Astronomický proseminář II

Galaxie a galaxie

hvězdné soustavy

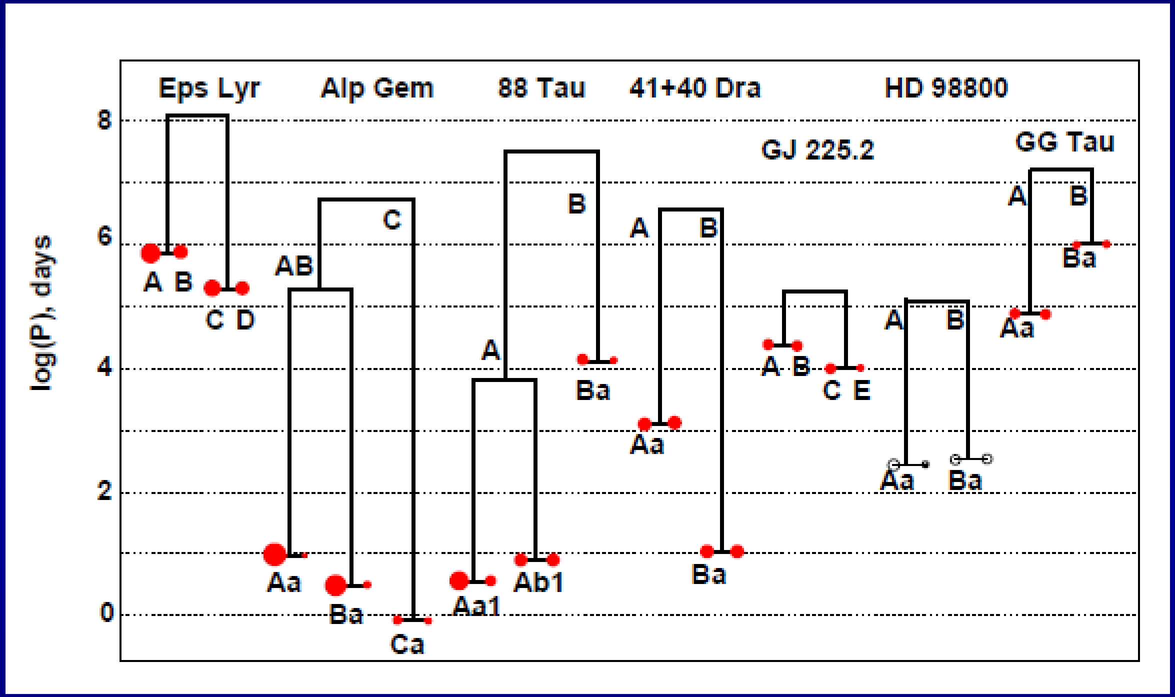
- dvojhvězdy, vícenásobné hvězdné soustavy
- hvězdokupy
- galaxie
- skupiny galaxií
- kupy galaxií
- nadkupy galaxií
- vyšší struktury

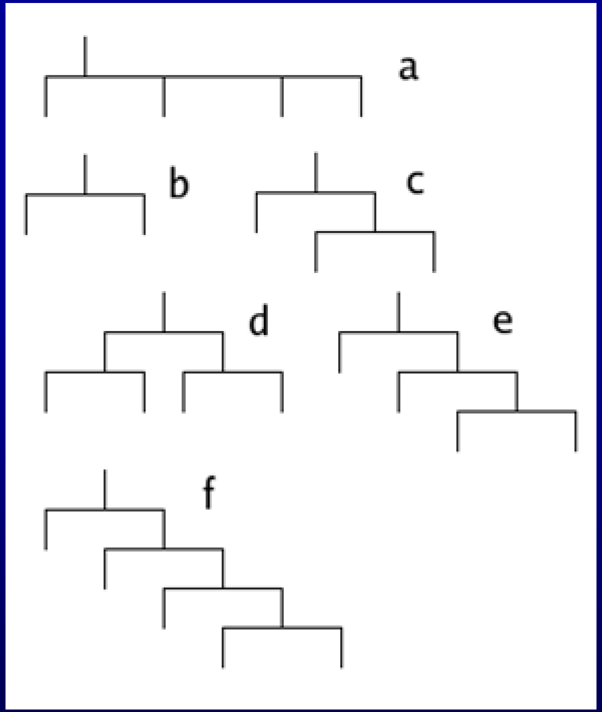
vícenásobné hvězdné soustavy

dvojhvězdy – např. Sirius, Prokyon, Mira
trojhvězdy – Polárka
čtyřhvězdy – Mizar, epsilon Lyr
pětihvězdy – 91 Aql, delta Ori
šestihvězdy – Castor, Alcor (s Mizarem)
sedmihvězdy – AR Cas

katalog Tokovinin
http://www.ctio.noao.edu/~atokovin/stars/intro.html

uspořádání soustav



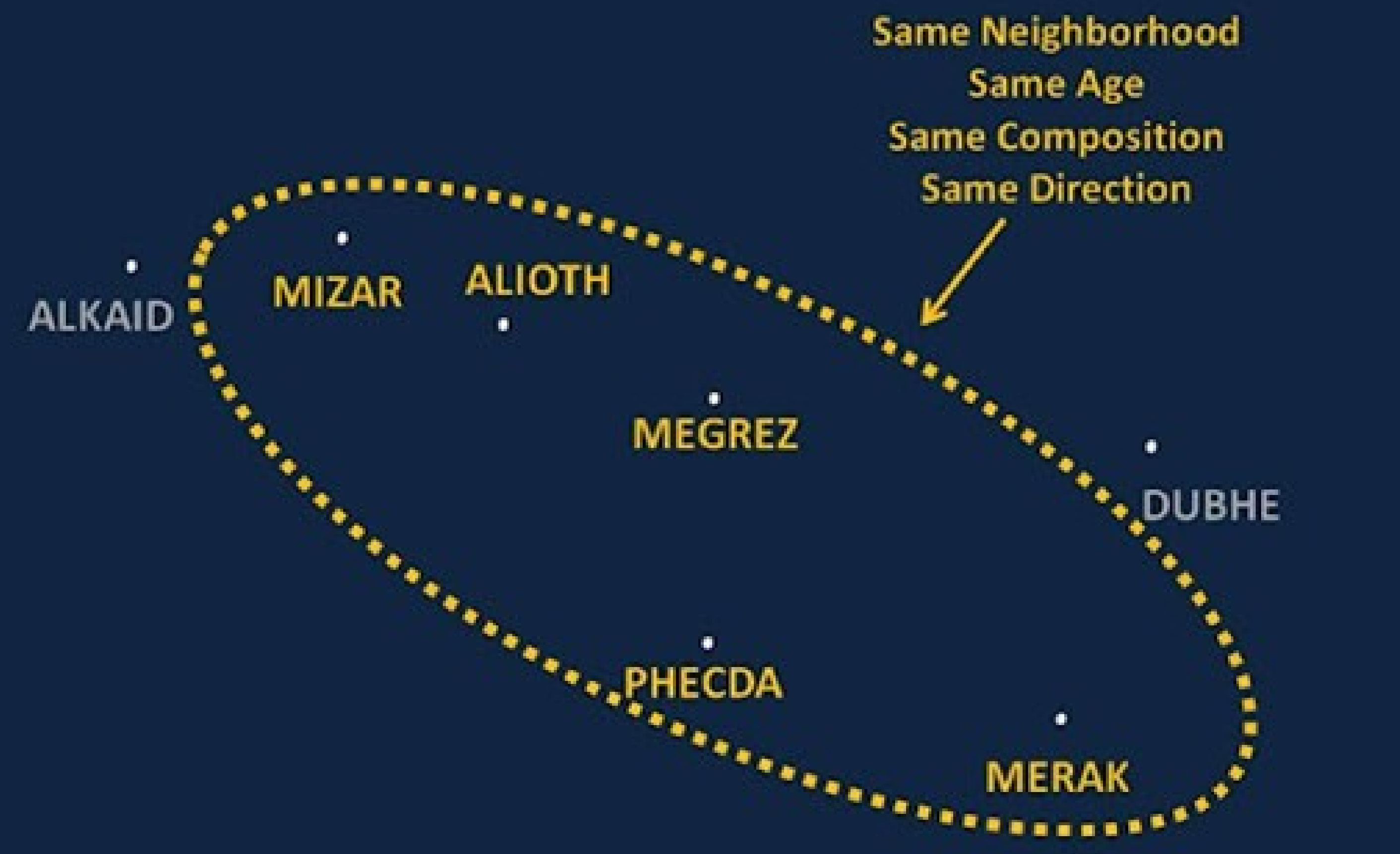


Hvězdné asociace

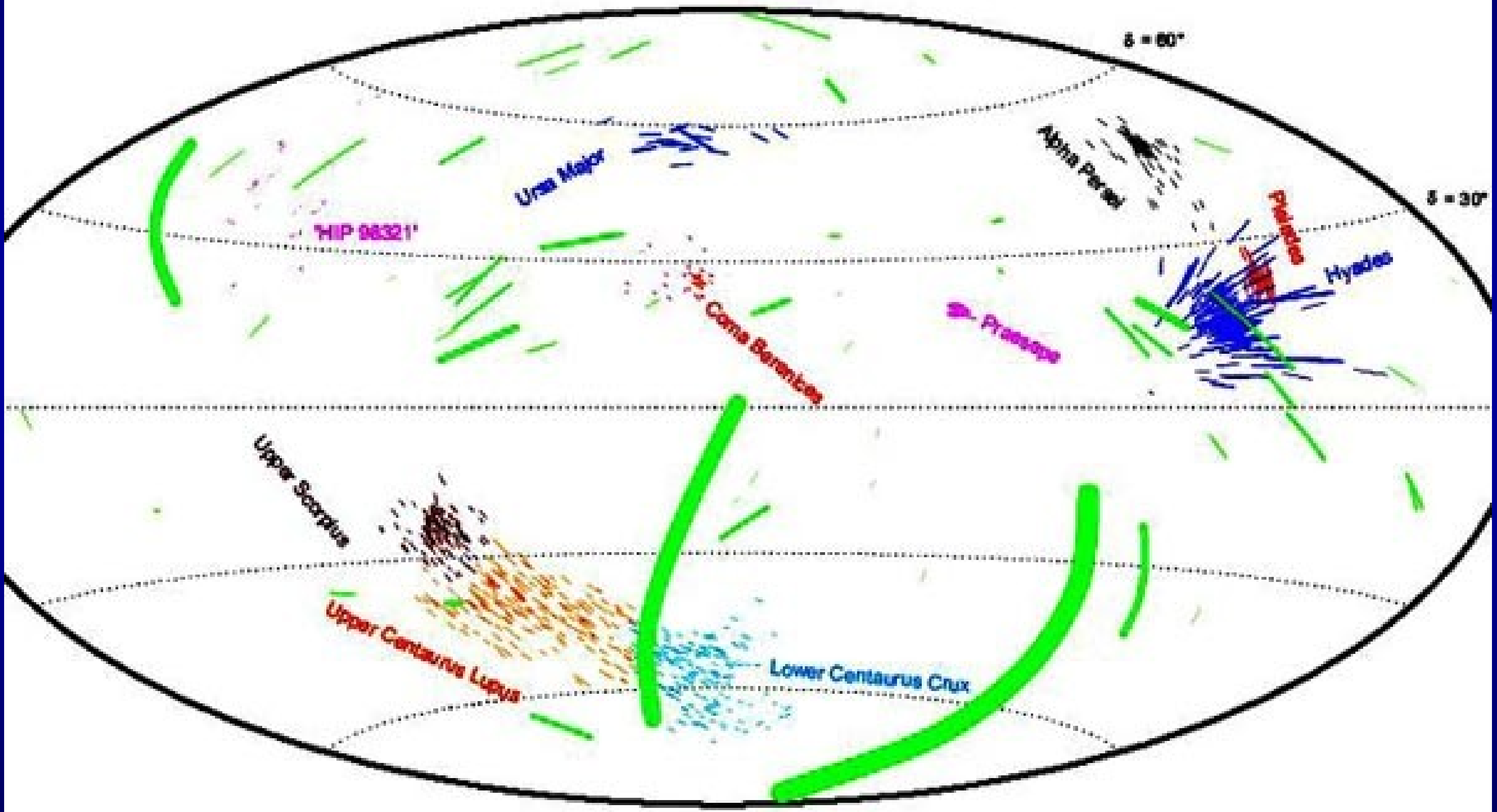
původ:

- rozpad hvězdokup
- nově vznikající hvězdokupy – hvězdy mají podobné trajektorie v prostoru
- pohybové asociace
  - skupina UMa – od UMa, Cep až TrA
  - Hyády
  - Jesličky
- hvězdné asociace
  - O asociace (v Ori)
  - OB asociace (v Sco – Cen)
  - R asociace (střední M, zbytky původní látky – Mon R2)
  - T asociace (hvězdy T Tauri)

Ursa Major Moving Group



Motions of Local Stellar Group Streams



OB asociace Ara OB1

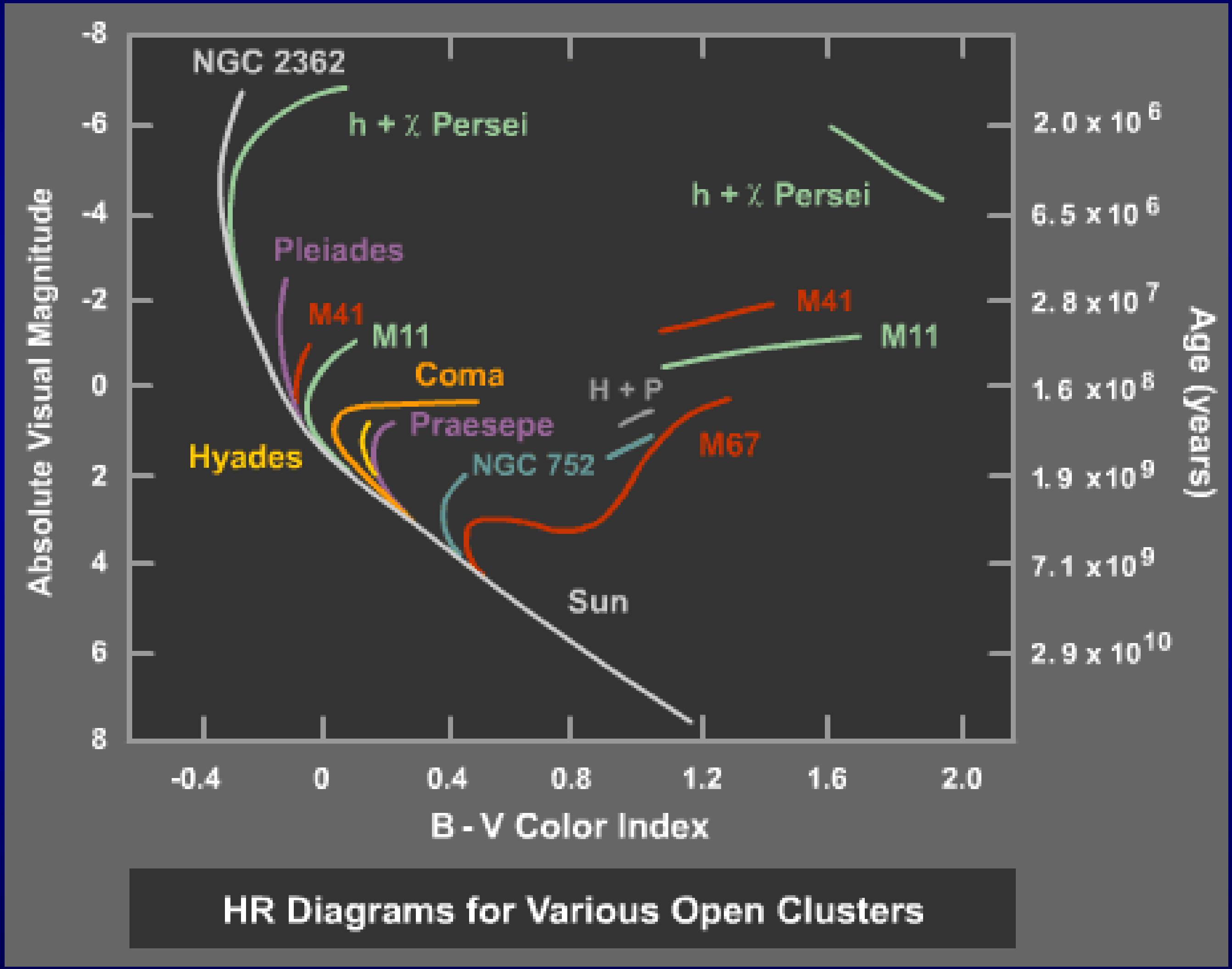
Otevřené hvězdokupy

- nepravidelný tvar
- stovky hvězd
- výskyt u galaktické roviny
- obsahují také mezihvězdný prach a plyn
- jedná se o relativně mladé hvězdy, jejich seskupení je gravitačně nestabilní
- Plejády, Hyády, Jesličky atd.
- určení stáří podle umístění charakter. zahnutí na HRD, který je sestaven pro hvězdy konkrétní hvězdokupy

Open Clusters

h + χ Persei
(young double cluster)

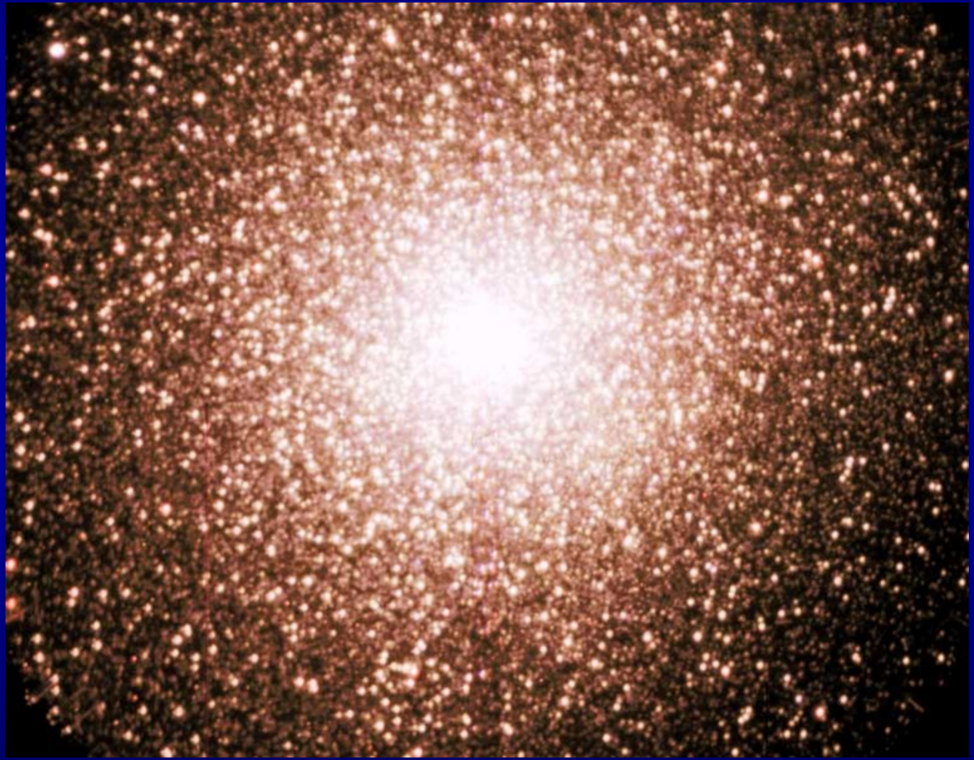
M67
(4 billion year old cluster)



Kulové hvězdokupy

- silná koncentrace hvězd směrem ke středu,
- počet hvězd řádově 10^6
- staré útvary ($\sim 10^{10}$ let)
- gravitačně stabilní
- jsou v tzv. galaktickém halu
- M 13, 47 Tuc

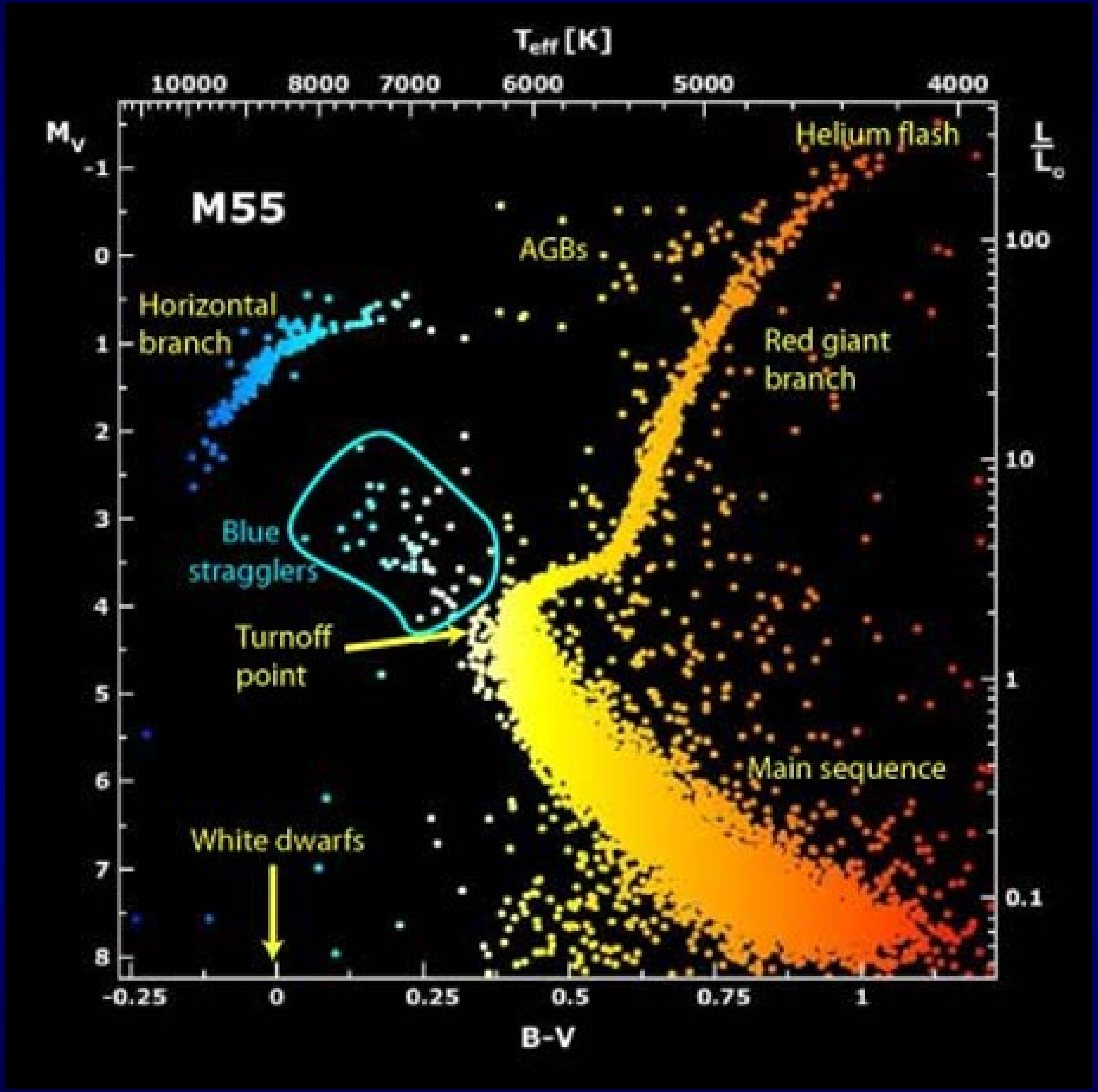
M 13



47 Tuc

Figure 25.24

- **Globular Cluster M54.** This beautiful Hubble Space Telescope image shows the globular cluster that is now believed to be the nucleus of the Sagittarius Dwarf Galaxy. (credit: ESA/Hubble & NASA)

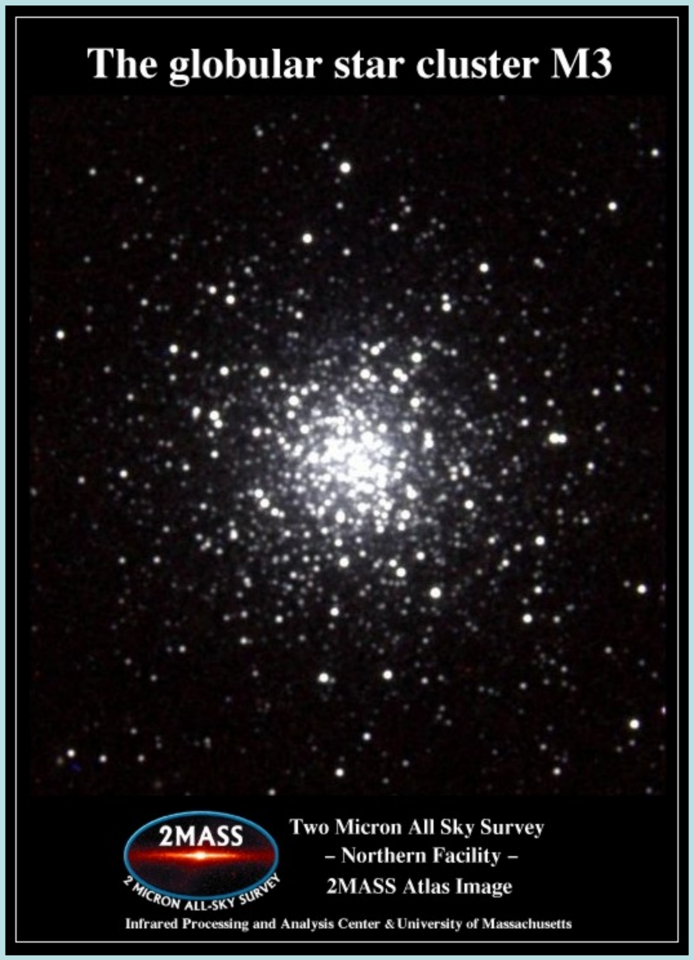


T_{eff} [K]
10000
8000
7000
6000
5000
4000
M_V
-1
0
1
2
3
4
5
6
7
8
$\frac{L}{L_\odot}$
100
10
1
0.1
M55
Helium flash
AGBs
Horizontal branch
Red giant branch
Blue stragglers
Turnoff point
Main sequence
White dwarfs
-0.25
0
0.25
0.5
0.75
1
B-V

základní údaje o hvězdokupách

	Asociace	Otevřené h.	Kulové h.
tvar	nepravidelný	nepravidelný	kulový
množství	málo hvězd	málo hvězd	mnoho hvězd
koncentrace	jen u některých	slabá k.	silná k.
místo výskytu v Galaxii	spirální ramena	galaktická rovina	galaktické halo
poloha v HR diagramu	jako u mladých hvězd	jako u hvězd populace I	jako u hvězd populace II

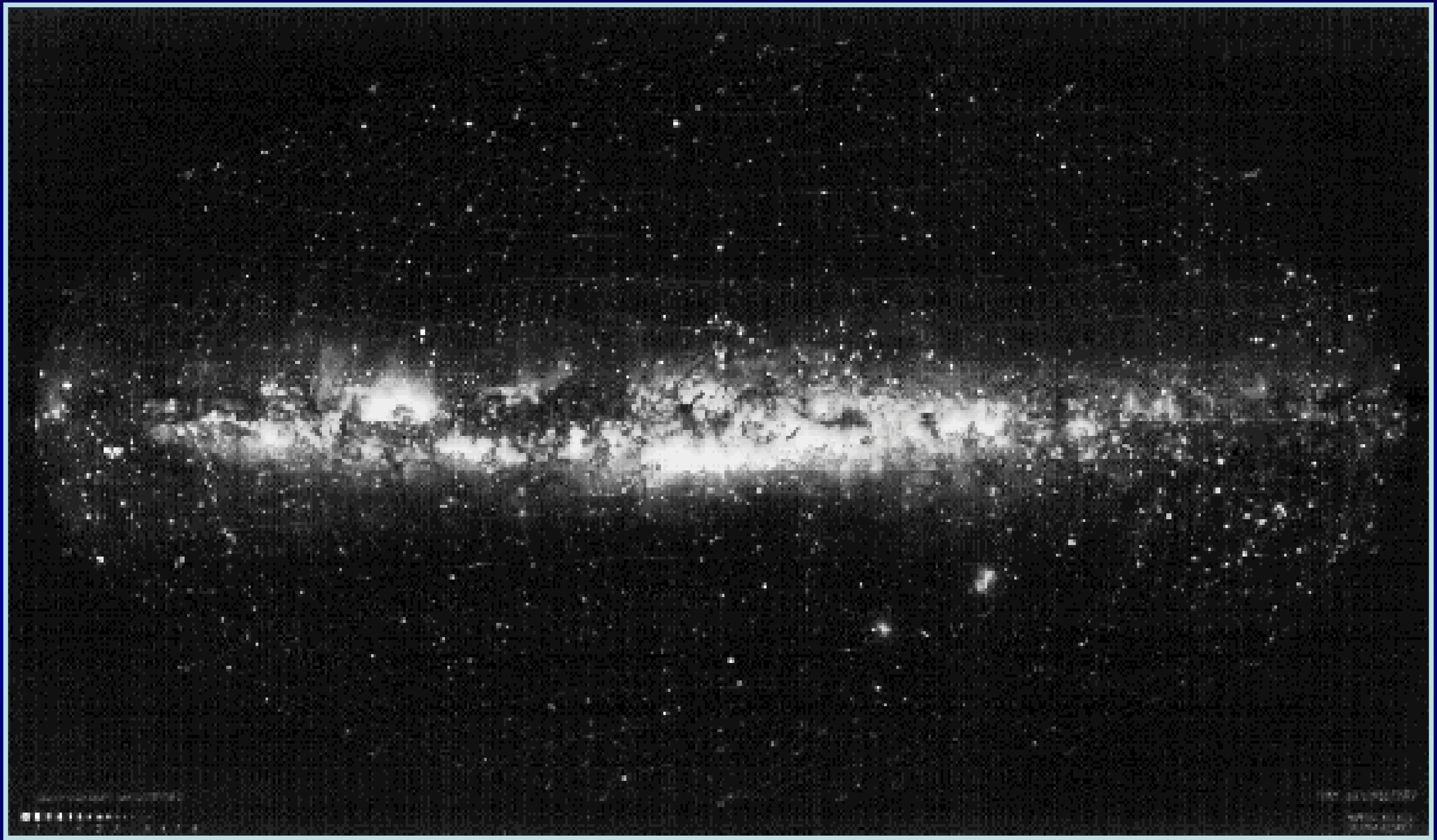
srovnání vzhledu



naše Galaxie

Galaxie

- naše Galaxie, resp. její spirální ramena jsou dobře viditelná jako tzv. Mléčná dráha. Také všechny ostatní hvězdy, které jsou viditelné pouhým okem, patří do tohoto systému
- Galaxii tvoří několik set miliard hvězd, velké množství mezihvězdné látky a patrně i tzv. skryté hmoty
- v centru Galaxie je velmi hmotná černá díra
- při pohledu z mimogalaktického prostoru by měla Galaxie plochý tvar (jako dva talíře přiklopené na sebe), pohled „shora“ by ukázal spirálovitou strukturu s centrální příčkou
- rotace Galaxie je poměrně složitá
- Slunce ve 2/3 vzdálenosti poloměru Galaxie od jejího středu 1 oběh za ~ 220 mil. let



Galaxie

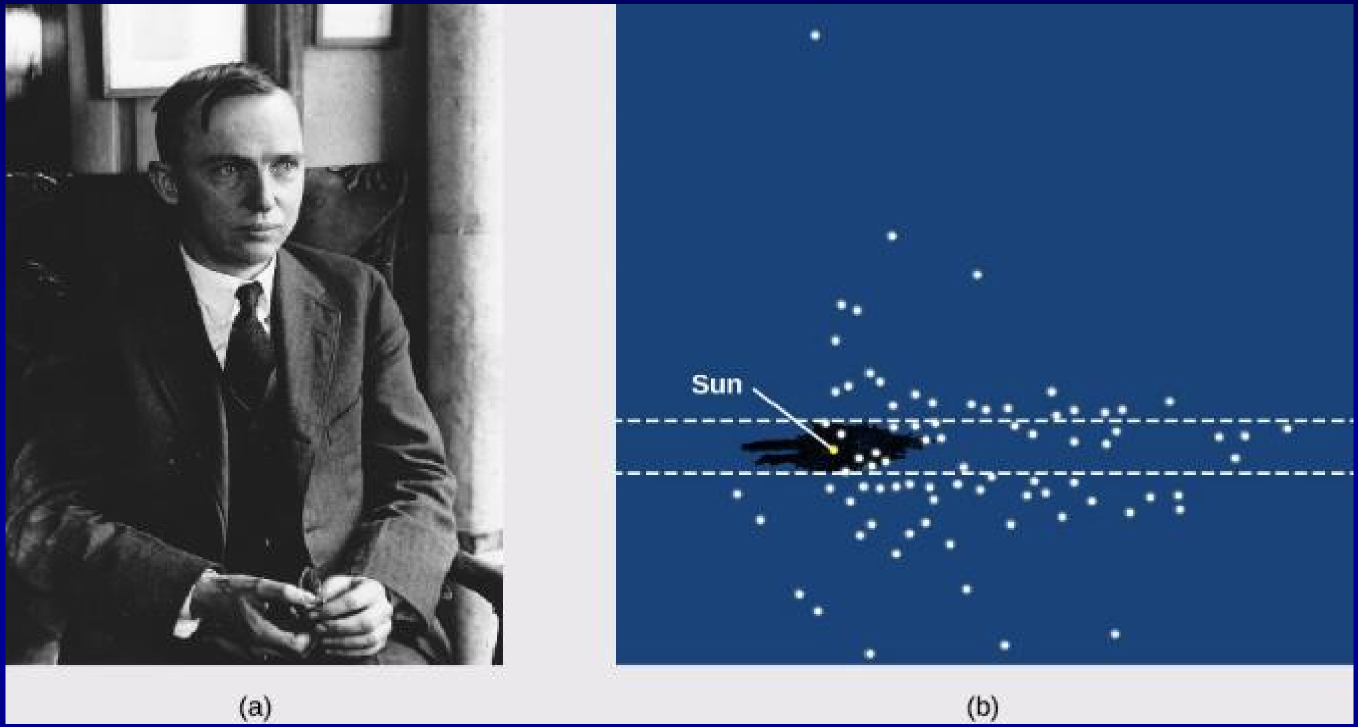
Jak jsme k těmto poznatkům dospěli?

- 1. model z pozorování – W. Herschel, 18. století
  - chyby: totožný zářivý výkon všech hvězd, konstantní prostorová hustota, neznalost mezihvězdné extinkce
  - výsledkem byl model Galaxie o průměru 3 kpc, Slunce uprostřed
- 1922 další model – Kapteyn
  - zářivé výkony různé, ale bez extinkce
  - elipsoid 8500 x 1700 pc, Slunce 650 pc od středu
- 1920 – Velká debata – Shapley x Curtis
- role mezihvězdné látky odhalena až později
  - plyn tvoří až 80 %
  - prach – Si, grafitová, kovová a ledová zrnka

Figure 25.3

- **Herschel's Diagram of the Milky Way.** Herschel constructed this cross section of the Galaxy by counting stars in various directions.

Figure 25.4



- **Harlow Shapley and His Diagram of the Milky Way.**

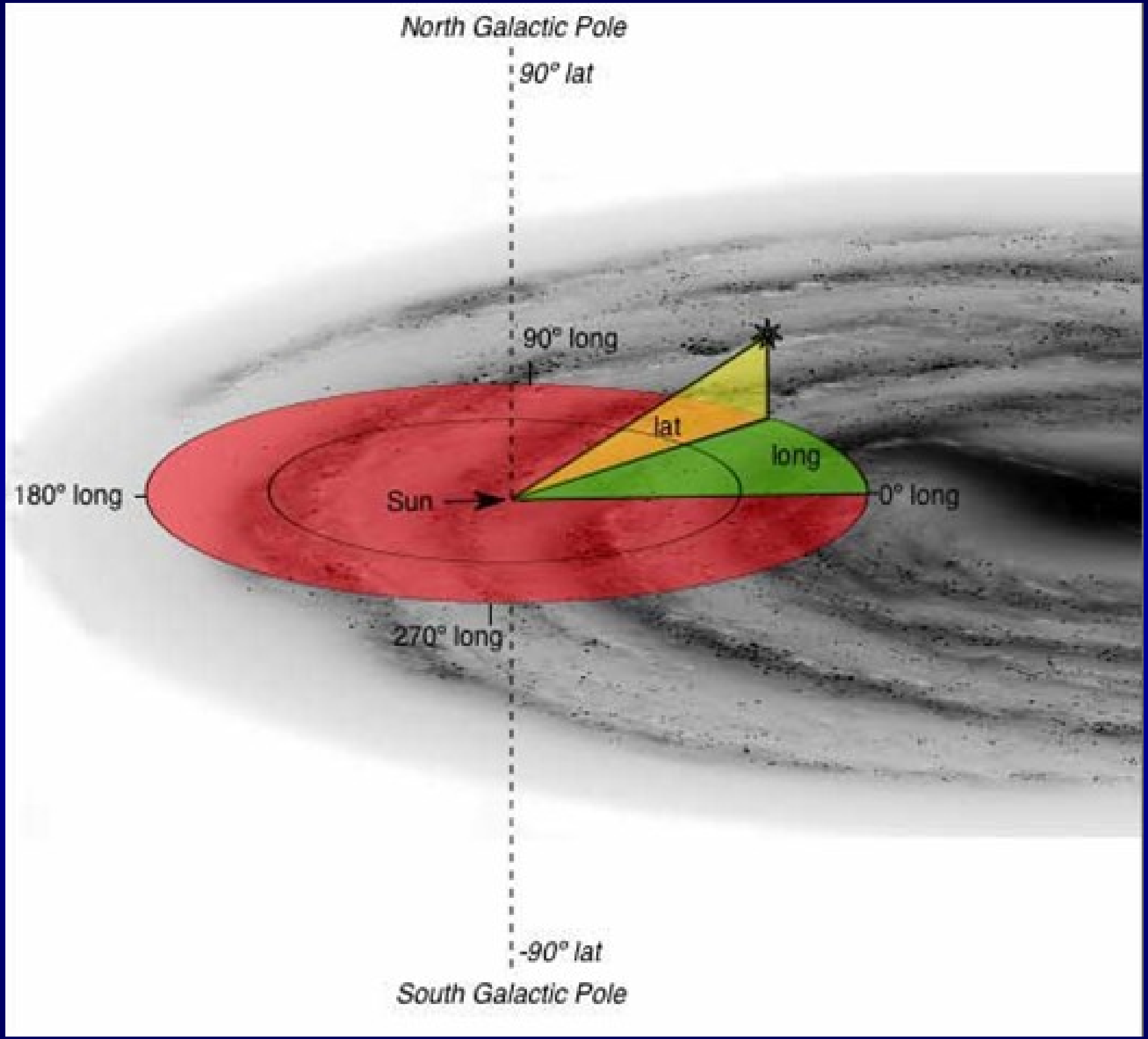
(a) Shapley poses for a formal portrait.

(b) His diagram shows the location of globular clusters, with the position of the Sun also marked. The black area shows Herschel’s old diagram, centered on the Sun, approximately to scale.

Galaxie

Galaktická souřadnicová soustava

- základní rovina – rovina největší koncentrace hvězd
  - úhel mezi rovinou galaktického rovníku a rovinou světového rovníku je 62 st. 36 min.
  - základní směr (ke středu G) je definován rezolucí IAU (1959): rekt. 17h 42min 29,3vt a deklinace -28st 59min 18vt
  - galaktická délka *l* a šířka *b*


North Galactic Pole
90° lat
90° long
lat
long
180° long
Sun
0° long
270° long
-90° lat
South Galactic Pole

Galaxie

Struktura

- složení – hvězdy, mezihvězdná látka, skrytá hmota
  - kulová složka (halo)
  - disková složka
  - plochá složka
  - jádro Galaxie

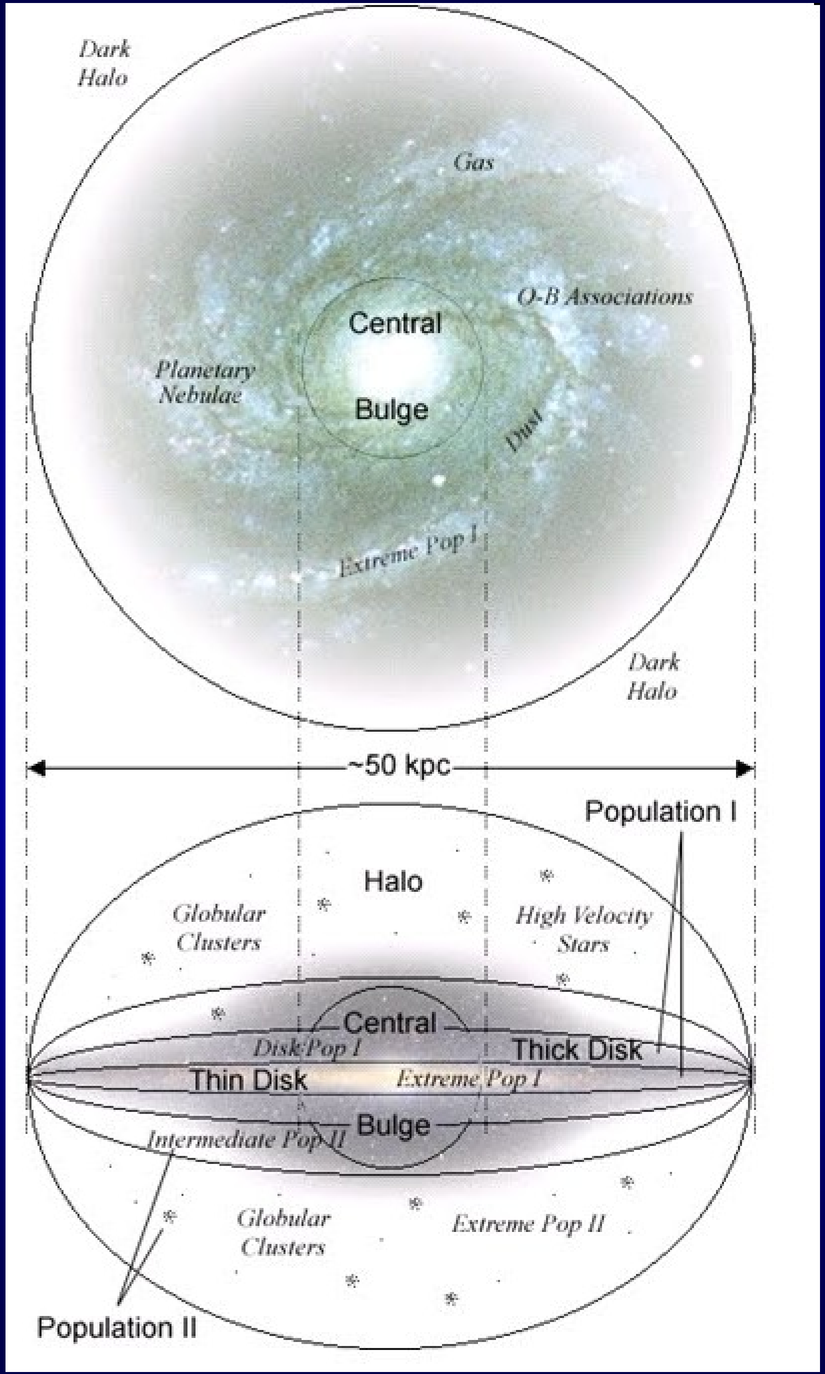
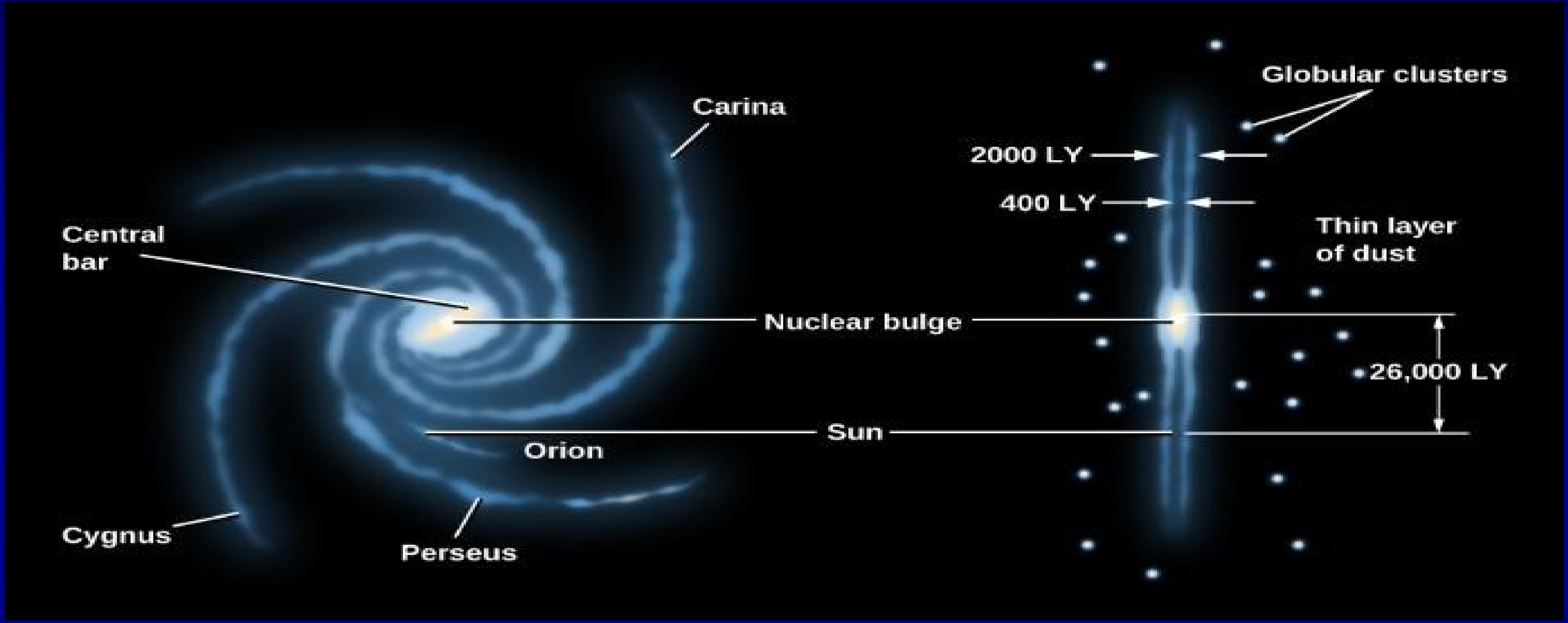
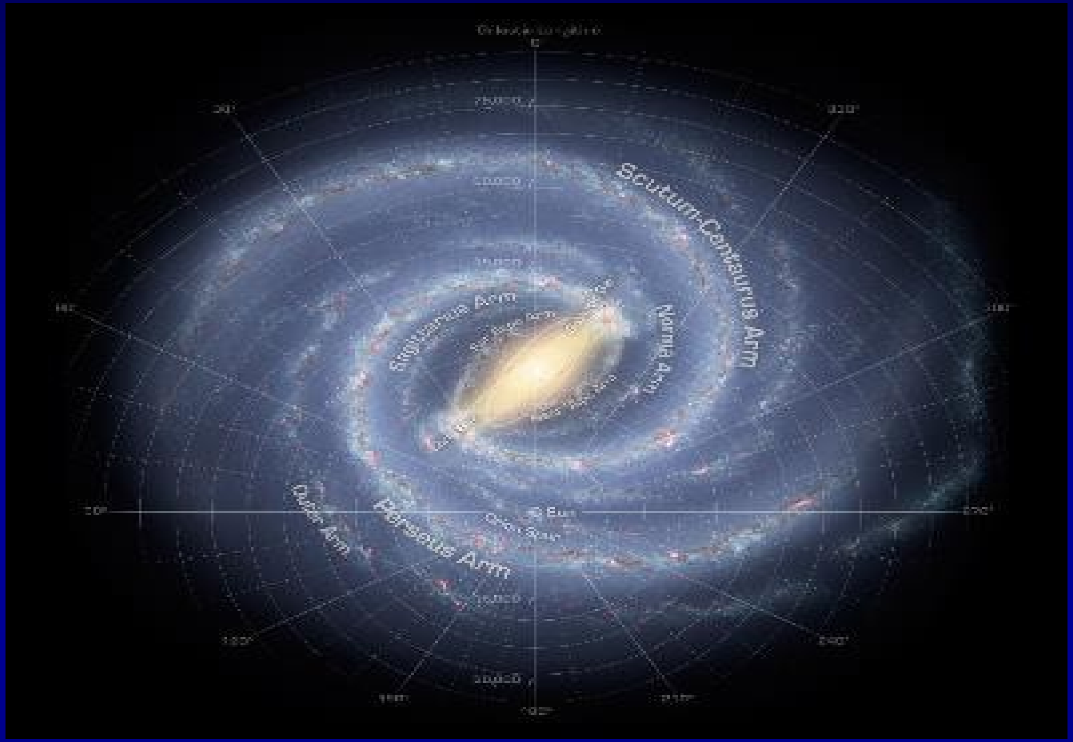


Figure 25.5



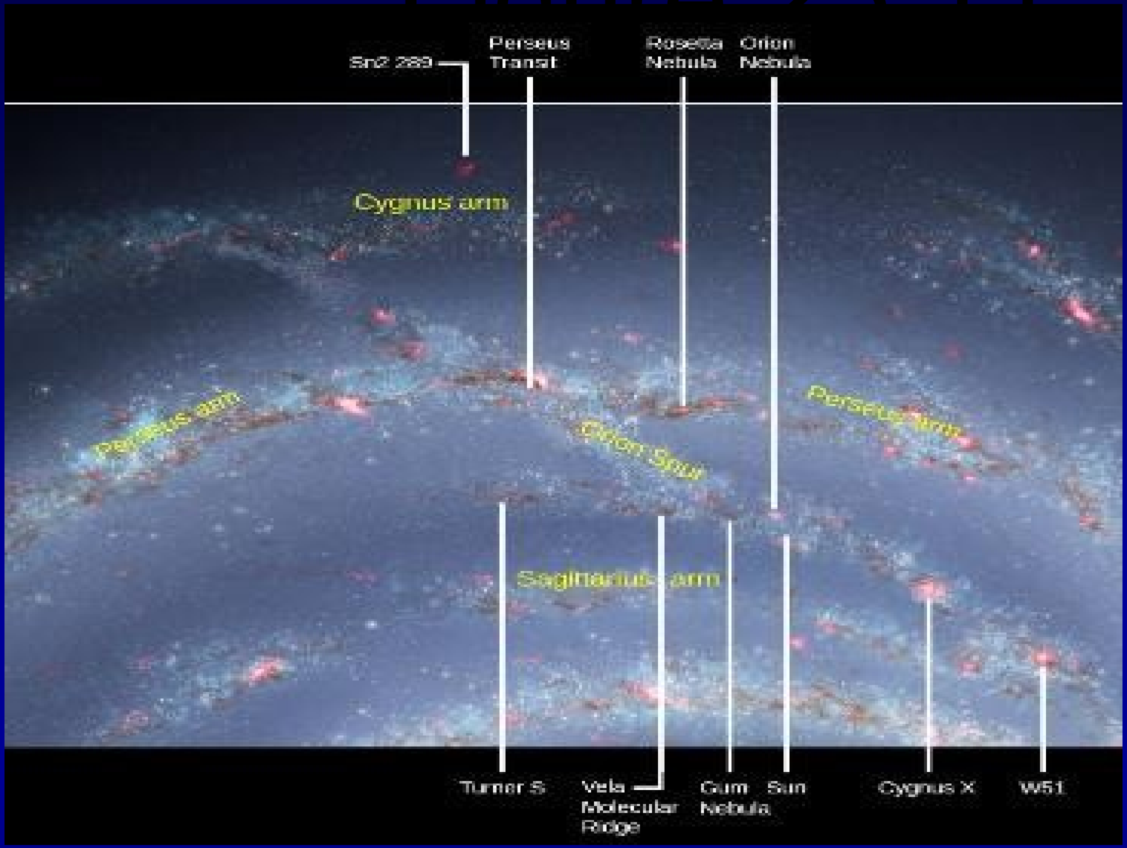
- **Schematic Representation of the Galaxy.** The left image shows the face-on view of the spiral disk; the right image shows the view looking edge-on along the disk. The major spiral arms are labeled. The Sun is located on the inside edge of the short Orion spur.

Figure 25.10



- **Milky Way Bar and Arms.** Here, we see the Milky Way Galaxy as it would look from above. This image, assembled from data from NASA’s WISE mission, shows that the Milky Way Galaxy has a modest bar in its central regions. Two spiral arms, Scutum-Centaurus and Perseus, emerge from the ends of the bar and wrap around the bulge. The Sagittarius and Outer arms have fewer stars than the other two arms. (credit: modification of work by NASA/JPL-Caltech/R. Hurt (SSC/Caltech))

Figure 25.11



- **Orion Spur.** The Sun is located in the Orion Spur, which is a minor spiral arm located between two other arms. In this diagram, the white lines point to some other noteworthy objects that share this feature of the Milky Way Galaxy with the Sun. (credit: modification of work by NASA/JPL-Caltech)

Galaxie

Spirální ramena

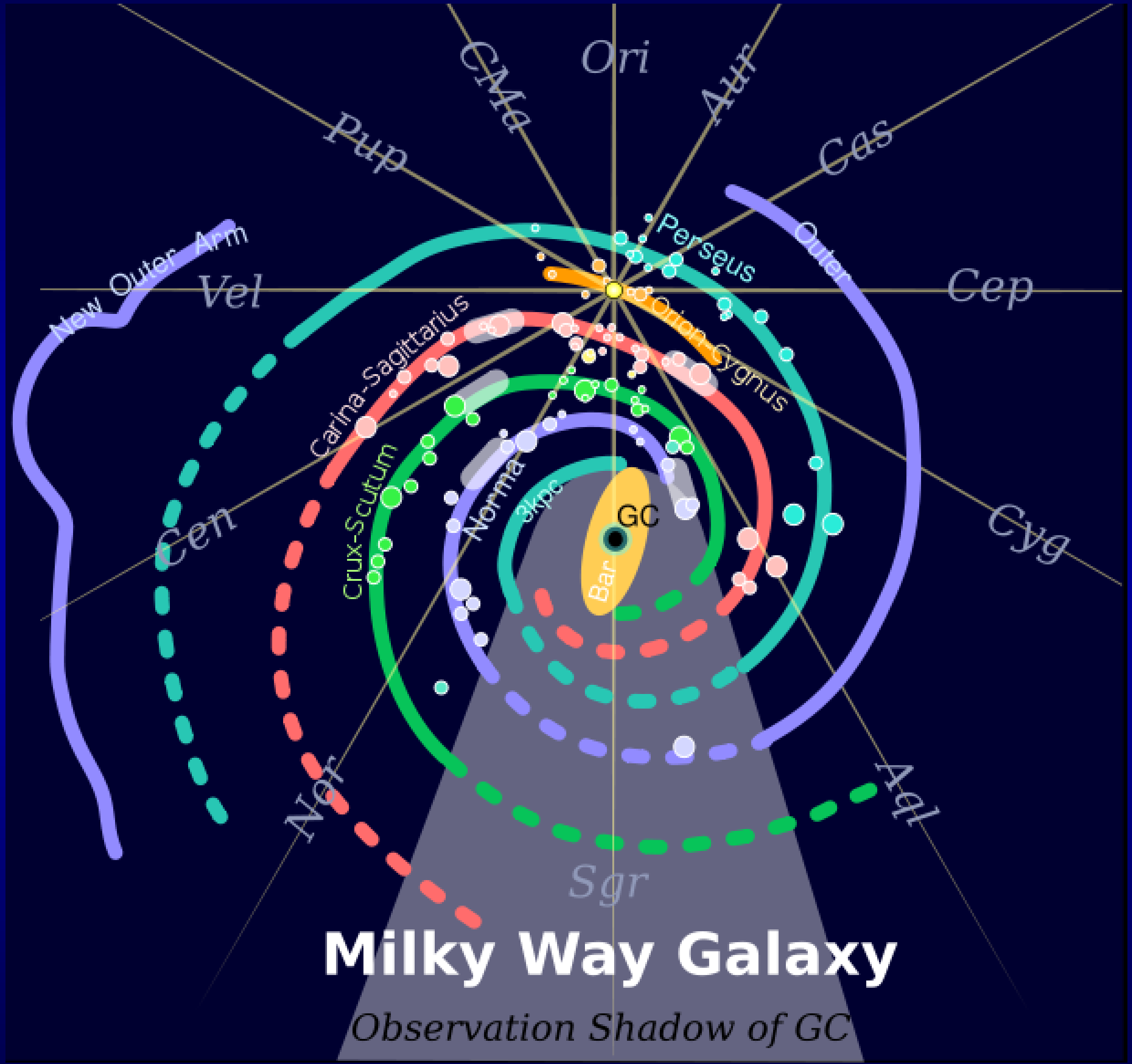
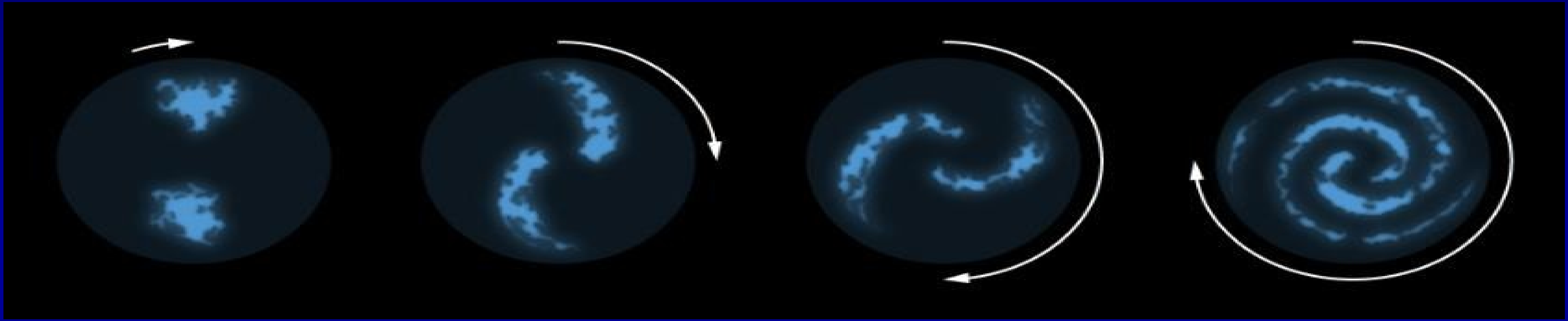
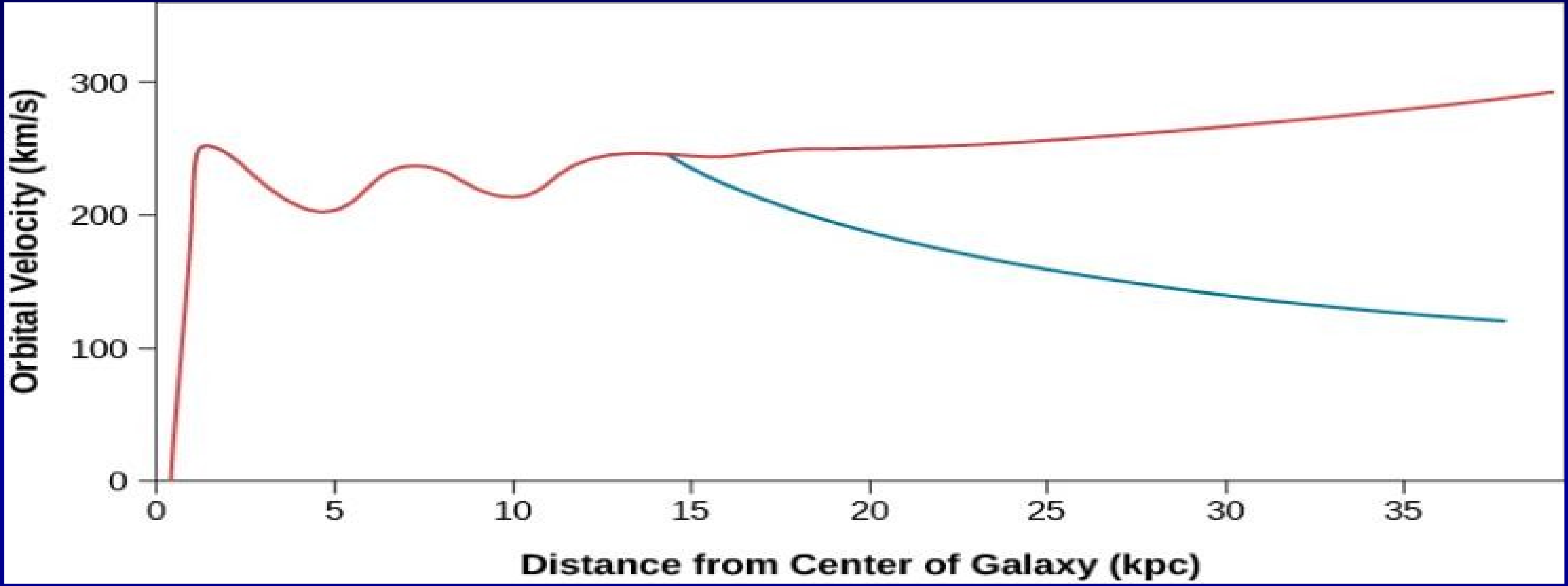


Figure 25.12



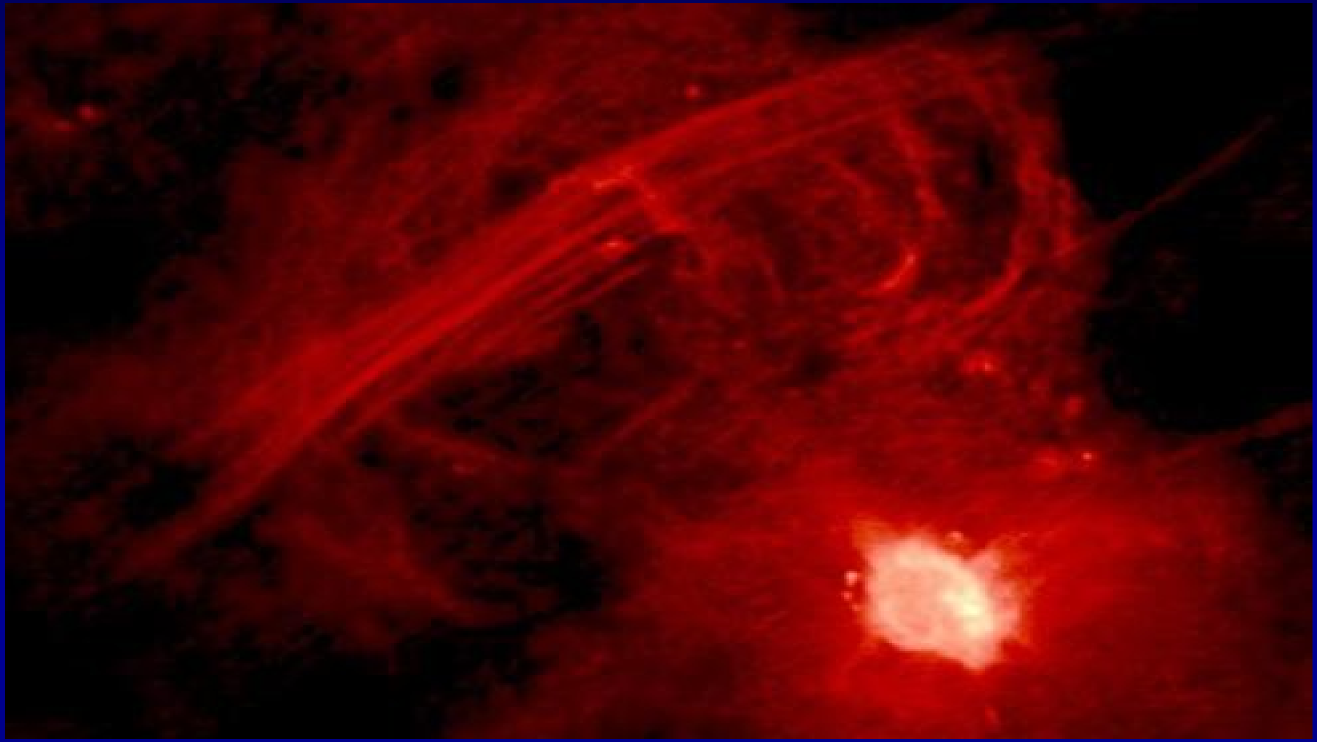
- **Simplified Model for the Formation of Spiral Arms.** This sketch shows how spiral arms might form from irregular clouds of interstellar material stretched out by the different rotation rates throughout the Galaxy. The regions farthest from the galactic center take longer to complete their orbits and thus lag behind the inner regions. If this were the only mechanism for creating spiral arms, then over time the spiral arms would completely wind up and disappear. Since many galaxies have spiral arms, they must be long-lived, and there must be other processes at work to maintain them.

Figure 25.13



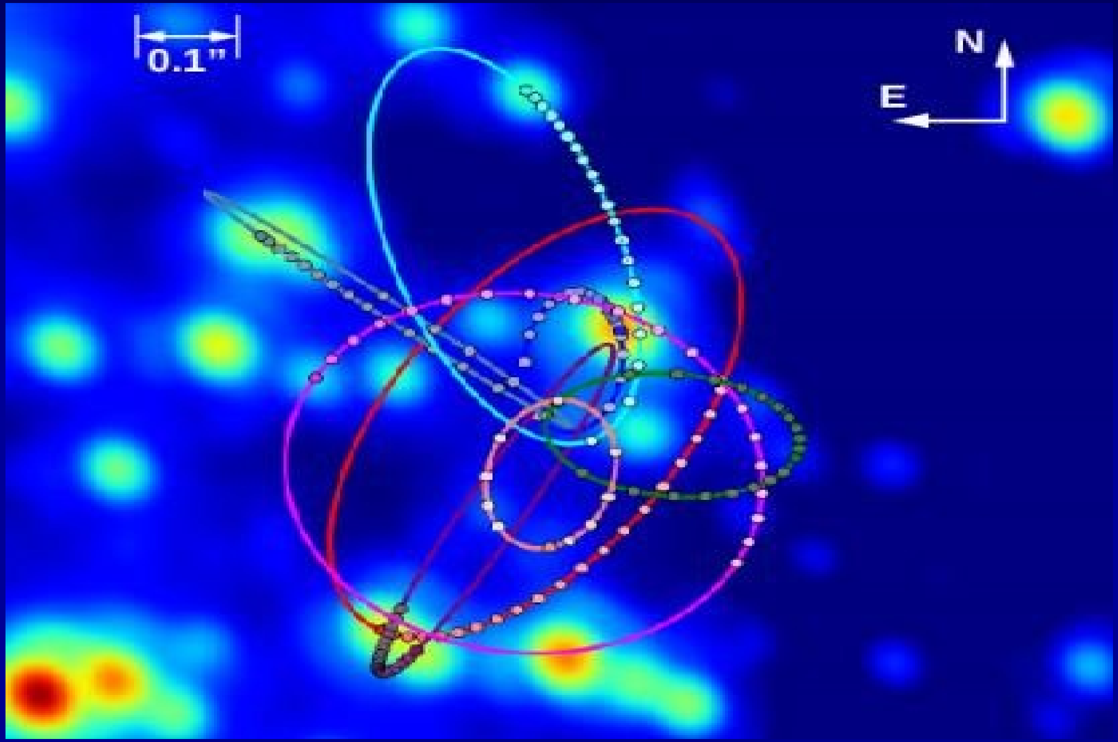
- **Rotation Curve of the Galaxy.** The orbital speed of carbon monoxide (CO) and hydrogen (H) gas at different distances from the center of the Milky Way Galaxy is shown in red. The blue curve shows what the rotation curve would look like if all the matter in the Galaxy were located inside a radius of 30,000 light-years. Instead of going down, the speed of gas clouds farther out remains high, indicating a great deal of mass beyond the Sun's orbit. The horizontal axis shows the distance from the galactic center in kiloparsecs (where a kiloparsec equals 3,260 light-years).

Figure 25.16



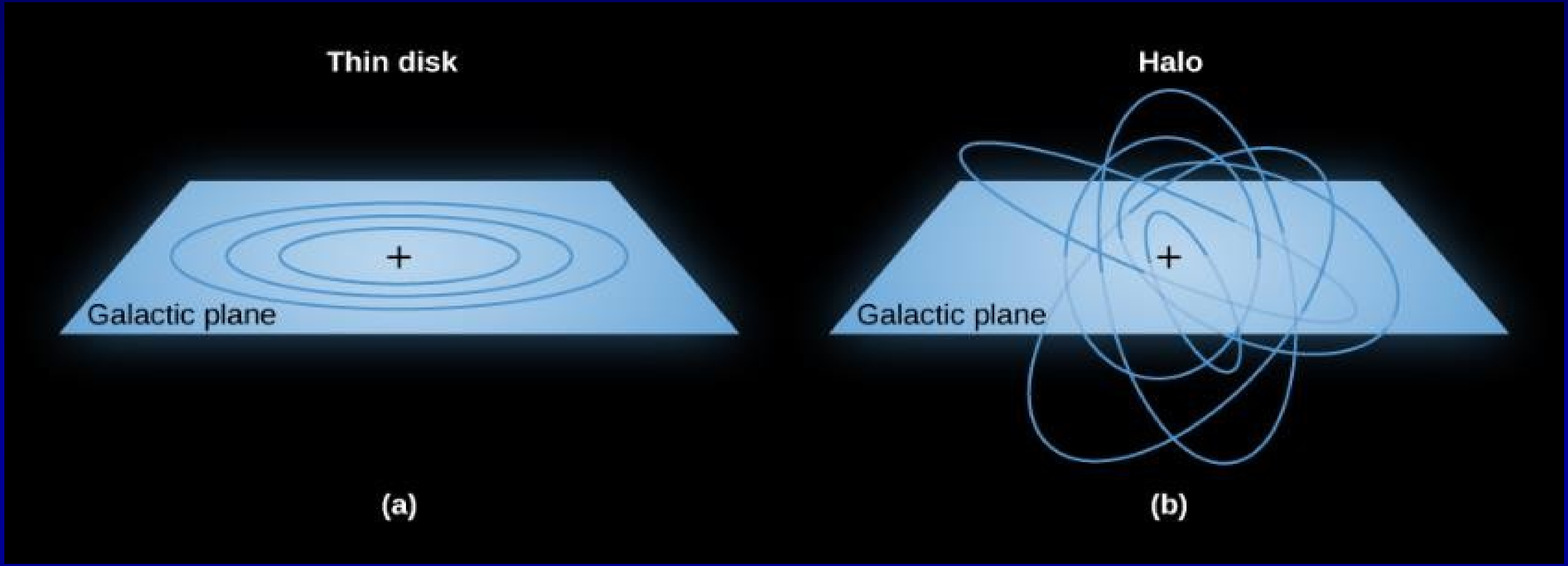
- **Sagittarius A.** This image, taken with the Very Large Array of radio telescopes, shows the radio emission from hot, ionized gas in the center of the Milky Way. The lines slanting across the top of the image are gas streamers. Sagittarius A* is the bright spot in the lower right. (credit: modification of work by Farhad Zadeh et al. (Northwestern), VLA, NRAO)

Figure 25.17



- **Near-Infrared View of the Galactic Center.** This image shows the inner 1 arcsecond, or 0.13 light-year, at the center of the Galaxy, as observed with the giant Keck Telescope. Tracks of the orbiting stars measured from 1995 to 2014 have been added to this “snapshot.” The stars are moving around the center very fast, and their tracks are all consistent with a single massive “gravitator” that resides in the very center of this image. (credit: modification of work by Andrea Ghez, UCLA Galactic Center Group, W.M. Keck Observatory Laser Team)

Figure 25.19



- **How Objects Orbit the Galaxy.**

(a) In this image, you see stars in the thin disk of our Galaxy in nearly circular orbits.

(b) In this image, you see the motion of stars in the Galaxy's halo in randomly oriented and elliptical orbits.

galaxie

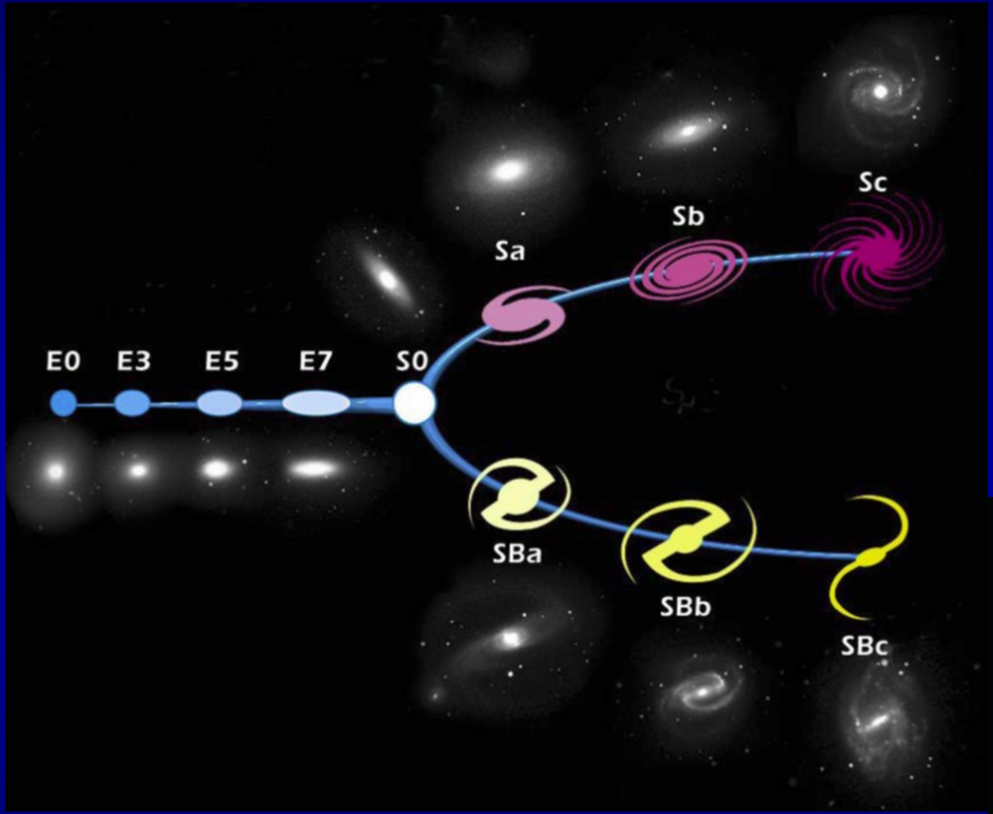
extragalaktické systémy

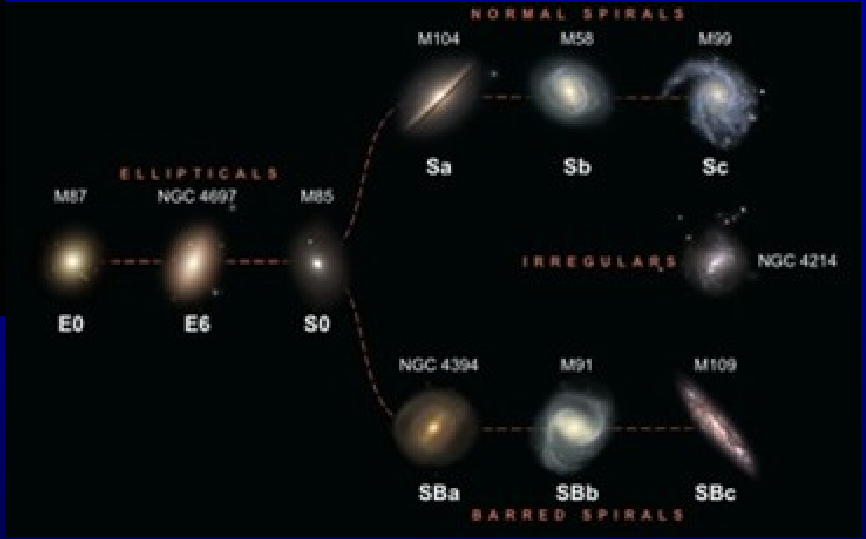
- 1. objev - 16. století - Magellanova mračna, dnes známo cca 100 miliard

- Hubbleova klasifikace (dle vzhledu)
  - E eliptické 13 %
  - S spirální 62 %
  - SO čočkovitý tvar 9 %
  - Ir nepravidelné 3 %

- 13 % zbývajících se z této klasifikace vymyká - tzv. aktivní galaxie
  - Seyfertovy
  - rádiové galaxie
  - kvasary (QSO - quasi stellar object)

Hubbleova klasifikace





Spirální galaxie

Eliptické galaxie

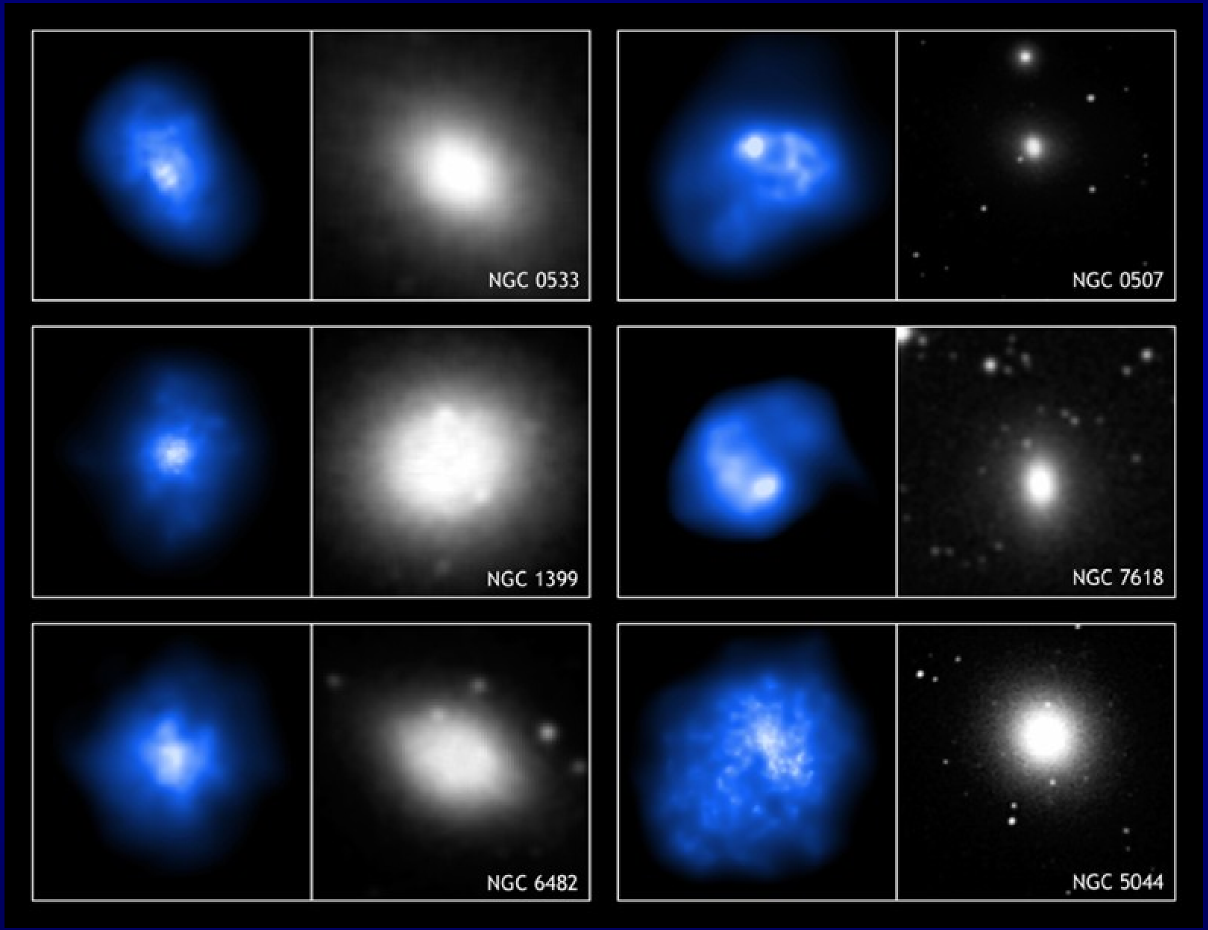
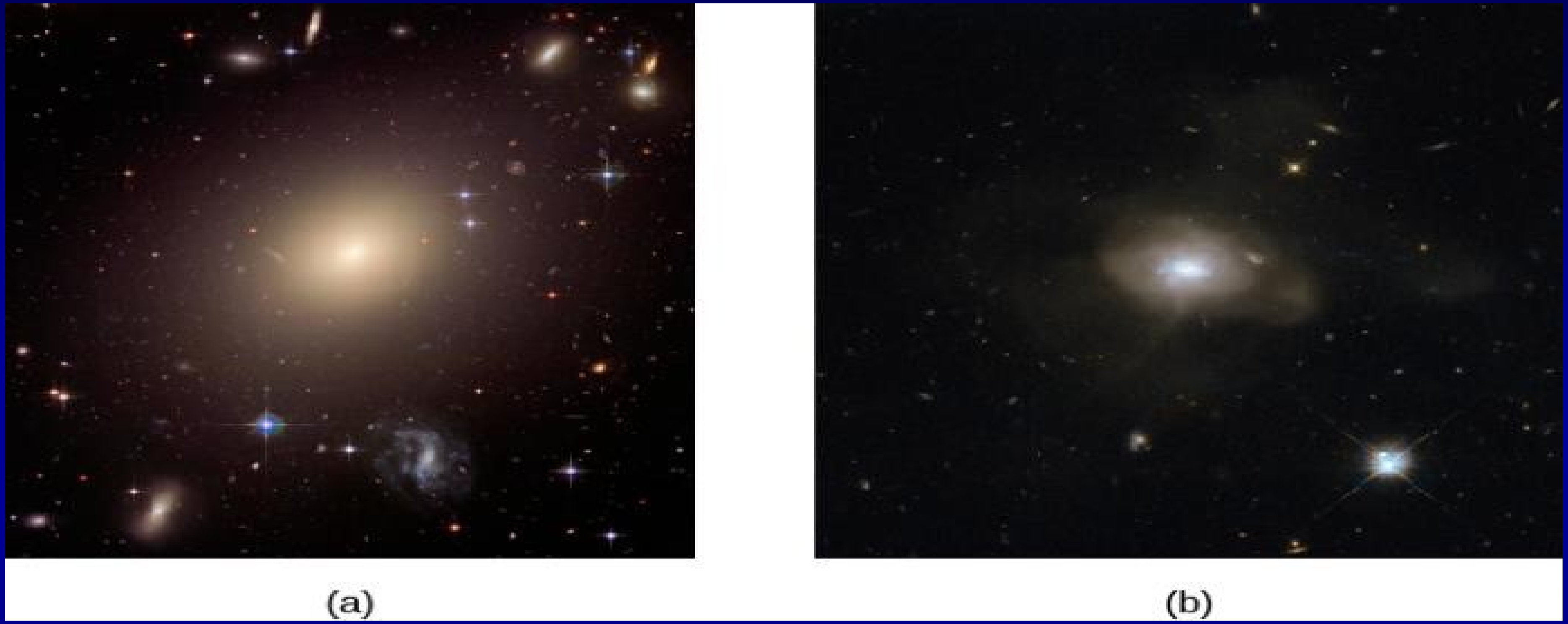


Figure 26.8

- **Dwarf Elliptical Galaxy.** M32, a dwarf elliptical galaxy and one of the companions to the giant Andromeda galaxy M31. M32 is a dwarf by galactic standards, as it is only 2400 light-years across. (credit: NOAO/AURA/NSF)

Figure 26.7



- **Elliptical Galaxies.**

(a) ESO 325-G004 is a giant elliptical galaxy. Other elliptical galaxies can be seen around the edges of this image.

(b) This elliptical galaxy probably originated from the collision of two spiral galaxies. (credit a: modification of work by NASA, ESA, and The Hubble Heritage Team (STScI/AURA); credit b: modification of work by ESA/Hubble, NASA)

Čočkovité galaxie

Nepravidelné galaxie

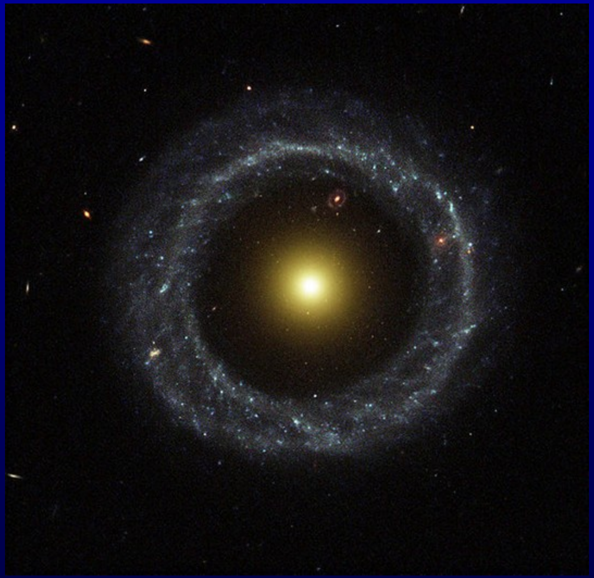
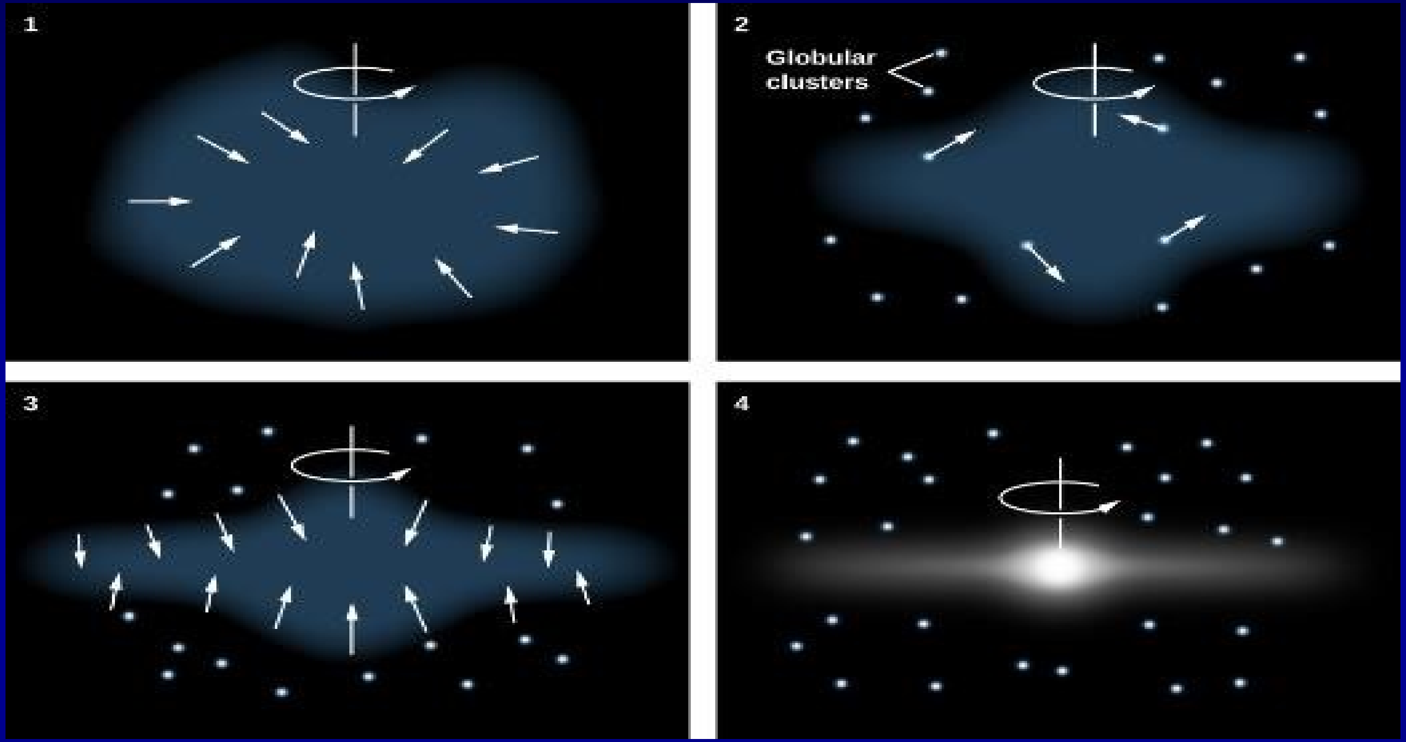


Figure 25.21

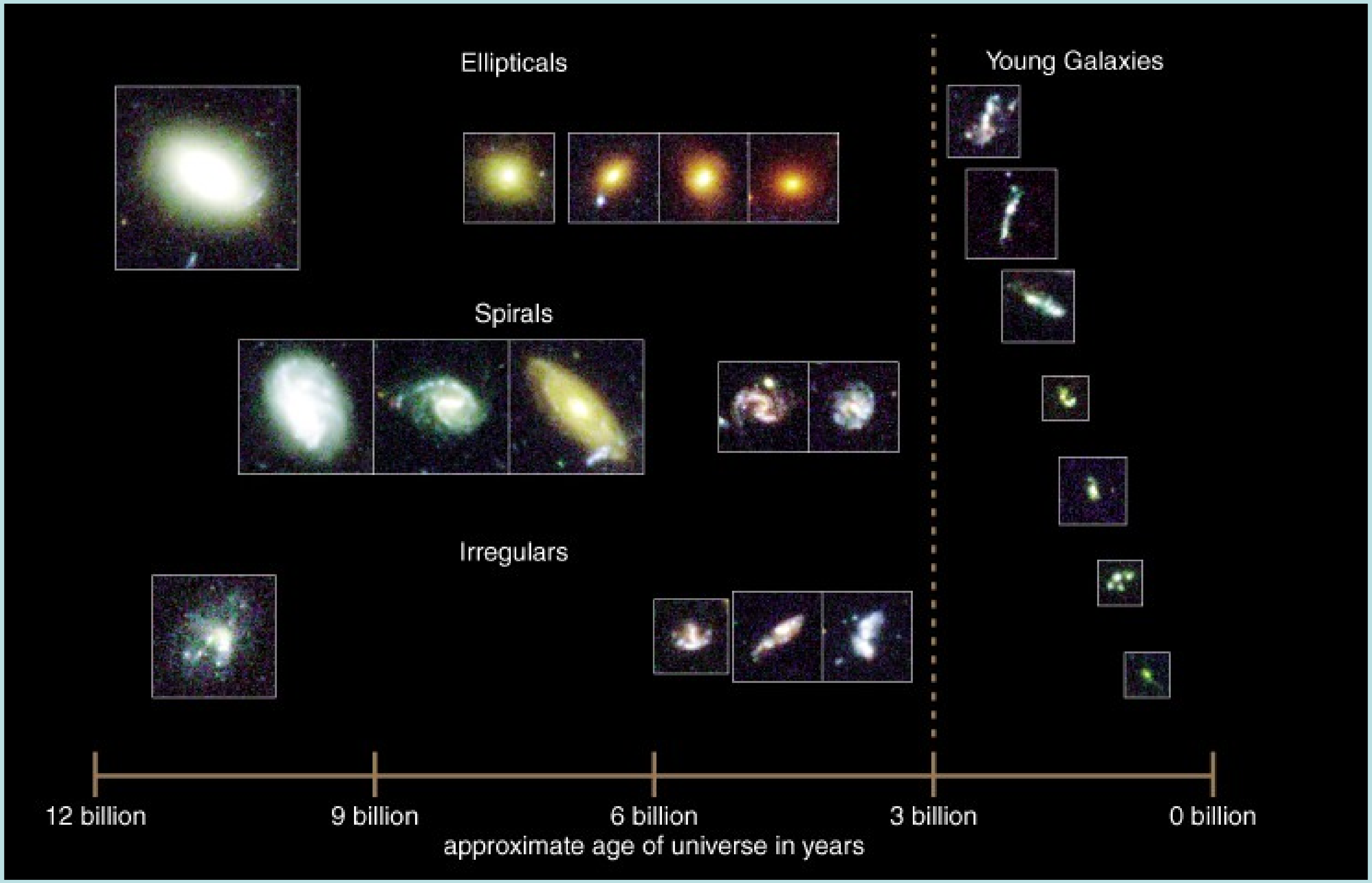


- **Monolithic Collapse Model for the Formation of the Galaxy.** According to this model, the Milky Way Galaxy initially formed from a rotating cloud of gas that collapsed due to gravity. Halo stars and globular clusters either formed prior to the collapse or were formed elsewhere. Stars in the disk formed later, when the gas from which they were made was already "contaminated" with heavy elements produced in earlier generations of stars.

Figure 25.25

- **Collision of the Milky Way with Andromeda.** In about 3 billion years, the Milky Way Galaxy and Andromeda Galaxy will begin a long process of colliding, separating, and then coming back together to form an elliptical galaxy. The whole interaction will take 3 to 4 billion years. These images show the following sequence: (1) In 3.75 billion years, Andromeda has approached the Milky Way. (2) New star formation fills the sky 3.85 billion years from now. (3) Star formation continues at 3.9 billion years. (4) The galaxy shapes change as they interact, with Andromeda being stretched and our Galaxy becoming warped, about 4 billion years from now. (5) In 5.1 billion years, the cores of the two galaxies are bright lobes. (6) In 7 billion years, the merged galaxies form a huge elliptical galaxy whose brightness fills the night sky. This artist’s illustrations show events from a vantage point 25,000 light-years from the center of the Milky Way. However, we should mention that the Sun may not be at that distance throughout the sequence of events, as the collision readjusts the orbits of many stars within each galaxy. (credit: NASA; ESA; Z. Levay, R. van der Marel, STScl; T. Hallas, and A. Mellinger)

vývoj galaxií podle HDF



Aktivní galaxie

- rádiově tiché
  - linery, Seyfertovy, kvasary
- rádiově hlučné
  - rádiové galaxie, blasary, OVV kvasary

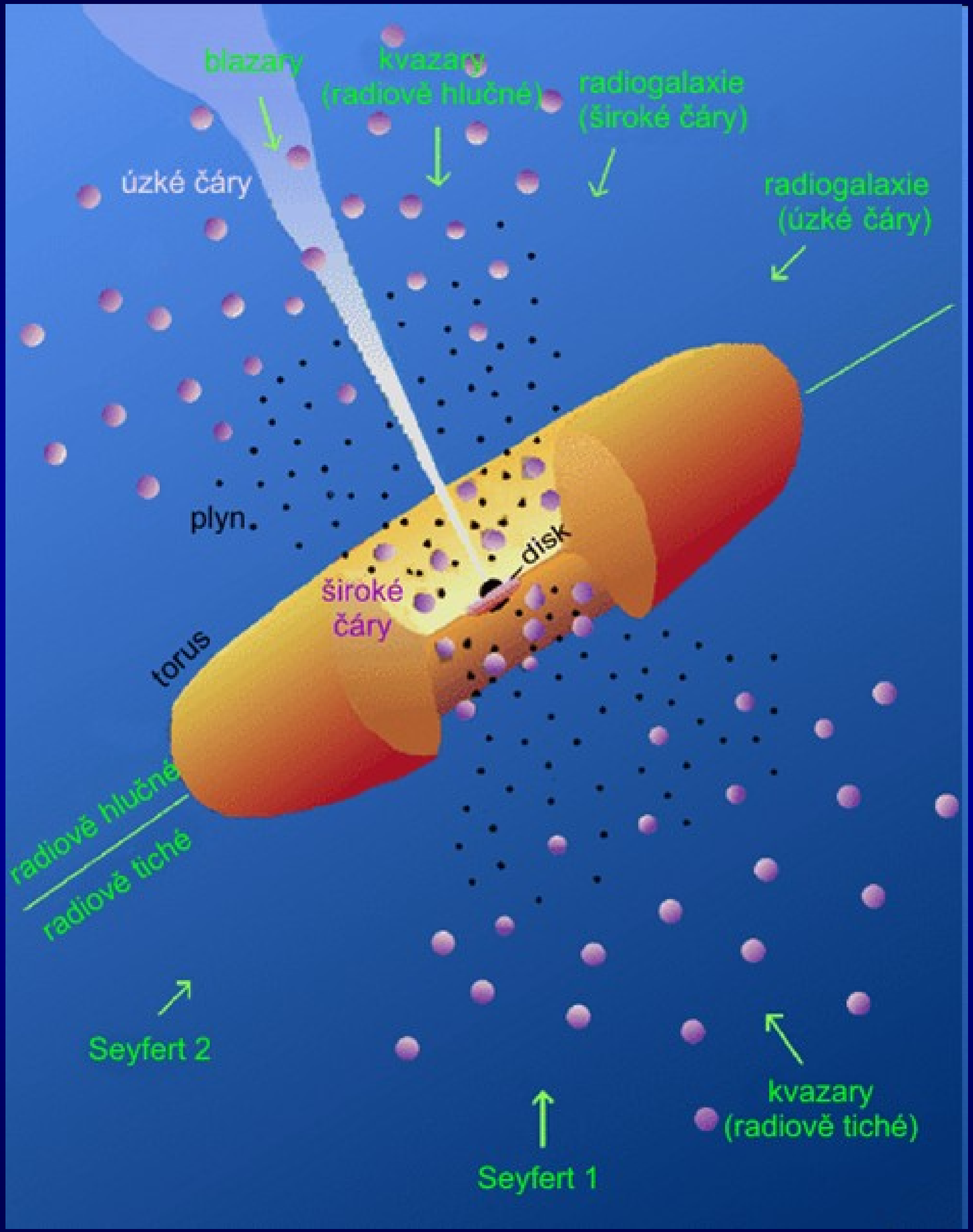
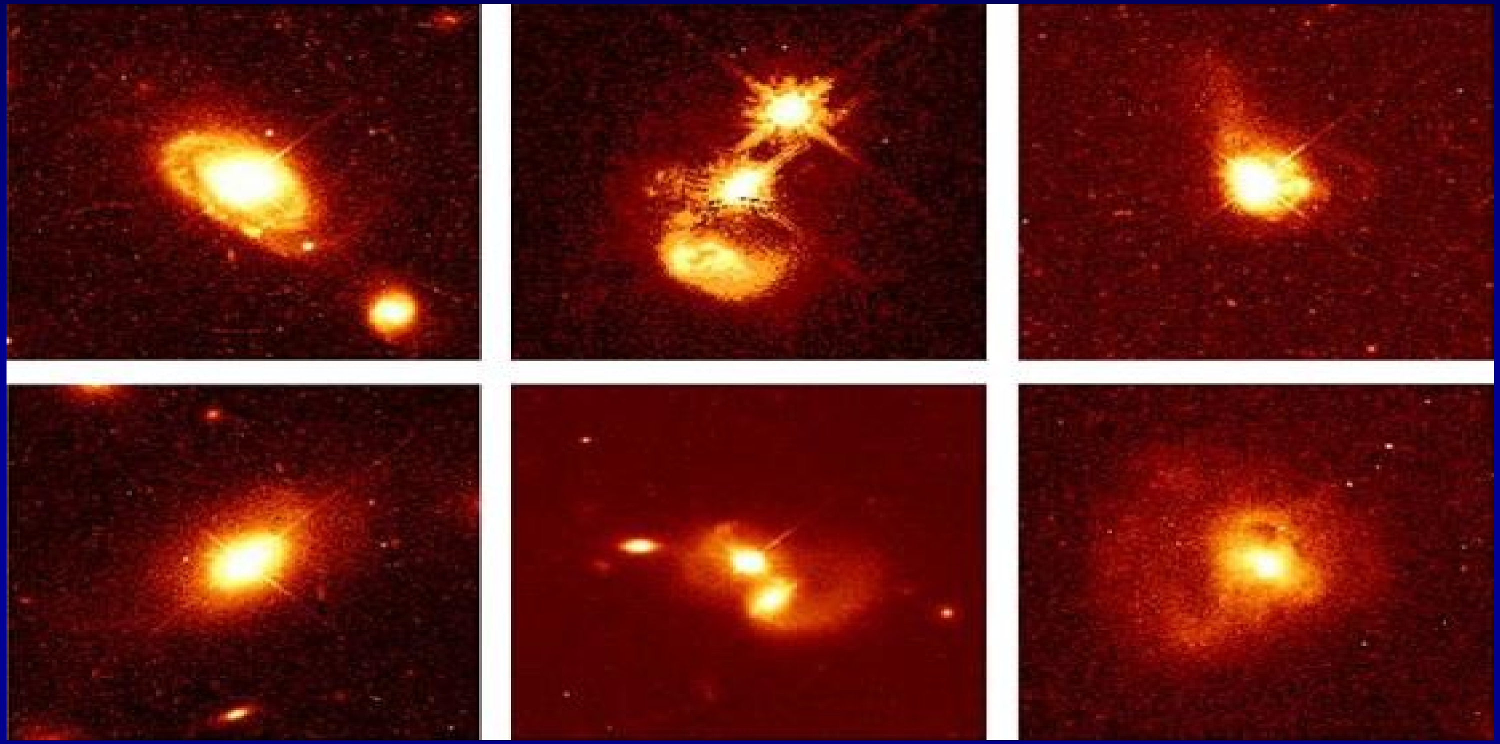


Figure 27.2

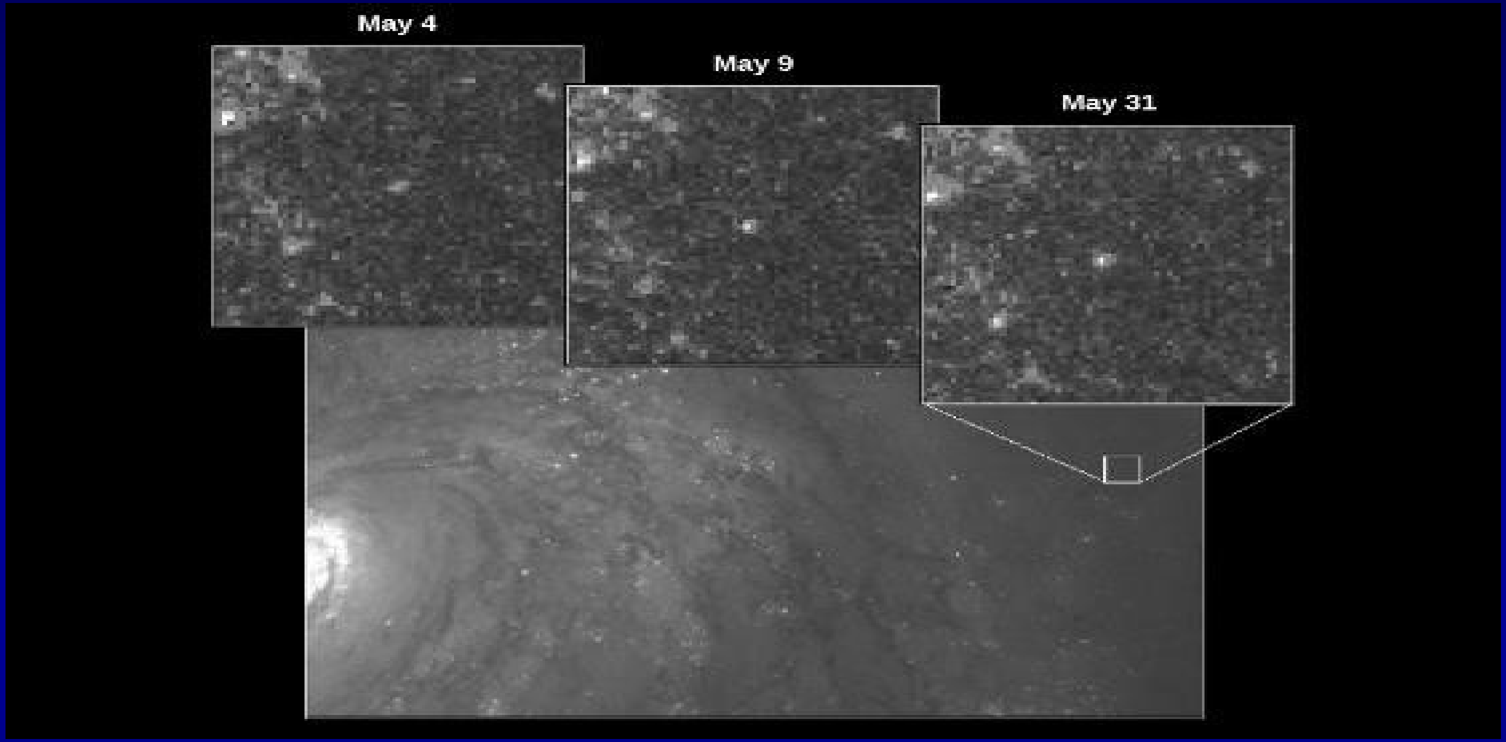
- **Typical Quasar.** The arrow in this image marks the quasar known by its catalog number, PKS 1117-248. Note that nothing in this image distinguishes the quasar from an ordinary star. Its spectrum, however, shows that it is moving away from us at a speed of 36% the speed of light, or 67,000 miles per second. In contrast, the maximum speed observed for any star is only a few hundred miles per second. (credit: modification of work by WIYN Telescope, Kitt Peak National Observatory, NOAO)

Figure 27.5



- **Quasar Host Galaxies.** The Hubble Space Telescope reveals the much fainter “host” galaxies around quasars. The top left image shows a quasar that lies at the heart of a spiral galaxy 1.4 billion light-years from Earth. The bottom left image shows a quasar that lies at the center of an elliptical galaxy some 1.5 billion light-years from us. The middle images show remote pairs of interacting galaxies, one of which harbors a quasar. Each of the right images shows long tails of gas and dust streaming away from a galaxy that contains a quasar. Such tails are produced when one galaxy collides with another. (credit: modification of work by John Bahcall, Mike Disney, NASA)

Figure 26.11

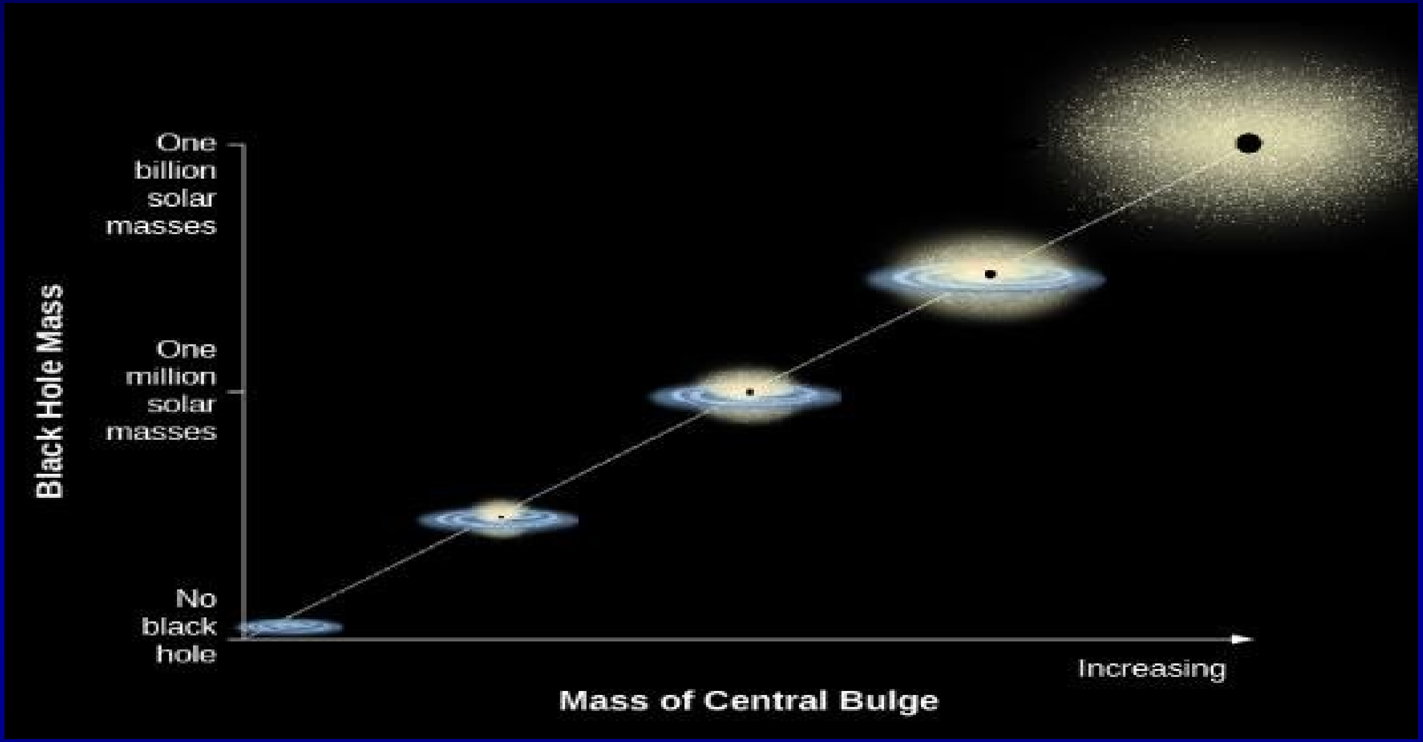


- **Cepheid Variable Star.** In 1994, using the Hubble Space Telescope, astronomers were able to make out an individual cepheid variable star in the galaxy M100 and measure its distance to be 56 million light-years. The insets show the star on three different nights; you can see that its brightness is indeed variable. (credit: modification of work by Wendy L. Freedman, Observatories of the Carnegie Institution of Washington, and NASA/ESA)

Figure 26.12

- **Type Ia Supernova.** The bright object at the bottom left of center is a type Ia supernova near its peak intensity. The supernova easily outshines its host galaxy. This extreme increase and luminosity help astronomers use Ia supernova as standard bulbs. (credit: NASA, ESA, A. Riess (STScI))

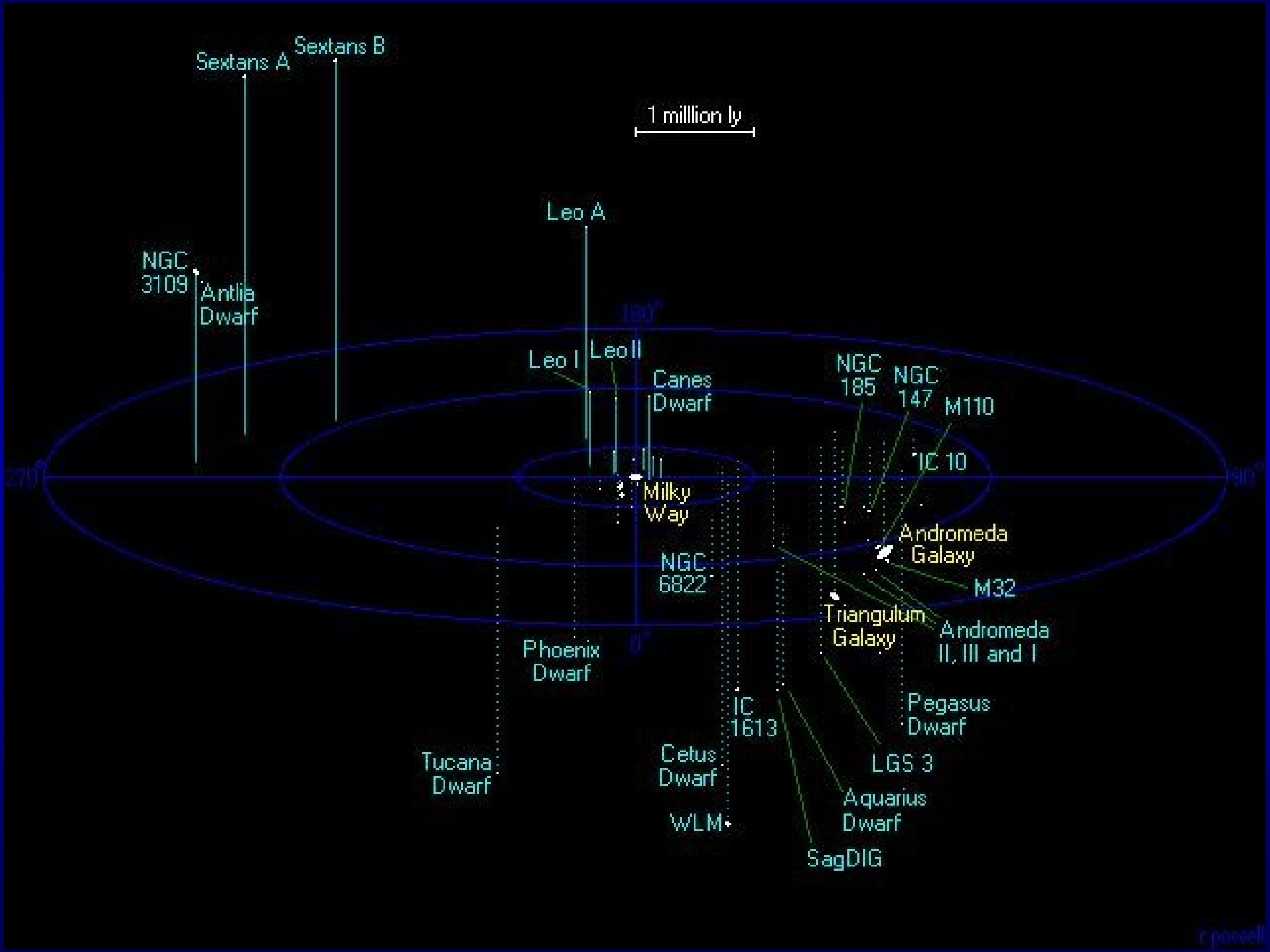
Figure 27.15



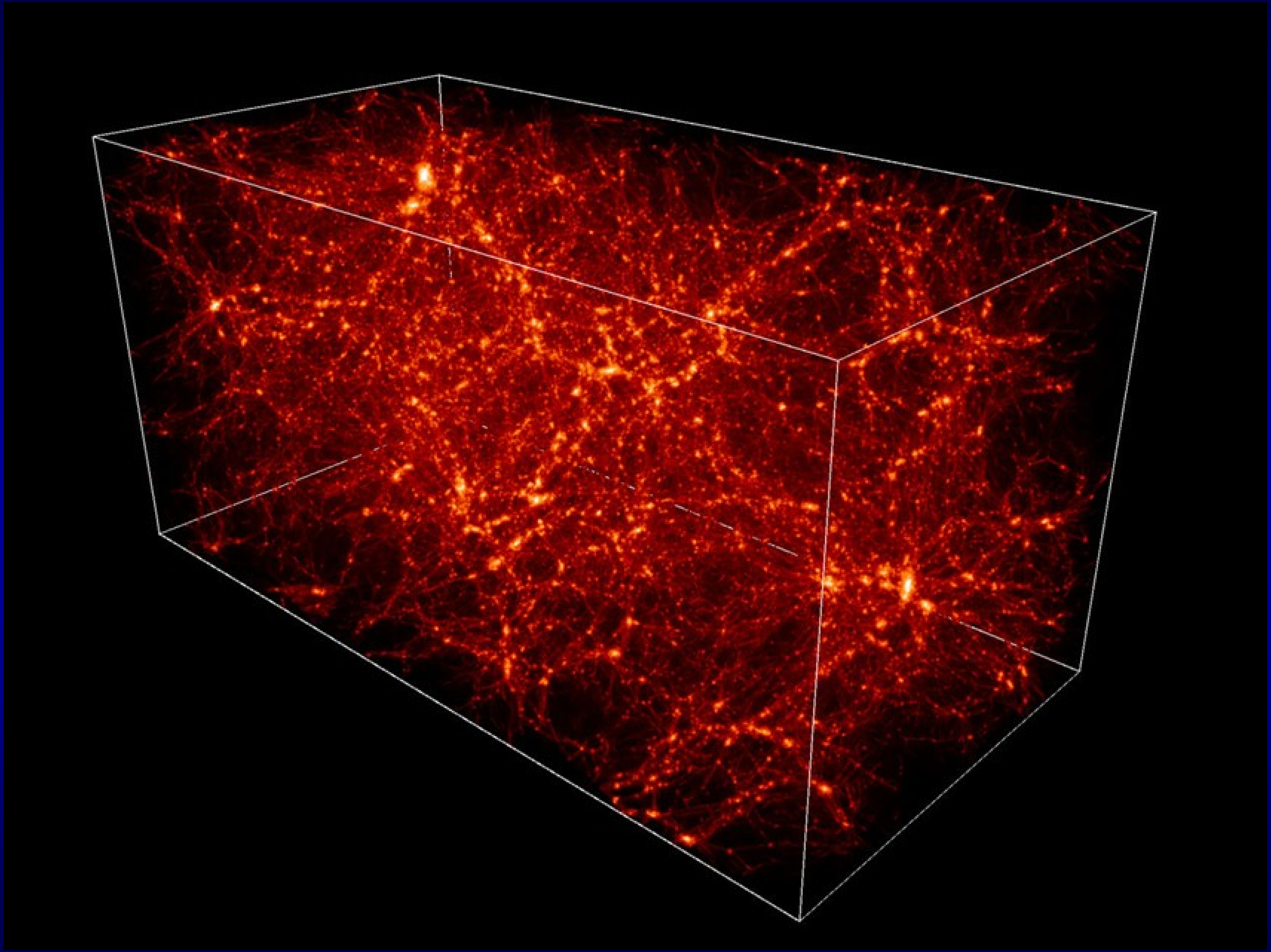
- **Relationship between Black Hole Mass and the Mass of the Host Galaxy.** Observations show that there is a close correlation between the mass of the black hole at the center of a galaxy and the mass of the spherical distribution of stars that surrounds the black hole. That spherical distribution may be in the form of either an elliptical galaxy or the central bulge of a spiral galaxy. (credit: modification of work by K. Cordes, S. Brown (STScI))

Velkorozměrové struktury

- galaxie jsou většinou ve skupinách
- Místní skupina galaxií
  - Galaxie, M 31, M 33, LMC, SMC
  - průměr 800 kpc
- kupy galaxií
- buněčná struktura



Sextans A
Sextans B
1 million ly
Leo A
NGC 3109
Antlia Dwarf
Leo I
Leo II
Canes Dwarf
NGC 185
NGC 147
M110
IC 10
Milky Way
Andromeda Galaxy
NGC 6822
M32
Triangulum Galaxy
Andromeda II, III and I
Phoenix Dwarf
IC 1613
Pegasus Dwarf
Tucana Dwarf
Cetus Dwarf
LGS 3
Aquarius Dwarf
WLM
SagDIG



… konec

Messierovy objekty

katalog