Cúmulos estelares

Constelaciones

Asterismos

Constelaciones

Asterismos

Asociaciones estelares

Cúmulos estelares (CE - SCs)

Constelaciones

Asterismos

Asociaciones estelares

Cúmulos estelares (CE - SCs)

Cúmulos estelares galácticos

Constelaciones

Asterismos

Asociaciones estelares

Cúmulos estelares (CE - SCs)

Cúmulos estelares galácticos
- Cúmulos abiertos (CA - OCs)
- Cúmulos globulares (CG - GCs)

Constelaciones

Asterismos

Asociaciones estelares

Cúmulos estelares (CE - SCs)

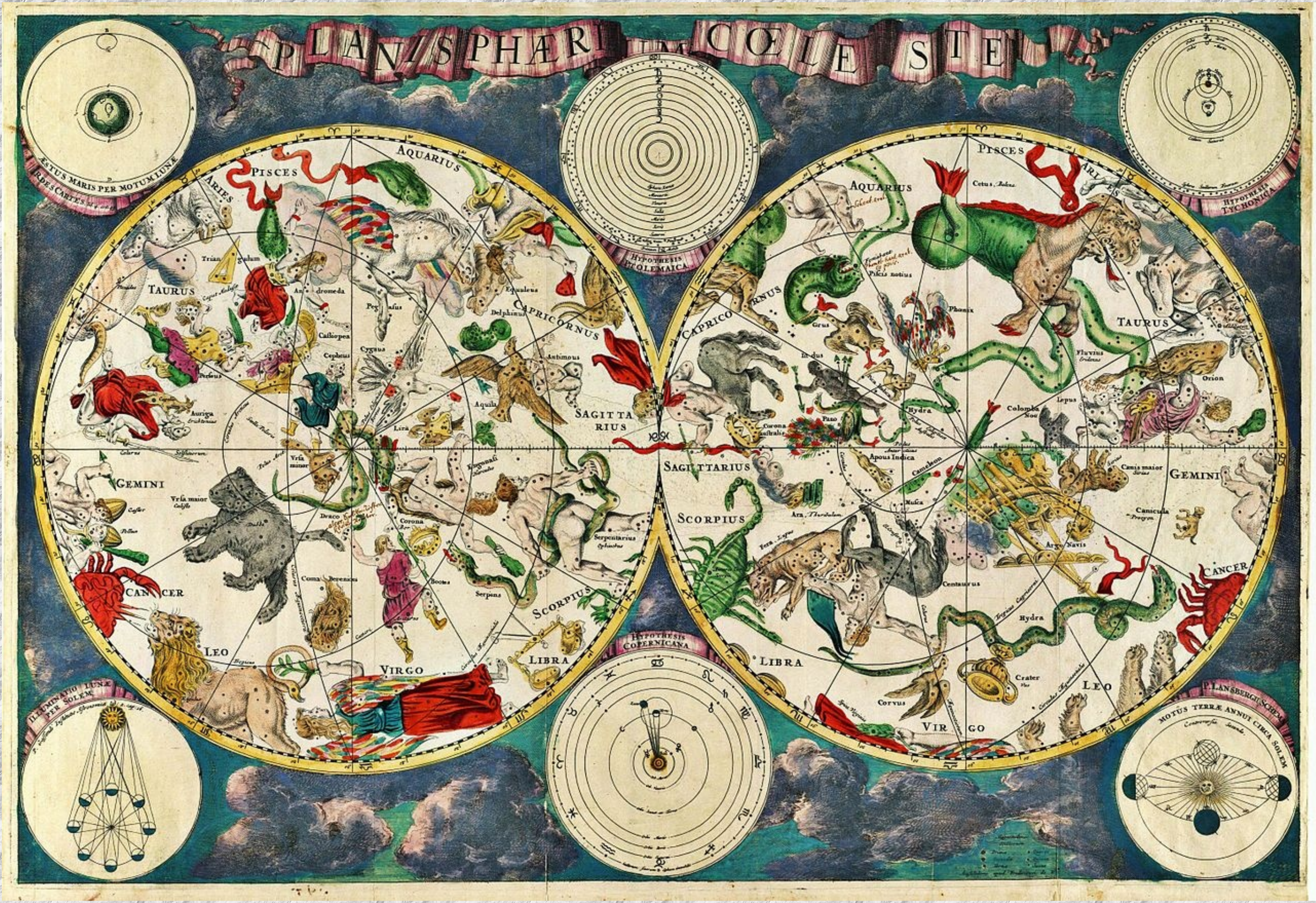
Cúmulos estelares galácticos
- Cúmulos abiertos (CA - OCs)
- Cúmulos globulares (CG - GCs)

Cúmulos estelares extragalácticos

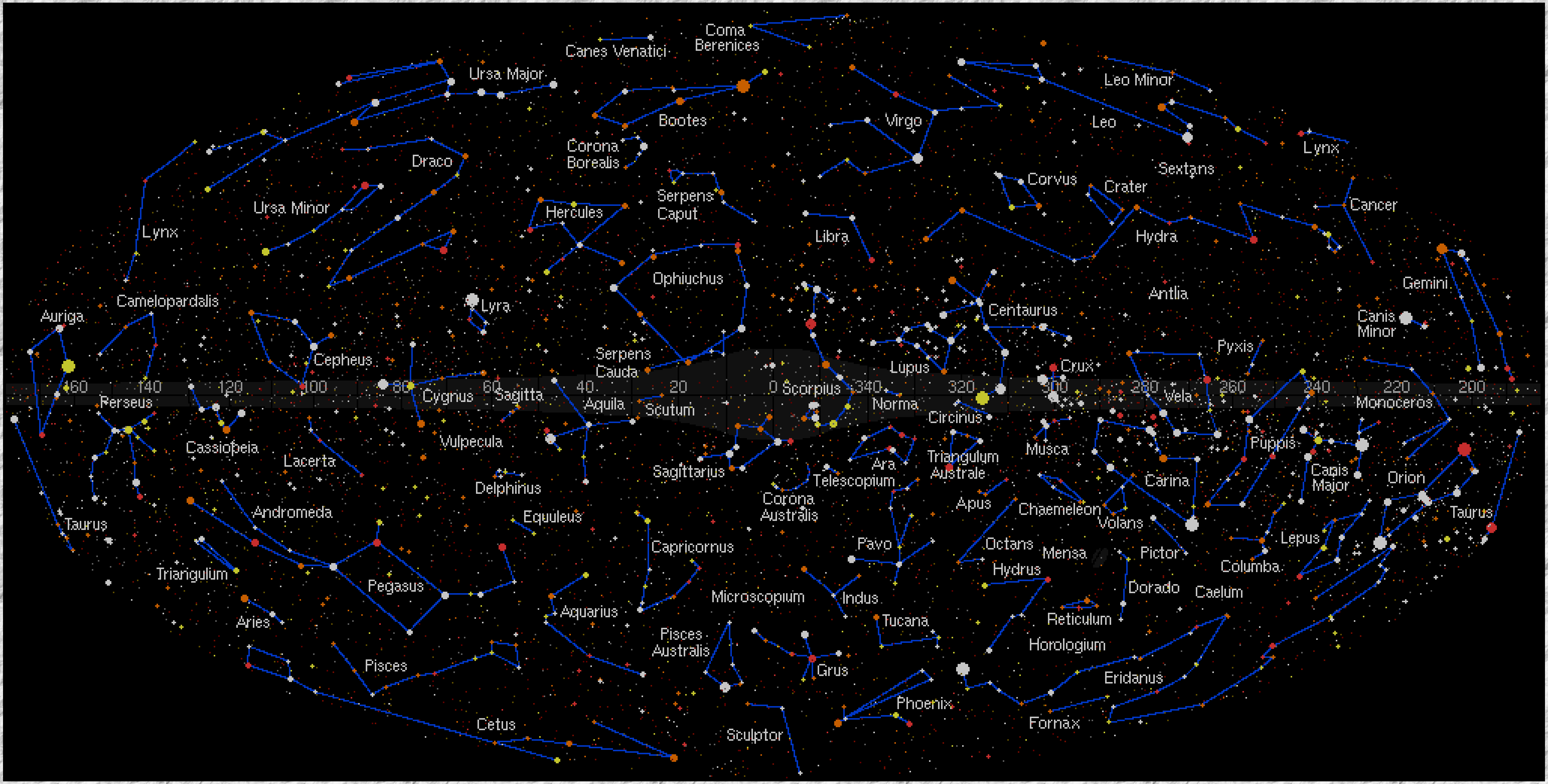
Constelaciones

88 constelaciones – IAU (1928)

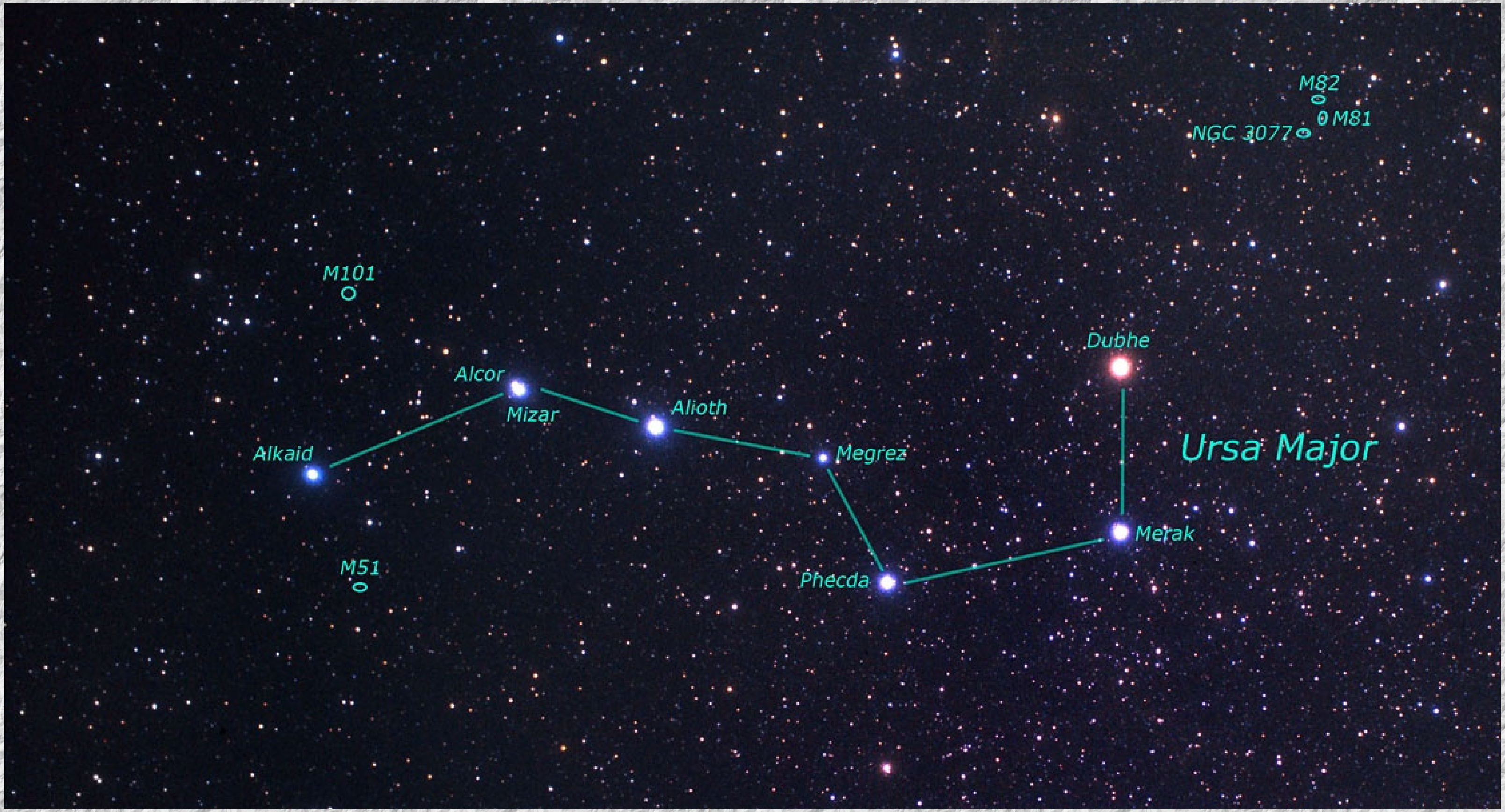
Constelaciones



Constelaciones

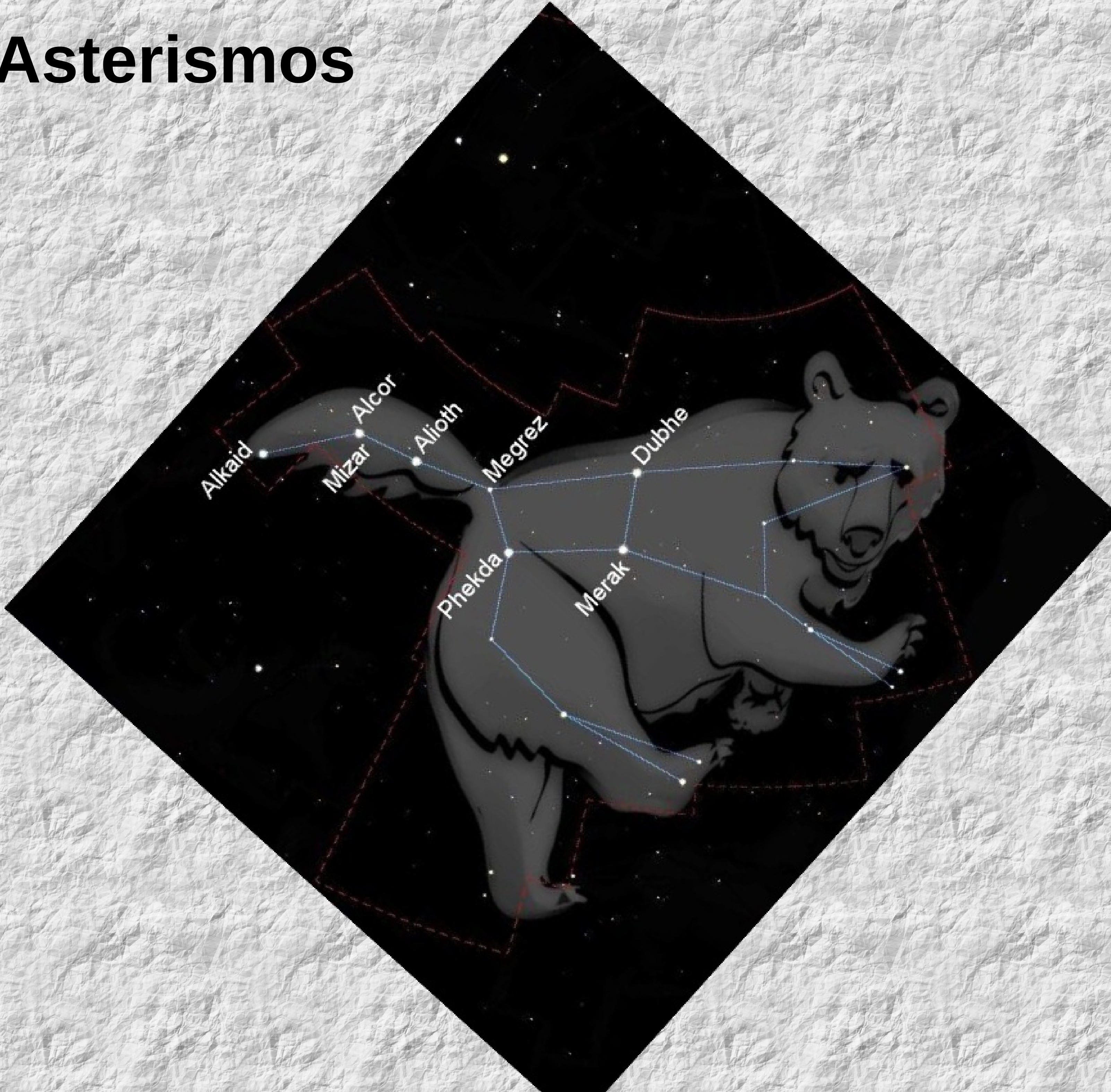


Asterismos



M82
M81
NGC 3077
M101
Dubhe
Alcor
Mizar
Alioth
Alkaid
Megrez
Ursa Major
Merak
M51
Phecda

Asterismos



Asterismos

Asterismos

Izquierda: Europa medieval llamaba a esas mismas estrellas la Carreta de Carlos o el Carro. Centro, los antiguos griegos y los pueblos nativos de América veían esas estrellas como la cola de la Osa mayor, Ursa major. Derecha: Los antiguos egipcios representaron en este grupo mayor de estrellas que incluye a la Osa mayor, una curiosa procesión formada por un toro, un hombre o dios horizontal, y un hipopótamo con un cocodrilo a cuestas. (Dibujos animados y fotografiados por Judy Kreijanovsky, Cartoon Kitchen.)

Asociaciones estelares
~ 10-100 estrellas ~~ligadas gravitacionalmente~~
(V. Ambartsumian, 1947)

OB, R, T, ... Associations

5. Discovery of Stellar Associations, 1947. V. Ambartsumian originally introduced the term Stellar Association, dividing them into two groups: OB and T associations. He recognized that they are star forming regions at a time when the whole idea of star formation as an ongoing process was regarded as very speculative. This interpretation of groups of stars with positive total energy, in combination with ideas that can be traced back to his thesis advisor, A. A. Belopolsky, played a role in his eventual interpretation of quasars and other active galaxies as due to explosive expansion from some dense core rather than as accretion-powered sources.

Asociaciones estelares
~ 10-100 estrellas ~~ligadas gravitacionalmente~~
(V. Ambartsumian, 1947)

Communications of BAO, Vol. 69, Issue 1, 2022, pp. 127-139

The Evolution of Stars and Astrophysics

V.A. Ambartsumian

Byurakan Astrophysical Observatory, Armenia

Abstract

Ambartsumian published this article in Russian 75 years ago. In this work, he showed for the first time that star formation was not interrupted in the past, but continues in our cosmological time. His conclusion was that at the same time as the old stars, such as the Sun, there are also much younger ones, which are only a few tens of millions of years old. Another important conclusion was that stars are born in groups. The author called the groups of young stars stellar associations. Actually, by publishing this article, Ambartsumian established a new, so-called "Byurakan concept" of the formation of space objects.

Asoc

~ 10-

(V. A

Star associations. Even stronger evidence in favor of this is the presence of scattered groups of hot stars around some clusters, for example, the double cluster χ and h Persei, the NGC 6231 cluster, and others. These scattered groups, which are associations of loosely connected members, are unstable and, for dynamic reasons, must disintegrate over several tens of millions of years. I would suggest calling them star associations. In such a stellar association around NGC6231, there are, among only twenty high luminosity stars, for example, two Wolf-Rayet stars and two P Cyg stars. According to Kozyrev's theory of extended photospheres (Kozyrev, 1934), stars of these types emit one hundred thousandths of the mass of the Sun every year. Therefore, such an outflow cannot continue for one star without change for more than a million or two million years. Therefore, it is not difficult to see that such a state of these stellar associations, which undoubtedly have a common origin, can last generally at most on the order of tens of millions of years.

Especially remarkable is the stellar association around the double cluster χ and h Persei. In a circle with a radius of 2.5 degrees centered in this cluster, there are several dozen type B and M supergiants. It is possible that this association also contains many stars of other physical types. Taking a distance of two thousand parsecs for this system, we find that its diameter is about two hundred parsecs. The double cluster forms the core of this association. This core itself may have the same degree of stability as other open clusters, but the entire association as a whole is certainly unstable and should disintegrate under the disturbing influence of the galactic center unless the mass of this system is estimated at millions of solar masses. However, there is no evidence in favor of such a large mass.

Groups of T Tauri variable stars are another striking example of young stellar associations.

The facts show that almost all the variable stars of this type known to us, characterized by extremely irregular changes in brightness and certain other physical characteristics, are concentrated in two or three specific parts of the sky. Such an extremely pronounced tendency towards crowding cannot in any way be connected with the accident in their discovery. There is no doubt that we are dealing here with members of certain physical groups of stars. However, the linear dimensions of each of these groups are so large that there can be no question of their proximity in space to be supported by the forces of mutual attraction. The tidal action emanating from the center of the Galaxy should destroy them very quickly. Most likely, one should assume that these stars are already slowly diverging. So, one of these groups of 7 T Tauri stars, according to Joy (1945), has a center at a point in the sky with a galactic longitude of 140° and a latitude of −14°. Joy's data (Joy, 1945) suggest that the linear dimensions of this system reach 10–20 parsecs. Even if we assume that the number of members of this system is more than a thousand, this stellar association, cannot be held for a long time under the influence of internal forces of attraction. The conclusion is that if we now observe these stars together, it is because they have recently formed and have not yet had time to disperse. This stellar association cannot be older than one hundred million years. This period is short compared to the age of the Galaxy, which we estimate at several billion years. Consequently, *even now, in our era, the formation of stars in the Galaxy continues*. This is also an extremely important conclusion from the data of modern astrophysics.

Asociaciones estelares
~ 10-100 estrellas ~~ligadas gravitacionalmente~~
(V. Ambartsumian, 1947)

OB, R, T, ... Associations

Associations are loose stellar systems that may contain as many as 2600 stars, as in Cyg OB2 (Albacete Colombo et al. 2002; Knödlseder 2000). Although sharing a common origin and moving approximately in the same direction through the Galaxy, the member stars are gravitationally unbound. This definition encompasses a wide variety of objects, from the extended OB associations in spiral arms (Blaauw 1964) to the post-T Tauri associations in the Solar neighbourhood (e.g. Torres et al. 2000). OB associations can be observed over a wide range of distances from the Sun, from the relatively nearby (≈140 pc) Scorpius-Centaurus Association (Maíz-Apellániz 2001) to the sparse and large (~400 pc) associations in the Large Magellanic Cloud and Andromeda (Efremov & Elmegreen 1998).

Most field stars appear to have been formed in stellar groups of different kinds, the OB associations in particular (Gomes et al. 1993; Massey et al. 1995). Rapid early gas removal is an efficient mechanism to drive cluster stars into the field and dissolve most of the very young star clusters on a time scale of 10–40 Myr, depending on cluster mass and star-formation efficiency (e.g. Goodwin & Bastian 2006). As a consequence of this, only about 5% (Lada & Lada 2003) of the embedded clusters are able to dynamically evolve into bound open clusters (OCs).

A&A 489, 1129–1140 (2008)
DOI: 10.1051/0004-6361:200810236

Investigating the borderline between a young star cluster and a small stellar association: a test case with Bochum 1

E. Bica[1], C. Bonatto[1], and C. M. Dutra[2]

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~ 10-100 estrellas ~~ligadas gravitacionalmente~~
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Cúmulos Estelares

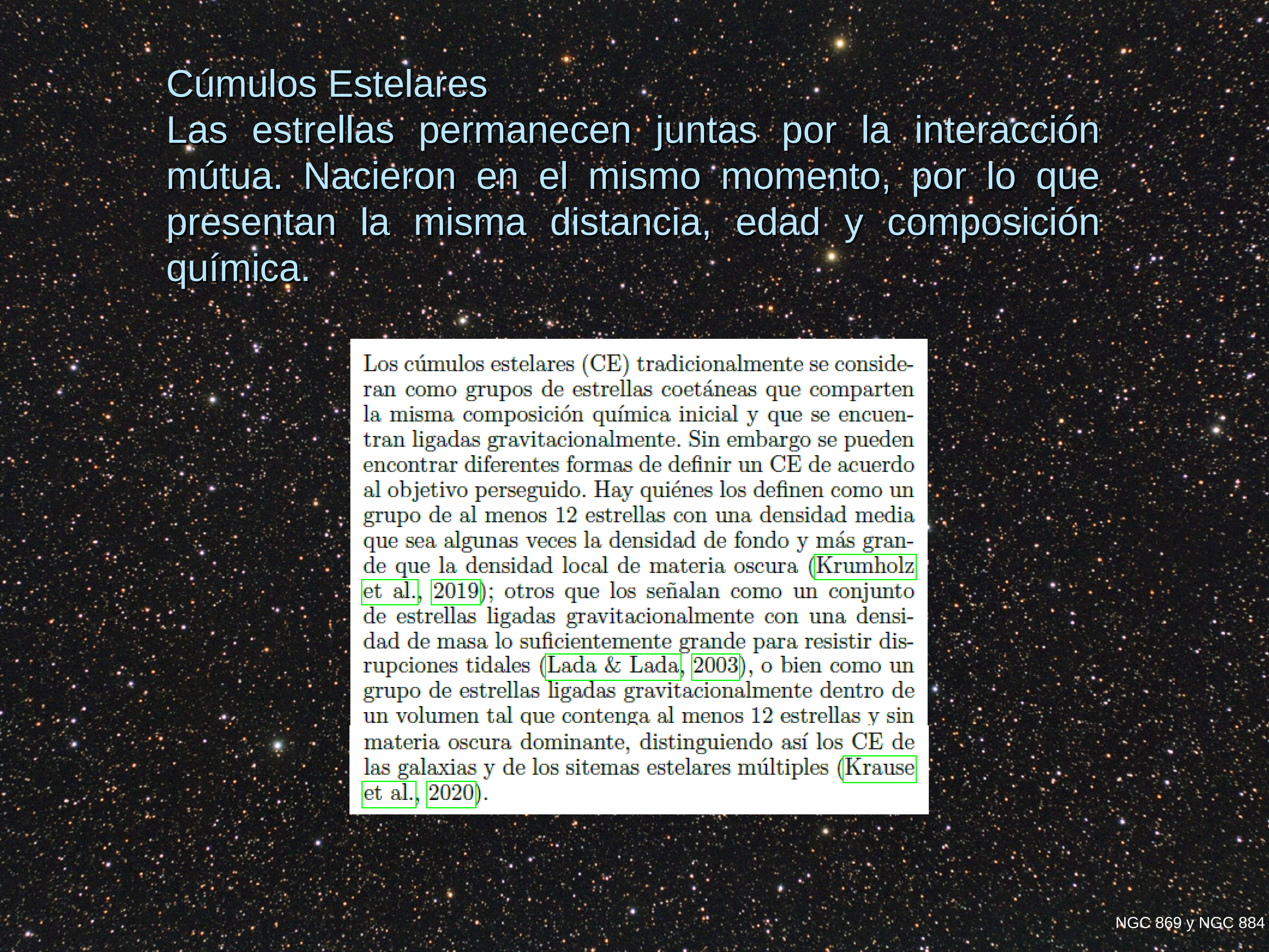
Las estrellas permanecen juntas por la interacción mútua. Nacieron en el mismo momento, por lo que presentan la misma distancia, edad y composición química.

NGC 869 y NGC 884

Cúmulos Estelares

Las estrellas permanecen juntas por la interacción mútua. Nacieron en el mismo momento, por lo que presentan la misma distancia, edad y composición química.

Los cúmulos estelares (CE) tradicionalmente se consideran como grupos de estrellas coetáneas que comparten la misma composición química inicial y que se encuentran ligadas gravitacionalmente. Sin embargo se pueden encontrar diferentes formas de definir un CE de acuerdo al objetivo perseguido. Hay quiénes los definen como un grupo de al menos 12 estrellas con una densidad media que sea algunas veces la densidad de fondo y más grande que la densidad local de materia oscura (Krumholz et al., 2019); otros que los señalan como un conjunto de estrellas ligadas gravitacionalmente con una densidad de masa lo suficientemente grande para resistir disrupciones tidales (Lada & Lada, 2003), o bien como un grupo de estrellas ligadas gravitacionalmente dentro de un volumen tal que contenga al menos 12 estrellas y sin materia oscura dominante, distinguiendo así los CE de las galaxias y de los sitemas estelares múltiples (Krause et al., 2020).



NGC 869 y NGC 884

Cúmulos Estelares (*Simple stellar populations*?)

Las estrellas permanecen juntas por la interacción mútua. Nacieron en el mismo momento (?), por lo que presentan la misma distancia, edad (?) y composición química (?).

Un poco de historia … M22

El primer cúmulo globular (CG - GC) (M22, A. Ihle, S XVII)

Un poco de historia …

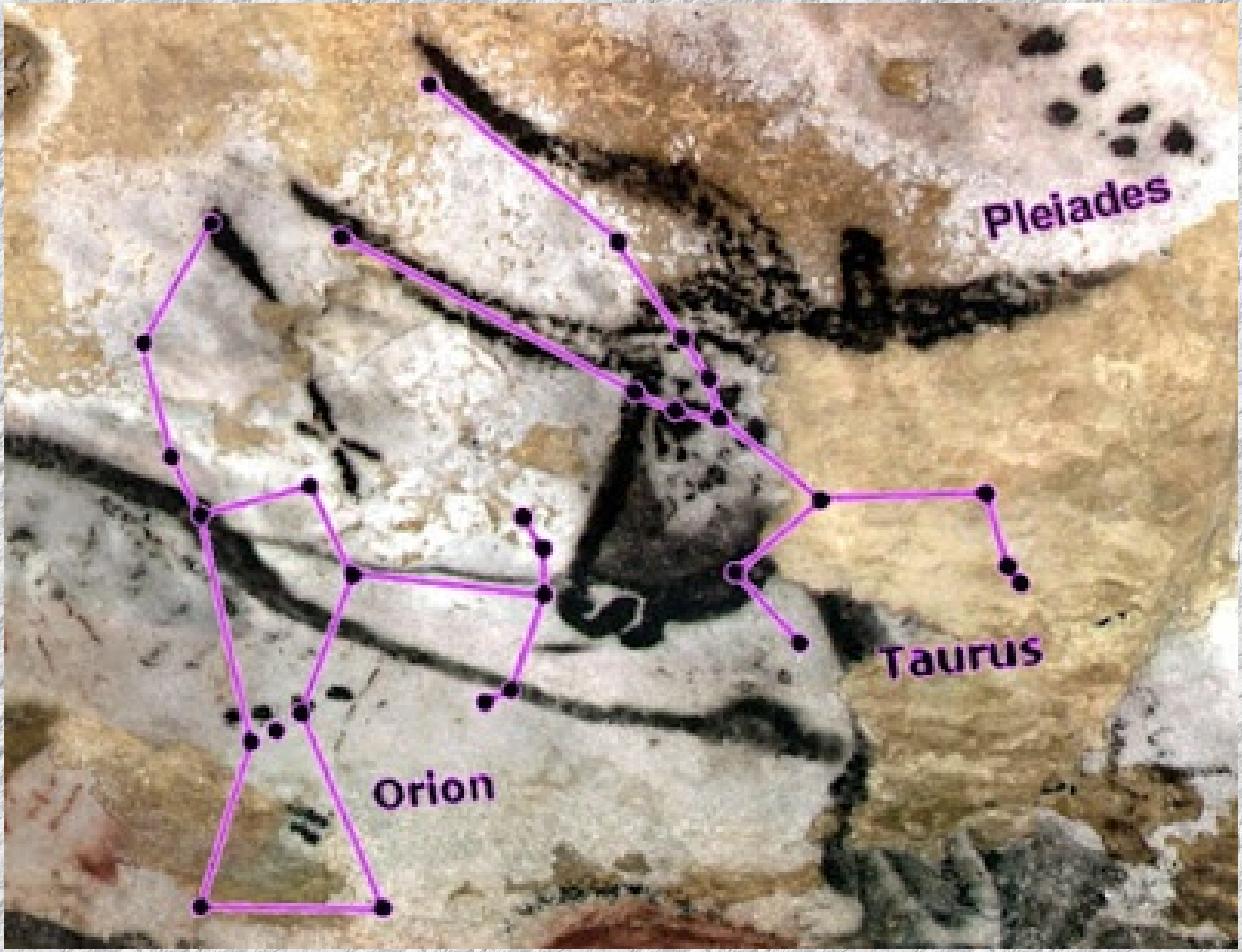
El primer cúmulo globular (CG - GC) (M22, A. Ihle, S XVII)

Un poco de historia

Un poco de historia

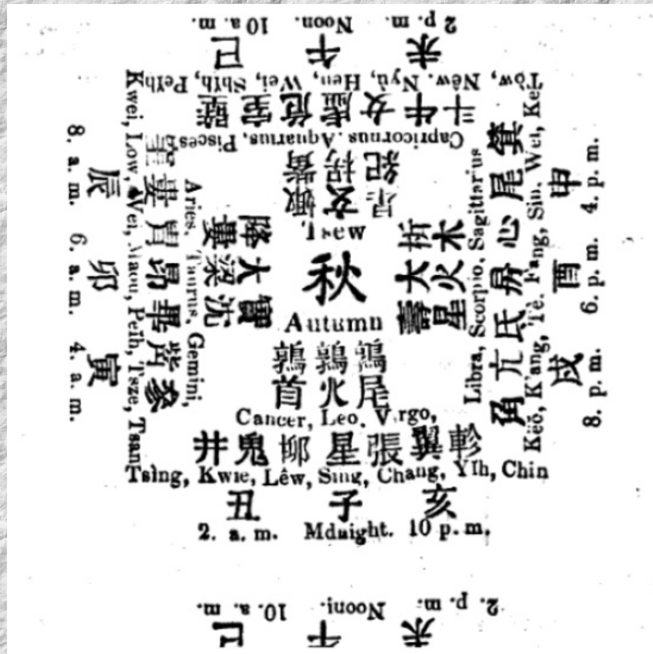
Un poco de historia …

El primer cúmulo abierto (CA - OC) (~ 17000, Lascaux, Fr.)

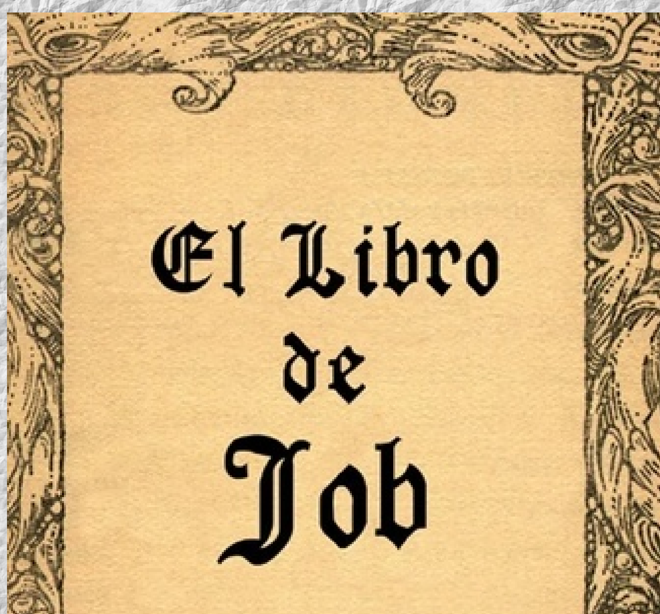


Pleiades: Disco de Nebra (~ 1600 AC, Alemania)

Pleiades:



(~ 4500 AC)



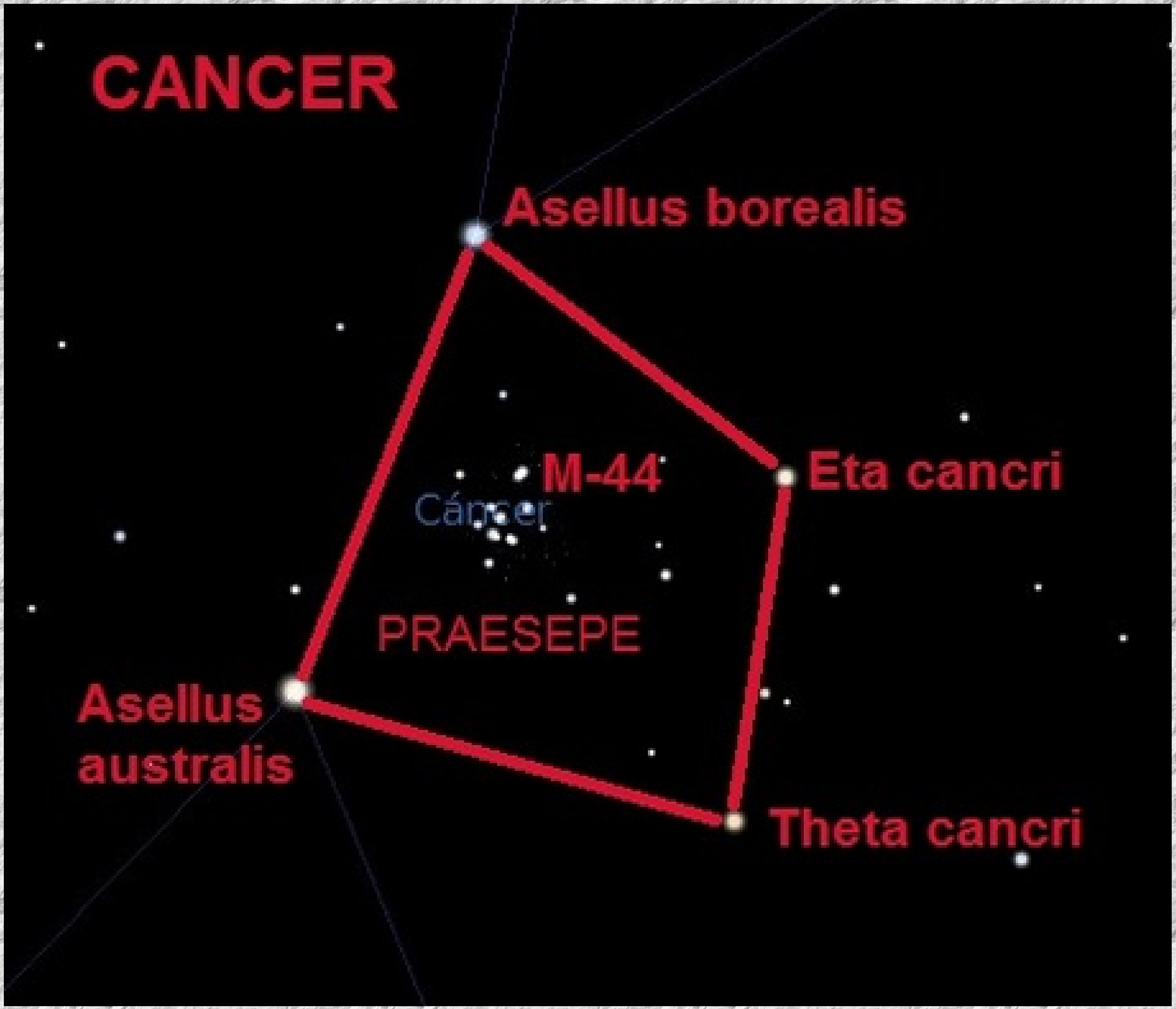
(~ 600 AC)

The Pleiades Constellation

The name Subaru is Japanese, meaning 'unite' - but it's also a term for a cluster of six stars in the Taurus constellation, named 'Pleiades' by the Ancient Greeks. At the time, these stars were thought to represent the seven daughters of Greek mythological figures Atlas and Pleione.

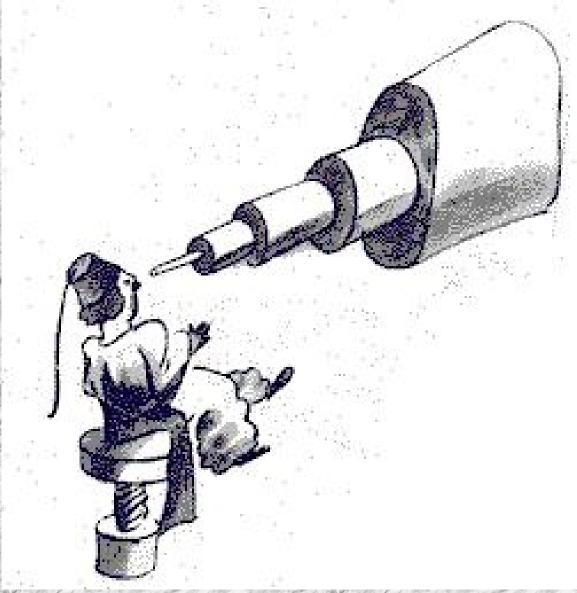
But how can there be seven daughters and only six stars in the Pleiades constellation? Because there are in fact seven stars, but only six are obviously visible to the naked eye.

S XVII: ¿9 OCs?



CANCER
Asellus borealis
M-44
Cáncer
Eta cancri
PRAESEPE
Asellus
australis
Theta cancri

Galileo Galilei (1610): “ ...conjuntos de innumerables Estrellas agrupadas en cúmulos demasiado pequeños y distantes para ser resueltas en estrellas individuales a simple vista ...”



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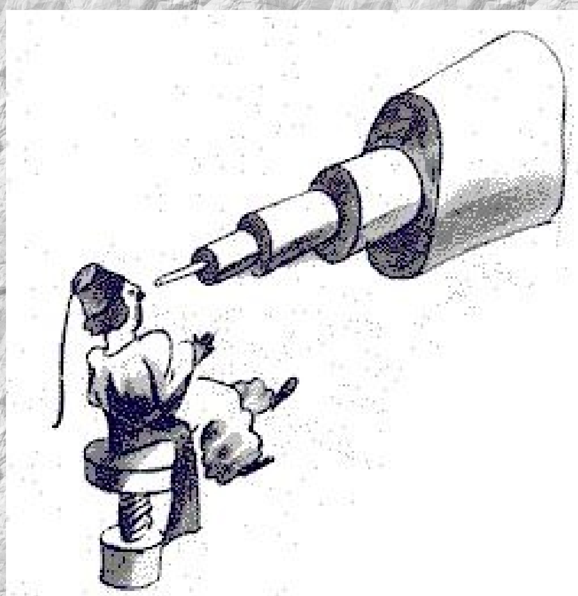
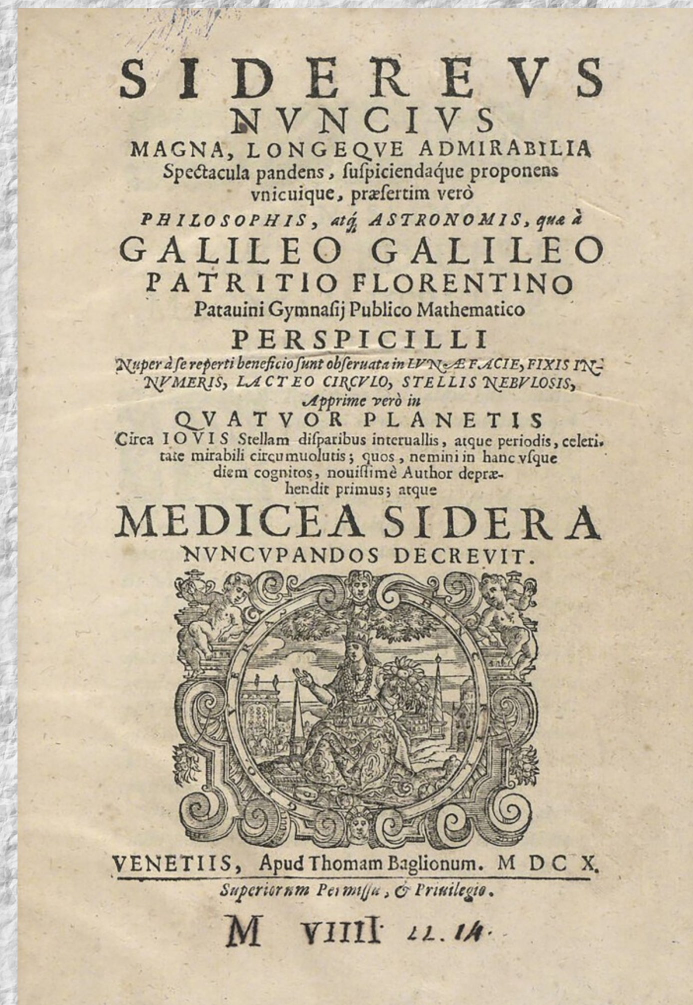
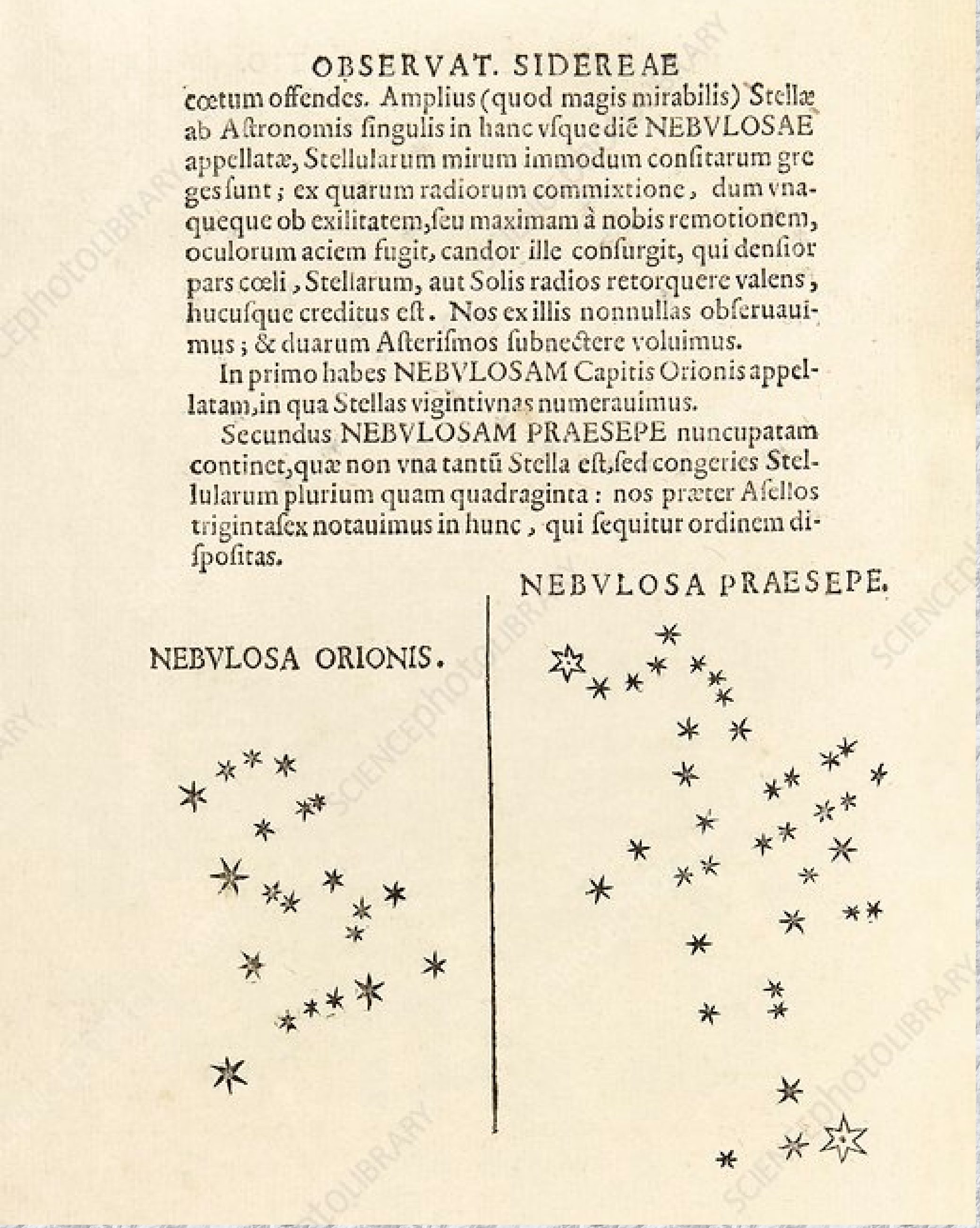




SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò
PHILOSOPHIS, atq; ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
Nuper à se reperti beneficio sunt obseruata in LVNÆ FACIE, FIXIS IN-
NVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeritate mirabili circumuolutis; quos, nemini in hanc vsque diem cognitos, nouissimè Author depræhendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permissu, & Priuilegio.

S XVII: ¿9 OCs?



OBSERVAT. SIDEREAE

cœtum offendes. Amplius (quod magis mirabilis) Stellæ ab Aſtronomis ſingulis in hanc vſque diē NEBVLOSAE appellatæ, Stellularum mirum immodum conſitarum greges ſunt; ex quarum radiorum commixtione, dum vnaqueque ob exilitatem, ſeu maximam à nobis remotionem, oculorum aciem fugit, candor ille conſurgit, qui denſior pars cœli, Stellarum, aut Solis radios retorquere valens, hucuſque creditus eſt. Nos ex illis nonnullas obſeruauimus; & duarum Aſteriſmos ſubnectere voluimus.

In primo habes NEBVLOSAM Capitis Orionis appellatam, in qua Stellas vigintivnas numerauimus.

Secundus NEBVLOSAM PRAESEPE nuncupatam continet, quæ non vna tantū Stella eſt, ſed congeries Stellularum plurium quam quadraginta: nos præter Aſellos trigintaſex notauimus in hunc, qui ſequitur ordinem diſpoſitas.

NEBVLOSA ORIONIS.

NEBVLOSA PRAESEPE.

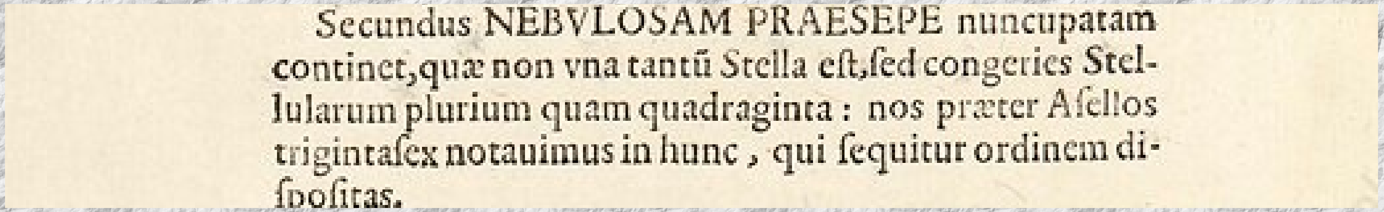
Un poco de historia

S XVII: 9 cúmulos abiertos

Secundus NEBVLOSAM PRAESEPE nuncupatam
continet,quæ non vna tantũ Stella eſt,ſed congeries Stel-
lularum plurium quam quadraginta : nos præter Aſellos
trigintaſex notauimus in hunc , qui ſequitur ordinem di-
ſpoſitas.

Un poco de historia

S XVII: 9 cúmulos abiertos


Secundus NEBVLOSAM PRAESEPE nuncupatam
continet, quæ non vna tantũ Stella eſt, ſed congeries Stel-
lularum plurium quam quadraginta : nos præter Aſellos
trigintaſex notauimus in hunc , qui ſequitur ordinem di-
ſpoſitas.

M 44

DE SYSTEMATE ORBIS COMETICI;

DEQVE

ADMIRANDIS COELI CHARACTERIBVS,

OPVSCVLA DVO,

IN QVORVM PRIMO

Cometarum Causæ disquiruntur, & explicantur,
necnon
Vię Cometarum, per Orbem Cometicum multiplices
Indicantur.
In Secundo vero
Quid, quales, quotue sint Stellæ Luminosæ; Nebulosæ;
necnon, & Occultæ, manifestantur,
& rerum Cælestium studiosis
commendantur.

AVTHORE
DON IOANNE BAPTISTA HODIERNA
Siculo Palmæ Archipræsbytero.

PANORMI, Typis Nicolai Bua, 1654.

SVPERIORVM PERMISSV.

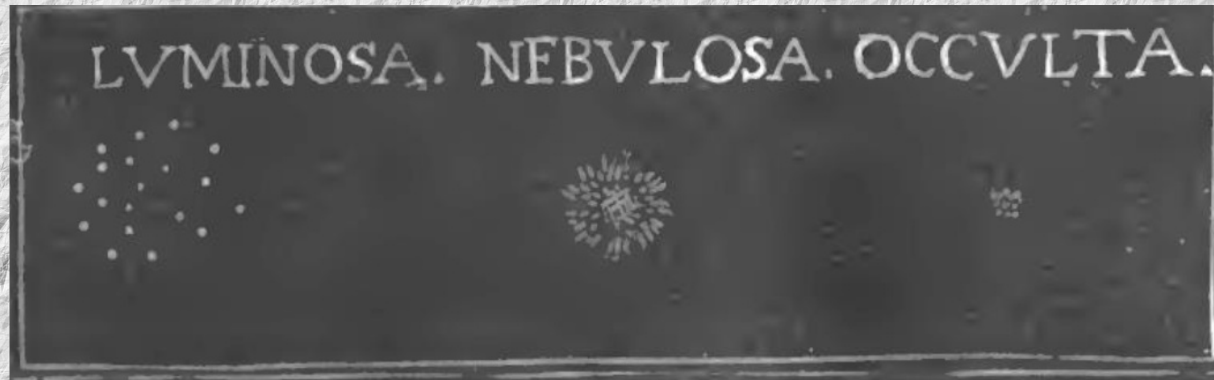
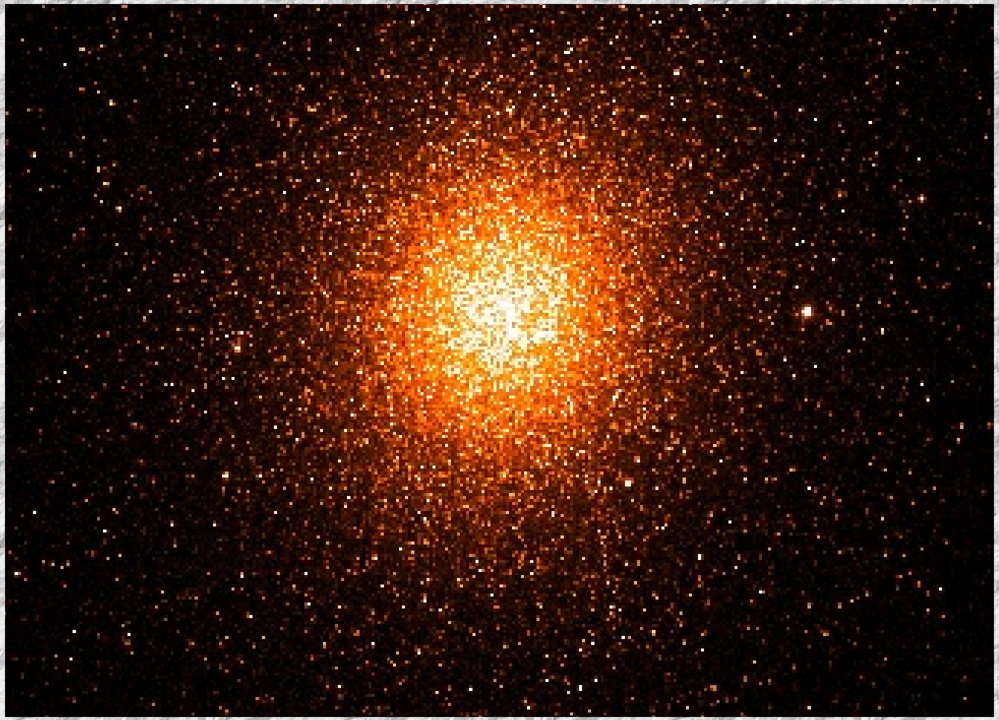


Table 1.1 Hodierna's Categorization of Objects

Luminosae	Nebulosae	Occultae
1. Pleiades	1. Praesepe	1. "Preceding the two southern stars of Coma Berenices" (asterism)
2. Hyades	2. M 7	2. "The one following these stars, in the shape of an open rose, according to Ptolemy, and of an ivy leaf according to Copernicus" (asterism)
3. Coma star cluster	3. NGC 869 & 884	3. M 31
4. α Per cluster	4. M 6	
5. M 42	5. ν_1, ν_2 Sagittarii (asterism)	
6. λ Ori cluster	6. M 8	
7. ζ Sco & NGC 6231	7. M 36/M 37/M 38	
8. "In the water of Aquarius" (unknown object)	8. Cr 399	
	9. 88 Her	
	10. σ Cap.	

Cúmulos estelares galácticos

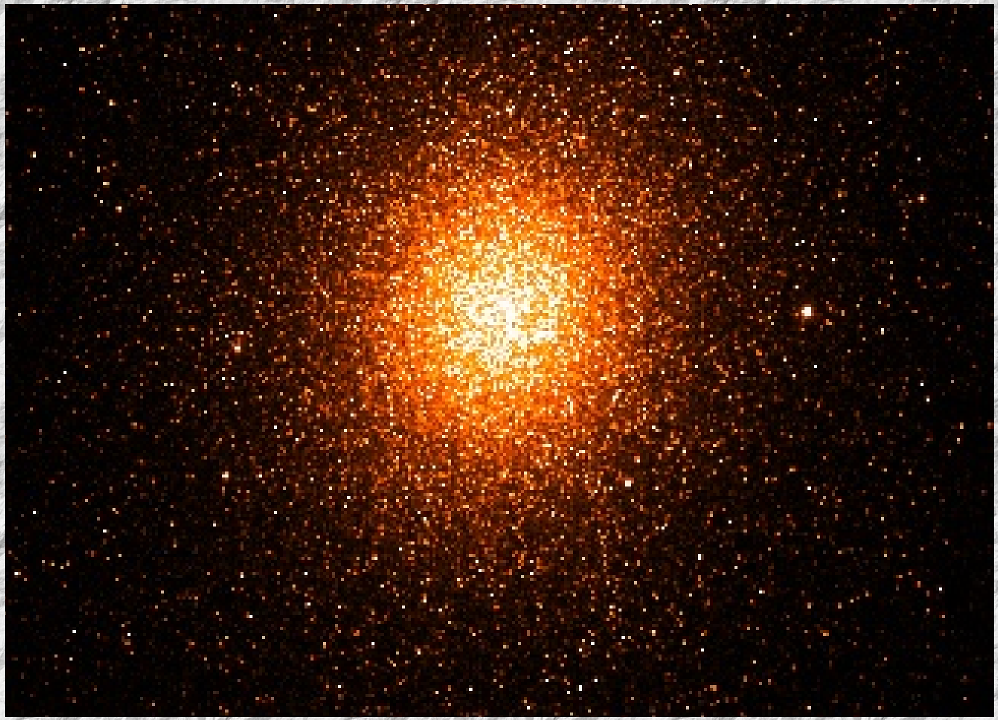


Cúmulos estelares galácticos

Cúmulos abiertos

Cúmulos globulares

M 45



NGC 5139 – Omega Cen

Cúmulos abiertos

Sistemas de estrellas

forma irregular

contienen ~ docenas / ~ cientos de estrellas

plano galáctico, orbitando el centro galáctico

composición química es, en gral., semejante a la del Sol

jóvenes

~ 2200.

Cúmulos abiertos

M 25, 67 Myr


CA: Las Pleiades (100 Myr)

UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 420

PRELIMINARY RESULTS ON THE DISTANCES, DIMENSIONS AND SPACE DISTRIBUTION OF OPEN STAR CLUSTERS

BY

ROBERT J. TRUMPLER

LICK OBSERVATORY,
January 22, 1930.
Issued April 7, 1930.

Clasificación de Trumpler (OCs)

Fig. 1. NGC 6819, Class I2r.

Fig. 2. NGC 2254, Class I2p.

Fig. 3. NGC 6705, Class II2r.

Fig. 4. NGC 1502, Class II3p.

Fig. 5. NGC 7789, Class III1r.

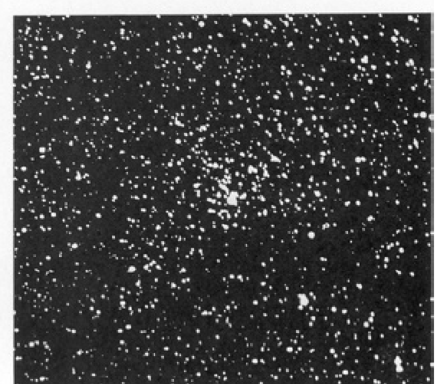


Fig. 6. NGC 1027, Class IV3m.

Clasificación de Trumpler (OCs)

In the first instance, the clusters were placed in four groups according to the degree of concentration:

- **I.** Detached clusters with strong central concentration.
- **II.** Detached clusters with little central concentration.
- **III.** Detached clusters with no noticeable concentration, in which the stars are more-or-less thinly but nearly uniformly scattered.
- **IV.** Clusters not well detached but merging gradually into the background and appearing like a star field condensation.

After this, the clusters were divided into three groups according to the range of brightness within the stars:

1. Most of the cluster stars of nearly the same apparent brightness.
2. Medium range in the brightness of the stars.
3. Clusters composed of bright and faint stars.

The third component in the cluster classification system is the number of members contained in the cluster, indicated as follows:

- **p.** Poor clusters with less than fifty stars.
- **m.** Moderately rich clusters with 50–100 stars.
- **r.** Rich clusters with more than 100 stars.

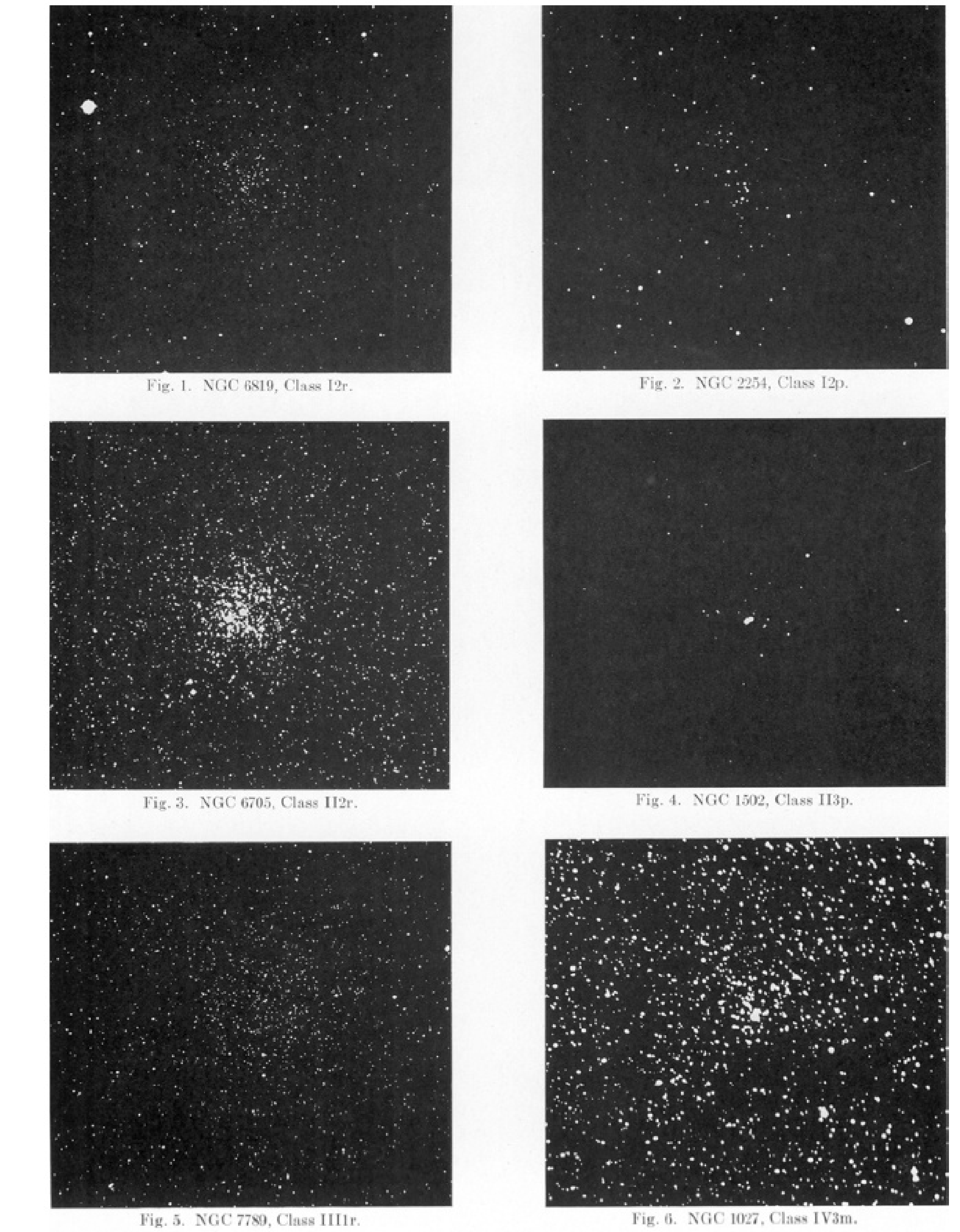


Fig. 1. NGC 6819, Class I2r.

Fig. 2. NGC 2254, Class I2p.

Fig. 3. NGC 6705, Class II2r.

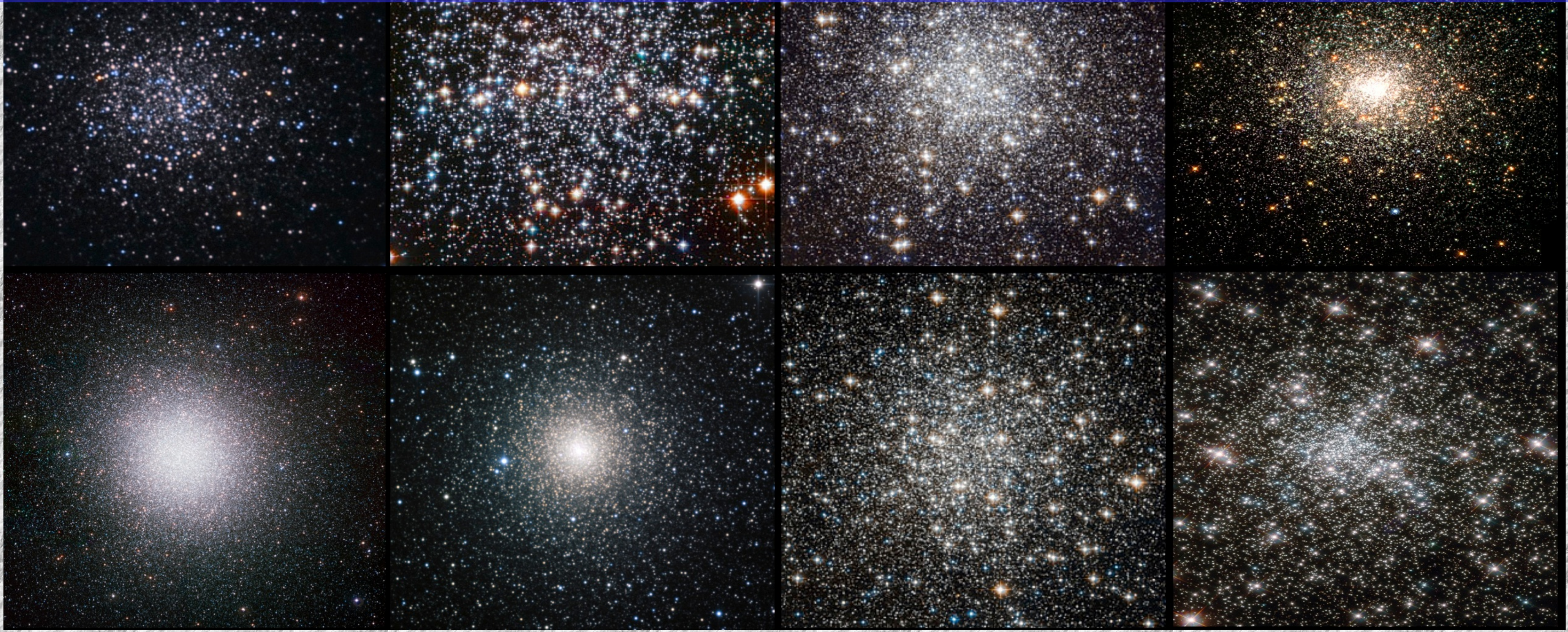
Fig. 4. NGC 1502, Class II3p.

Fig. 5. NGC 7789, Class III1r.

Fig. 6. NGC 1027, Class IV3m.

Cúmulos globulares

Sistemas de estrellas de **forma esferoidal** que contienen ~ 10.000 / ~ 100.000 (1.000.000) de estrellas. Se ubican en el **halo galáctico**, orbitando el centro galáctico, y sus estrellas son viejas. Sus edades son ~ 10-13 mil millones de años. ~ 150 C.G. (+ 250).



Cúmulos globulares

Sistemas de estrellas de **forma esferoidal**

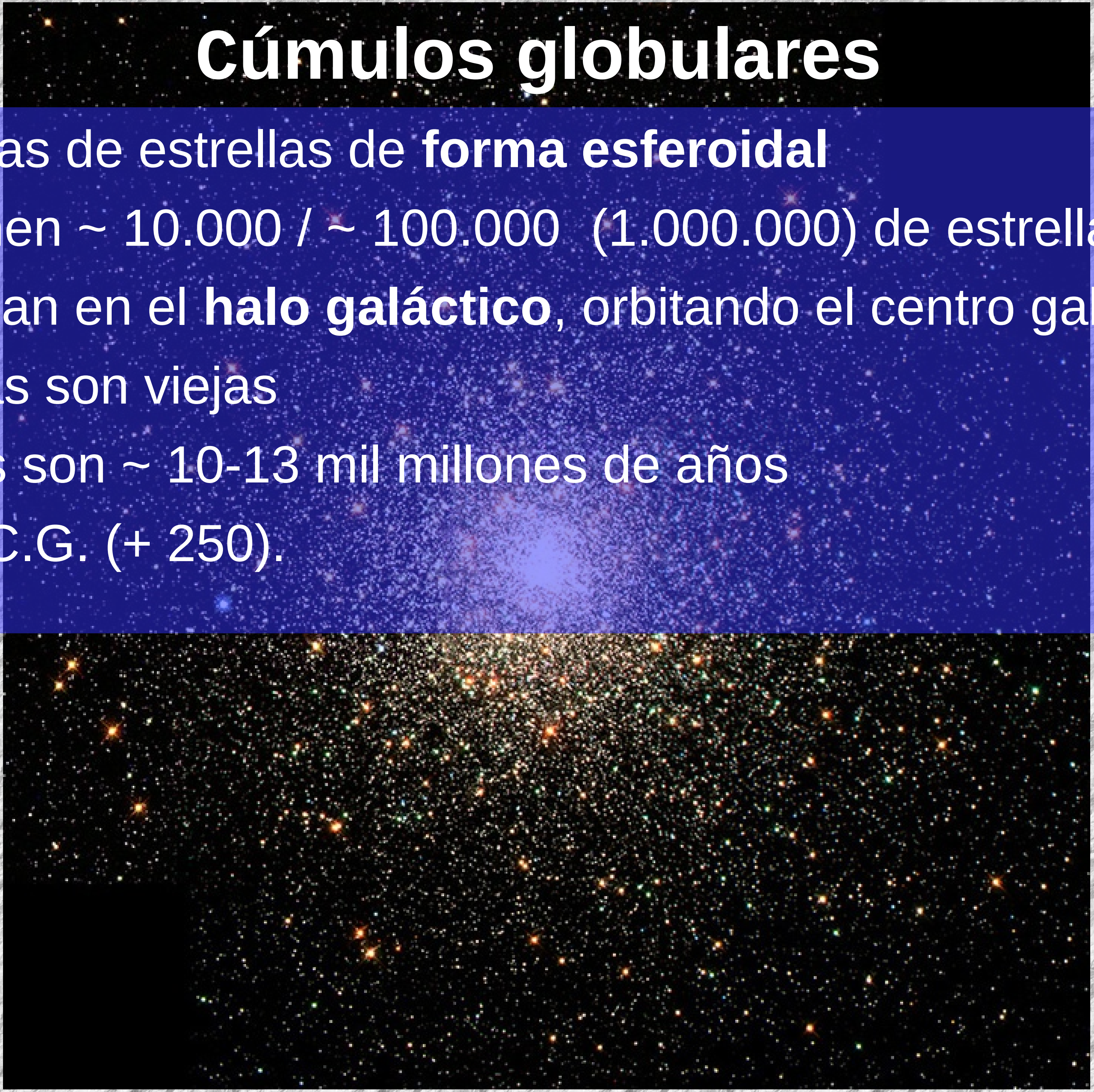
contienen ~ 10.000 / ~ 100.000 (1.000.000) de estrellas

se ubican en el **halo galáctico**, orbitando el centro galáctico

estrellas son viejas

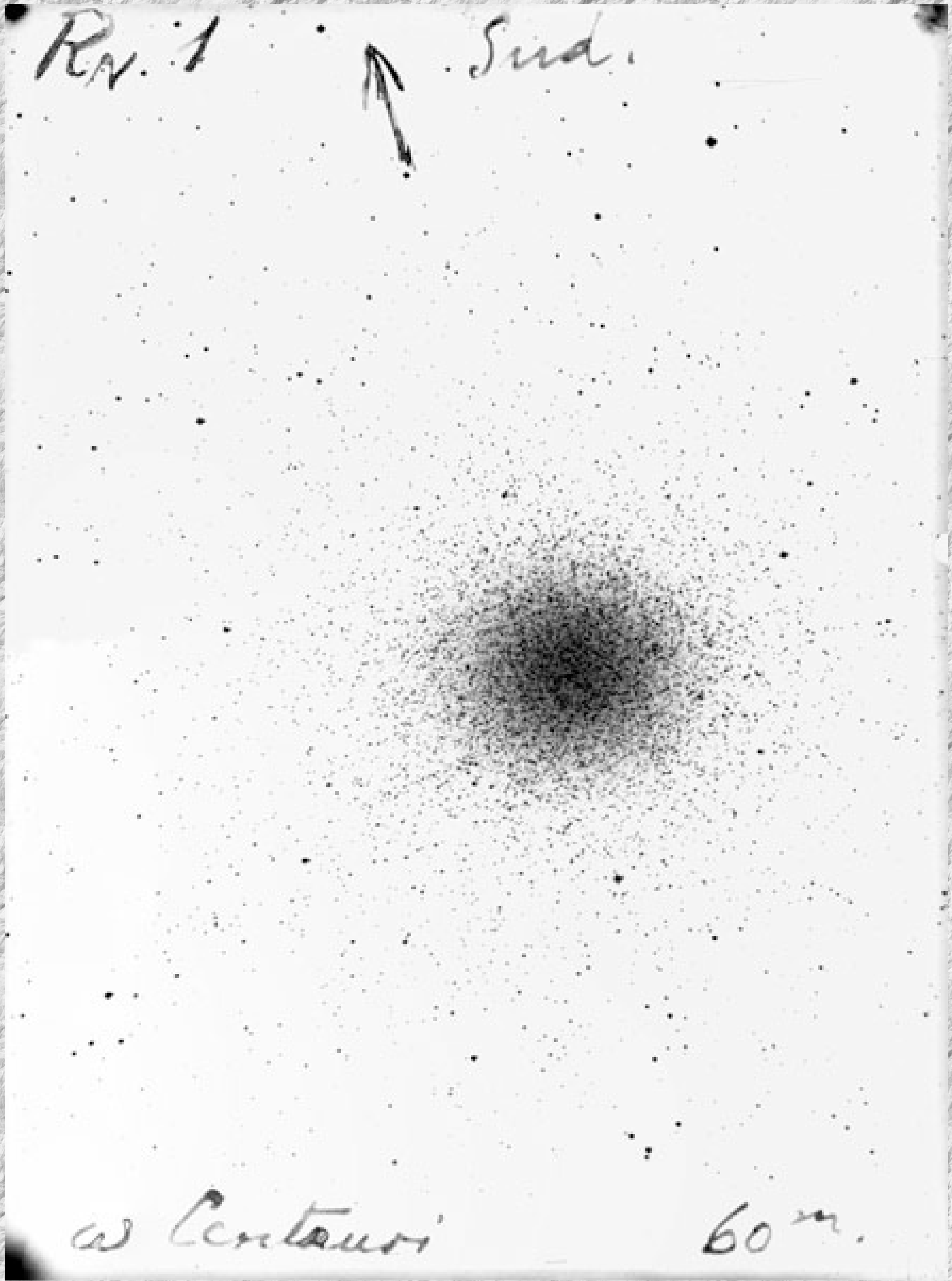
edades son ~ 10-13 mil millones de años

~ 150 C.G. (+ 250).



M 80, 12.5 Gyr

Cúmulos globulares

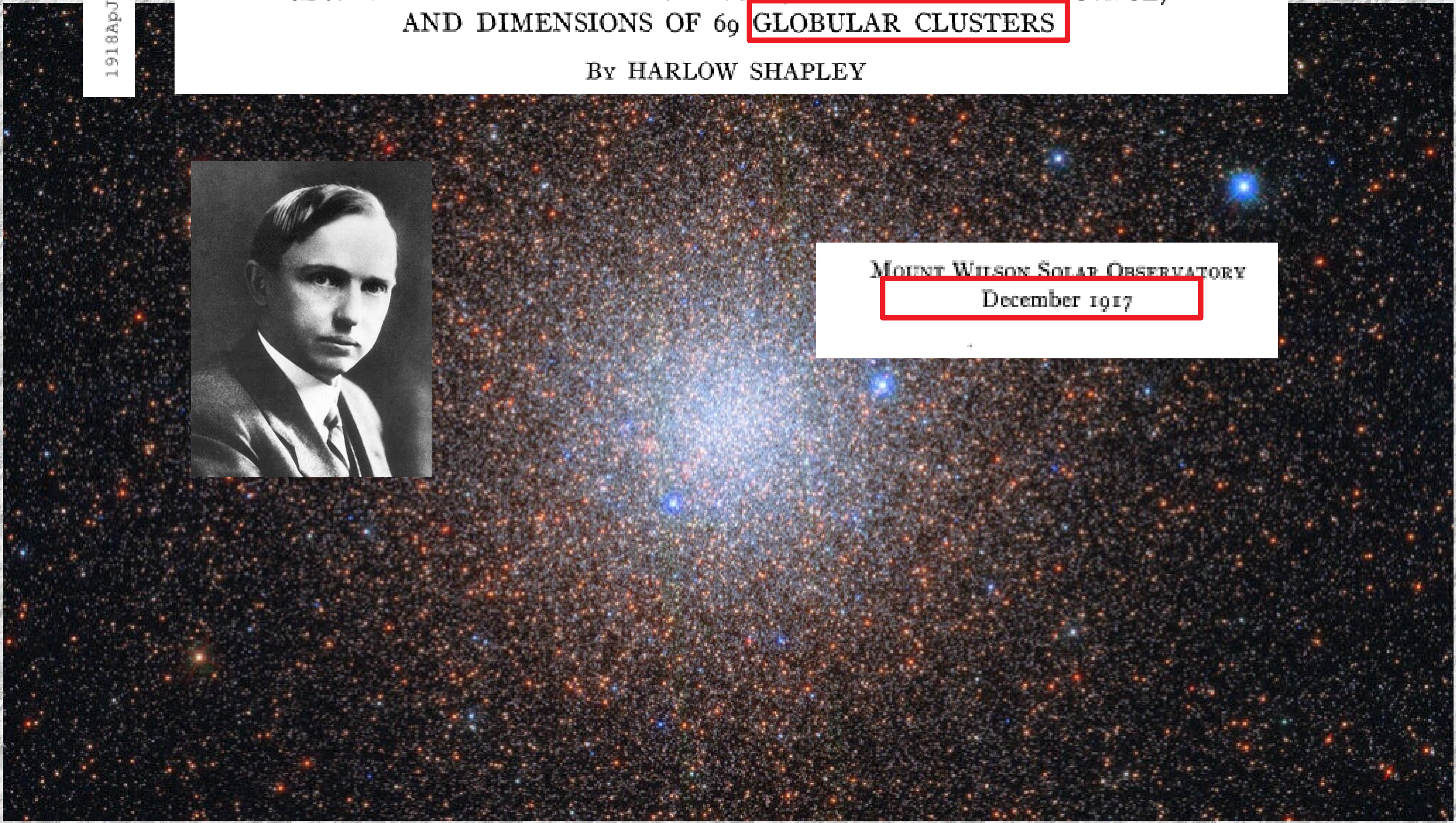


1918ApJ.....48..154S

STUDIES BASED ON THE COLORS AND MAGNITUDES IN STELLAR CLUSTERS[1]

SEVENTH PAPER: THE DISTANCES, DISTRIBUTION IN SPACE, AND DIMENSIONS OF 69 GLOBULAR CLUSTERS

By HARLOW SHAPLEY



Mount Wilson Solar Observatory
December 1917

NGC 6441

STUDIES BASED ON THE COLORS AND MAGNITUDES IN STELLAR CLUSTERS[1]

SEVENTH PAPER: THE DISTANCES, DISTRIBUTION IN SPACE, AND DIMENSIONS OF 69 GLOBULAR CLUSTERS

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TABLE V

PARALLAXES OF 28 GLOBULAR CLUSTERS FROM MAGNITUDES AND DIAMETERS

Designation		Position in 1900		Galactic		Parallax (Unit is 0".00001)			Distance (Unit is 100 Parsecs)		
N.G.C.	Messier	R.A.	Decl.	Long.	Lat.	From Mag.	From Diam.	Adopted	Radial	Projected on Galactic Plane	From Galactic Plane
288	....	$0^h47^m.8$	−27° 8'	214°	−88°	55	52	53	189	7	−189
1904	79	5 20.1	−24 37	195	−28	44	36	39	256	226	−120
4147	....	12 5.0	+19 6	227	+78	24	17	19	526	109	+514
5024	53	13 8.0	+18 42	307	+79	48	62	53	189	36	+186
5139	....	13 20.8	−46 47	277	+16	150	155	155	65	62	+ 18
5272	3	13 37.6	+28 53	8	+77	72	72	72	139	31	+135
5904	5	15 13.5	+ 2 27	333	+45	80	81	80	125	88	+ 88
6093	80	16 11.1	−22 44	320	+18	53	48	50	200	190	+ 62
6121	4	16 17.5	−26 17	319	+15	85	90	88	114	110	+ 30
6205	13	16 38.1	+36 39	26	+40	89	91	90	111	85	+ 71
6218	12	16 42.0	− 1 46	344	+25	80	82	81	123	111	+ 52
6229	....	16 44.2	+47 42	41	+39	29	20	23	435	338	+274
6254	10	16 51.9	− 3 57	343	+22	77	89	83	120	111	+ 45
6333	9	17 13.3	−18 25	334	+ 9	38	44	40	250	247	+ 39
6341	92	17 14.1	+43 15	35	+34	84	78	81	123	102	+ 69
6356	....	17 17.8	−17 43	335	+ 9	19	30	26	385	380	+ 60
6402	14	17 32.4	− 3 11	349	+14	41	46	43	233	226	+ 56
6626	28	18 18.4	−24 55	336	− 7	53	57	54	185	184	− 23
6638	....	18 24.8	−25 34	335	− 8	29	28	29	345	342	− 48
6642*	....	18 25.8	−23 32	337	− 7	31	22	26	385	382	− 47
6656	22	18 30.3	−23 59	338	− 9	118	116	118	85	84	− 13
6712	....	18 47.6	− 8 50	352	− 6	30	33	32	312	310	− 32
6779	56	19 12.7	+30 0	30	+ 7	41	37	40	250	248	+ 30
6864	75	20 0.2	−22 12	348	−28	19	26	22	455	401	−213
6934	....	20 29.3	+ 7 4	20	−20	35	24	30	333	313	−114
6981	72	20 48.0	−12 55	3	−34	33	35	34	294	244	−164
7078	15	21 25.2	+11 44	33	−29	68	59	68	147	129	− 71
7089	2	21 28.3	− 1 16	22	−37	60	72	64	156	125	− 94
7099	30	21 34.7	−23 38	356	−48	59	56	58	172	115	−128

*See n. 1 on p. 160.

SEVENTH PAPER: THE DISTANCES, DISTRIBUTION IN SPACE, AND DIMENSIONS OF 69 GLOBULAR CLUSTERS

By HARLOW SHAPLEY

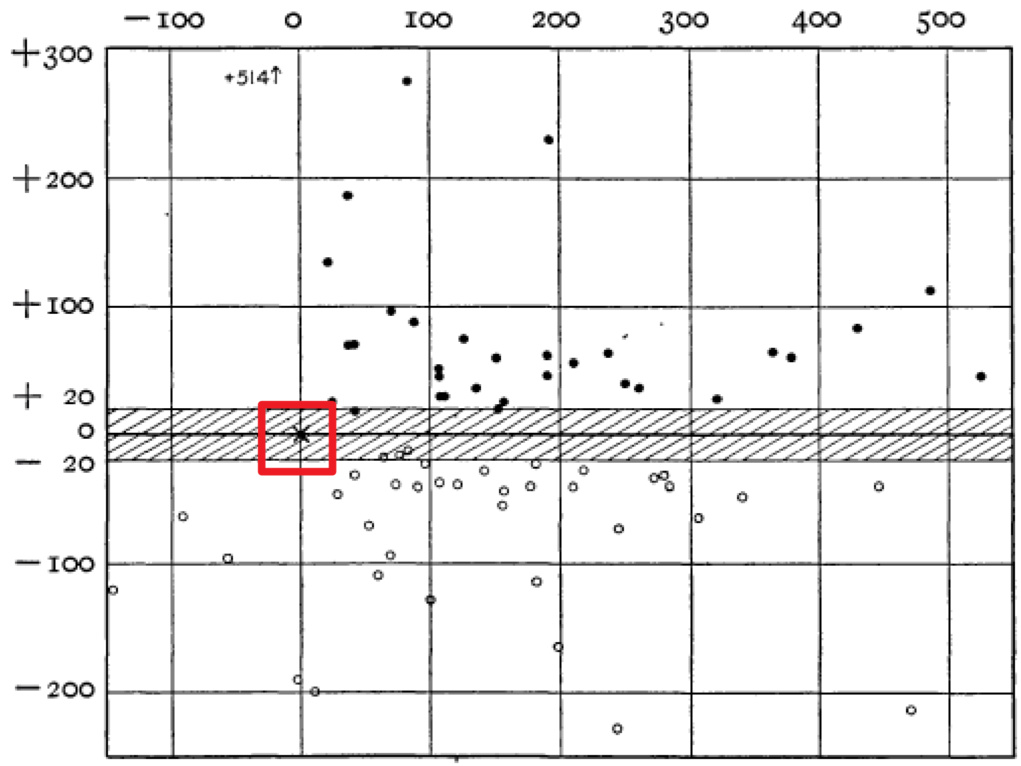
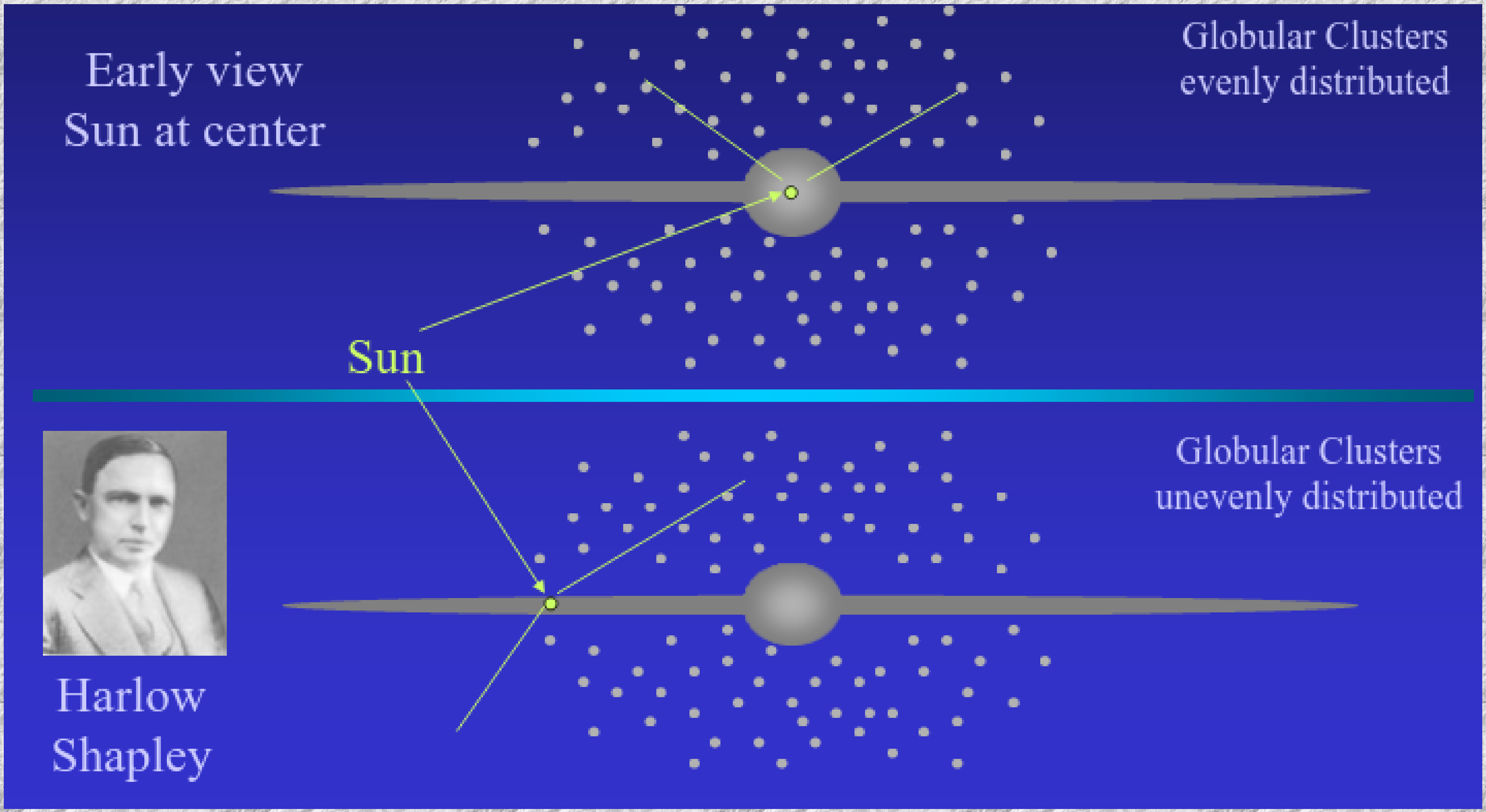


Fig. 4.—Projection of the positions of globular clusters on a plane perpendicular to the Galaxy, illustrating (1) the absence of clusters from the mid-galactic region, (2) their symmetrical arrangement with respect to the Galaxy, (3) the eccentric position of the sun (the cross) with respect to the center of the system of clusters. The ordinates are distances from the galactic plane, $R \sin \beta$; the abscissae are projected distances in the direction of the center, $R \cos \beta \cos (\lambda - 325^{\circ})$. The unit of distance is 100 parsecs; the side of a square is accordingly 10,000 parsecs. On this scale the actual diameter of the clusters is about one-fifth the diameter of the circles and dots. The cluster N.G.C. 4147 is outside the boundary of the diagram, as indicated by the arrow.

Estructura de la Vía Láctea a partir de los cúmulos estelares



UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

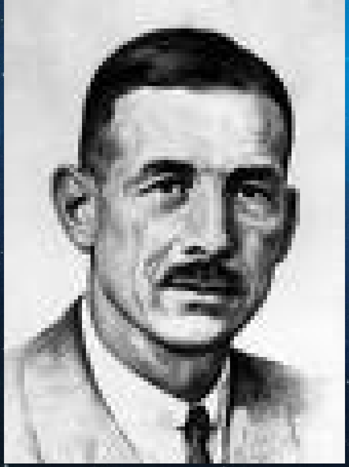
LICK OBSERVATORY BULLETIN

NUMBER 420

PRELIMINARY RESULTS ON THE DISTANCES, DIMENSIONS AND SPACE DISTRIBUTION OF $\boxed{\text{OPEN STAR CLUSTERS}}$

BY

ROBERT J. TRUMPLER



LICK OBSERVATORY,
January 22, 1930.

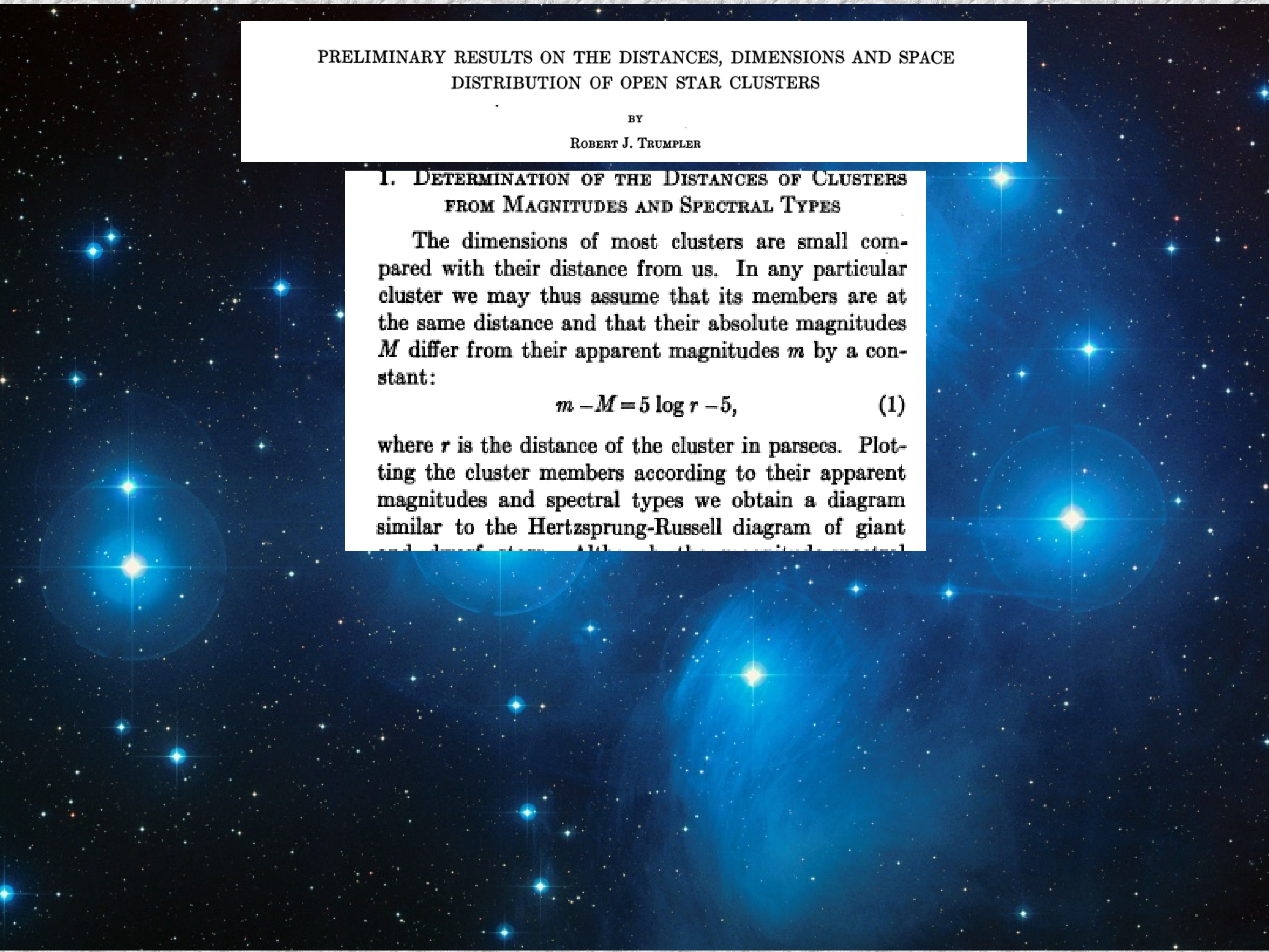
Issued April 7, 1930.

PRELIMINARY RESULTS ON THE DISTANCES, DIMENSIONS AND SPACE DISTRIBUTION OF OPEN STAR CLUSTERS

BY

ROBERT J. TRUMPLER

Although the observations of magnitudes and spectral types in open star clusters of the Milky Way undertaken by the writer are still far from being complete, it seemed of interest to utilize the data at present available for a preliminary investigation of the distances and diameters of these clusters and for a study of their space distribution.



PRELIMINARY RESULTS ON THE DISTANCES, DIMENSIONS AND SPACE DISTRIBUTION OF OPEN STAR CLUSTERS

BY

ROBERT J. TRUMPLER

I. DETERMINATION OF THE DISTANCES OF CLUSTERS FROM MAGNITUDES AND SPECTRAL TYPES

The dimensions of most clusters are small compared with their distance from us. In any particular cluster we may thus assume that its members are at the same distance and that their absolute magnitudes M differ from their apparent magnitudes m by a constant:

$$m - M = 5 \log r - 5, \qquad (1)$$

where r is the distance of the cluster in parsecs. Plotting the cluster members according to their apparent magnitudes and spectral types we obtain a diagram similar to the Hertzsprung-Russell diagram of giant

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7. ABSORPTION OF LIGHT IN THE MILKY WAY SYSTEM

Our method of deriving cluster distances from magnitudes and spectral types was based on formula (1) which expresses the law that the apparent brightness of a star diminishes with the square of the distance from the observer. If interstellar space is not perfectly transparent this law does not hold; the apparent brightness decreases more rapidly, our distance results are too large, and the error increases with the distance of the cluster. The linear diameters computed with these distance results are then also too large, and the error also progresses with distance, just like the residuals in column 3 of Table 10.

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It is natural to interpose here the question why such an absorption of light should not have been discovered in the discussion of the diameters of globular clusters which are much more distant, and how it is possible that we still find small color-indices in some globular clusters (such as Messier 13) despite of their great distances. There is only one way which seems to lead out of the dilemma: the hypothesis that the absorbing medium, like the open clusters, is very much concentrated toward the galactic plane. We shall see later that two-thirds of all open clusters lie

PRELIMINARY RESULTS ON THE DISTANCES, DIMENSIONS AND SPACE DISTRIBUTION OF OPEN STAR CLUSTERS

BY

ROBERT J. TRUMPLER

TABLE 16

CLASSIFICATION, DIAMETERS AND DISTANCES OF 334 OPEN GALACTIC STAR CLUSTERS

(An asterisk in the first column refers to a remark at the end of the table)

N.G.C. I. C.	R. A. 1900	Decl. 1900	Galactic Long.	Galactic Lat.	Galactic coordinates x	y	z	Angul. diam.	Class	Adopted distance parsecs	Wt.	Rectangular coordinates X	Y	Z
103	0h19m.8	+60° 47	87°.5	− 1°.1	+.043	+ .999	−.020	4′	I 2p	2580	......	+ 110	+2580	− 51
129	24.3	+59 40	88.0	− 2.3	+.034	+ .999	−.040	13	IV 2p U	2090	......	+ 70	+2090	− 83
136	25.9	+60 58	88.3	− 1.0	+.030	+ .999	−.017	2.2	II 2p	5320	......	+ 160	+5310	− 90
188	35.1	+84 47	89.9	+22.8	+.002	+ .922	+.387	14	II 1r	1180	......	0	+1090	+456
225	37.6	+61 14	89.7	− 0.7	+.005	+1.000	−.013	14	III 1p	1100	......	+ 10	+1100	− 14
381	1 2.1	+61 3	92.7	− 0.8	−.047	+ .999	−.014	7	III 2p	2210	......	− 100	+2210	− 31
436	9.4	+58 17	93.8	− 3.5	−.067	+ .996	−.061	6	I 3m	1970	2	− 130	+1960	−120
457	12.8	+57 48	94.4	− 3.9	−.076	+ .995	−.068	12	I 3r	1480	2	− 110	+1470	−101
559	22.8	+62 47	94.9	+ 1.2	−.085	+ .996	+.021	6	I 2m	2290	......	− 190	+2280	+ 48
581	26.6	+60 11	95.8	− 1.3	−.100	+ .995	−.023	6.5	II 3m	1960	2	− 200	+1950	− 45
An. 1	29.0	+60 46	96.0	− 0.6	−.104	+ .994	−.011	4.5	I 3p	2290	......	− 240	+2280	− 25
609	30.3	+64 2	95.5	+ 2.6	−.095	+ .995	+.045	3	I 2p :	3430	......	− 330	+3410	+155
*637	36.0	+63 30	96.2	+ 2.2	−.108	+ .993	+.038	3.5	II 3p :	3340	......	− 360	+3320	+127

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BY

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CLASS
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N.G.C. I. C.	R. A. 1900	Decl. 1900
103	0h19m8	+60° 47
129	24.3	+59 40
136	25.9	+60 58
188	35.1	+84 47
225	37.6	+61 14
381	1 2.1	+61 3
436	9.4	+58 17
457	12.8	+57 48
559	22.8	+62 47
581	26.6	+60 11
An. 1	29.0	+60 46
609	30.3	+64 2
*637	36.0	+63 30

11. THE APPARENT DISTRIBUTION OF OPEN STAR CLUSTERS

TABLE 18

APPARENT DISTRIBUTION OF OPEN CLUSTERS ACCORDING TO GALACTIC LONGITUDE

Galactic longitude	Number of clusters	Constellations
0°– 20°	5	Aquila.
20 – 40	7	Vulp.-Cygn.
40 – 60	15	Cygnus.
60 – 80	19	Cygn.-Ceph.-Lac.
80 –100	21	Cassiop.
100 –120	19	Camel.-Perseus
120 –140	11	Pers.-Auriga
140 –160	17	Auriga-Taur.-Gem.
160 –180	19	Monoceros.
180 –200	27	Monoc.-Can. Major
200 –220	27	Puppis
220 –240	14	Puppis-Vela.
240 –260	29	Vela-Carina
260 –280	22	Crux-Cent.
280 –300	19	Circin.-Norm.
300 –320	22	Norma-Scorp.
320 –340	22	Scorp.-Sag.-Ophiuch.
340 –360	19	Sagittar.-Scutum.
	334	

USTERS
able)

Wt.	Rectangular coordinates X	Y	Z
......	+ 110	+2580	− 51
......	+ 70	+2090	− 83
......	+ 160	+5310	− 90
......	0	+1090	+456
......	+ 10	+1100	− 14
......	− 100	+2210	− 31
2	− 130	+1960	−120
2	− 110	+1470	−101
......	− 190	+2280	+ 48
2	− 200	+1950	− 45
......	− 240	+2280	− 25
......	− 330	+3410	+155
......	− 360	+3320	+127

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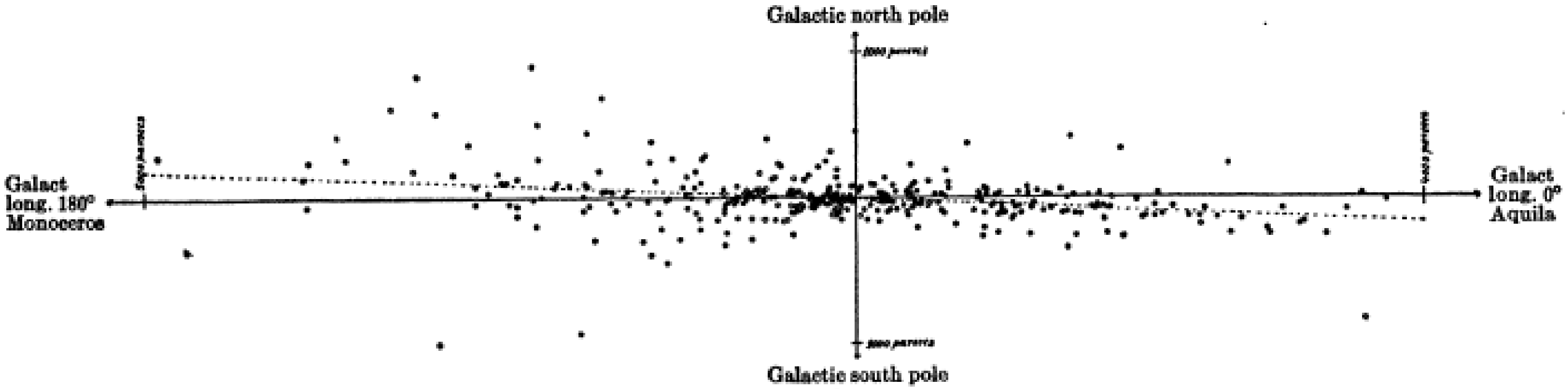

Fig. 5. Space distribution of 334 open clusters.

The figure gives the projection of the clusters on the XZ plane which is perpendicular to the galactic plane and intersects the latter at longitudes 0° and 180°. Clusters within 1000 parsecs of the Sun are plotted as open circles. The dotted line marks the plane of symmetry of the open clusters.

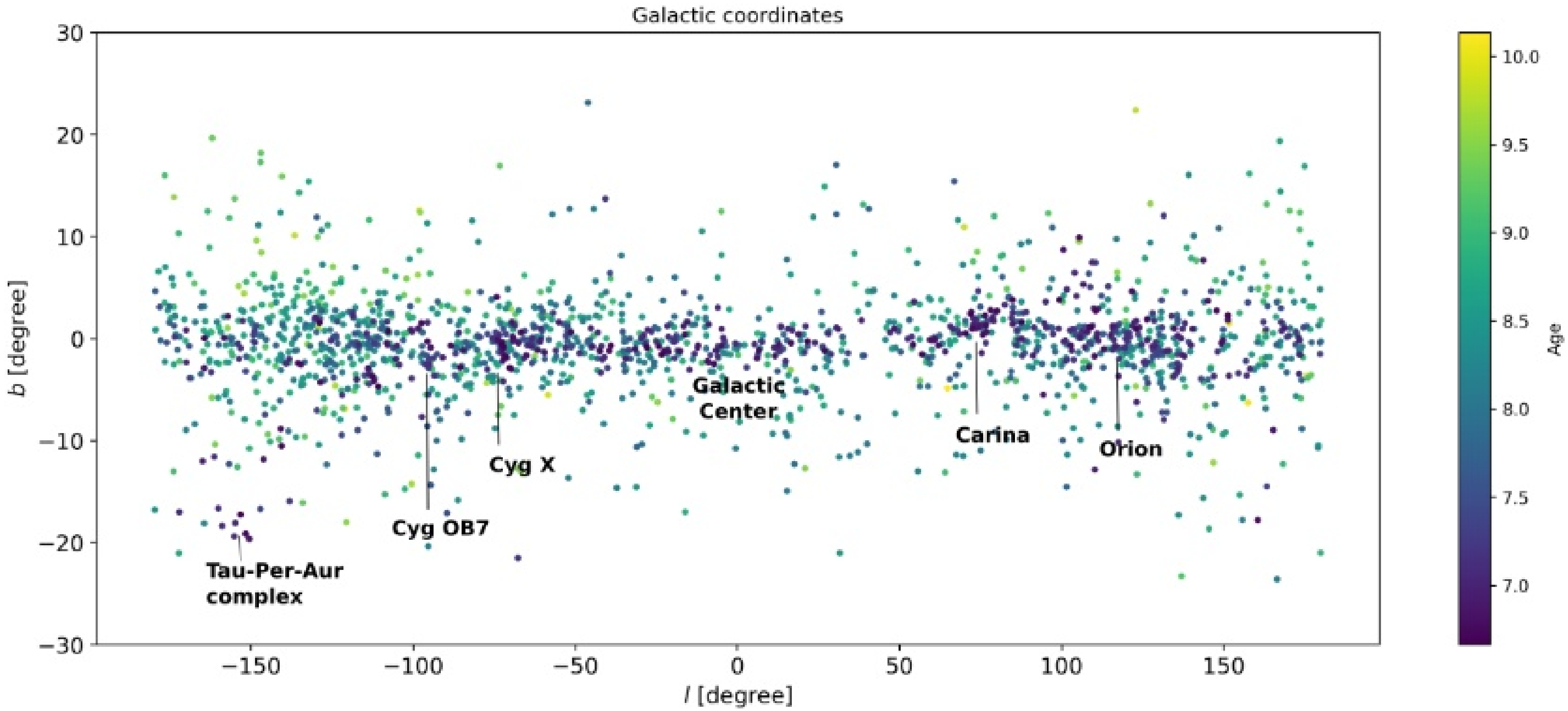

Figure 1. Galactic distribution of the 1743 open clusters analysed in this work. The plot present the clusters in Galactic coordinates with the main regions of star formation highlighted. The color is proportional to the age in the sense blue is young, green is intermediate age and yellow is old.

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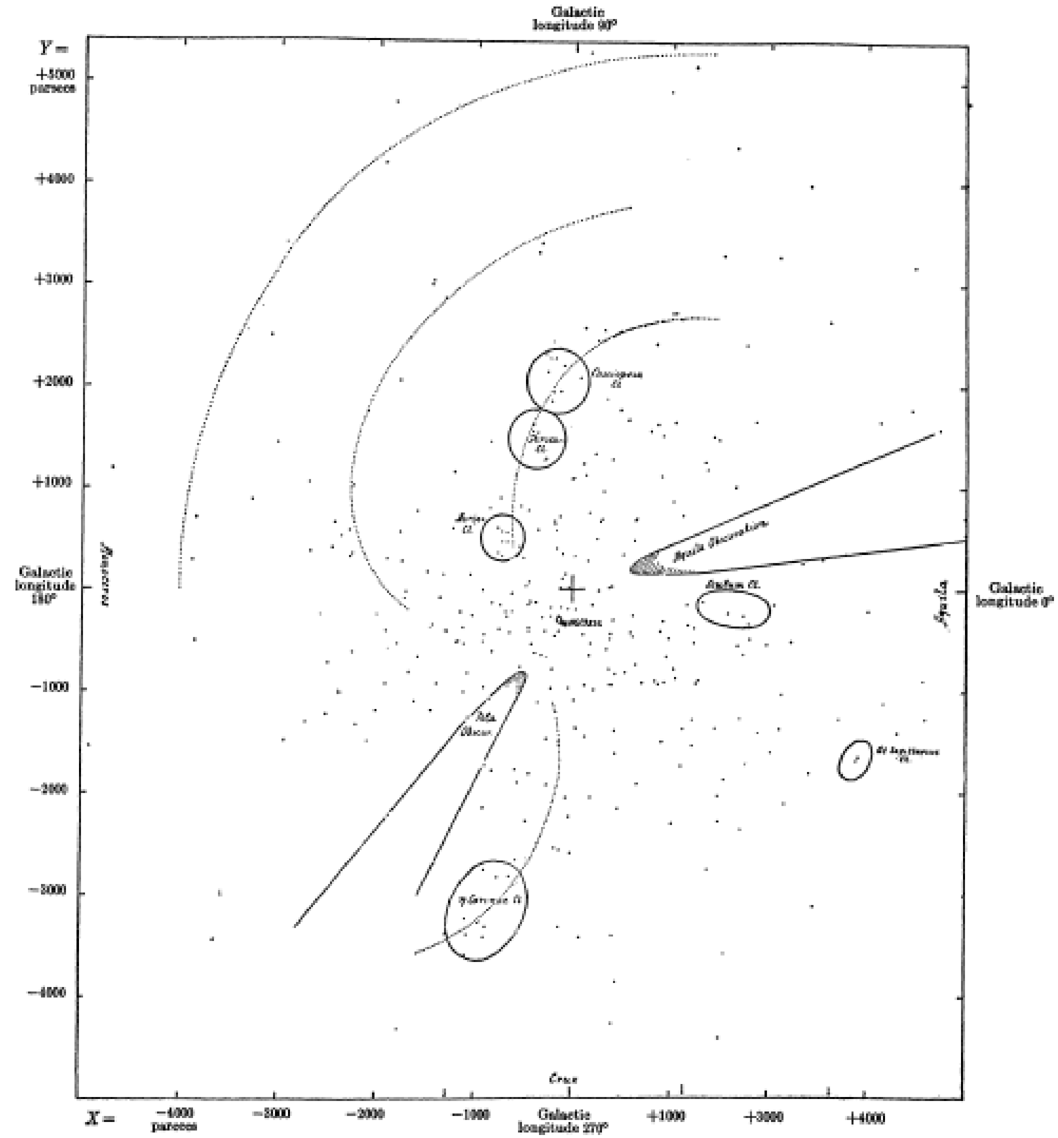
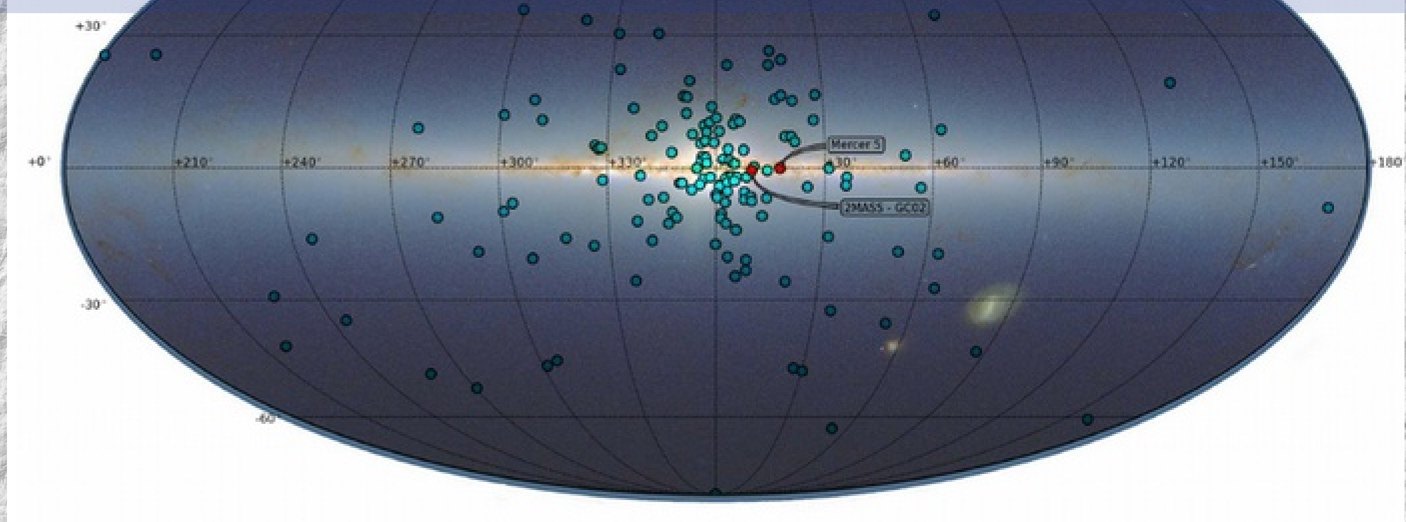
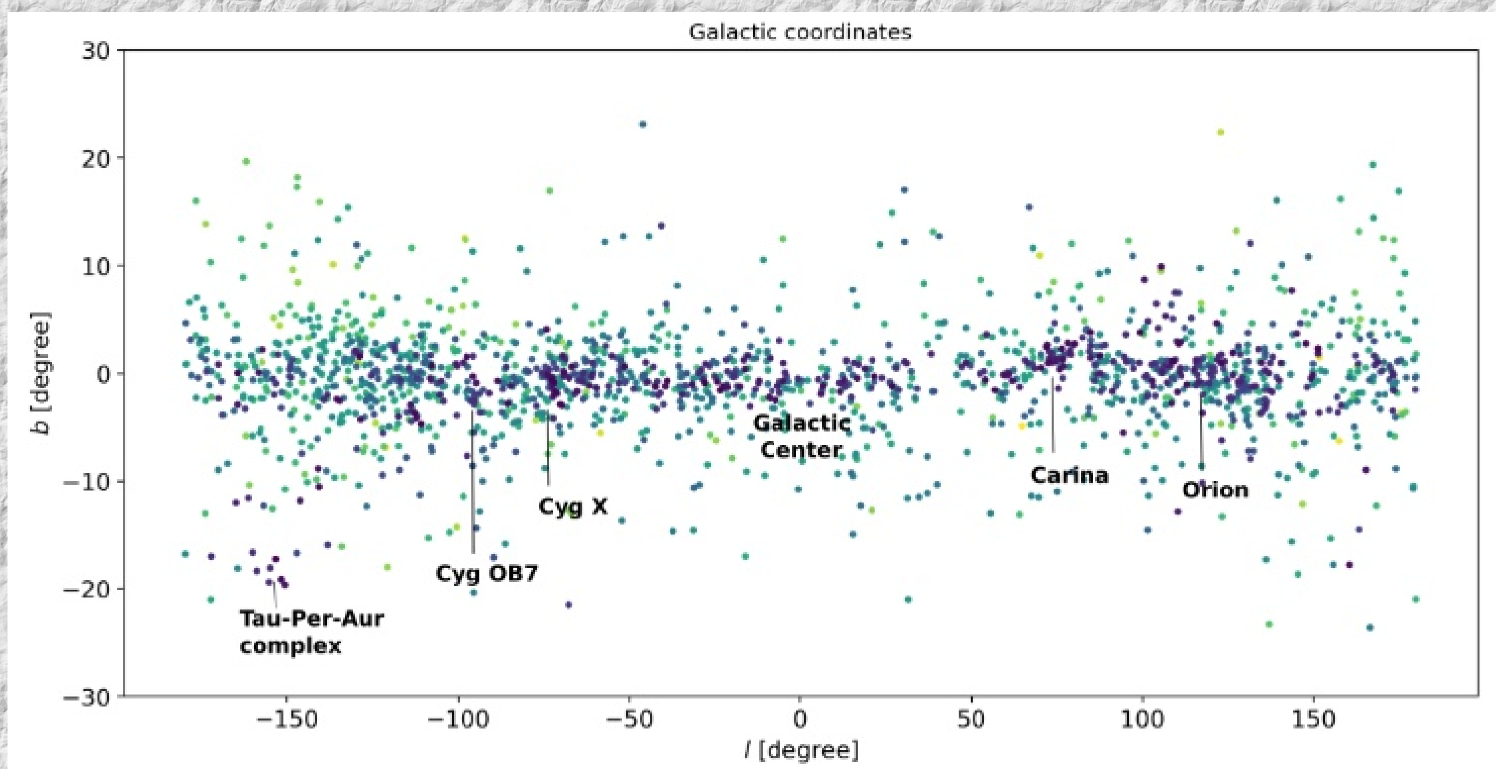


Fig. 8. Special features of the cluster system.

This figure gives a projection of the clusters on the galactic plane like Fig. 4. The position of the Sun is marked by a cross, that of the median point of the system by an open circle, the cluster NGC 3532 by an asterisk. Some traces of spiral structure are indicated by the dotted lines; the large open circles or ovals represent the probable location of cluster groups or star clouds, the shaded areas, dark clouds of absorbing material with their sectors of obscuration.

Estructura de la Vía Láctea a partir de los cúmulos estelares





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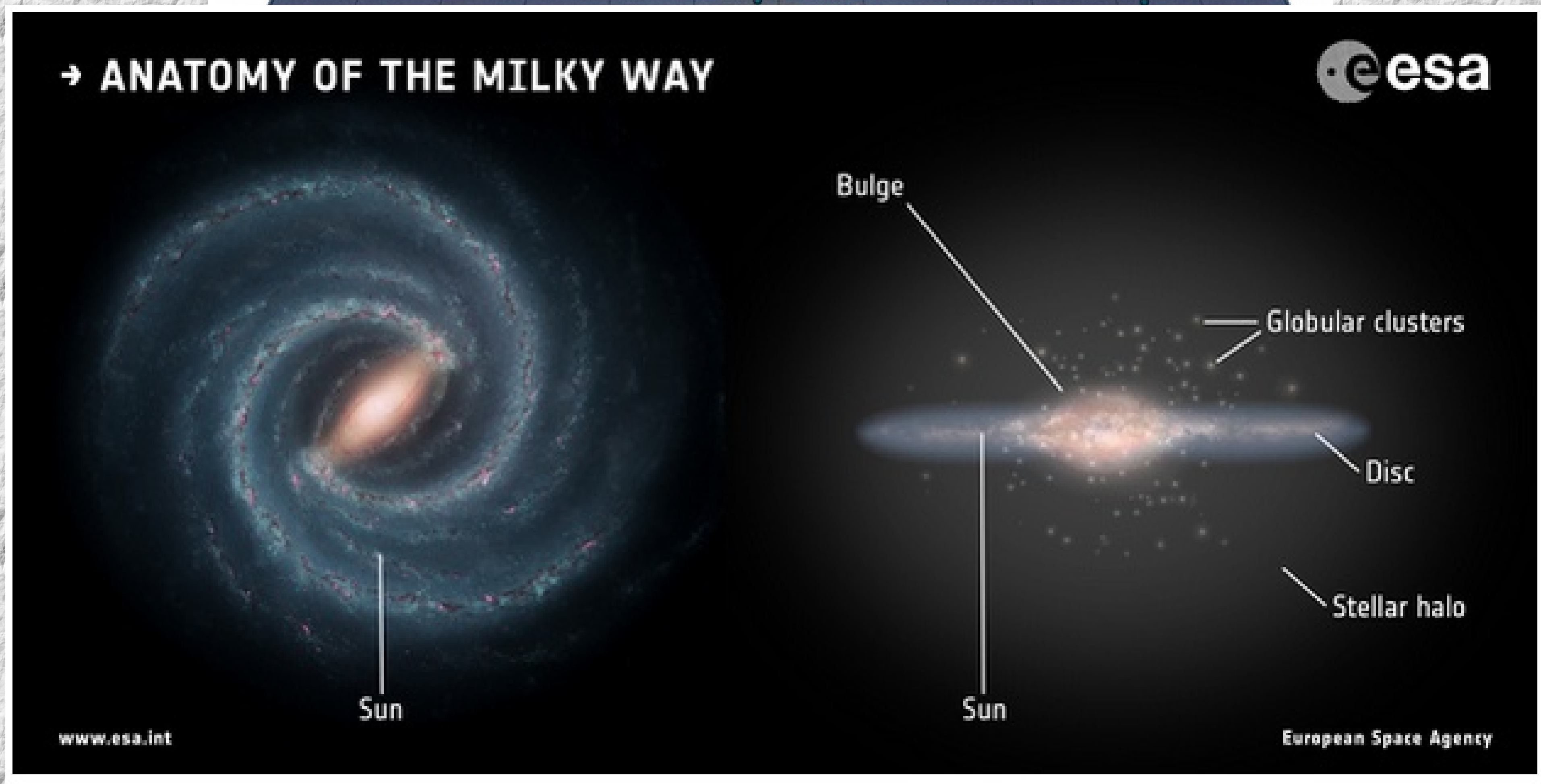

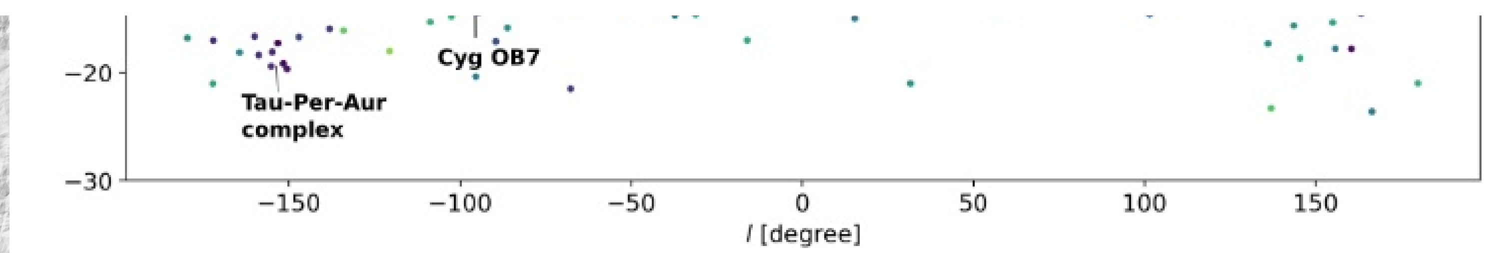

Cúmulos estelares extragalácticos

The Astronomical Journal, 156:116 (10pp), 2018 September https://doi.org/10.3847/1538-3881/aad3cd

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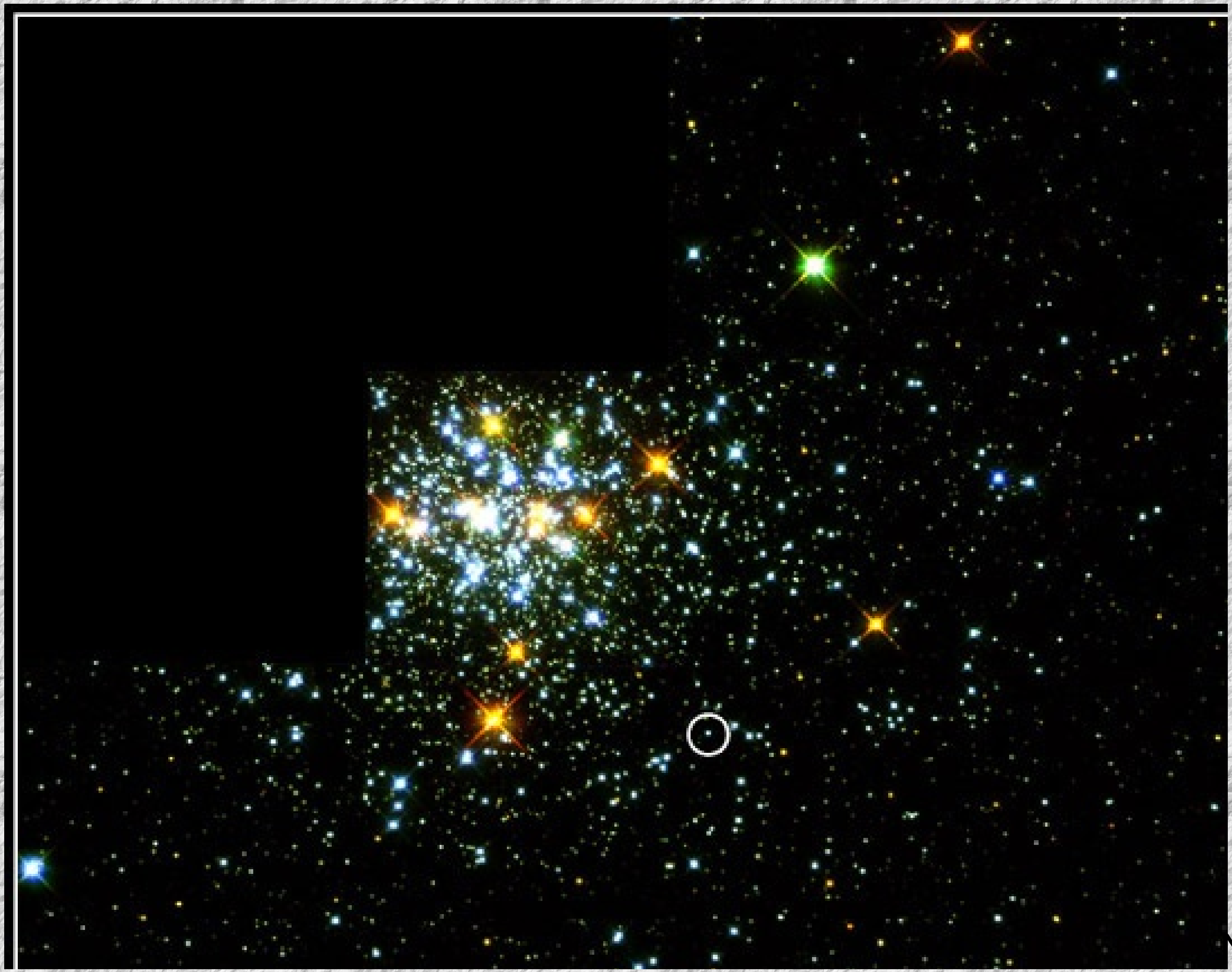
Different Stellar Rotations in the Two Main Sequences of the Young Globular Cluster NGC 1818: The First Direct Spectroscopic Evidence*



NGC 1818, 40 Myr

¿El nacimiento de un cúmulo globular?

NGC 3603, 1 Myr

The Astrophysical Journal, 720:1108–1117, 2010 September 10 doi:10.1088/0004-637X/720/2/1108

PROGRESSIVE STAR FORMATION IN THE YOUNG GALACTIC SUPER STAR CLUSTER NGC 3603

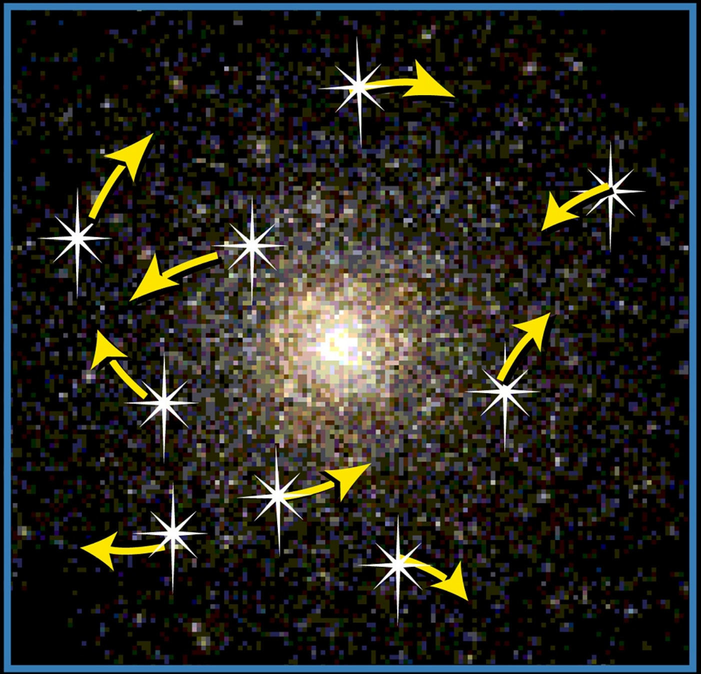
Giacomo Beccari[1], Loredana Spezzi[1], Guido De Marchi[1], Francesco Paresce[2], Erick Young[3], Morten Andersen[1], Nino Panagia[4,5,6], Bruce Balick[7], Howard Bond[4], Daniela Calzetti[8], C. Marcella Carollo[9], Michael J. Disney[10], Michael A. Dopita[11], Jay A. Frogel[12], Donald N. B. Hall[13], Jon A. Holtzman[14], Randy A. Kimble[15], Patrick J. McCarthy[16], Robert W. O'Connell[17], Abhijit Saha[18], Joseph I. Silk[19], John T. Trauger[20], Alistair R. Walker[21], Bradley C. Whitmore[4], and Rogier A. Windhorst[22]

ABSTRACT

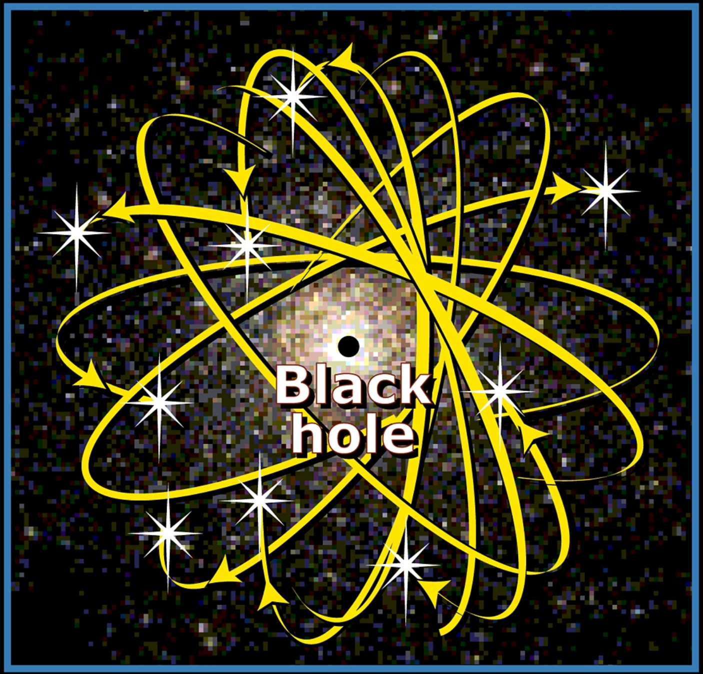
Early Release Science observations of the cluster NGC 3603 with the WFC3 on the refurbished *Hubble Space Telescope* allow us to study its recent star formation history. Our analysis focuses on stars with Hα excess emission, a robust indicator of their pre-main sequence (PMS) accreting status. The comparison with theoretical PMS isochrones shows that 2/3 of the objects with Hα excess emission have ages from 1 to 10 Myr, with a median value of 3 Myr, while a surprising 1/3 of them are older than 10 Myr. The study of the spatial distribution of these PMS stars allows us to confirm their cluster membership and to statistically separate them from field stars. This result establishes unambiguously for the first time that star formation in and around the cluster has been ongoing for at least 10–20 Myr, at an apparently increasing rate.

Theoretical interpretation

Astronomers can deduce the presence of a central black hole and measure its mass.



Globular cluster without black hole



Globular cluster with black hole

THE ASTROPHYSICAL JOURNAL, 676:1008–1015, 2008 April 1

GEMINI AND *HUBBLE SPACE TELESCOPE* EVIDENCE FOR AN INTERMEDIATE-MASS BLACK HOLE IN ω CENTAURI

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Received 2006 May 14; accepted 2007 December 22

ABSTRACT

The globular cluster ω Centauri is one of the largest and most massive members of the galactic system. However, its classification as a globular cluster has been challenged making it a candidate for being the stripped core of an accreted dwarf galaxy; this together with the fact that it has one of the largest velocity dispersions for star clusters in our galaxy makes it an interesting candidate for harboring an intermediate-mass black hole. We measure the surface brightness profile from integrated light on an *HST* ACS image of the center, and find a central power-law cusp of logarithmic slope -0.08. We also analyze Gemini GMOS-IFU kinematic data for a $5'' \times 5''$ field centered on the nucleus of the cluster, as well as for a field $14''$ away. We detect a clear rise in the velocity dispersion from 18.6 km s^{-1} at $14''$ to 23 km s^{-1} in the center. A rise in the velocity dispersion could be due to a central black hole, a central concentration of stellar remnants, or a central orbital structure that is radially biased. We discuss each of these possibilities. An isotropic, spherical dynamical model implies a black hole mass of $4.0^{+0.75}_{-1.0} \times 10^4\ M_\odot$, and excludes the no black hole case at greater than 99% significance. We have also run flattened, orbit-based models and find similar results. While our preferred model is the existence of a central black hole, detailed numerical simulations are required to confidently rule out the other possibilities.

MNRAS 433, 1966–1969 (2013)
Advance Access publication 2013 June 13
doi:10.1093/mnras/stt865

Segue 3: the youngest globular cluster in the outer halo★

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181–189 (2007)
051/0004-6361:20066825
7
Astronomy & Astrophysics

Whiting 1: the youngest globular cluster associated with the Sagittarius dwarf spheroidal galaxy★,★★,★★★

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: 10.1051/0004-6361:20031578
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Astrono & Astroph

The age of the oldest Open Clusters

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A&A 630, L4 (2019)
https://doi.org/10.1051/0004-6361/201936135

Astronomy & Astrophysic

LETTER TO THE EDITOR

Origin of the system of globular clusters in the Milky Way

D. Massari[1,2,3], H. H. Koppelman[1], and A. Helmi[1]

The age of the oldest Open Clusters

M. Salaris[1,2], A. Weiss[2], and S. M. Percival[1]

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Abstract. We determine ages of 71 old Open Clusters by a two-step method: we use main-sequence fitting to 10 selected clusters, in order to obtain their distances, and derive their ages from comparison with our own isochrones used before for Globular Clusters. We then calibrate the morphological age indicator $\delta(V)$, which can be obtained for all remaining clusters, in terms of age and metallicity. Particular care is taken to ensure consistency in the whole procedure. The resulting Open Cluster ages connect well to our previous Globular Cluster results. From the Open Cluster sample, as well as from the combined sample, questions regarding the formation process of Galactic components are addressed. The age of the oldest open clusters (NGC 6791 and Be 17) is of the order of 10 Gyr. We determine a delay by 2.0 ± 1.5 Gyr between the start of the halo and thin disk formation, whereas thin and thick disk started to form approximately at the same time. We do not find any significant age–metallicity relationship for the open cluster sample. The cumulative age distribution of the whole open cluster sample shows a moderately significant ($\sim 2\sigma$ level) departure from the predictions for an exponentially declining dissolution rate with timescale of 2.5 Gyr. The cumulative age distribution does not show any trend with galactocentric distance, but the clusters with larger height to the Galactic plane have an excess of objects between 2–4 and 6 Gyr with respect to their counterpart closer to the plane of the Galaxy.

Segue 3: the youngest globular cluster in the outer halo★

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ABSTRACT

Deep Galileo (Telescopio Nazionale Galileo) *B*, *V* and *I* images of Segue 3, reaching $V \sim 25$, reveal that it is the youngest globular cluster known so far in the Galaxy. A young age of 3.2 Gyr is found, differently from a previous estimate of 12 Gyr. It also appears to be moderately metal rich with $[Fe/H] \sim -0.8$, rather than $[Fe/H] \sim -1.7$, as previously suggested by Fadely et al. A main difference in the age derivation relative to Fadely et al. comes from the consideration of subgiant branch stars in the isochrone fitting. A deduced distance of $d_{\odot} = 29.1$ kpc is compatible with the outer halo location of other low luminosity globular clusters.

Whiting 1: the youngest globular cluster associated with the Sagittarius dwarf spheroidal galaxy*,**,***

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ABSTRACT

Context. Recently, Carraro (2005) drew attention to the remarkable star cluster Whiting 1 by showing that it lies about 40 kpc from the Sun and is therefore unquestionably a member of the Galactic halo ($b = -60.6$ deg). Its Color Magnitude Diagram (CMD) indicated that Whiting 1 is very young (~5 Gyr) for a globular cluster. It is very likely that Whiting 1 originated in a dwarf galaxy that has since been disrupted by the Milky Way.
Aims. The main goals of this investigation were to constrain better the age, metallicity, and distance of Whiting 1 and to assess whether it belongs to a stellar stream from the Sagittarius dwarf spheroidal galaxy (Sgr dSph).
Methods. Deep CCD photometry in the *BVI* pass-bands obtained with the VLT is used to improve the quality of the CMD and to determine the cluster's luminosity function and surface density profile. High-resolution spectrograms obtained with Magellan are used to measure the cluster's radial velocity and to place limits on its possible metallicity. The measurements of distance and radial velocity are used to test the cluster's membership in the stellar streams from the Sgr dSph.
Results. From our CMD of Whiting 1, we derive new estimates for the cluster's age ($6.5^{+1.0}_{-0.5}$ Gyr), metallicity ($Z = 0.004 \pm 0.001$, [Fe/H] = –0.65), and distance ($29.4^{+1.8}_{-2.0}$ kpc). From echelle spectrograms of three stars, we obtain -130.6 ± 1.8 km s^{-1} for the cluster's radial velocity and show from measurements of two infra-red CaII lines that the [Fe/H] of the cluster probably lies in the range –1.1 to –0.4. Both the luminosity function and the surface density profile suggest that the cluster has undergone tidal stripping by the Milky Way. We demonstrate that the position of Whiting 1 on the sky, its distance from the Sun, and its radial velocity are identical to within the errors of both the theoretical predictions of the trailing stream of stars from the Sgr dSph galaxy and the previous observations of the M giant stars that delineate the streams.
Conclusions. With the addition of Whiting 1, there is now strong evidence that 6 globular clusters formed within the Sgr dSph. Whiting 1 is particularly interesting because it is the youngest and among the most metal rich. The relatively young age of Whiting 1 demonstrates that this dwarf galaxy was able to form star clusters for a period of at least 6 Gyr, and the age and metallicity of Whiting 1 are consistent with the age-metallicity relationship in the main body of the Sgr dSph. The presence now of Whiting 1 in the Galactic halo provides additional support for the view that the young halo clusters originated in dwarf galaxies that have been accreted by the Milky Way.

Origin of the system of globular clusters in the Milky Way

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ABSTRACT

Context. The assembly history experienced by the Milky Way is currently being unveiled thanks to the data provided by the *Gaia* mission. It is likely that the globular cluster system of our Galaxy has followed a similarly intricate formation path.
Aims. To constrain this formation path, we explore the link between the globular clusters and the known merging events that the Milky Way has experienced.
Methods. To this end, we combined the kinematic information provided by *Gaia* for almost all Galactic clusters, with the largest sample of cluster ages available after carefully correcting for systematic errors. To identify clusters with a common origin we analysed their dynamical properties, particularly in the space of integrals of motion.
Results. We find that about 40% of the clusters likely formed in situ. A similarly large fraction, 35%, appear to be possibly associated to known merger events, in particular to *Gaia*-Enceladus (19%), the Sagittarius dwarf galaxy (5%), the progenitor of the Helmi streams (6%), and to the Sequoia galaxy (5%), although some uncertainty remains due to the degree of overlap in their dynamical characteristics. Of the remaining clusters, 16% are tentatively associated to a group with high binding energy, while the rest are all on loosely bound orbits and likely have a more heterogeneous origin. The resulting age–metallicity relations are remarkably tight and differ in their detailed properties depending on the progenitor, providing further confidence on the associations made.
Conclusions. We provide a table listing the likely associations. Improved kinematic data by future *Gaia* data releases and especially a larger, systematic error-free sample of cluster ages would help to further solidify our conclusions.

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Updated parameters of 1743 open clusters based on *Gaia* DR2

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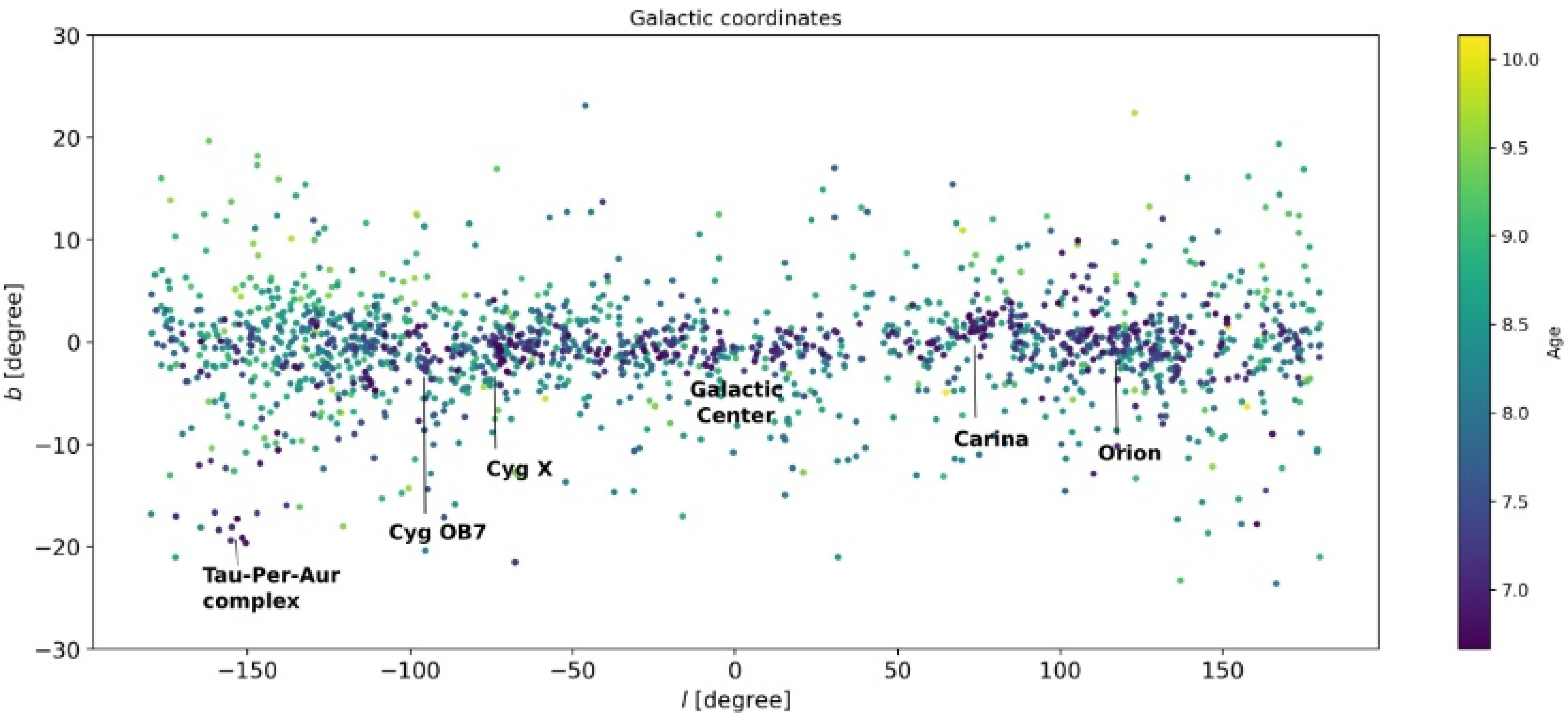


Figure 1. Galactic distribution of the 1743 open clusters analysed in this work. The plot present the clusters in Galactic coordinates with the main regions of star formation highlighted. The color is proportional to the age in the sense blue is young, green is intermediate age and yellow is old.

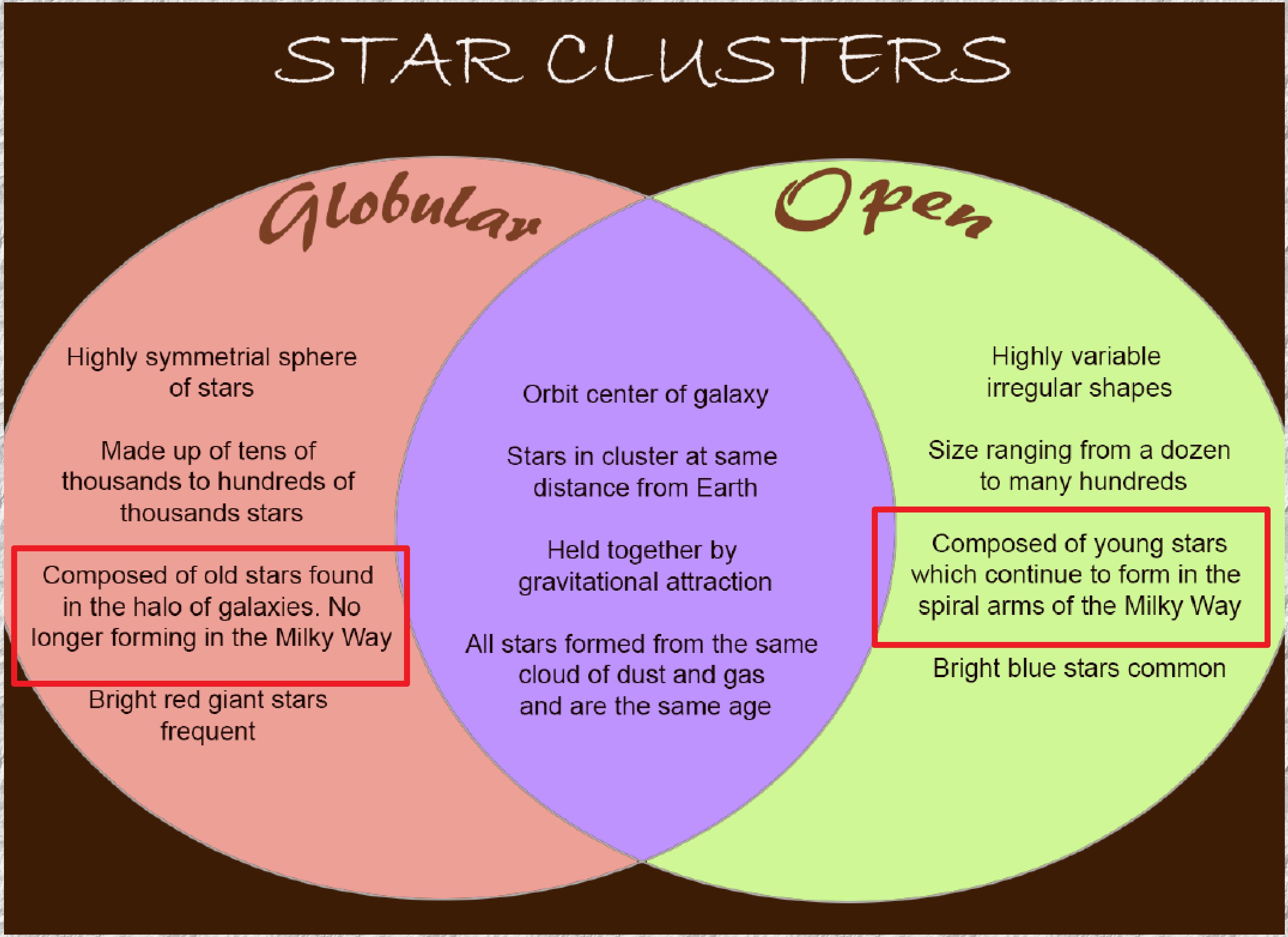
http://cdsarc.u-strasbg.fr/ftp/cats/B/ocl/v3.3/

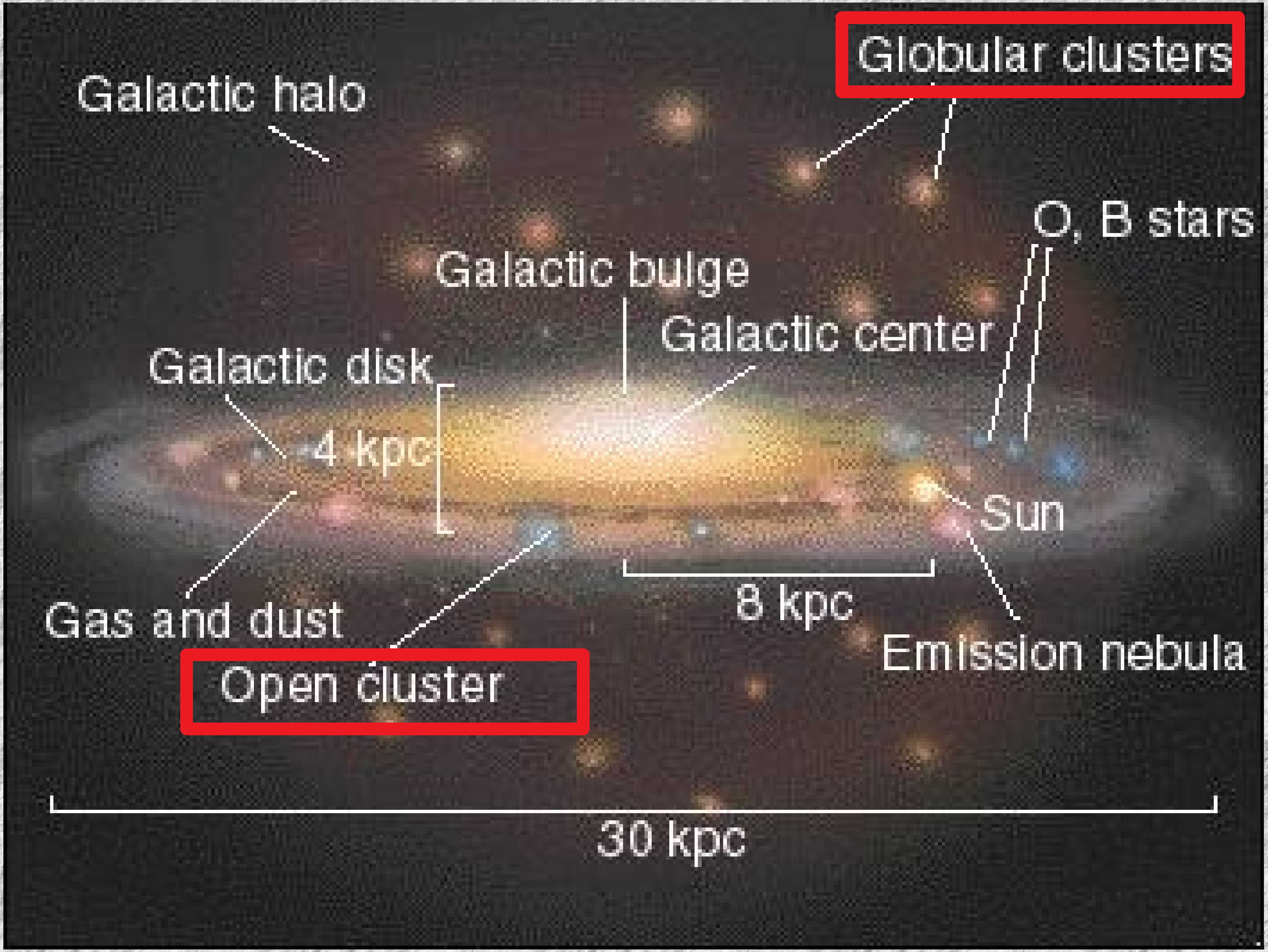
http://www.astro.iag.usp.br/ocdb/file/clusters.txt

https://www.physics.mcmaster.ca/~harris/mwgc.dat

https://webda.physics.muni.cz/

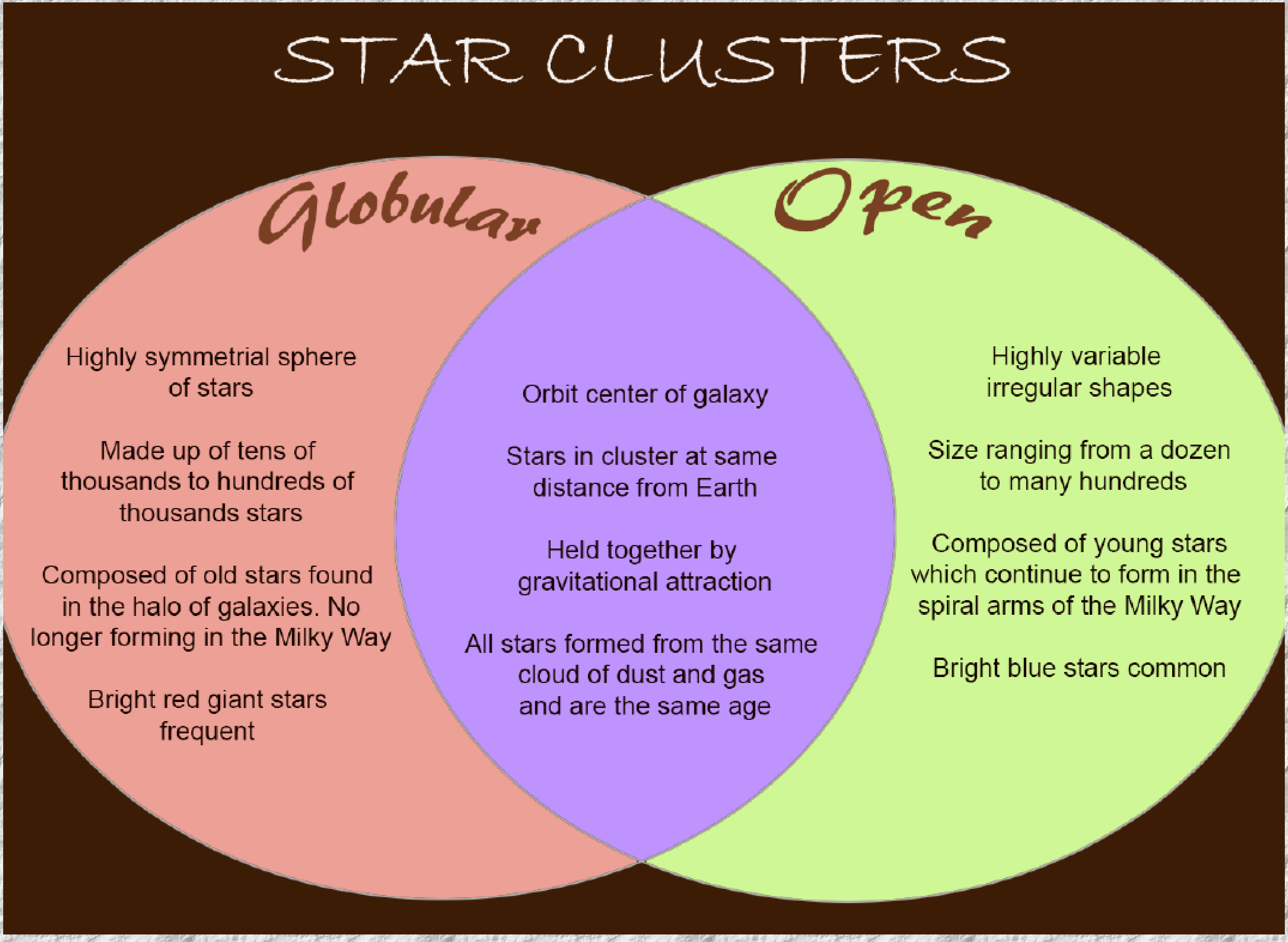
CE de la **Vía Láctea**





Globular clusters
Galactic halo
O, B stars
Galactic bulge
Galactic center
Galactic disk
4 kpc
Sun
Gas and dust
8 kpc
Emission nebula
Open cluster
30 kpc

CE de la **Vía Láctea**



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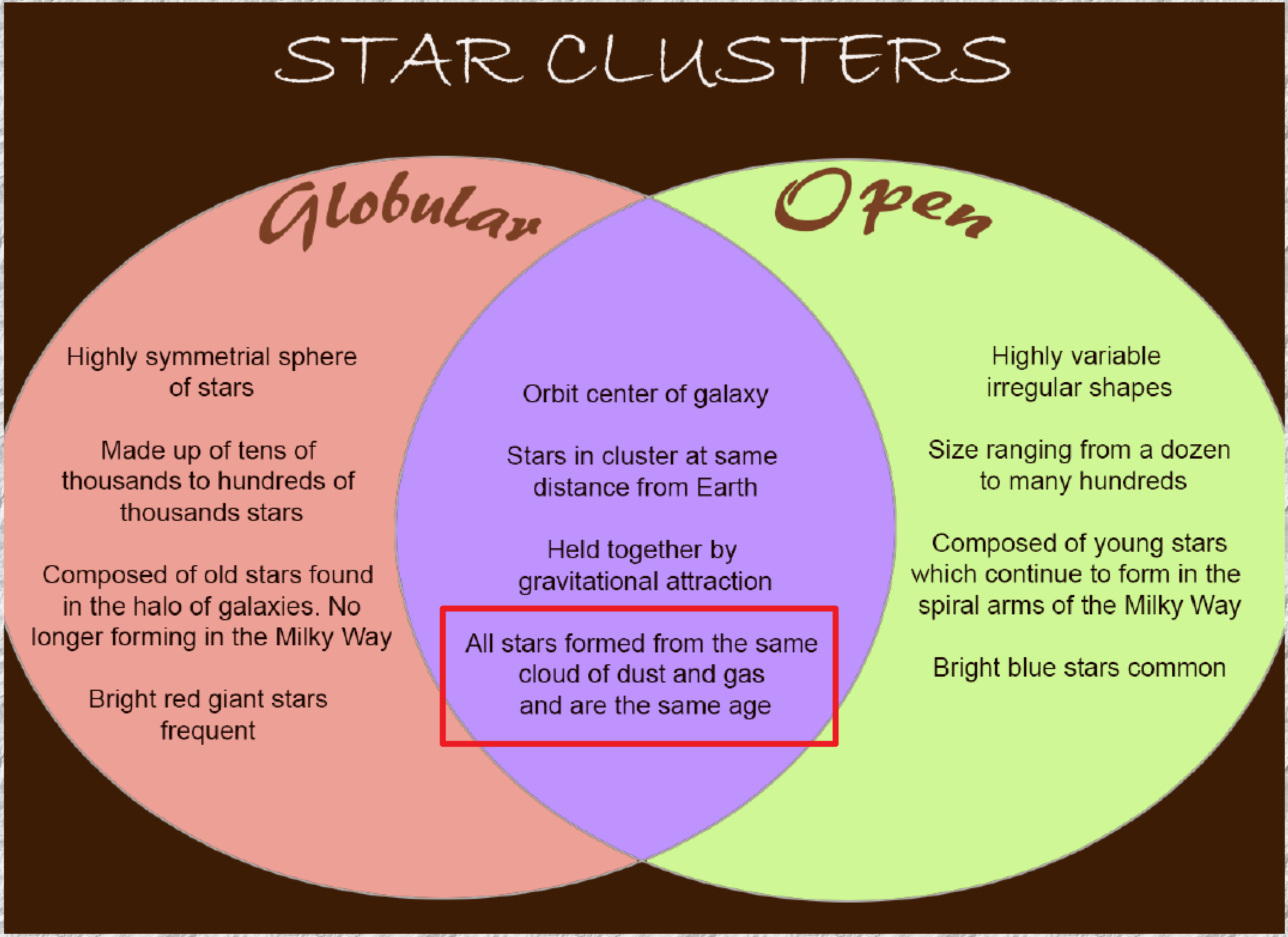
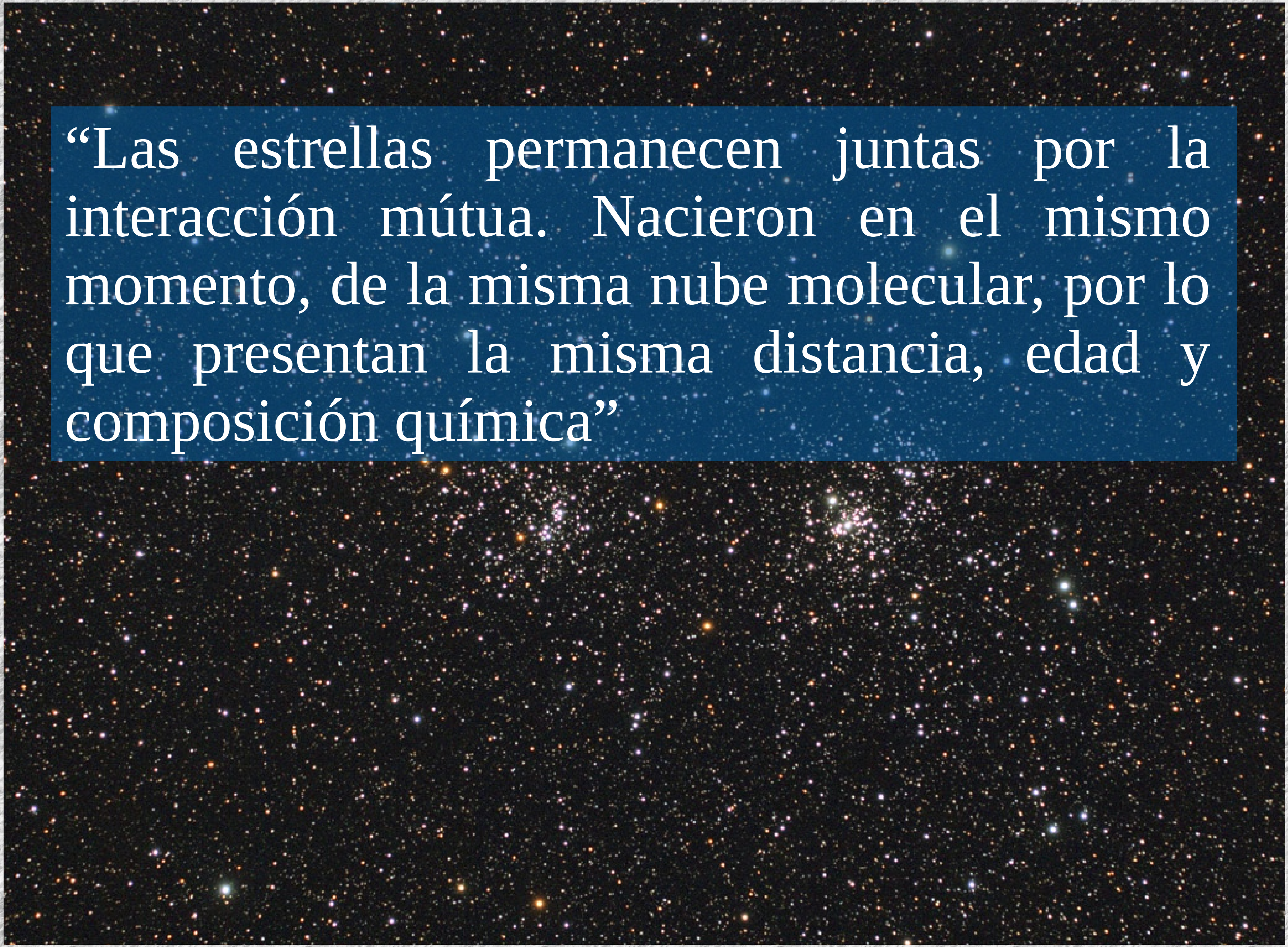


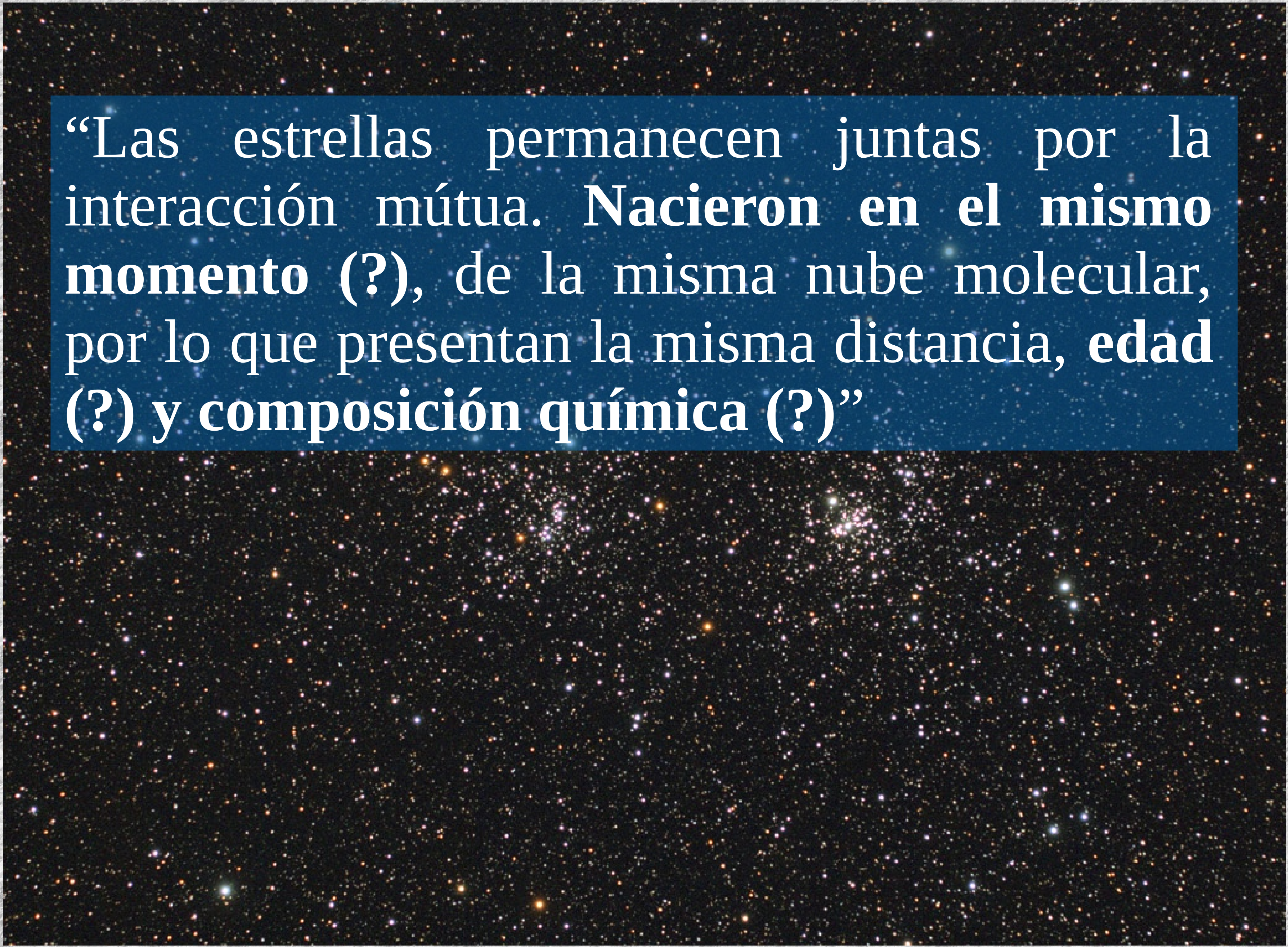
Cúmulos estelares
¿Poblaciones estelares “simples”?



“Las estrellas permanecen juntas por la interacción mútua. Nacieron en el mismo momento, de la misma nube molecular, por lo que presentan la misma distancia, edad y composición química”

Cúmulos estelares
¿Poblaciones estelares “simples”?

“Las estrellas permanecen juntas por la interacción mútua. **Nacieron en el mismo momento (?)**, de la misma nube molecular, por lo que presentan la misma distancia, **edad (?) y composición química (?)**”



Cúmulos estelares
¿Poblaciones estelares “simples”?

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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]

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Astronomy & Astrophysics

Multiple stellar populations in Magellanic Cloud clusters⋆,⋆⋆

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

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