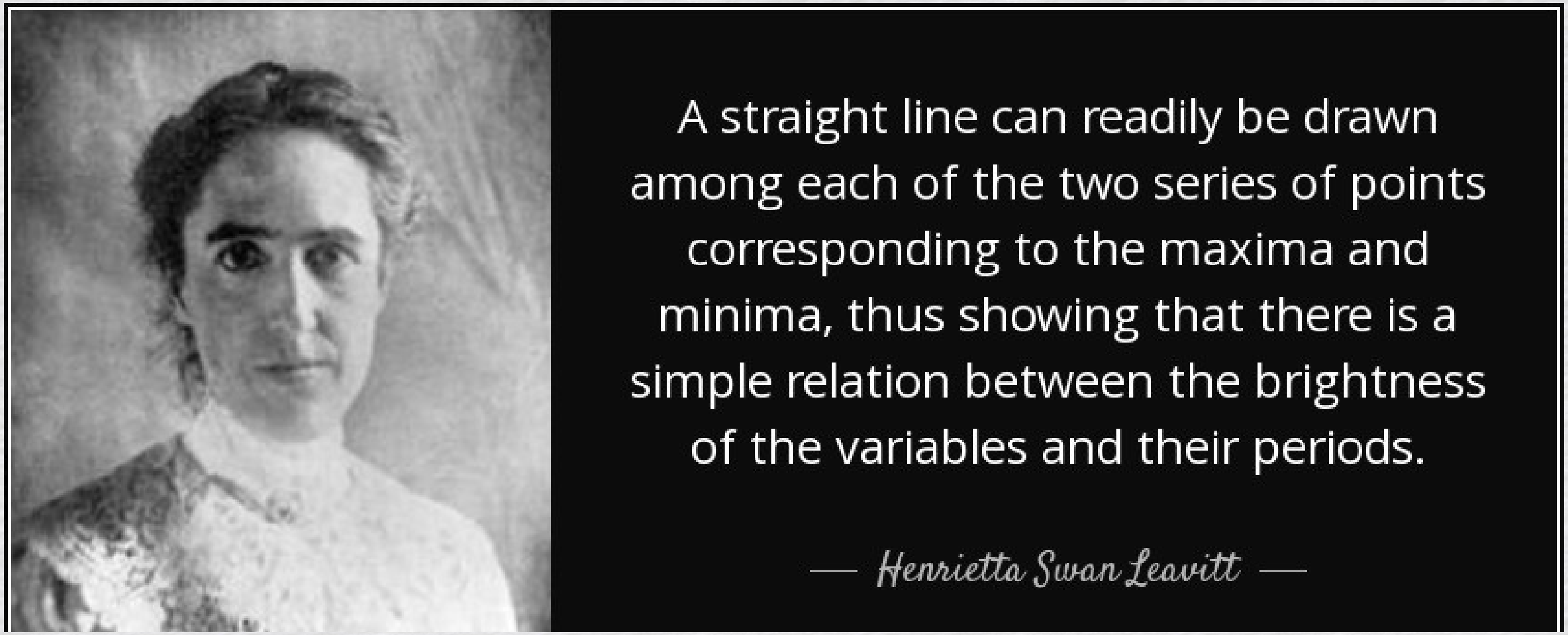
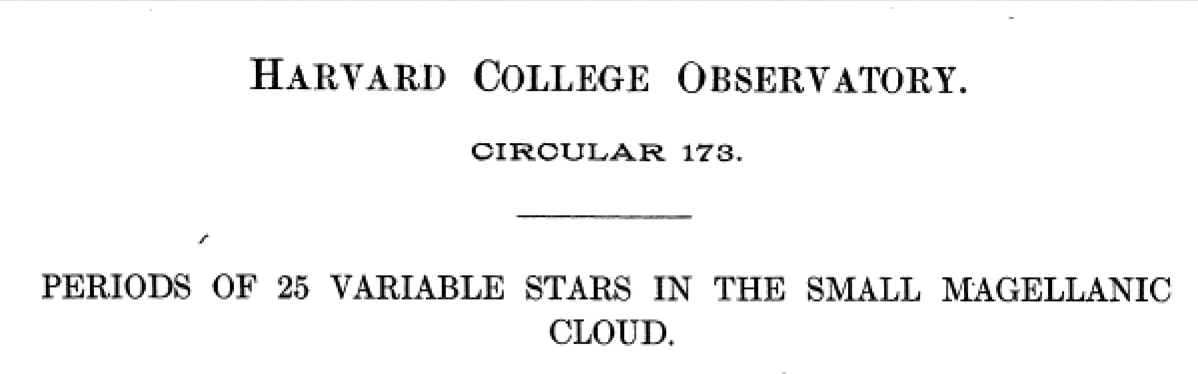


Fig. 2.

Gráficas originales del artículo de Henrietta S. Leavitt. En las ordenadas la magnitud aparente de las veinticinco cefeidas estudiadas. En la abcisa sus periodos. En la segunda gráfica el periodo es expresado en logaritmo. La curva superior corresponde al máximo de la curva de luz, y la otra al mínimo.



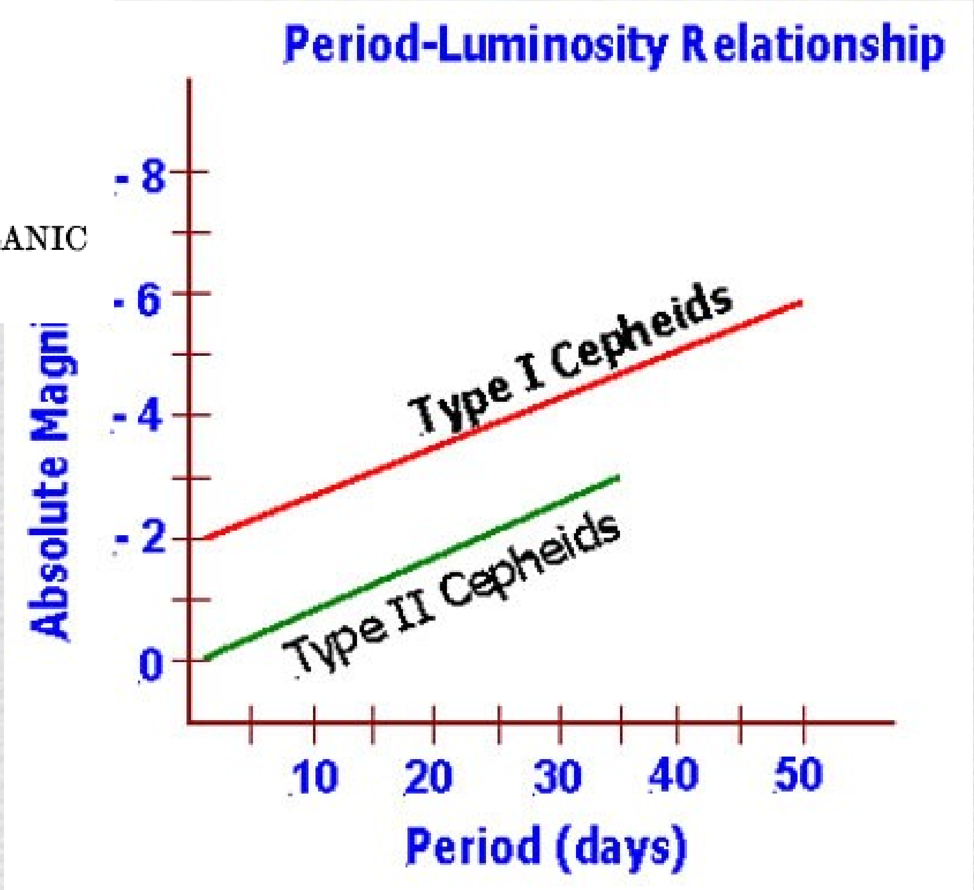
Cefeidas



HARVARD COLLEGE OBSERVATORY.

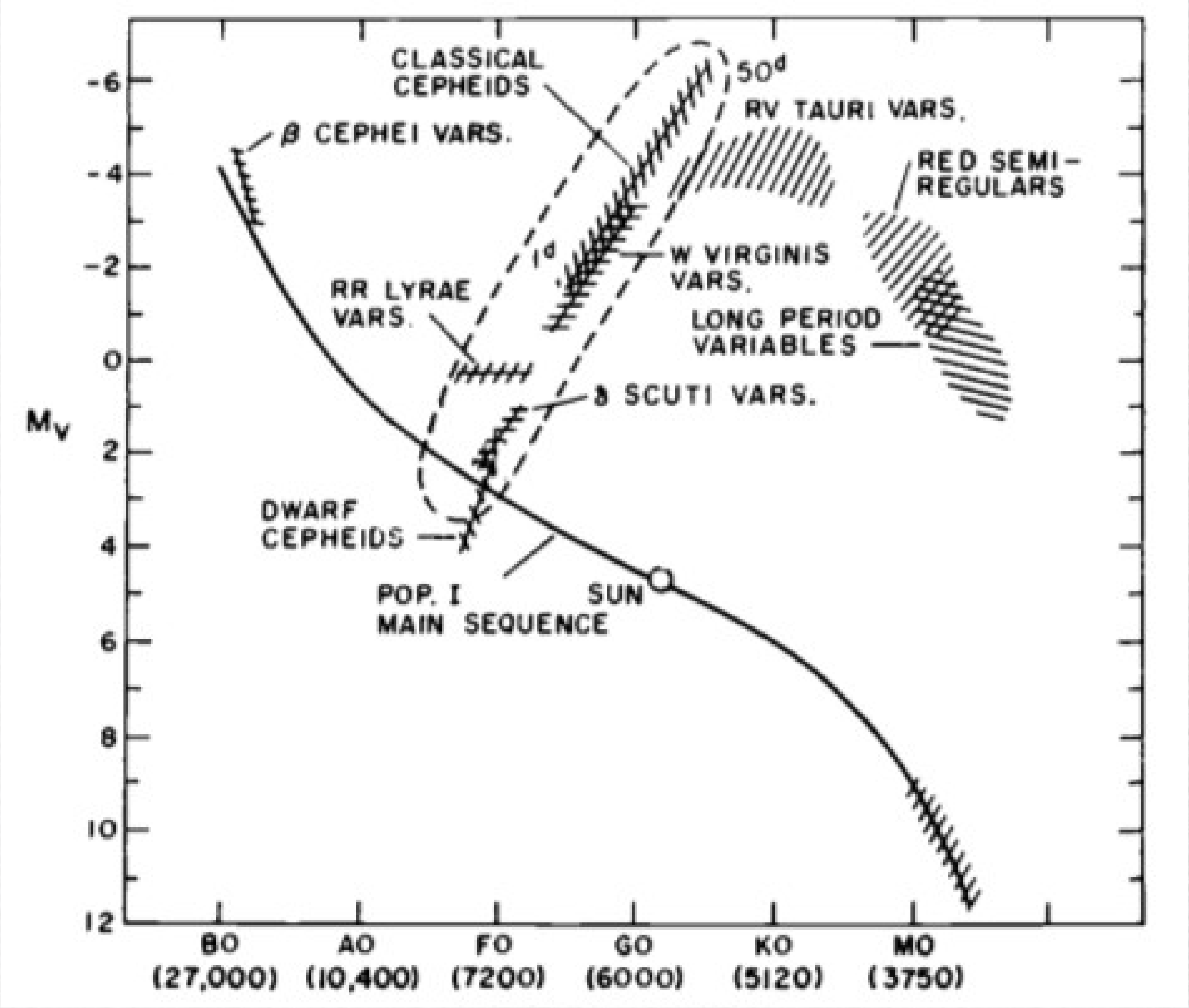
CIRCULAR 173.

PERIODS OF 25 VARIABLE STARS IN THE SMALL MAGELLANIC CLOUD.



A straight line can readily be drawn among each of the two series of points corresponding to the maxima and minima, thus showing that there is a simple relation between the brightness of the variables and their periods.

RR Lyrae



Mv ~ 0.5 → débiles

→ no pueden ser observadas a grandes distancias.

RR Lyrae
(P = 0.5 día; Población II → CG)

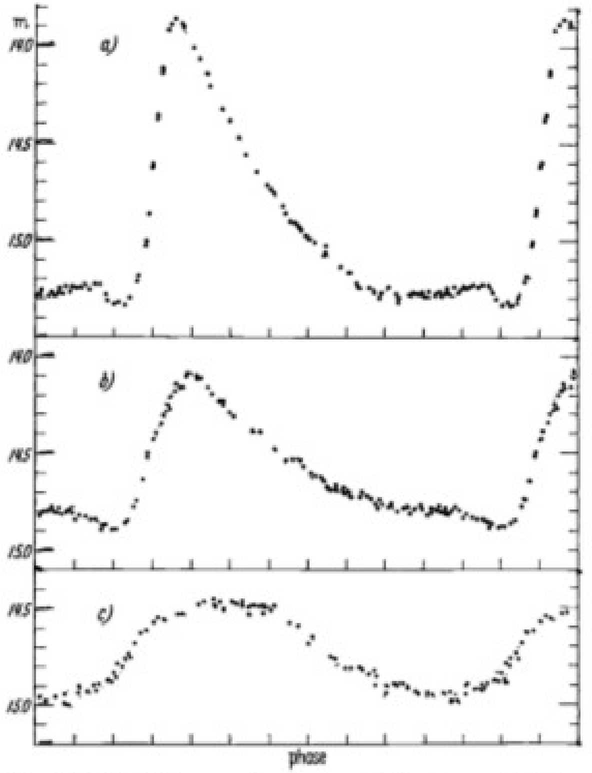
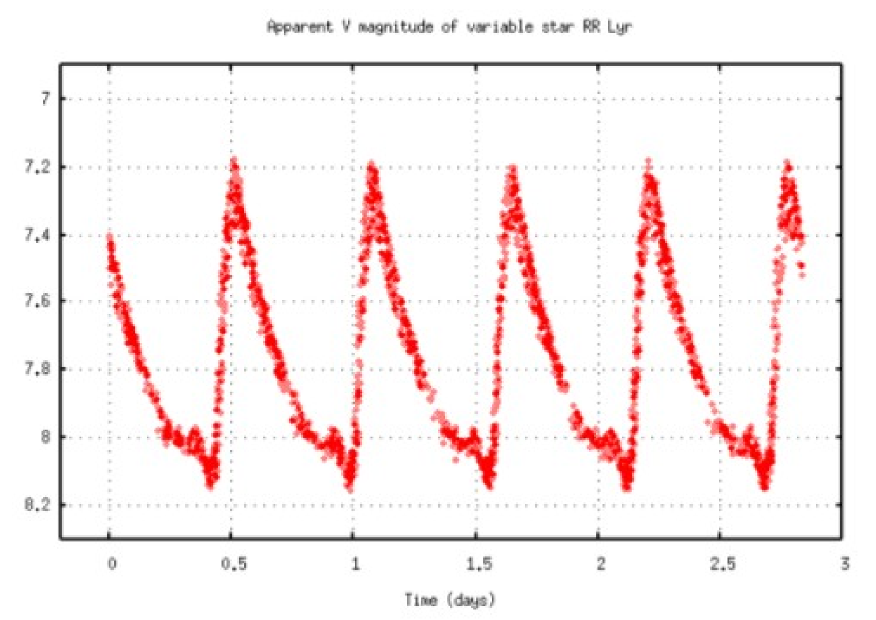


Fig. 16.5. The light curves for the three Bailey types of RR Lyrae stars are shown. Types *a* and *b* only differ in amplitude. The *c* RR Lyraes show a nearly sinusoidal light variation. (From Ledoux & Walraven 1958.)

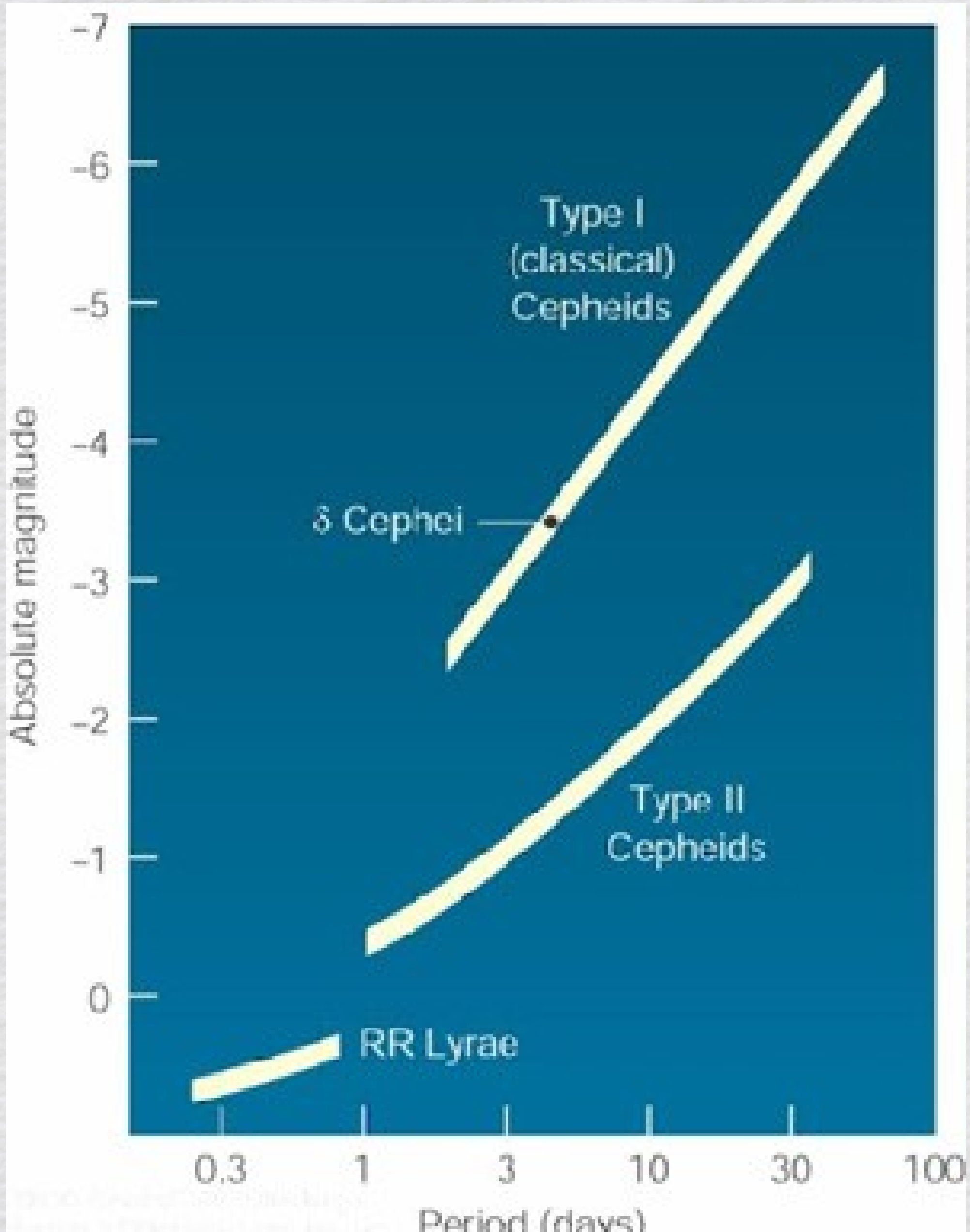


Curvas abruptas

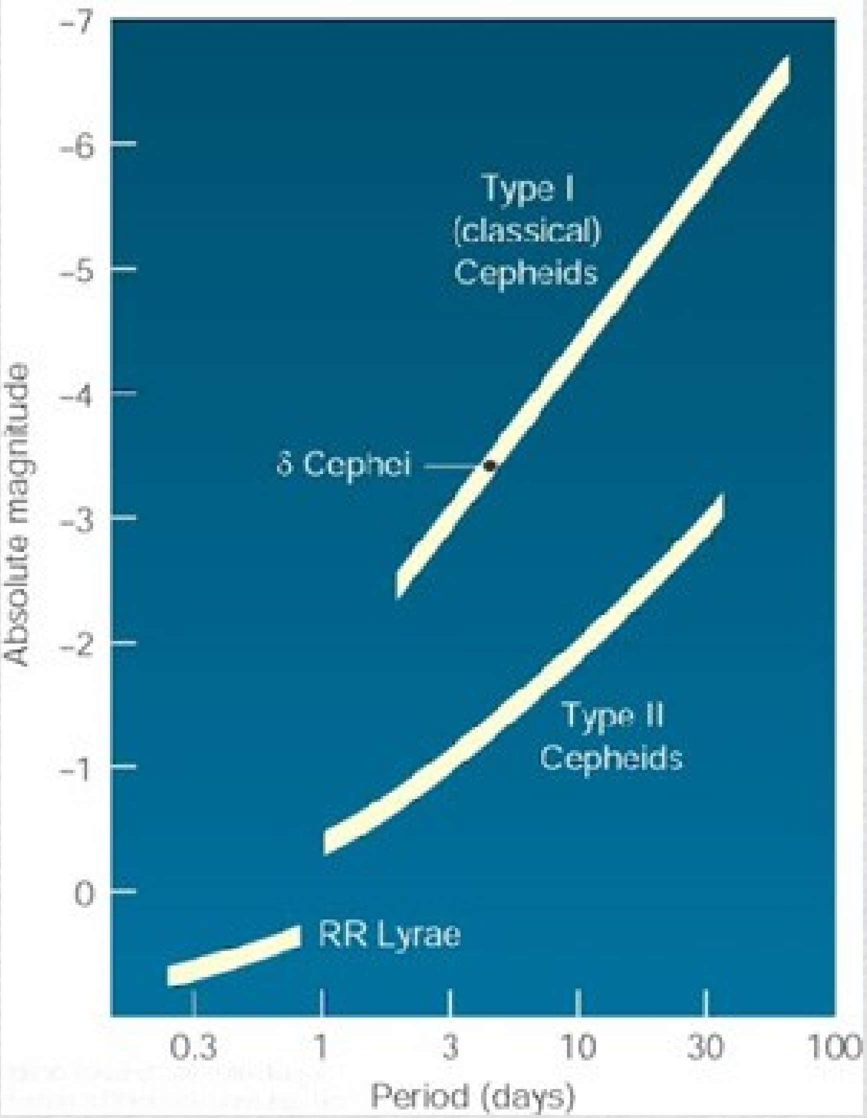
Mv ~ 0.5 → débiles

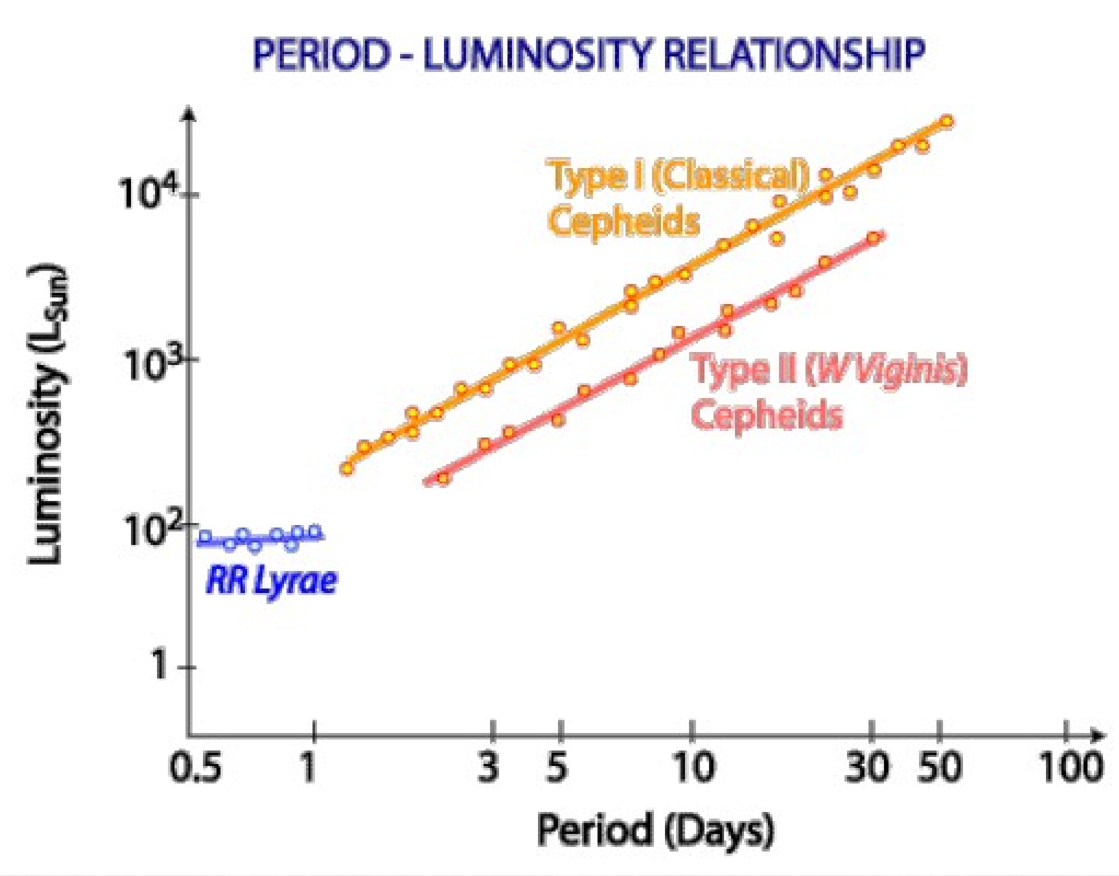
→ no pueden ser observadas a grandes distancias.

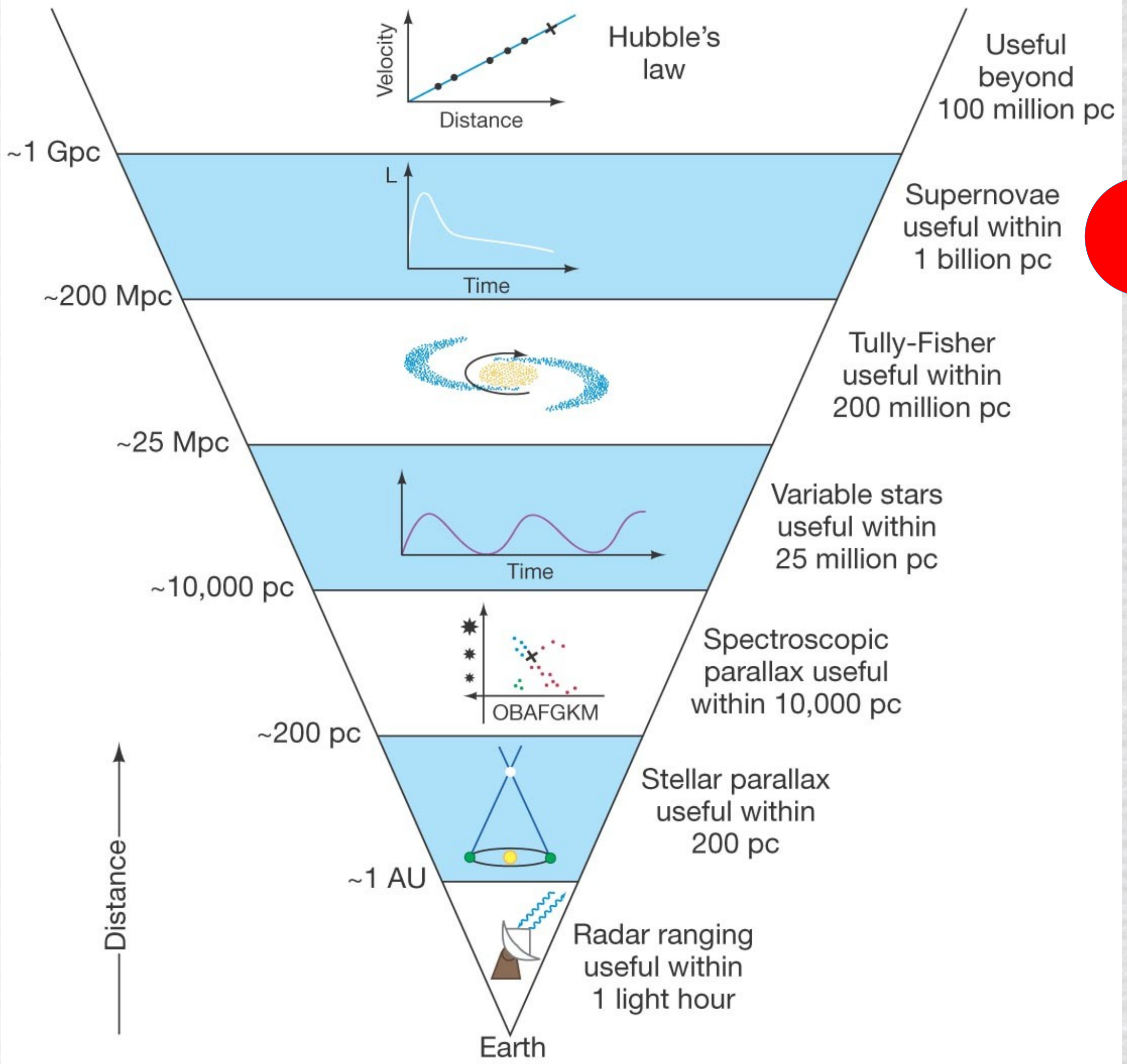
Cepheids y RR Lyrae: P-L



Cepheids y RR Lyrae: P-L

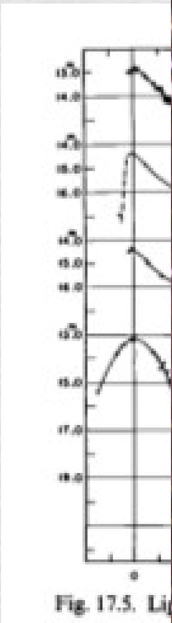


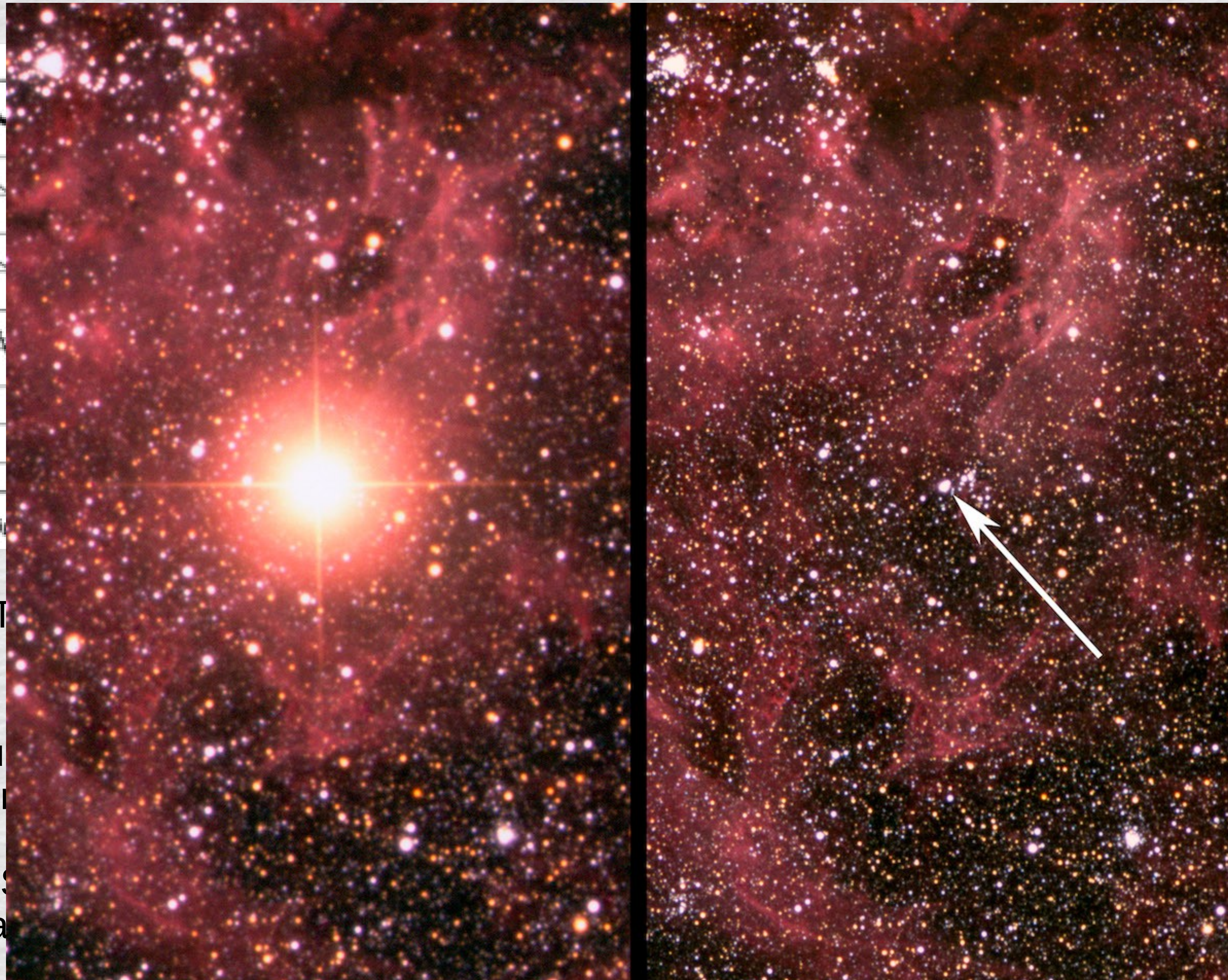


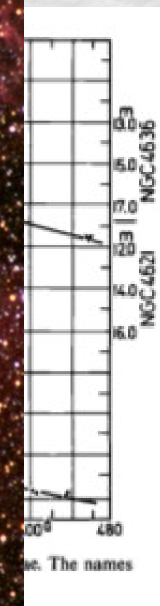


Velocity
Distance
Hubble's law
Useful beyond 100 million pc
~1 Gpc
L
Time
Supernovae useful within 1 billion pc
~200 Mpc
Tully-Fisher useful within 200 million pc
~25 Mpc
Time
Variable stars useful within 25 million pc
~10,000 pc
OBAFGKM
Spectroscopic parallax useful within 10,000 pc
~200 pc
Stellar parallax useful within 200 pc
~1 AU
Radar ranging useful within 1 light hour
Distance
Earth

Supernovas



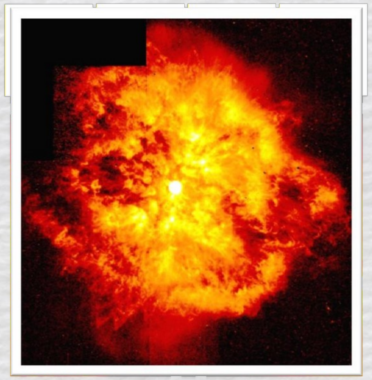




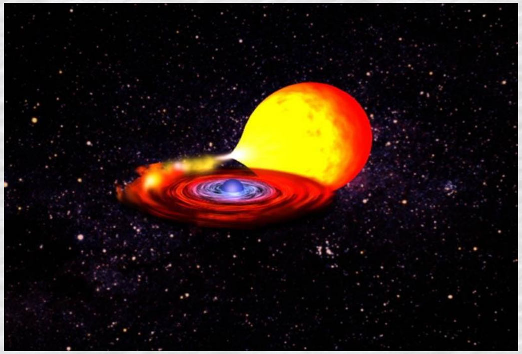
Las SN T … enana blanca
masivas … stelar binario

Es u … pas
exter
Una … de años.
Las S … xias que
las a

Tipos de Supernovas



SN Tipo II (Ib y Ic) involucran estrellas muy masivas al final de sus vidas



SN Tipo Ia involucran una enana blanca que es parte de un sistema estelar binario

SN Ia → determinar distancias

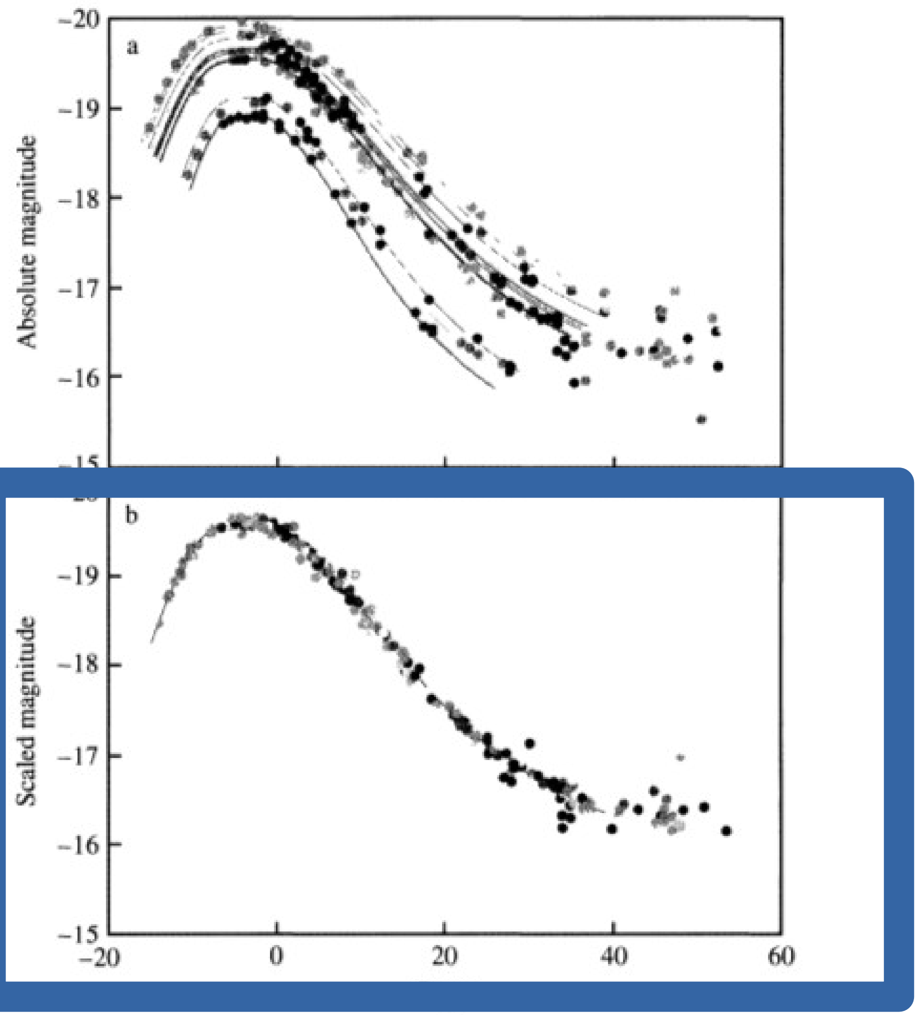
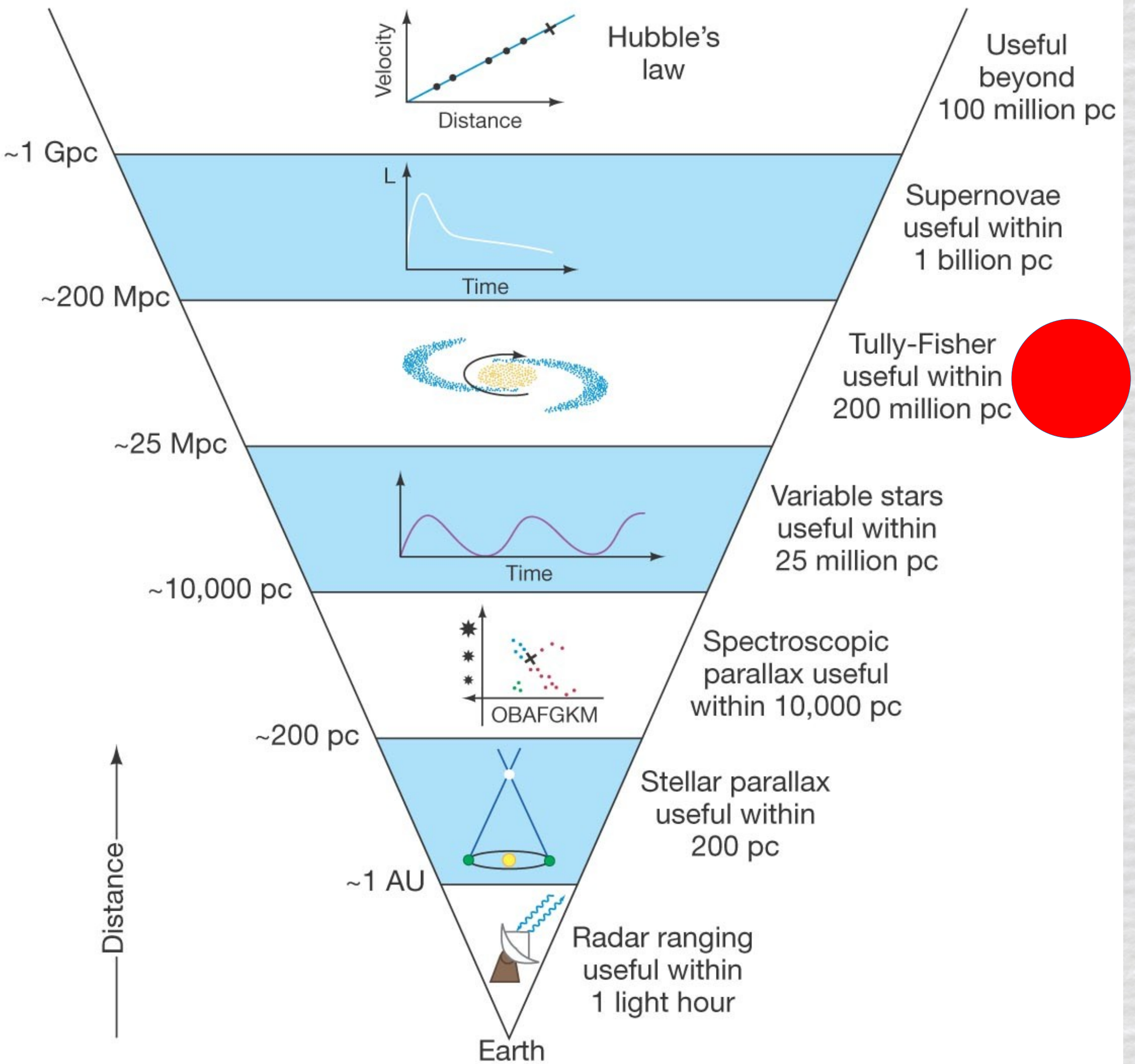


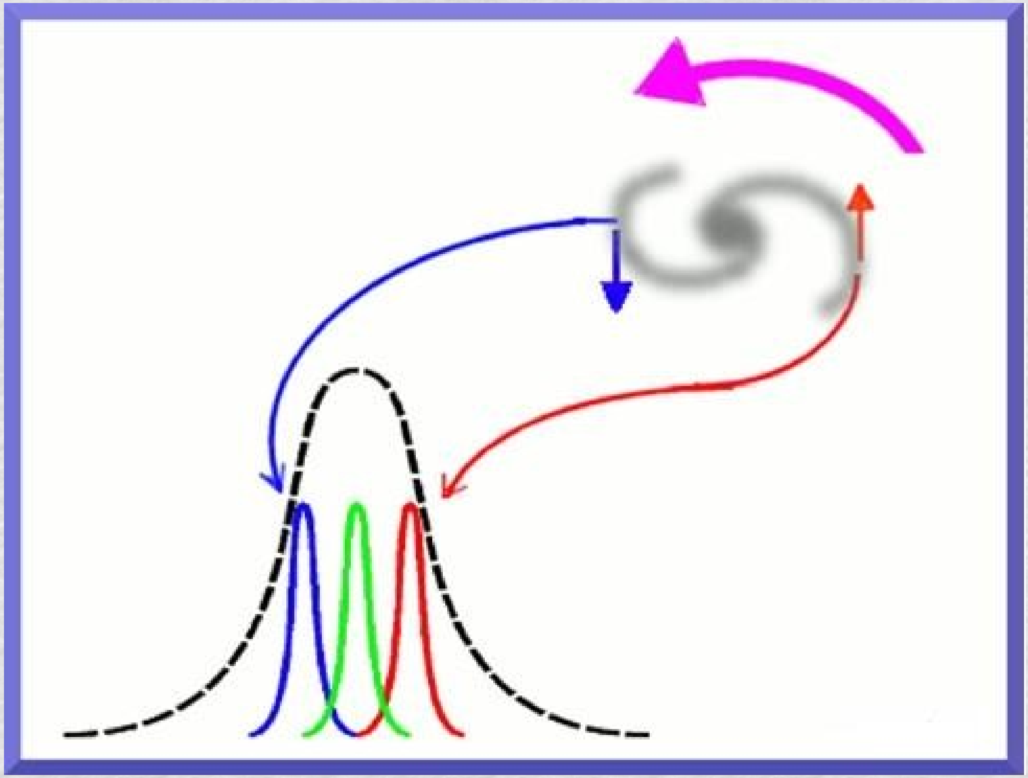
FIGURE 27.1 Low-redshift Type Ia template light curves. (a) The light curves of several Type Ia supernovae, as measured. (b) The light curves after applying the time scale stretch factor. The blue absolute magnitude is displayed on the vertical axis. (Figure adapted from Perlmutter, *Physics Today*, *56*, No. 4, 53, 2003.)



Hubble's law
Velocity
Distance
Useful beyond 100 million pc
~1 Gpc
L
Time
Supernovae useful within 1 billion pc
~200 Mpc
Tully-Fisher useful within 200 million pc
~25 Mpc
Time
Variable stars useful within 25 million pc
~10,000 pc
OBAFGKM
Spectroscopic parallax useful within 10,000 pc
~200 pc
Stellar parallax useful within 200 pc
~1 AU
Radar ranging useful within 1 light hour
Distance
Earth

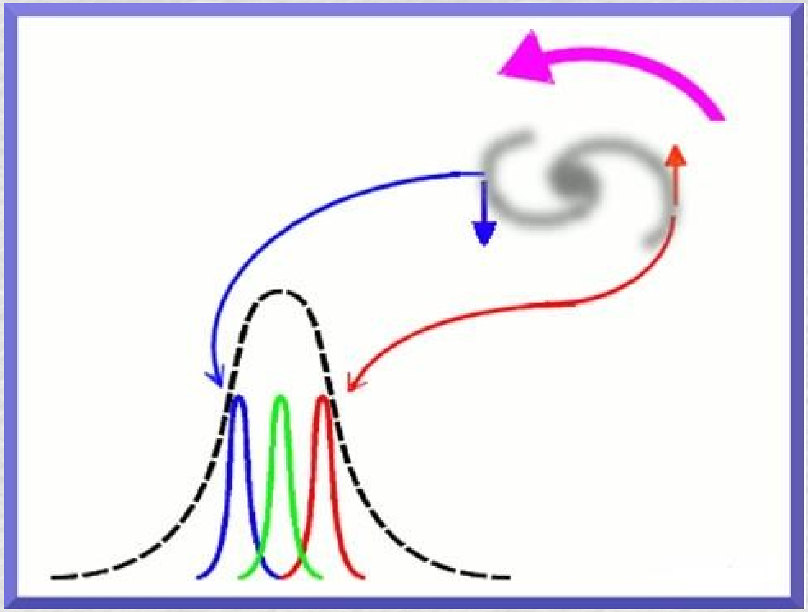
RELACIÓN TULLY – FISHER (Galaxias espirales)

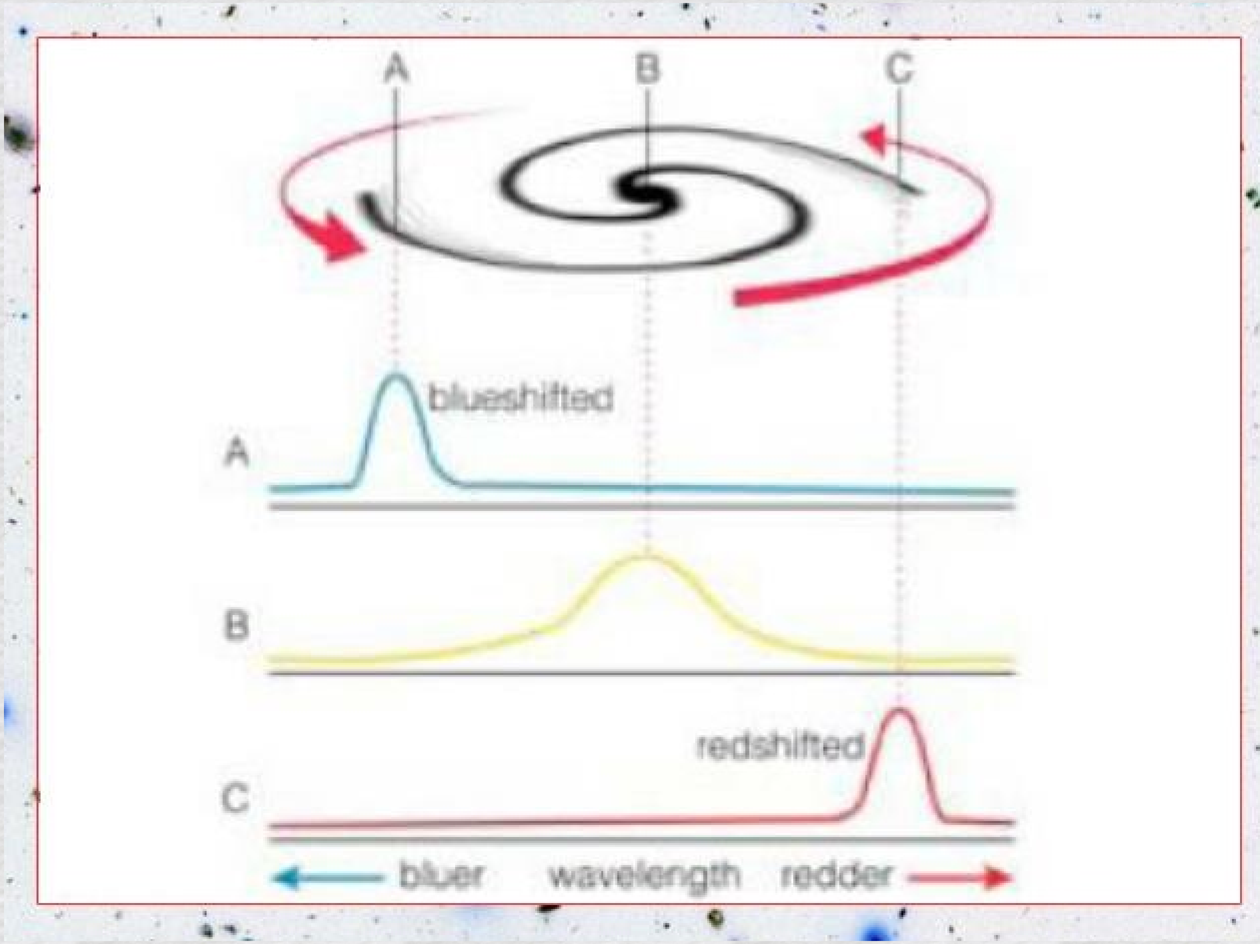
Relación entre la velocidad con la que se mueven esas estrellas y la luminosidad total de la gx.



RELACIÓN TULLY – FISHER (Galaxias espirales)

spiral galaxies rotate, and the rotation speed is proportional to the mass of the galaxy





RELACIÓN TULLY - FISHER

Relación entre la velocidad con la que se mueven esas estrellas y la luminosidad total de la gx.

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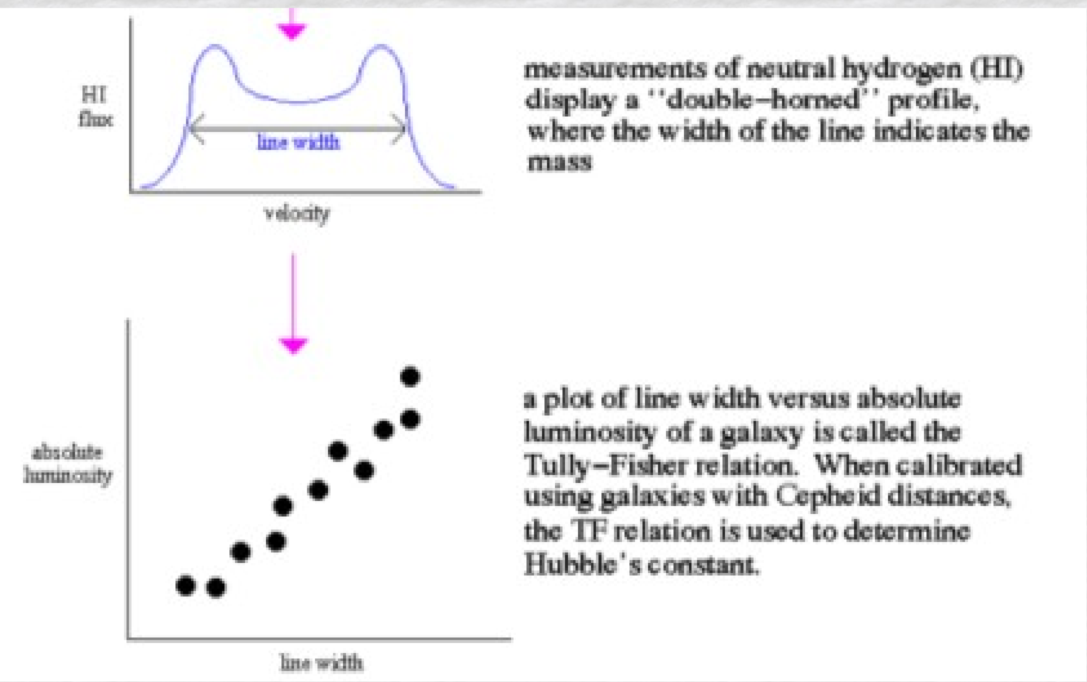
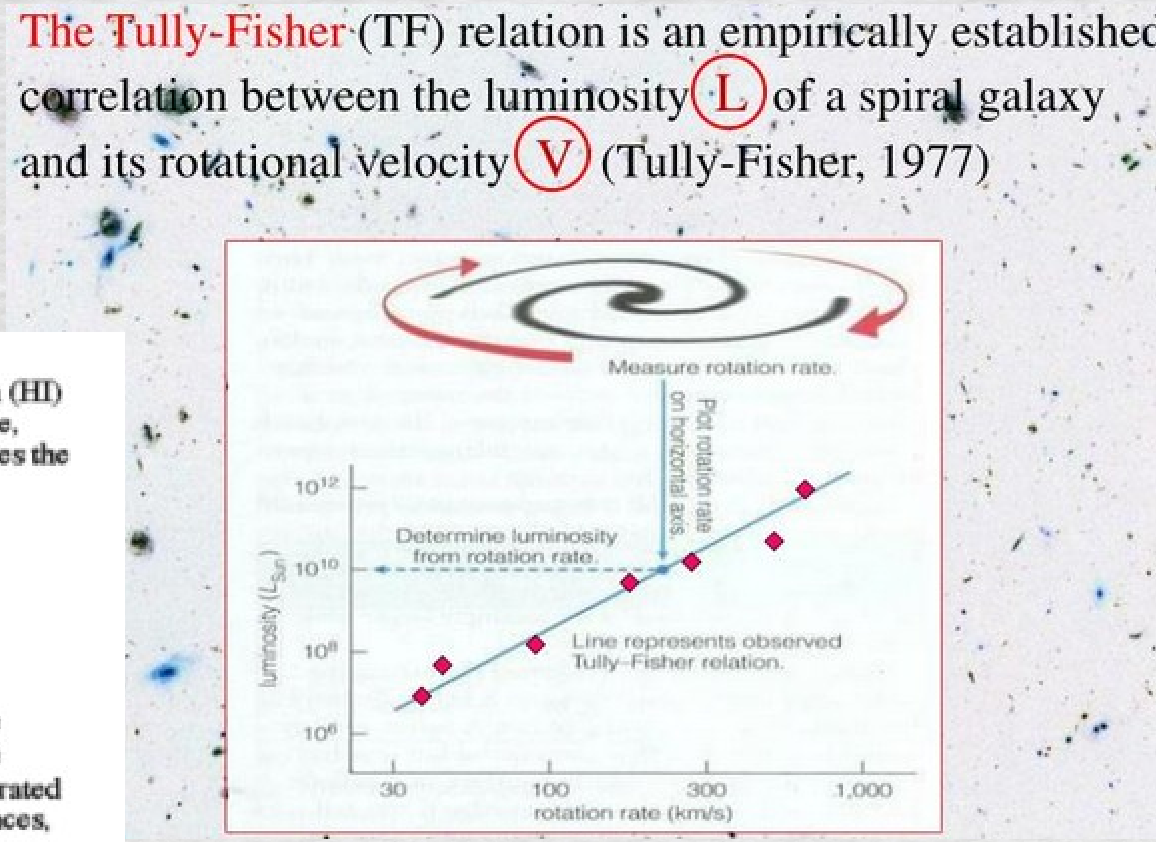
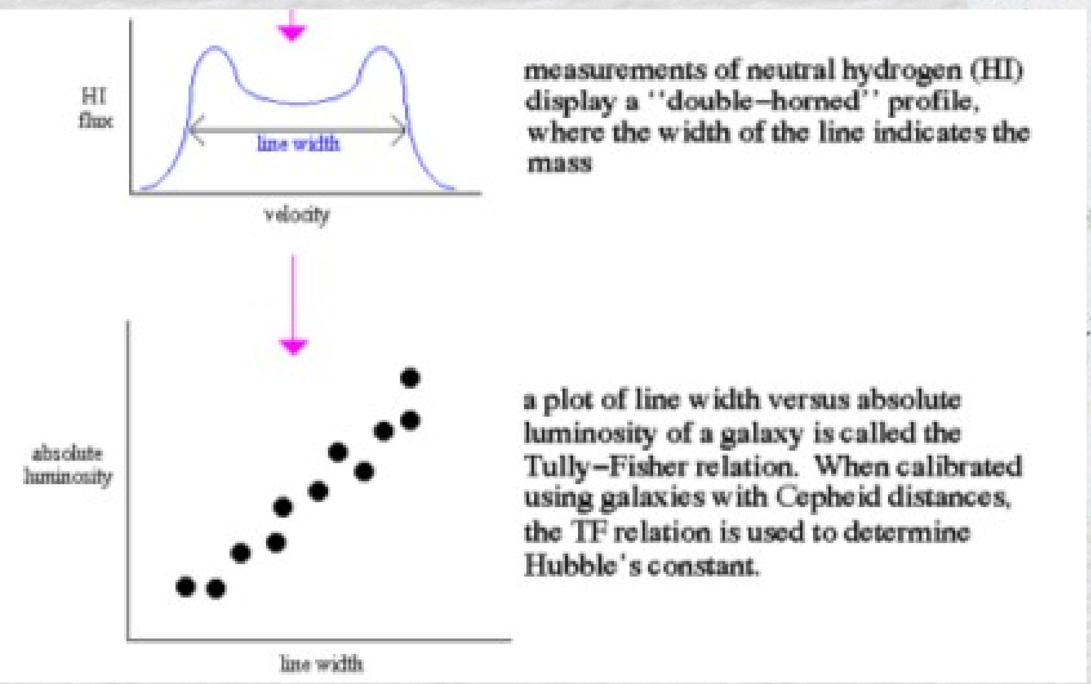


RELACIÓN TULLY - FISHER

Relación entre la velocidad con la que se mueven esas estrellas y la luminosidad total de la gx.

spiral galaxies rotate, and the rotation speed is proportional to the mass of the galaxy





RELACIÓN TULLY - FISHER

Relación entre la velocidad con la que se mueven esas estrellas y la

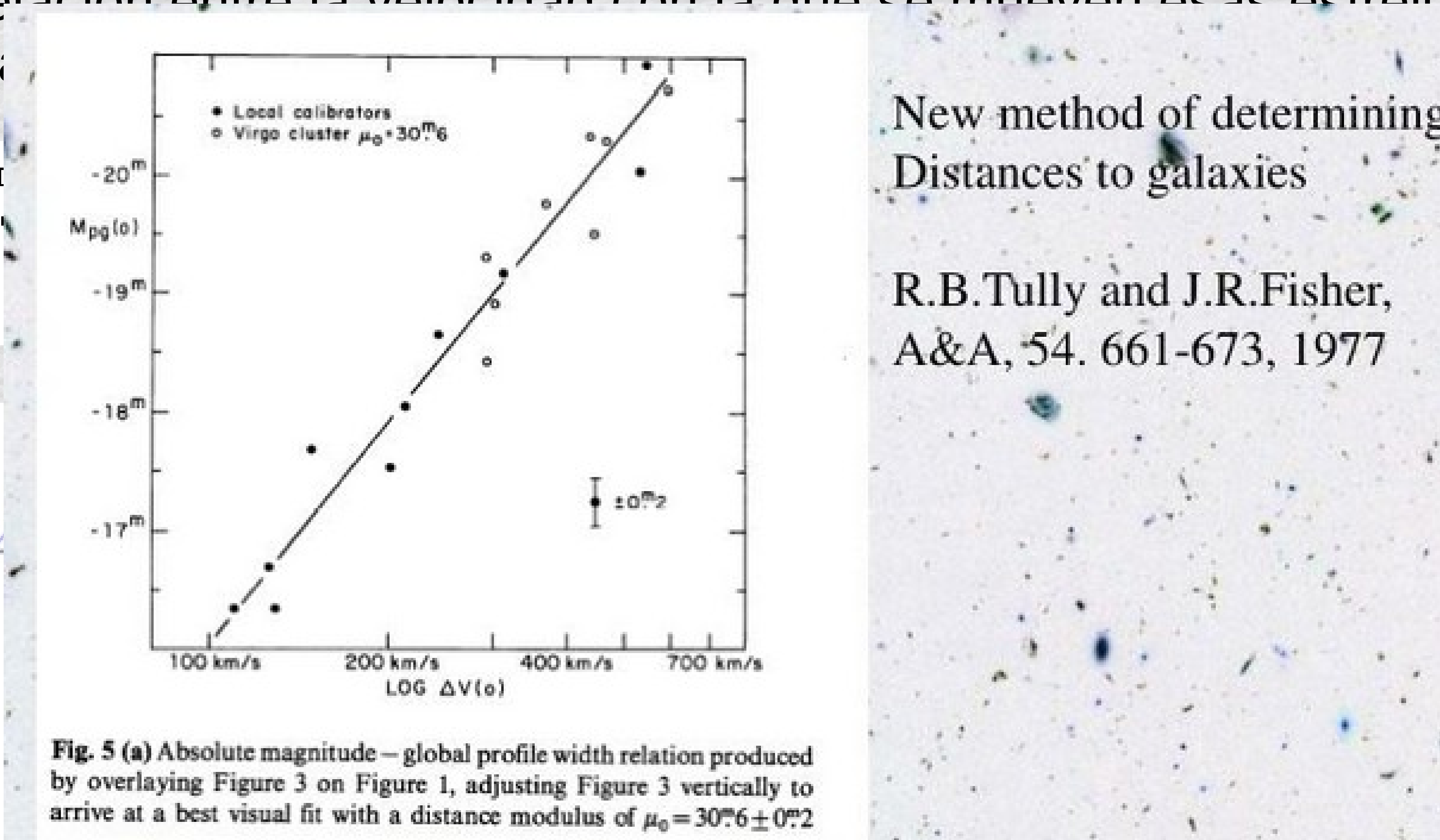
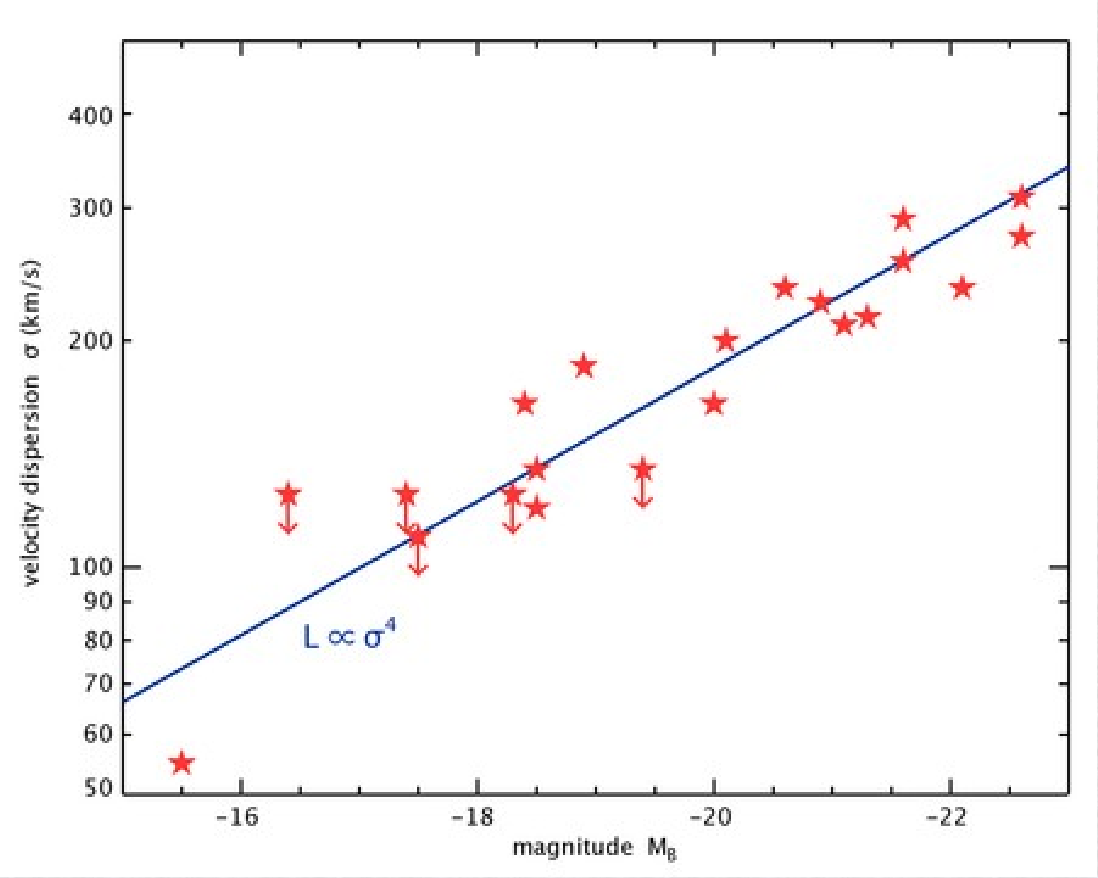
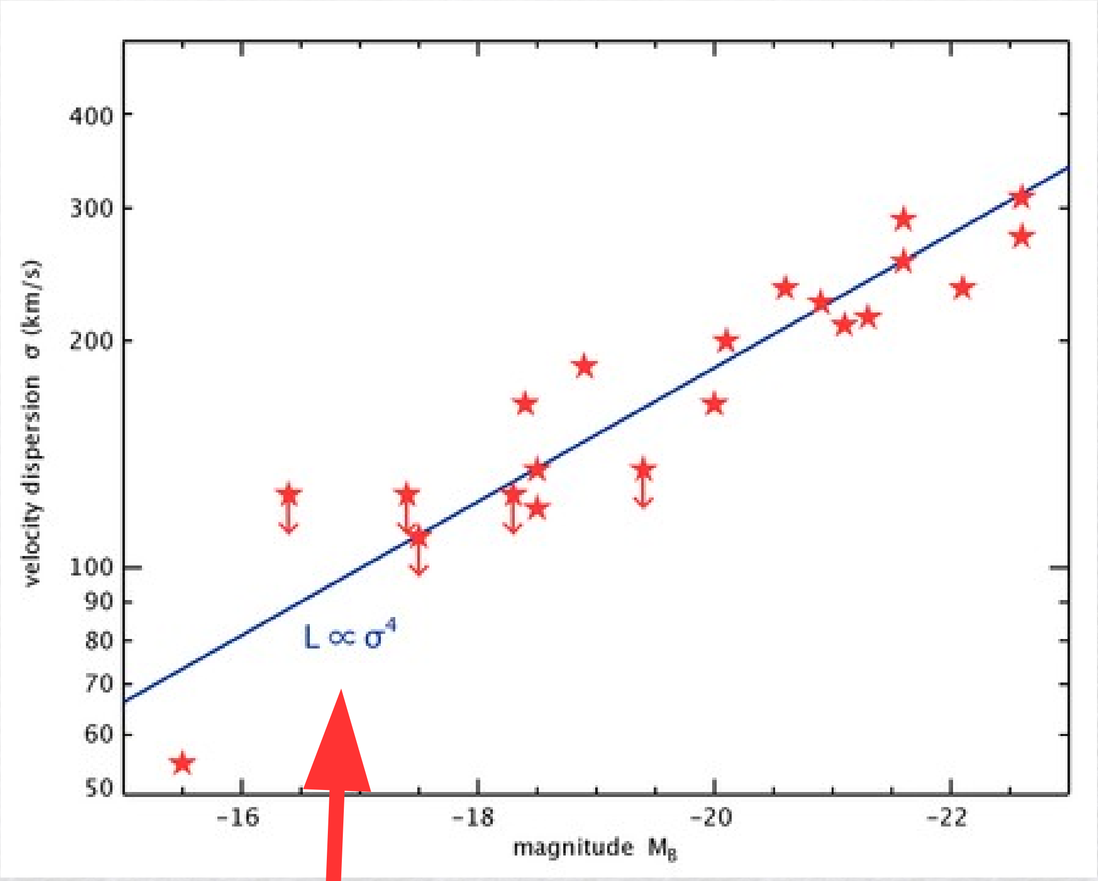


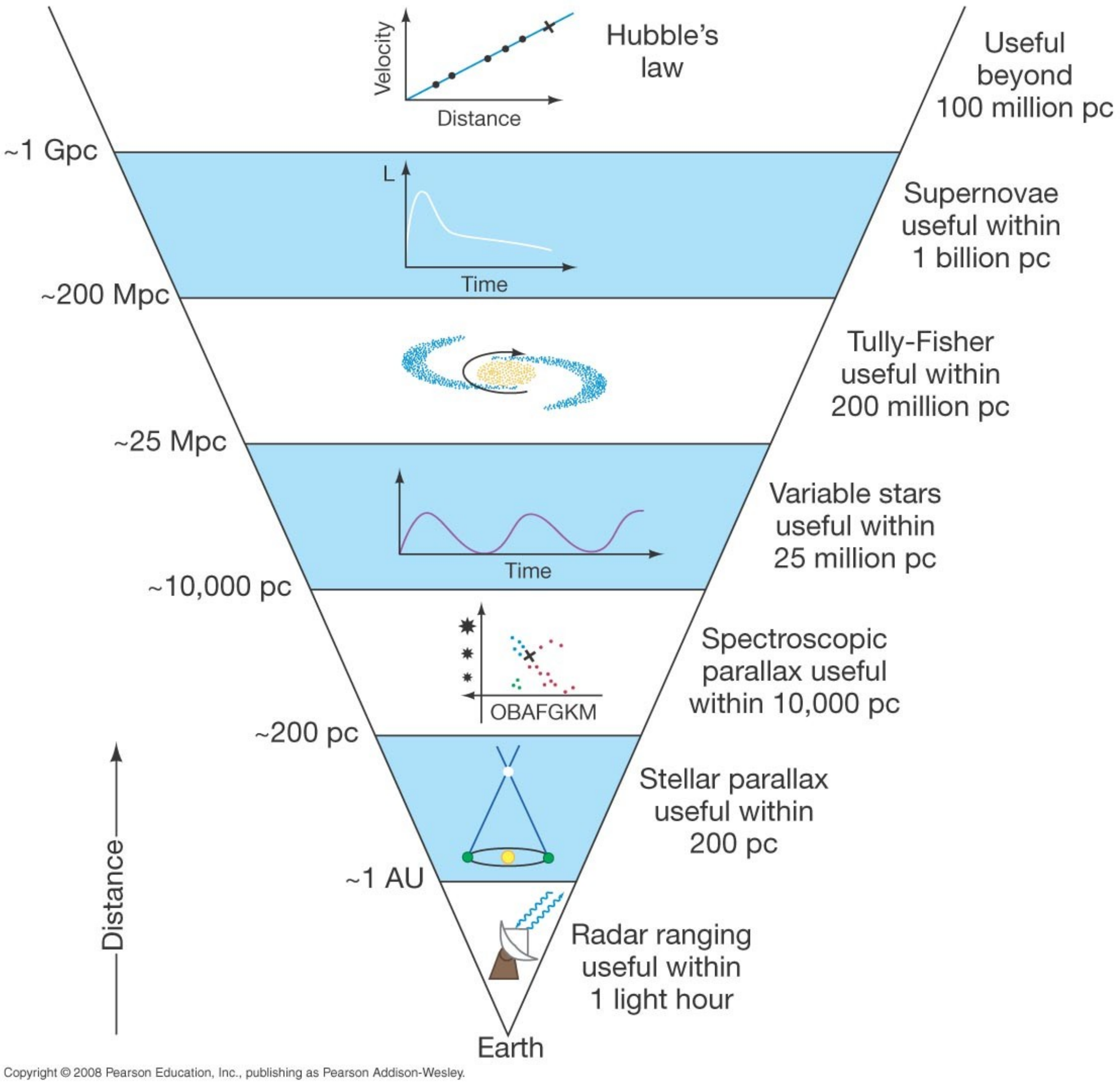
Fig. 5 (a) Absolute magnitude – global profile width relation produced by overlaying Figure 3 on Figure 1, adjusting Figure 3 vertically to arrive at a best visual fit with a distance modulus of $\mu_0 = 30^m.6 \pm 0^m.2$

RELACIÓN FABER – JACKSON (Galaxias elípticas)



RELACIÓN FABER – JACKSON
(Galaxias elípticas)





Velocity
Distance
Hubble's law
Useful beyond 100 million pc
~1 Gpc
L
Time
Supernovae useful within 1 billion pc
~200 Mpc
Tully-Fisher useful within 200 million pc
~25 Mpc
Time
Variable stars useful within 25 million pc
~10,000 pc
OBAFGKM
Spectroscopic parallax useful within 10,000 pc
~200 pc
Stellar parallax useful within 200 pc
~1 AU
Radar ranging useful within 1 light hour
Distance
Earth

Ley de Hubble

$$\boxed{v = H_0 d,} \tag{27.6}$$

is today called **Hubble's law**, and H_0 is the **Hubble constant**. Usually v is given in km s^{-1} and d in Mpc, so H_0 has units of km s^{-1} Mpc^{-1}.

Ley de Hubble-Lemaitrê

$$\boxed{v = H_0 d,} \qquad (27.6)$$

is today called **Hubble's law**, and H_0 is the **Hubble constant**. Usually v is given in km s^{-1} and d in Mpc, so H_0 has units of km s^{-1} Mpc^{-1}.

Ley de Hubble (Humason)-Lemaitrê

$$\boxed{v = H_0 d,} \tag{27.6}$$

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Ley de Hubble

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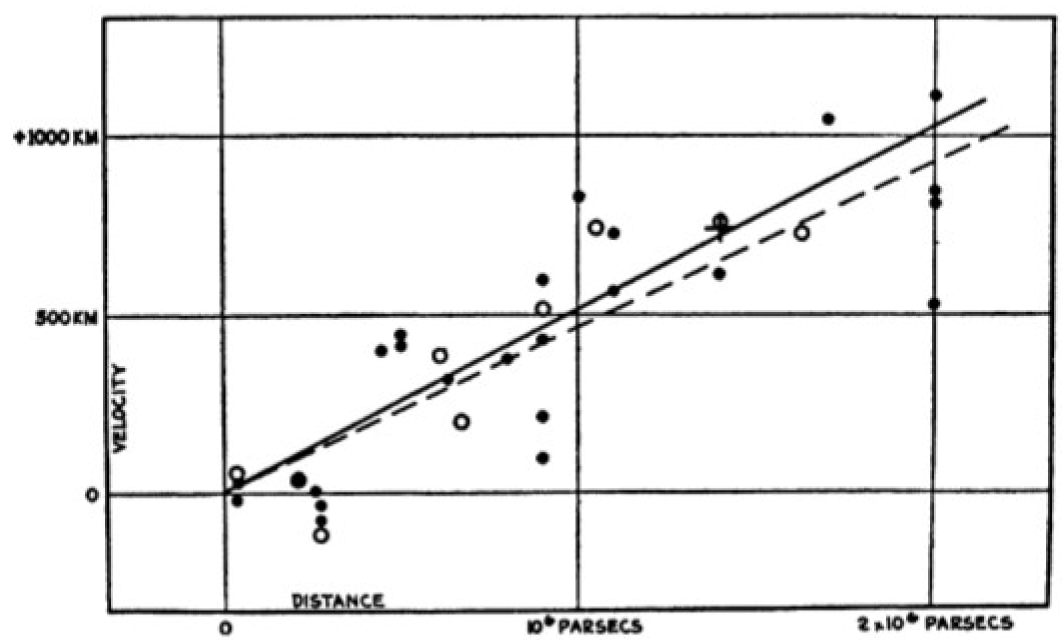


FIGURE 27.7 Hubble's 1936 velocity–distance relation. The two lines use different corrections for the Sun's motion. (Note: The vertical units should be km s^{-1}.) (Figure from Hubble, *Realm of the Nebulae*, Yale University Press, New Haven, CT, ©1936.)

A SPIRAL NEBULA AS A STELLAR SYSTEM, MESSIER 31[1]

By EDWIN HUBBLE

ABSTRACT

Material.—The present discussion of M 31 is *based on the study of about 350 photographs* taken with the 60- and 100-inch reflectors, distributed over an interval of about eighteen years. Two-thirds of the total number were obtained by the writer during the five years 1923–1928. Since the image of the nebula is much larger than the usable fields of the telescopes, *attention was concentrated on four regions centered* on (1) the nucleus, (2) 23′ north following, (3) 17′ south, (4) 48′ south preceding the nucleus. The combined *area*, with allowance for overlapping, *represents about 40 per cent of the entire nebula.*

Resolution.—The *outer regions* of the spiral arms are *partially resolved into swarms of faint stars*, while the *nuclear* region *shows no* indications of *resolution under any conditions* with the 100-inch reflector. Intermediate regions show isolated patches where resolution is pronounced or suggested.

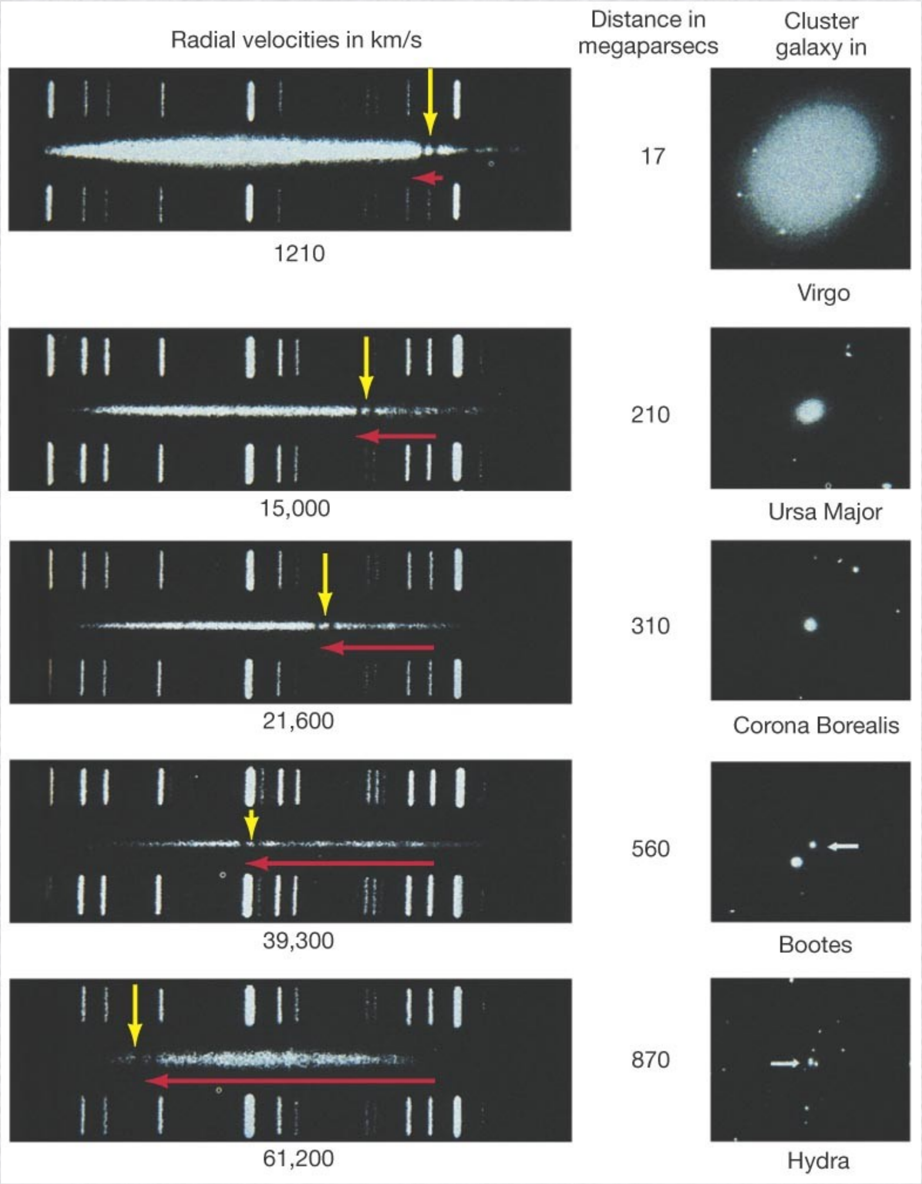
Variables.—*Fifty variables* have been found, nearly all in the outer regions where resolution is pronounced. The *survey* is believed to be *fairly exhaustive in the four selected regions down to 19.0 photographic magnitude.*

Cepheids.—*Forty* of the *variables* are *known to be Cepheids* with periods from *48 days to 10 days* and *maxima from 18.1 to 19.3 photographic magnitude;* one exceptional star varies from 17.9 to 19.2 in a period of 175 days. The *period-luminosity relation is conspicuous*, and the slope is *approximately that* found among *Cepheids in other extra-galactic systems.*

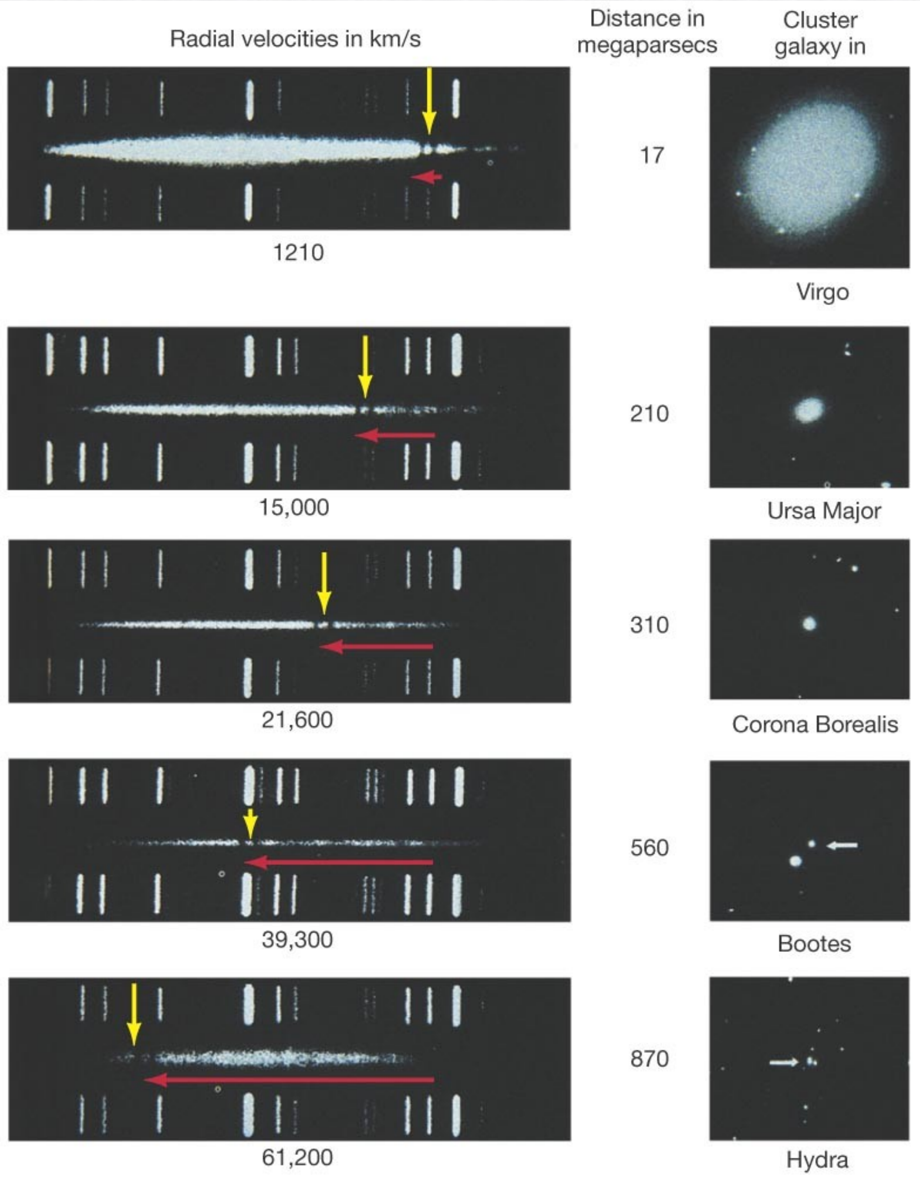
Distance of M 31 derived from Cepheid criteria.—Comparisons of period-luminosity diagrams indicate that M 31 is about 0.1 mag. or 5 per cent more distant than M 33, and about 8.5 times more distant than the Small Magellanic Cloud. Using Shapley's value for the Cloud, we find the *distance of M 31* to be *275,000 parsecs.*

Variables other than Cepheids.—Of the 10 remaining variables, 4 are probably very

Ley de Hubble



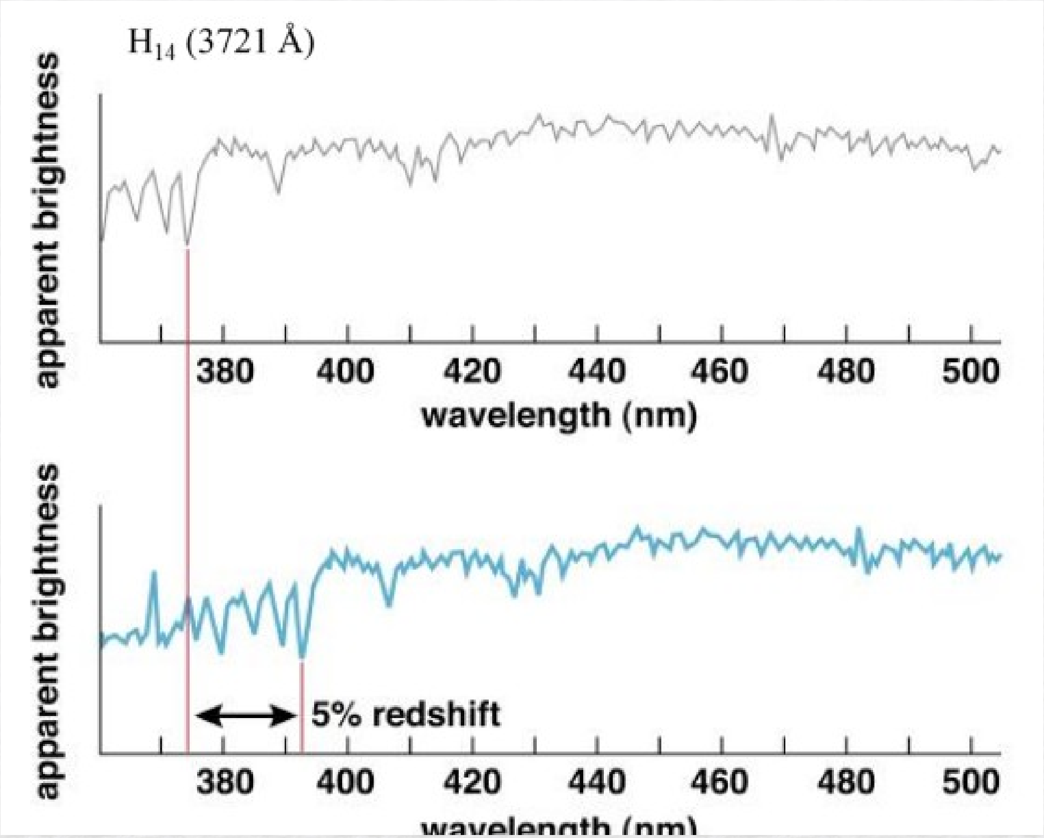
Ley de Hubble



Efecto Doppler

$V_r/c = \Delta\lambda/\lambda$

$$\boxed{v = H_0 d,}$$



$V_r/c = \Delta\lambda/\lambda$

$$\boxed{v = H_0 d,}$$