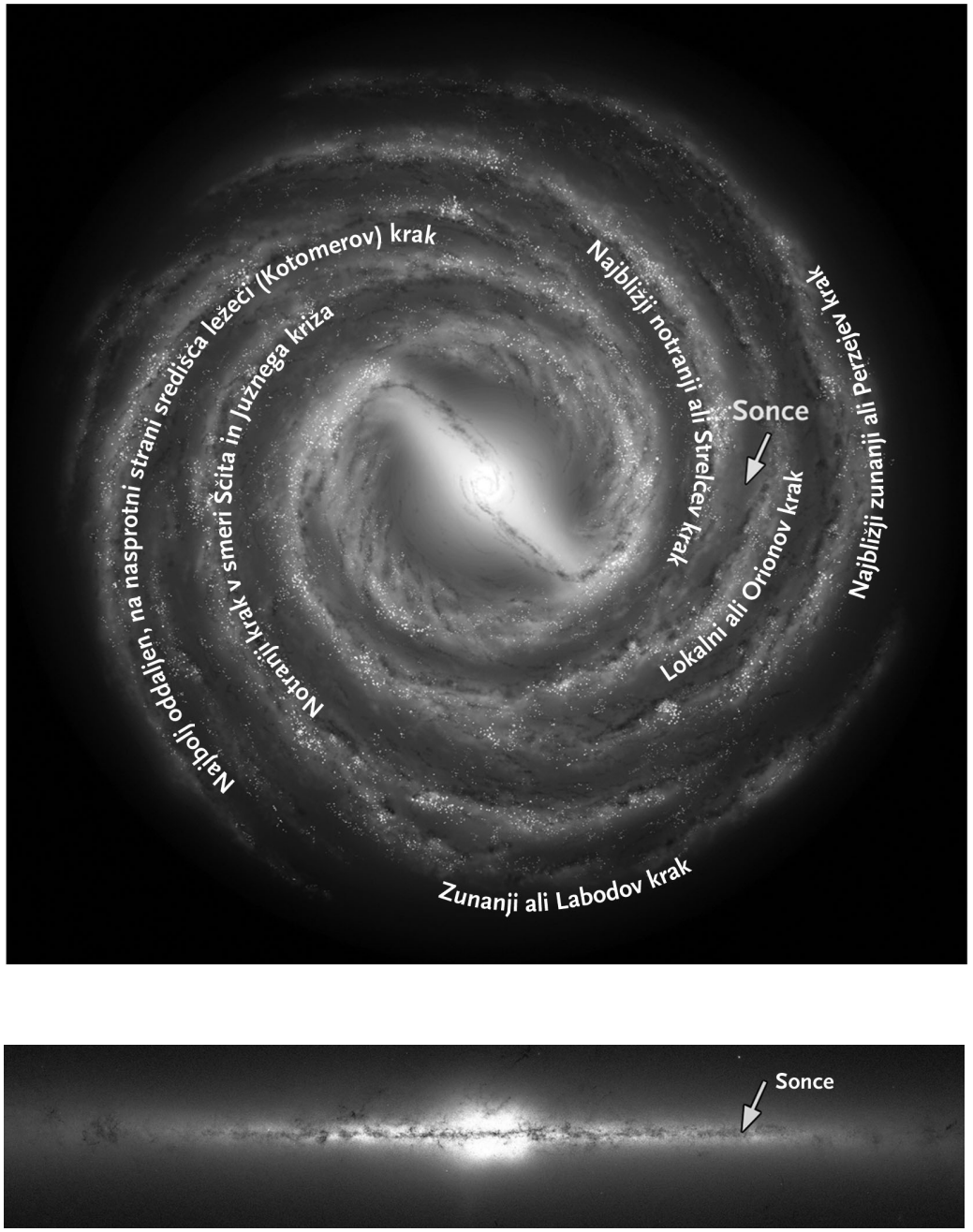
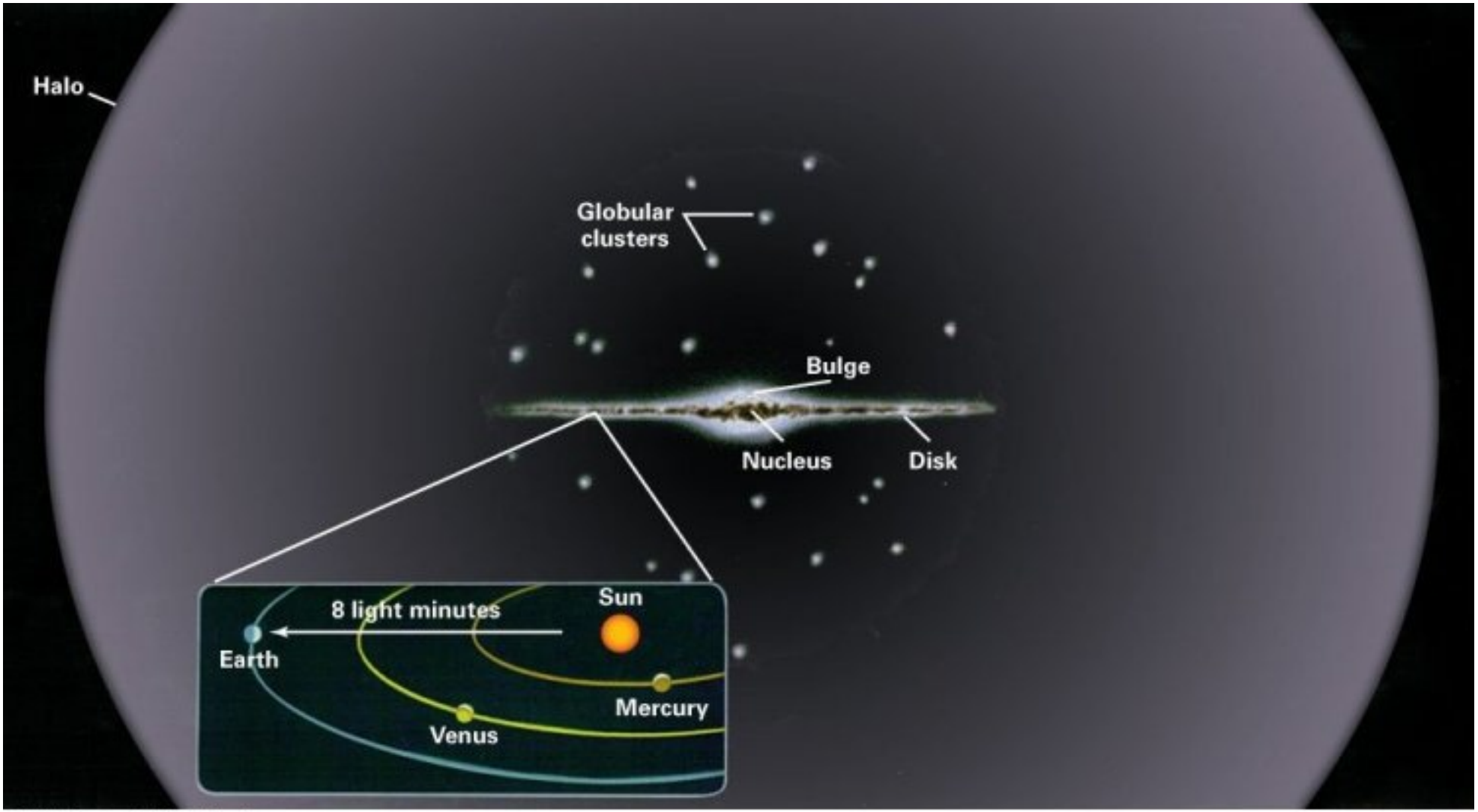
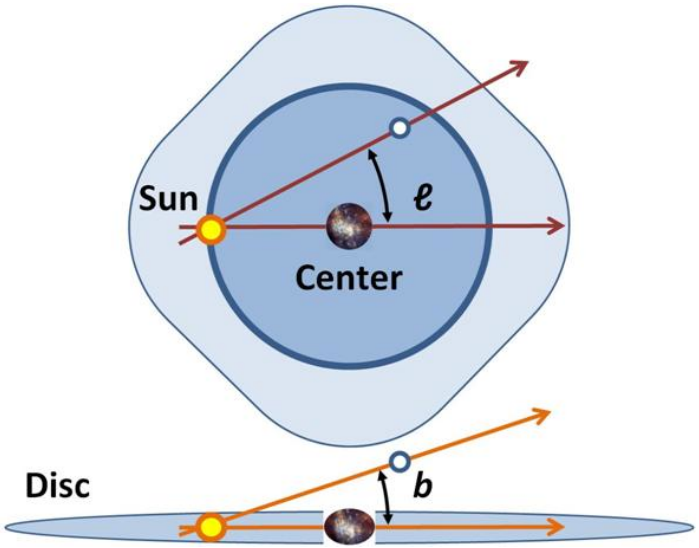
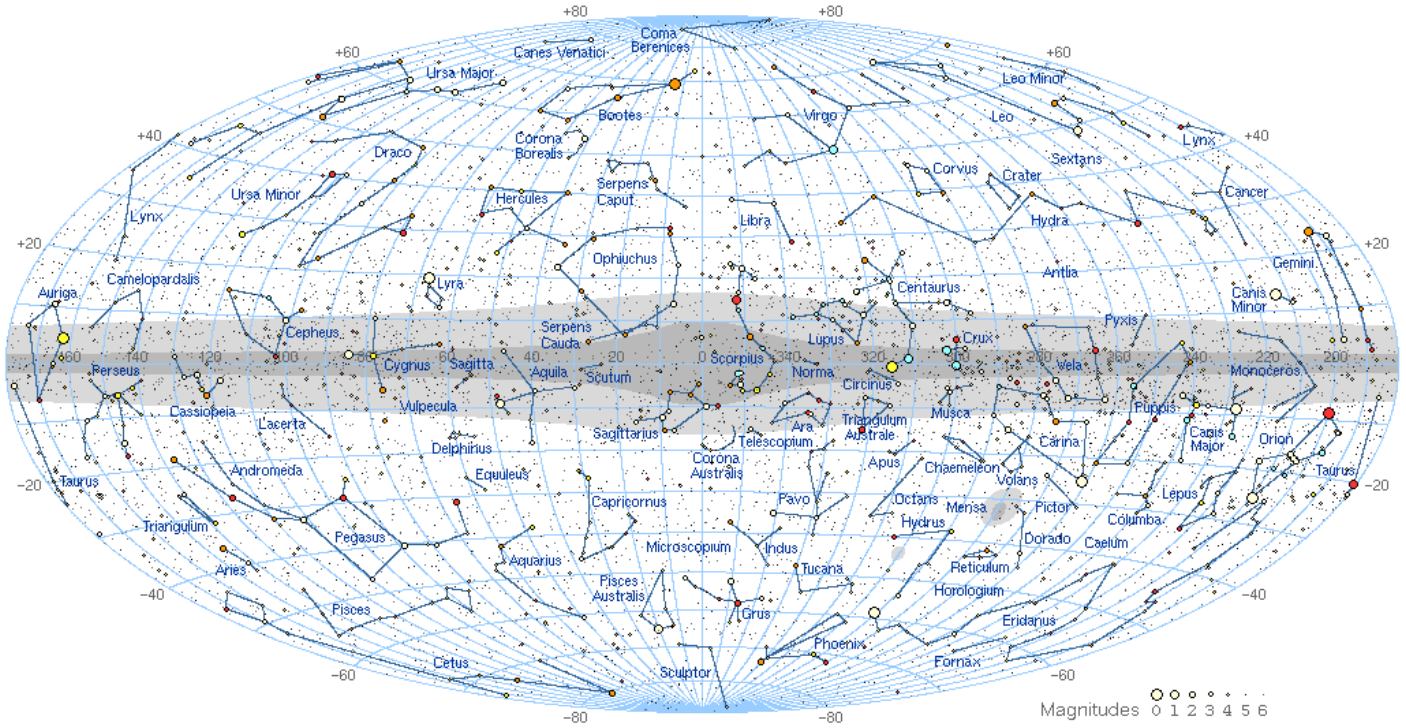
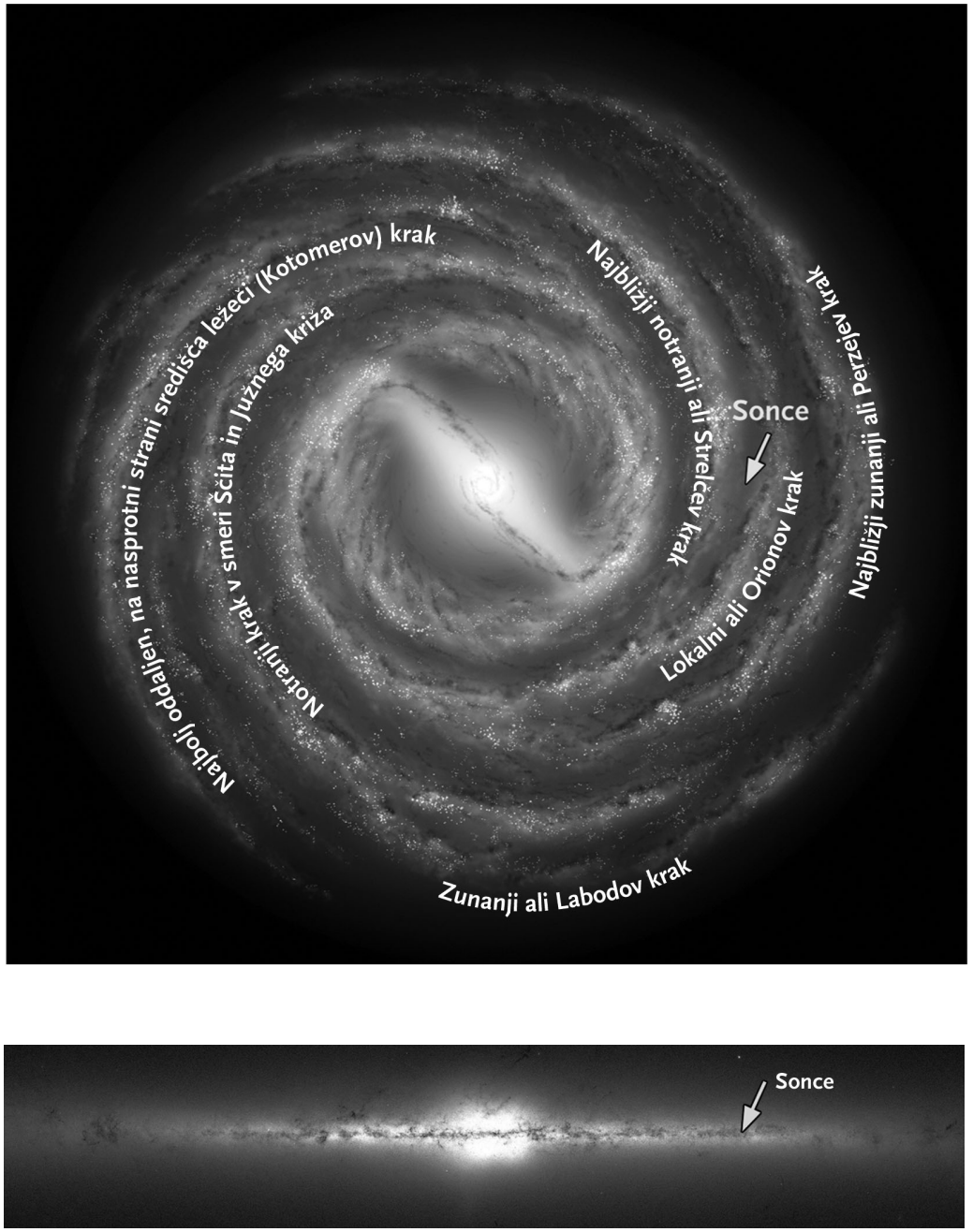


B. Kambič: Ozvezdja, 2007




Sun
ℓ
Center
Disc
b

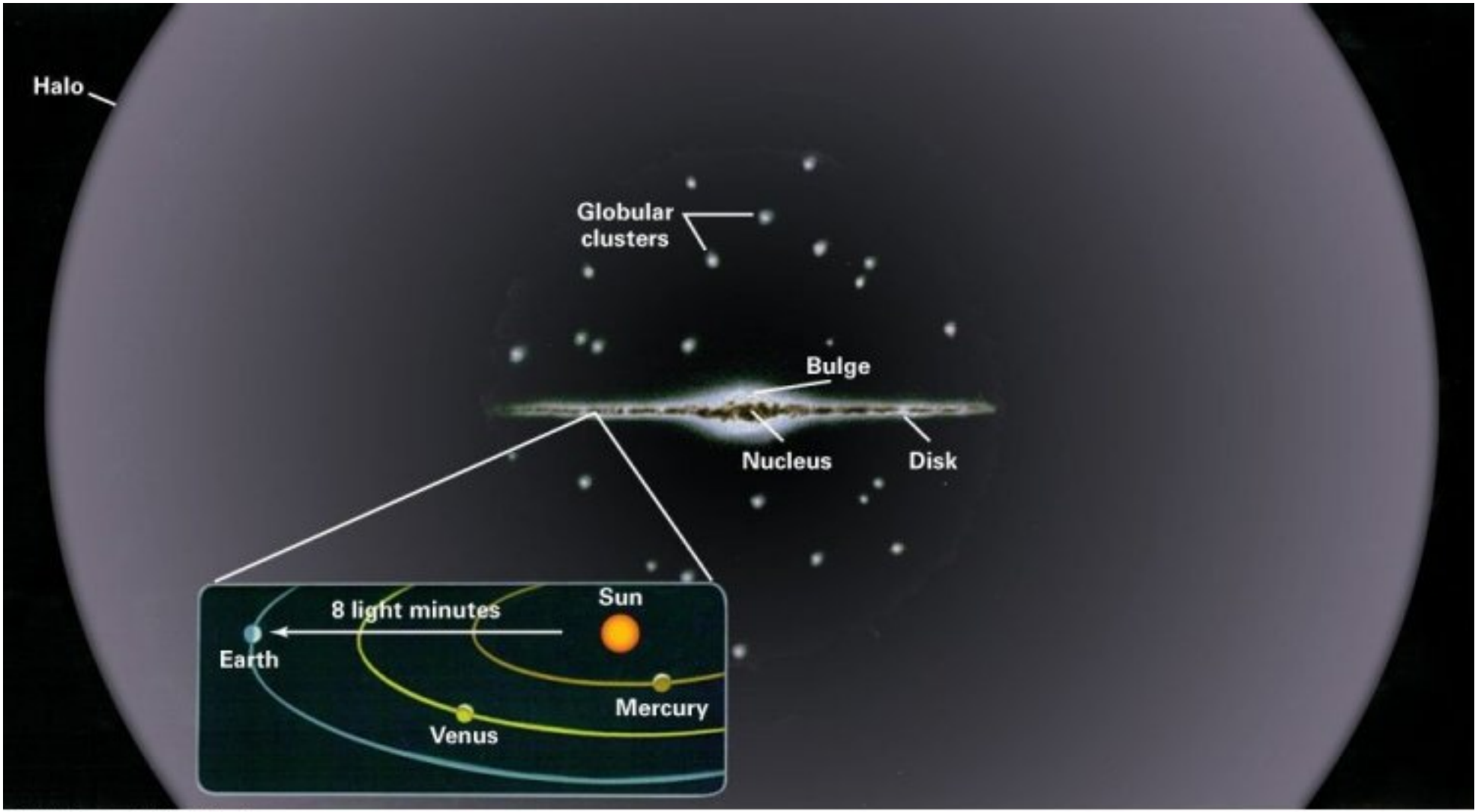

Coma Berenices
Canes Venatici
Ursa Major
Leo Minor
Leo
Virgo
Lynx
Bootes
Corona Borealis
Draco
Sextans
Corvus
Crater
Cancer
Ursa Minor
Serpens Caput
Hercules
Hydra
Lynx
Libra
Ophiuchus
Gemini
Antlia
Camelopardalis
Auriga
Lyra
Centaurus
Canis Minor
Pyxis
Cepheus
Serpens Cauda
Crux
Lupus
Cygnus
Sagitta
Aquila
Scutum
Scorpius
Norma
Vela
Monoceros
Perseus
Circinus
Puppis
Cassiopeia
Vulpecula
Musca
Triangulum Australe
Lacerta
Sagittarius
Ara
Telescopium
Carina
Canis Major
Orion
Delphinus
Corona Australis
Apus
Chamaeleon
Volans
Taurus
Andromeda
Equuleus
Capricornus
Pavo
Octans
Mensa
Pictor
Lepus
Columba
Hydrus
Triangulum
Pegasus
Microscopium
Indus
Dorado
Caelum
Aquarius
Tucana
Reticulum
Aries
Pisces Australis
Horologium
Pisces
Grus
Eridanus
Phoenix
Fornax
Cetus
Sculptor
+80
+60
+40
+20
-20
-40
-60
-80
Magnitudes 0 1 2 3 4 5 6

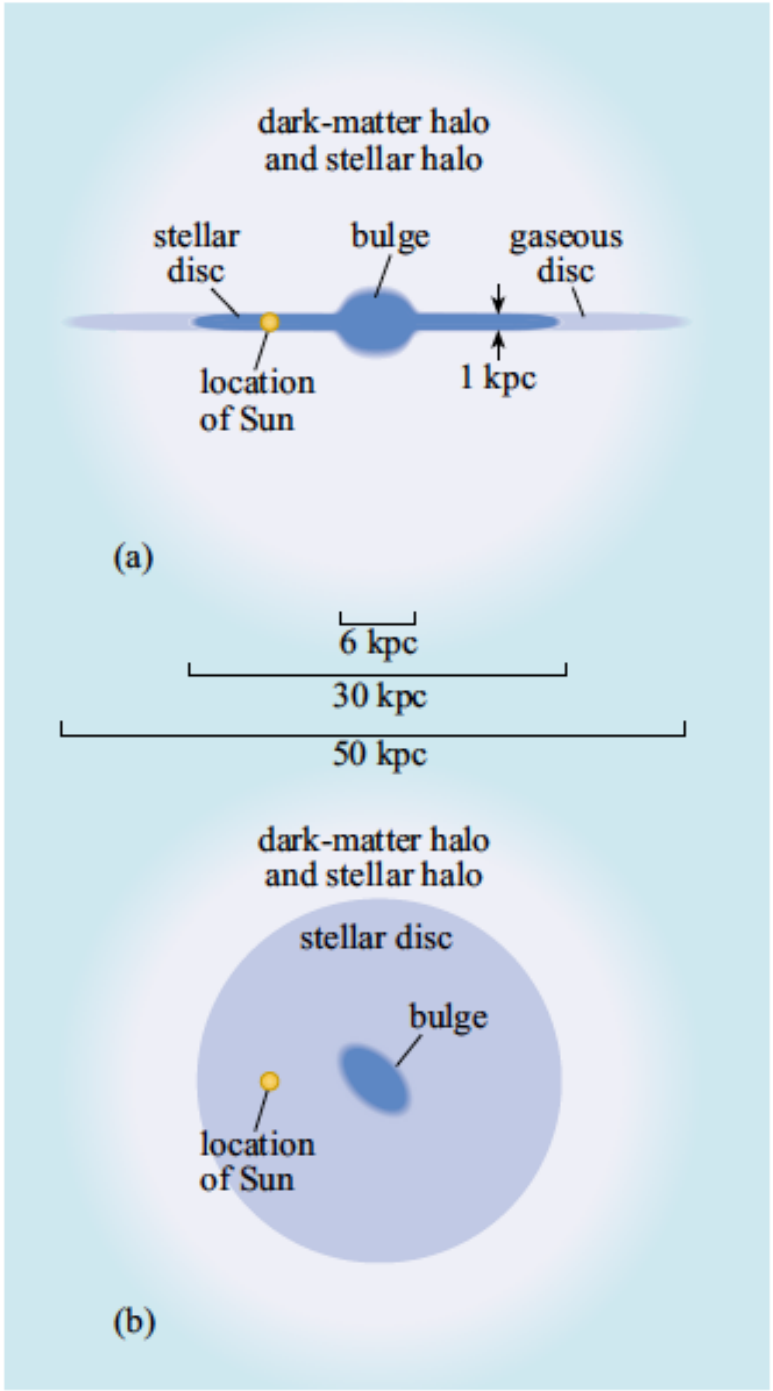


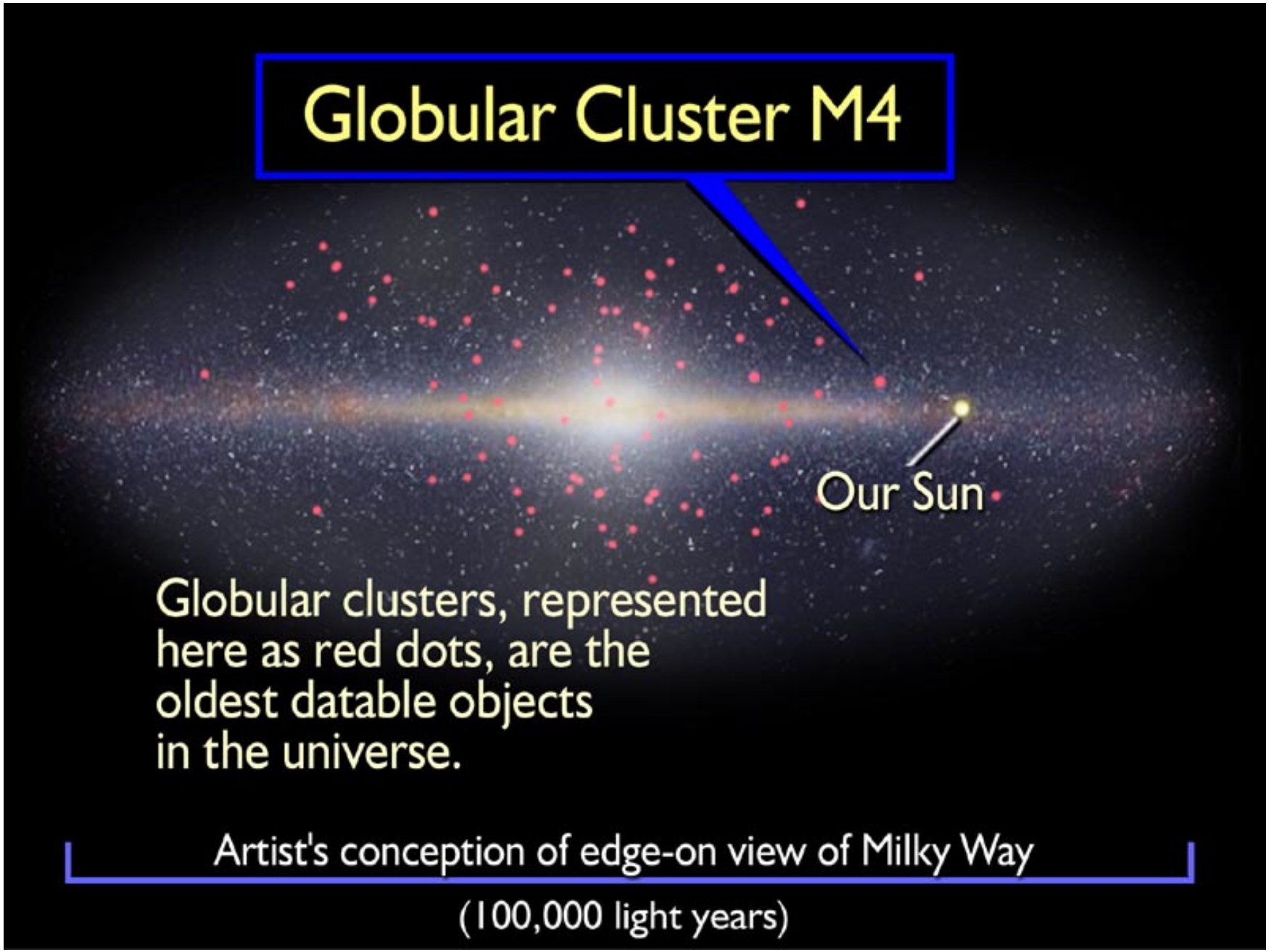
B. Kambič: Ozvezdja, 2007

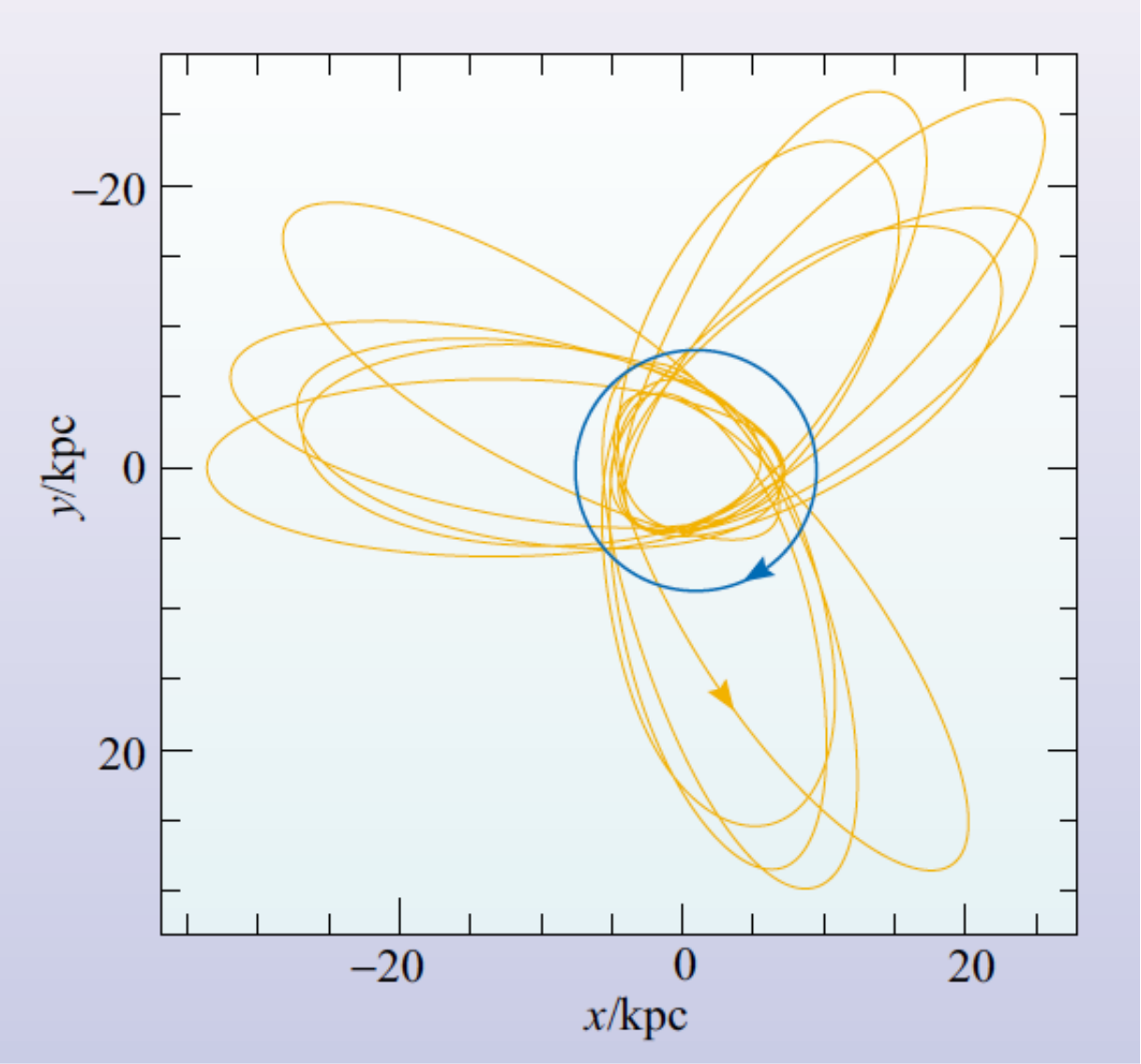

NGC 891

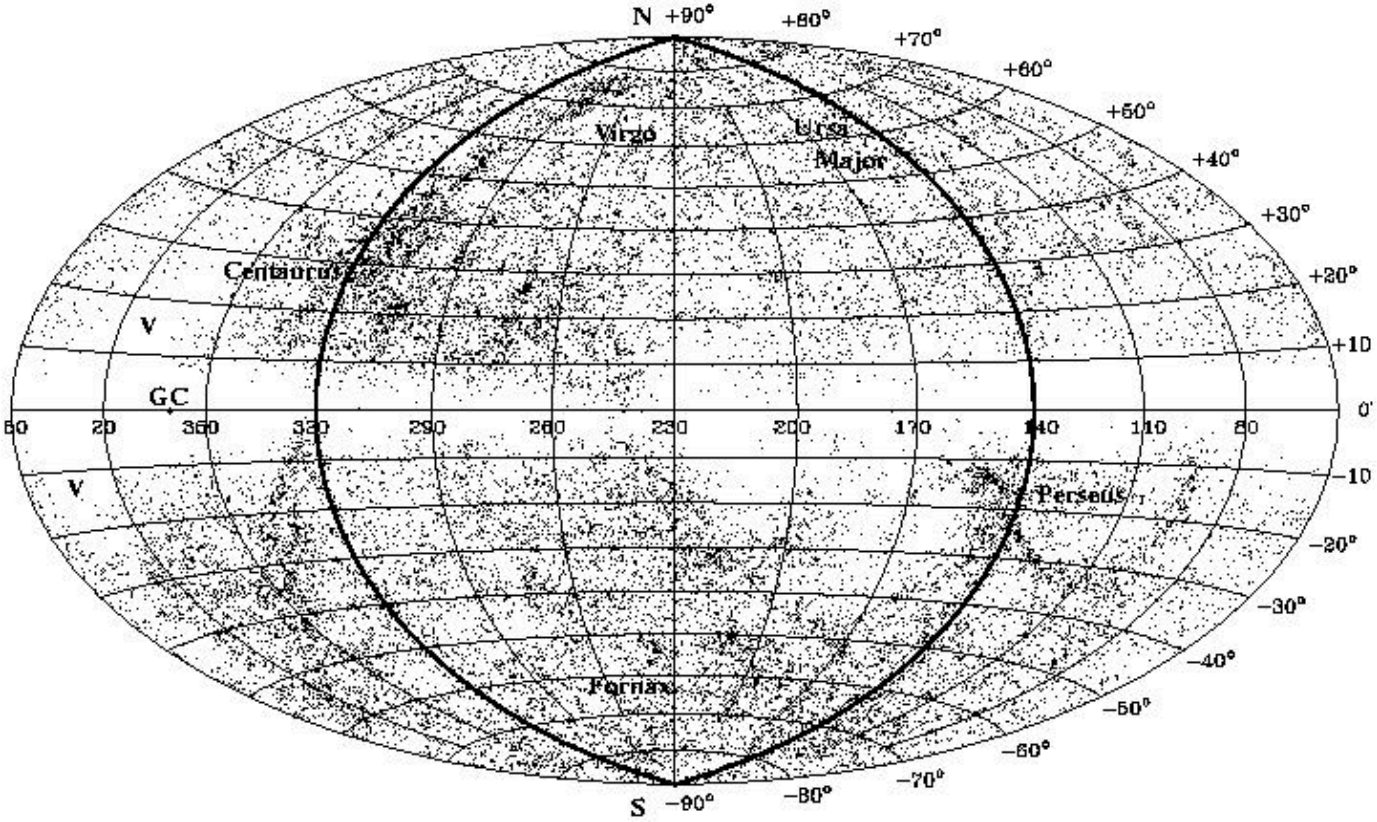

NGC 6744



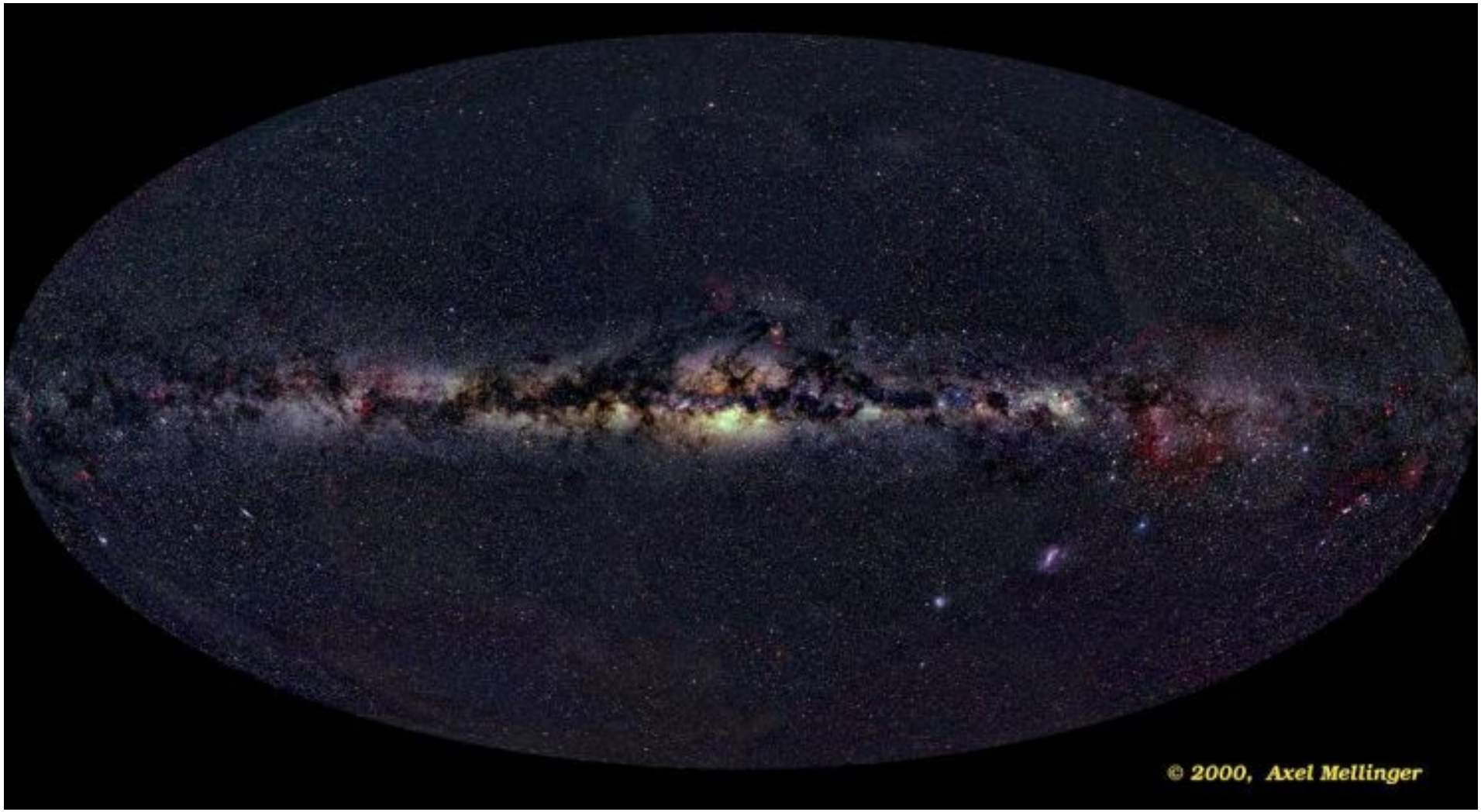

dark-matter halo
and stellar halo
stellar
disc
bulge
gaseous
disc
location
of Sun
1 kpc
(a)
6 kpc
30 kpc
50 kpc
dark-matter halo
and stellar halo
stellar disc
bulge
location
of Sun
(b)


Globular Cluster M4
Our Sun
Globular clusters, represented here as red dots, are the oldest datable objects in the universe.
Artist's conception of edge-on view of Milky Way
(100,000 light years)


−20
0
20
y/kpc
−20
0
20
x/kpc

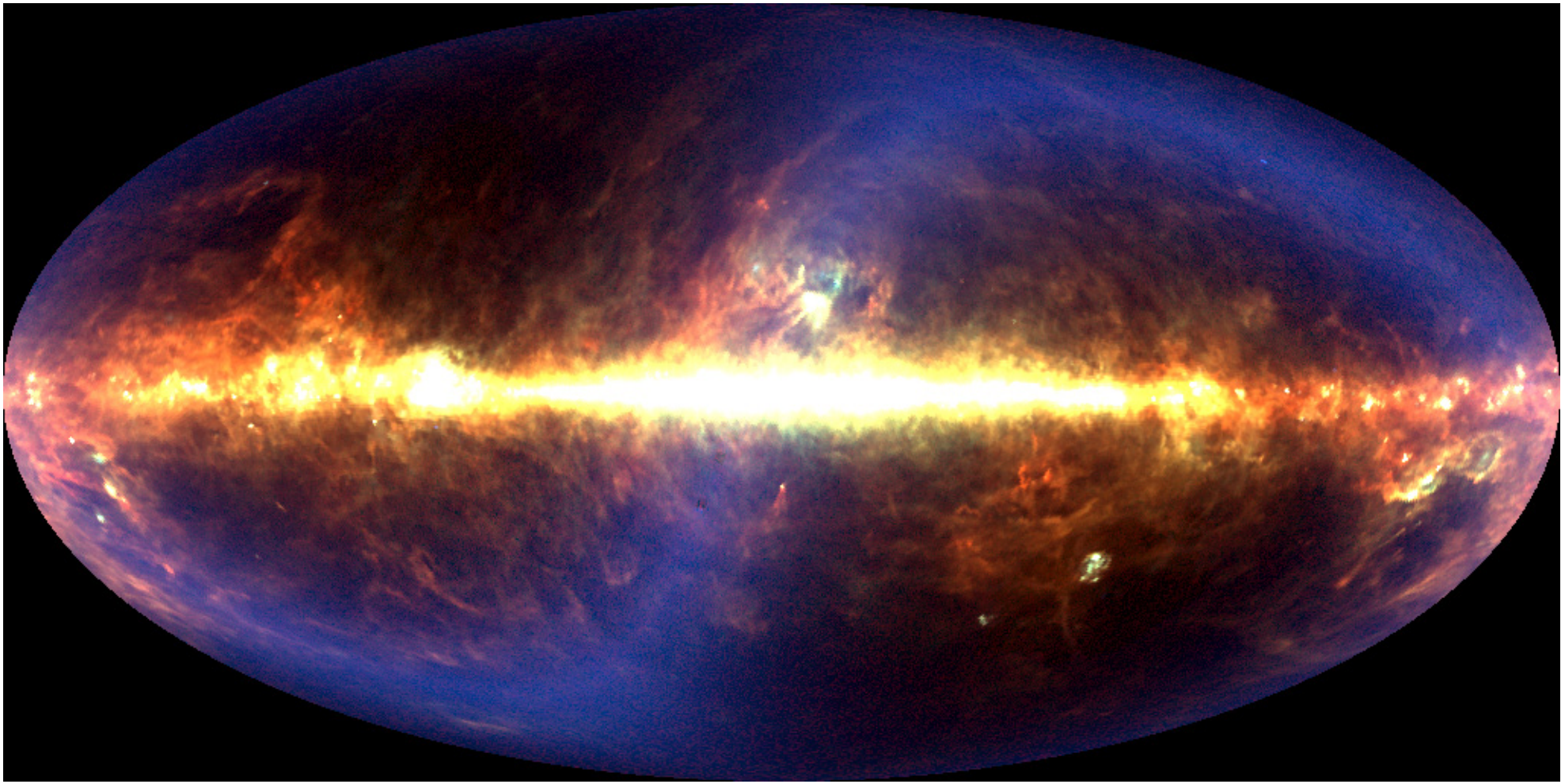

N +90°
+80°
+70°
+60°
+50°
+40°
+30°
+20°
+10
0°
−10
−20°
−30°
−40°
−50°
−60°
−70°
−80°
S −90°
Virgo
Ursa
Major
Centaurus
V
GC
V
Perseus
Fornax
50
20
360
330
290
260
230
200
170
140
110
80

vidna svetloba

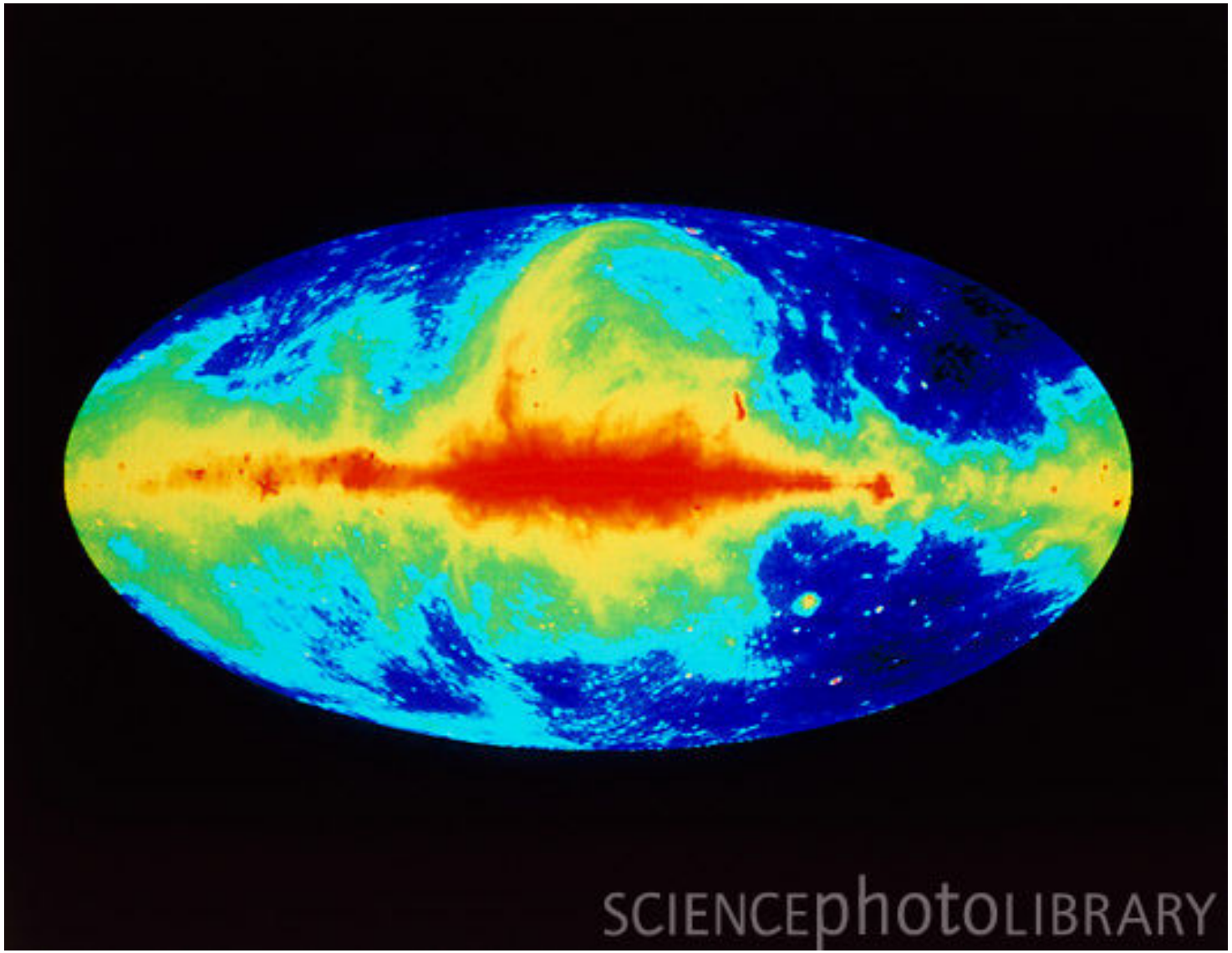


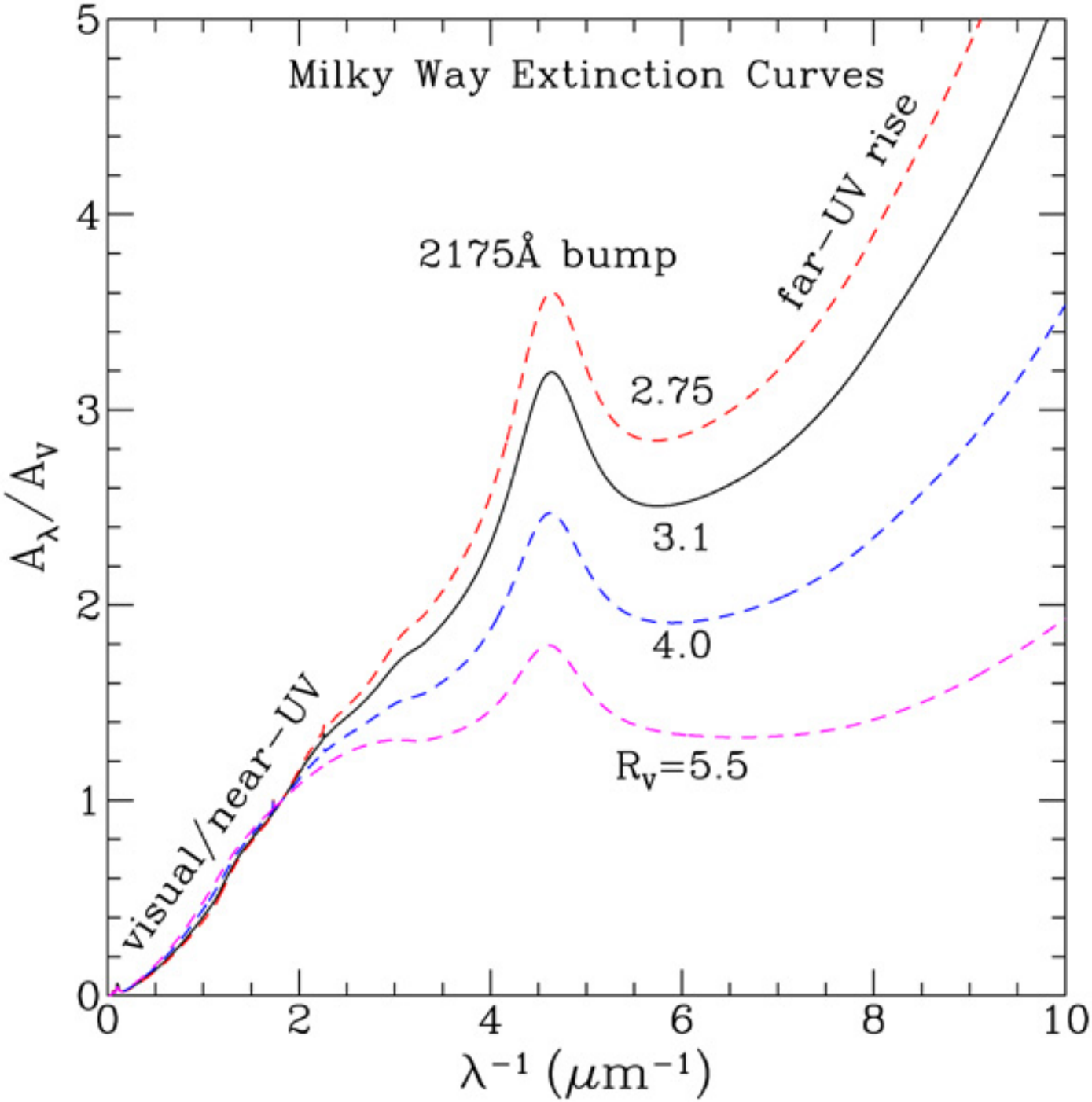
bližnja IR

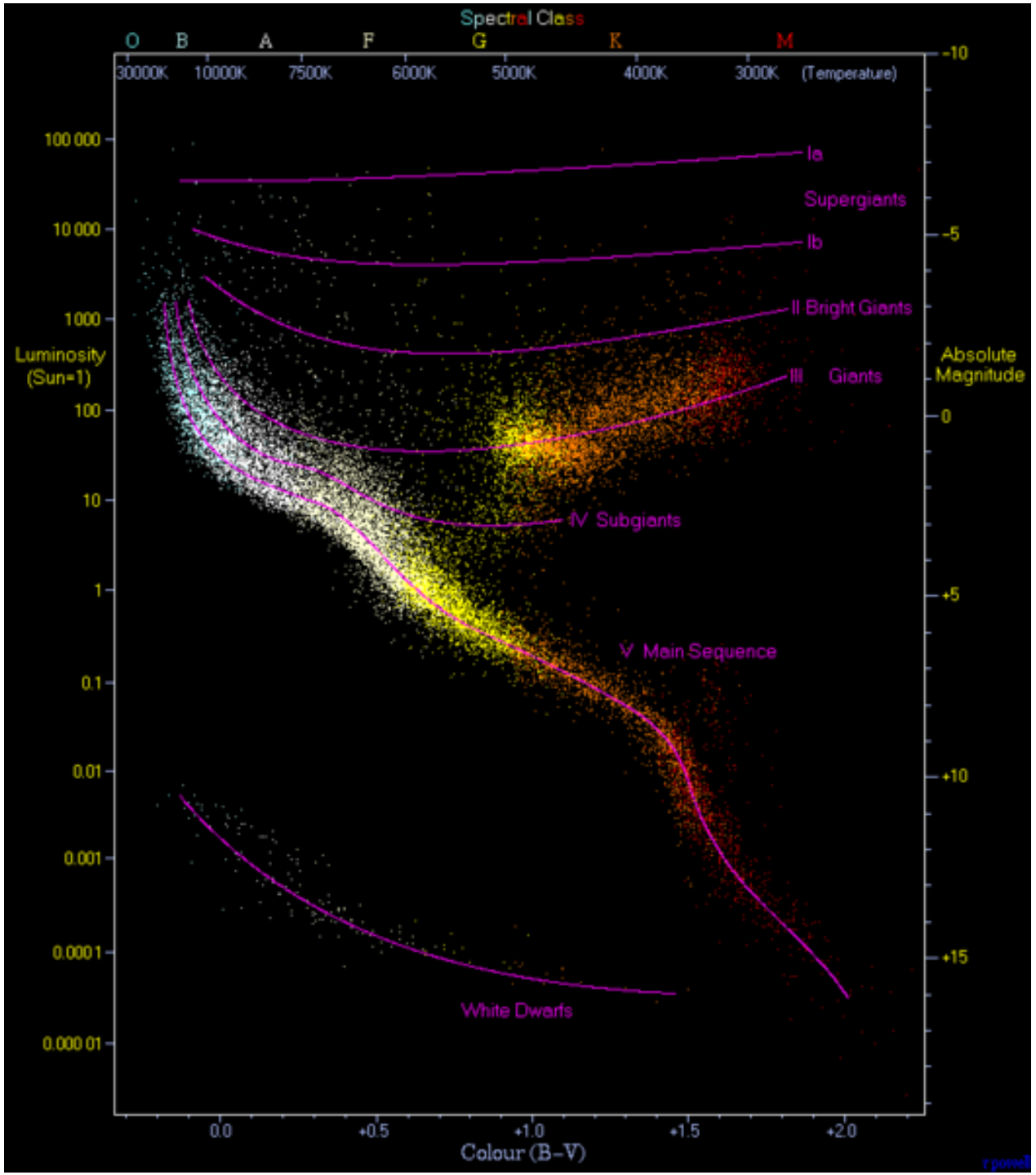
daljna IR

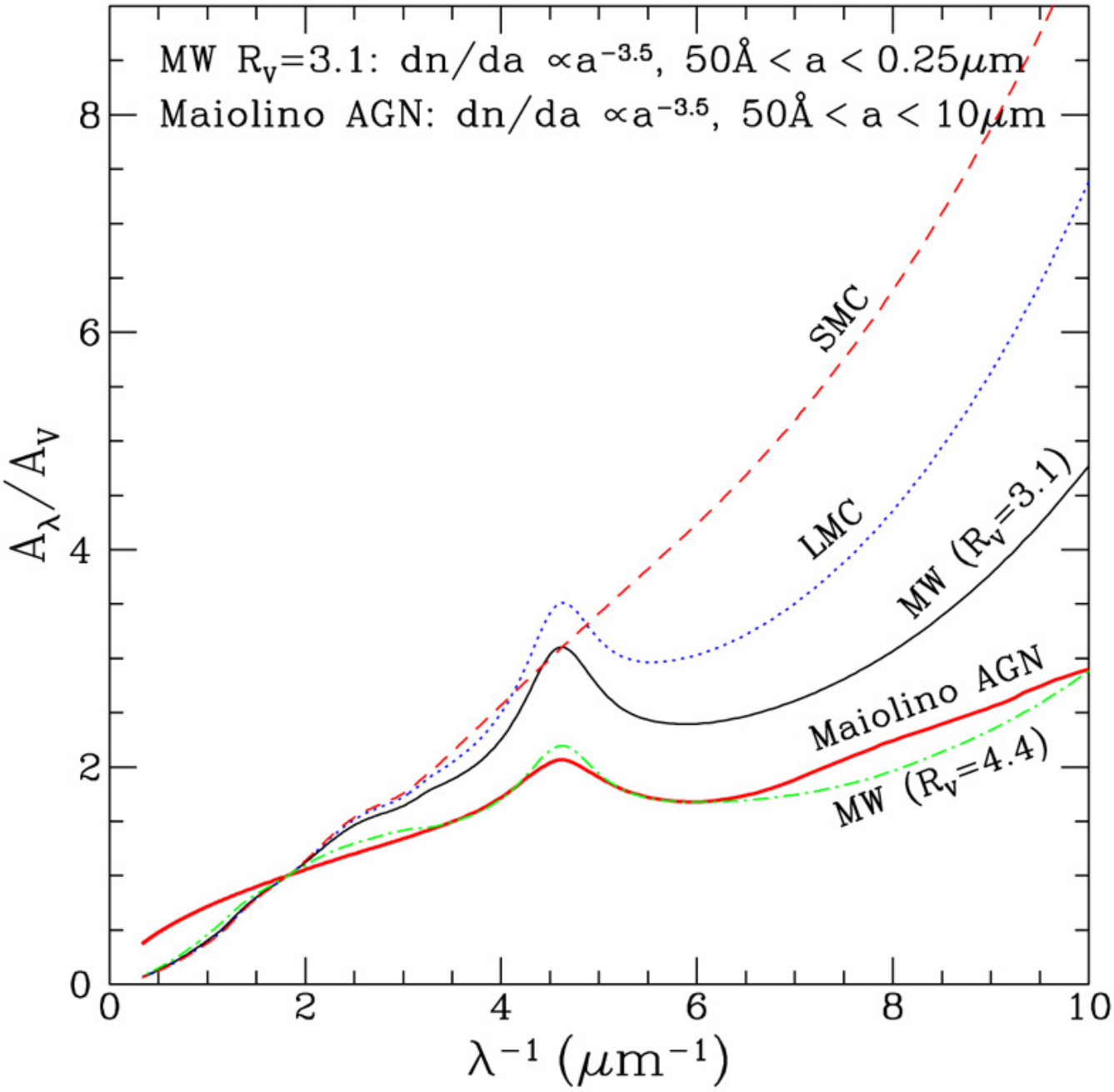


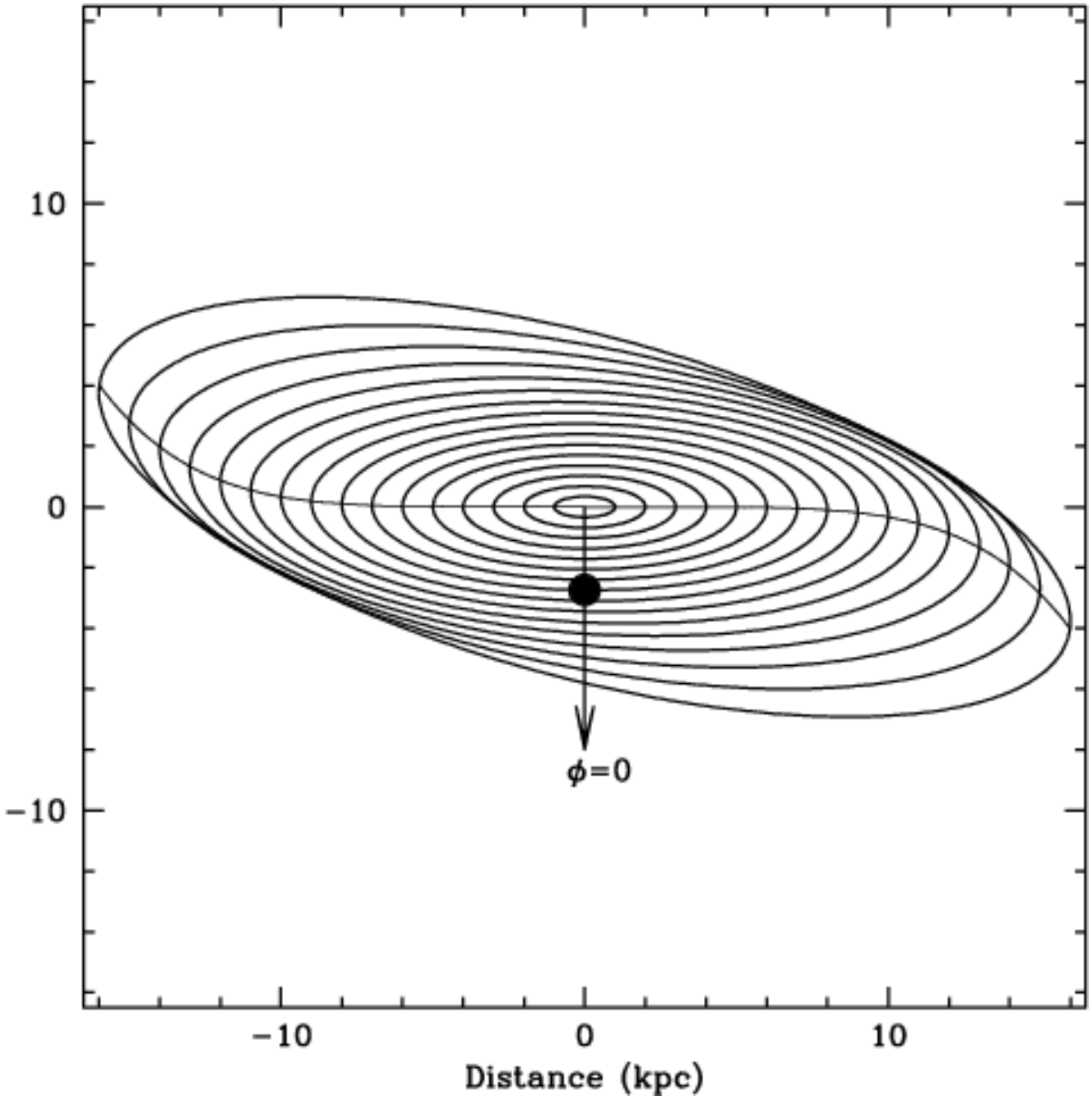
radijska svetloba

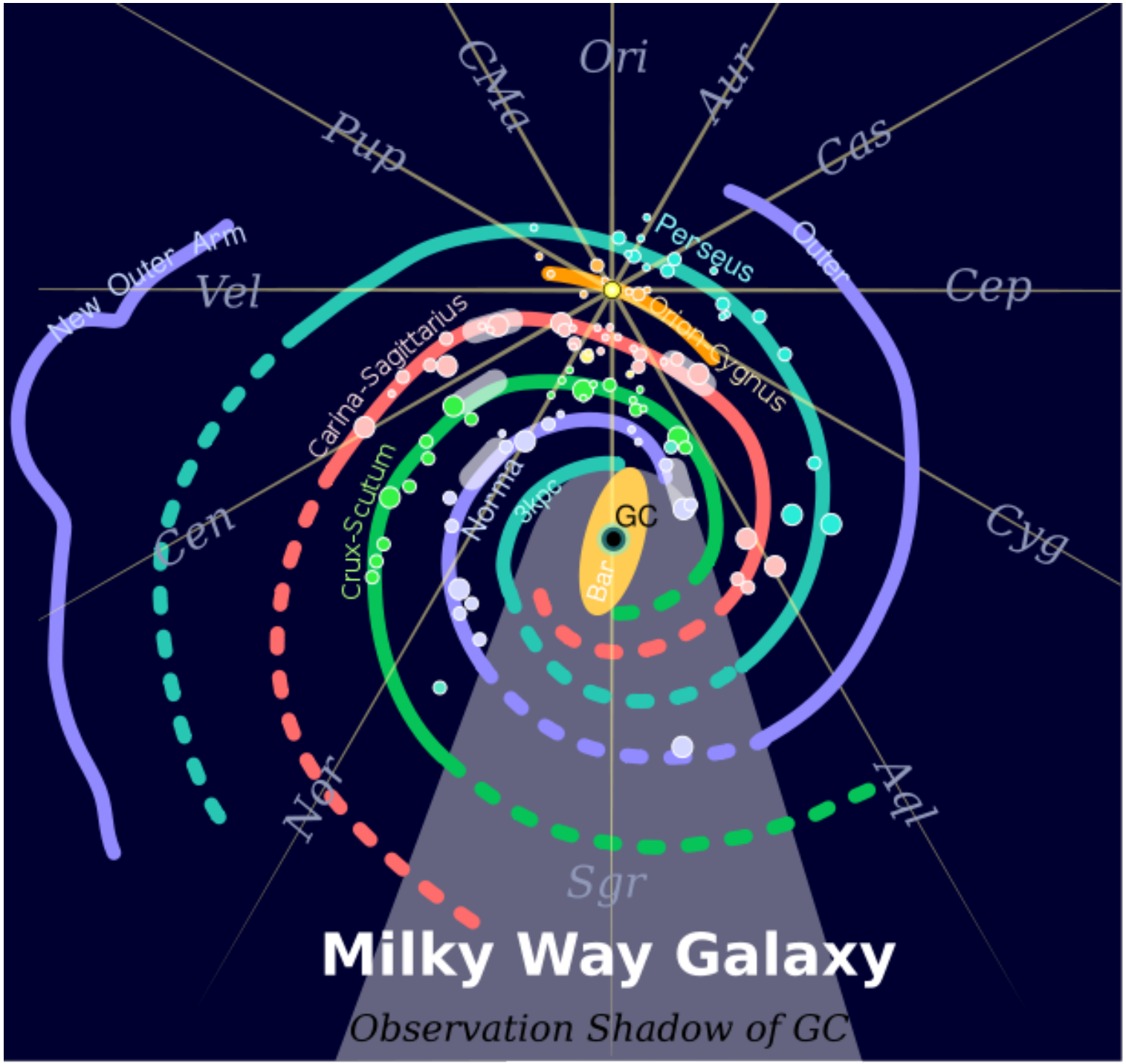


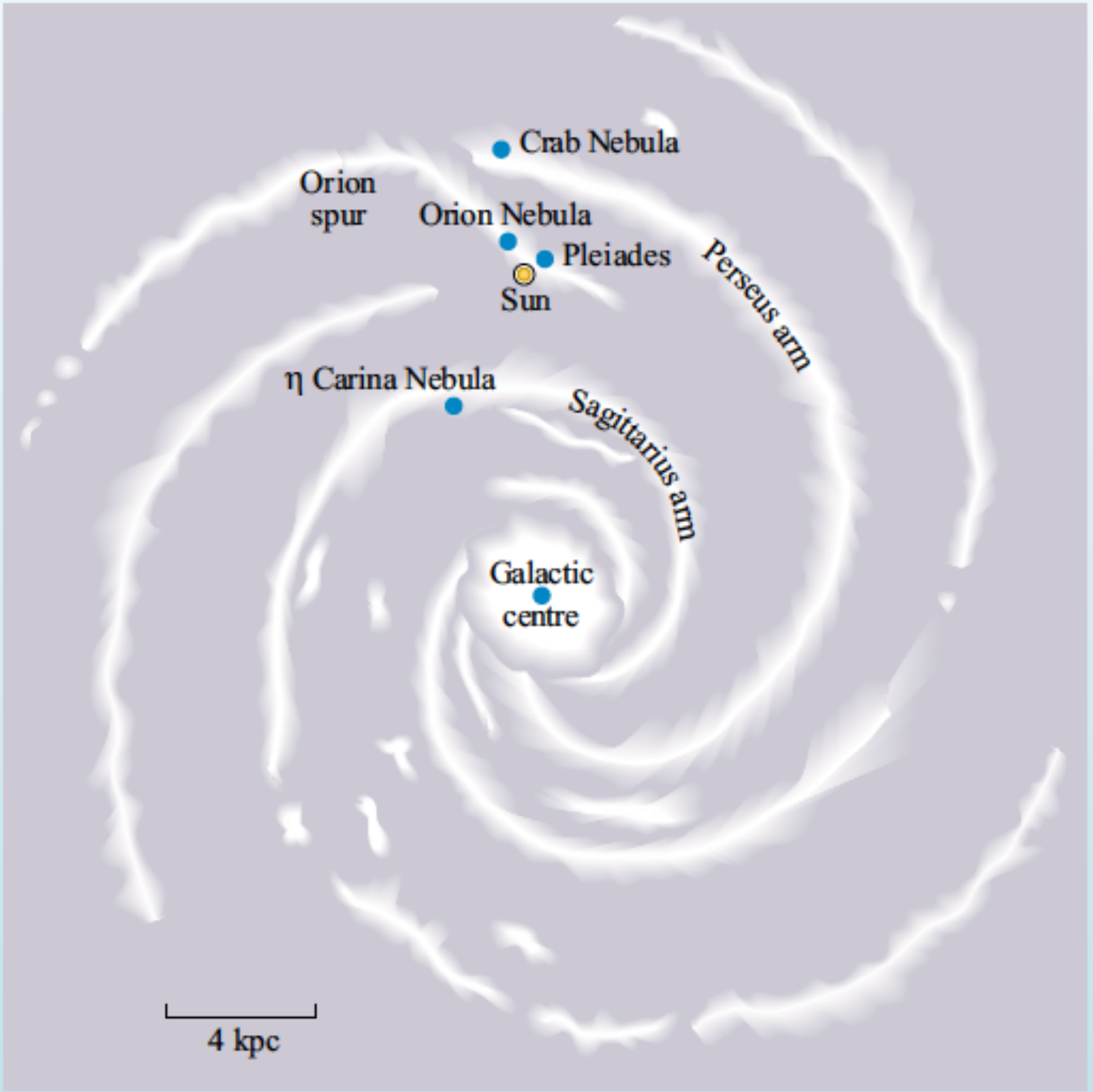

Milky Way Extinction Curves
2175Å bump
far−UV rise
2.75
3.1
4.0
R_V=5.5
visual/near−UV
A_λ/A_V
λ^{-1} (μm^{-1})
0
1
2
3
4
5
0
2
4
6
8
10


Spectral Class
O
B
A
F
G
K
M
30000K
10000K
7500K
6000K
5000K
4000K
3000K
(Temperature)
-10
100 000
Ia
Supergiants
10 000
-5
Ib
1000
II Bright Giants
Luminosity
(Sun=1)
III Giants
Absolute
Magnitude
100
0
10
IV Subgiants
1
+5
V Main Sequence
0.1
0.01
+10
0.001
0.0001
+15
White Dwarfs
0.000 01
0.0
+0.5
+1.0
+1.5
+2.0
Colour (B–V)


MW R_V=3.1: dn/da ∝$a^{-3.5}$, 50Å < a < 0.25μm
Maiolino AGN: dn/da ∝$a^{-3.5}$, 50Å < a < 10μm
SMC
LMC
MW (R_V=3.1)
Maiolino AGN
MW (R_V=4.4)
A_λ/A_V
λ^{-1} (μm^{-1})
0
2
4
6
8
10

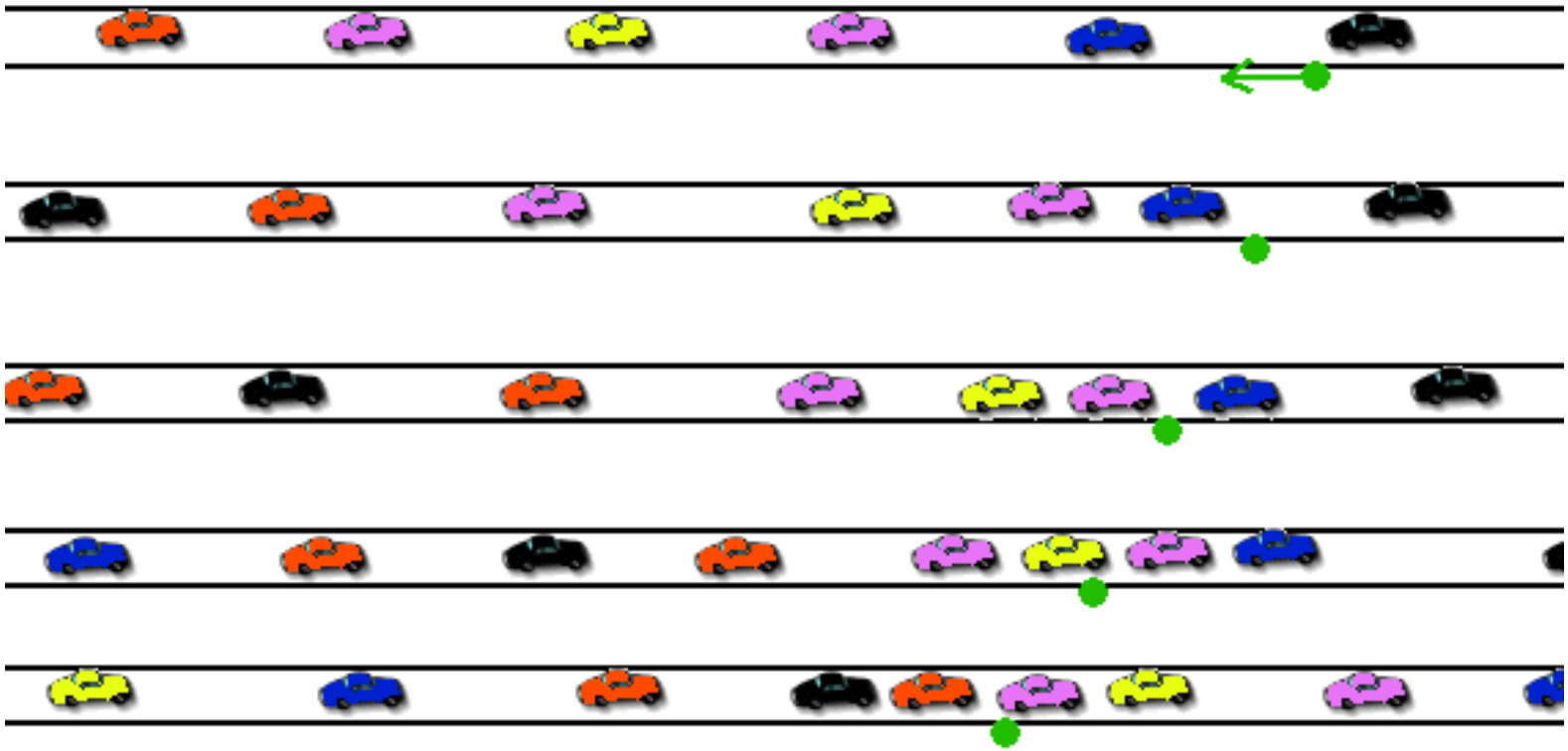

10
0
−10
−10
0
10
Distance (kpc)
ϕ=0

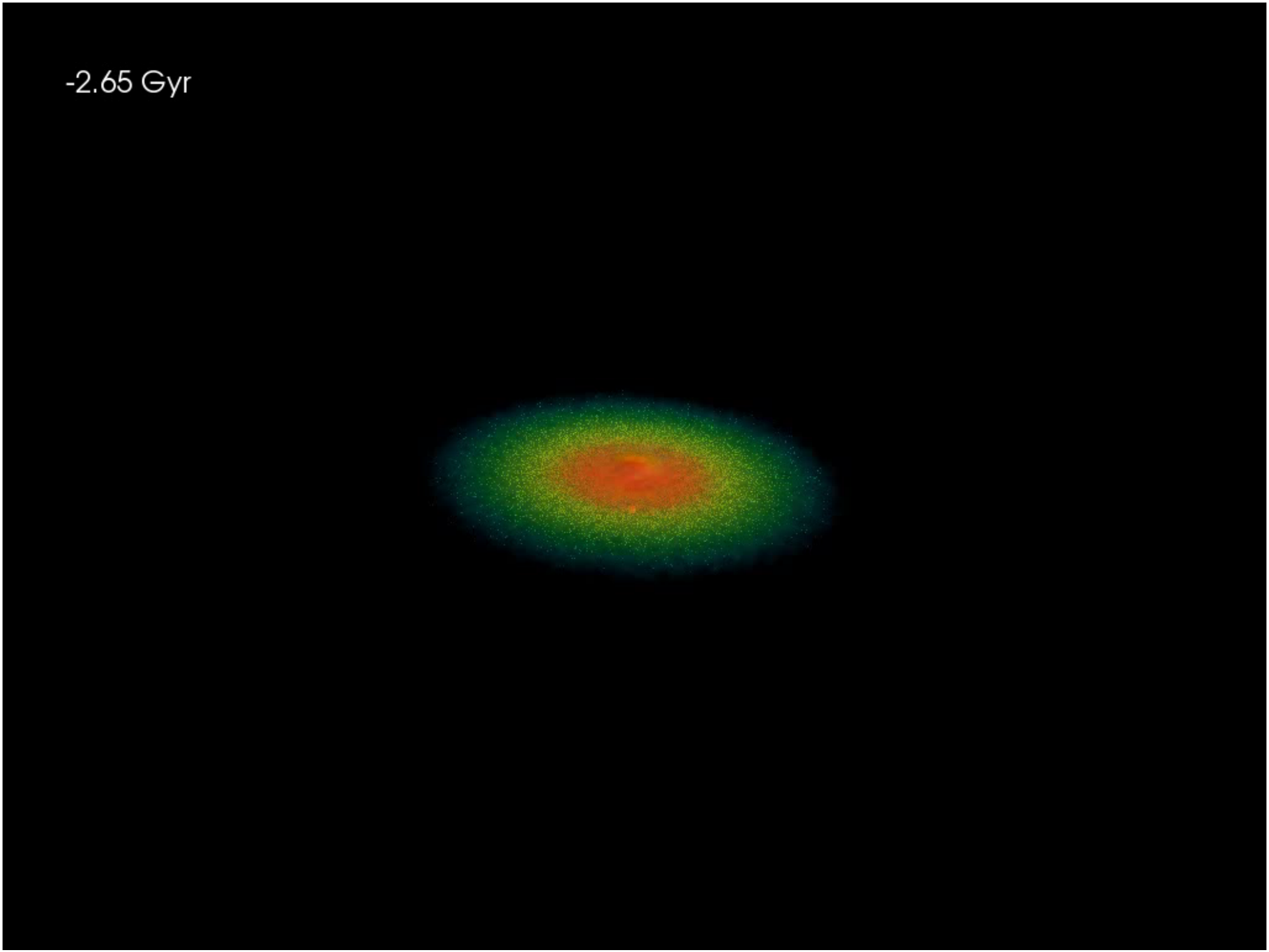

CMa
Ori
Aur
Pup
Cas
Perseus
Outer
New Outer Arm
Vel
Cep
Carina-Sagittarius
Orion-Cygnus
Cen
Crux-Scutum
Norma
3kpc
GC
Bar
Cyg
Nor
Aql
Sgr
Milky Way Galaxy
Observation Shadow of GC

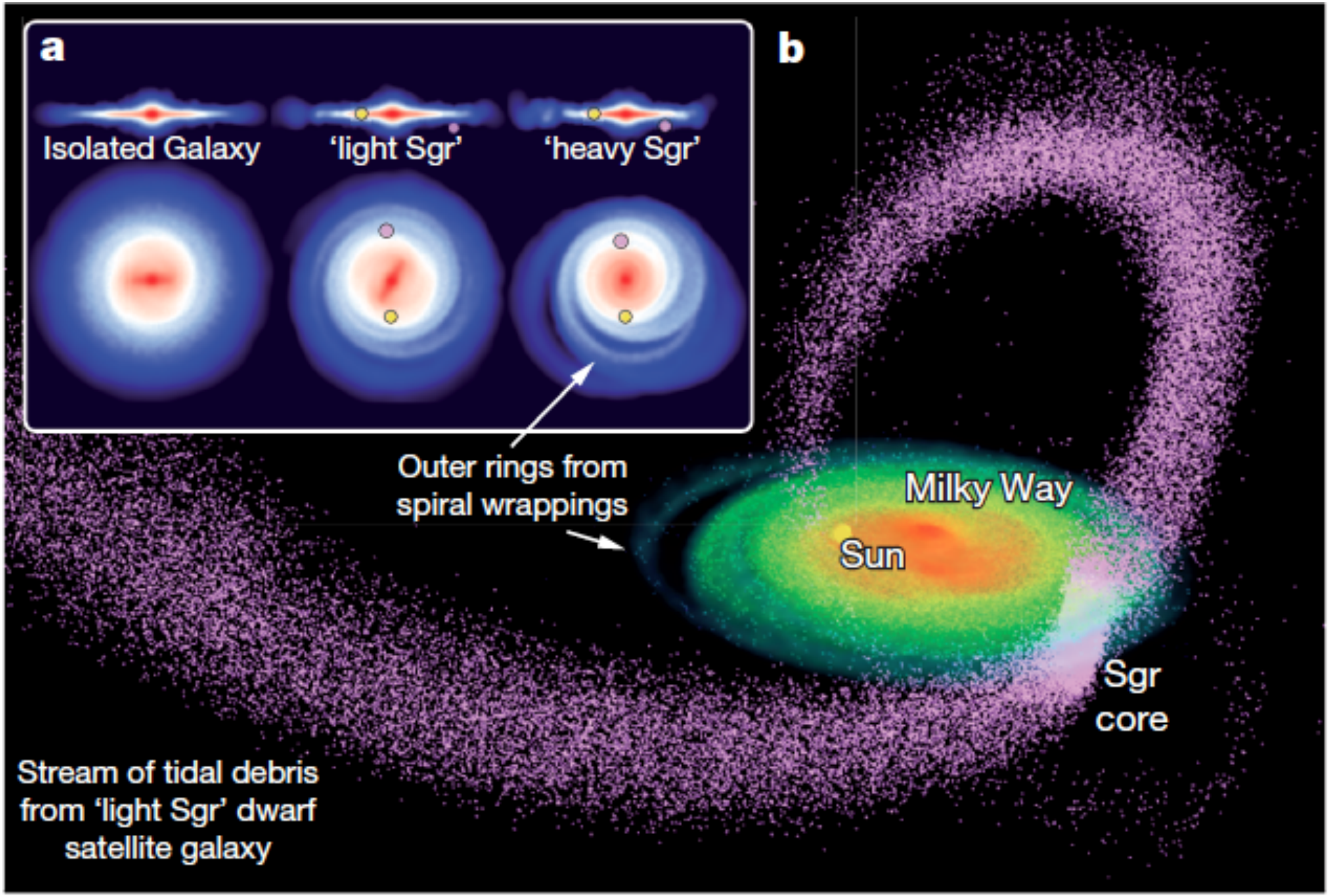

Crab Nebula
Orion
spur
Orion Nebula
Pleiades
Sun
Perseus arm
η Carina Nebula
Sagittarius arm
Galactic
centre
4 kpc

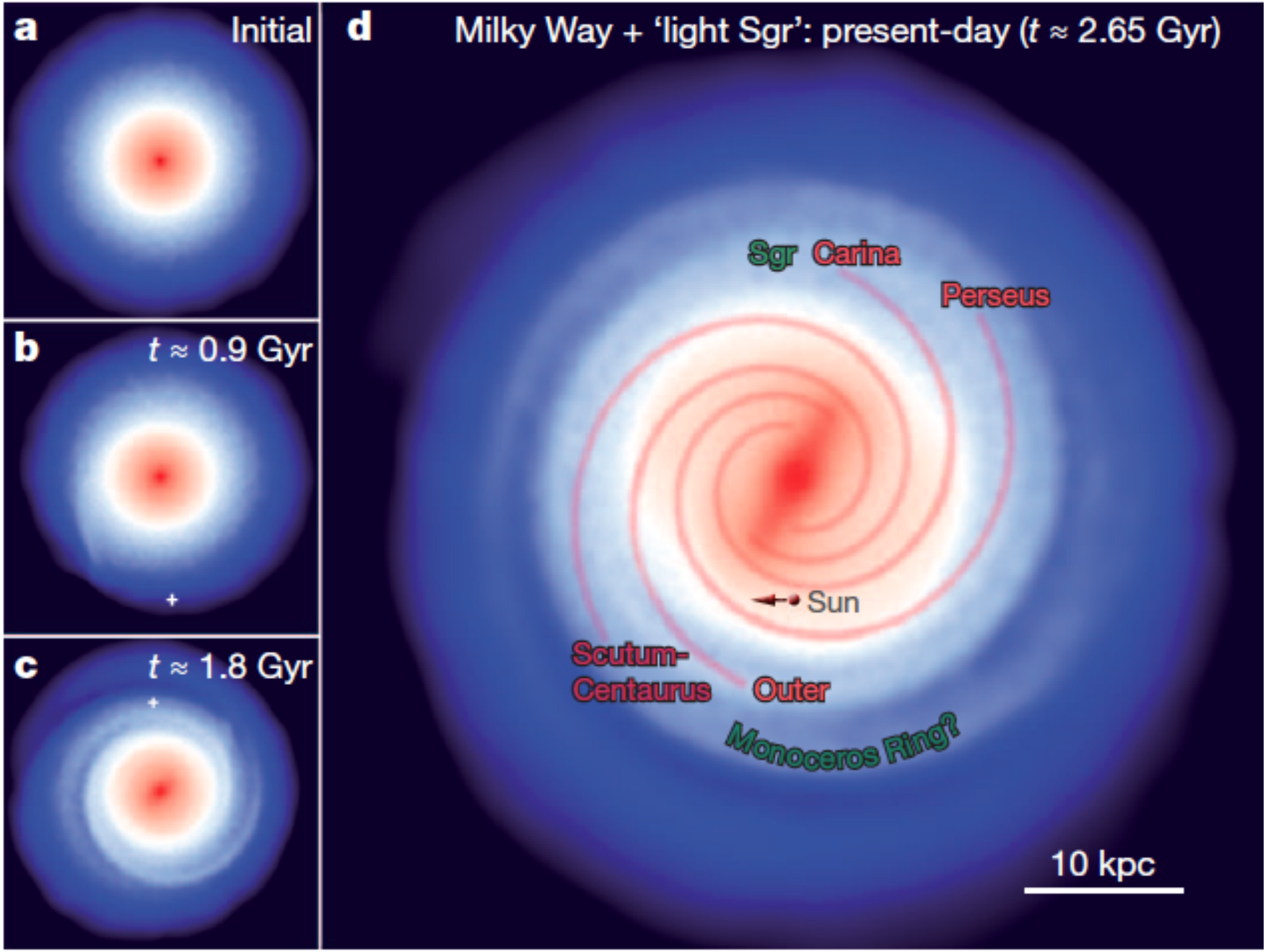
(b)

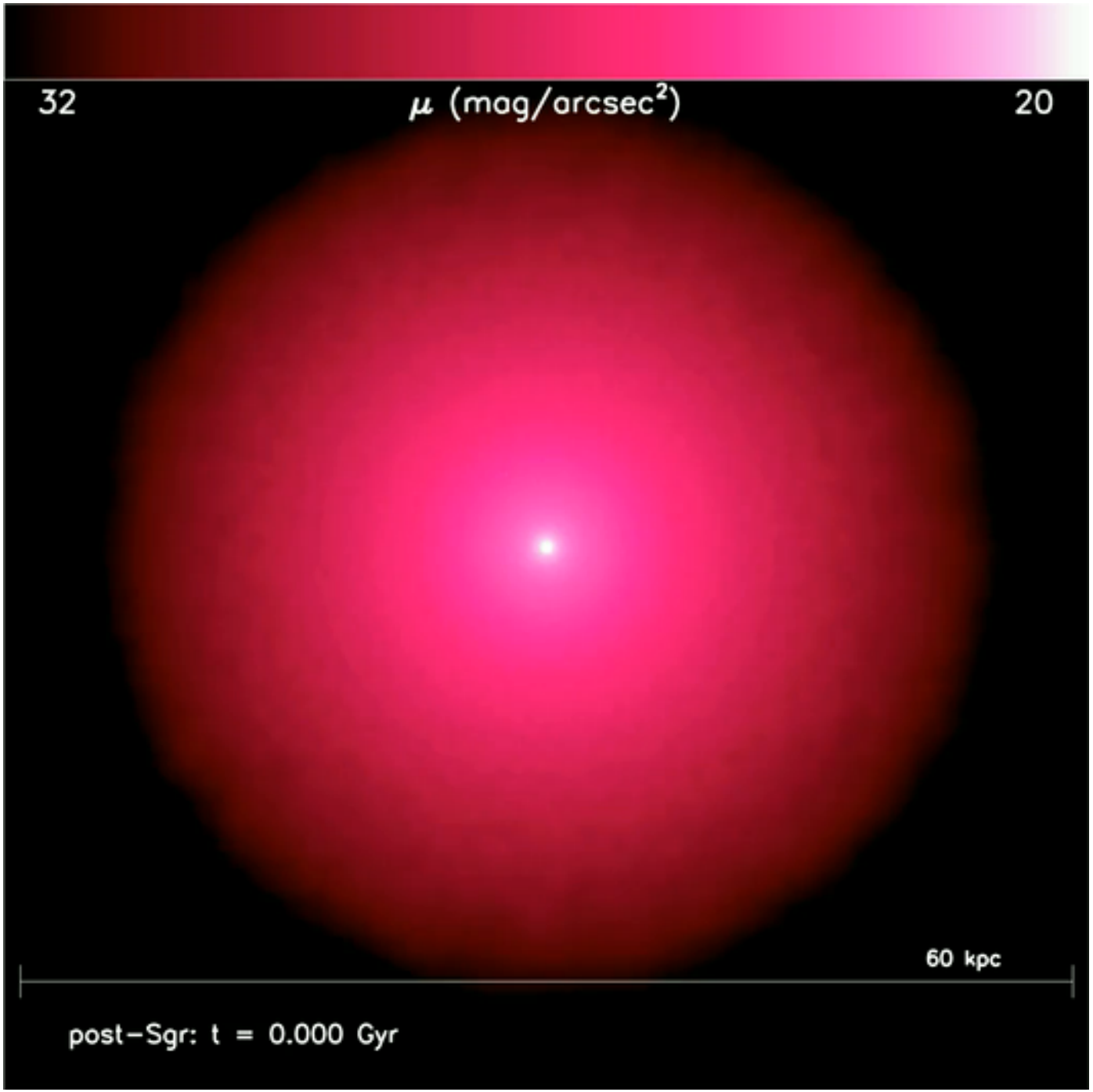
NGC 1365




-2.65 Gyr

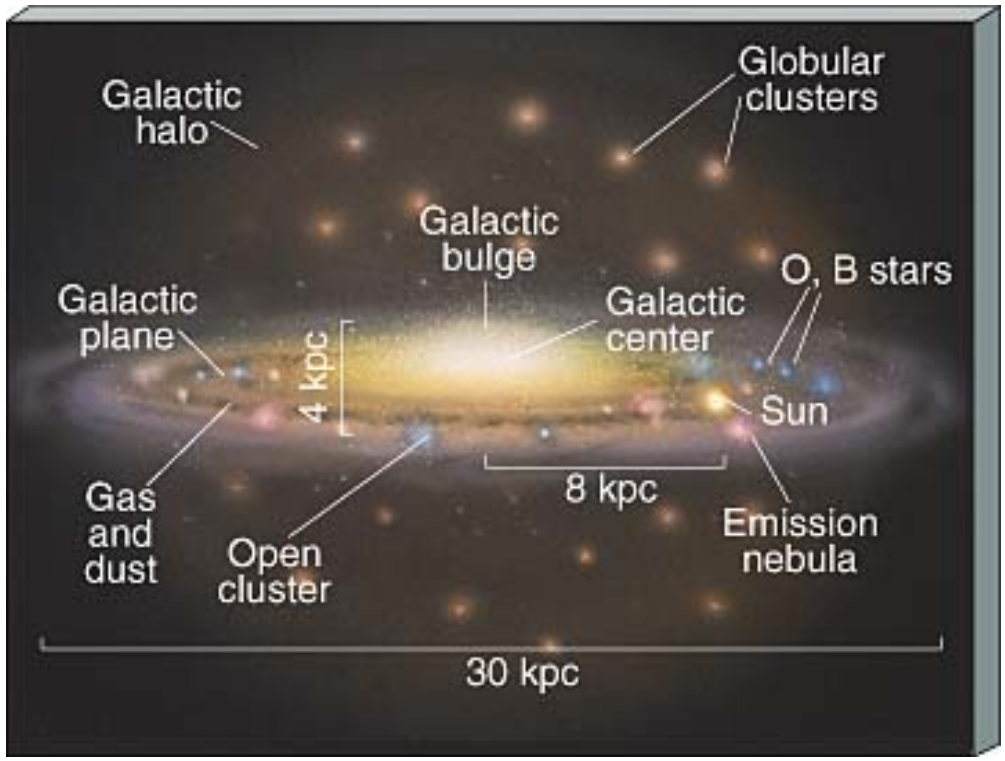

a
Isolated Galaxy
'light Sgr'
'heavy Sgr'
b
Outer rings from
spiral wrappings
Milky Way
Sun
Sgr
core
Stream of tidal debris
from 'light Sgr' dwarf
satellite galaxy

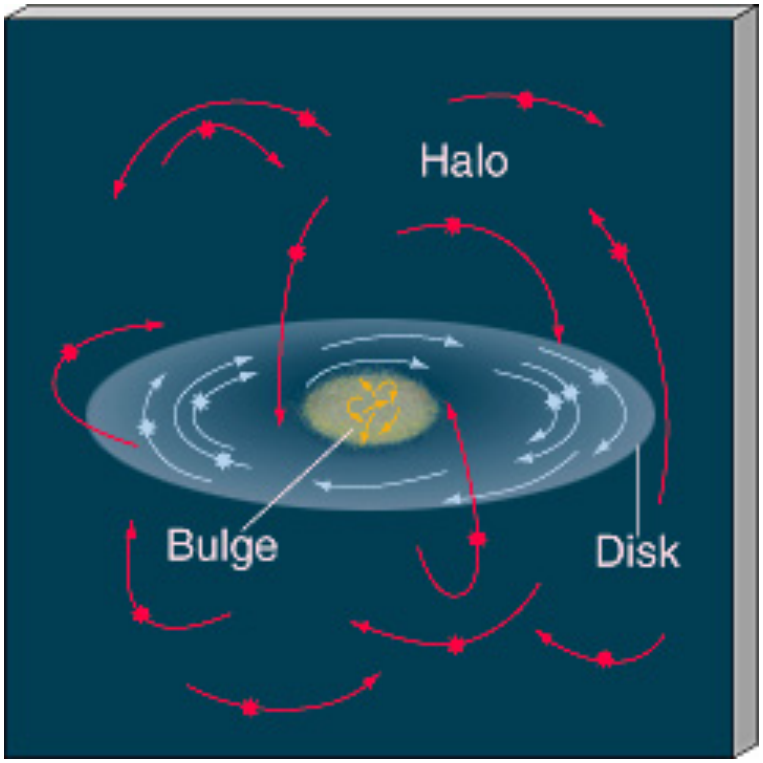

a
Initial
b
t ≈ 0.9 Gyr
c
t ≈ 1.8 Gyr
d
Milky Way + 'light Sgr': present-day (t ≈ 2.65 Gyr)
Sgr
Carina
Perseus
Sun
Scutum-
Centaurus
Outer
Monoceros Ring?
10 kpc



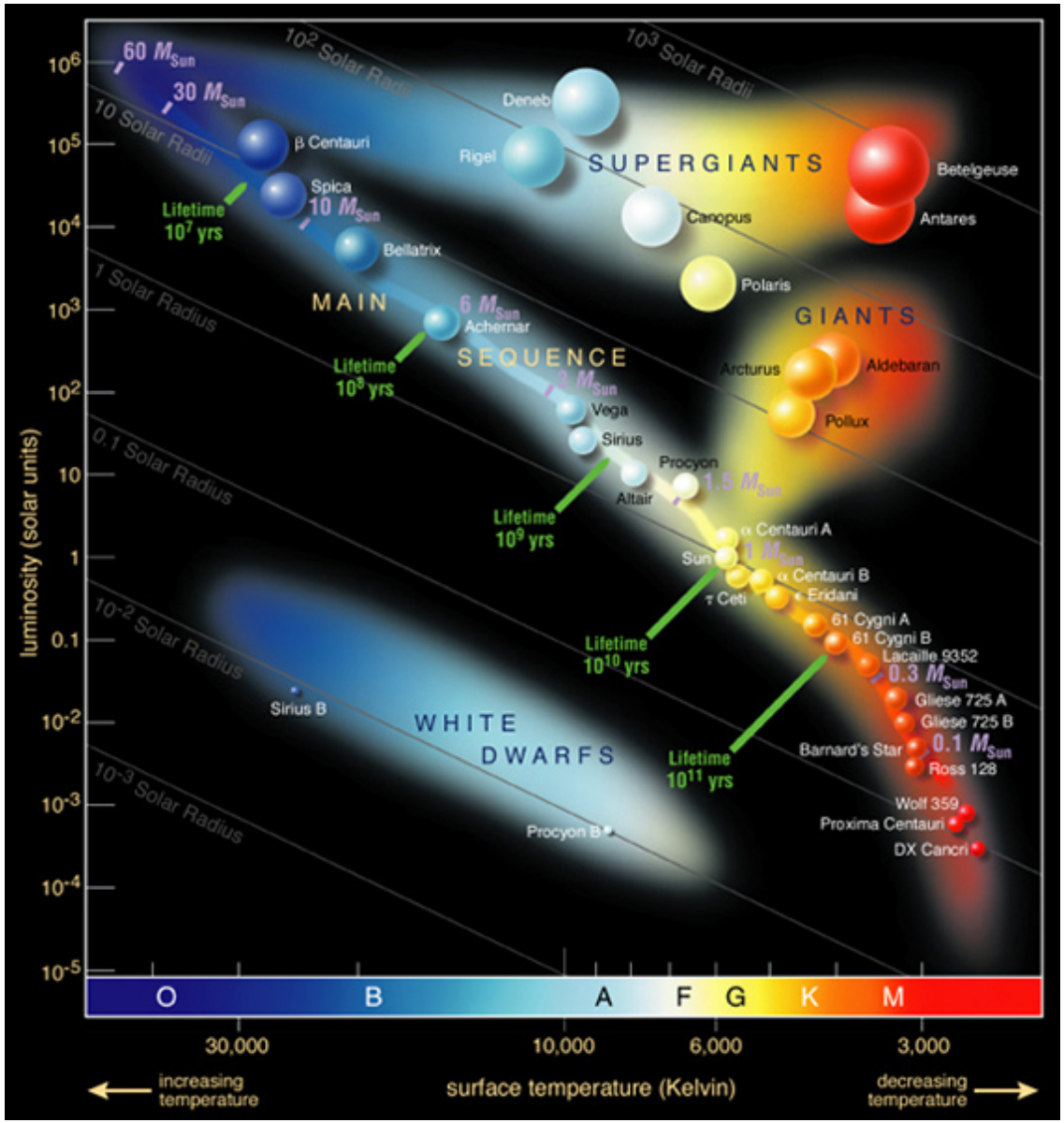
Purcell et al. 2011, Nature

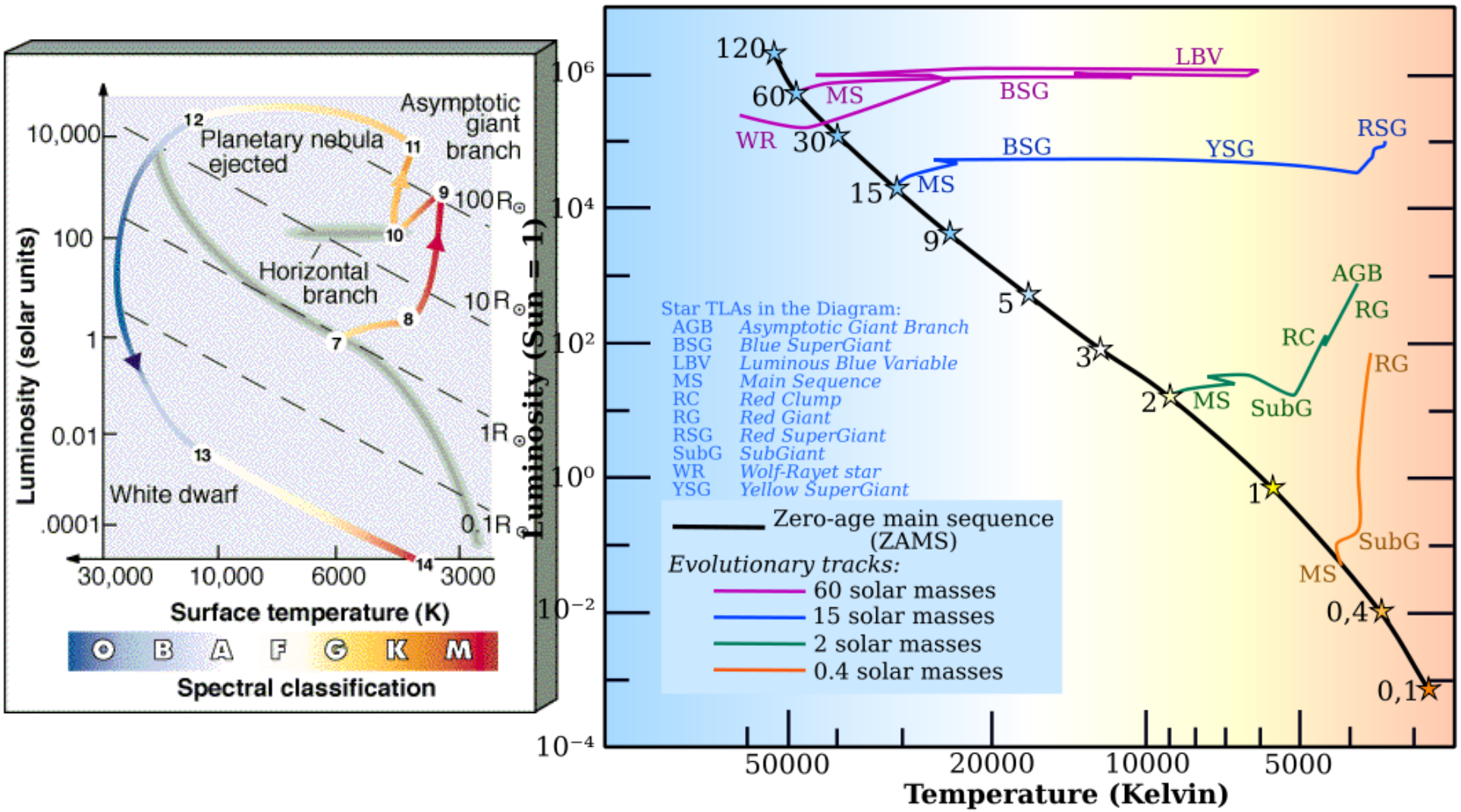
Halo in odebelitev



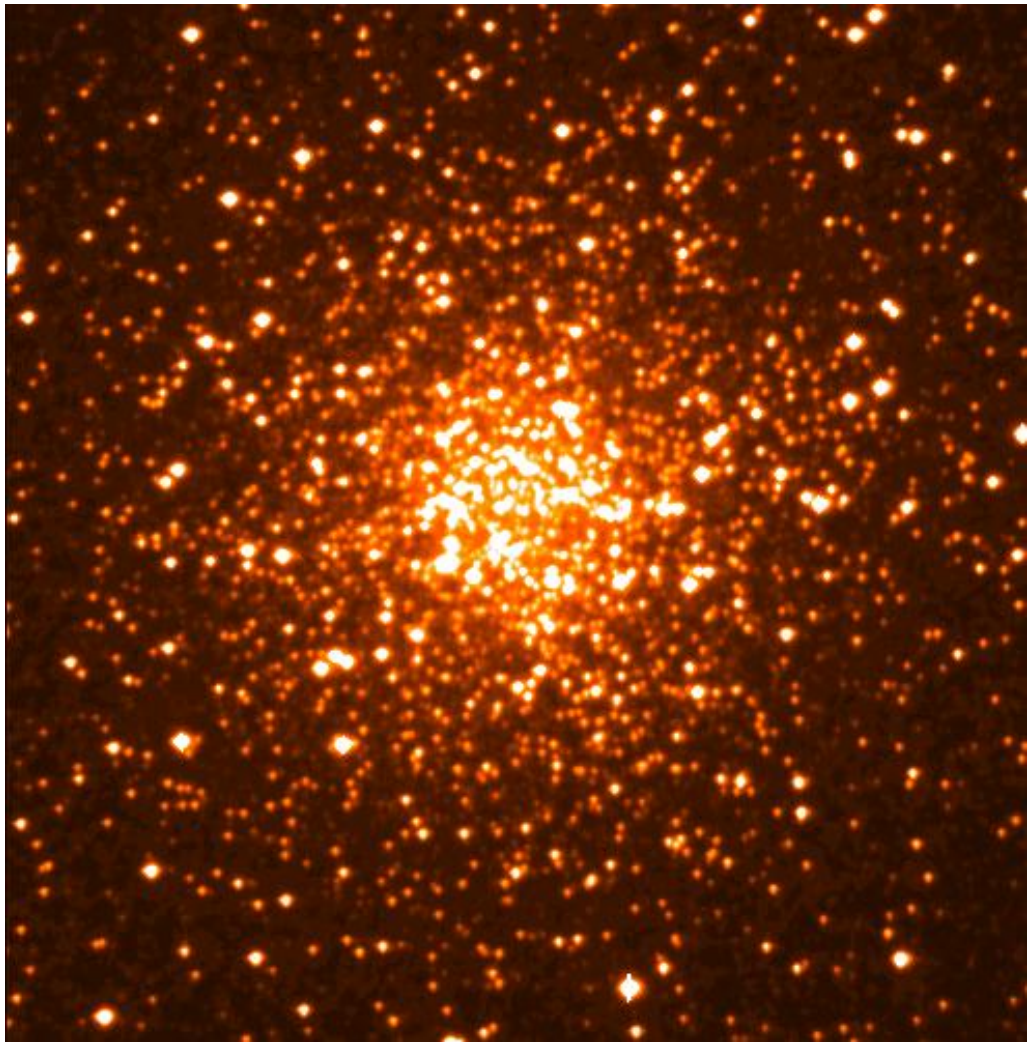


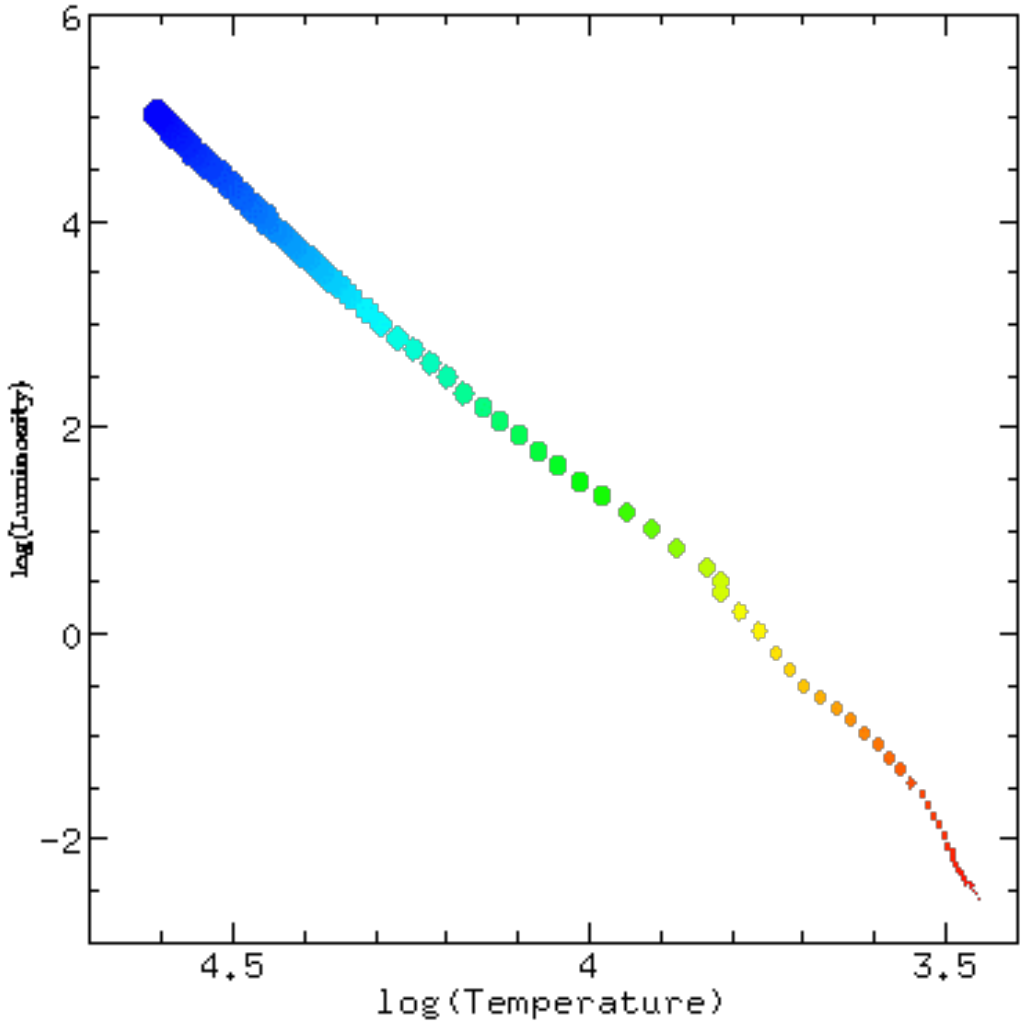
stare zvezde, Pop II, nizka Z,

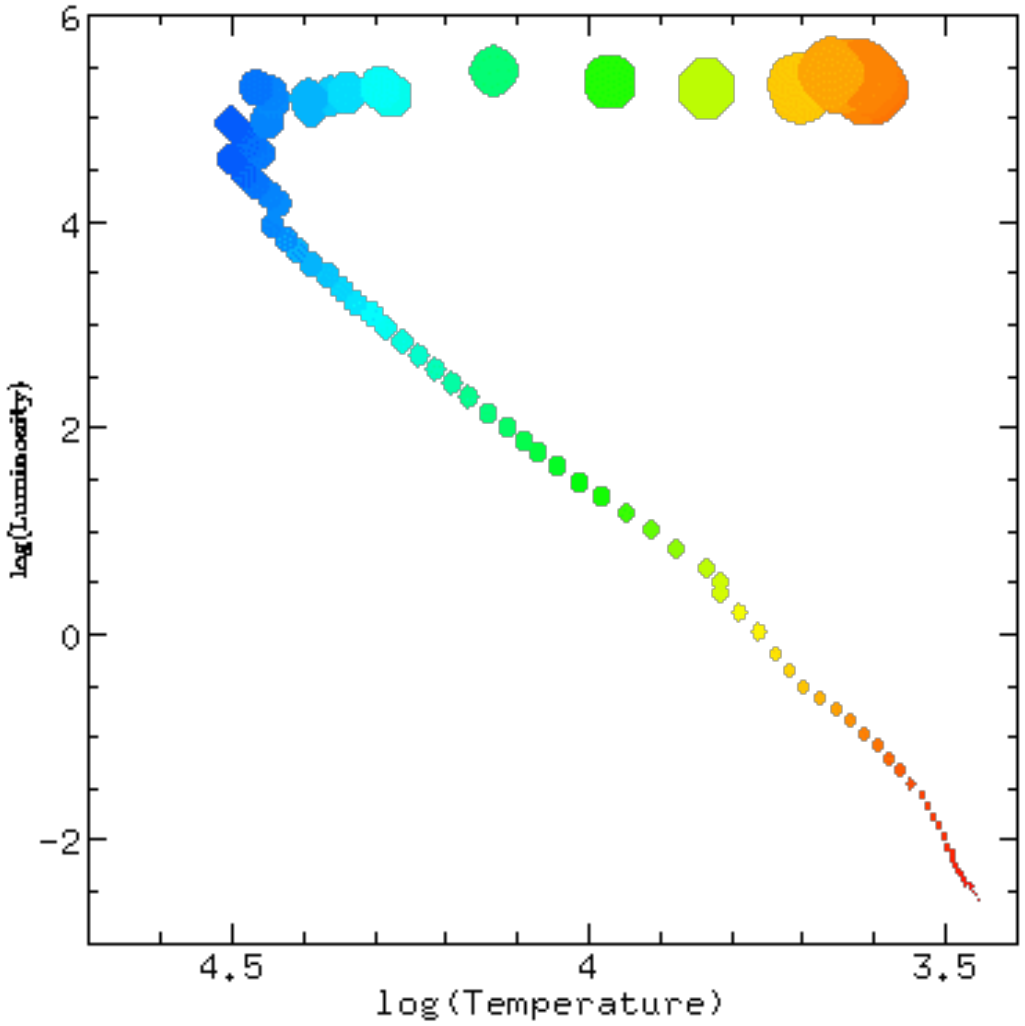

luminosity (solar units)
10^6
10^5
10^4
10^3
10^2
10
1
0.1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
60 M_{Sun}
30 M_{Sun}
10^2 Solar Radii
10^3 Solar Radii
10 Solar Radii
1 Solar Radius
0.1 Solar Radius
10^{-2} Solar Radius
10^{-3} Solar Radius
Deneb
Rigel
SUPERGIANTS
Betelgeuse
Antares
Canopus
Polaris
β Centauri
Spica
10 M_{Sun}
Lifetime 10^7 yrs
Bellatrix
MAIN
SEQUENCE
6 M_{Sun}
Achernar
Lifetime 10^8 yrs
GIANTS
Arcturus
Aldebaran
Pollux
3 M_{Sun}
Vega
Sirius
Procyon
1.5 M_{Sun}
Altair
Lifetime 10^9 yrs
α Centauri A
1 M_{Sun}
Sun
α Centauri B
ε Eridani
τ Ceti
Lifetime 10^{10} yrs
61 Cygni A
61 Cygni B
Lacaille 9352
0.3 M_{Sun}
Gliese 725 A
Gliese 725 B
0.1 M_{Sun}
Barnard's Star
Ross 128
Lifetime 10^{11} yrs
Wolf 359
Proxima Centauri
DX Cancri
Sirius B
WHITE
DWARFS
Procyon B
O
B
A
F
G
K
M
30,000
10,000
6,000
3,000
increasing temperature
surface temperature (Kelvin)
decreasing temperature

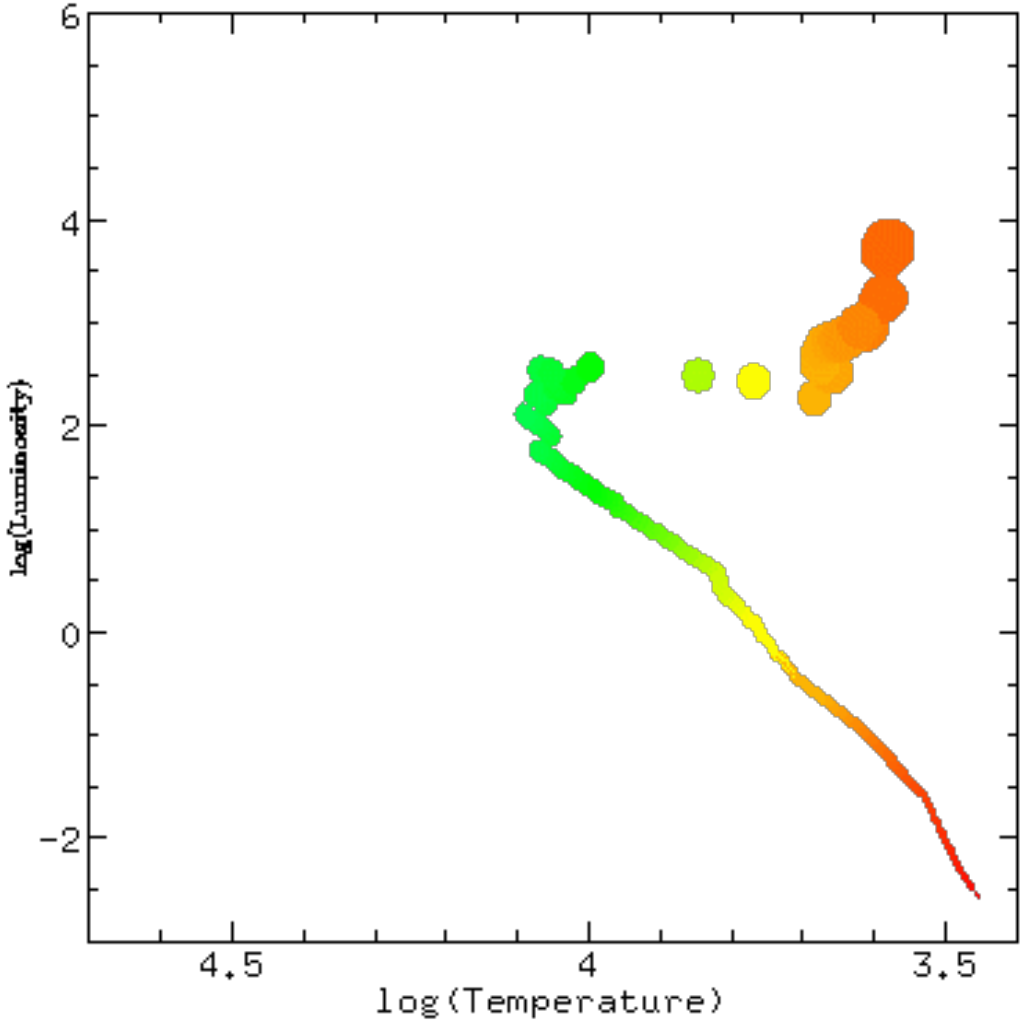

Luminosity (solar units)
10,000
100
1
0.01
.0001
Planetary nebula ejected
Asymptotic giant branch
Horizontal branch
White dwarf
100 R⊙
10 R⊙
1 R⊙
0.1 R⊙
12
11
9
10
8
7
13
14
30,000
10,000
6000
3000
Surface temperature (K)
O B A F G K M
Spectral classification
Luminosity (Sun = 1)
10⁶
10⁴
10²
10⁰
10⁻²
10⁻⁴
120
60
30
15
9
5
3
2
1
0,4
0,1
WR
MS
BSG
LBV
YSG
RSG
AGB
RG
RC
SubG
Star TLAs in the Diagram:
AGB Asymptotic Giant Branch
BSG Blue SuperGiant
LBV Luminous Blue Variable
MS Main Sequence
RC Red Clump
RG Red Giant
RSG Red SuperGiant
SubG SubGiant
WR Wolf-Rayet star
YSG Yellow SuperGiant
Zero-age main sequence (ZAMS)
Evolutionary tracks:
60 solar masses
15 solar masses
2 solar masses
0.4 solar masses
50000
20000
10000
5000
Temperature (Kelvin)

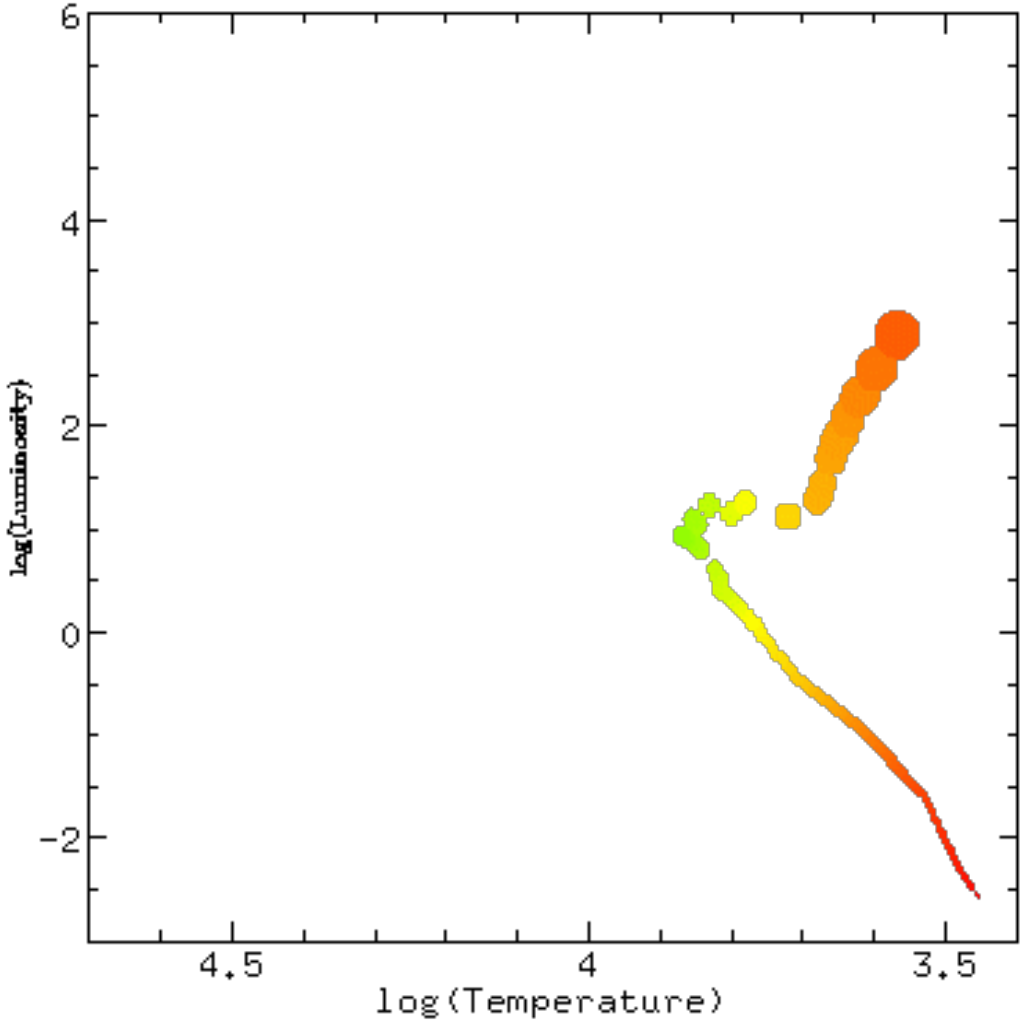
47 Tucanae

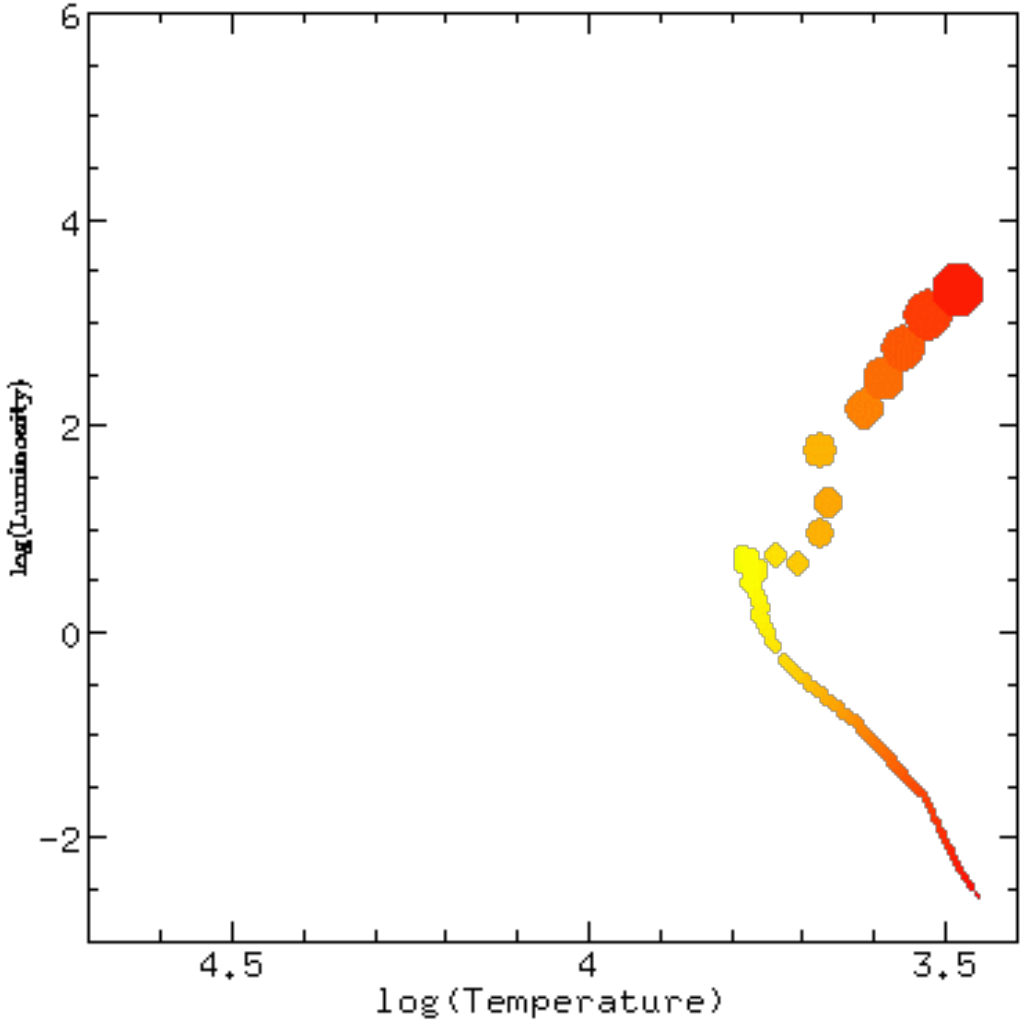


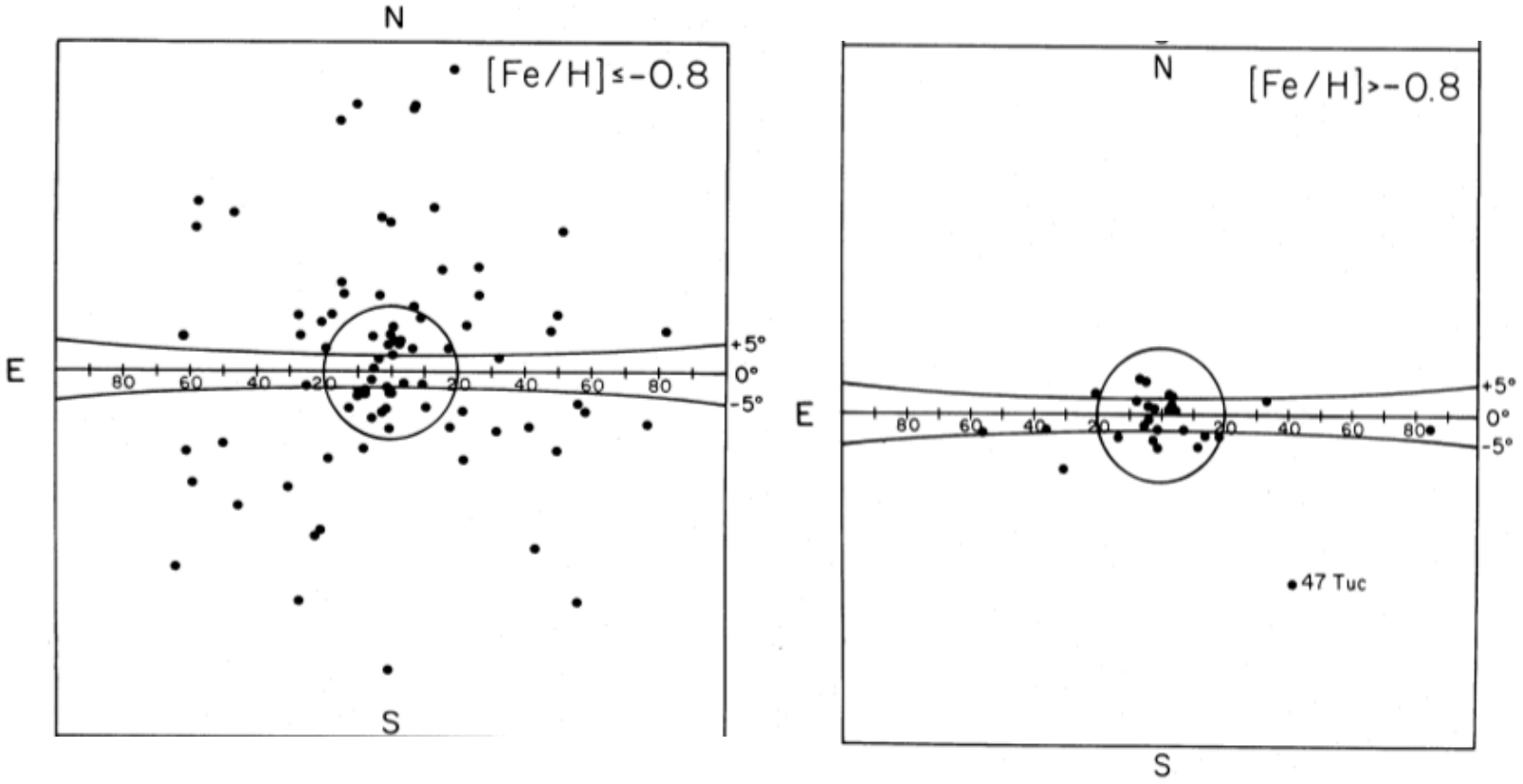

6
4
2
0
-2
log(Luminosity)
4.5
4
3.5
log(Temperature)

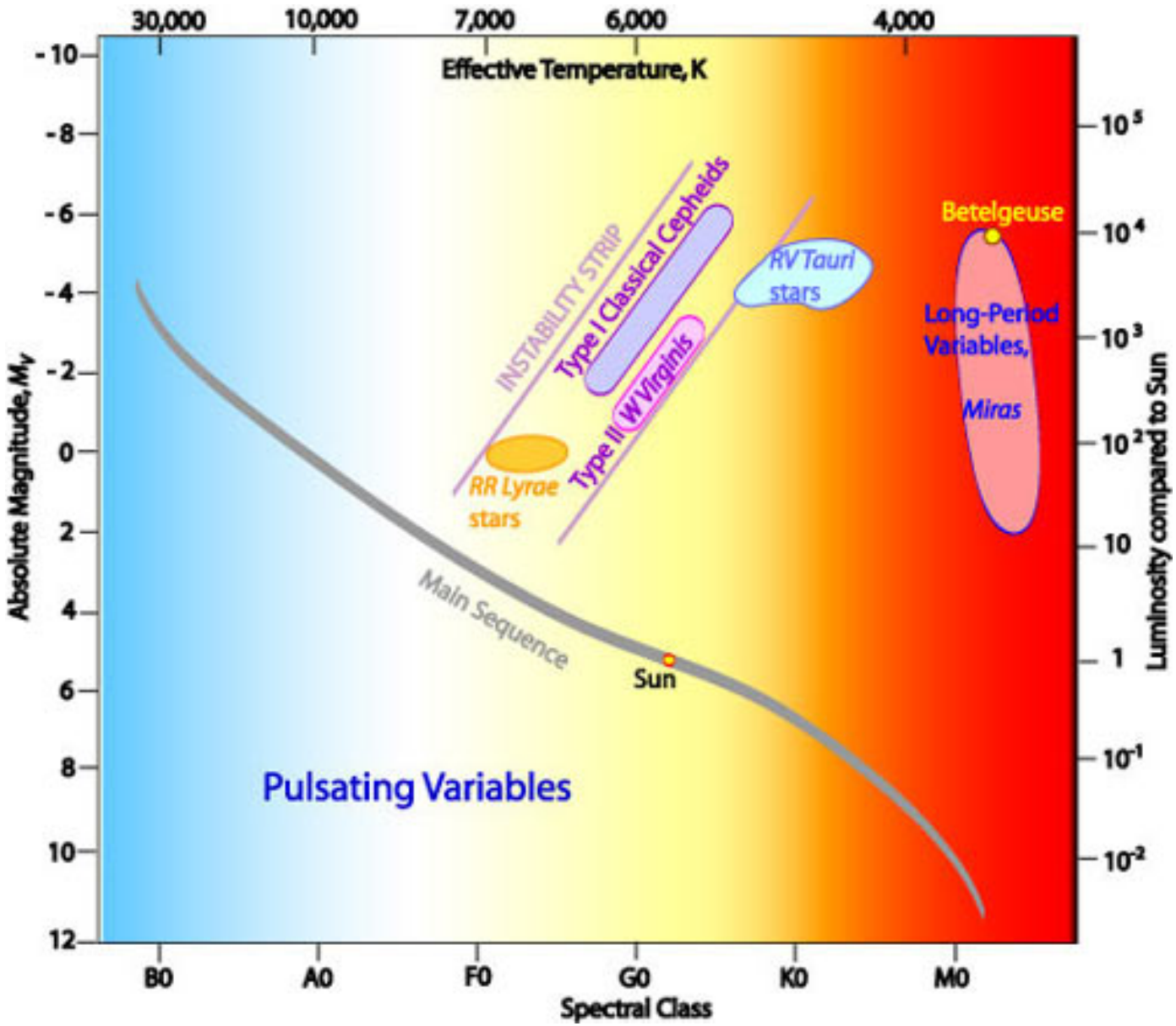

6
4
2
0
−2
log(Luminosity)
4.5
4
3.5
log(Temperature)


6
4
2
0
-2
log(Luminosity)
4.5
4
3.5
log(Temperature)

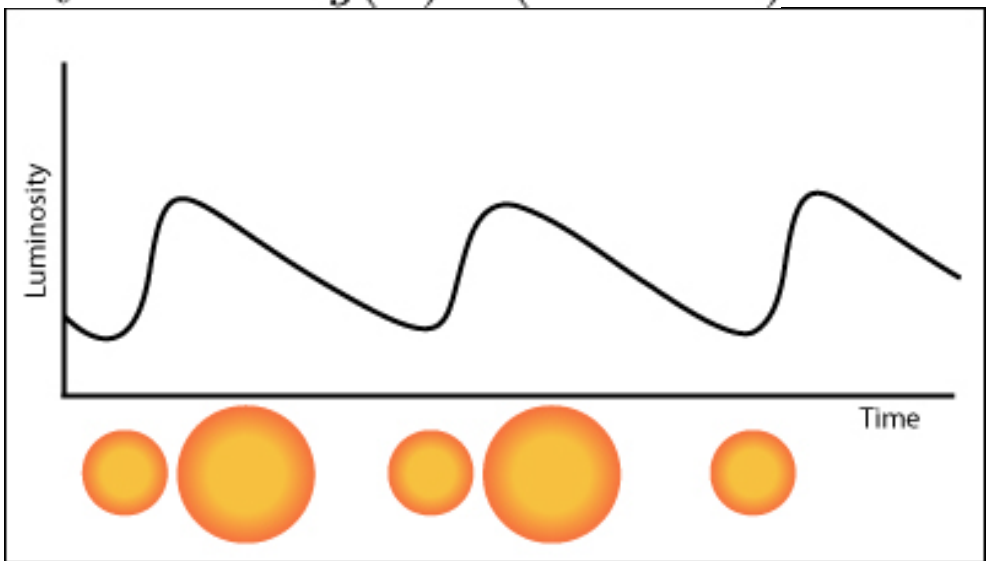

6
4
2
0
-2
log(Luminosity)
4.5
4
3.5
log(Temperature)

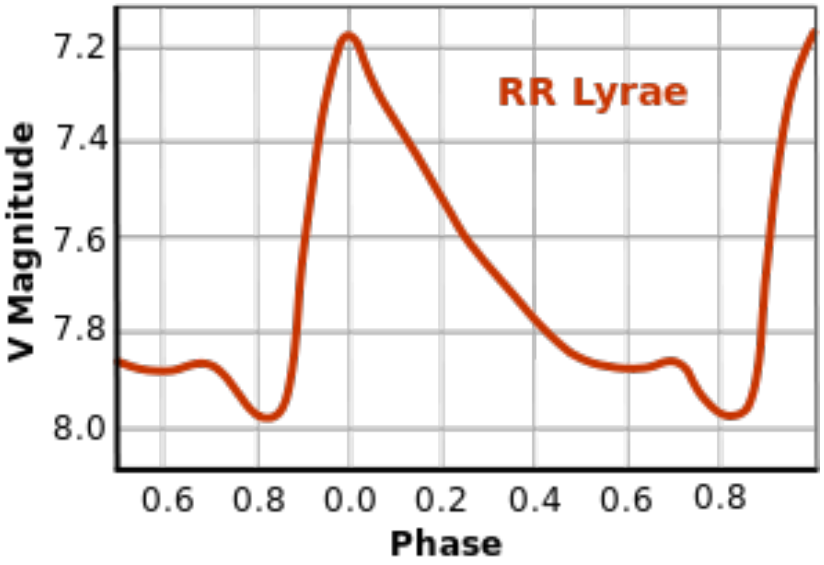

6
4
2
0
-2
log(Luminosity)
4.5
4
3.5
log(Temperature)

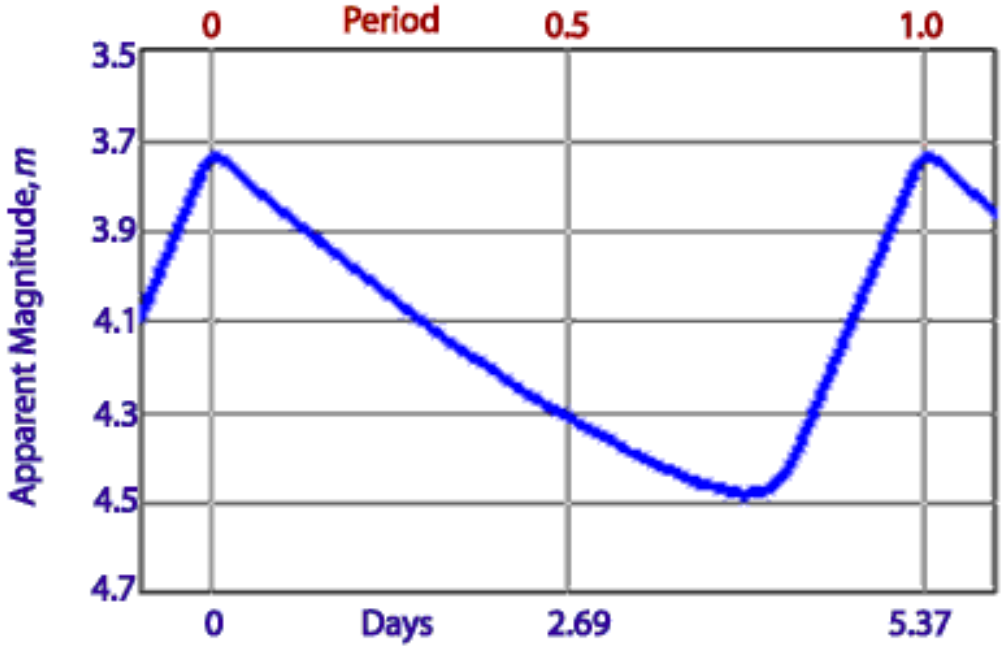

N
[Fe/H]≤-0.8
E
80
60
40
20
0
20
40
60
80
+5°
0°
-5°
S
N
[Fe/H]>-0.8
E
80
60
40
20
0
20
40
60
80
+5°
0°
-5°
47 Tuc
S


30,000
10,000
7,000
6,000
4,000
Effective Temperature, K
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
Absolute Magnitude, M_V
10^5
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
Luminosity compared to Sun
INSTABILITY STRIP
Type I Classical Cepheids
Type II W Virginis
RV Tauri stars
Betelgeuse
Long-Period Variables,
Miras
RR Lyrae stars
Main Sequence
Sun
Pulsating Variables
B0
A0
F0
G0
K0
M0
Spectral Class

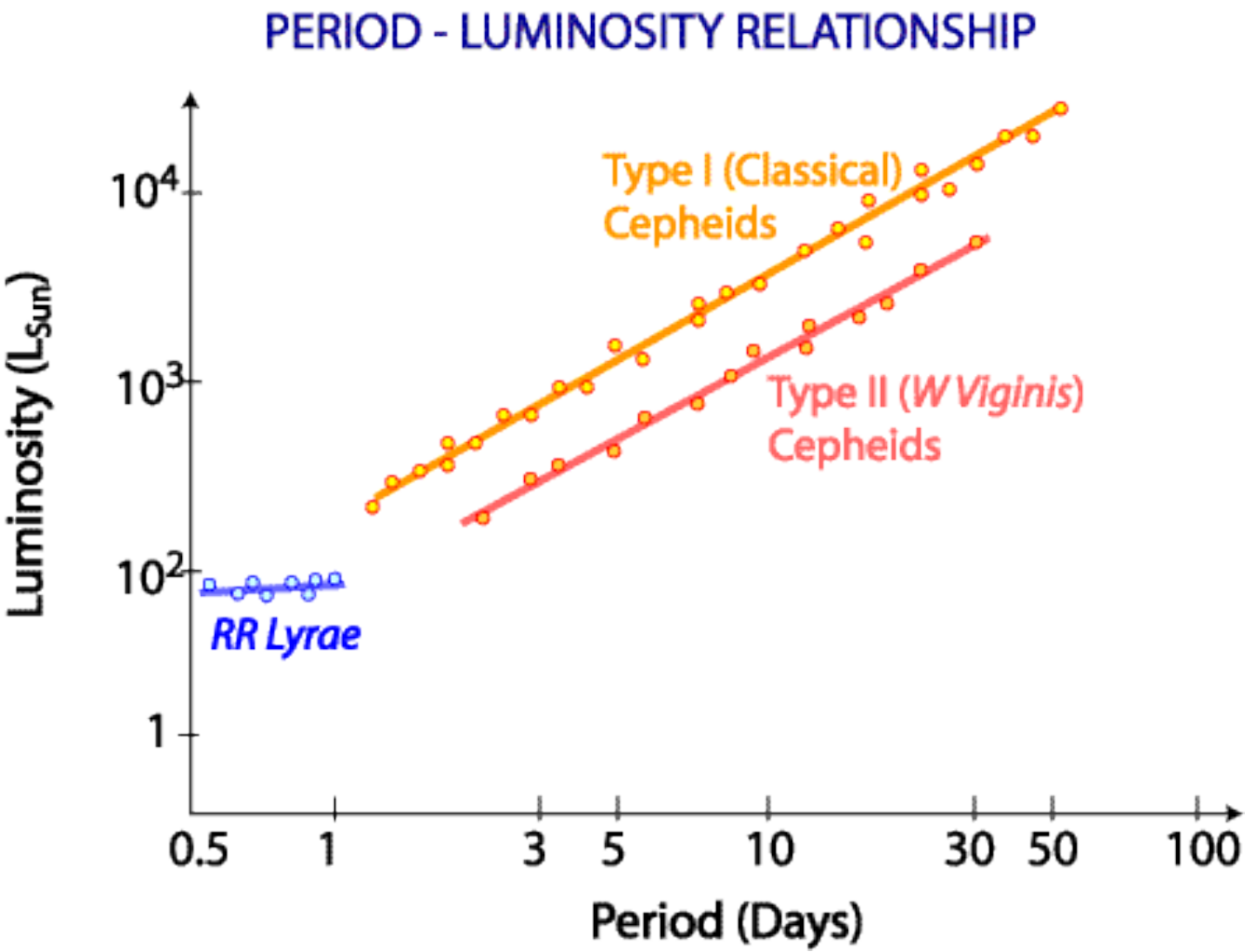
$$M_v = -2.81log(P) - (1.43 \pm 0.1)$$

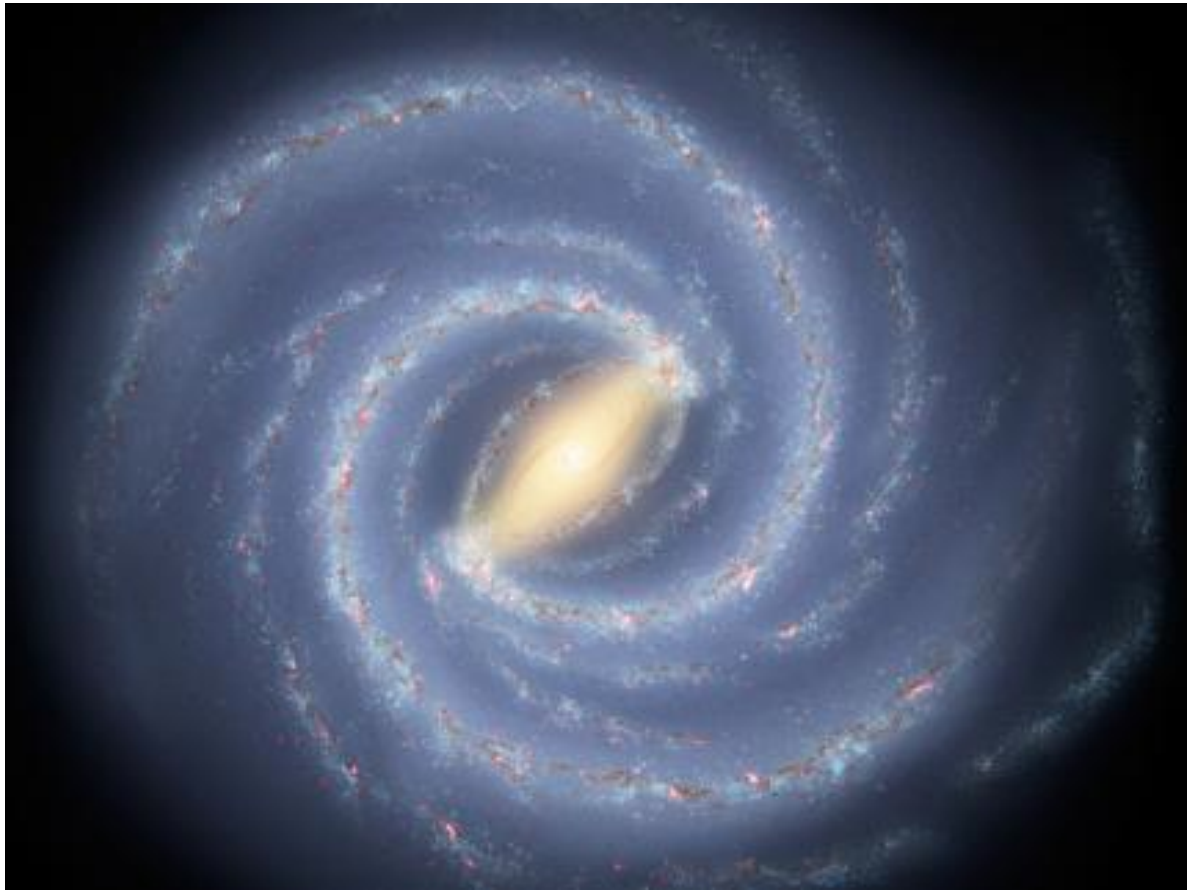




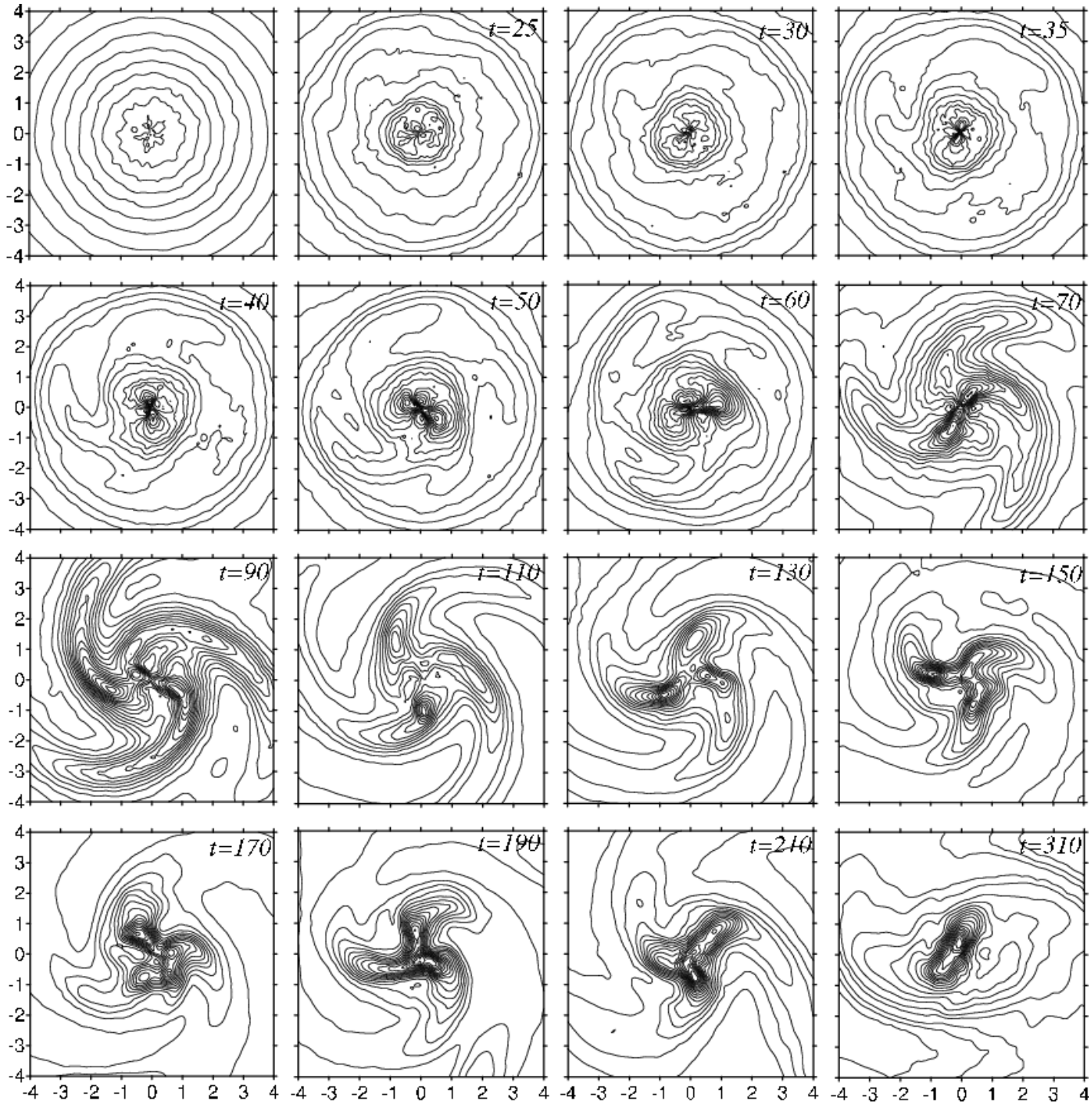


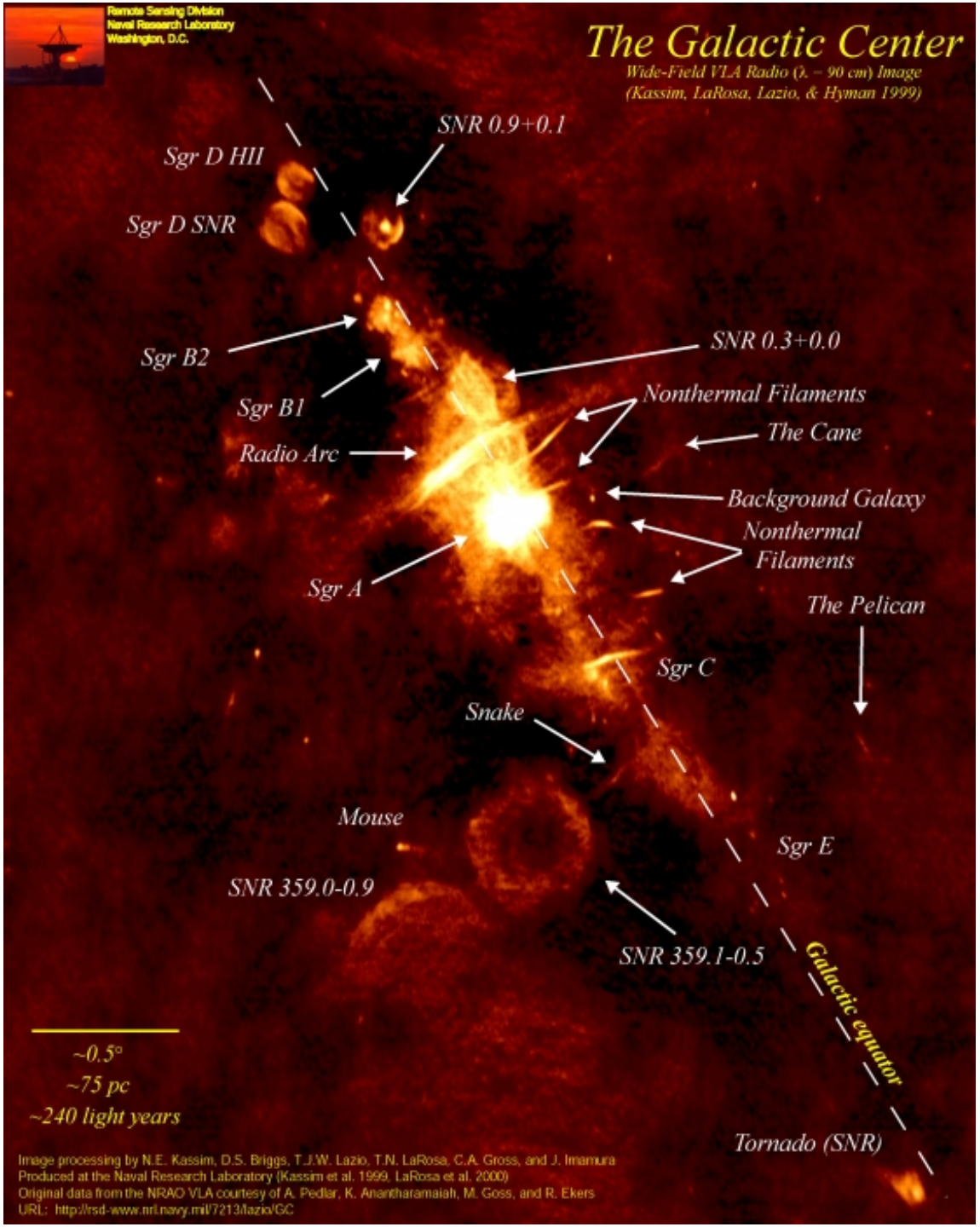
Light Curve for δ Cephei

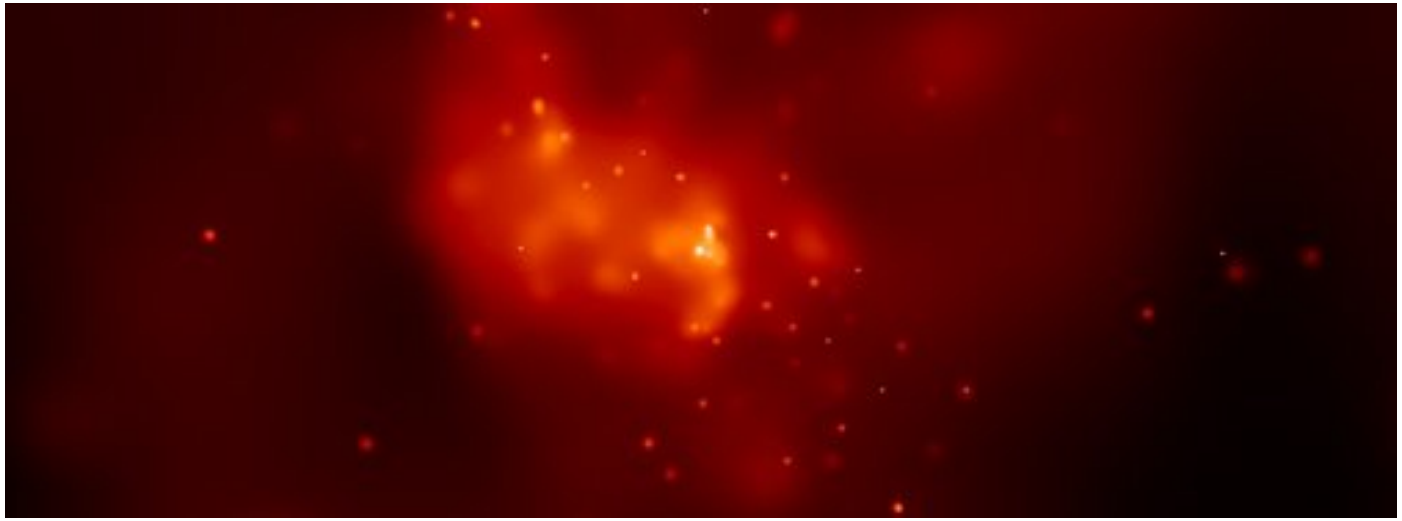

PERIOD - LUMINOSITY RELATIONSHIP
Luminosity (L_{Sun})
10^4
10^3
10^2
1
Type I (Classical) Cepheids
Type II (*W Viginis*) Cepheids
RR Lyrae
0.5
1
3
5
10
30
50
100
Period (Days)

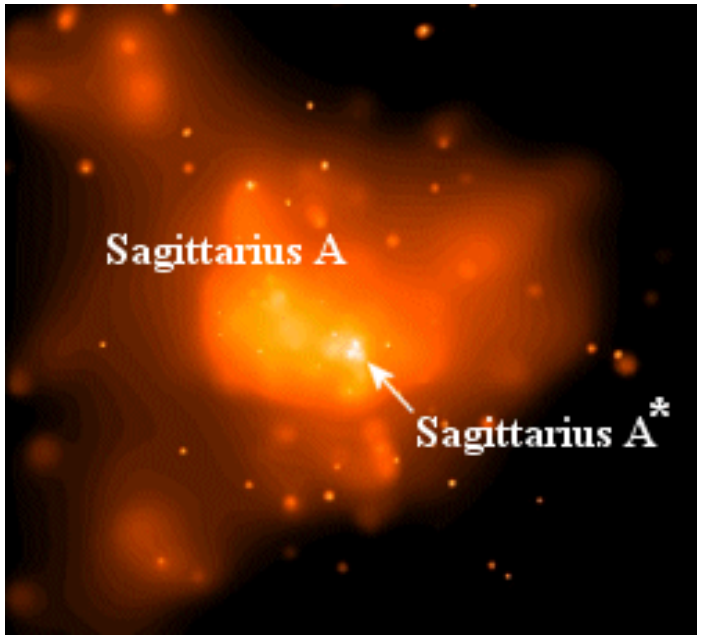


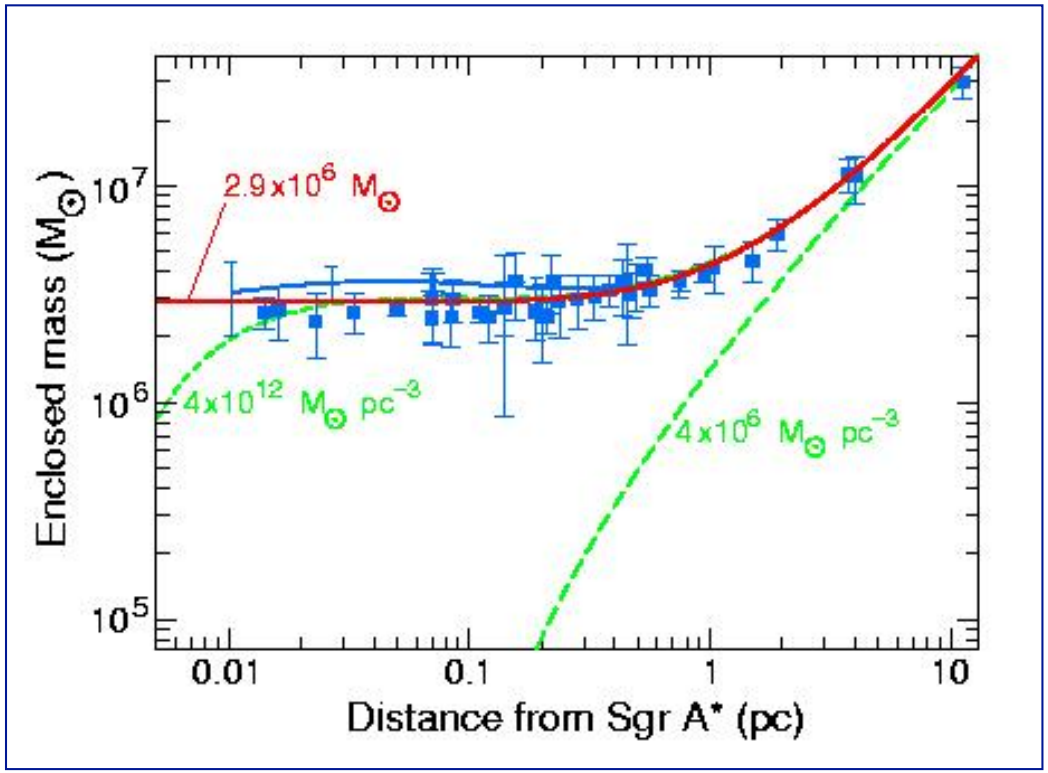
bližnja IR

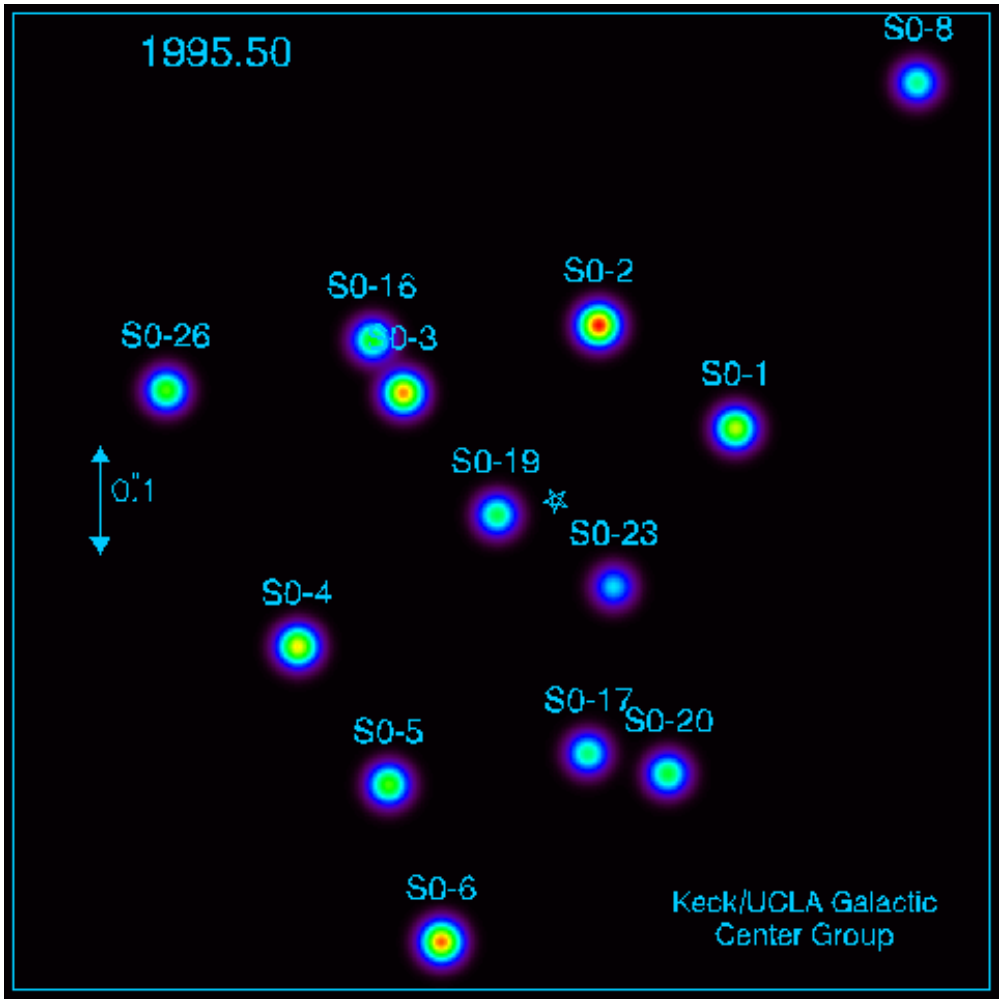

t=25
t=30
t=35
t=40
t=50
t=60
t=70
t=90
t=110
t=130
t=150
t=170
t=190
t=210
t=310


Remote Sensing Division
Naval Research Laboratory
Washington, D.C.
The Galactic Center
Wide-Field VLA Radio (λ ~ 90 cm) Image
(Kassim, LaRosa, Lazio, & Hyman 1999)
SNR 0.9+0.1
Sgr D HII
Sgr D SNR
Sgr B2
SNR 0.3+0.0
Nonthermal Filaments
Sgr B1
The Cane
Radio Arc
Background Galaxy
Nonthermal
Filaments
Sgr A
The Pelican
Sgr C
Snake
Mouse
Sgr E
SNR 359.0-0.9
SNR 359.1-0.5
Galactic equator
~0.5°
~75 pc
~240 light years
Tornado (SNR)
Image processing by N.E. Kassim, D.S. Briggs, T.J.W. Lazio, T.N. LaRosa, C.A. Gross, and J. Imamura
Produced at the Naval Research Laboratory (Kassim et al. 1999, LaRosa et al. 2000)
Original data from the NRAO VLA courtesy of A. Pedlar, K. Anantharamaiah, M. Goss, and R. Ekers
URL: http://rsd-www.nrl.navy.mil/7213/lazio/GC

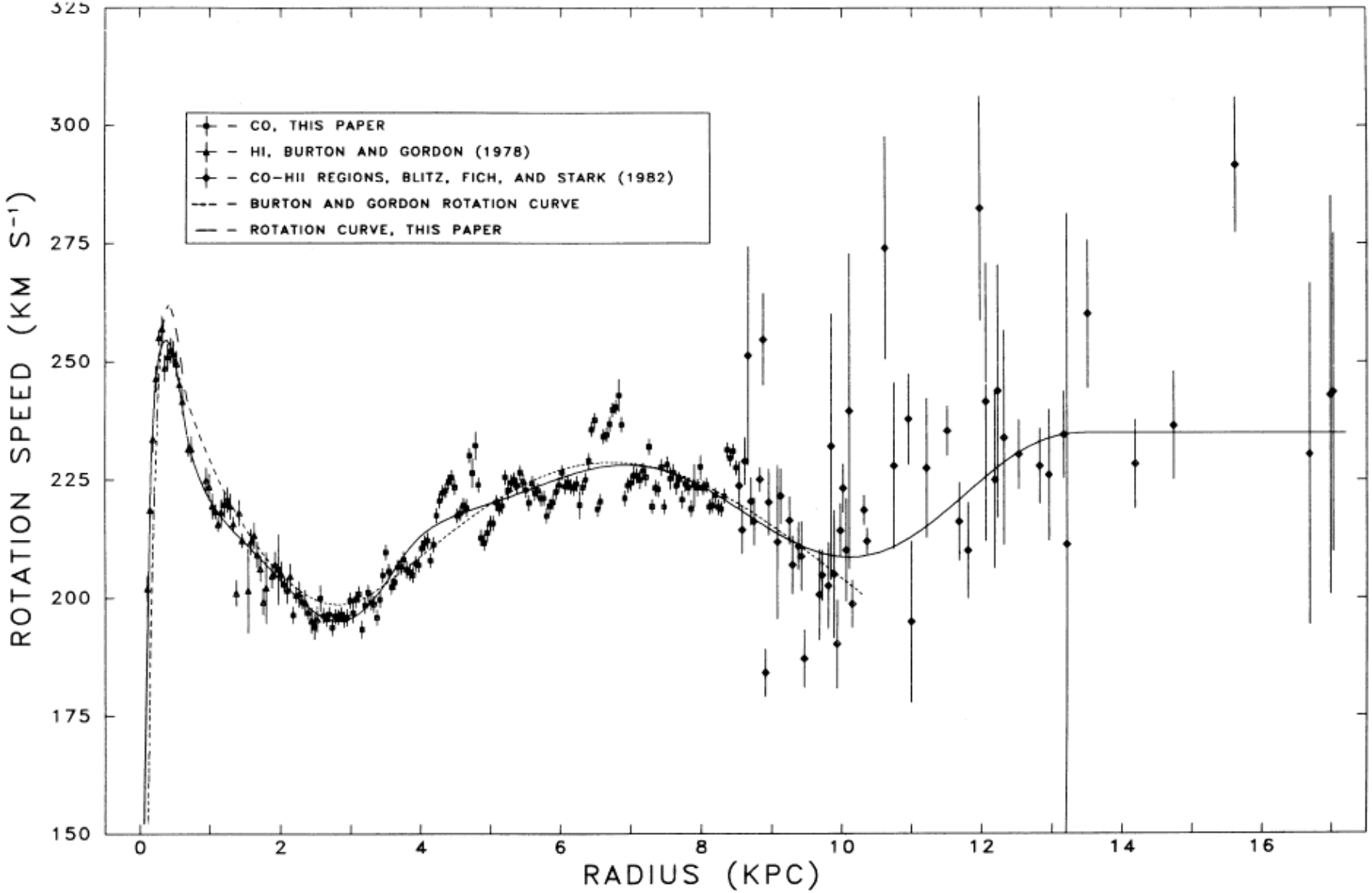


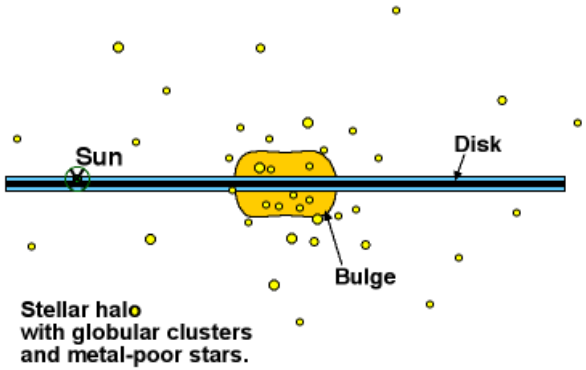

Sagittarius A
Sagittarius A*

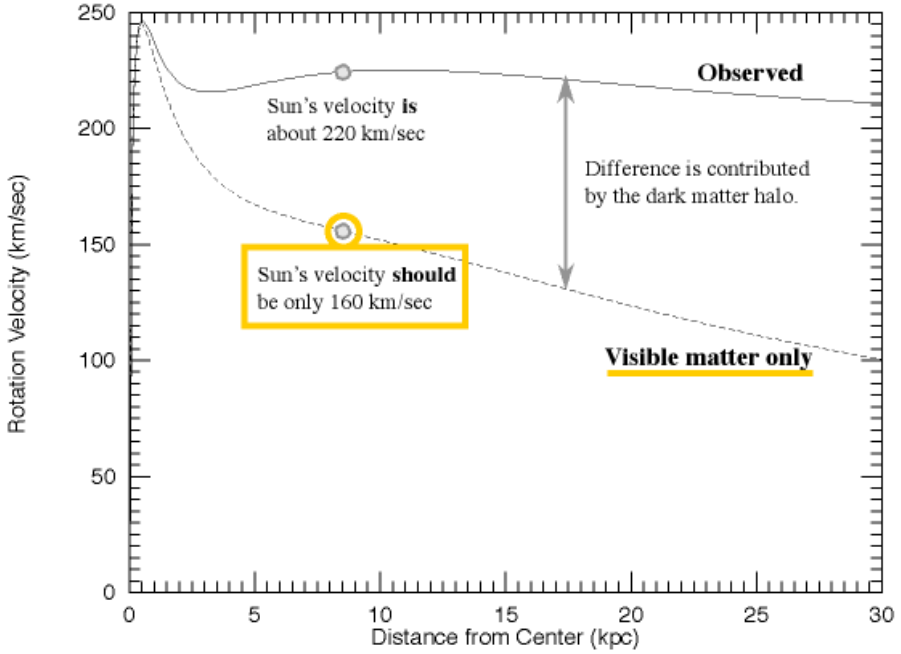

Enclosed mass ($M_\odot$)
10^7
10^6
10^5
2.9×10^6 $M_\odot$
4×10^{12} $M_\odot$ pc^{-3}
4×10^6 $M_\odot$ pc^{-3}
0.01
0.1
1
10
Distance from Sgr A* (pc)


1995.50
S0-8
S0-16
S0-2
S0-26
S0-3
S0-1
0".1
S0-19
S0-23
S0-4
S0-17
S0-20
S0-5
S0-6
Keck/UCLA Galactic
Center Group

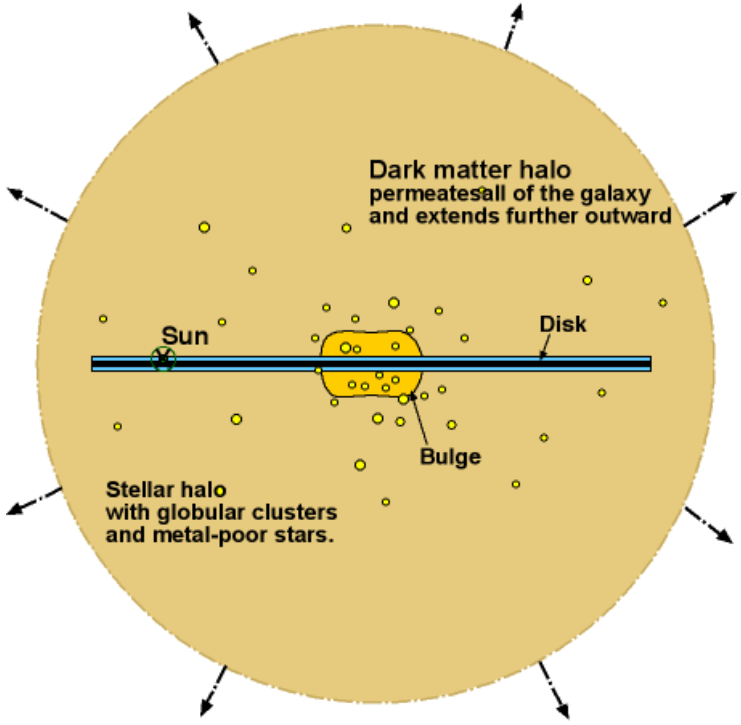
So-16... 90 a.e.

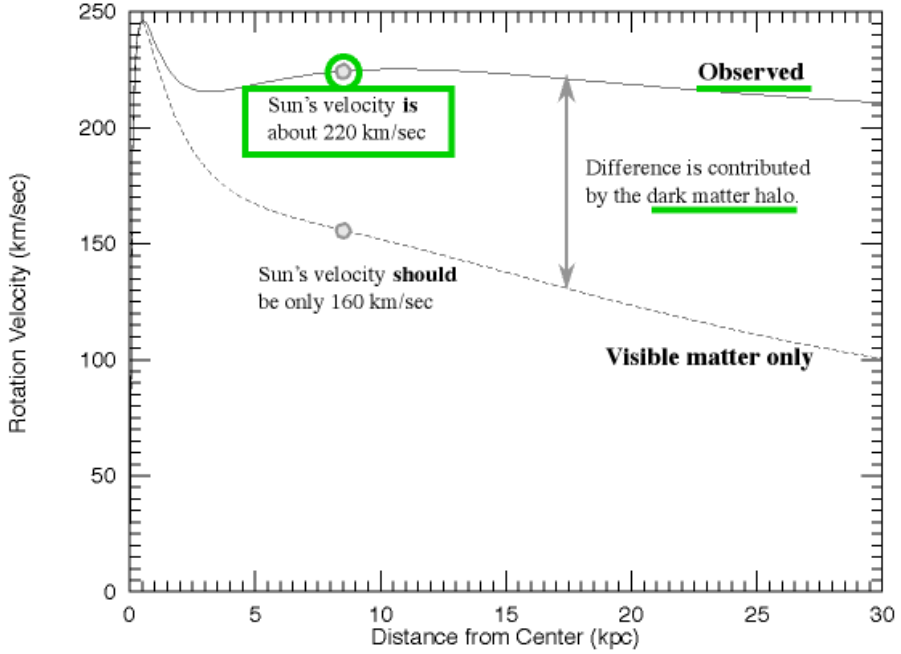

CO, THIS PAPER
HI, BURTON AND GORDON (1978)
CO–HII REGIONS, BLITZ, FICH, AND STARK (1982)
BURTON AND GORDON ROTATION CURVE
ROTATION CURVE, THIS PAPER
ROTATION SPEED (KM S⁻¹)
RADIUS (KPC)
325
300
275
250
225
200
175
150
0
2
4
6
8
10
12
14
16



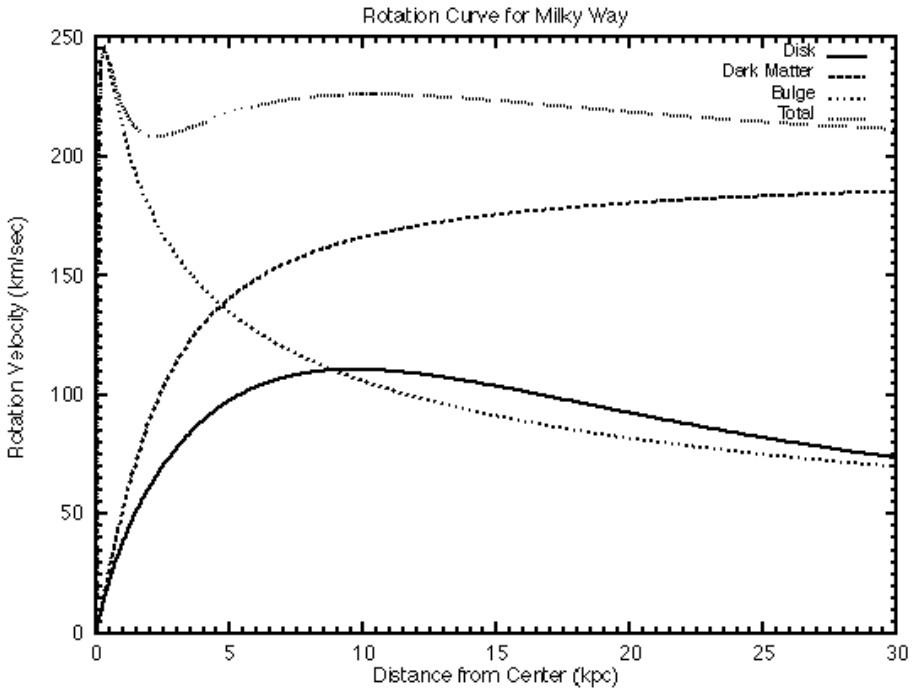


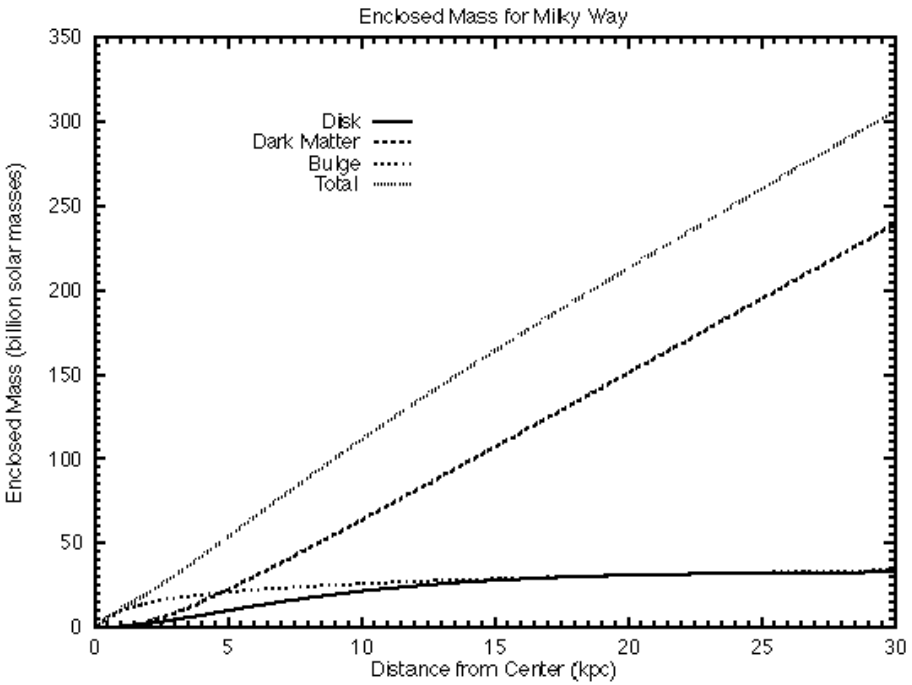
Rotation curve shows that there is "extra" gravity.



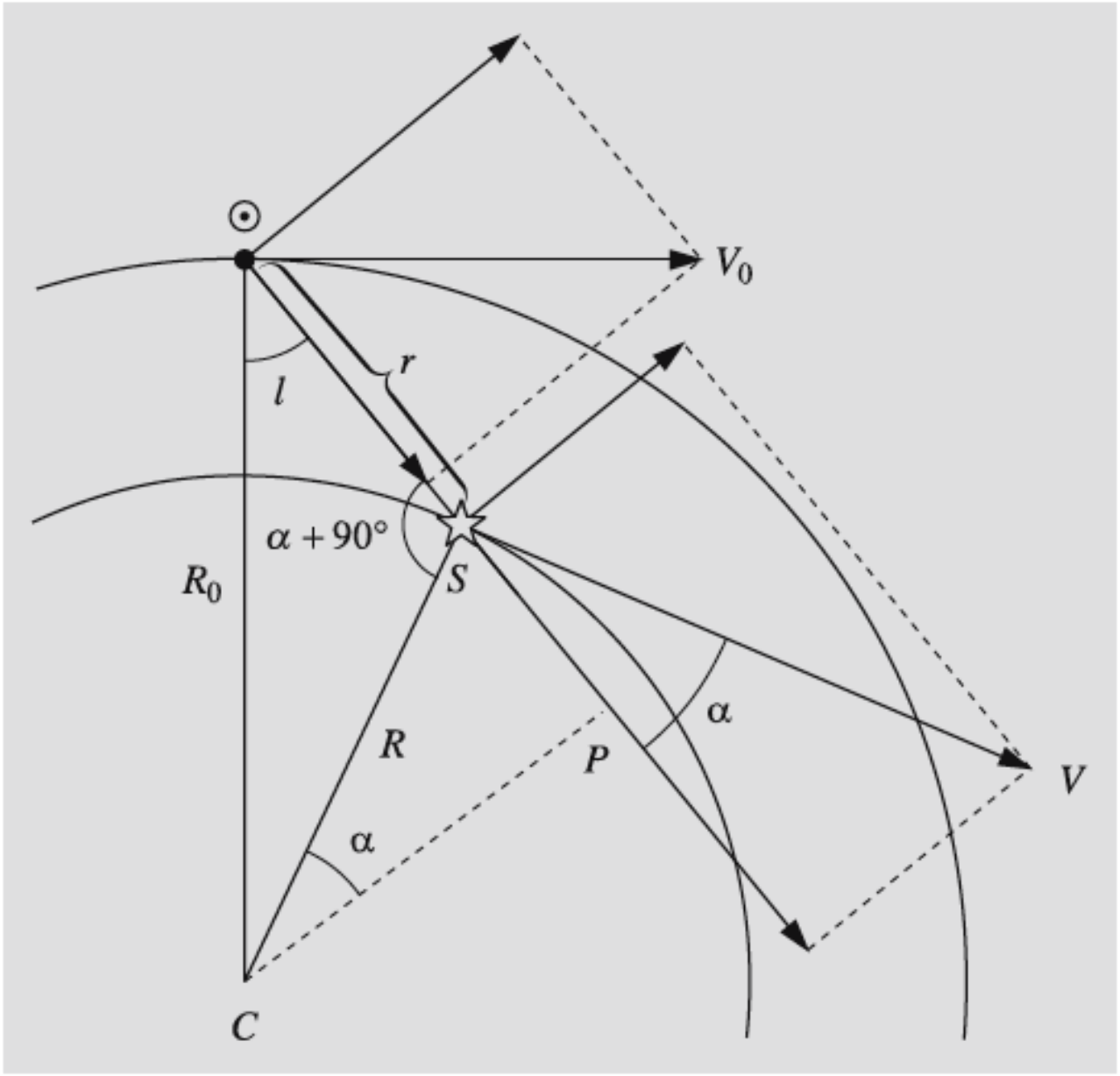


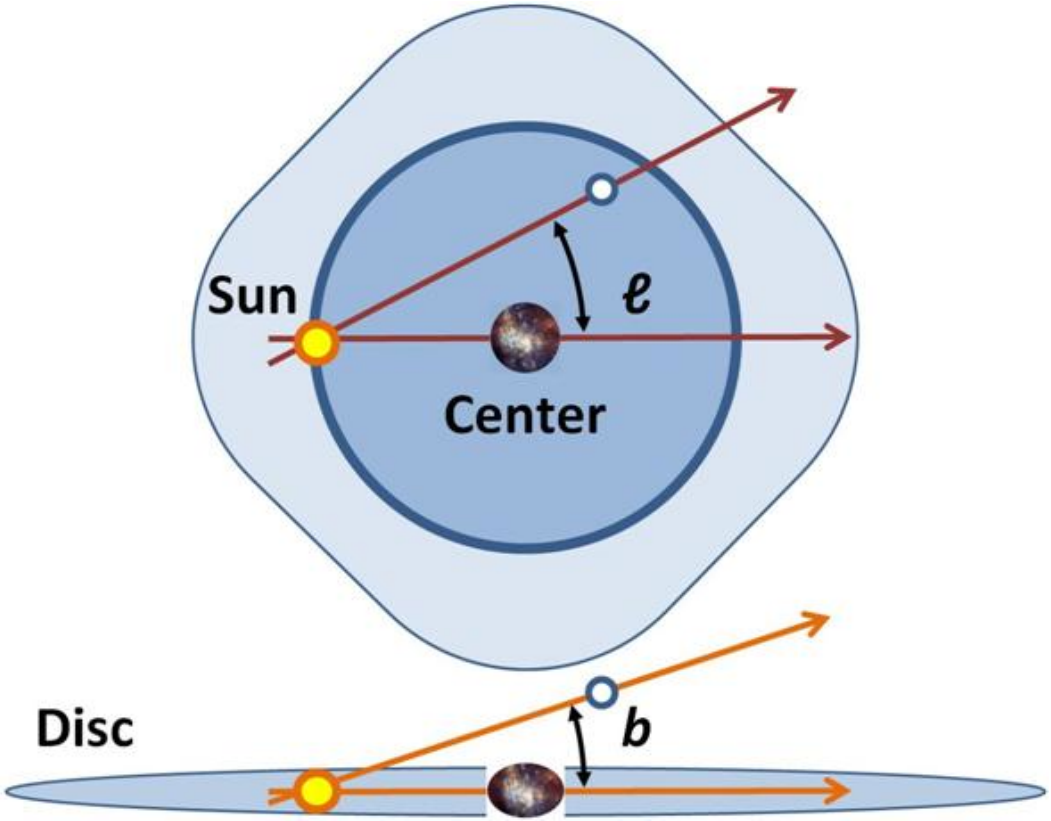
The gravity of the visible matter in the Galaxy is not enough to explain the high orbital speeds of stars in the Galaxy. For example, the Sun is moving about 60 km/sec too fast. The part of the rotation curve contributed by the visible matter only is the bottom curve.

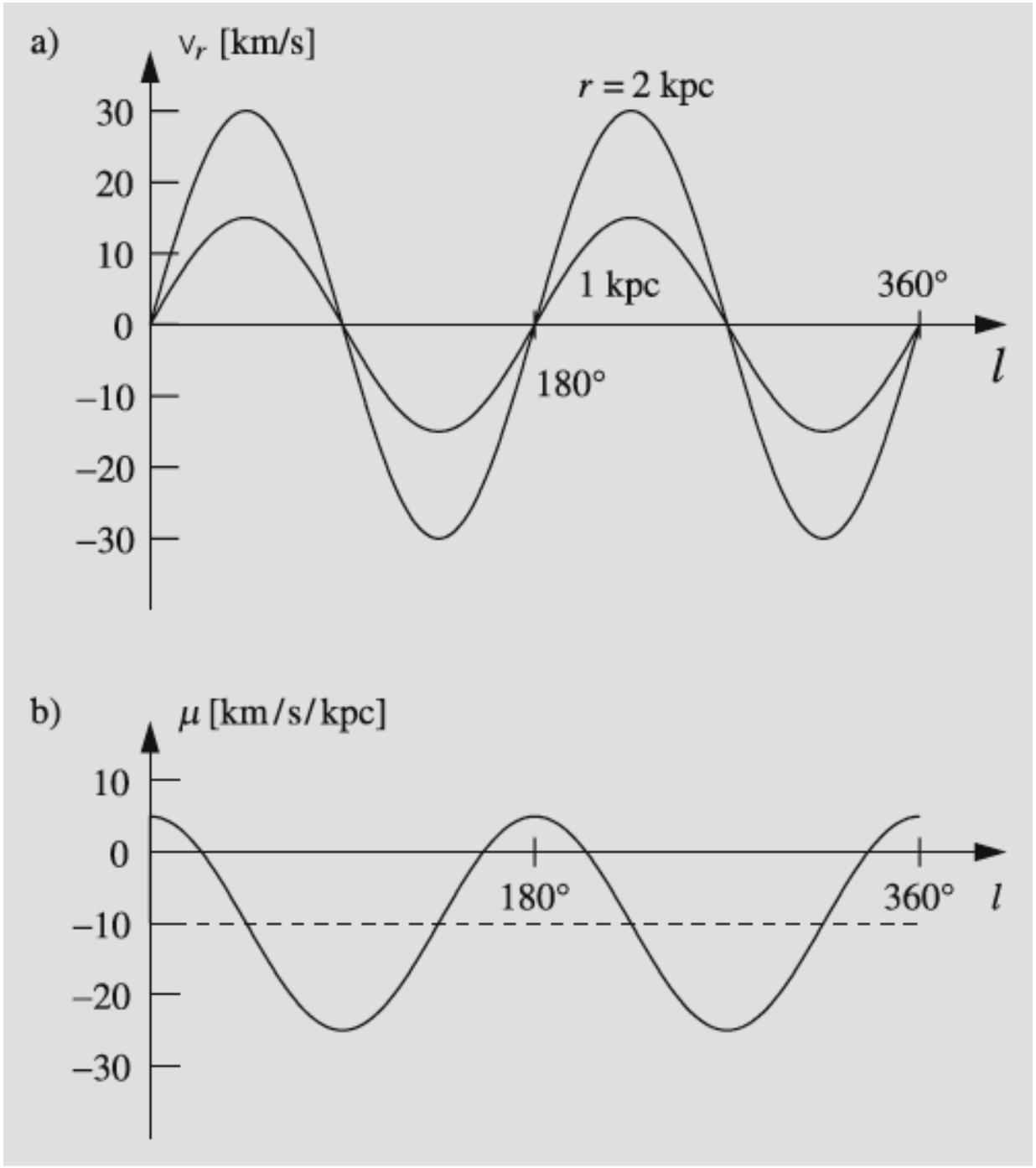

Rotation Curve for Milky Way
Rotation Velocity (km/sec)
Distance from Center (kpc)
Disk
Dark Matter
Bulge
Total
0
50
100
150
200
250
0
5
10
15
20
25
30

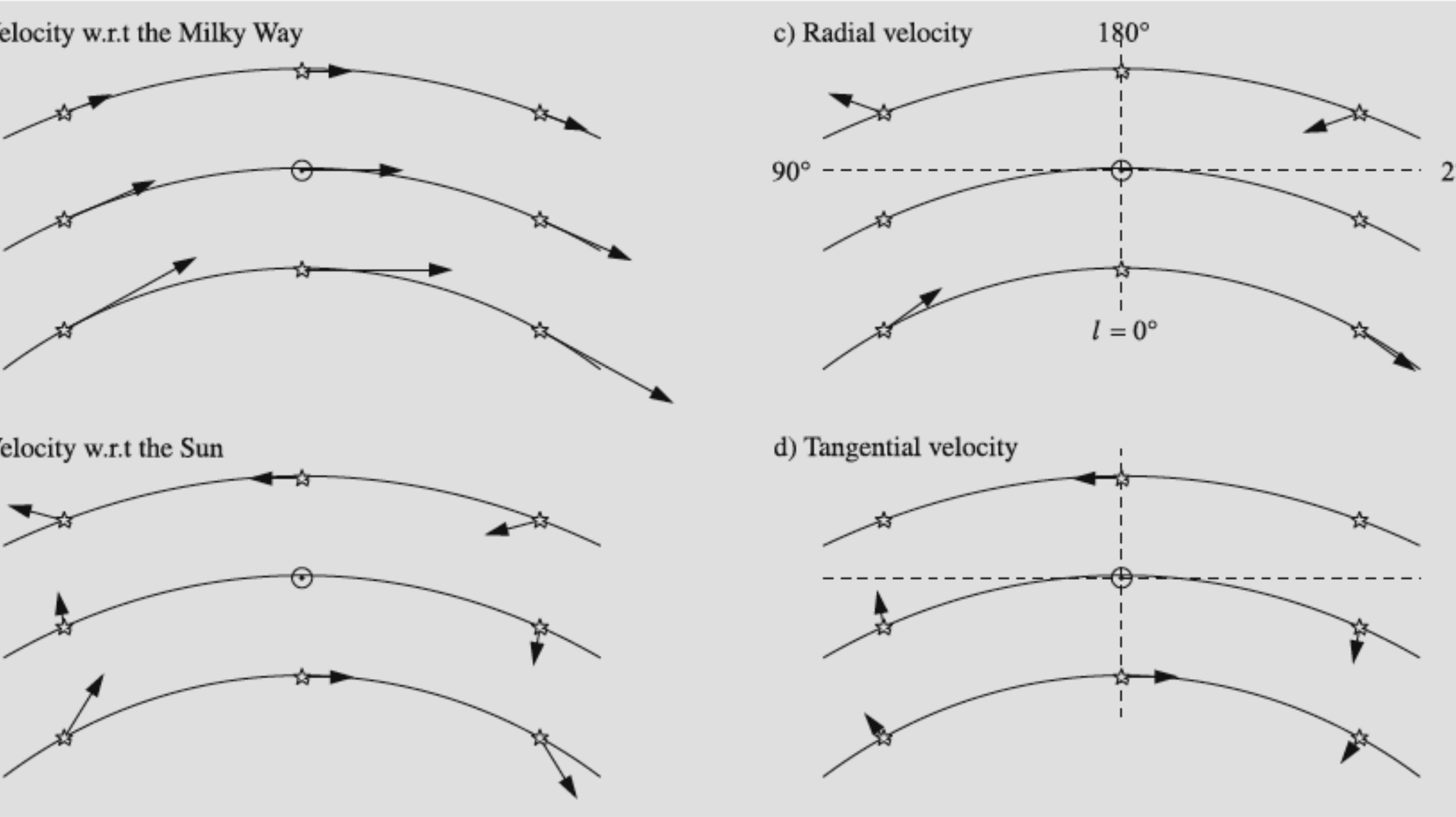

Enclosed Mass for Milky Way
Enclosed Mass (billion solar masses)
Distance from Center (kpc)
Disk
Dark Matter
Bulge
Total
0
50
100
150
200
250
300
350
0
5
10
15
20
25
30

Oortove konstante

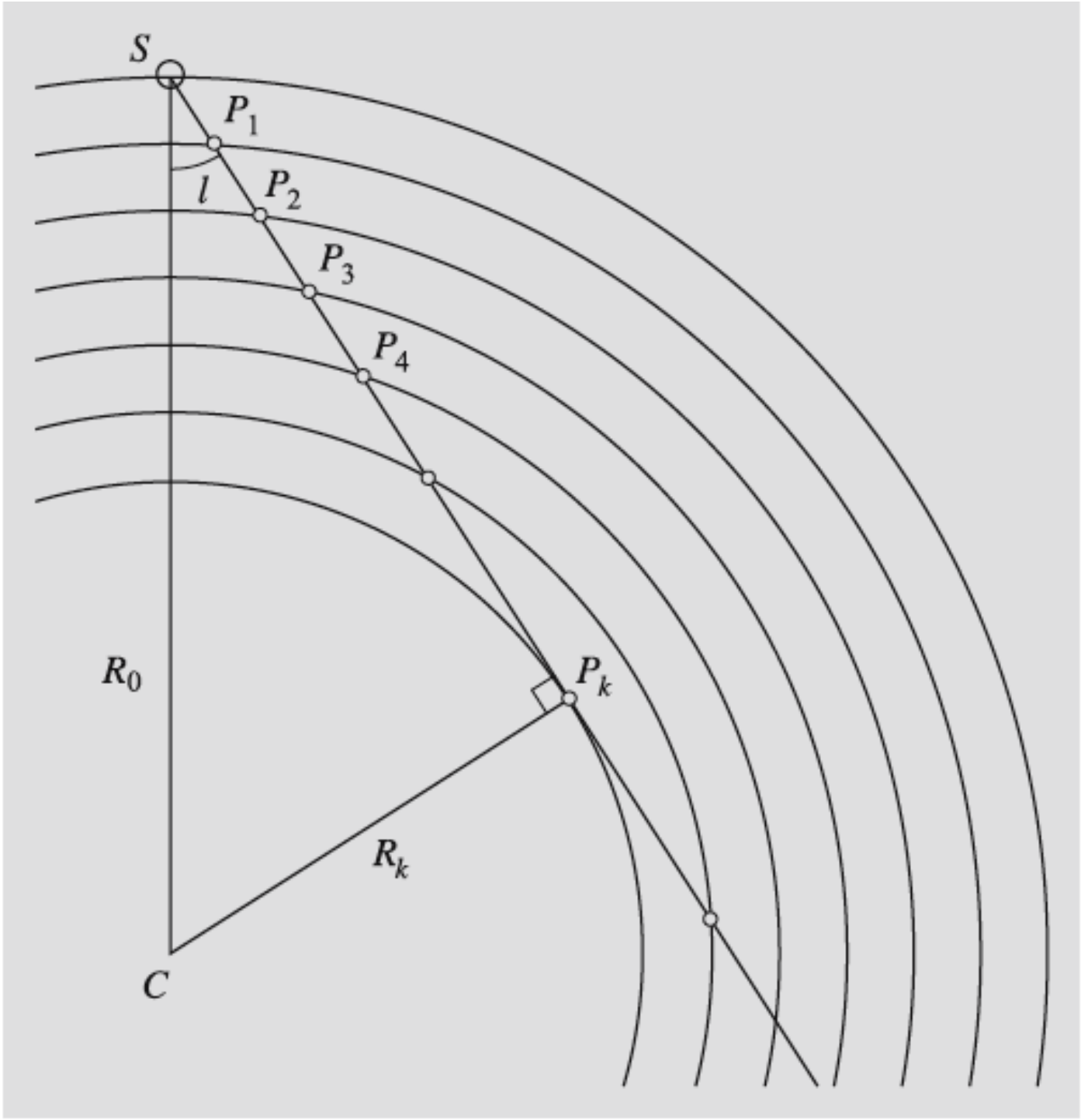


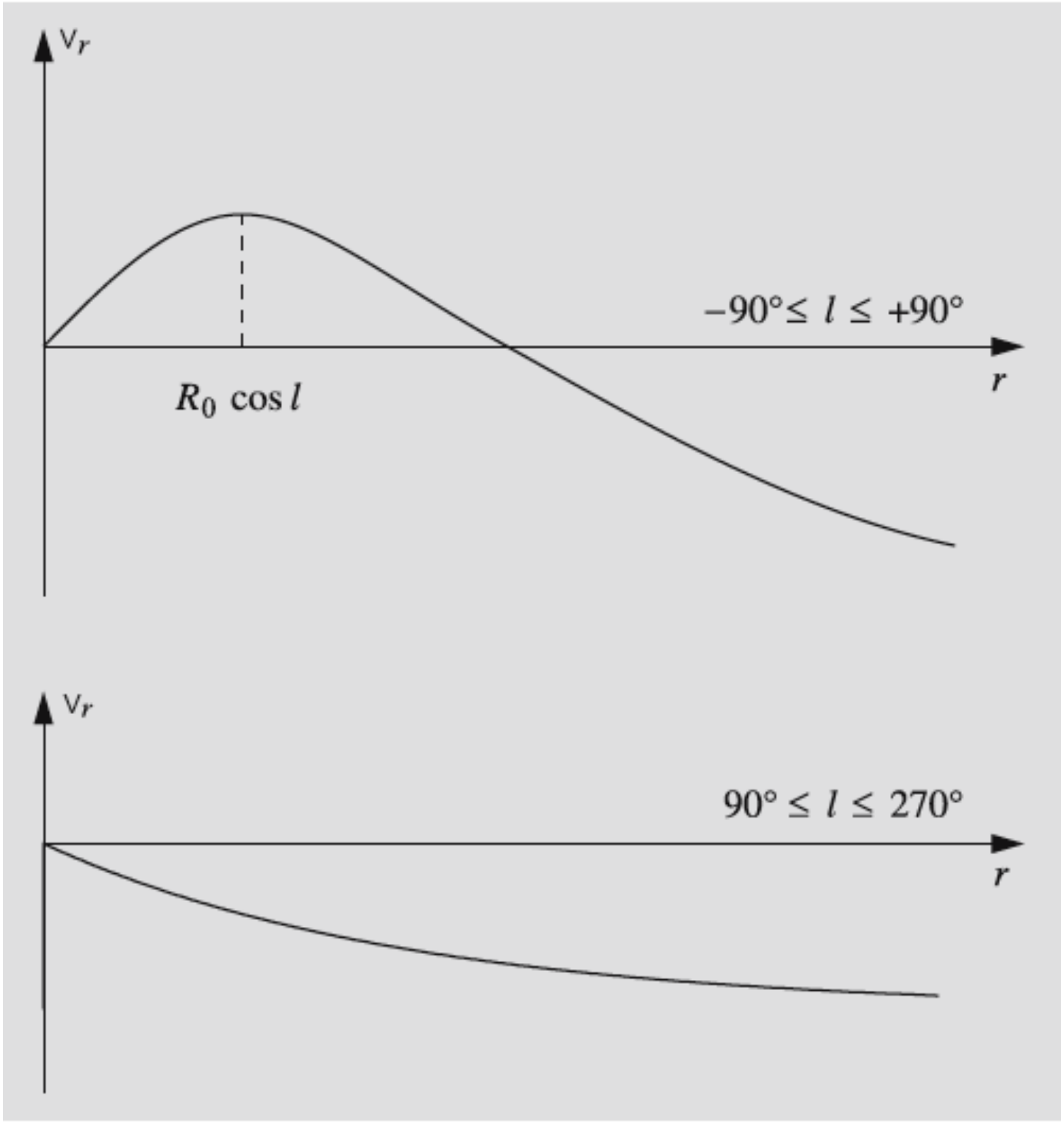

Sun
ℓ
Center
Disc
b


a)
v_r [km/s]
30
20
10
0
–10
–20
–30
$r = 2$ kpc
1 kpc
360°
180°
l
b)
μ [km/s/kpc]
10
0
–10
–20
–30
180°
360°
l



7.13a–d. The effect of differential rotation on the radial ities and proper motions of stars. (**a**) Near the Sun the l velocities of stars decrease outwards in the Galaxy. he relative velocity with respect to the Sun is obtained by subtracting the solar velocity from the velocity vectors in (**c**) The radial components of the velocities with respect t Sun. This component vanishes for stars on the same orb the Sun. (**d**) The tangential components of the velocities


S
P1
l
P2
P3
P4
R0
Pk
Rk
C


V_r
$-90° \leq l \leq +90°$
r
$R_0 \cos l$
V_r
$90° \leq l \leq 270°$
r

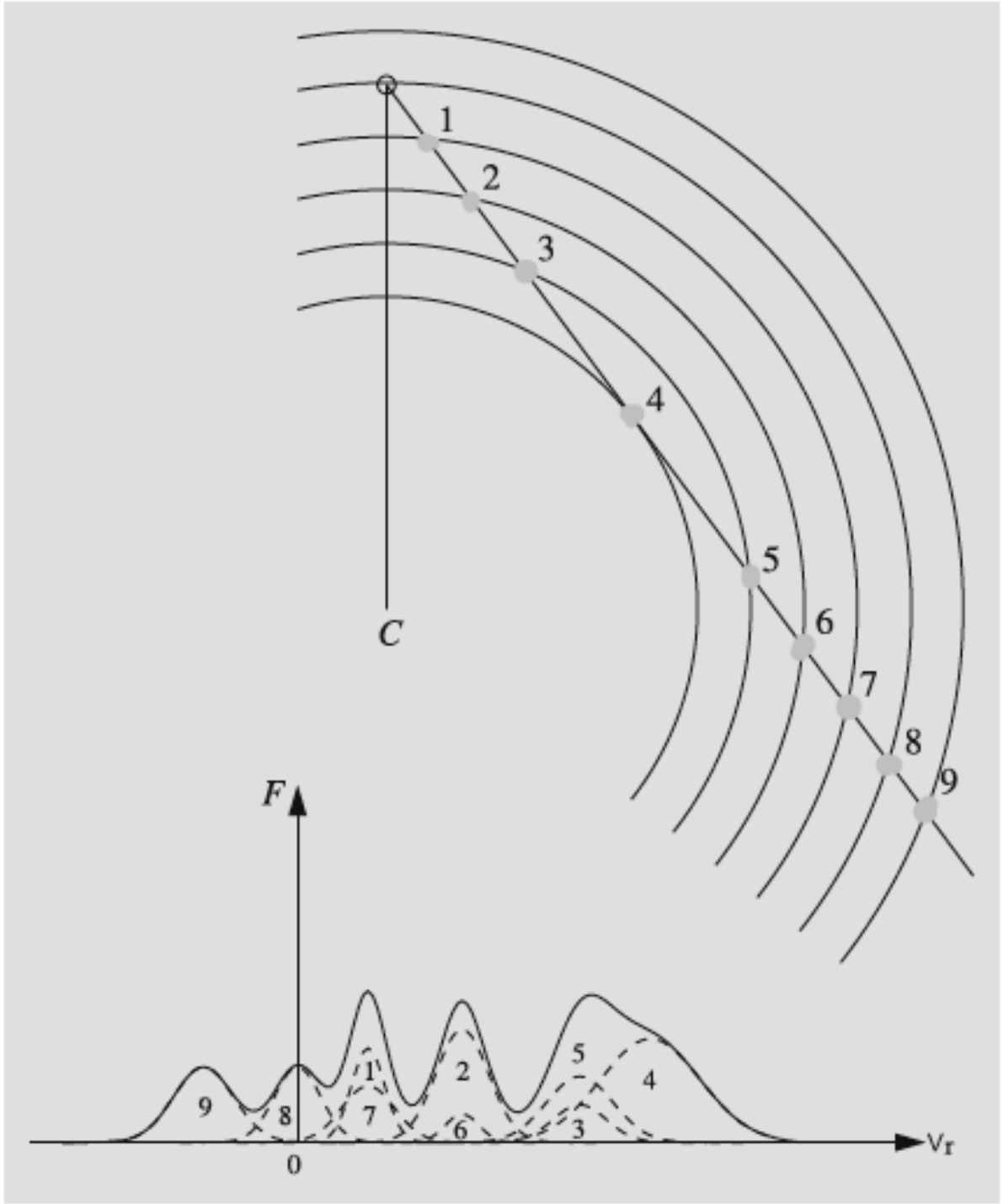
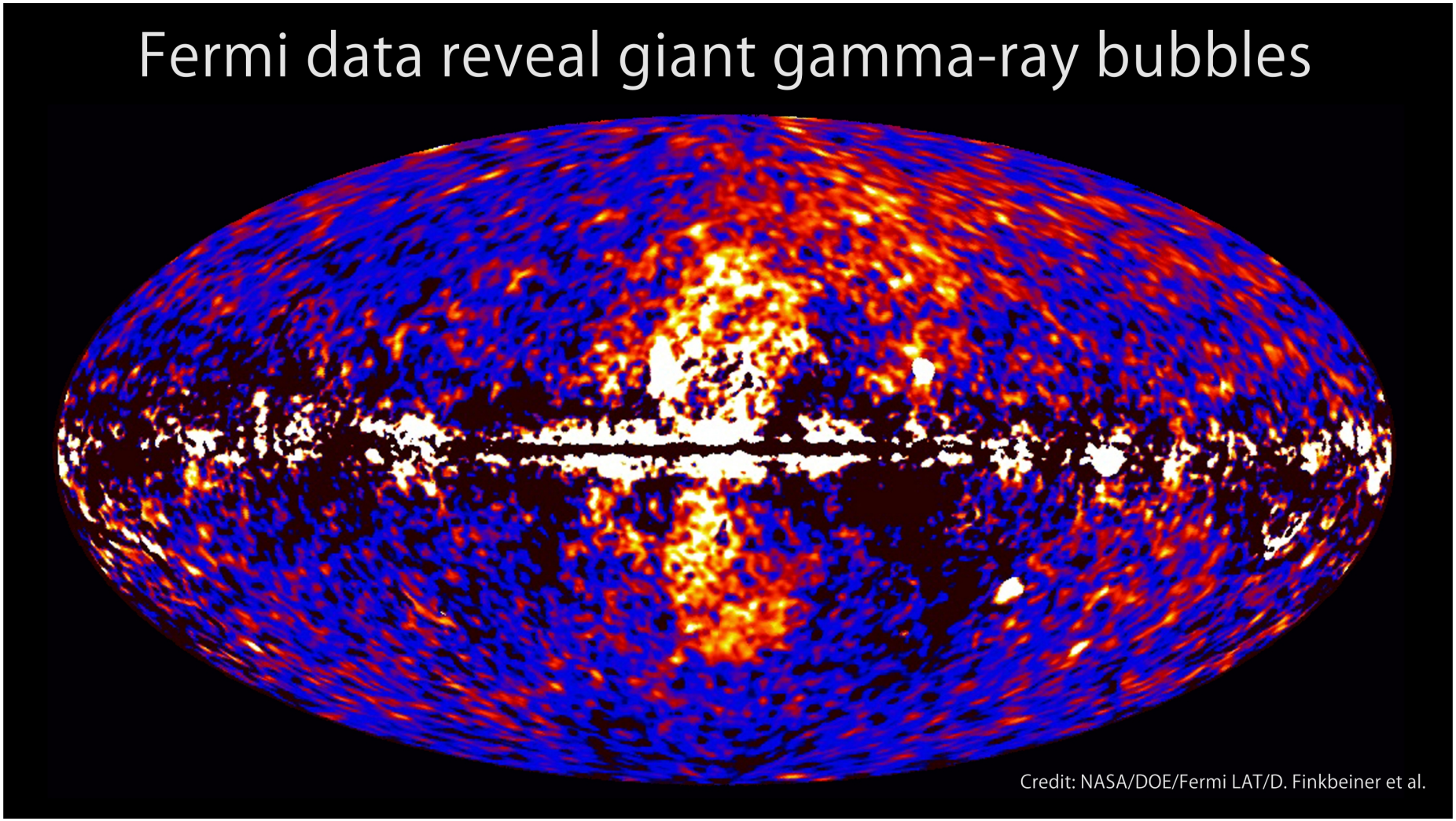


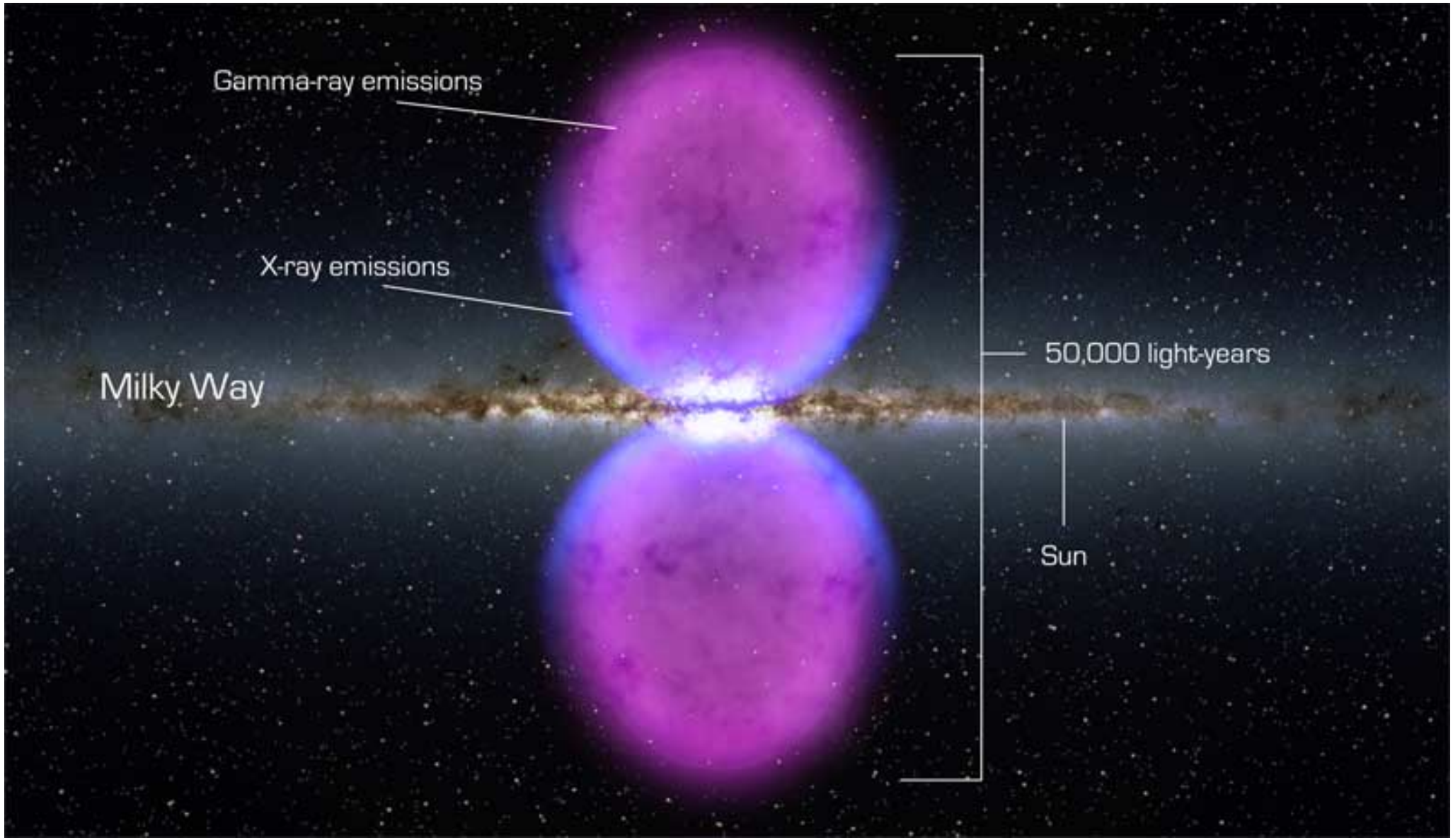
Fig. 17.18. Clouds at different distances have different velocities and therefore give rise to emission lines with different

Fermi data reveal giant gamma-ray bubbles



Credit: NASA/DOE/Fermi LAT/D. Finkbeiner et al.

gamma ray bubbles



Nastanek in razvoj Galaksije

- opazovanja -> zavrtimo čas nazaj.... do neke mere
- teoretični modeli – vrtimo čas naprej, primerjamo z opazovanji

upoštevati:
- ISM v zvezde : kozmično recikliranje
- vpliv vidne in temne snovi na plin, nastanek zvezd...
- nastanek struktur v zgodnjem vesolju

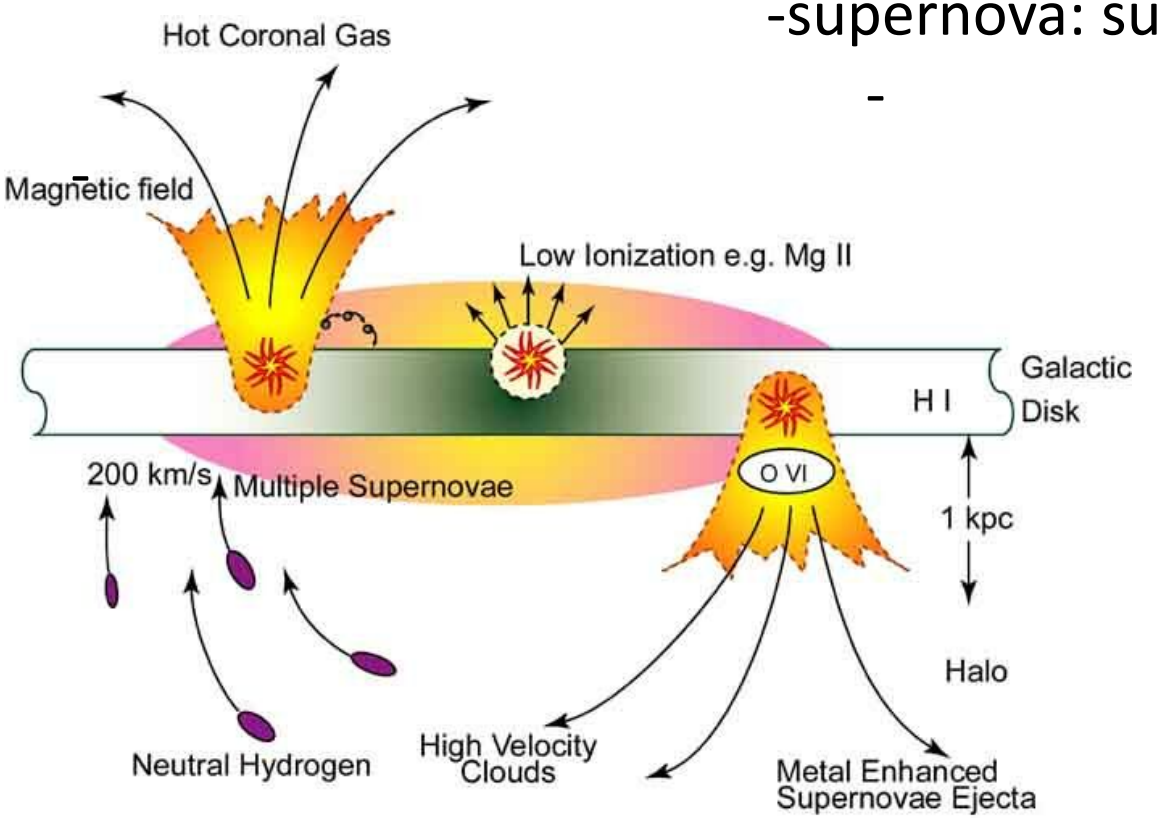
ISM

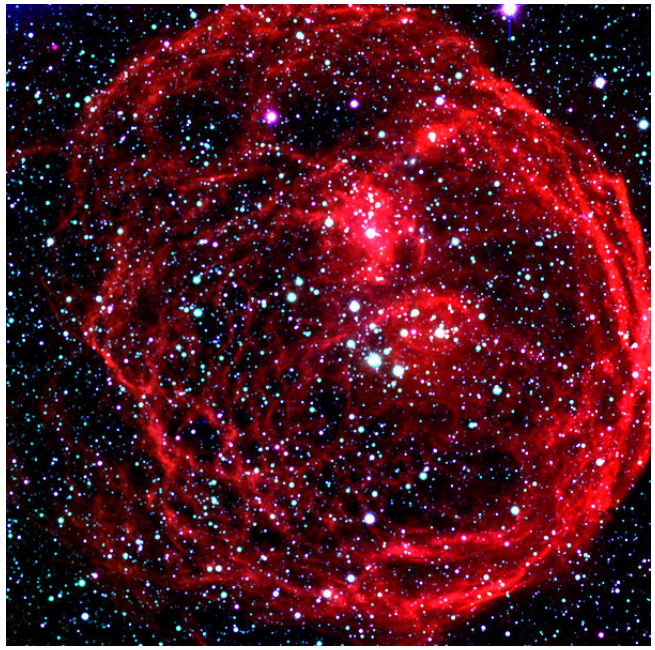
- iz ISM v zvezde
- del v bele pritlikavke, nevtrosnke zvezde, črne luknje
- kozmično recikliranje: Z,

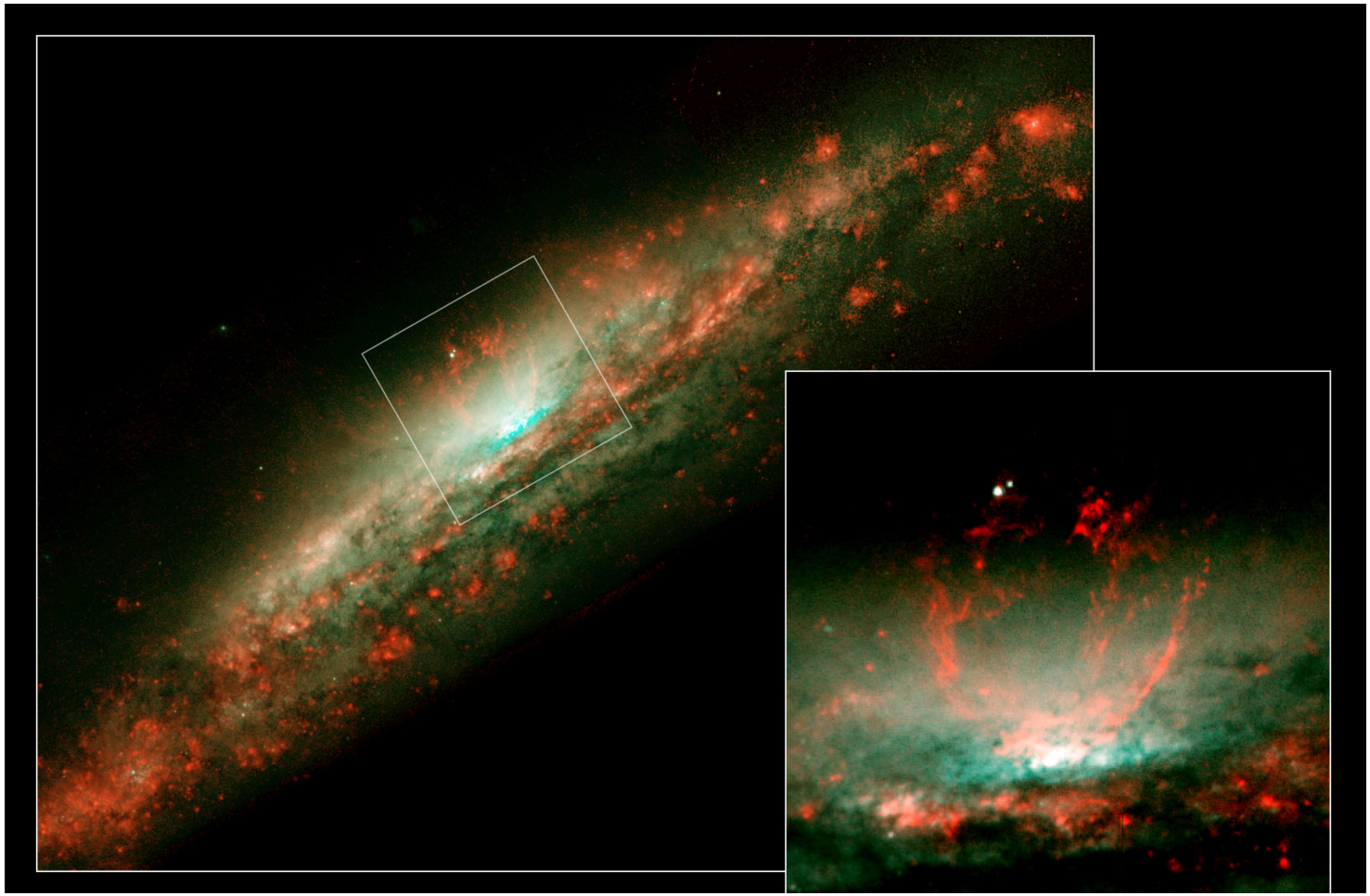
-obogatenje ISM: zvezdni veter, planetarna meglica,

-supernova: supermehurček,

- galaktična fontana







Galaksija NGC 3079
Hubble Space Telescope

-IGM
-v ISM: 0.4-3M_S na leto: intergalactic medum < 1.4 M_S
-iz ISM: 3-10M_S v nove zvezde
- doslej 2% mase
- Z okrog 10^{-9}, zdaj do 0.04

-relacija med starostjo in kovinskostjo zvezde
(izjema zvezde v odebelitvi)
-porazdelitev zvezd: debel in tanek disk, halo

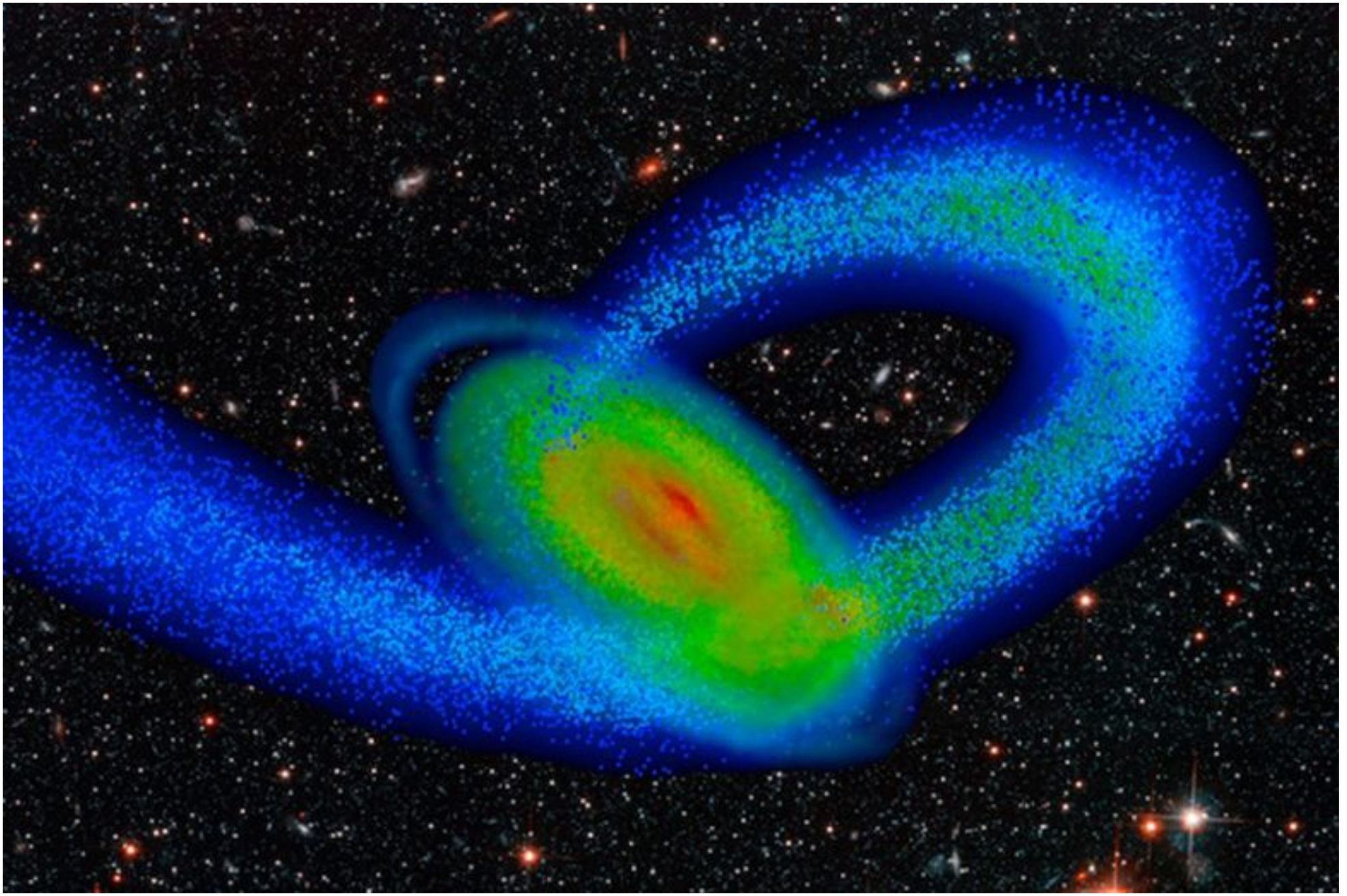
Kako je Galaksija nastala in se razvijala?

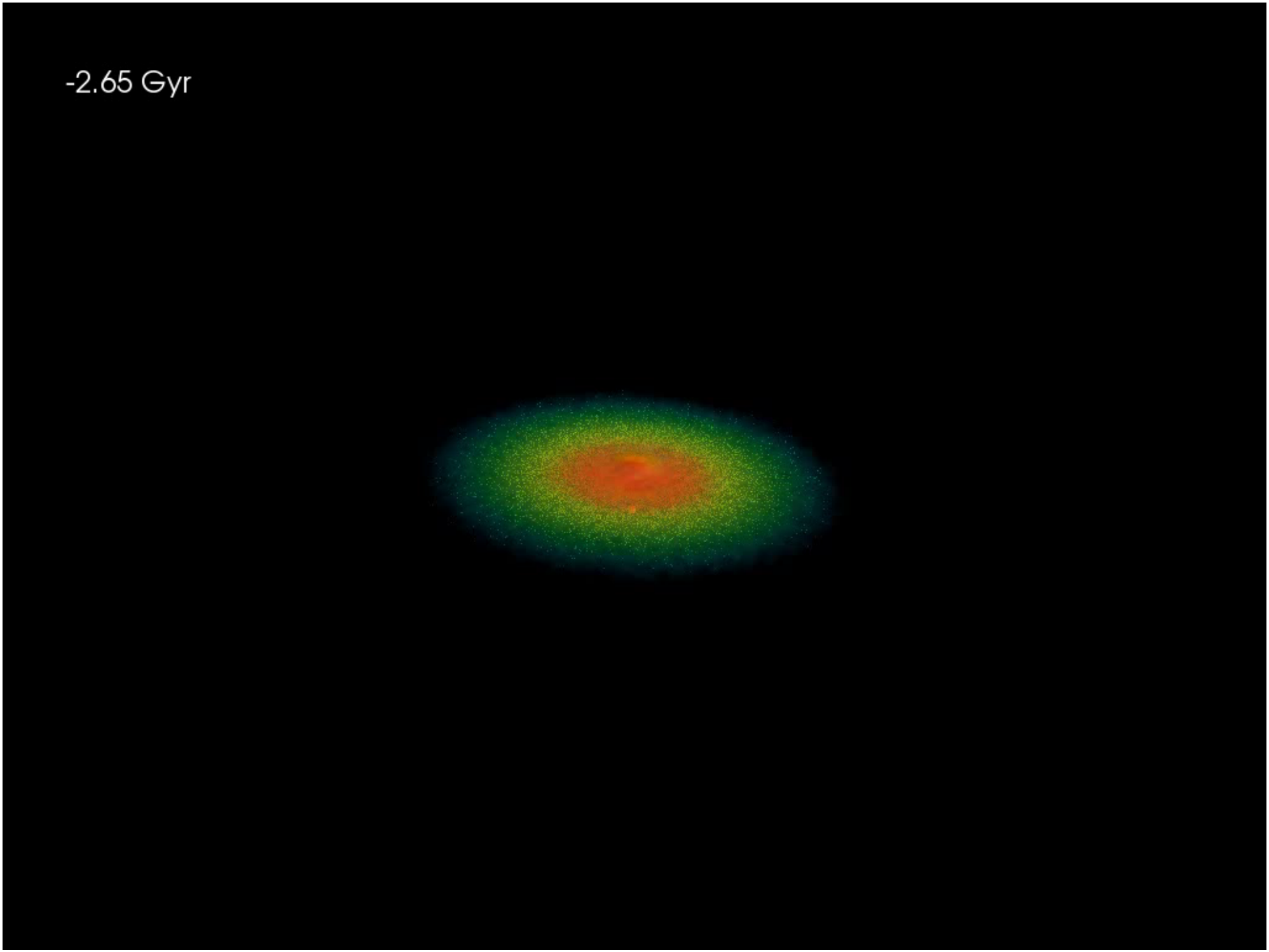
He

- zvezde v Galaksiji:

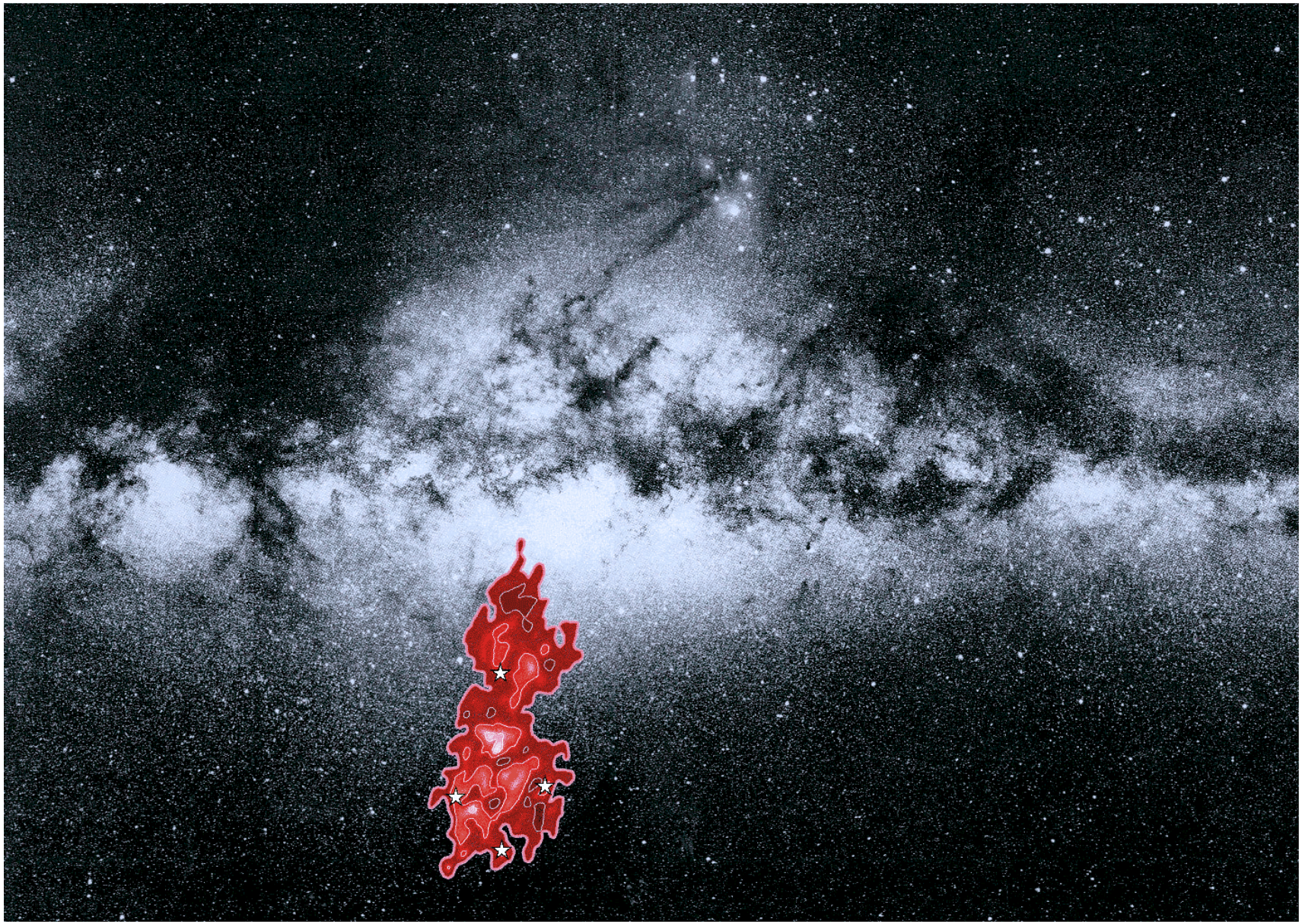
  $L_{Galaksije} = 2x10^{10}\ L_s$, $M_{Galaksije} = 10^{11}\ M_S$
- 10 Glet, $L_s=3.8x10^{26}$ J/s $\Longrightarrow$ $2.4x10^{54}$ J
- pri fuziji H$\rightarrow$He: Δm=0.7% m
- ves H: $1.3x10^{56}$ J
- $2.4x10^{54}$ J/ $1.3x10^{56}$ J = 2% << 25% helija !

Zvezde ne proizvedejo opažene količine helija!

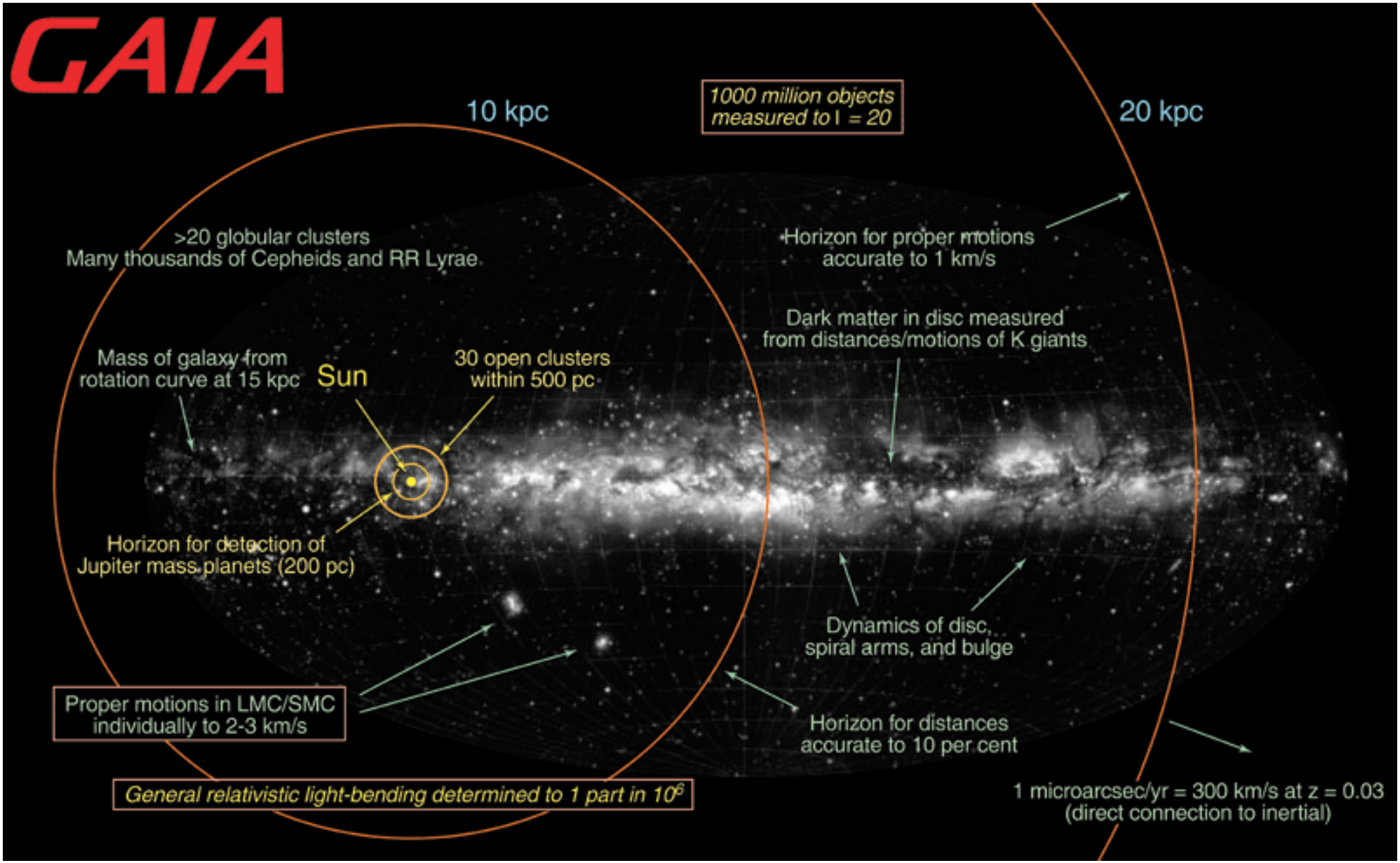



-2.65 Gyr

prišleki - pritlikava galaksija v Strelcu



satelit Gaia – jeseni 2013


GAIA
10 kpc
1000 million objects measured to I = 20
20 kpc
>20 globular clusters
Many thousands of Cepheids and RR Lyrae
Horizon for proper motions accurate to 1 km/s
Dark matter in disc measured from distances/motions of K giants
Mass of galaxy from rotation curve at 15 kpc
Sun
30 open clusters within 500 pc
Horizon for detection of Jupiter mass planets (200 pc)
Dynamics of disc, spiral arms, and bulge
Proper motions in LMC/SMC individually to 2-3 km/s
Horizon for distances accurate to 10 per cent
General relativistic light-bending determined to 1 part in 10^6
1 microarcsec/yr = 300 km/s at z = 0.03
(direct connection to inertial)

napredek v astrometriji