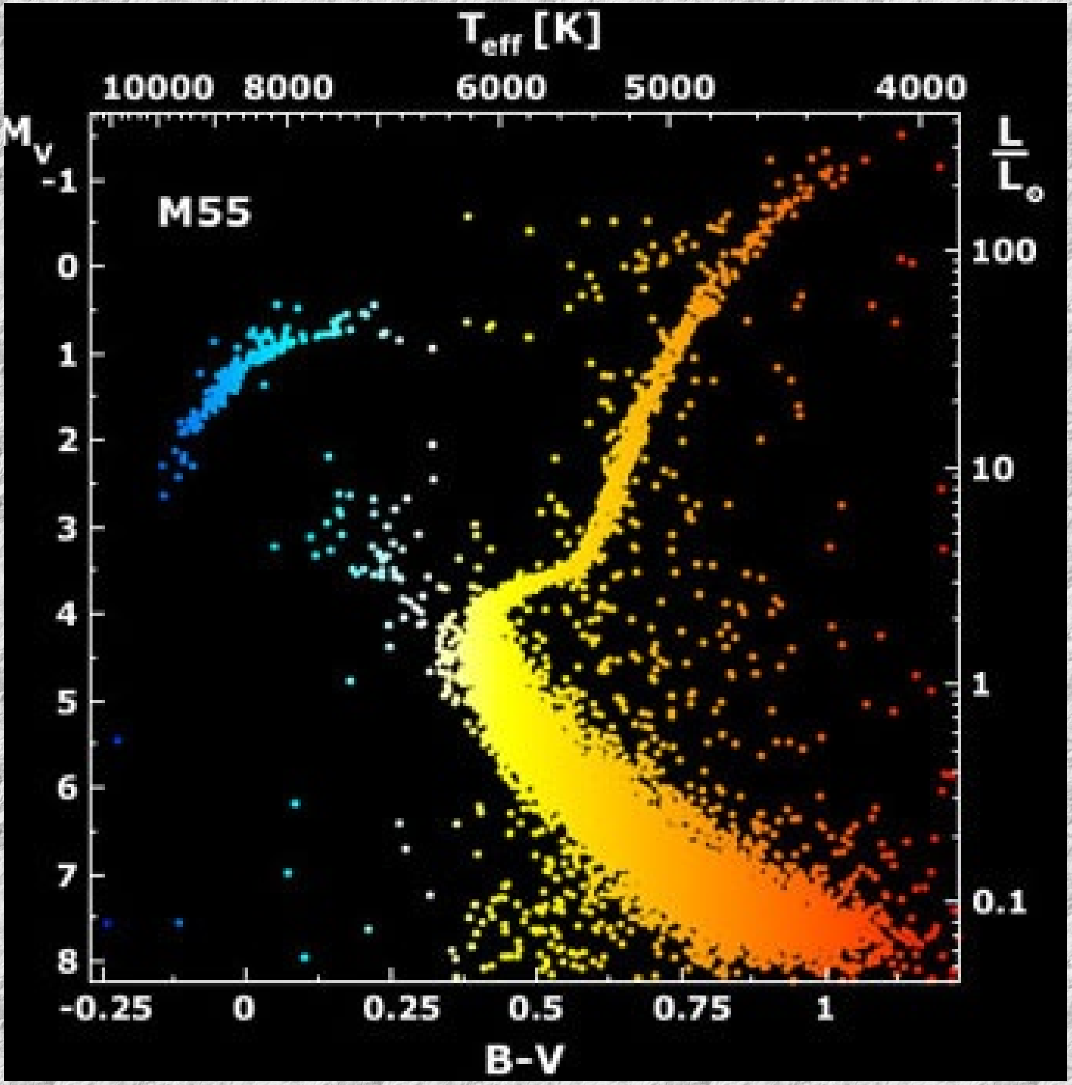
Diagrama de Herzsprung-Russell



Ejnar Hertzsprung (1873-1967)

Hertzsprung was born in Frederiksberg, near Copenhagen, on October 8, 1873. His father, Severin Hertzsprung, had a master's degree in astronomy from the University of Copenhagen, but for financial reasons he had given up astronomy to accept a position in the Department of Finances in the Danish government and at a very early age became director of the State Life Insurance Company. His interest in astronomy and mathematics inspired his son's interest in the same fields. Hertzsprung has told how, as a small boy, he would lie on the floor and observe a star chart which his father had mounted in one of the living-room windows. Each star was marked by a pinhole with its size depending upon the star's magnitude. However, for the same financial reasons, his father did not want his son to pursue these fields, and Ejnar Hertzsprung decided to study chemical engineering instead. He had become interested in chemistry from the study of a small book on this subject by the famous Danish chemist, Julius Thomsen. Hertzsprung received his degree from the Polytechnical Institute in Copenhagen in 1898, spent the next several years as a chemist in St. Petersburg (now Leningrad), and then went to Leipzig in 1901 to study photochemistry under Professor Ostwald. Upon his return to Denmark the same year, he began the study of astronomy in earnest and spent the next several years making photographic observations of various kinds with the telescopes of the University and Urania Observatories in Copenhagen. During this period he began to correspond with the famous German astronomer Karl Schwarzschild who invited Hertzsprung to visit him in Göttingen in 1909.

Schwarzschild, realizing Hertzsprung's unusual talents in astronomy ("Hertzsprung thinks all the time, I—only occasionally"), had him appointed professor at the University within a few months. When Schwarzschild, the same year, was offered the directorship of

Zur Stralung Der Strerne

Show affiliations

Hertzsprung, Ejnar

No abstract

Publication: Zeitschrift Fur Wissenschaftliche Photographie, Vol 3, p. 442-449

Pub Date: July 1905

AMERICAN ACADEMY
MAY 23 1911
ARTS AND SCIENCES

PUBLIKATIONEN

DES

ASTROPHYSIKALISCHEN OBSERVATORIUMS

ZU POTSDAM.

HERAUSGEGEBEN VOM DIREKTOR

K. SCHWARZSCHILD.

Nr. 63.

ZWEIUNDZWANZIGSTEN BANDES ERSTES STÜCK.

POTSDAM, 1911.

IN KOMMISSION BEI WILHELM ENGELMANN IN LEIPZIG.

Henry N. Russell
1877-1957

RELATIONS BETWEEN THE SPECTRA AND OTHER CHARACTERISTICS OF THE STARS.*

II.

Brightness and Spectral Class.

dots, representing the results derived from the poor parallaxes, should scarcely be used as a basis for any argument. The solid black dots represent stars the parallaxes of which depend on the mean of two or more determinations; the open circles, those observed but once. In the latter case, only the results of those observers whose work appears to be nearly free from

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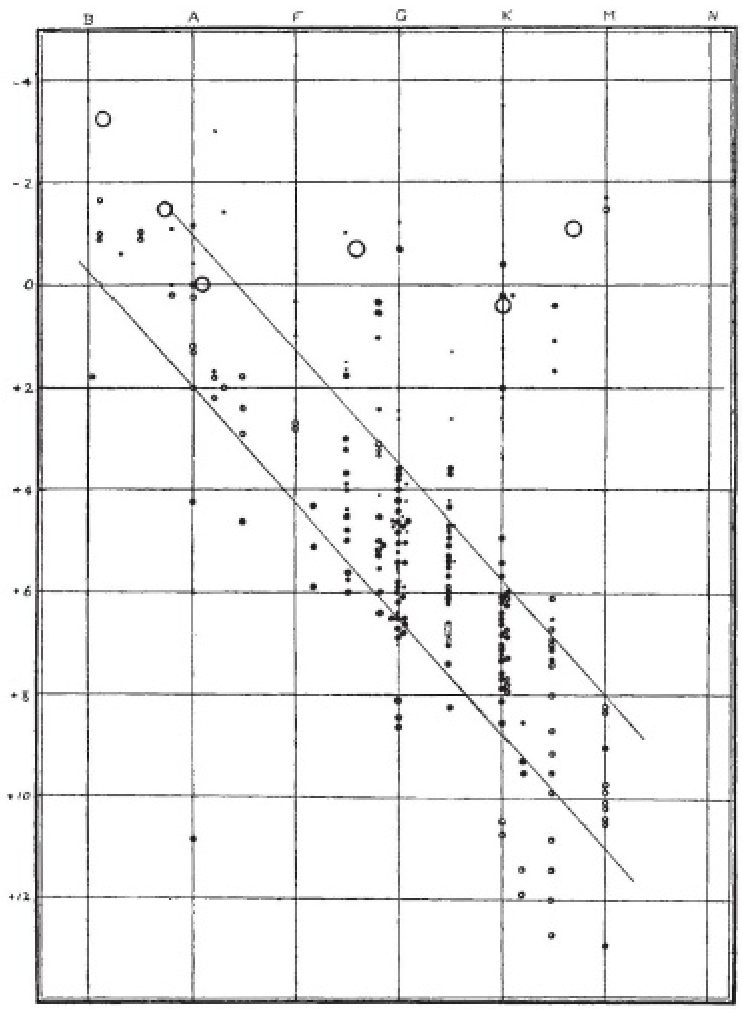

Fig. 1.

THE ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND
ASTRONOMICAL PHYSICS

VOLUME 117 MAY 1953 NUMBER 3

FUNDAMENTAL STELLAR PHOTOMETRY FOR STANDARDS OF SPECTRAL TYPE ON THE REVISED SYSTEM OF THE YERKES SPECTRAL *ATLAS**

H. L. Johnson and W. W. Morgan
Yerkes and McDonald Observatories
Received November 29, 1952

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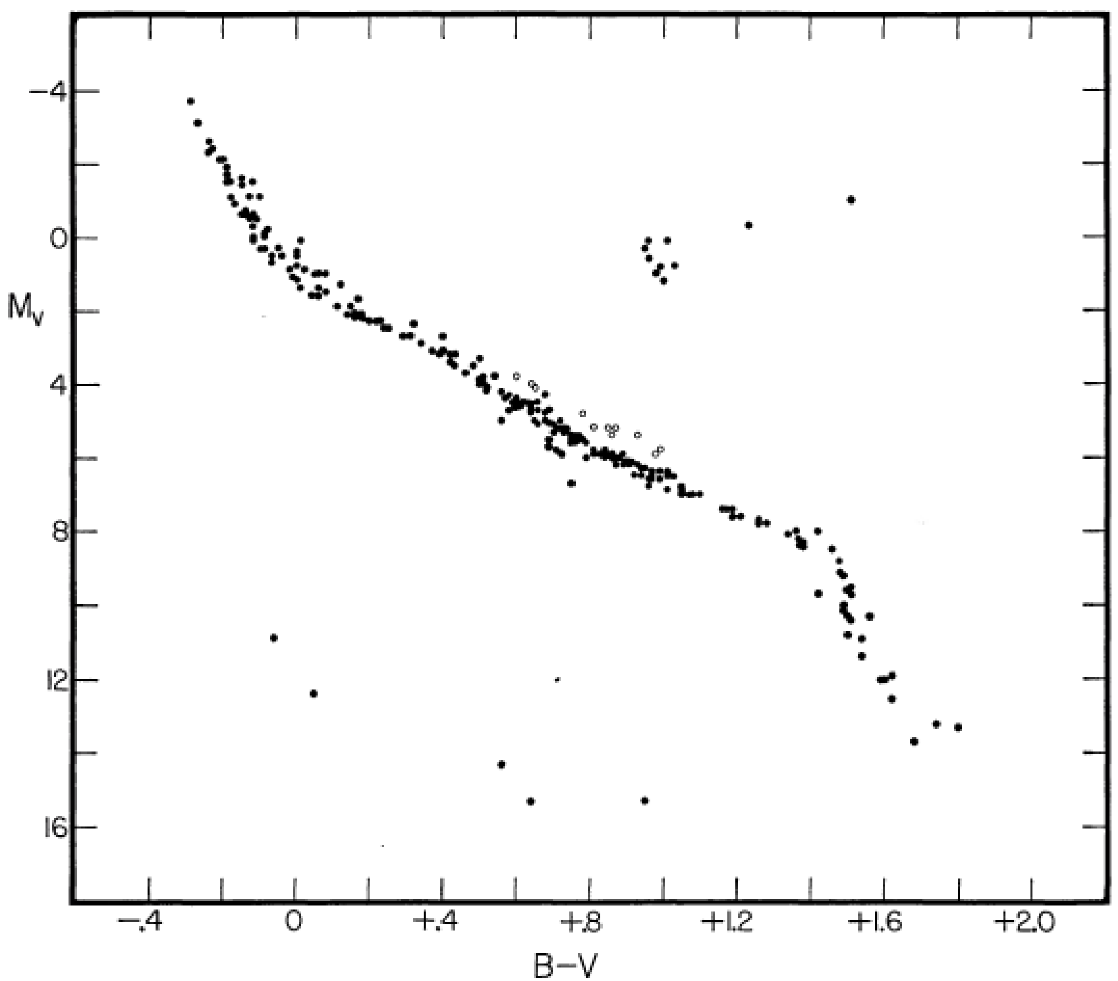


Fig. 5.—A standard main sequence for the color system $B - V$ and the absolute-magnitude system M_V. The stars plotted include main-sequence objects: (*a*), which have trigonometric parallaxes $\geqslant 0\overset{''}{.}100$; (*b*) the Pleiades, corrected for a mean interstellar reddening (one highly reddened A star omitted); (*c*) Praesepe; (*d*) NGC 2362 corrected for a mean interstellar reddening. In addition, five white dwarfs, three yellow giants from the Hyades, and several other yellow giants of large parallax are included. The open circles refer to a few stars lying above the main sequence in Praesepe which may be binaries.

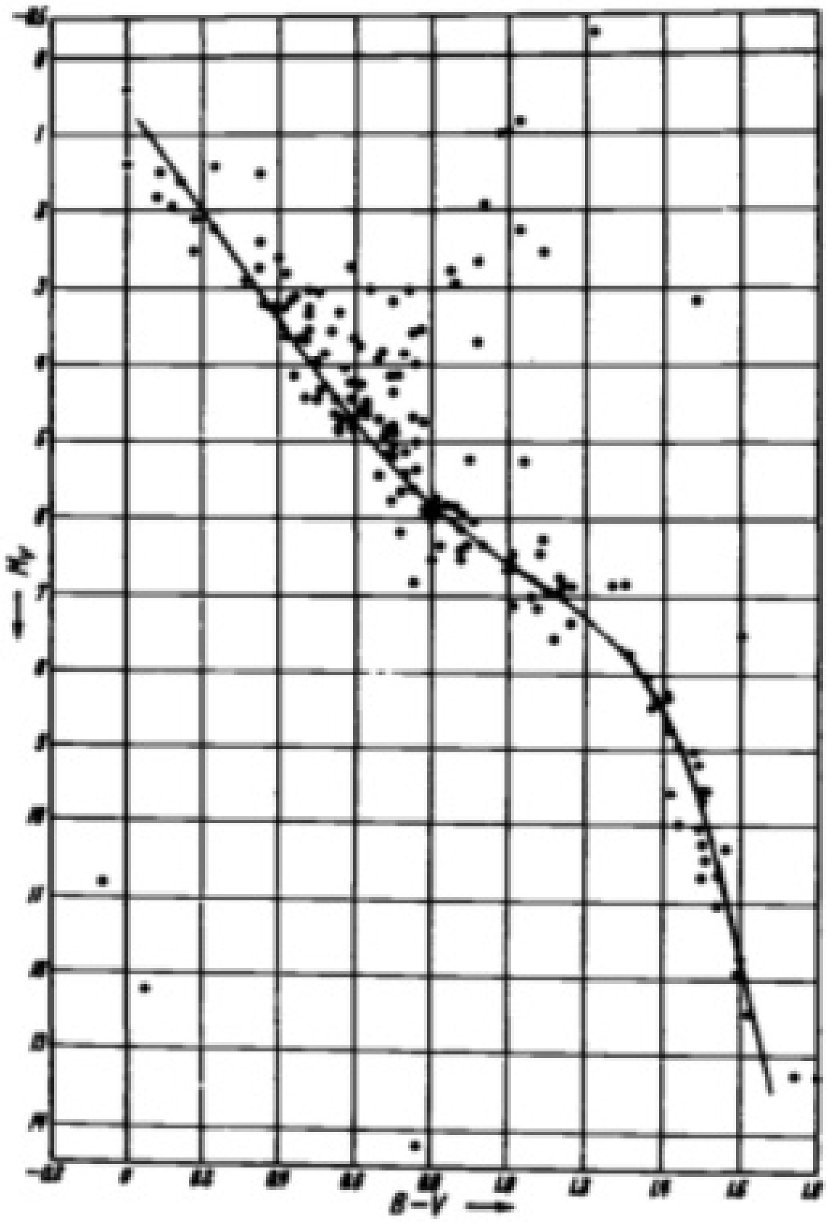


Fig. 5.1. The color magnitude diagram for nearby stars is shown according to Johnson and Morgan (1953). For better comparison with the following color magnitude diagrams we have added an eye-fitted average curve for the main sequence stars.

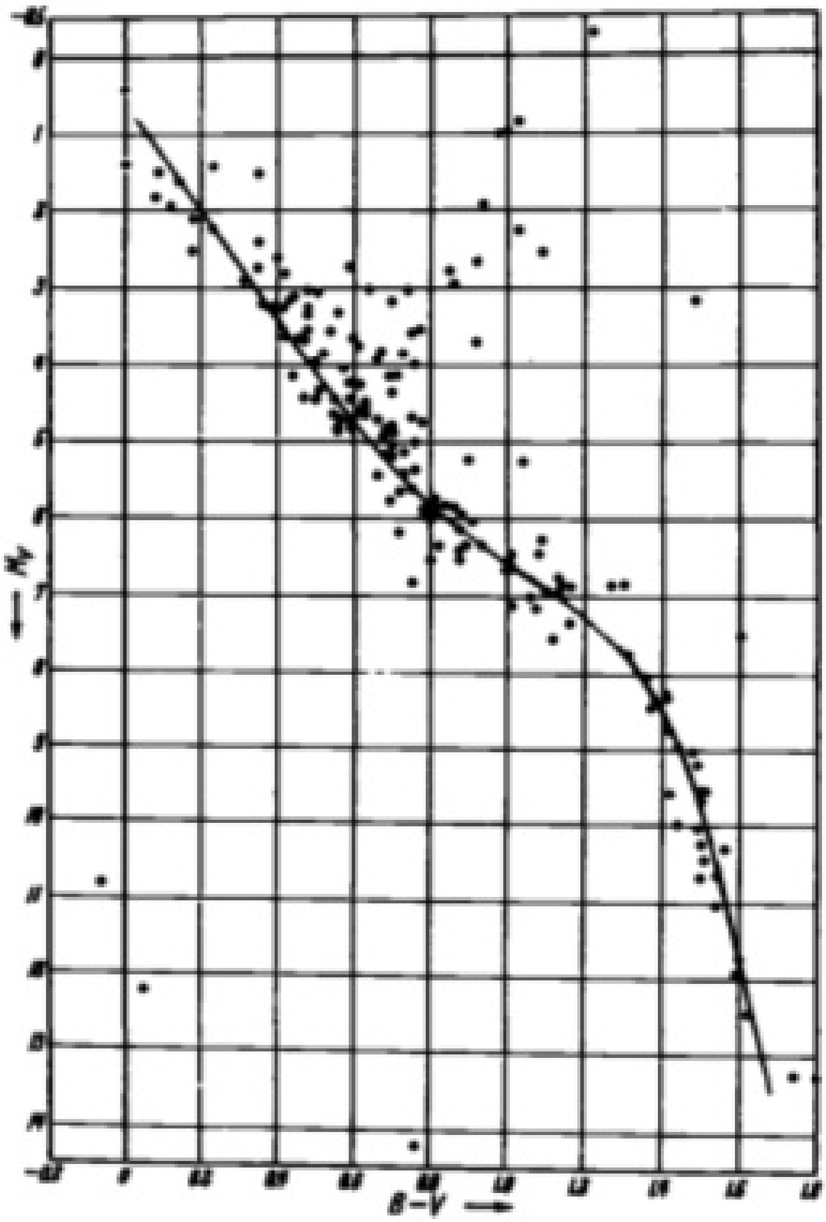


Fig. 5.1. The color magnitude diagram for nearby stars is shown according to Johnson and Morgan (1953). For better comparison with the following color magnitude diagrams we have added an eye-fitted average curve for the main sequence stars.

$$L = 4\pi R^2 \sigma T^4,$$

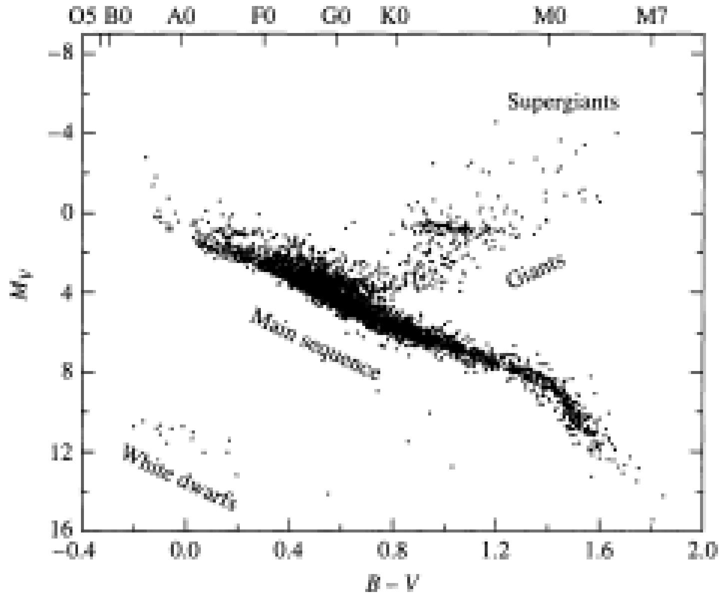
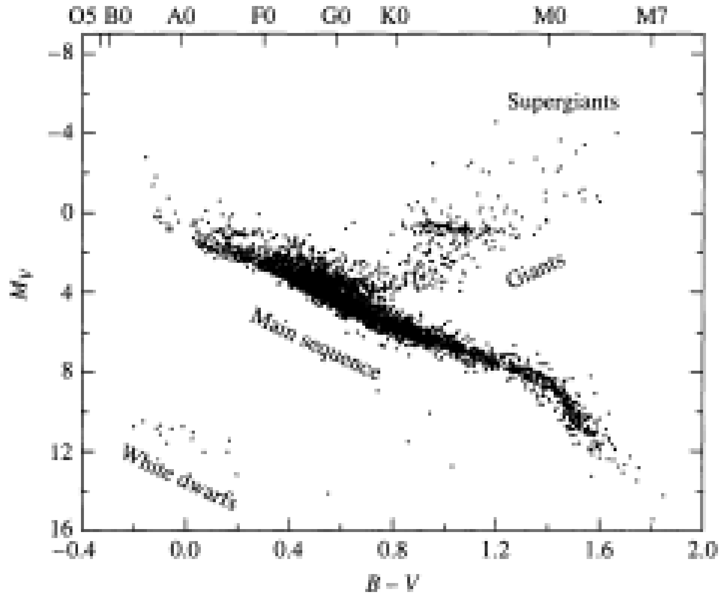


FIGURE 8.13 An observer's H–R diagram. The data are from the Hipparcos catalog. More than 3700 stars are included here with parallax measurements determined to better than 20%. (Data courtesy of the European Space Agency.)



$$R = \frac{1}{T_e^2}\sqrt{\frac{L}{4\pi\sigma}}. \tag{8.10}$$

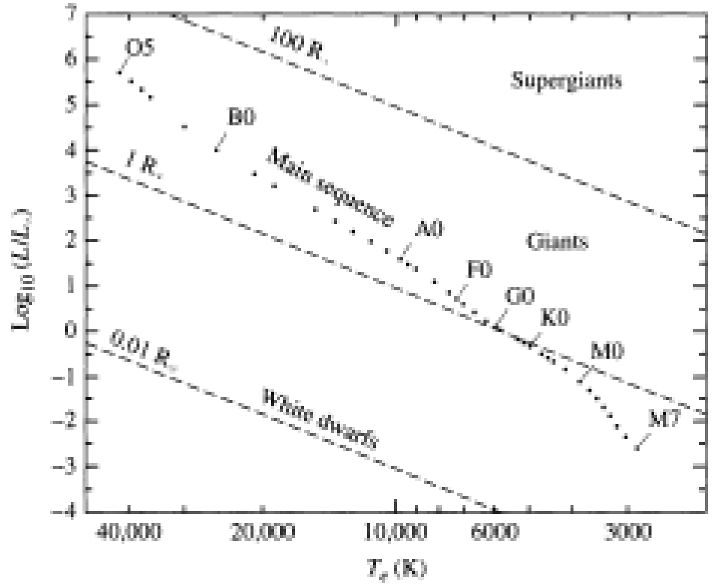
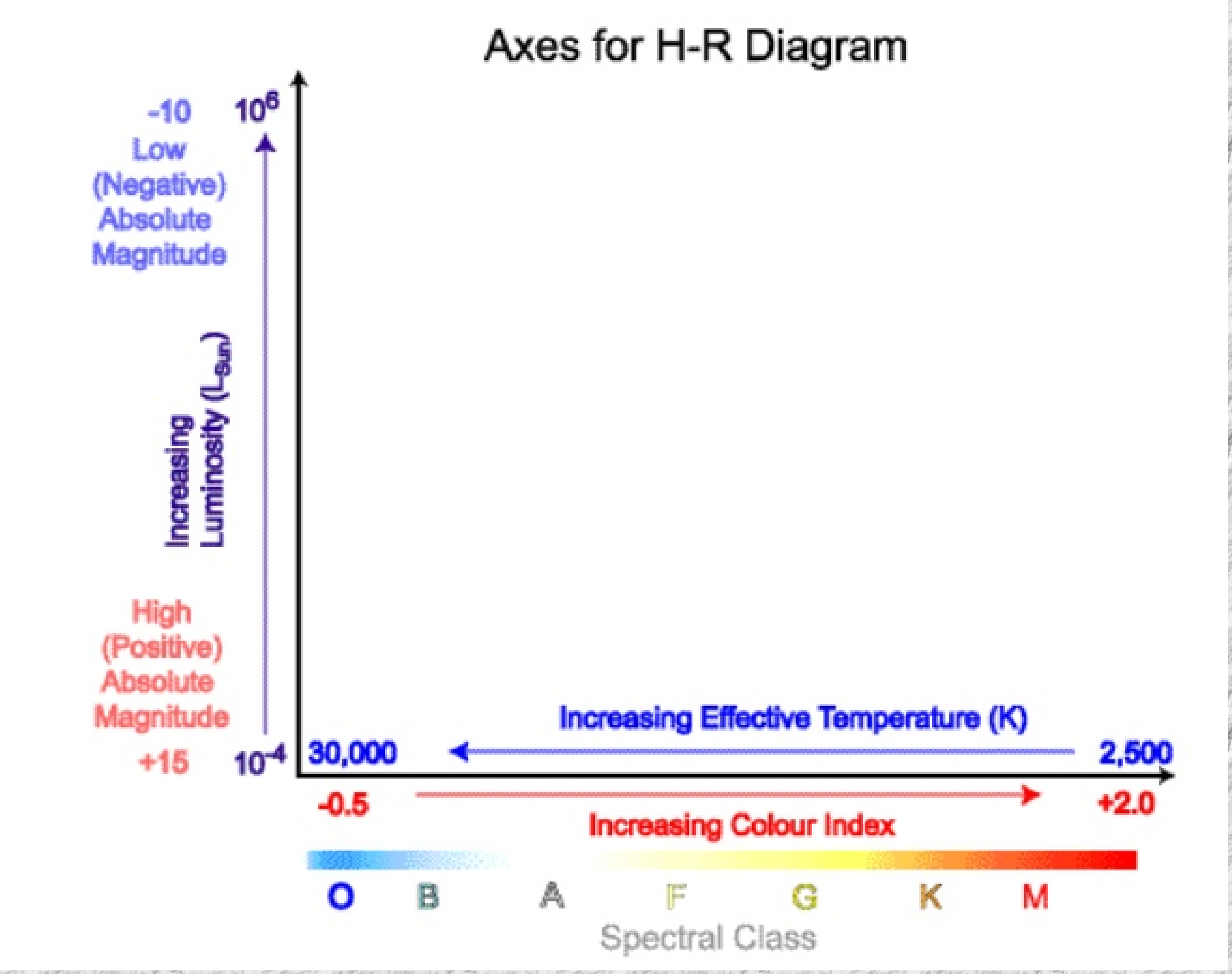


FIGURE 8.14 The theorist's Hertzsprung–Russell diagram. The dashed lines indicate lines of constant radius.


Axes for H-R Diagram
-10
10^6
Low
(Negative)
Absolute
Magnitude
Increasing
Luminosity (L_{Sun})
High
(Positive)
Absolute
Magnitude
+15
10^{-4}
Increasing Effective Temperature (K)
30,000
2,500
-0.5
+2.0
Increasing Colour Index
O
B
A
F
G
K
M
Spectral Class

El Diagrama HR y los cúmulos estelares

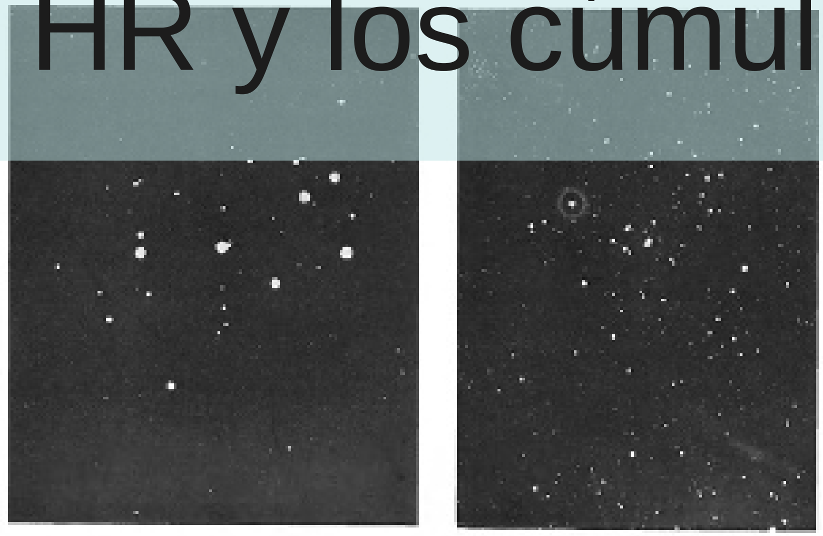


Fig. 5.2. Photographs of the well-known star clusters, the Pleiades (*a*), and the Hyades (*b*), in the constellation of Taurus. (From Burnham 1978.)

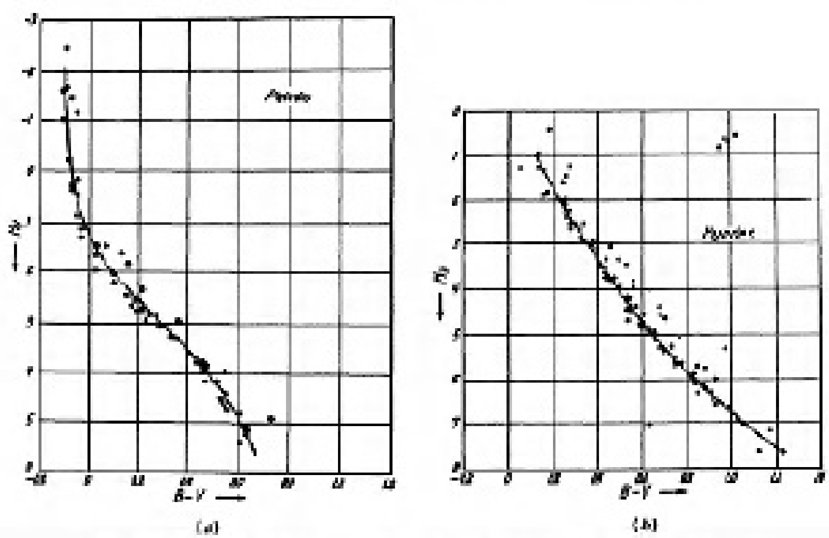
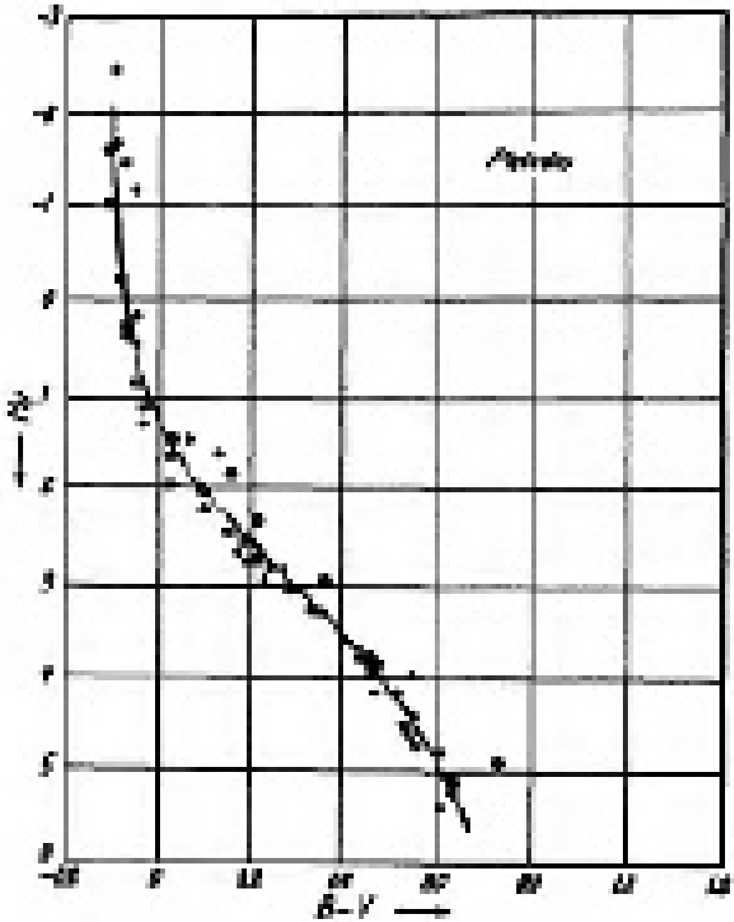
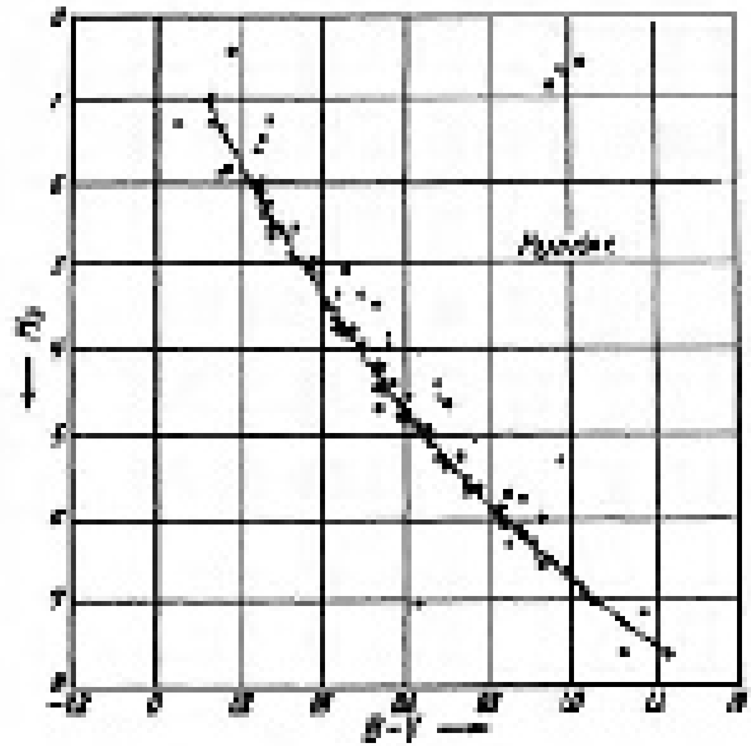


Fig. 5.3. The color, absolute magnitude diagrams for the Pleiades (*a*) and Hyades (*b*) star clusters are shown according to Arp (1958). A distance modulus $m_V - M_V = 5.3$ was used for the Pleiades. For the Hyades individual distance moduli were used, averaging $m_V - M_V = 3.08$. Distance moduli larger by 0.2 magnitudes would be considered more appropriate now.

For better comparison of the different main sequences we have added some eye-fitted average curves.

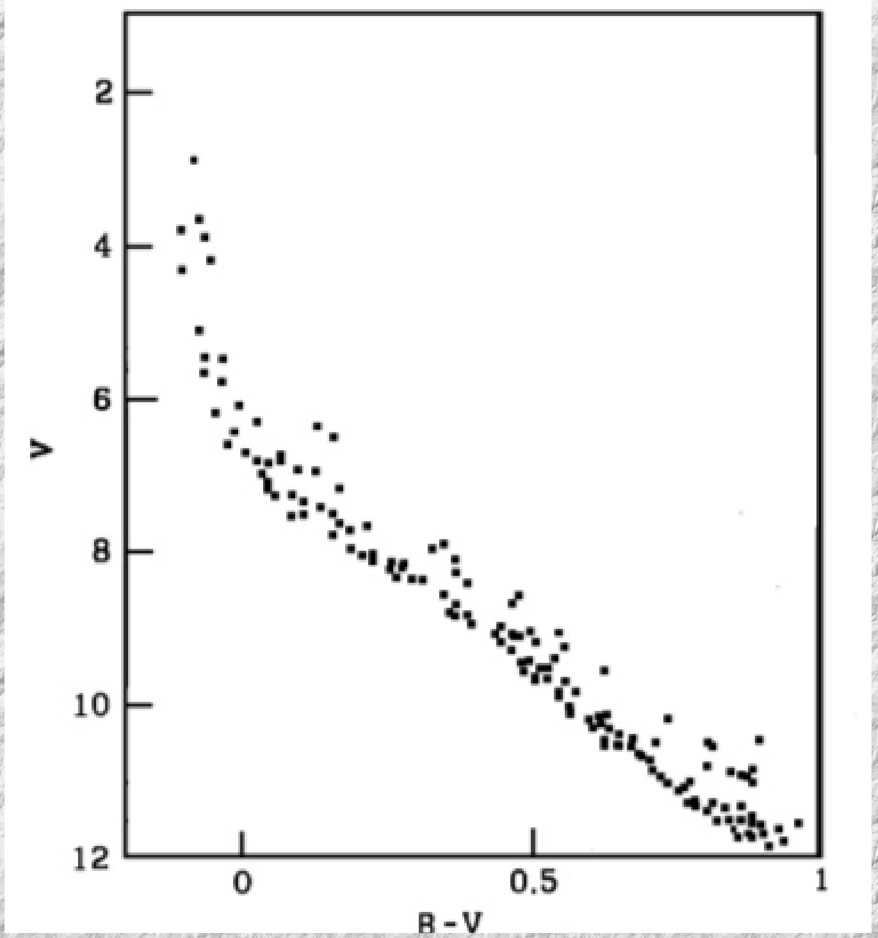


(a)



(b)

Diagrama de Hertzsprung-Russell
Un cúmulo abierto joven (125 Myr)

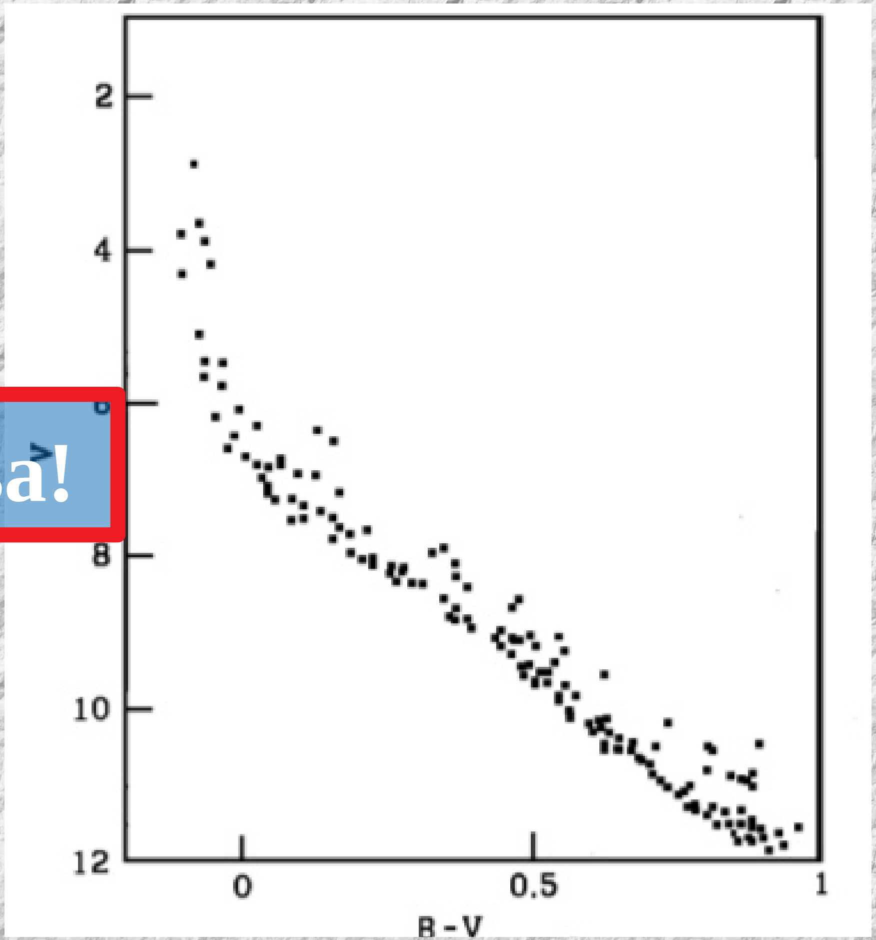


"… presentan la misma distancia, edad y composición química ..."

M 45, 125 Myr

Diagrama de Hertzsprung-Russell
Un cúmulo abierto joven

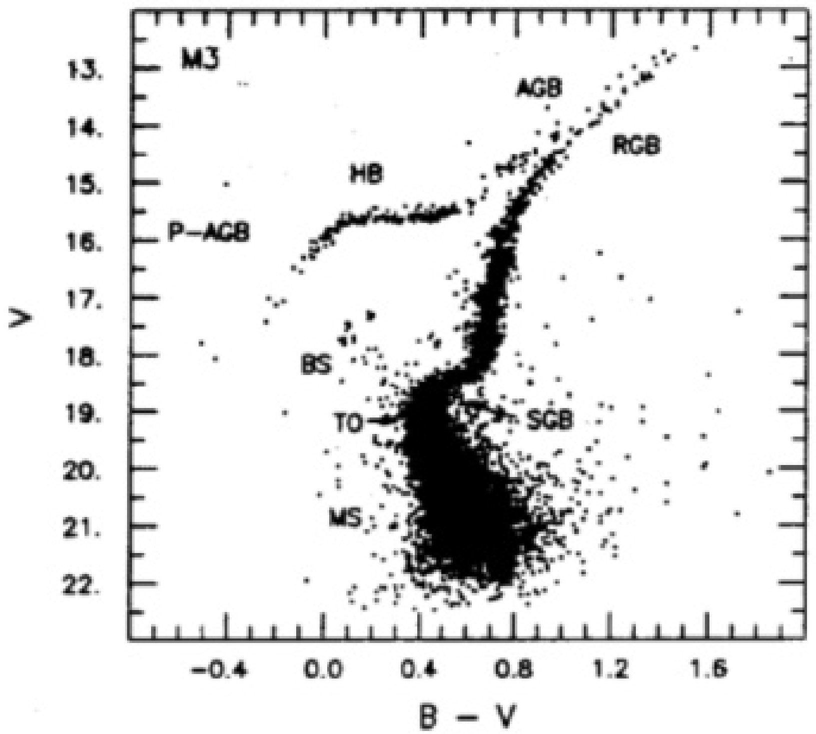
¡Masa!



" … presentan la misma distancia, edad y composición química ..."

M 45, 125 Myr

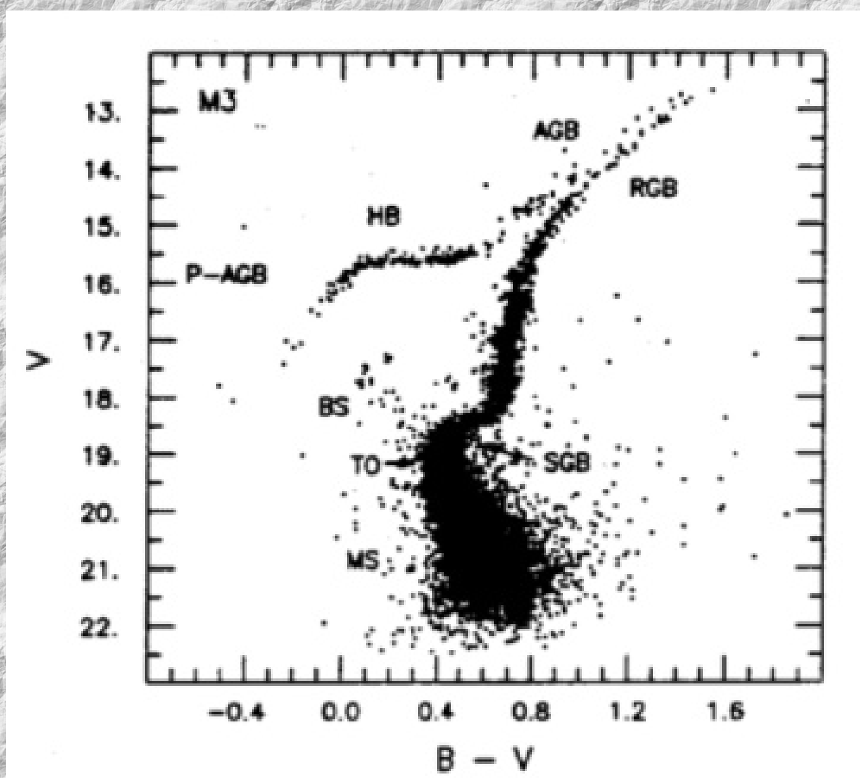
Diagrama de Hertzsprung-Russell
Un cúmulo globular



"… presentan la misma distancia, edad y composición química … y **diferente masa**"

M 3, 12 Gyr

Diagrama de Hertzsprung-Russell
Evolución estelar



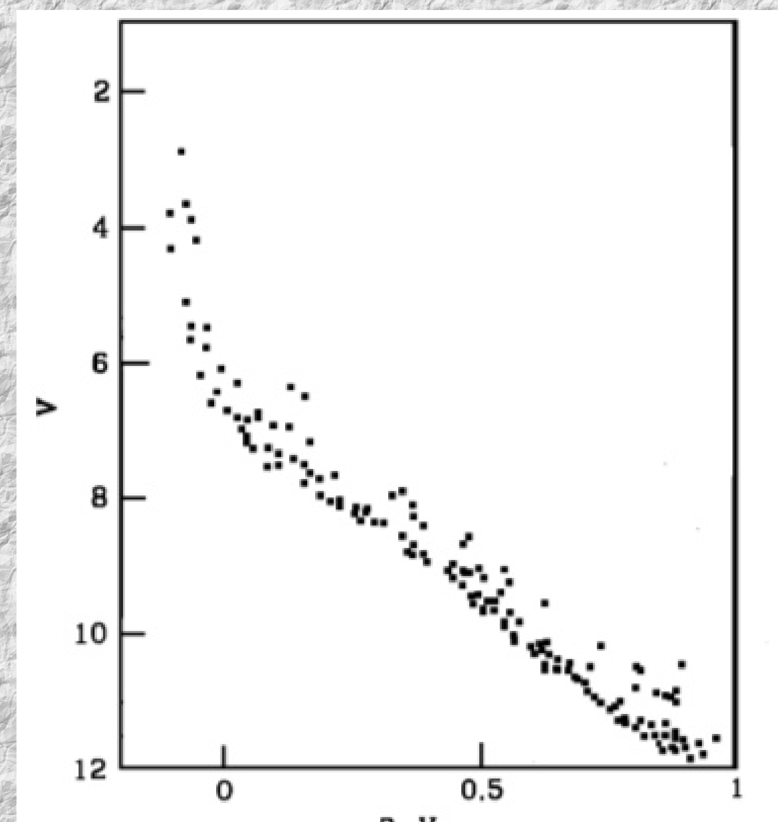
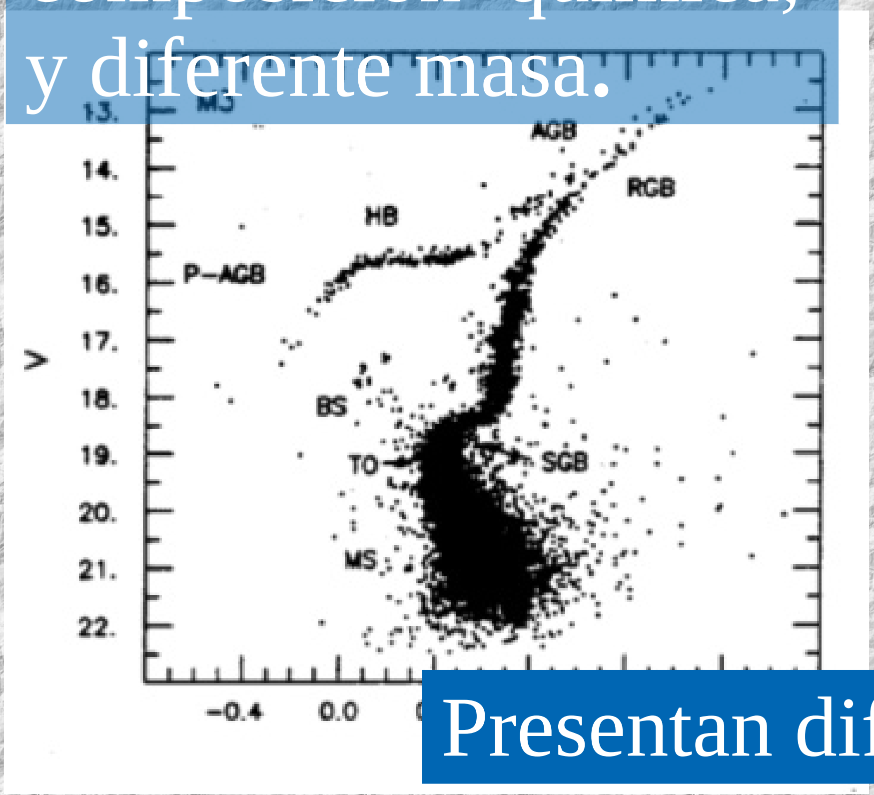
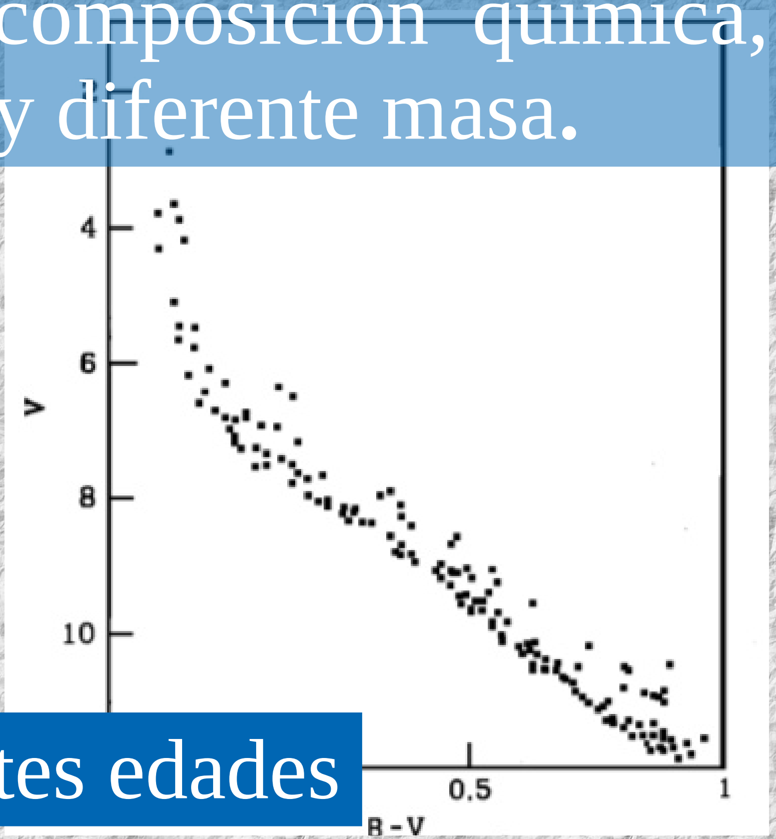


Diagrama de Hertzsprung-Russell
Evolución estelar

Presentan la misma distancia, edad y composición química, y diferente masa.

Presentan la misma distancia, edad y composición química, y diferente masa.





Presentan diferentes edades

Astron. Astrophys. 345, 485–498 (1999)

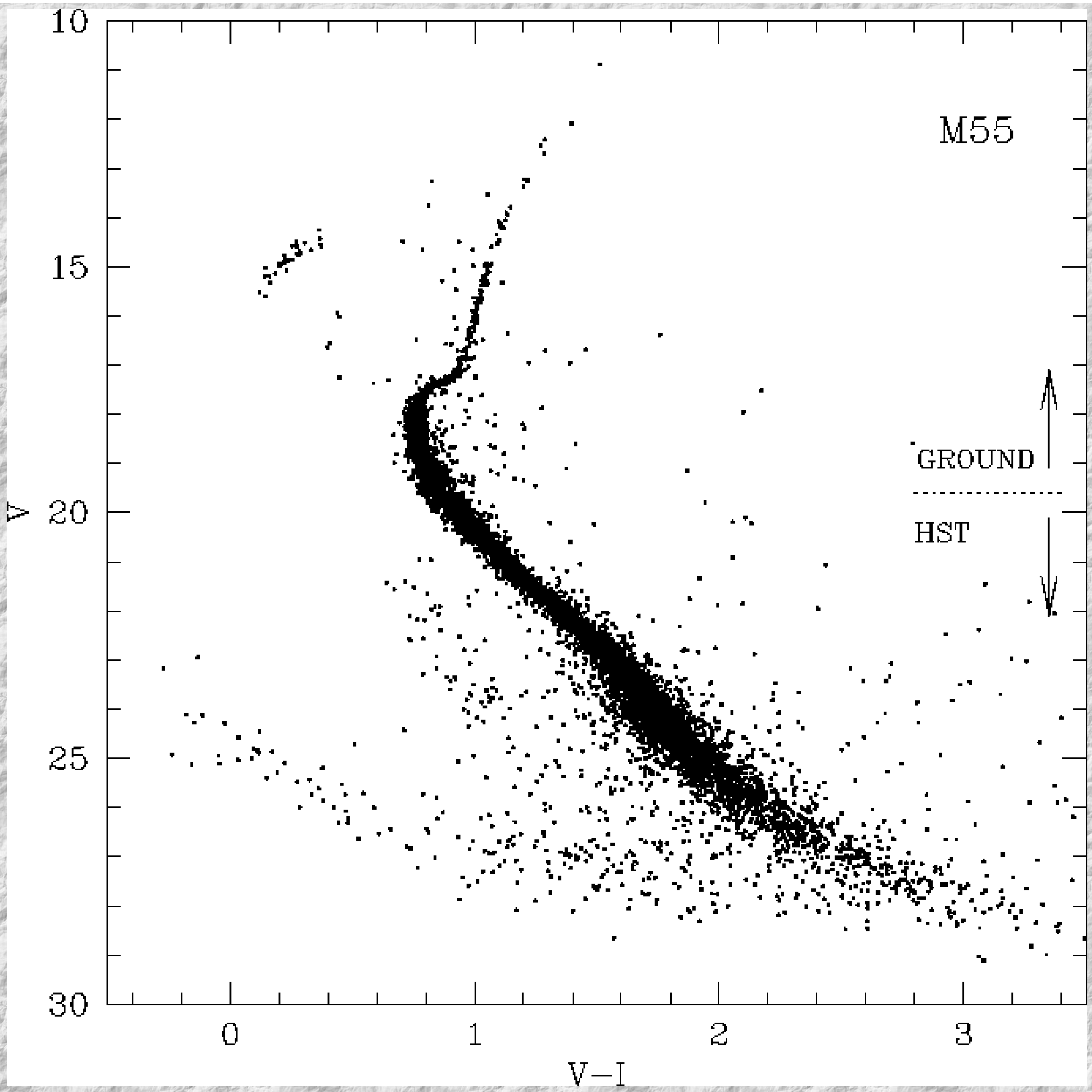
ASTRONOMY AND ASTROPHYSICS

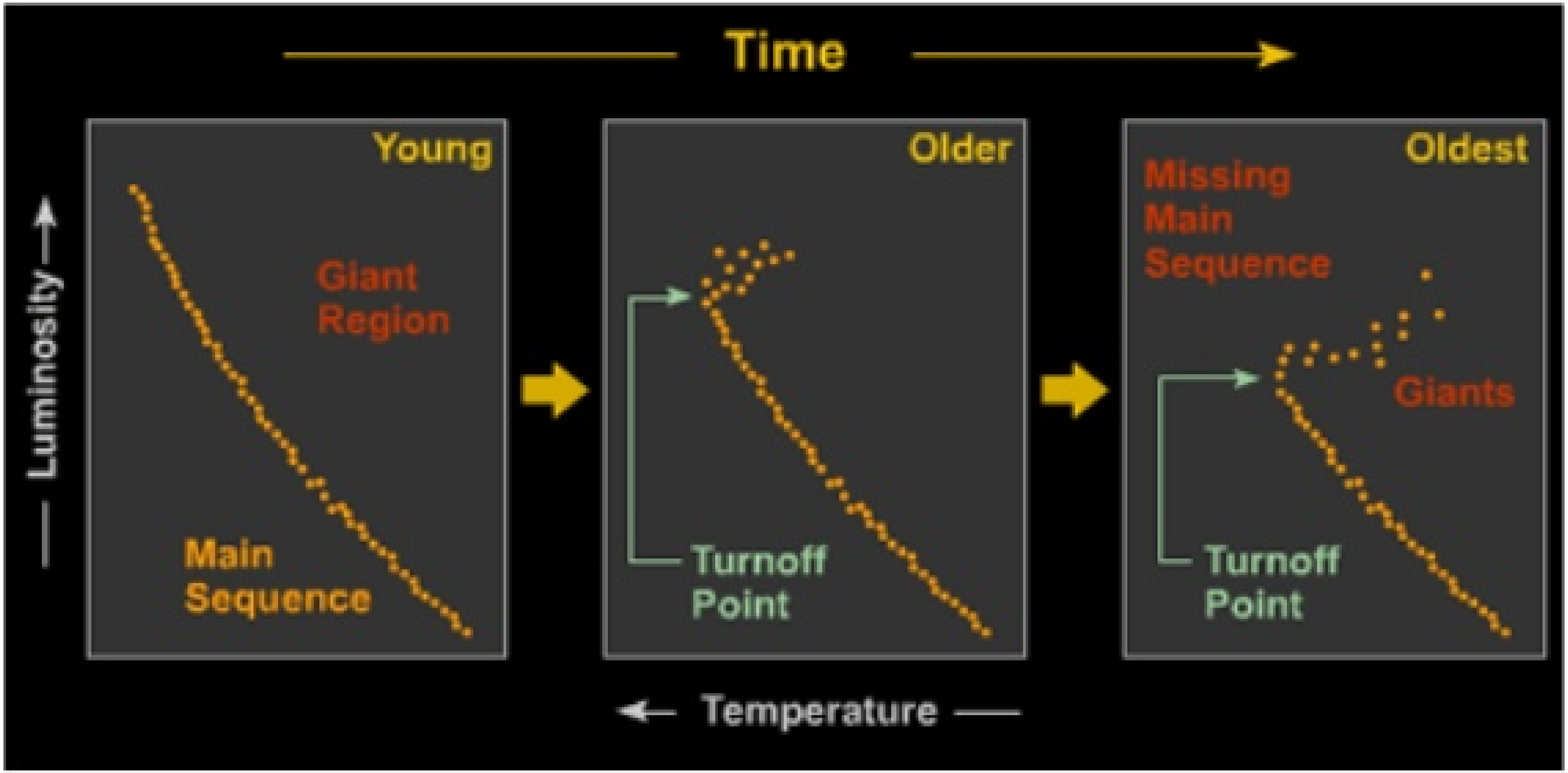
HST luminosity functions of the globular clusters M10, M22, and M55

A comparison with other clusters*

G. Piotto[1] and M. Zoccali[1]

Dipartimento di Astronomia – Università di Padova, I-35122 Padova, Italy




Time
Young
Older
Oldest
Luminosity
Giant Region
Main Sequence
Turnoff Point
Missing Main Sequence
Giants
Turnoff Point
Temperature

Astronomy & Astrophysics manuscript no. DR2HRD
April 20, 2018
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Gaia Data Release 2: Observational Hertzsprung-Russell diagrams

Gaia Collaboration, C. Babusiaux[1,2], F. van Leeuwen[3], M.A. Barstow[4], C. Jordi[5], A. Vallenari[6], D. Bossini[6], A.

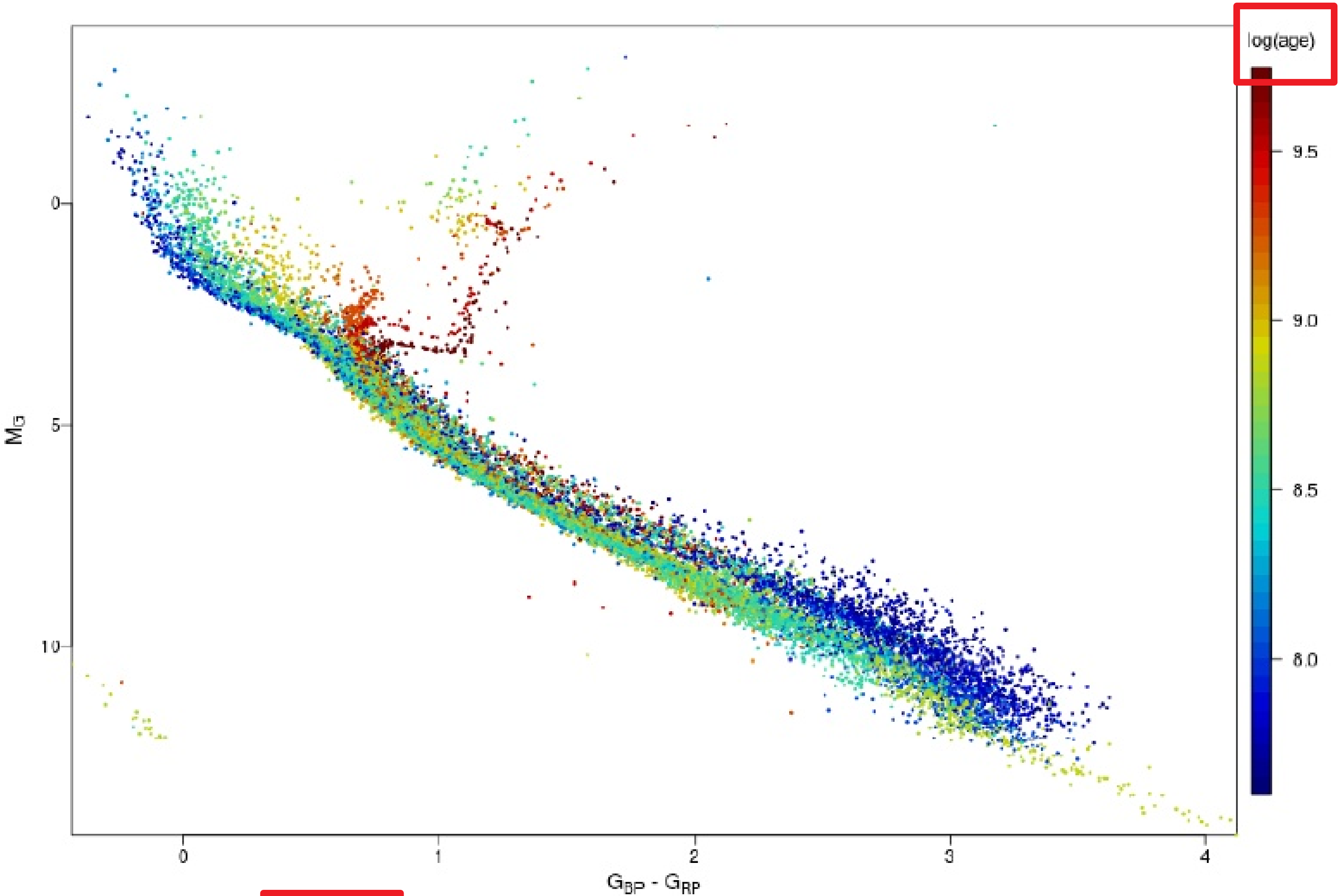

Fig. 2. Composite HRD for 32 open clusters, coloured according to log(age), using the extinction and distance moduli as determined from the *Gaia* data (Table 2).

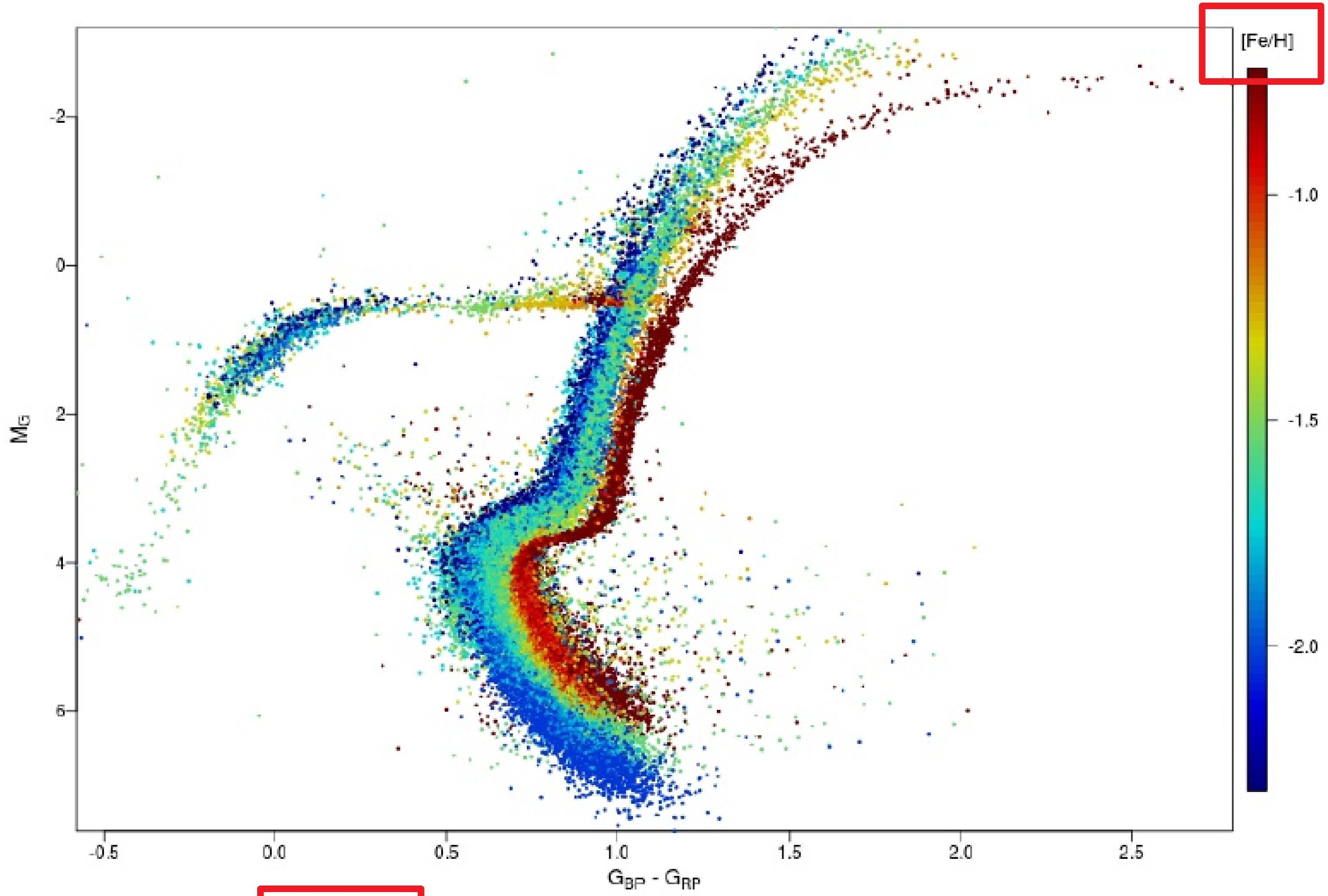

Fig. 3. Composite HRD for 14 globular clusters, coloured according to metallicity (Table 3).

Astronomy & Astrophysics manuscript no. DR2HRD
April 20, 2018

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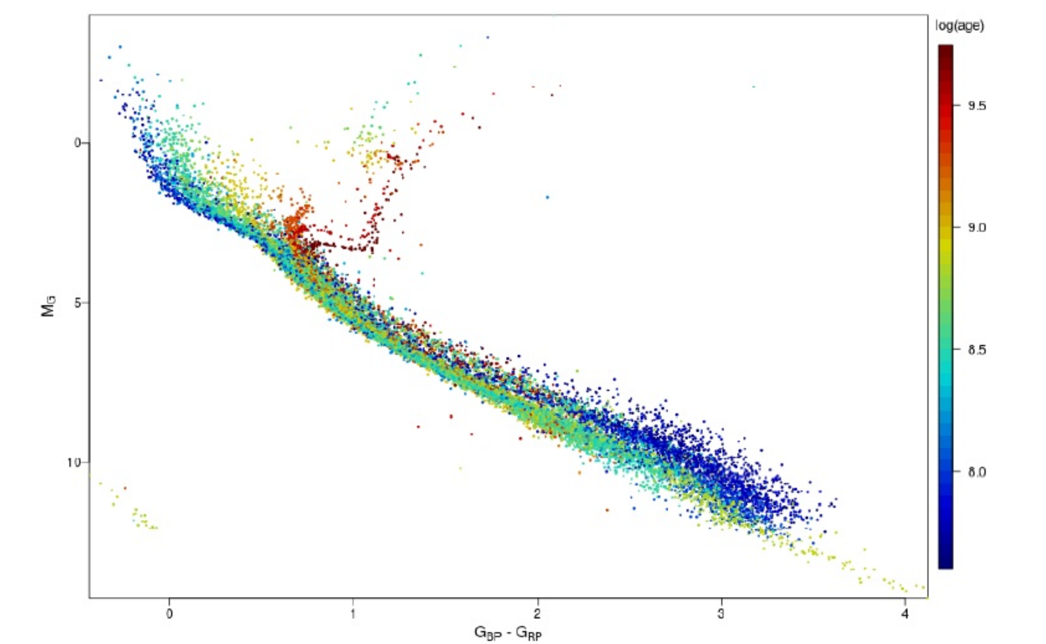
Gaia Data Release 2: Observational Hertzsprung-Russell diagrams

Gaia Collaboration, C. Babusiaux[1,2], F. van Leeuwen[3], M.A. Barstow[4], C. Jordi[5], A. Vallenari[6], D. Bossini[6], A.



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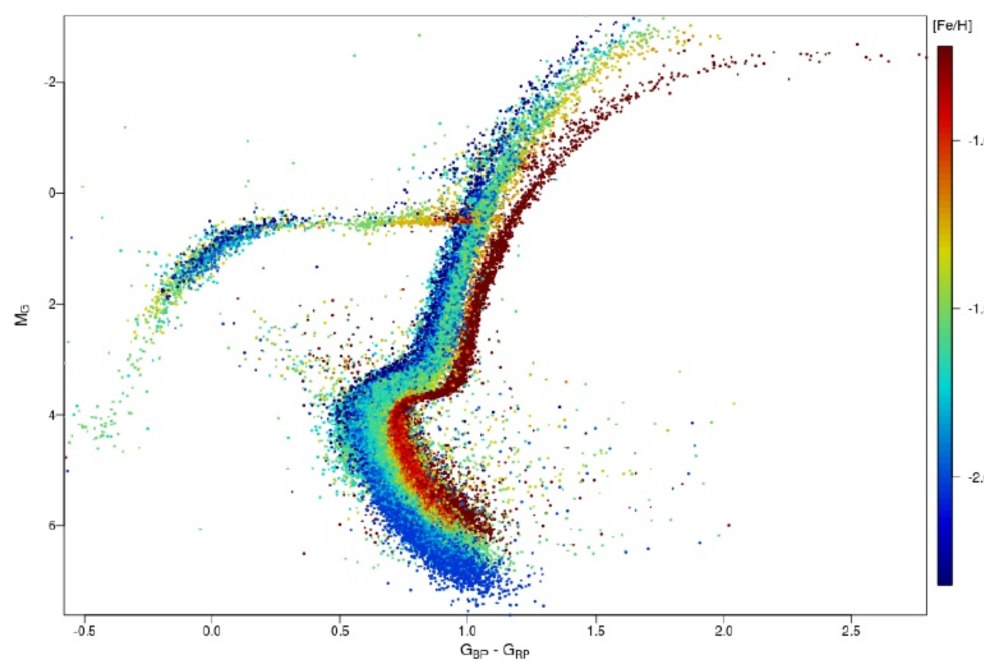
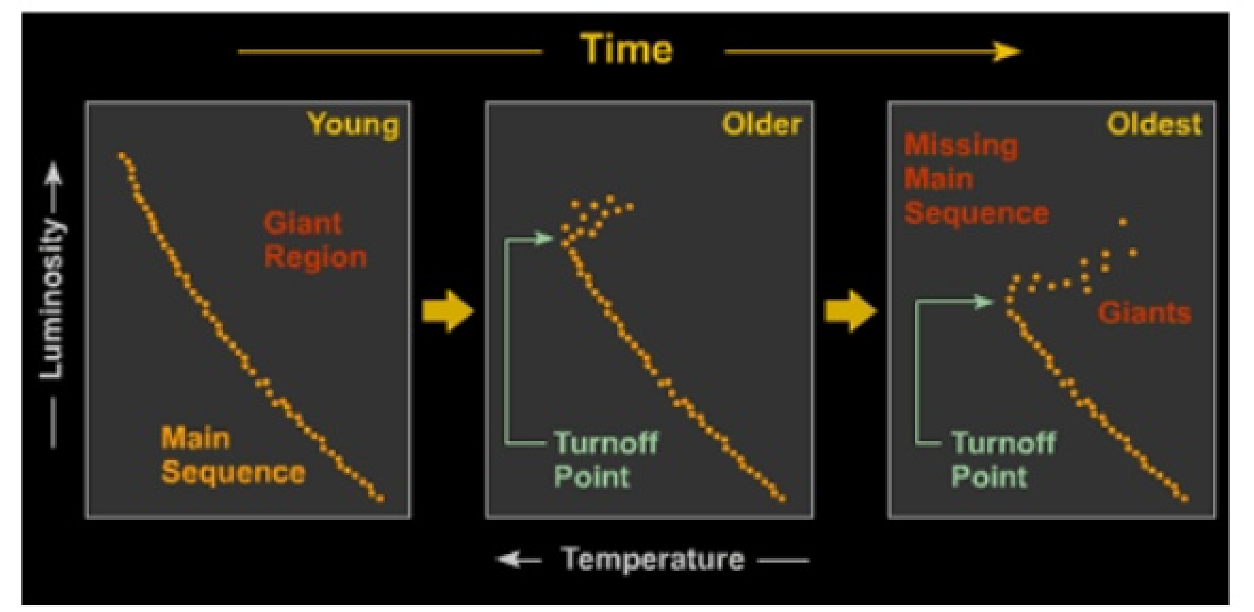
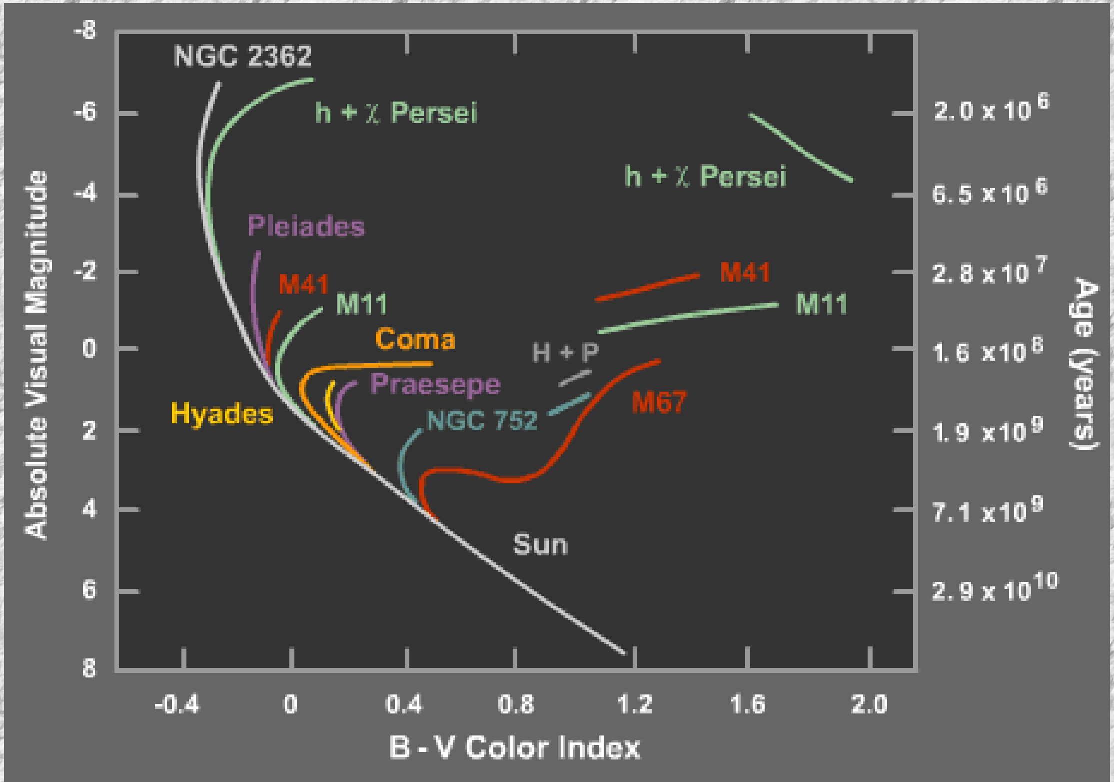


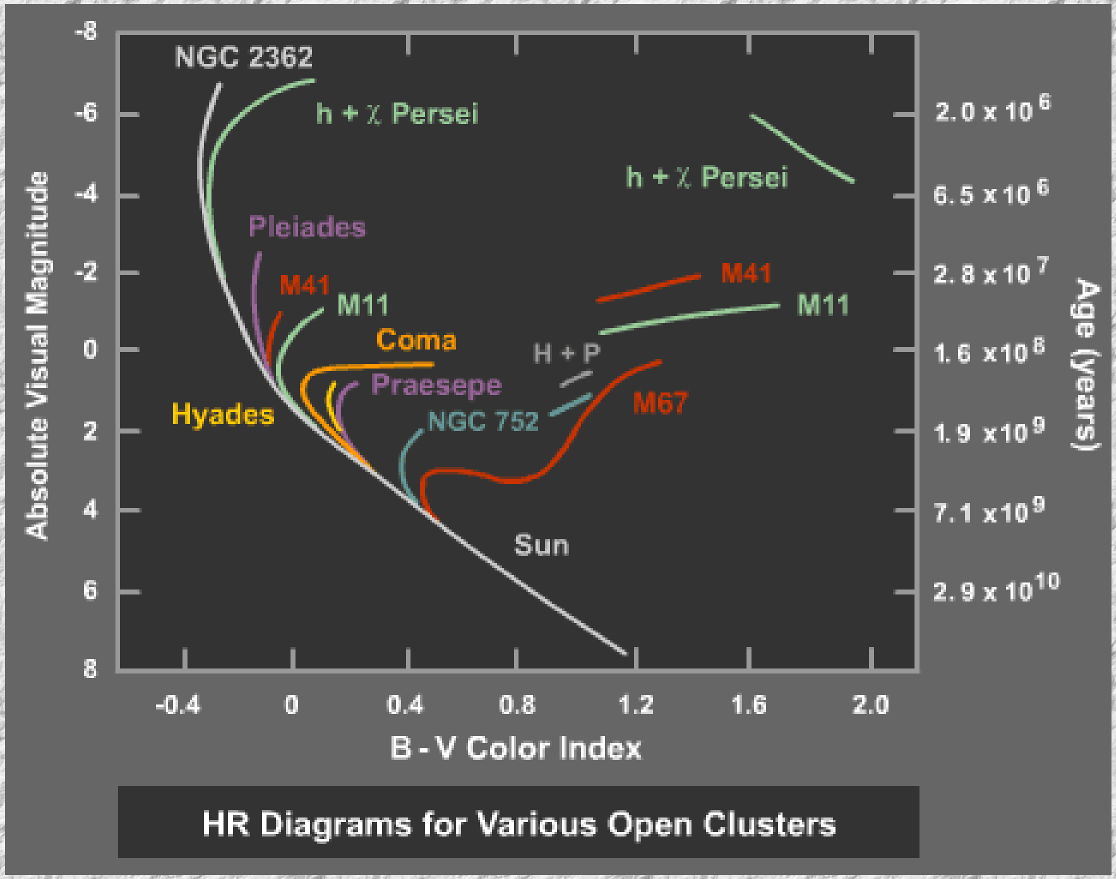
Fig. 3. Composite HRD for 14 globular clusters, coloured according to metallicity (Table 3).



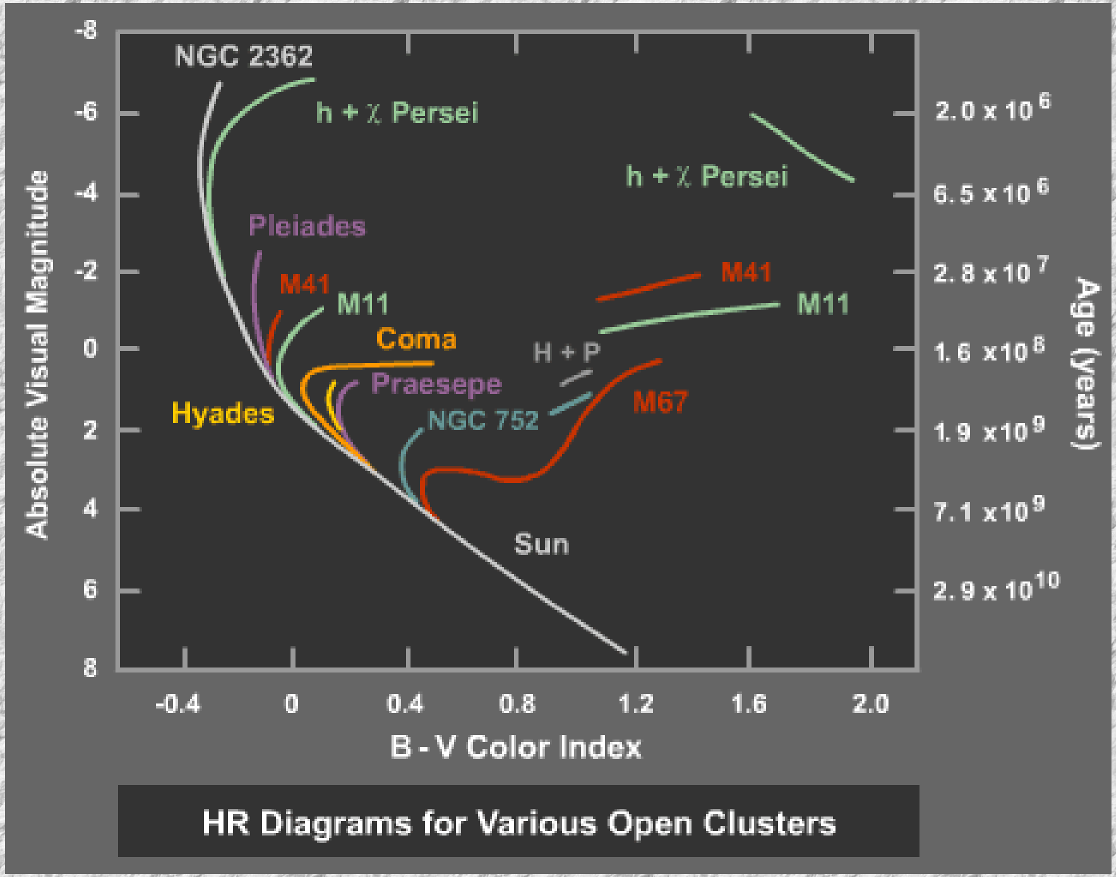


HR Diagrams for Various Open Clusters

Cada CE provee una imagen de cómo lucen sus estrellas de **diferente masa y de una misma edad y composición química** ("*coeval populations*")



Isócrona teórica: es la línea que une los diferentes puntos del DCM (teórico) de una **determinada edad**. El mejor ajuste (*match*) de la isócrona teórica con nuestro DCM (observado) nos indicará la edad del CE (entre otros parámetros).



http://stev.oapd.inaf.it/cgi-bin/cmd

http://stellar.dartmouth.edu/models/index.html

Isochrone fitting of Galactic globular clusters – I. NGC 5904

George A Gontcharov, Aleksandr V Mosenkov, Maxim Yu Khovritchev

Monthly Notices of the Royal Astronomical Society, Volume 483, Issue 4, March 2019, Pages 4949–4967, https://doi.org/10.1093/mnras/sty3439

ABSTRACT

We present new isochrone fits to colour-magnitude diagrams of the Galactic globular cluster NGC 5904 (M5). We utilise 29 photometric bands from the ultraviolet to mid-infrared by use of the data from the *Hubble Space Telescope*, *Gaia* DR2, *Wide-field Infrared Survey Explorer*, Sloan Digital Sky Survey (SDSS), and other photometric data. In our isochrone fitting we use the PAdova and TRieste Stellar Evolution Code, the MESA Isochrones and Stellar Tracks, the Dartmouth Stellar Evolution Program, and a Bag of Stellar Tracks and Isochrones both for the solar-scaled and enhanced He and α abundances with a metallicity about [Fe/H]$= -1.33$ adopted from the literature. All tools provide us with estimates of the distance, age, and extinction law to the cluster. The best-fit distance, true distance modulus, and age are 7.4 ± 0.3 kpc, 14.34 ± 0.09 mag, and 12.15 ± 1.00 Gyr, respectively. The derived distance agrees with the literature, including the *Gaia* DR2 parallax with its known global zero-point correction. All the data and models, except some UV and SDSS data, agree with the extinction law of Cardelli-Clayton-Mathis with $R_V = 3.60 \pm 0.05$ and $A_V = 0.20 \pm 0.02$ mag. This extinction is twice as high as generally accepted due to a rather high extinction between 625 and 2000 nm. An offset of the model colours instead of the high extinction in this range is a less likely, yet possible explanation of the discovered large deviations of the isochrones from the data.

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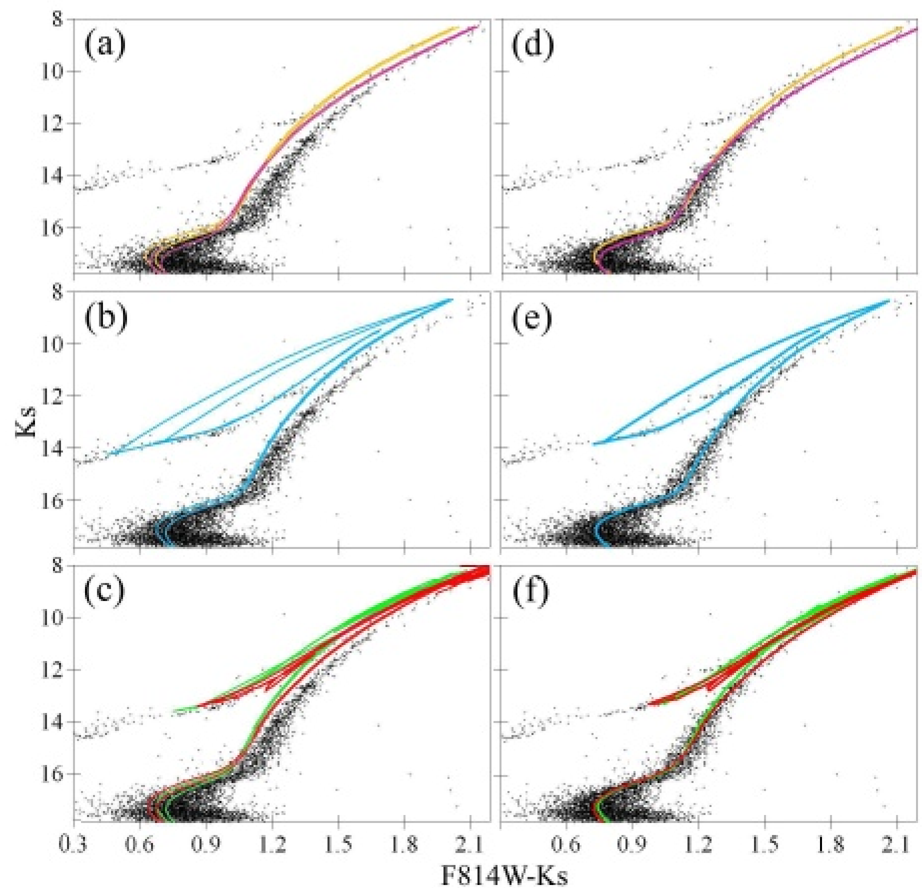

Figure 1. $F814W - K_s$ versus K_s CMD of NGC 5904 with the isochrones from (a) and (d) DSEP solar-scaled (yellow), DSEP He and α enhanced (magenta), (b) and (e) new BaSTI solar-scaled (blue), (c) and (f) PARSEC solar-scaled (green) and MIST solar-scaled (red). The left column of the plots shows the pairs of the isochrones for 11 (left in the pair) and 13 Gyr (right in the pair) for the distance and reddening from Harris (1996) (7.5 kpc and $E(B-V) = 0.03$ mag) and the CCM89 extinction law with $R_V = 3.1$. The right column of the plots shows the best fit isochrones for the age, distance and reddening from Table 3.

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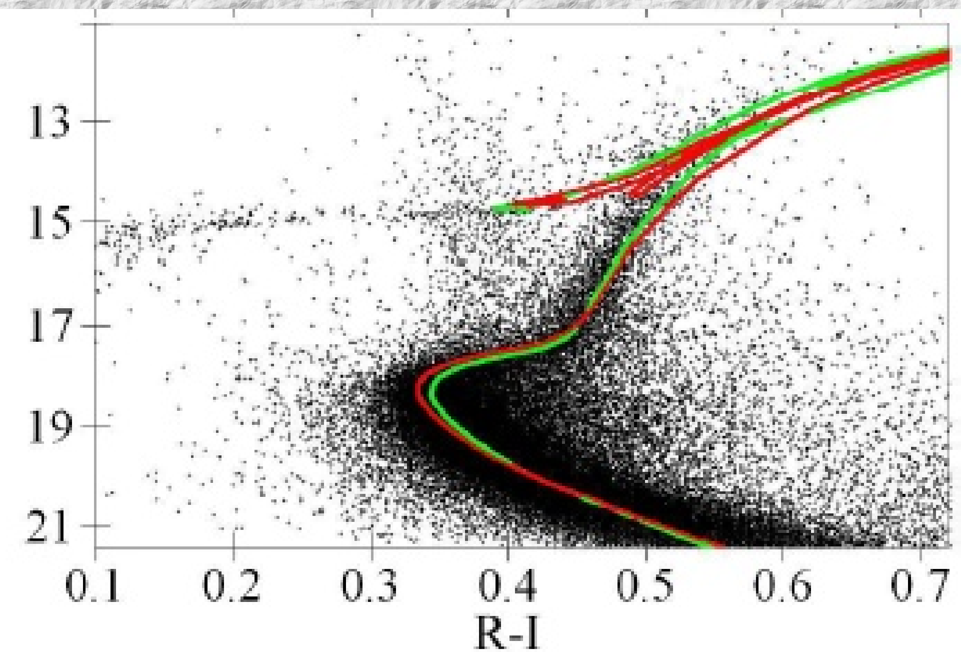

Figure A5. The same as Fig. A1 but for $R-I$ versus R.

	PARSEC	MIST	DSEP	Old BaSTI	New BaSTI	APM	Harris
$E(F275W-F336W)$	0.073 ± 0.10	0.105 ± 0.08	0.000 ± 0.12	0.066 ± 0.05	0.067 ± 0.07		0.03
age, Gyr	11.5	13.0	11.0	**11.5**	11.5		
distance, kpc	7.5	**6.9**	8.3	7.1	**7.2**		
$E(F336W-F438W)$	0.060 ± 0.10	0.080 ± 0.06	0.030 ± 0.03	0.035 ± 0.04	0.040 ± 0.04		0.03
age, Gyr	12.0	12.5	**11.0**	**12.0**	12.5		
distance, kpc	7.5	**7.1**	7.5	7.3	**7.5**		
$E(F438W-F606W)$	0.101 ± 0.01	0.114 ± 0.04	0.070 ± 0.02	0.089 ± 0.03	0.070 ± 0.03		0.04
age, Gyr	11.5	13.5	**12.0**	**12.5**	13.0		
distance, kpc	**7.3**	**7.0**	7.2	6.8	**7.2**		
$E(F606W-F814W)$	0.045 ± 0.01	0.050 ± 0.03	0.040 ± 0.01	0.010 ± 0.03	0.030 ± 0.02		0.03
age, Gyr	12.0	13.5	**12.5**	**12.5**	12.5		
distance, kpc	**7.5**	**7.4**	7.3	7.3	**7.6**		
$E(F555W-F814W)$	0.073 ± 0.06	0.080 ± 0.04	0.066 ± 0.03	0.044 ± 0.04	0.066 ± 0.04		0.04
age, Gyr	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*		
distance, kpc	*7.4*	*7.4*	*7.4*	*7.4*	*7.4*		
$E(G_{BP}-G_{RP})$	0.080 ± 0.02	0.080 ± 0.04	0.093 ± 0.01		0.013 ± 0.03		0.04
age, Gyr	11.5	12.5	**11.5**		12.5		
distance, kpc	**7.6**	**7.6**	7.4		**8.4**		
$E(U-B)$	0.046 ± 0.06	0.076 ± 0.06	0.061 ± 0.05	-0.008 ± 0.06	0.019 ± 0.06		0.02
age, Gyr	11.5	12.5	**12.0**	**11.0**	12.5		
distance, kpc	**7.6**	**7.1**	7.0	7.8	**7.6**		
$E(B-V)$	0.060 ± 0.04	0.080 ± 0.07	0.050 ± 0.04	0.050 ± 0.05	0.030 ± 0.05		0.03
age, Gyr	12.5	13.5	**13.0**	**12.0**	13.5		
distance, kpc	**7.1**	**7.0**	6.8	7.0	**7.2**		
$E(V-R)$	-0.003 ± 0.04	0.016 ± 0.04	0.019 ± 0.03	0.013 ± 0.04	-0.009 ± 0.06		0.02
age, Gyr	11.5	12.5	**11.5**	**12.0**	12.0		
distance, kpc	**7.9**	**7.5**	7.3	7.4	**8.1**		
$E(R-I)$	0.062 ± 0.03	0.062 ± 0.04	0.051 ± 0.02	0.038 ± 0.04	0.041 ± 0.03		0.02
age, Gyr	12.0	14.0	**13.5**	**13.5**	14.0		
distance, kpc	**7.6**	**7.3**	7.0	7.1	**7.7**		
$E(u-g)$	0.125 ± 0.06	0.125 ± 0.05	0.114 ± 0.05	0.103 ± 0.05	0.070 ± 0.06	0.066 ± 0.05	0.03
age, Gyr	11.5	11.5	11.5	11.5	11.5	12.6	
distance, kpc	7.0	7.0	6.7	6.9	7.2	7.4	
$E(g-r)$	0.042 ± 0.03	0.048 ± 0.04	0.032 ± 0.04	0.021 ± 0.04	0.053 ± 0.03	0.058 ± 0.04	0.03
age, Gyr	11.5	13.5	12.0	13.0	13.0	12.6	
distance, kpc	7.7	7.4	7.2	7.2	7.0	7.2	
$E(r-i)$	0.053 ± 0.02	0.050 ± 0.02	0.056 ± 0.02	0.053 ± 0.02	0.062 ± 0.02	0.047 ± 0.02	0.02
age, Gyr	11.5	13.0	11.5	12.5	13.0	12.6	
distance, kpc	7.2	7.2	6.8	6.7	6.7	7.2	
$E(i-z)$	0.023 ± 0.02	0.026 ± 0.02	0.029 ± 0.02	0.026 ± 0.02	0.044 ± 0.02	0.012 ± 0.02	0.02
age, Gyr	12.0	12.5	11.5	12.5	12.0	12.6	
distance, kpc	7.8	7.6	7.4	7.0	7.1	7.5	

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Astronomy & Astrophysics

Multiple stellar populations in Magellanic Cloud clusters⋆,⋆⋆

I. An ordinary feature for intermediate age globulars in the LMC?

A. P. Milone[1], L. R. Bedin[2], G. Piotto[1], and J. Anderson[2]

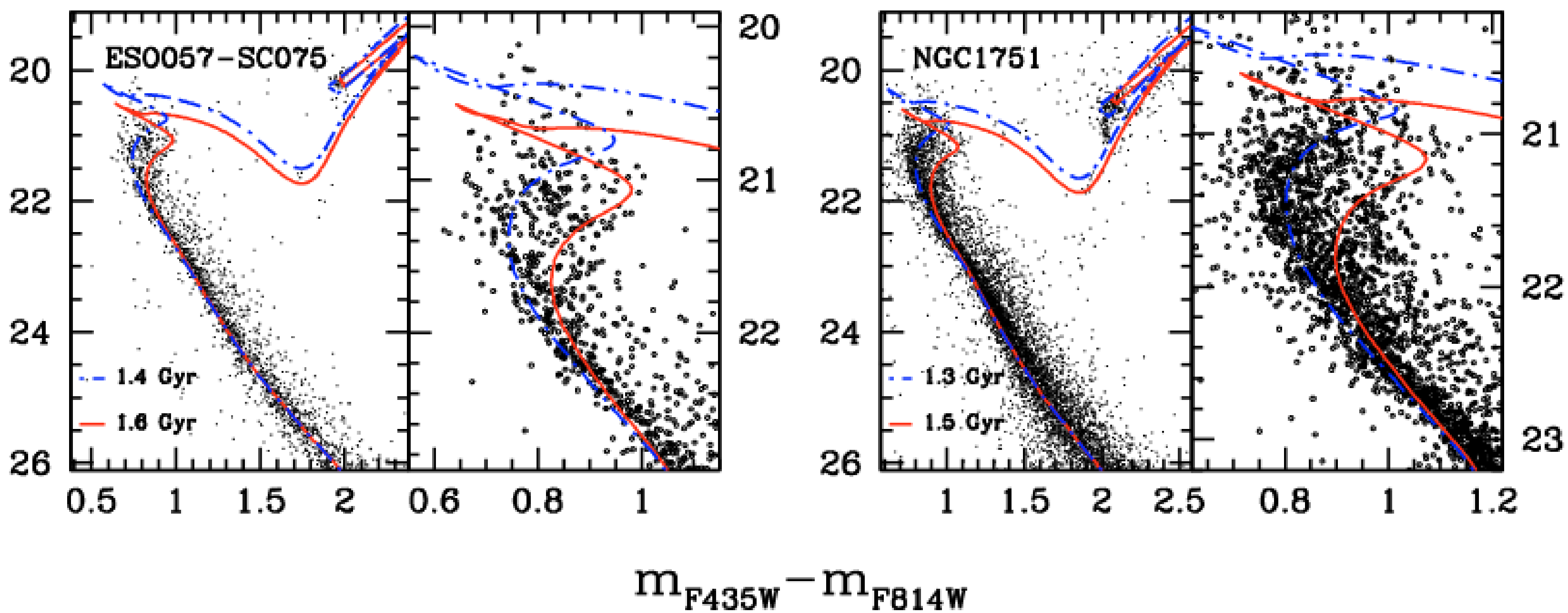

Fig. 37. The best-fitting isochrones, obtained by using the distance modulus, reddening, metallicity, and age(s) of NGC 1846, NGC 1987, NGC 1783, NGC 1806, ESO057-SC075, and NGC 1751 listed in Table 3 and overplotted on the CMD of the cluster field of (*left*). A zoom of the region around the MSTO is shown *on the right*.

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Not-so-simple stellar populations in nearby, resolved massive star clusters

Richard de Grijs[1,2,4] and Chengyuan Li[3]

1. Simple or not?

Since the launch of the *Hubble Space Telescope* (*HST*), more than 20 years ago now, studies of 'populous' star clusters (that is, clusters with masses in excess of $\sim 10^4$ M$_\odot$ and of any age) have unveiled major new insights. The concept of star clusters as 'simple' stellar populations, that is, composed of stars of approximately the same age and the same chemical abundance (since all stars were thought to have formed roughly at the same time from the same progenitor molecular cloud), is now no longer viable. Our understanding of star cluster formation and evolution has been revolutionised (and has also become confused) by (i) old Milky Way 'globular' clusters that exhibit anticorrelations between the sodium and oxygen abundances of their member stars or star-by-star chemical variations (Kraft 1994, Gratton *et al* 2001, 2004, Carretta *et al* 2009); (ii) clusters of any age displaying multiple sequences in the diagnostic Hertzsprung–Russell diagram (relating stellar luminosities to their surface temperatures; e.g., Piotto *et al* 2007, Villanova *et al* 2007, Mackey *et al* 2008, Milone *et al* 2008, 2017), at any age; and (iii) the significant widths of the so-called main-sequence turn-off regions in many star clusters as young as a few tens of millions of years (e.g., Milone *et al* 2009).

Simple stellar populations were always predominantly a theoretical construct, which—at best—could be closely approximated but never fully matched by real observations. Colour–magnitude diagrams (the observational counterparts of the theoretical Hertzsprung–Russell diagrams) showing sharp, well-defined main-sequence turn-offs imply that cluster member stars closely resemble single-age populations; tight main-sequence ridge lines suggest that any spread in their chemical composition is minimal, so that the only free parameter determining the morphology from the bottom of the main sequence to the turn-off region is stellar mass.

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PROPIEDADES FISICAS DE ESTRELLAS ROJAS EVOLUCIONADAS EN CUMULOS ABIERTOS

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BOL. N°25 - ASOC. ARG. DE ASTR.

Para explicar tales diferencias podríamos presentar varias alternativas posibles. Aquélla que nos parece mas razonable consiste en aceptar que la causa principal radica en la diferencia de las masas típicas de las dos clases de agregados considerados. En efecto, los cúmulos globulares, al ser mas masivos, podrían estar en condiciones de producir una segunda o quizás tercera generación de estrellas con diferentes composiciones. Por el contrario, los cúmulos abiertos, con masas considerablemente menores, es probable

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BVI photometry of the very old open cluster Berkeley 17*

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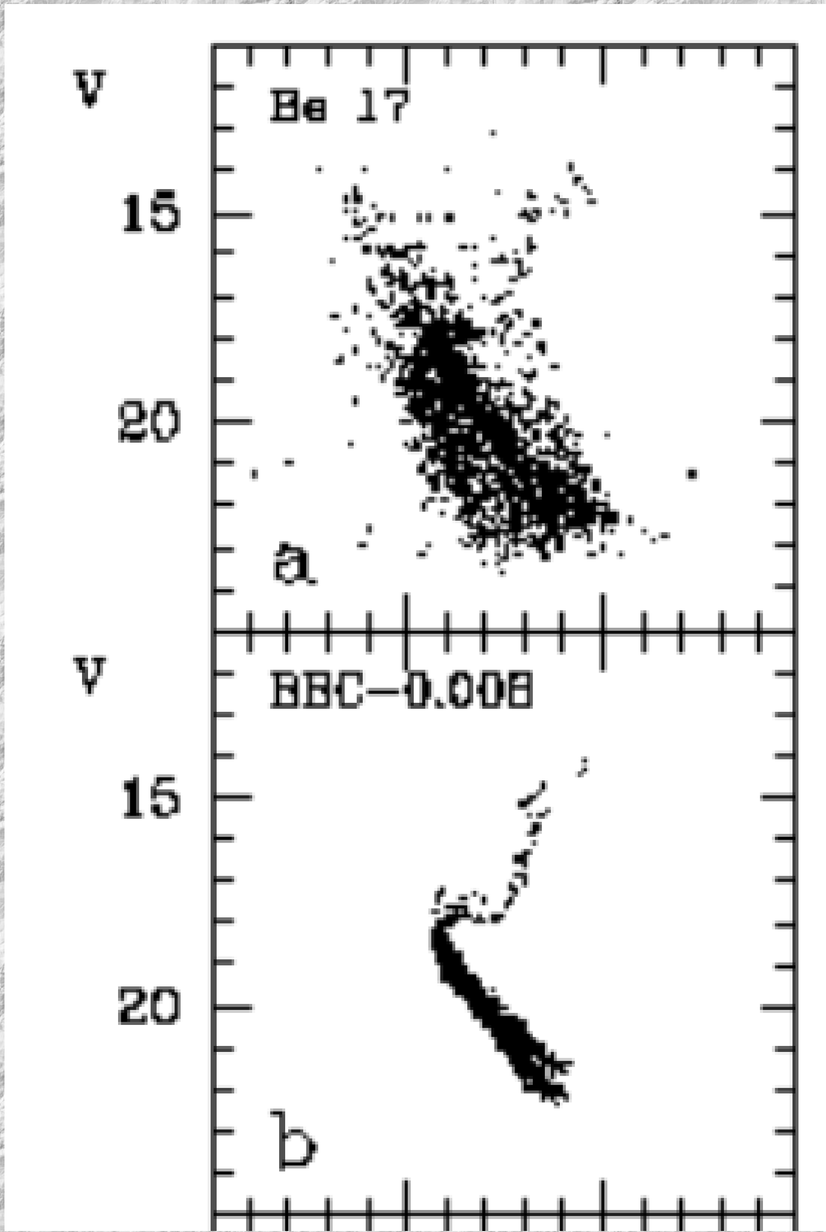
ABSTRACT

We have obtained *BVI* CCD imaging of Berkeley 17, an anticentre open cluster that competes with NGC 6791 as the oldest known open cluster. Using the synthetic colour–magnitude diagrams (CMDs) technique with three sets of evolutionary tracks, we have determined that its age is 8.5–9.0 Gyr, it distance modulus is $(m-M)_0 = 12.2$, with a reddening of $E(B-V) =$ 0.62–0.60. Differential reddening, if present, is at the 5 per cent level. All these values have been obtained using models with metallicity about half of solar ($Z = 0.008$ or 0.01 depending on the stellar evolution tracks), which allows us to reproduce the features of the cluster CMD better than other metallicities. Finally, from the analysis of a nearby comparison field, we think to have intercepted a portion of the disrupting Canis Major dwarf galaxy.



BVI photometry of the very old open cluster Berkeley 17*

Angela Bragaglia[1]†, Monica Tosi[1], Gloria Andreuzzi[2,3] and Gianni Marconi[4]

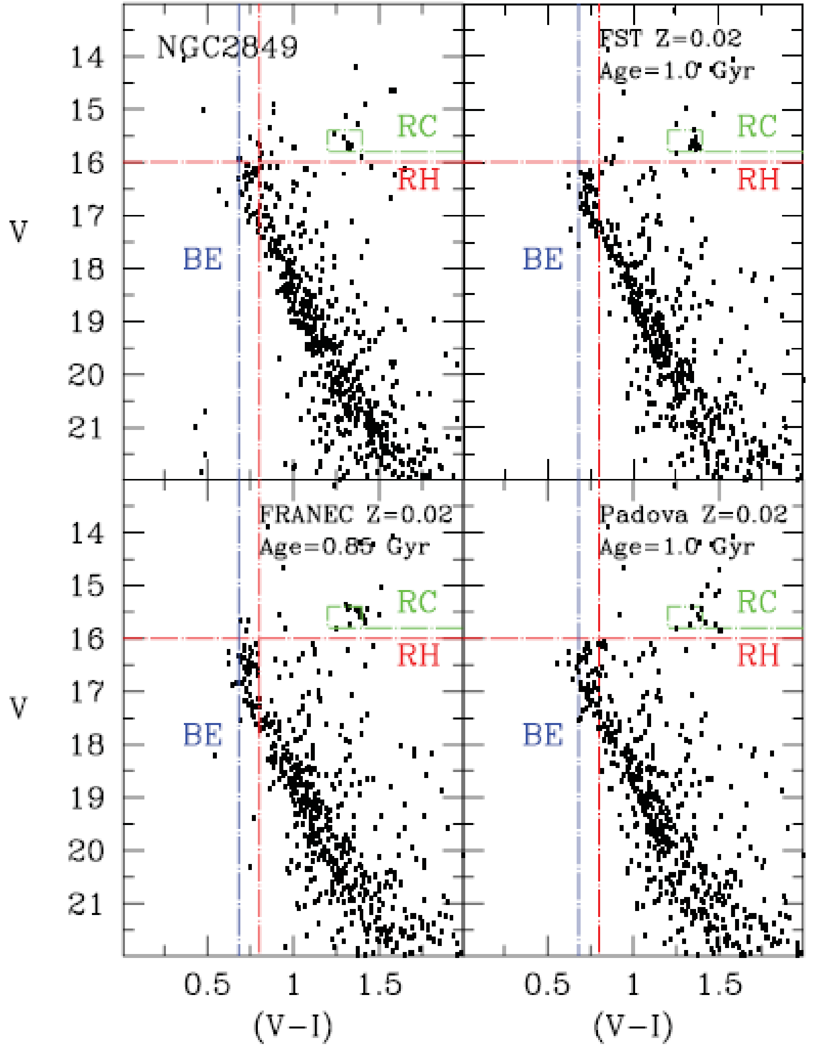
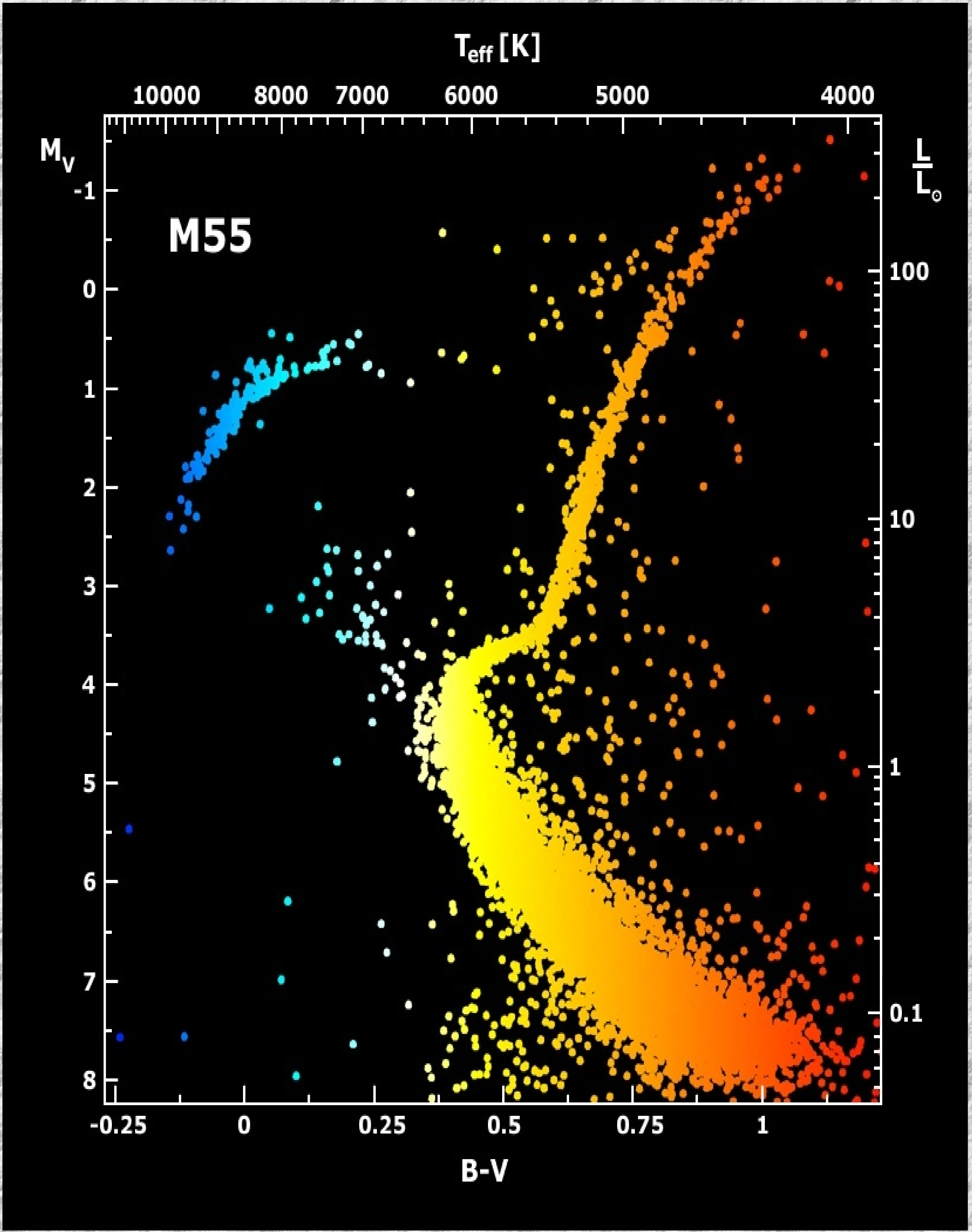
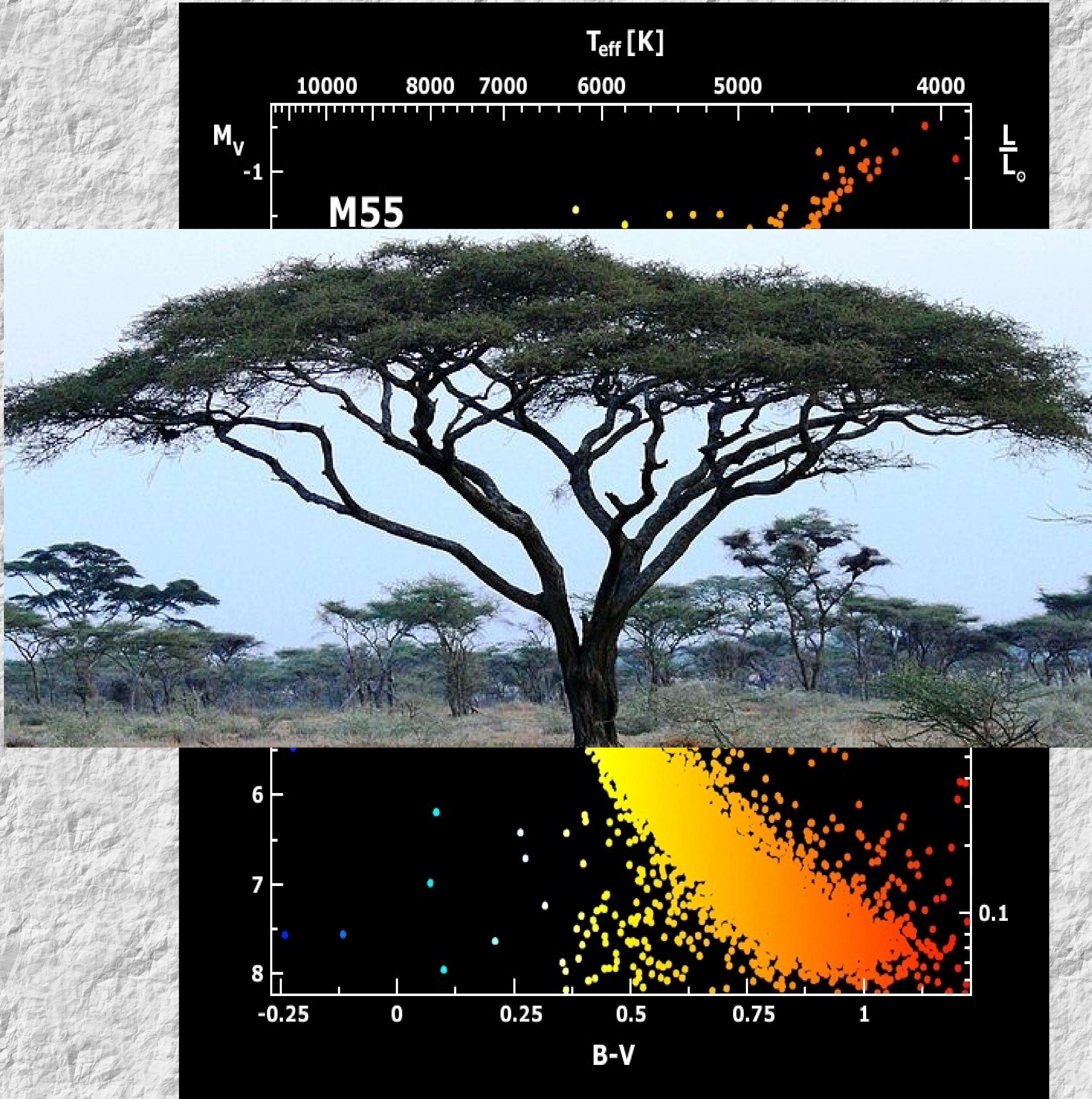


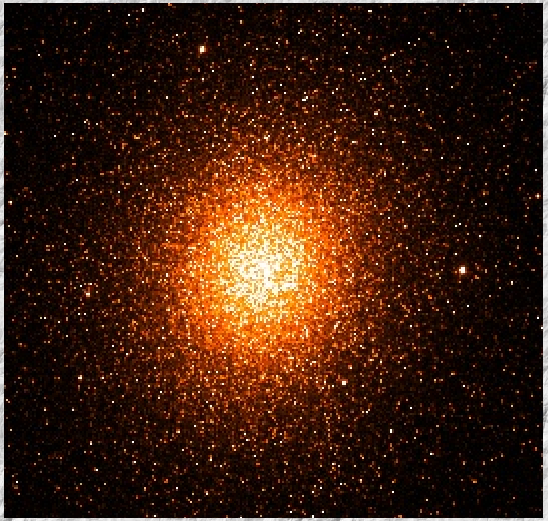
Figure 13. The upper-left panel shows the $V, V - I$ CMD for NGC 2849. The magnitude and colours of main evolutionary features are indicated with red (RH), green (RC) and blue (BE) dot–dashed lines. The other panels, clockwise from this, show the best-fitting synthetic CMDs for the following parameters: FST $Z = 0.02$, age 1.0 Gyr, $E(B - V) = 0.325 \pm 0.025$ and $(m - M)_0 = 13.8$; Padova $Z = 0.02$, age 1.0 Gyr, $E(B - V) = 0.285 \pm 0.025$ and $(m - M)_0 = 13.9$; FRANEC $Z = 0.02$, age 0.85 Gyr, $E(B - V) = 0.315 \pm 0.025$ and $(m - M)_0 = 13.95$. The adopted percentage of binaries (with random mass ratio) is always 30 per cent.

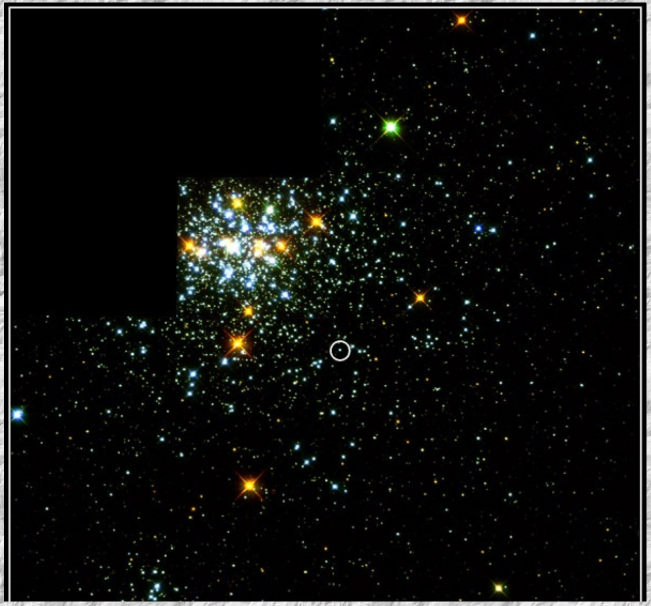


T_{eff} [K]
10000
8000
7000
6000
5000
4000
M_V
-1
0
1
2
3
4
5
6
7
8
M55
$\frac{L}{L_\odot}$
100
10
1
0.1
-0.25
0
0.25
0.5
0.75
1
B-V

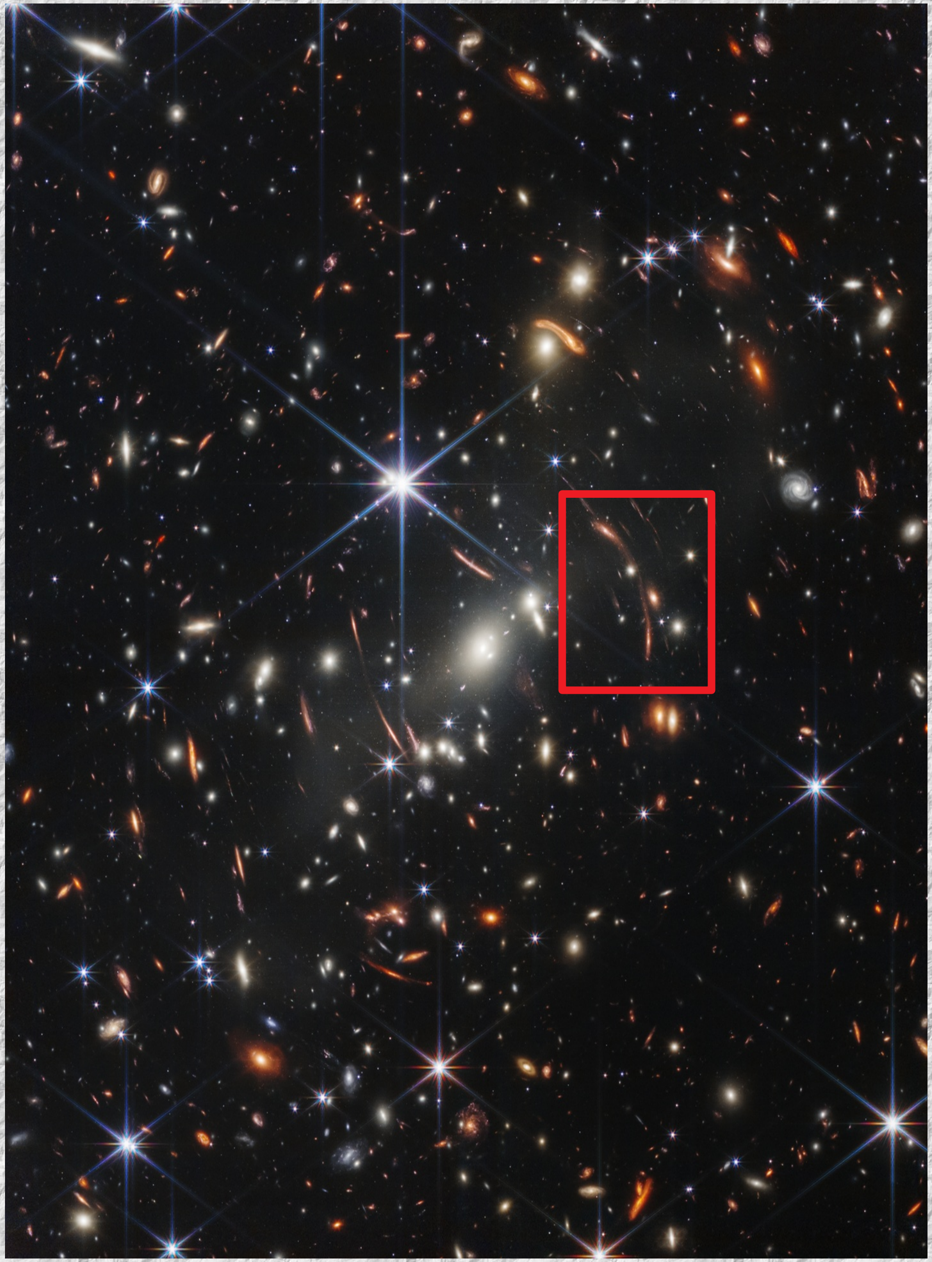

T_eff [K]
10000
8000
7000
6000
5000
4000
M_V
-1
M55
L/L☉
6
7
8
0.1
-0.25
0
0.25
0.5
0.75
1
B-V

Cúmulos estelares





EVOLUCIÓN ESTELAR
~ composición química
~ edad
~ distancia



EVOLUCIÓN ESTELAR
Cúmulos estelares:

~ composición química
~ edad
~ distancia

Relax ...