Universidad Nacional de Río Negro
Int. Partículas, Astrofísica & Cosmología - 2016

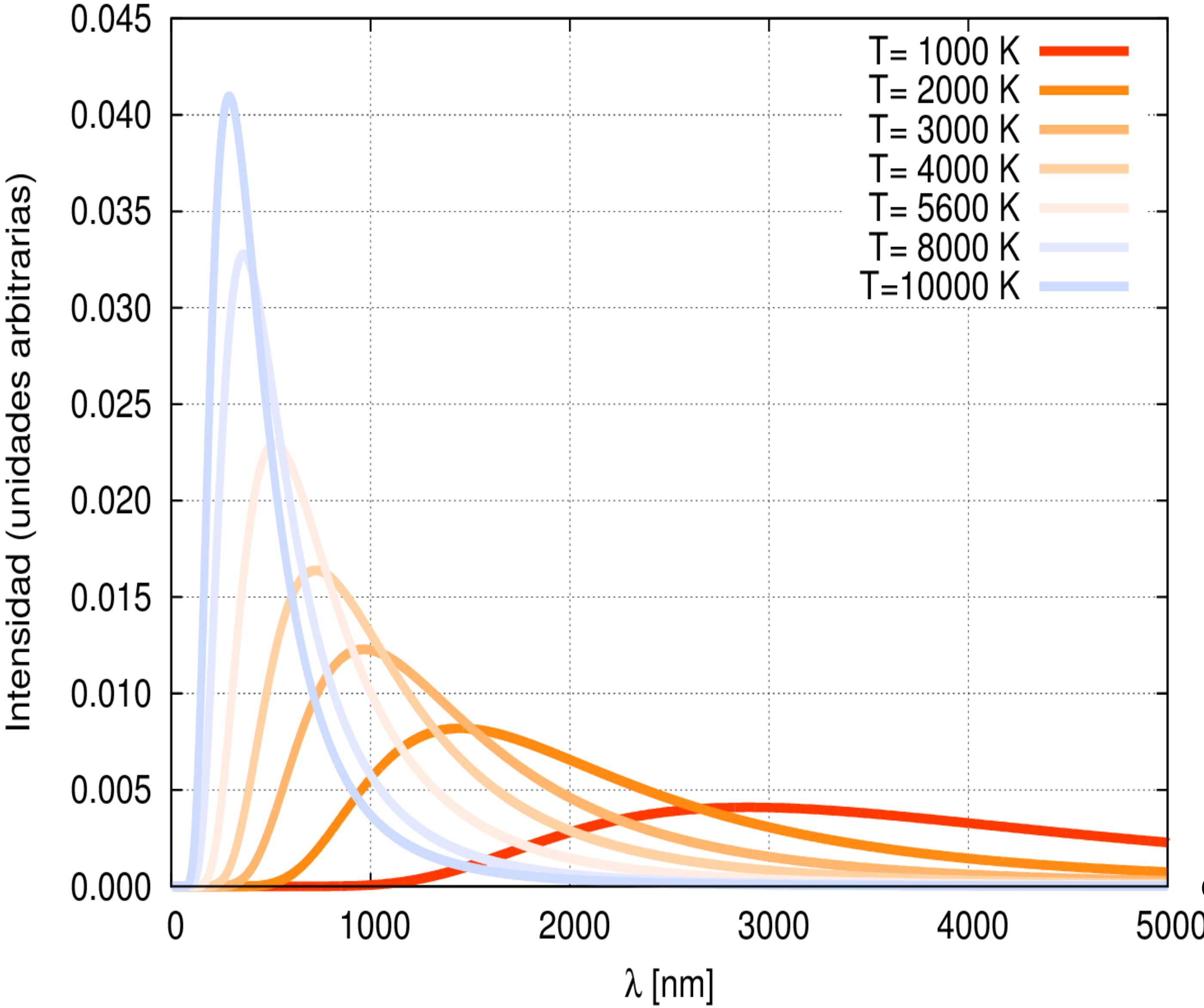
- **Unidad** 02 – Astrofísica
- **Clase** 0204 – 09/16
- **Fecha** 13 Oct 2016
- **Cont** Galaxias
- **Cátedra** Asorey
- **Web** github.com/asoreyh/unrn-ipac
- **Youtube** próximamente
- **Archivo** a-2016-U02-C04-1013-galaxias

Contenidos: un viaje en el tiempo

Temas de monografía para trabajo final algunas ideas, lista no excluyente

- Cosmogonía de los pueblos originarios (elegir alguno)
- Cosmogonía y Constelaciones
- Evolución estelar (vida y obra de las estrellas)
- Objetos compactos (enanas blancas, estrellas de neutrones, agujeros negros)
- Ensayo sobre posibilidades de vida en Europa (luna de Júpiter)
- Vida basada en Amoníaco como disolvente
- El Galaxyzoo: principales resultados
- Otras Tierras: exoplanetas similares a la Tierra
- El impacto de Galileo Galilei en la concepción moderna de la Astronomía
- Spirit, Opportunity y Curiosity: explorando la superficie de Marte
- La sonda Cassini-Huygens: Saturno y Titán
- El Big Bang

¿Qué ruido hace un fotón al caer?



- Ley de Wien
  - Posición de λ_{max}

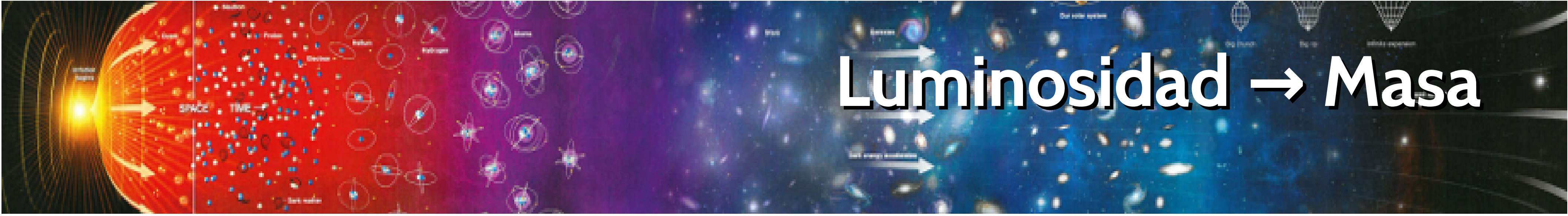
$$\lambda_{max} = \frac{b}{T}$$

$$b = 2.9\, mm\, K$$

- Ley de Stefan-Boltzmann

$$L \equiv \frac{\Delta E}{\Delta t} = \sigma A T^4$$

$$\sigma = 5.67 \times 10^{-8}\, W\, m^{-2}\, K^{-4}$$



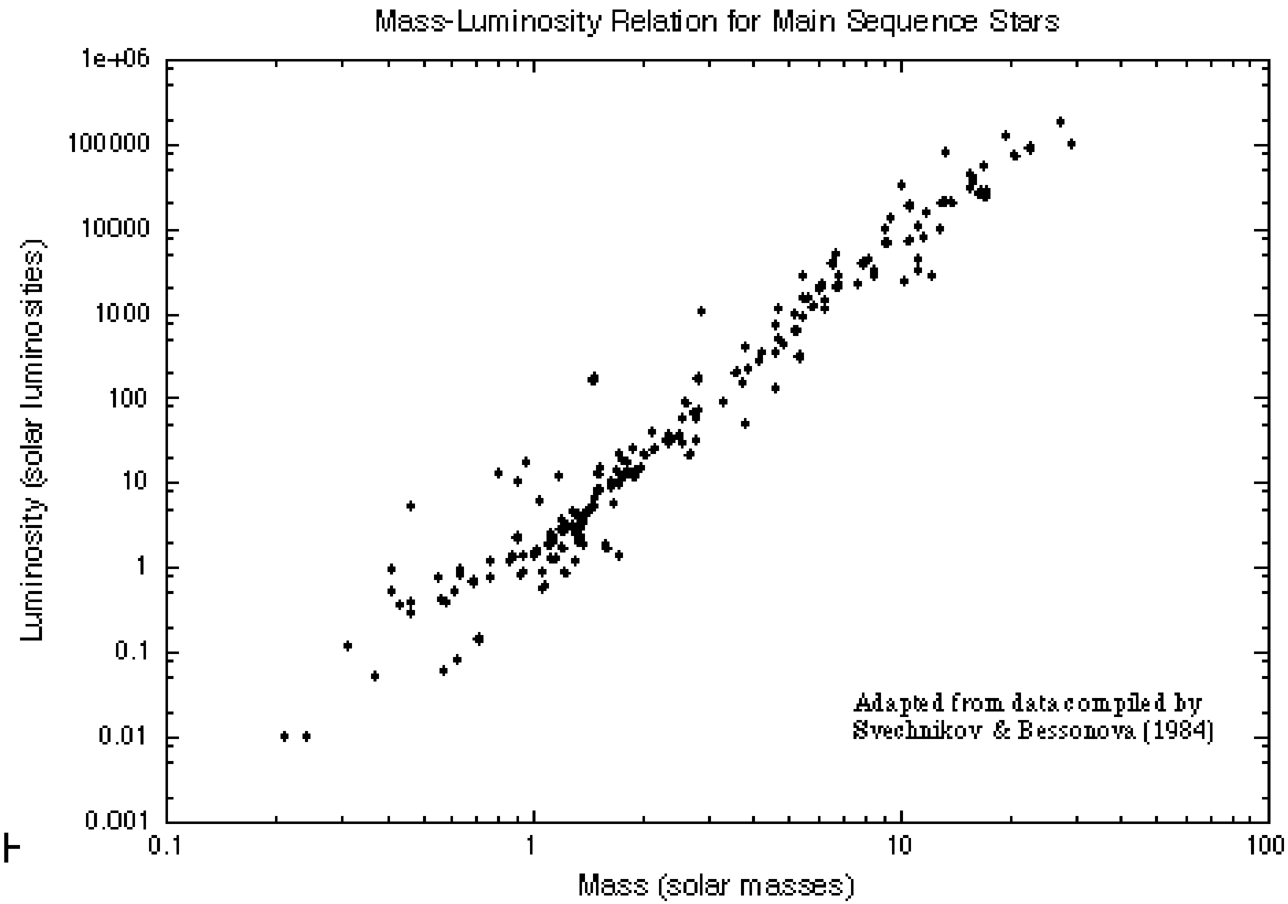
Luminosidad → Masa

- **Si: (0.1 < Masa Estelar < 50) masas solares:**

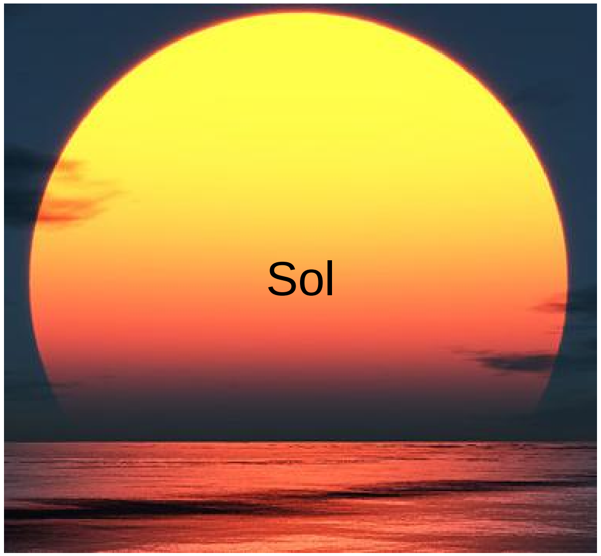
  L es proporcional a la M^4

- Nota: En general, M^a , con **a** entre 3 y 4 (~ masa)

$$\left(\frac{L_{Estrella}}{L_{Sol}}\right) = \left(\frac{M_{Estrella}}{M_{Sol}}\right)^4$$



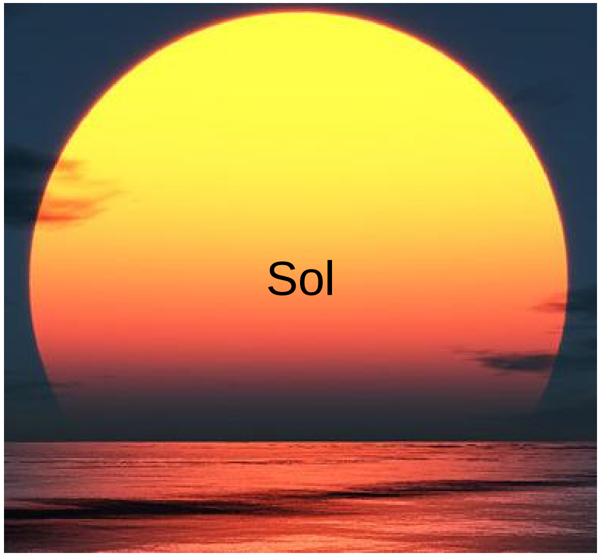
Y: (Luminosidad, Temperatura) → Radio



- T = 5700 K (Amarilla)
- $L = L_S$

- T = 3400 K (Roja)
- $L = 135000\ L_S$

Y: (Luminosidad, Temperatura) → Radio



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- $L = L_S$

Menor temperatura, menos emisión
Pero, la emisión es mucho mayor

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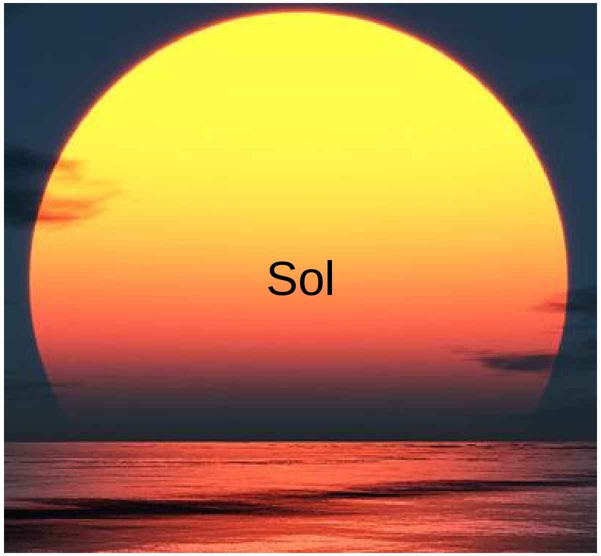

- T = 5700 K (Amarilla)
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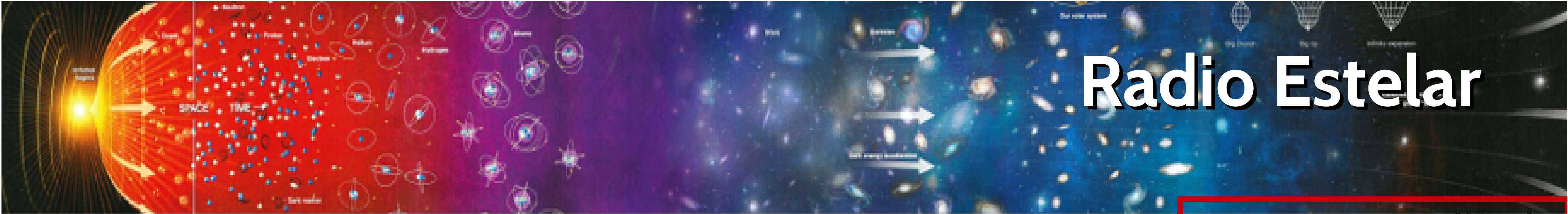
- L = 135000 L_S

Menor temperatura, menos emisión
Pero, la emisión es mucho mayor

→

Betelgeuse debe ser mucho más grande que el Sol

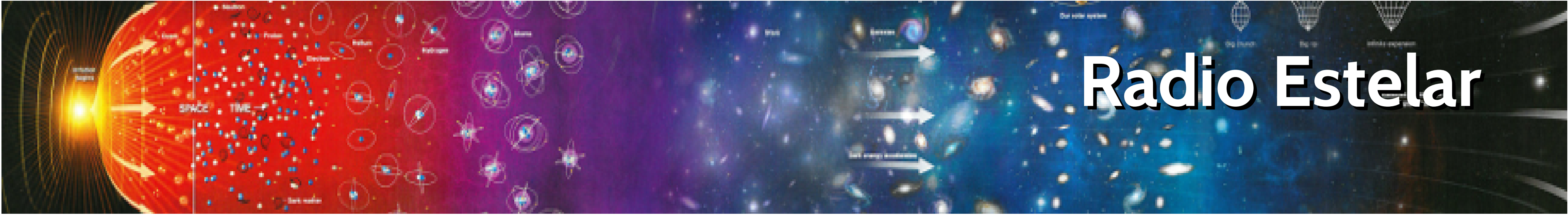


Radio Estelar

$$\boxed{L = 4\pi\sigma R^2 T^4}$$

- Comparando las temperaturas

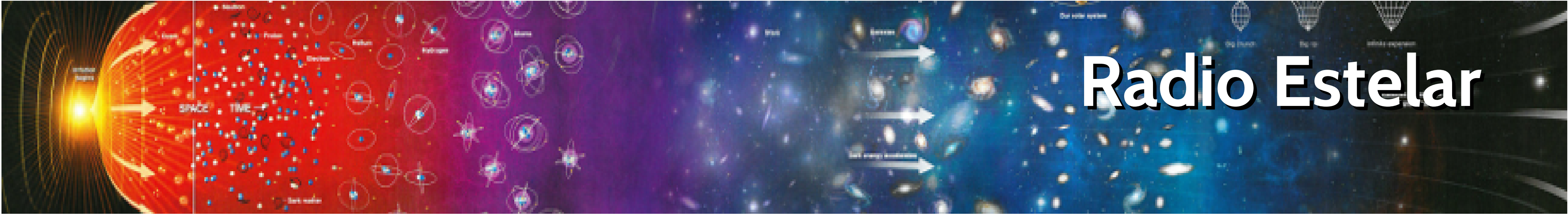
- ¡Pero también depende del radio!



Radio Estelar

- Veamos.... $(T_B/T_S)^4$
  - $(3400 / 5700)^4 \sim= 1/7.8$
  - Si dependiera sólo de T, el Sol sería 7.8 veces más luminoso que Betelguese
- Pero...

$$L_B / L_S = [(4\pi R_B^2)\, \sigma\, T_B^4]/[(4\pi R_S^2)\, \sigma\, T_S^4]$$
$$135000 = (R_B/R_S)^2\, (T_B/T_S)^4$$
$$135000 = (R_B/R_S)^2/7.8$$
$$1.053\text{x}10^6 = (R_B/R_S)^2$$



Radio Estelar

- Veamos.... $(T_B/T_S)^4$

R_B = 1026 R_{Sol}

Betelgeuse es una supergigante roja

más luminoso que Betelguese

- Pero...

$$L_B / L_S = [(4\pi R_B^2)\,\sigma\, T_B^4]/[(4\pi R_S^2)\,\sigma\, T_S^4]$$

$$135000 = (R_B/R_S)^2\,(T_B/T_S)^4$$

$$135000 = (R_B/R_S)^2/7.8$$

$$1.053\times10^6 = (R_B/R_S)^2$$

Es cómodo medir las cosas en términos solares

- Masa Solar:

$$M_{Sol}=1.989\times10^{30}\,\mathrm{kg}\simeq1000\,M_{Júpiter}\simeq333000\,M_{Tierra}$$

- Radio Solar:

$$R_{Sol}=6.96\times10^{8}\,\mathrm{m}=696000\,\mathrm{km}\simeq110\,R_{Tierra}$$

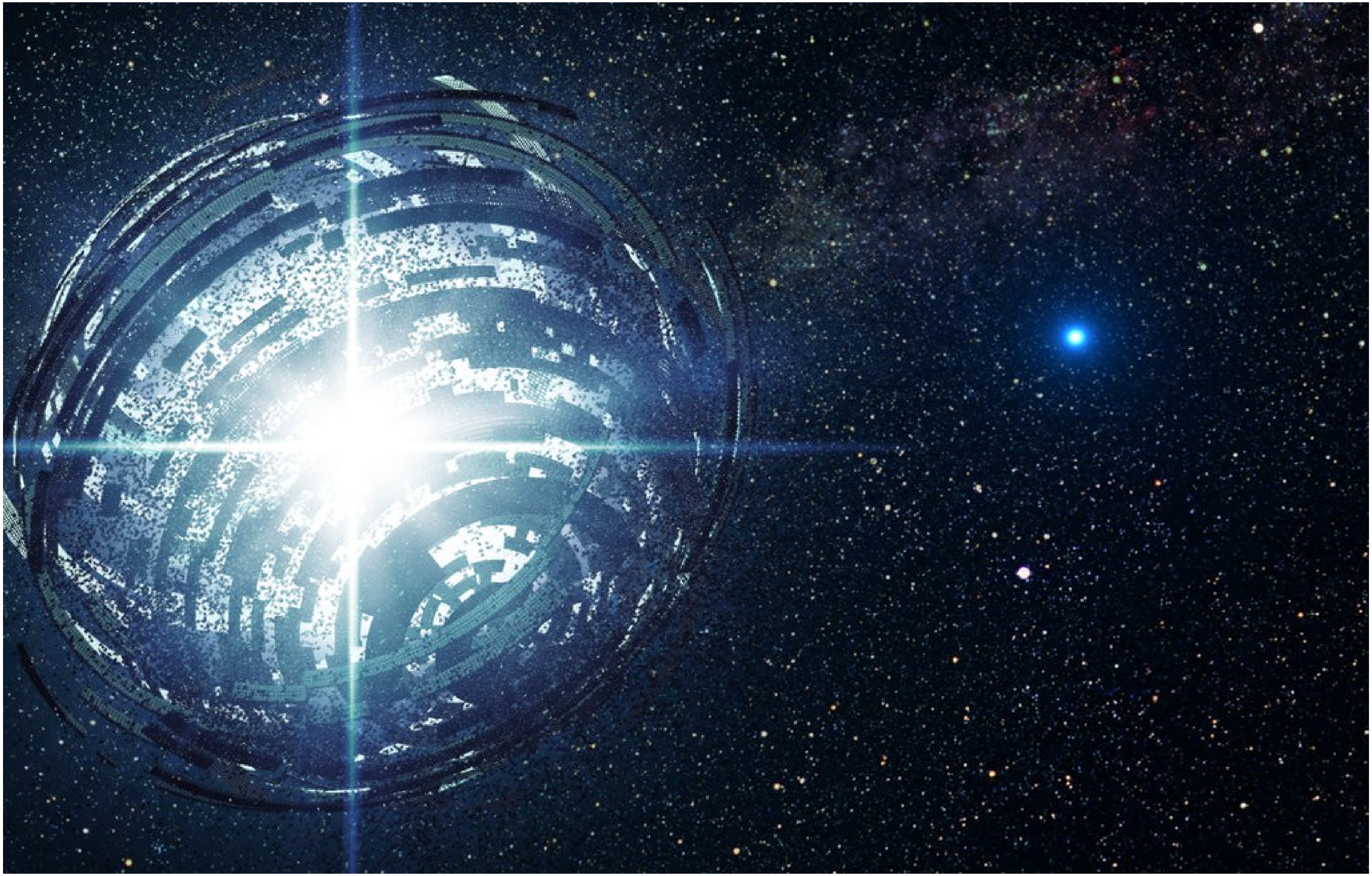
- Luminosidad Solar:

$$L_{Sol}=3.83\times10^{26}\,\mathrm{W}$$

- Alto:

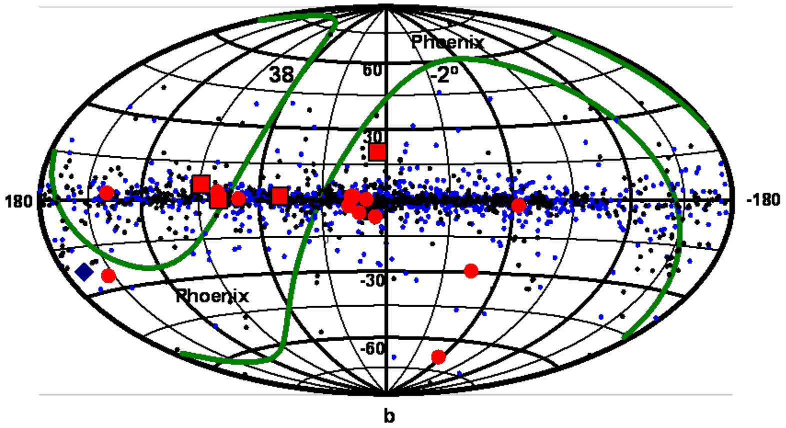
1 segundo de energía liberada en el Sol equivale a 800000 años de consumo humano (2013)

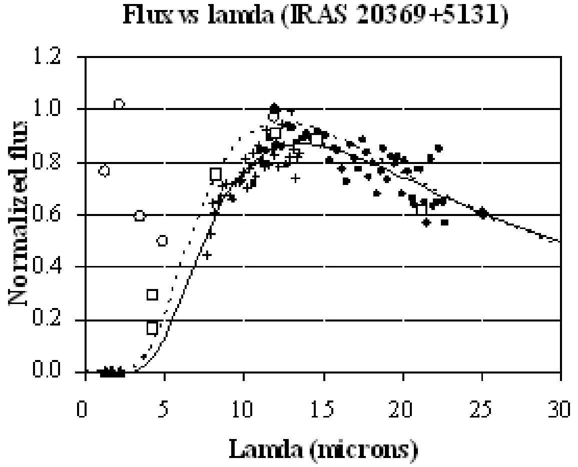
Esferas de Dyson

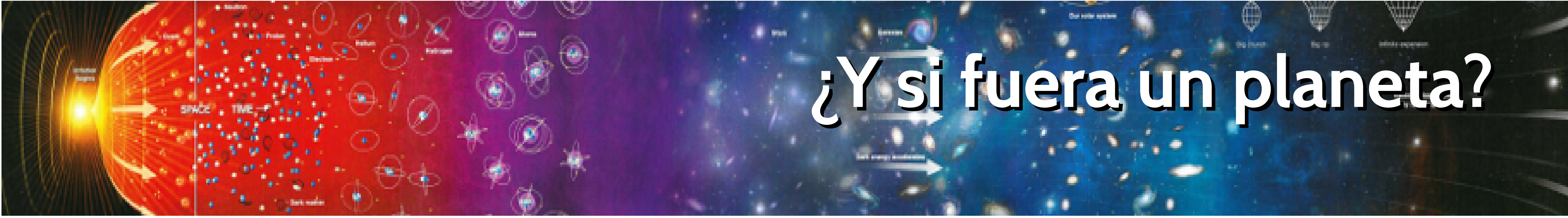


IRAS (InfraRed Astronomical Satellite)

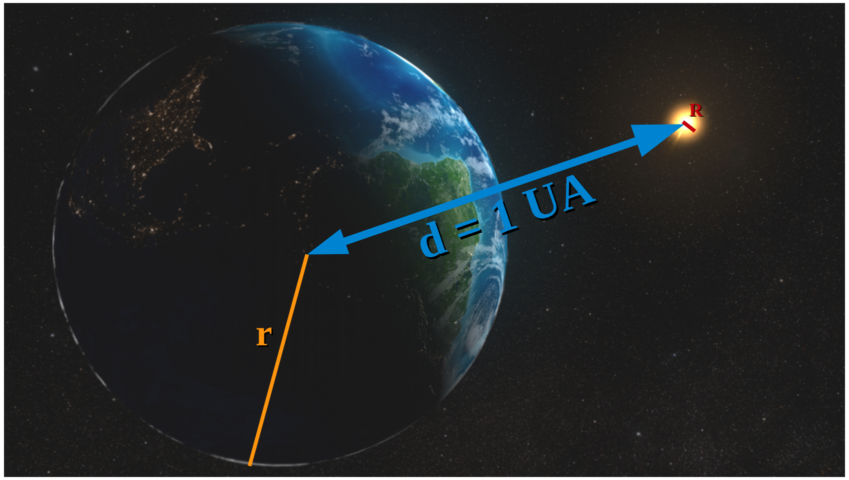
http://home.fnal.gov/~carrigan/infrared_astronomy/Fermilab_search.htm







¿Y si fuera un planeta?



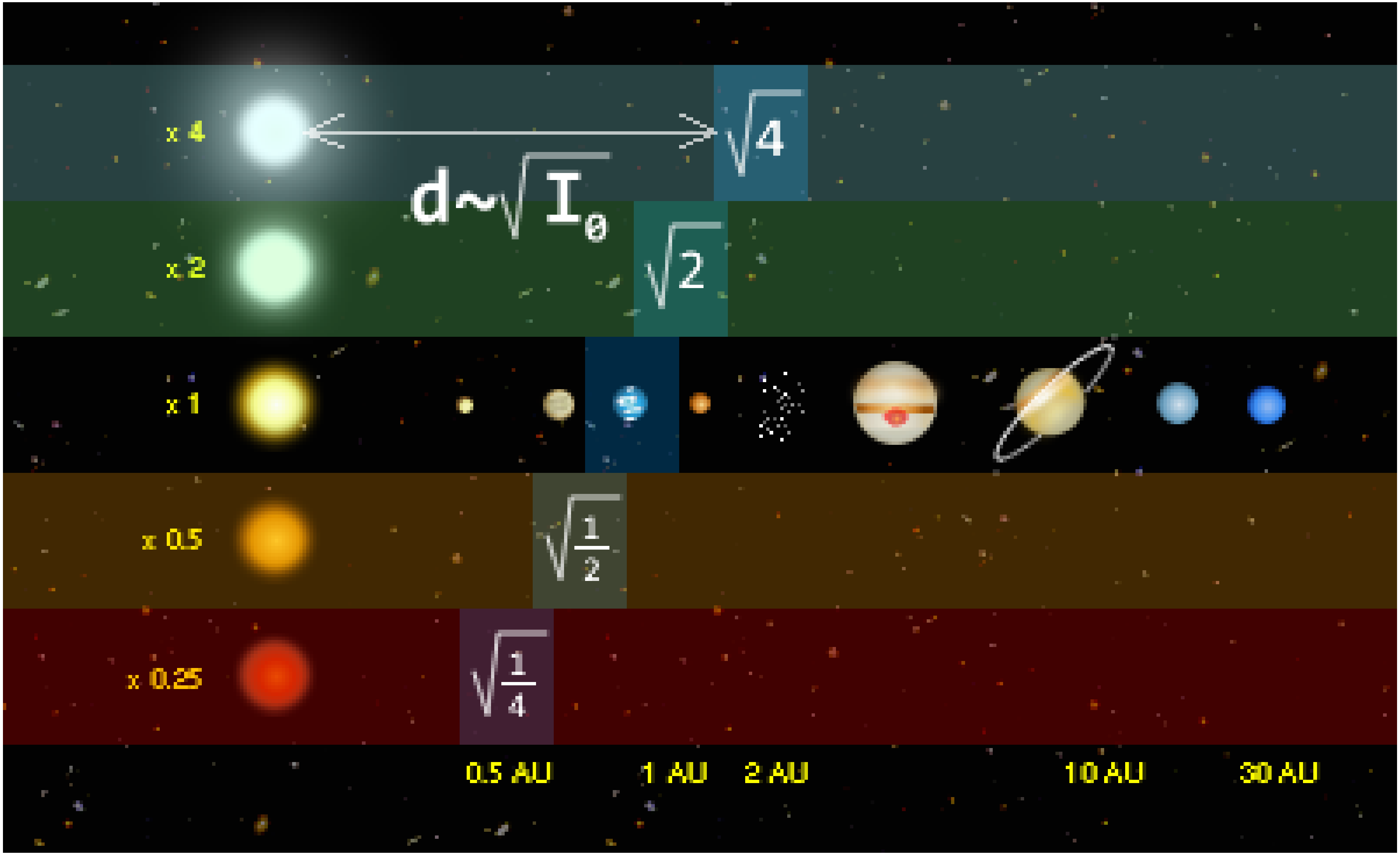
- ¿Que fracción de la energía captura un planeta de radio r?

$$T_{\oplus} = \sqrt[4]{\frac{L_{\odot}}{16\pi\sigma d^2}}$$

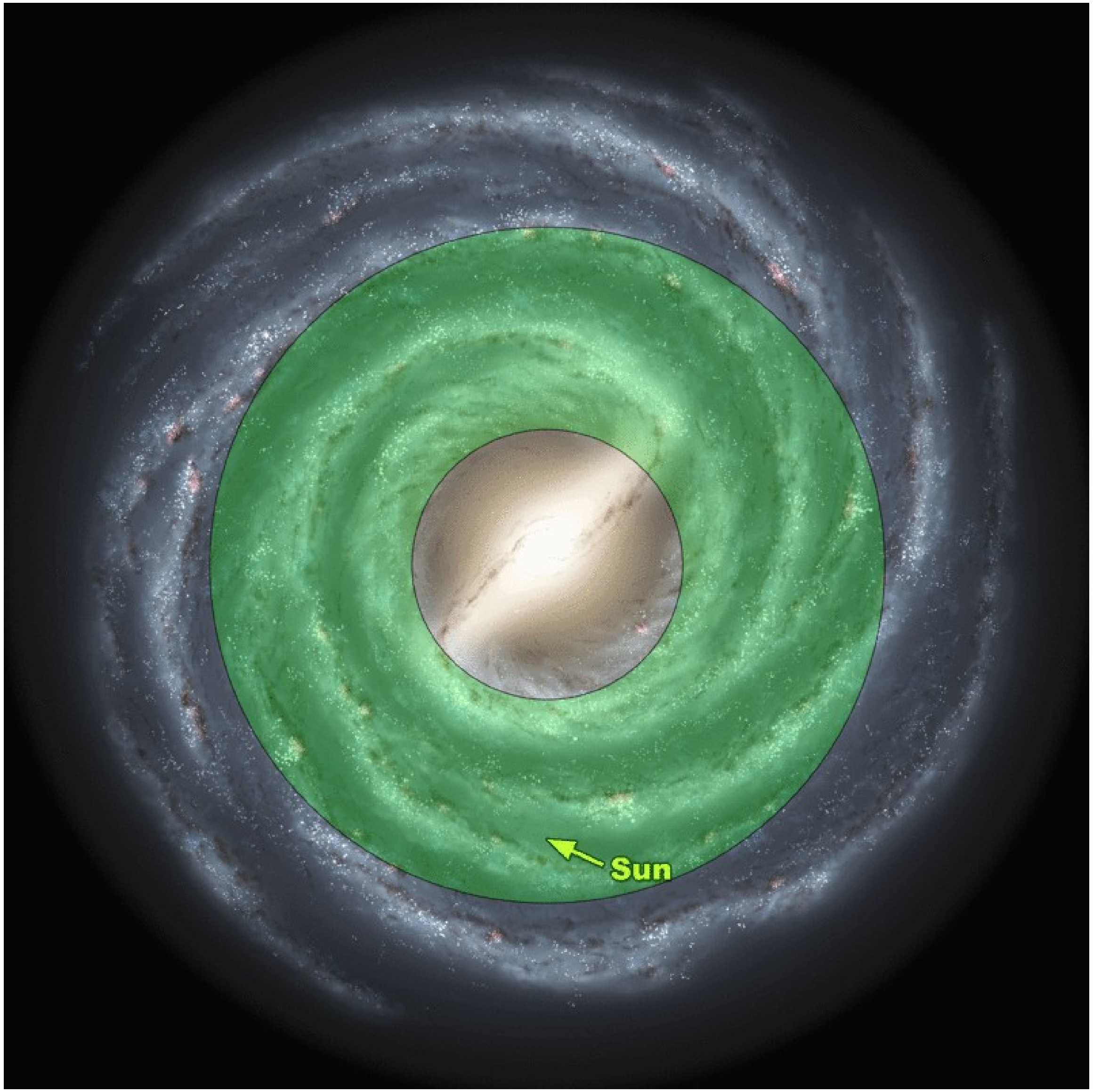
$$T_{\oplus} = \sqrt{\frac{R_{\odot}}{2d}}\, T_{\odot}$$

$$d = \frac{1}{2}\left(\frac{T_{\odot}}{T_{\oplus}}\right)^2 R_{\odot}$$

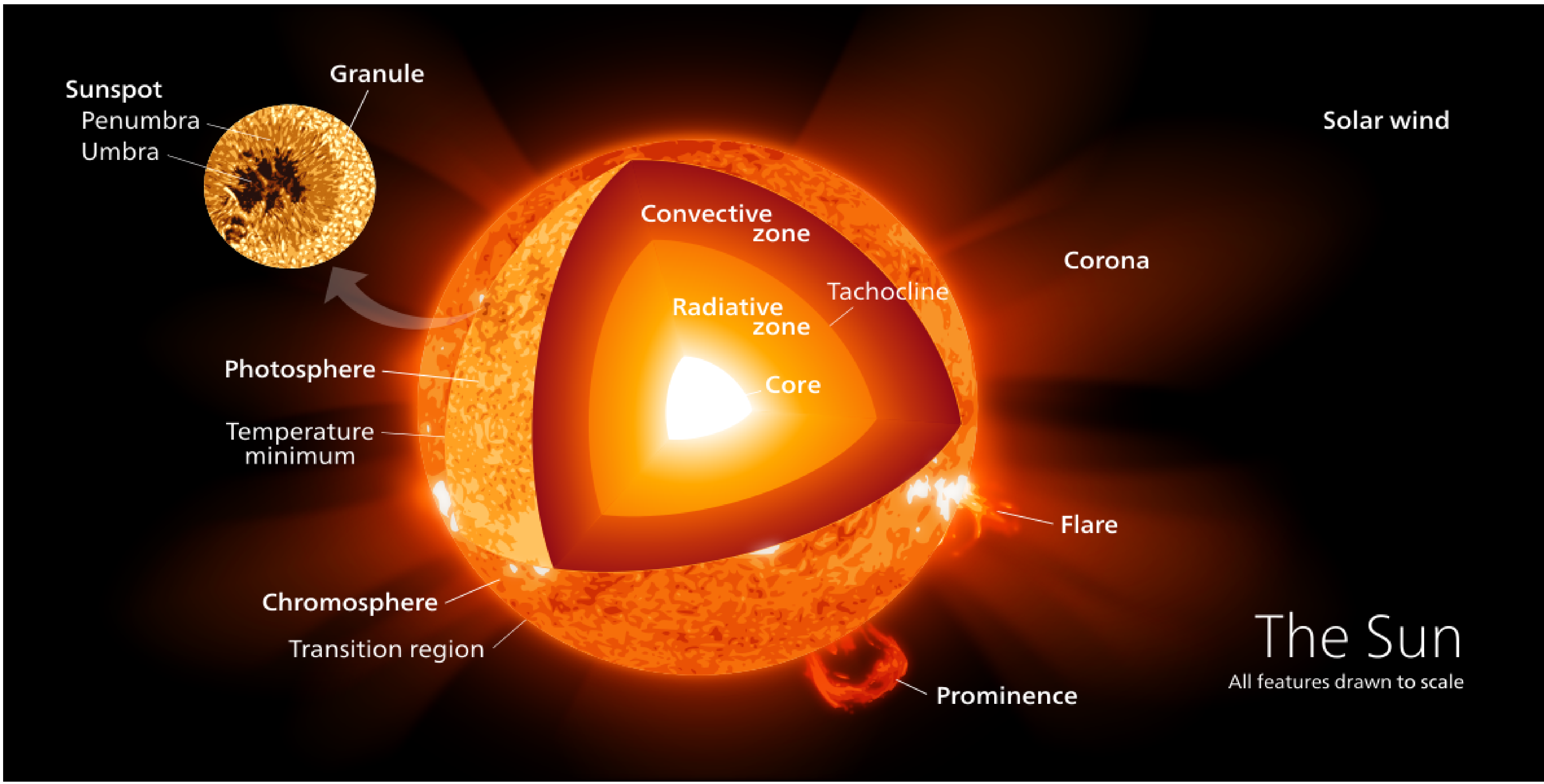
Zona habitable: Agua líquida (volveremos...)



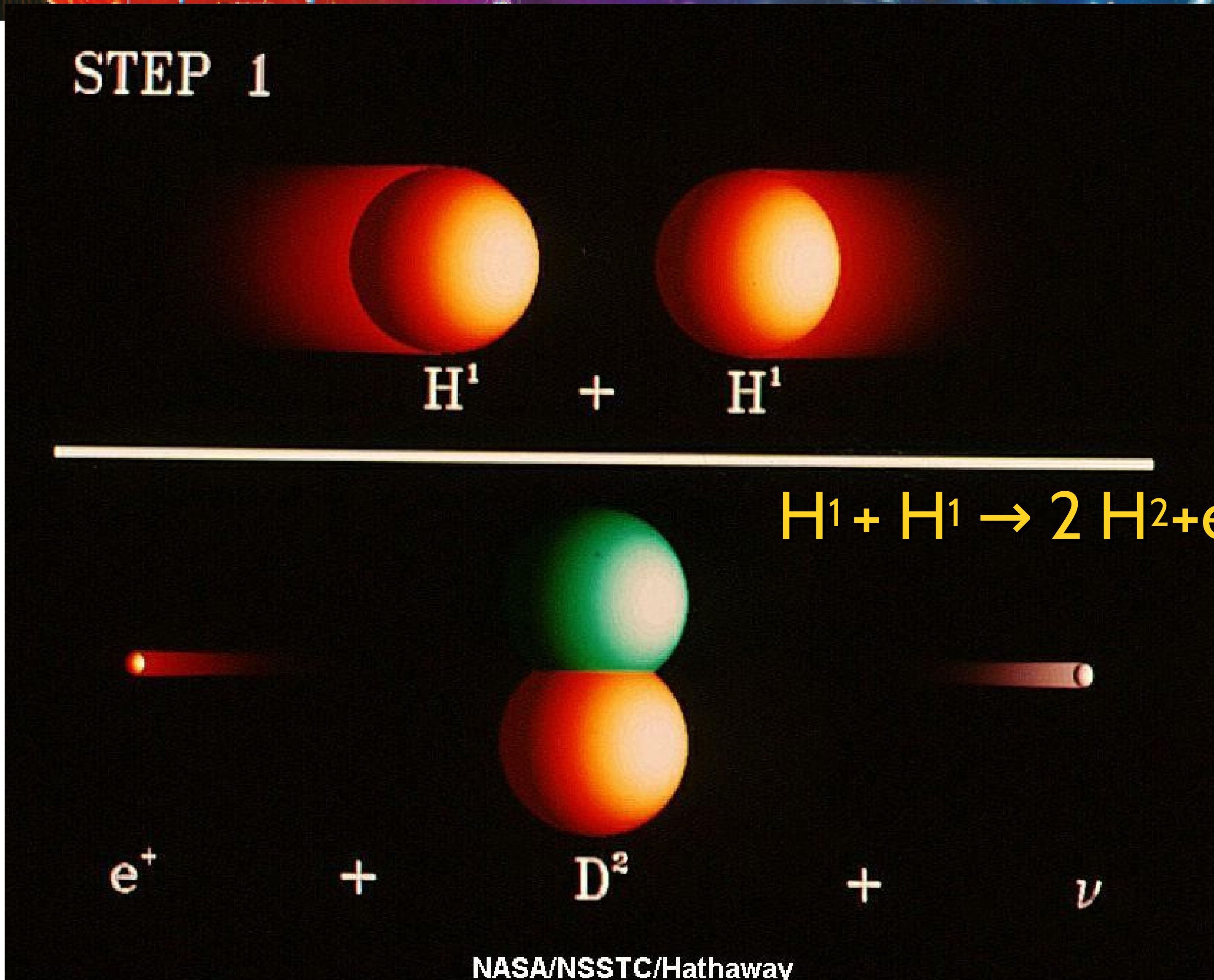
zona habitable... galáctica



Estructura de una estrella típica (Sol)

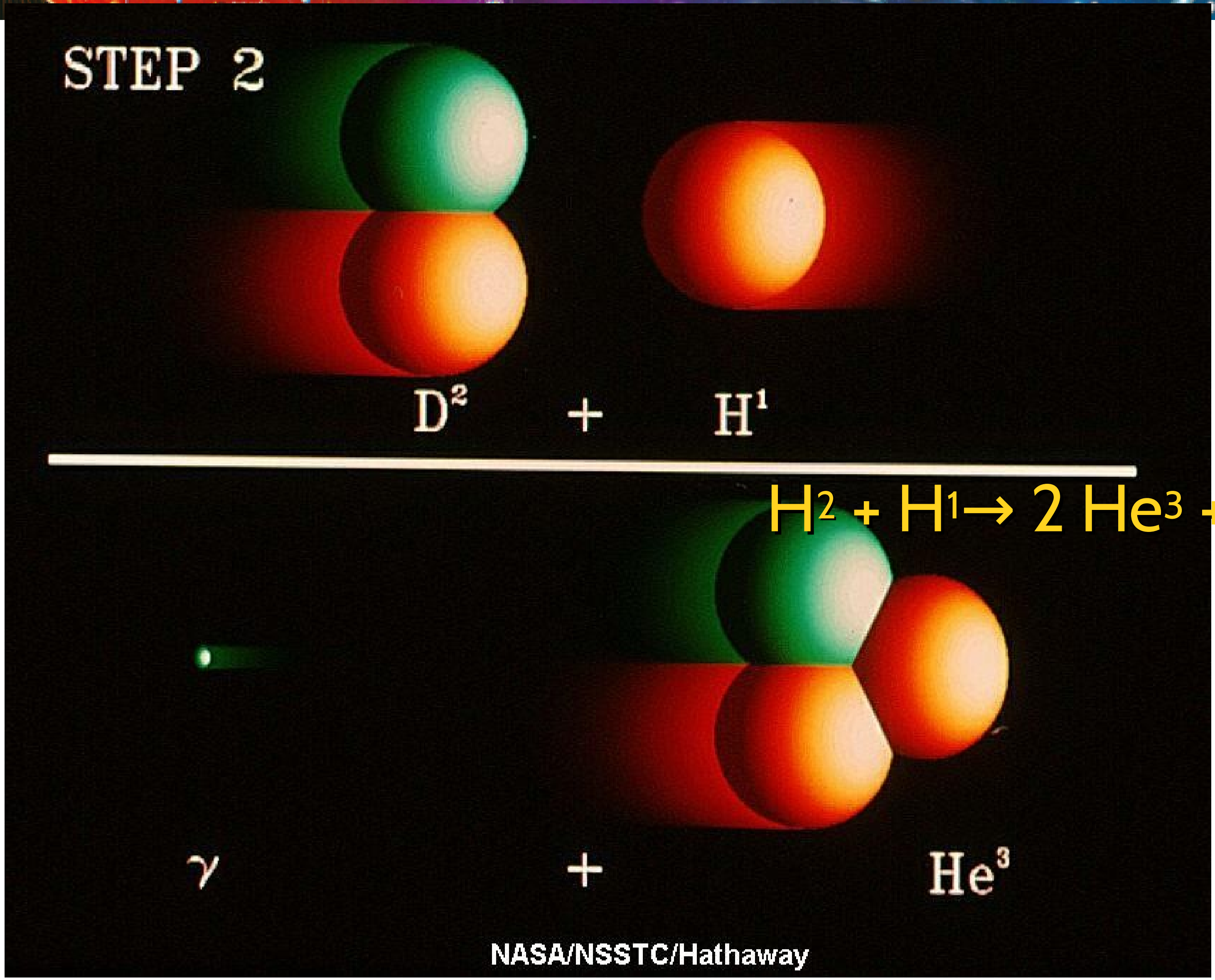


Fusión: Paso 1



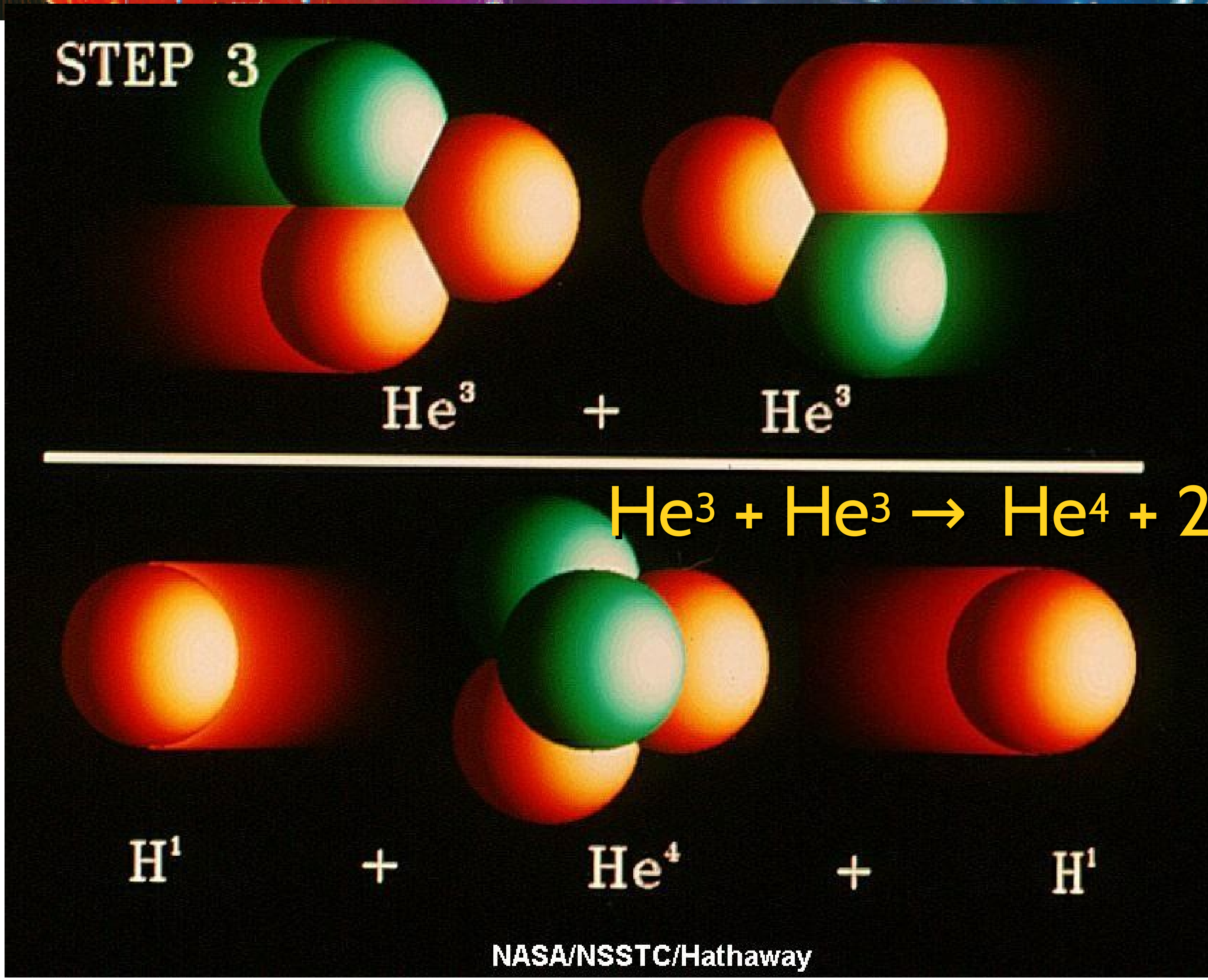
$H^1 + H^1 \rightarrow 2\ H^2 + e^+ + \nu + \text{Energía}$

Fusión: Paso 2



$H^2 + H^1 \rightarrow 2\ He^3 + \gamma +$ Energía

Fusión: Paso 3



$He^3 + He^3 \rightarrow He^4 + 2\,H^1 + \text{Energía}$

Fusión: Producción neta

$$4\ H^1 \rightarrow He^4 + 2\ e^+ + 2\ \nu_e + \text{Energía}$$

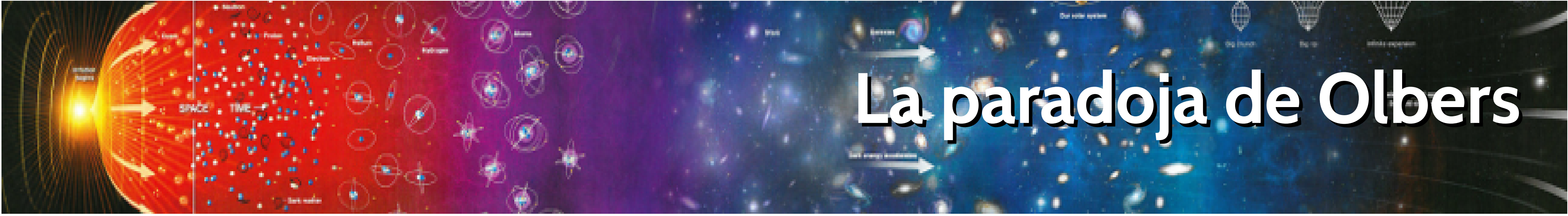
Masa inicial: 1.003×10^{-26} kg

Masa final: 0.991×10^{-26} kg

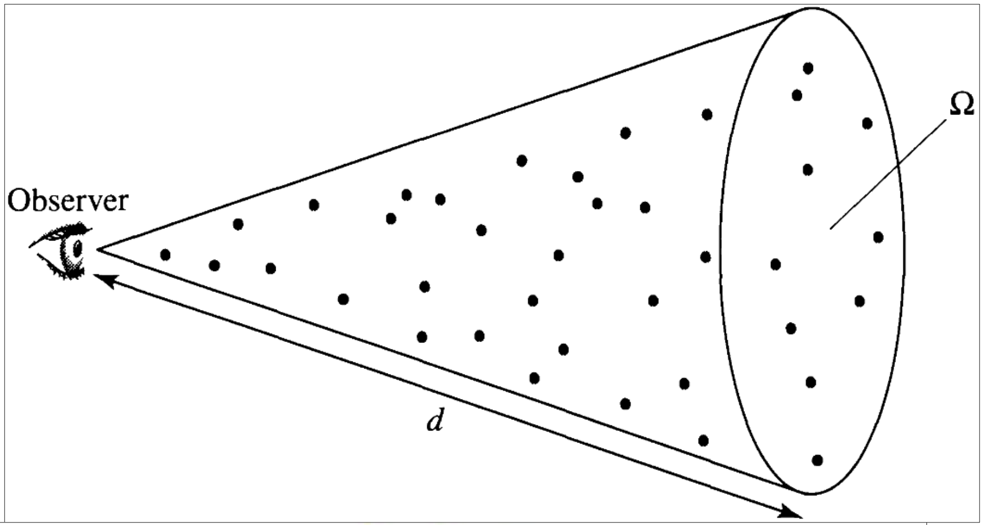
$$E=mc^2$$

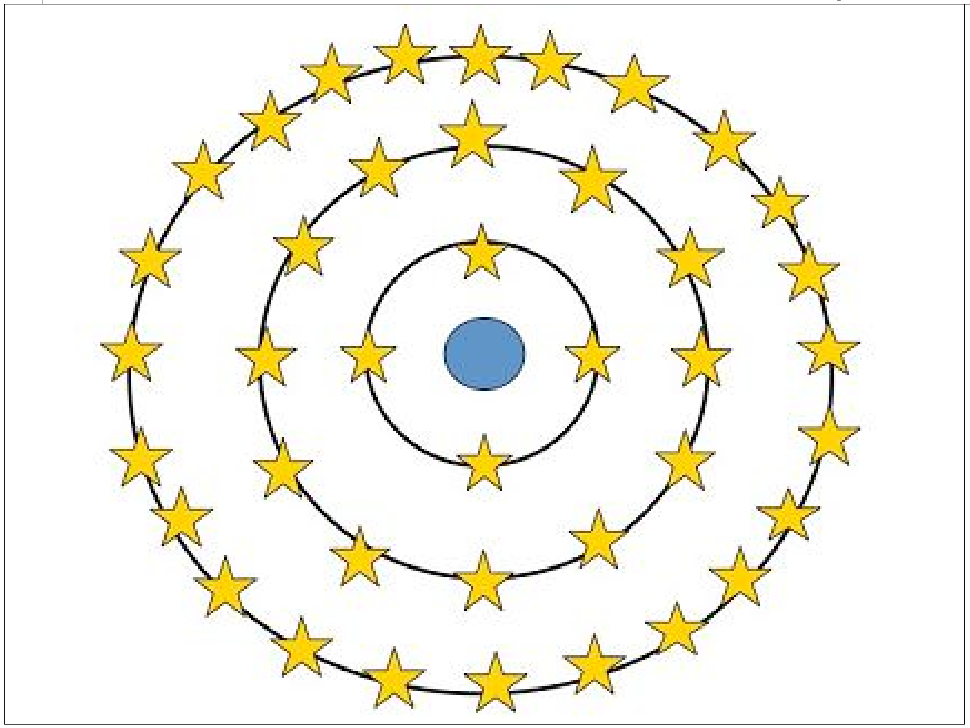
~ 27 MeV por reacción

Conversión 4.000.000 toneladas/seg



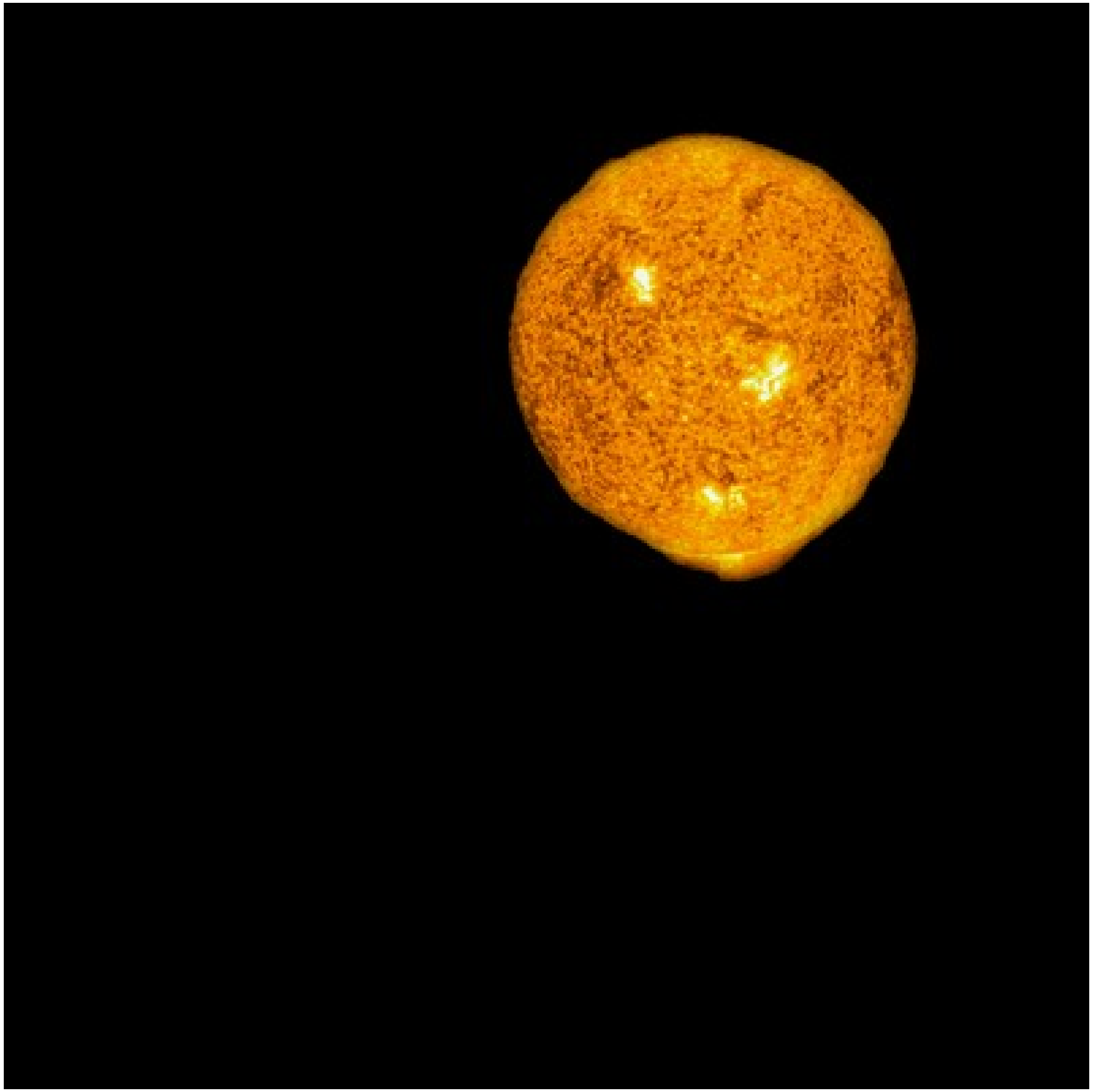
La paradoja de Olbers



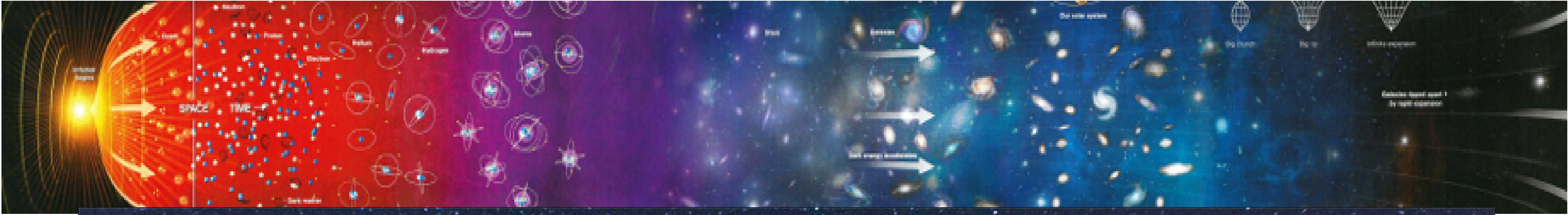


- Supongamos que hay infinitas estrellas...
- El número de estrellas en la superficie de un cono crece como d^2.
- Pero el flujo disminuye como d^2.
- Ergo, el flujo de energía de la superficie del cono es constante
- El cielo completo brillaría como las estrellas → T=5700 K

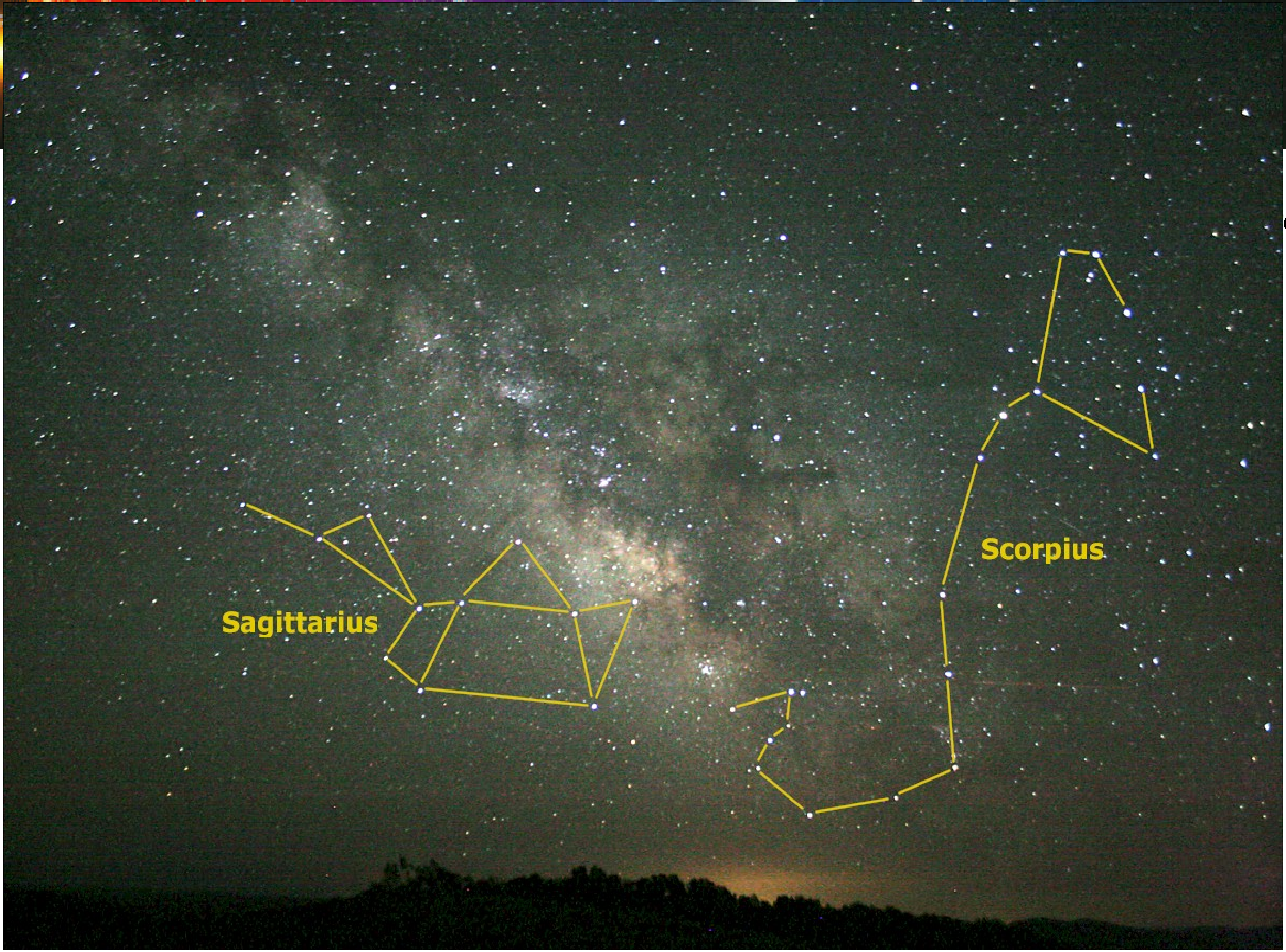
Paradoja de Olbers



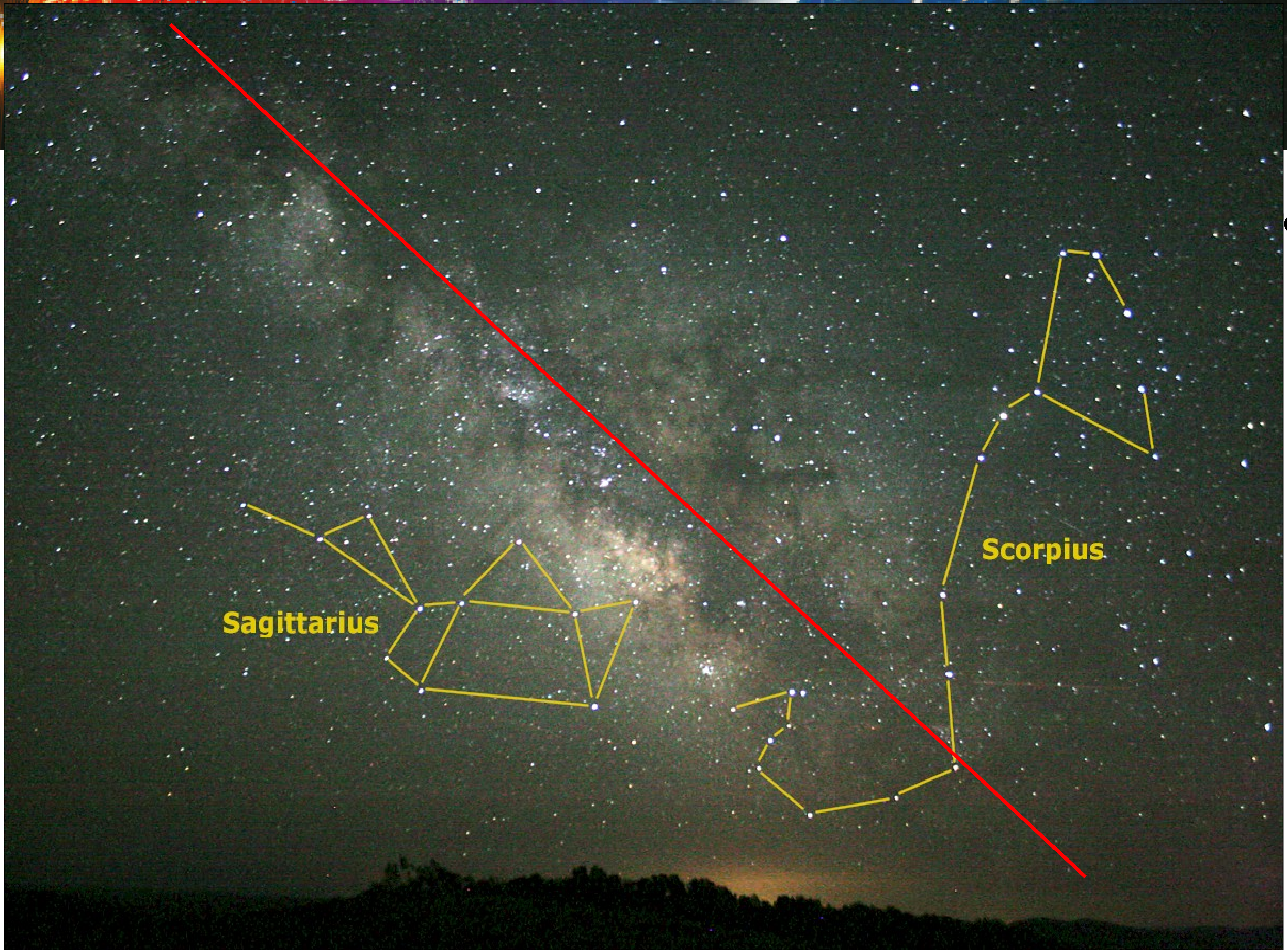
- No hay infinitas estrellas
- Hay absorción en el espacio



La Vía Láctea desde Cerro Paranal

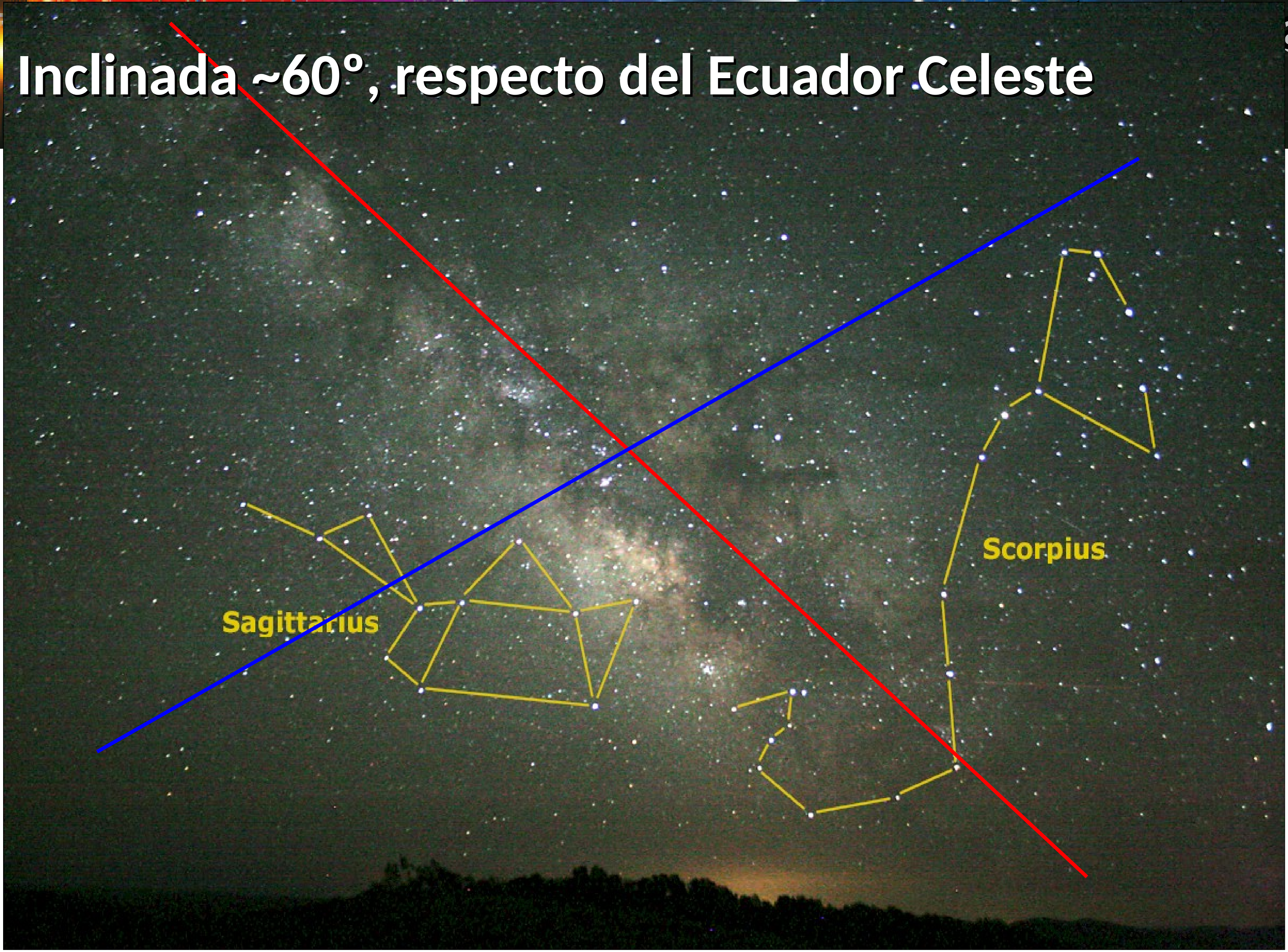


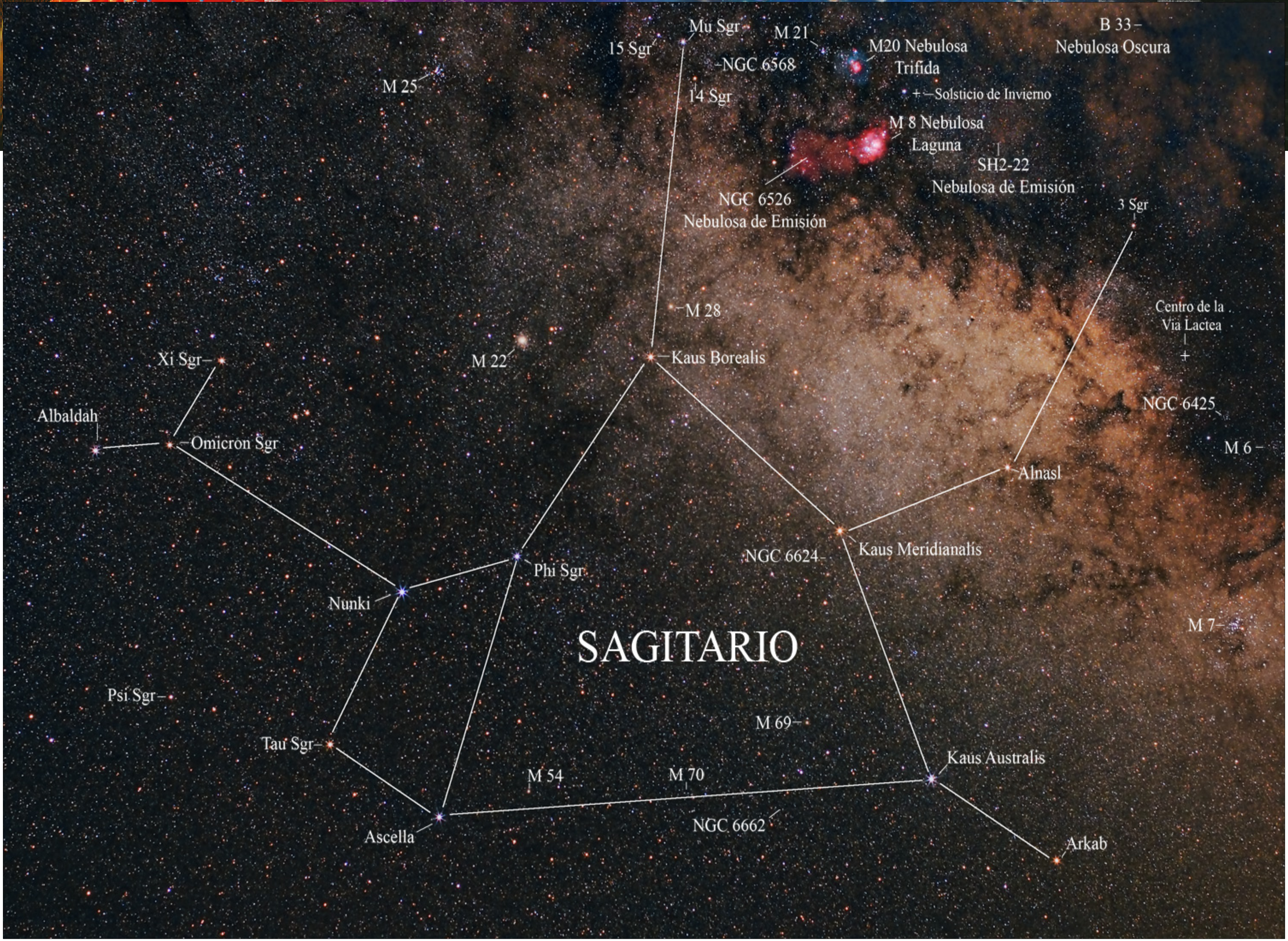
a

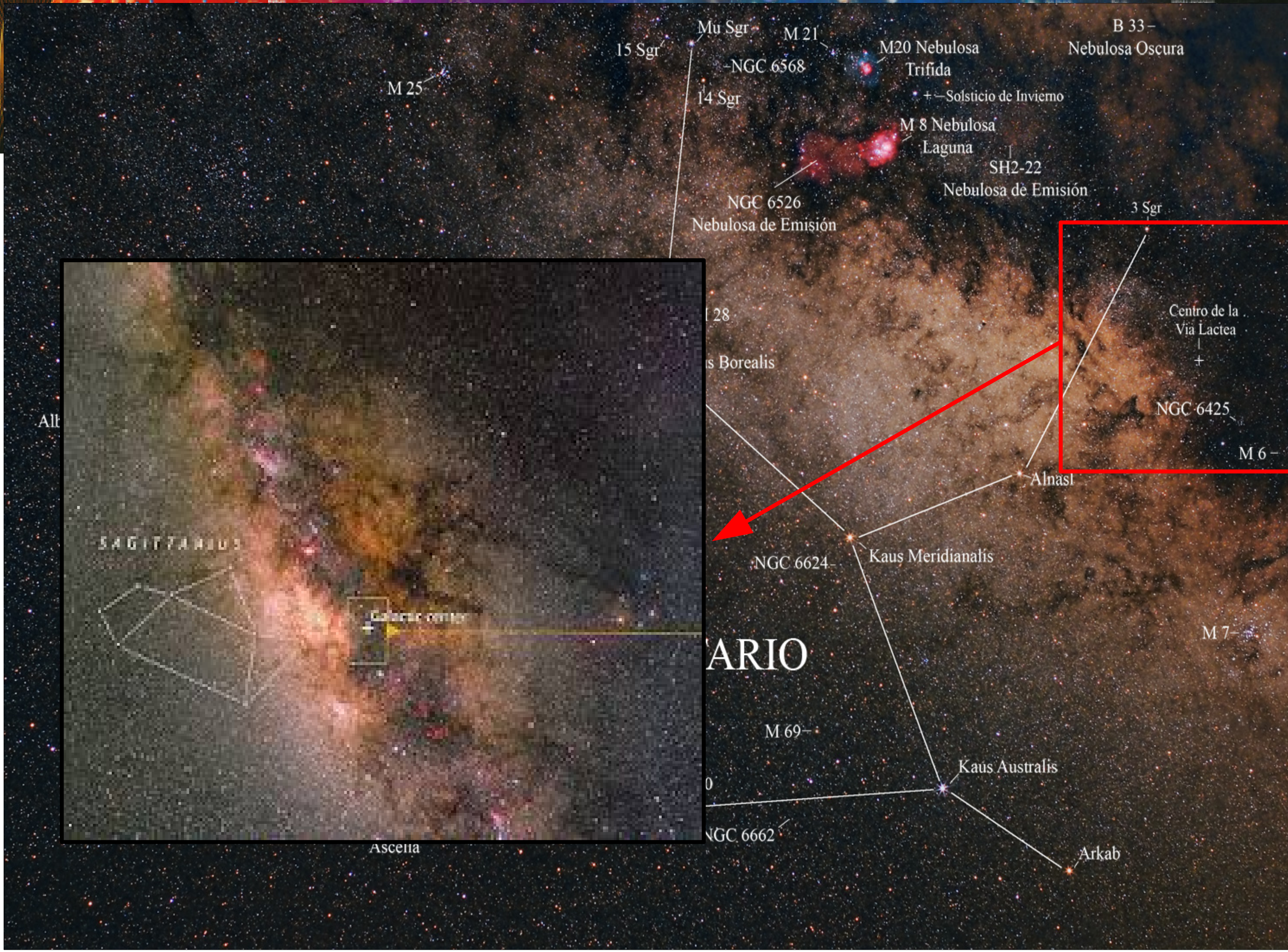


a

Inclinada ~60°, respecto del Ecuador Celeste




Mu Sgr
M 21
15 Sgr
M20 Nebulosa
Trifida
B 33
Nebulosa Oscura
NGC 6568
M 25
14 Sgr
Solsticio de Invierno
M 8 Nebulosa
Laguna
SH2-22
Nebulosa de Emisión
NGC 6526
Nebulosa de Emisión
3 Sgr
M 28
Centro de la
Via Lactea
Xi Sgr
M 22
Kaus Borealis
Albaldah
NGC 6425
Omicron Sgr
M 6
Alnasl
NGC 6624
Kaus Meridianalis
Phi Sgr
Nunki
M 7
SAGITARIO
Psi Sgr
M 69
Tau Sgr
Kaus Australis
M 54
M 70
NGC 6662
Ascella
Arkab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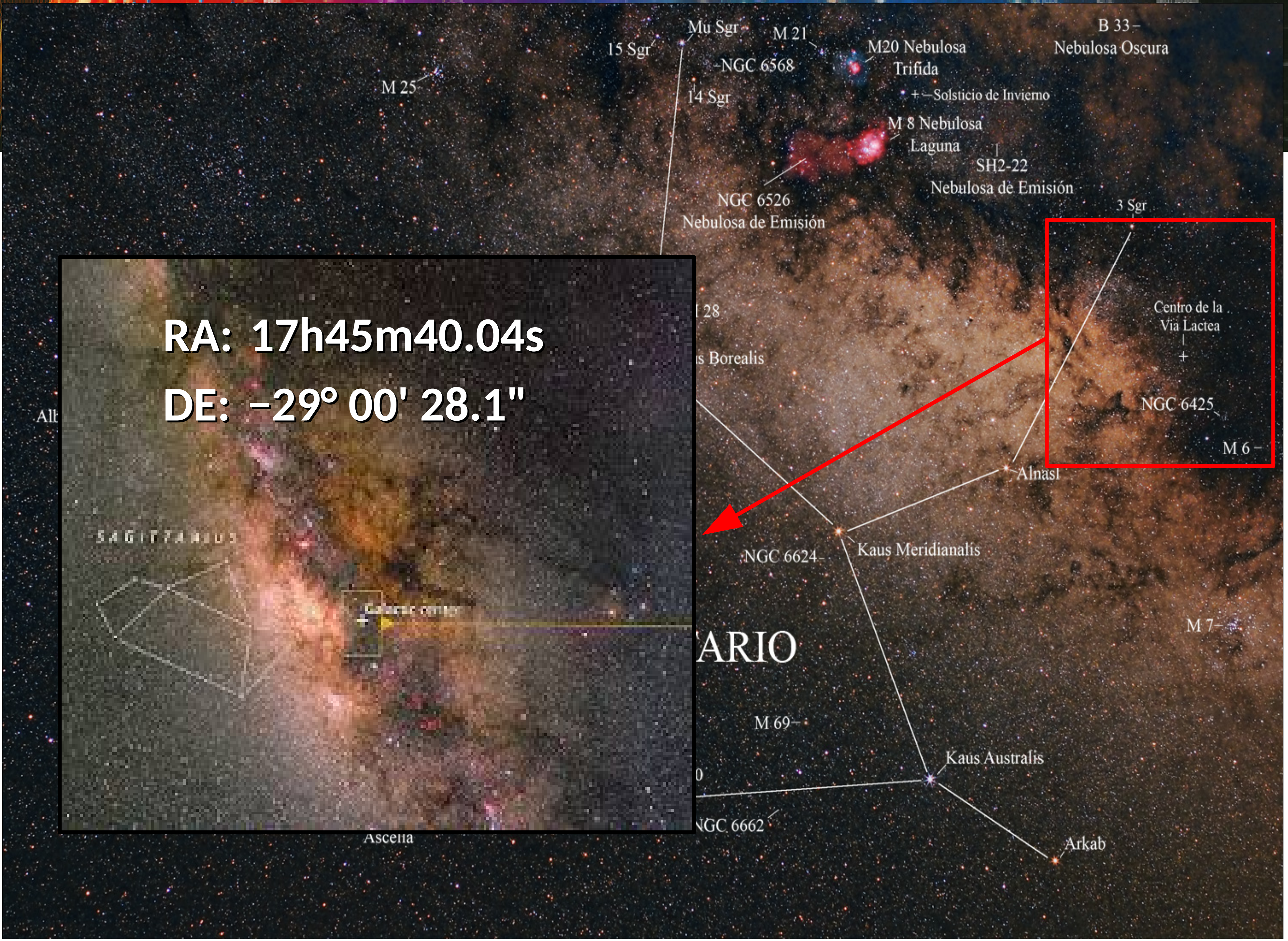
SAGITTARIUS


RA: 17h45m40.04s
DE: −29° 00' 28.1"
SAGITTARIUS
Galactic center
Mu Sgr
15 Sgr
M 21
NGC 6568
M20 Nebulosa
Trifida
B 33
Nebulosa Oscura
M 25
14 Sgr
Solsticio de Invierno
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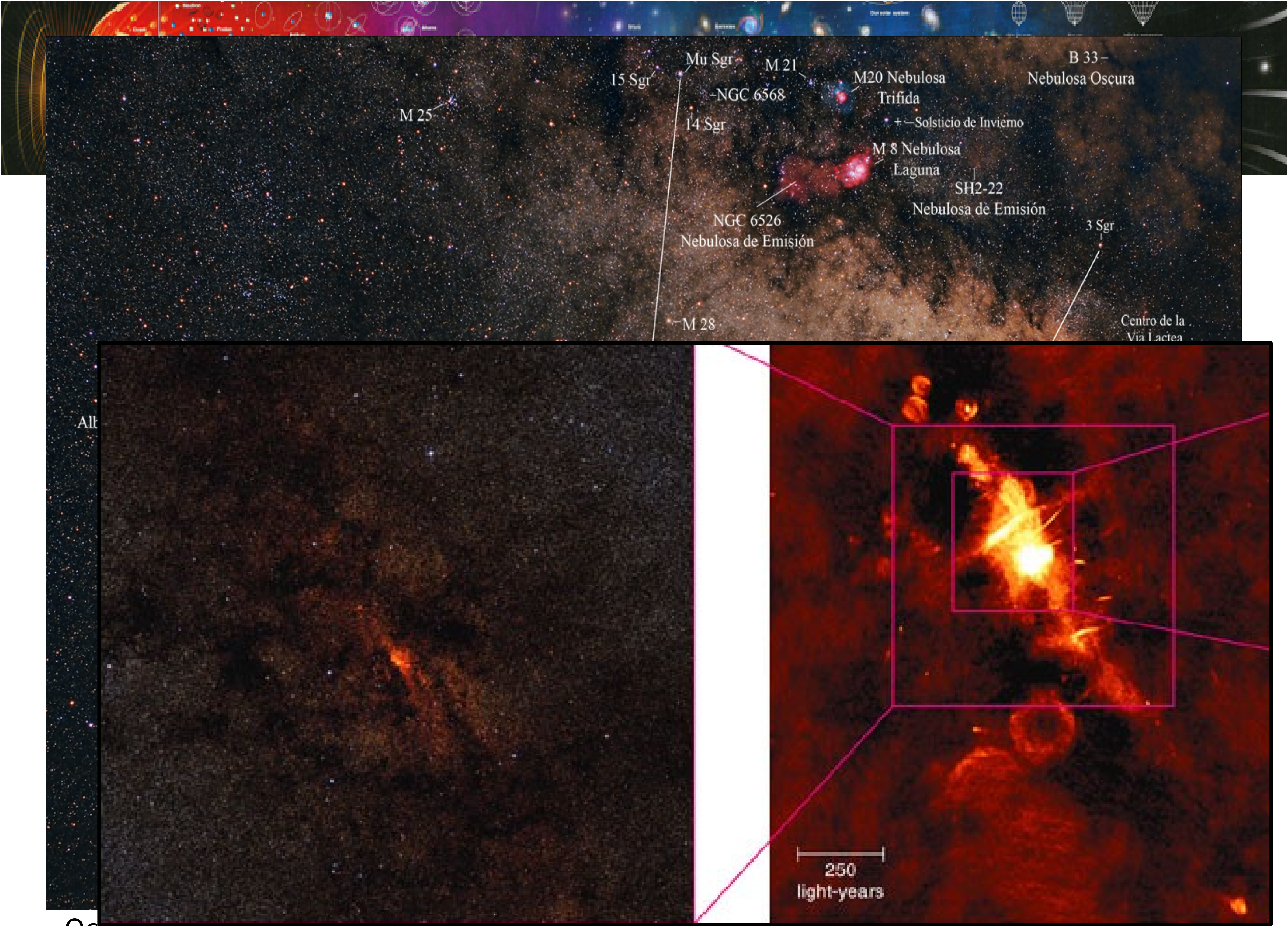
Mu Sgr
M 21
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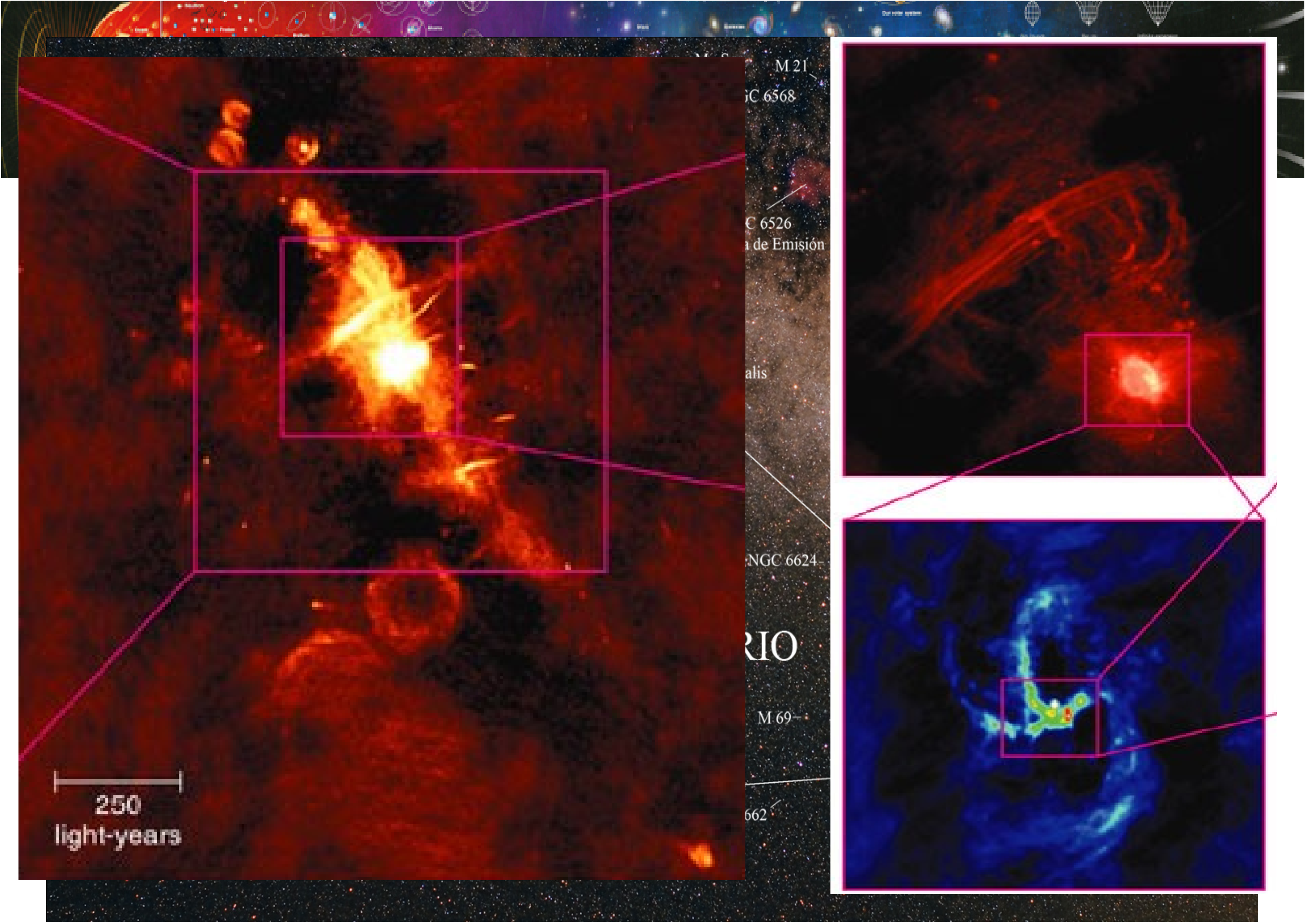
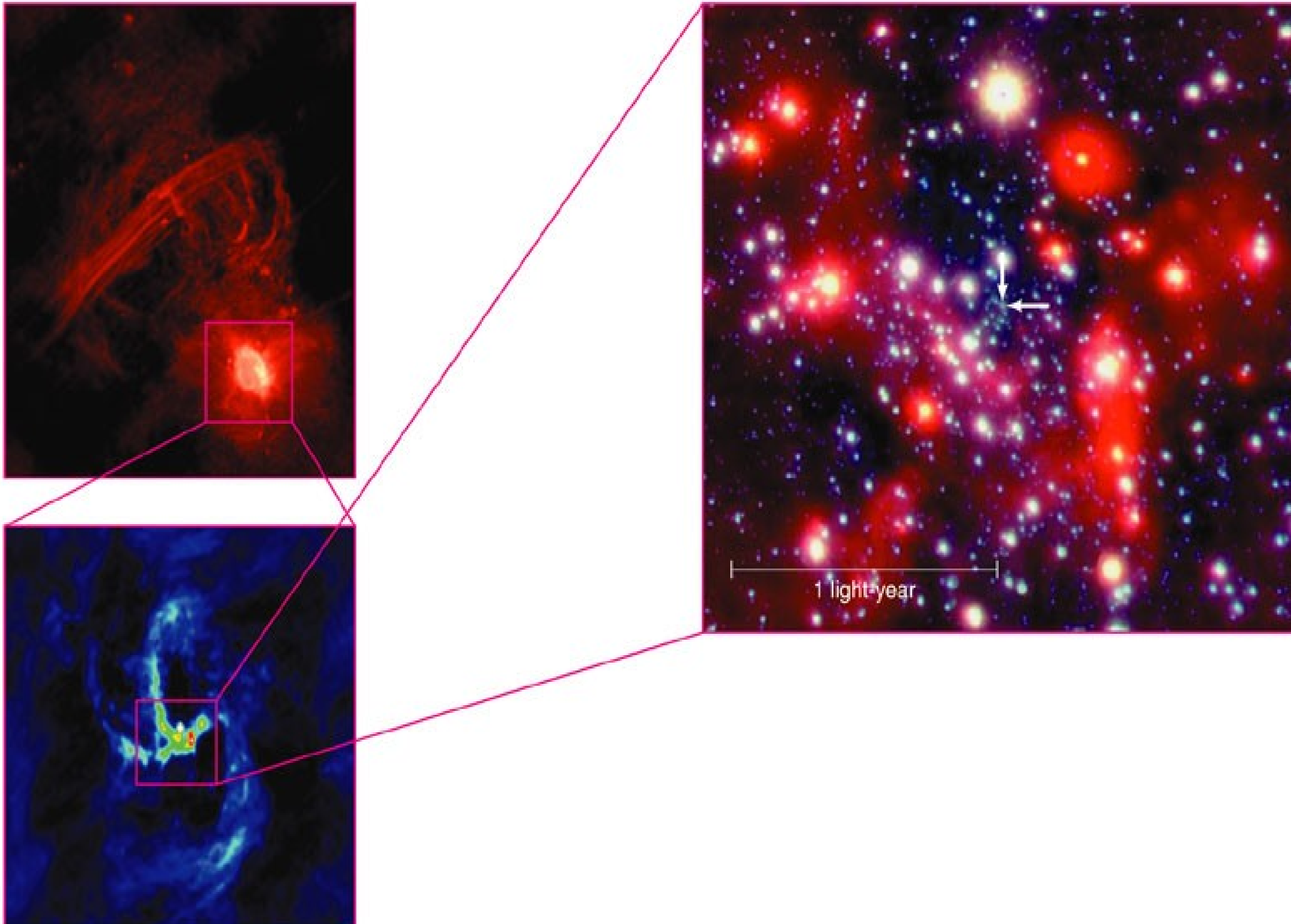
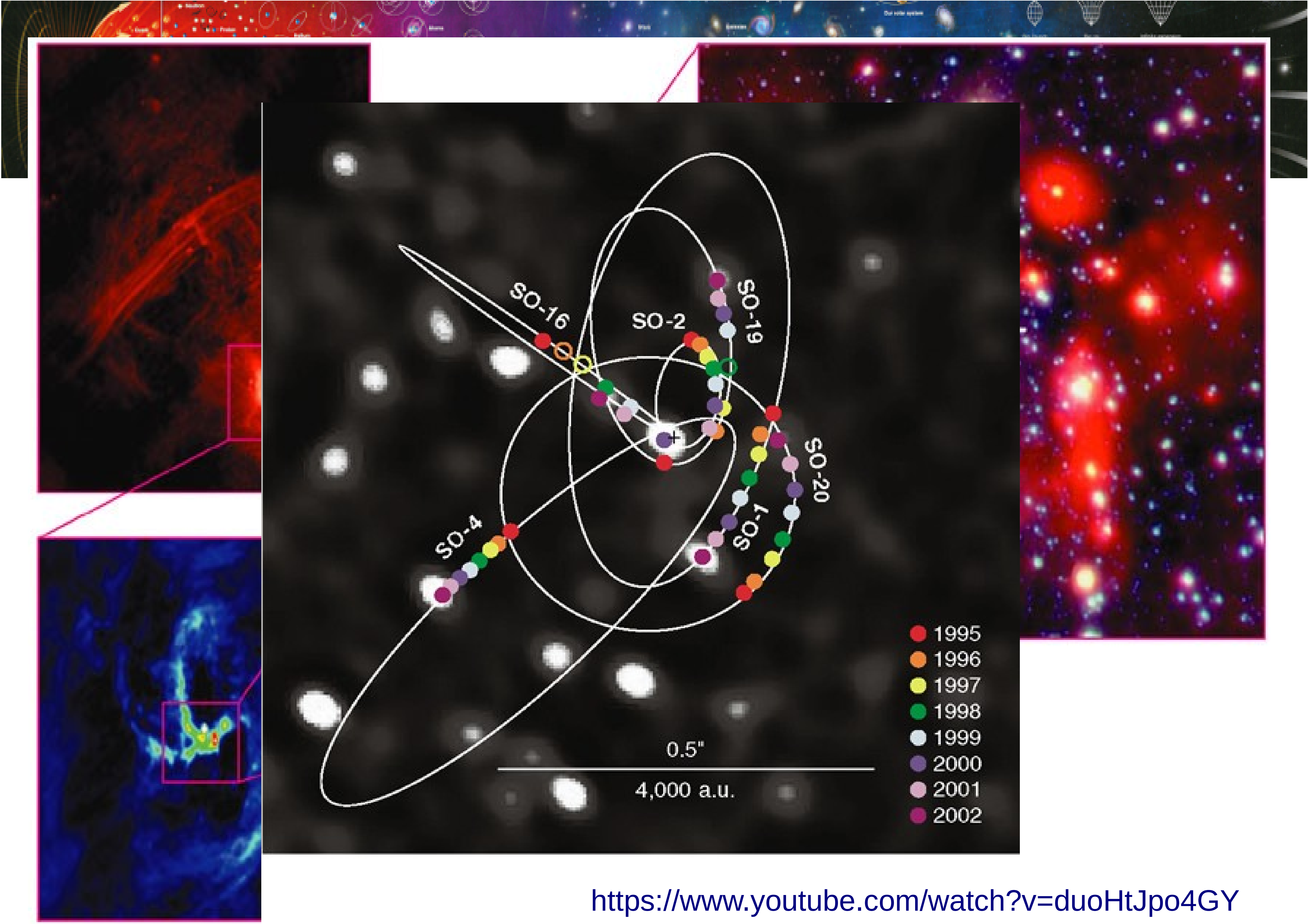
Nebulosa de Emisión
NGC 6526
Nebulosa de Emisión
3 Sgr
M 28
Centro de la
Via Lactea
250
light-years

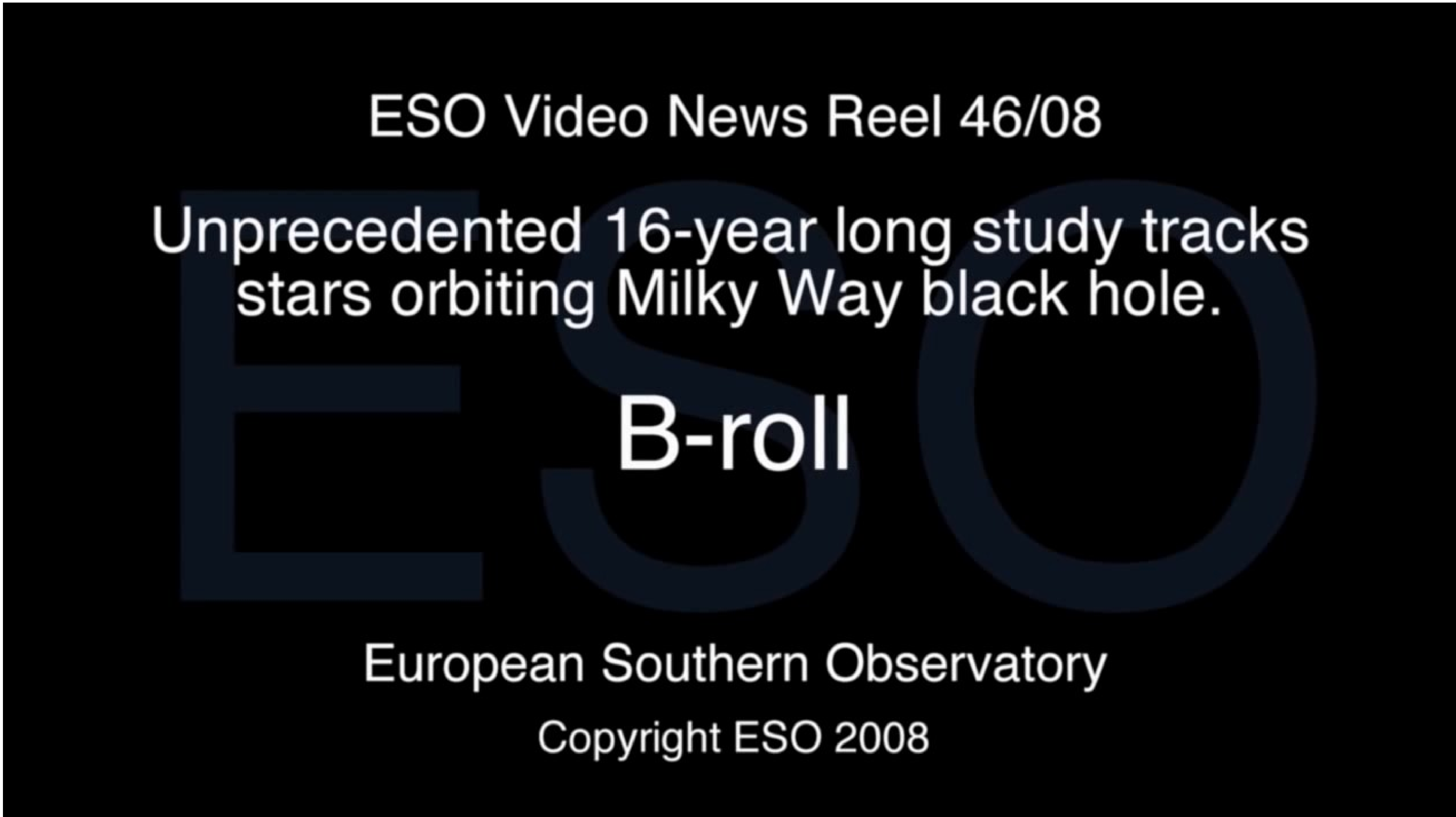

M 21
M 69
250
light-years


1 light-year

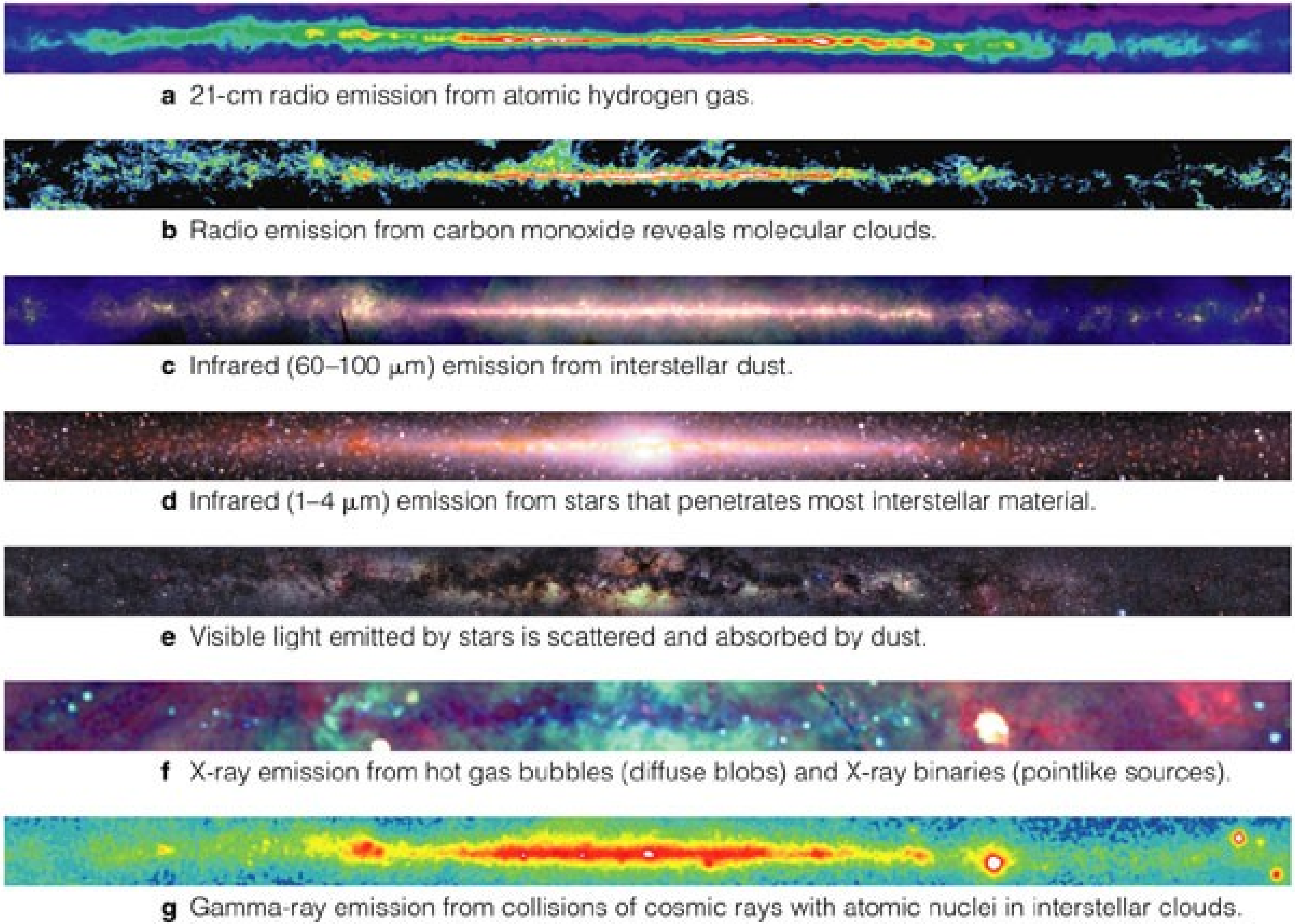


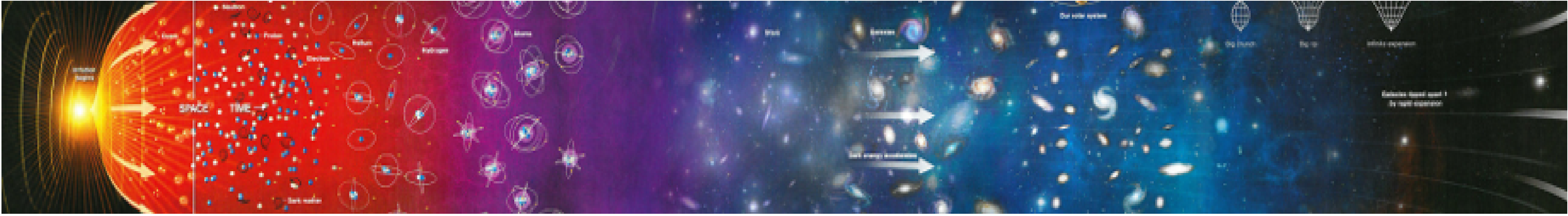
https://www.youtube.com/watch?v=duoHtJpo4GY

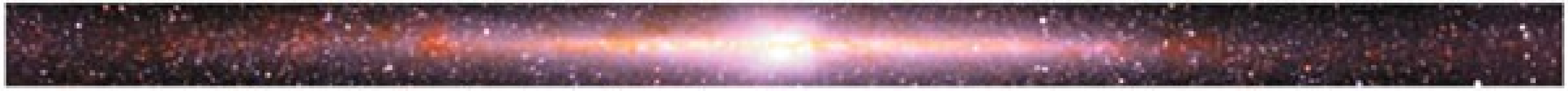
El agujero negro central



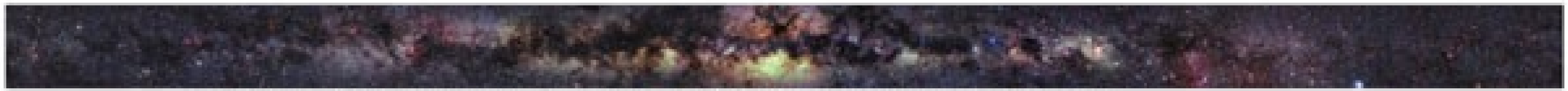
¿Y qué forma tiene nuestra galaxia?


a 21-cm radio emission from atomic hydrogen gas.
b Radio emission from carbon monoxide reveals molecular clouds.
c Infrared (60–100 μm) emission from interstellar dust.
d Infrared (1–4 μm) emission from stars that penetrates most interstellar material.
e Visible light emitted by stars is scattered and absorbed by dust.
f X-ray emission from hot gas bubbles (diffuse blobs) and X-ray binaries (pointlike sources).
g Gamma-ray emission from collisions of cosmic rays with atomic nuclei in interstellar clouds.

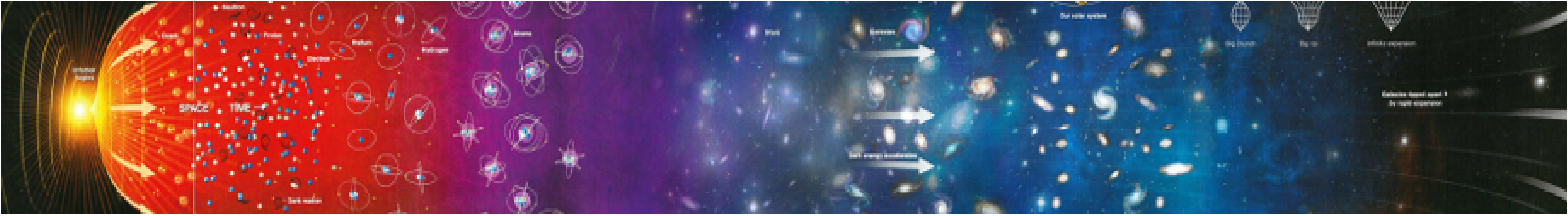




d Infrared (1–4 μm) emission from stars that penetrates most interstellar material.



e Visible light emitted by stars is scattered and absorbed by dust.



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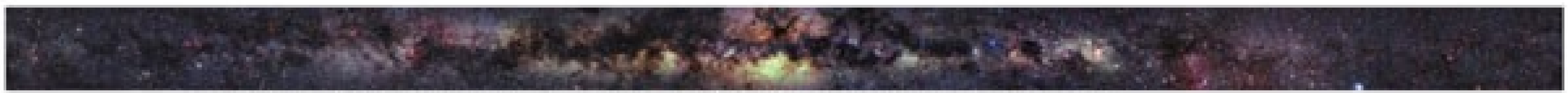
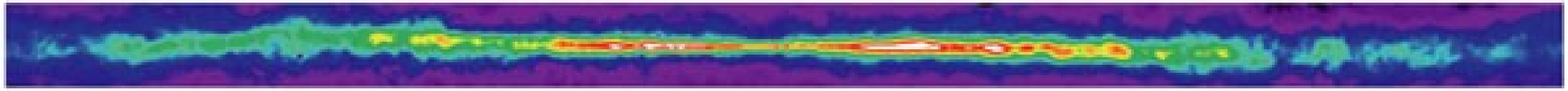


e Visible light emitted by stars is scattered and absorbed by dust.

f X-ray emission from hot gas bubbles (diffuse blobs) and X-ray binaries (pointlike sources).



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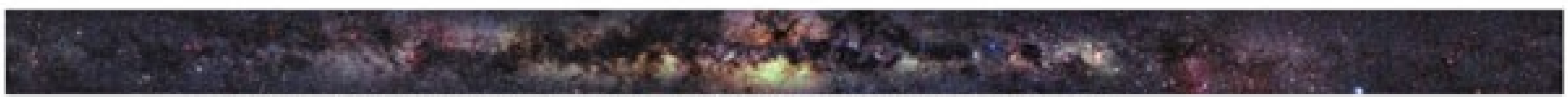

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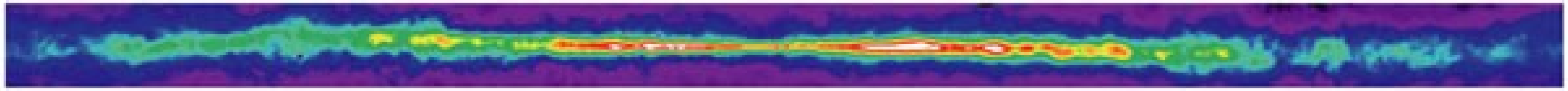

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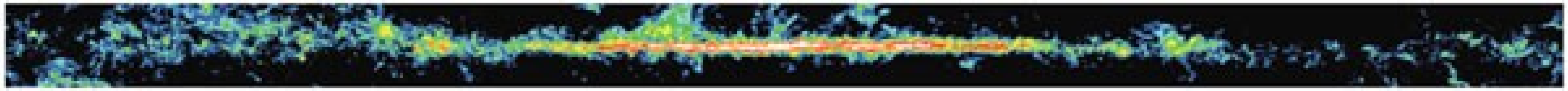

b Radio emission from carbon monoxide reveals molecular clouds.

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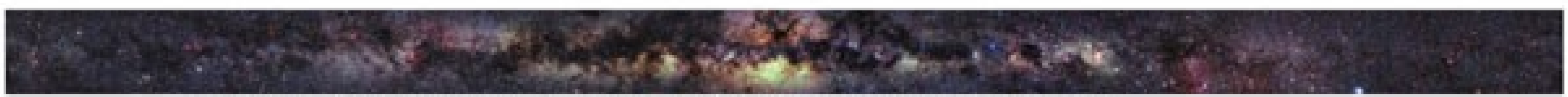
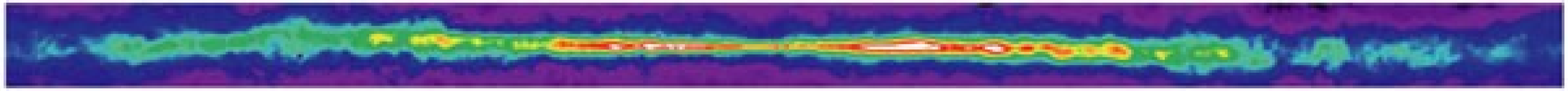
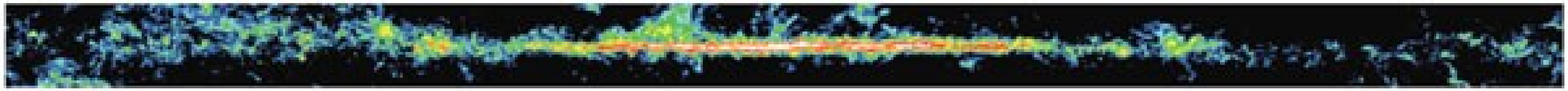


e Visible light emitted by stars is scattered and absorbed by dust.

f X-ray emission from hot gas bubbles (diffuse blobs) and X-ray binaries (pointlike sources).

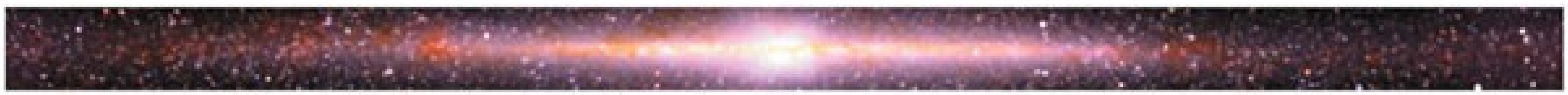


a 21-cm radio emission from atomic hydrogen gas.

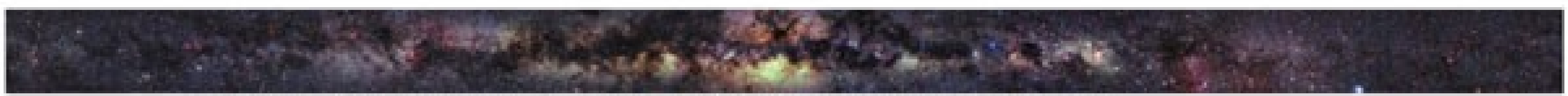


b Radio emission from carbon monoxide reveals molecular clouds.

c Infrared (60–100 μm) emission from interstellar dust.



d Infrared (1–4 μm) emission from stars that penetrates most interstellar material.



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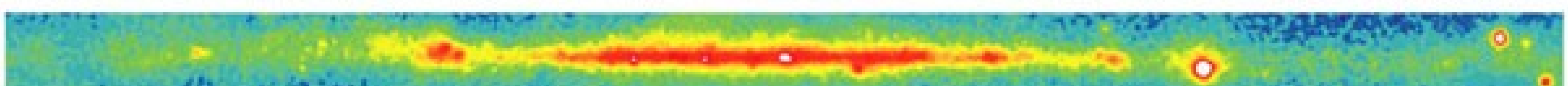
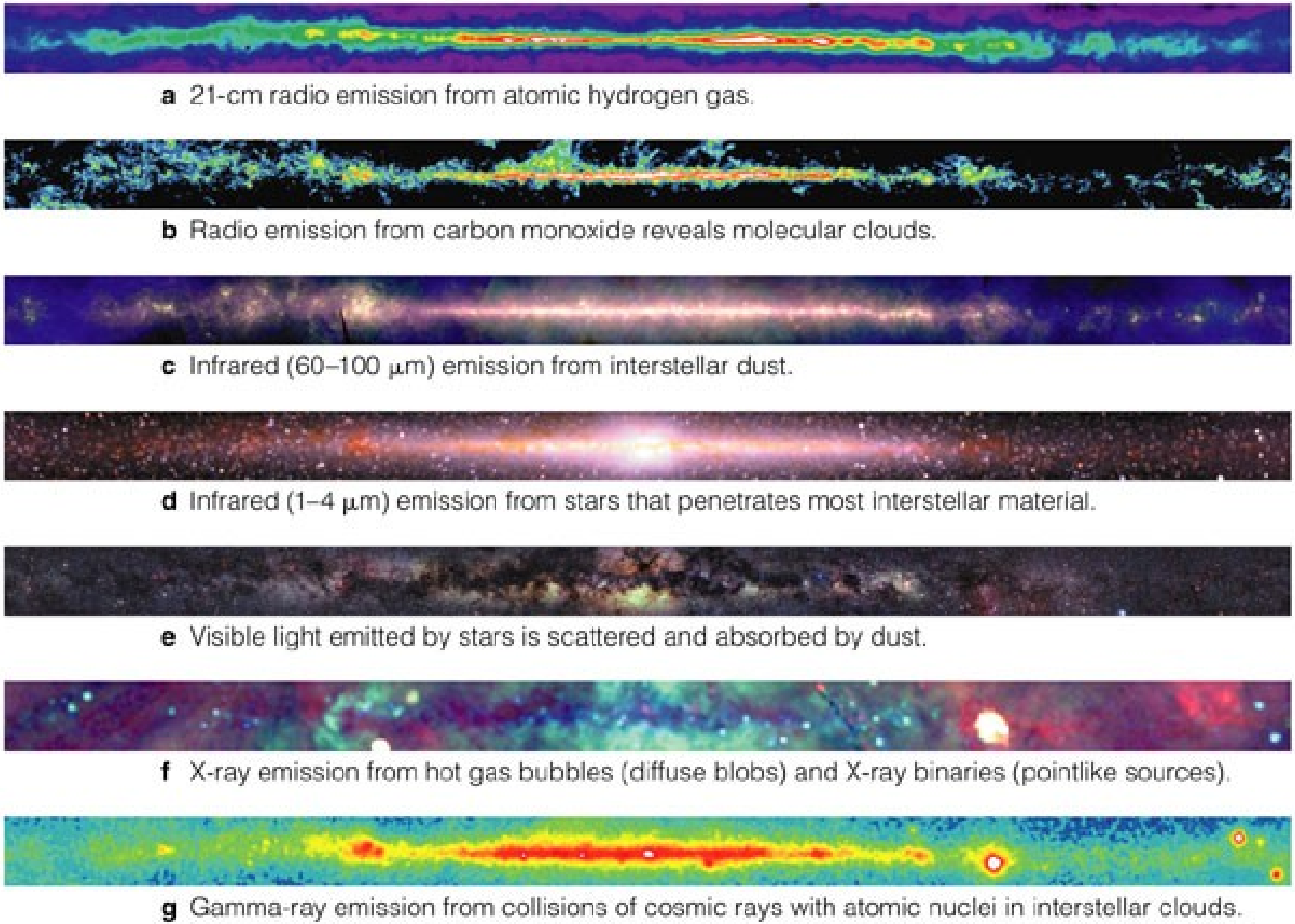
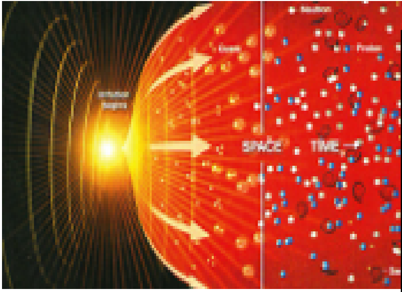
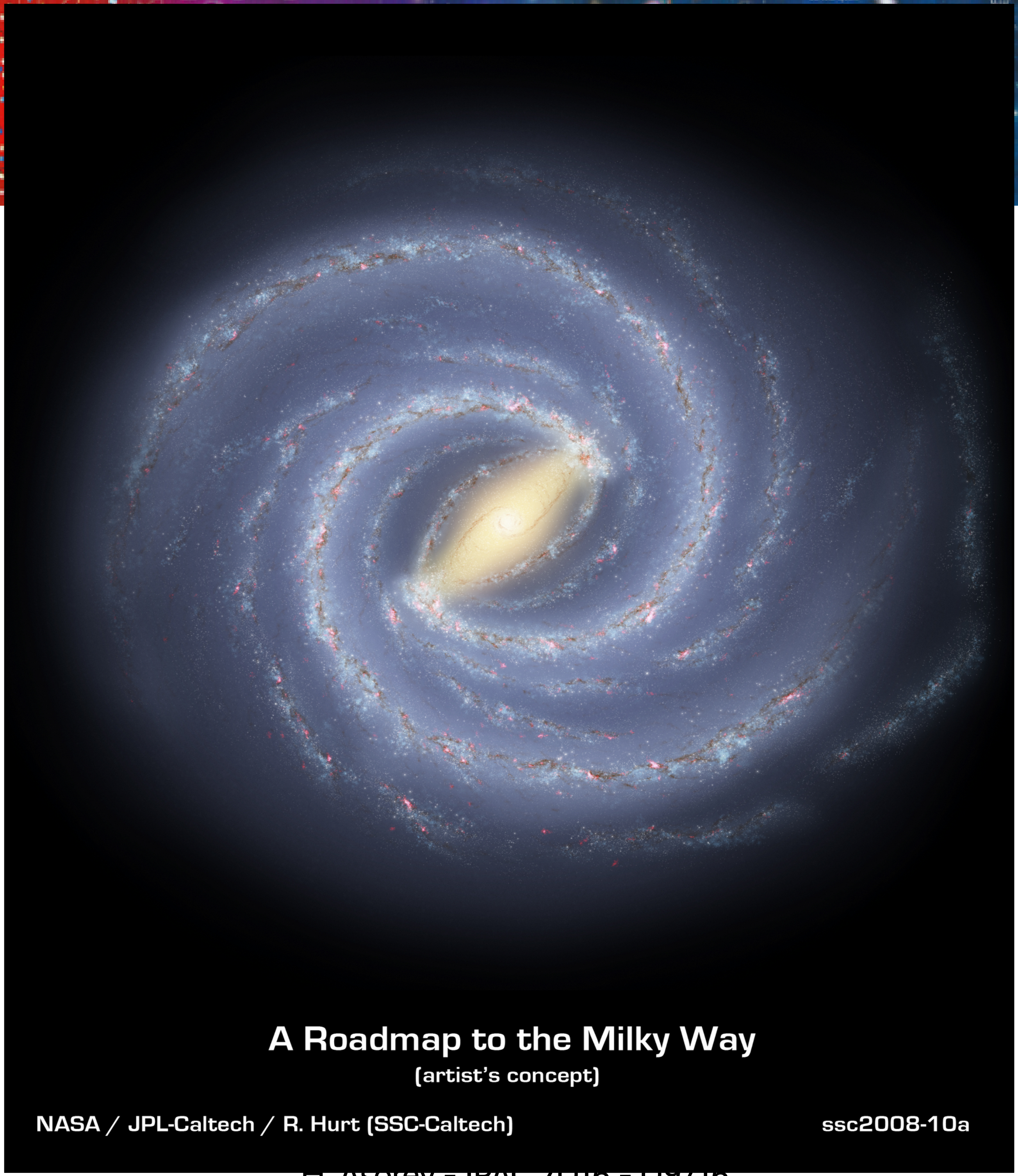


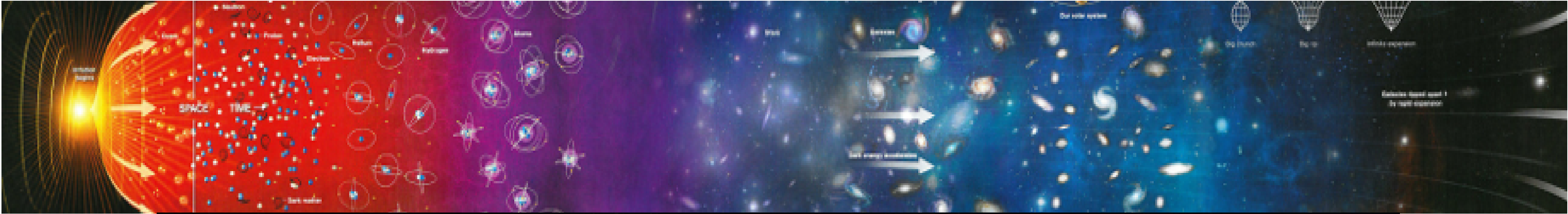
g Gamma-ray emission from collisions of cosmic rays with atomic nuclei in interstellar clouds.

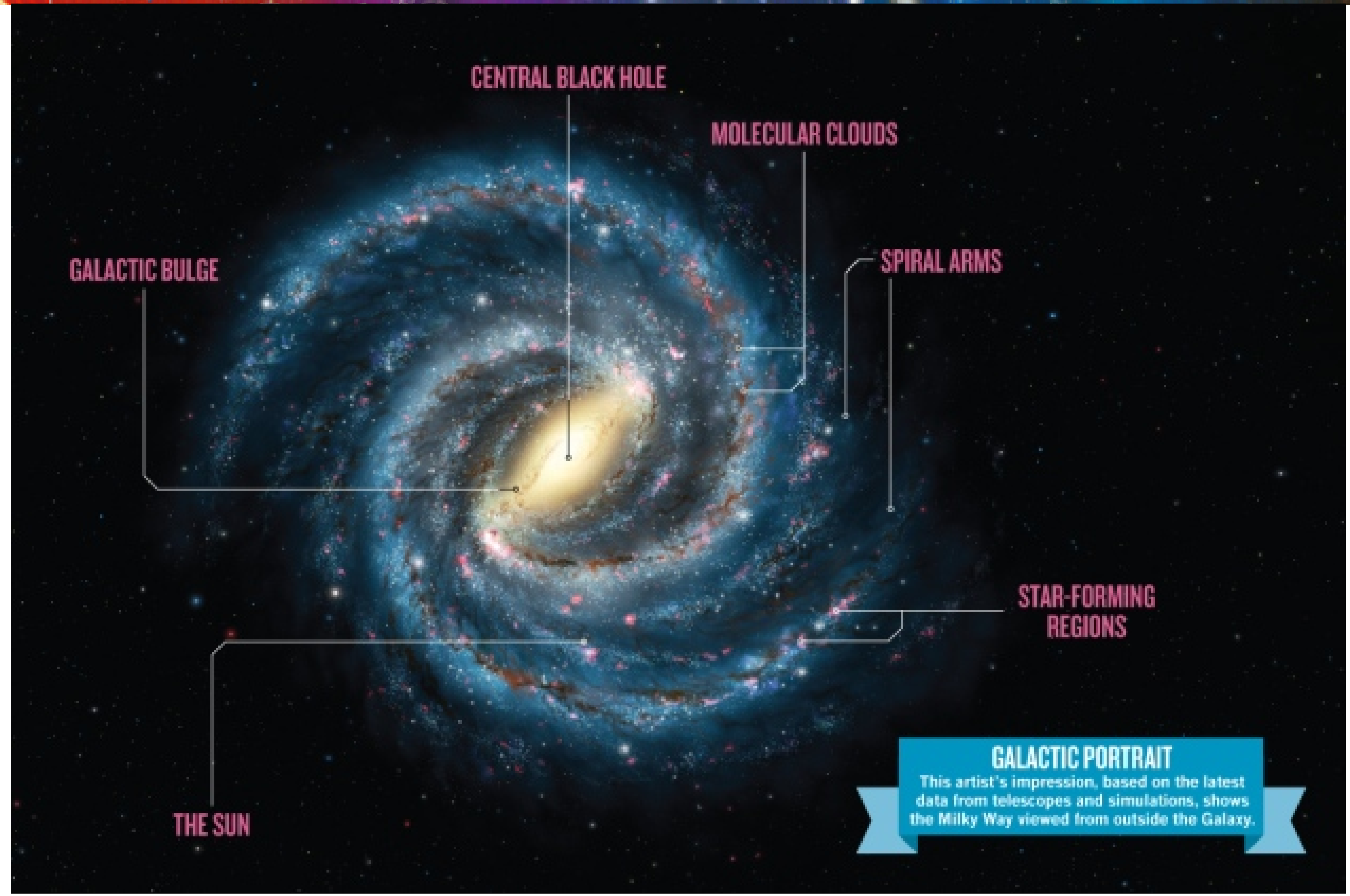


http://en.wikipedia.org/wiki/File:Infrared-visible_light_comparison_of_VISTA's_gigapixel_view_of_the_centre_of_the_Milky_Way.ogv

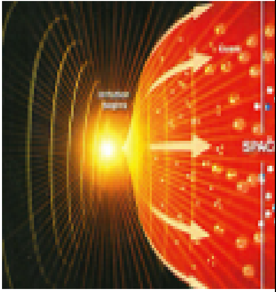

SPACE
TIME

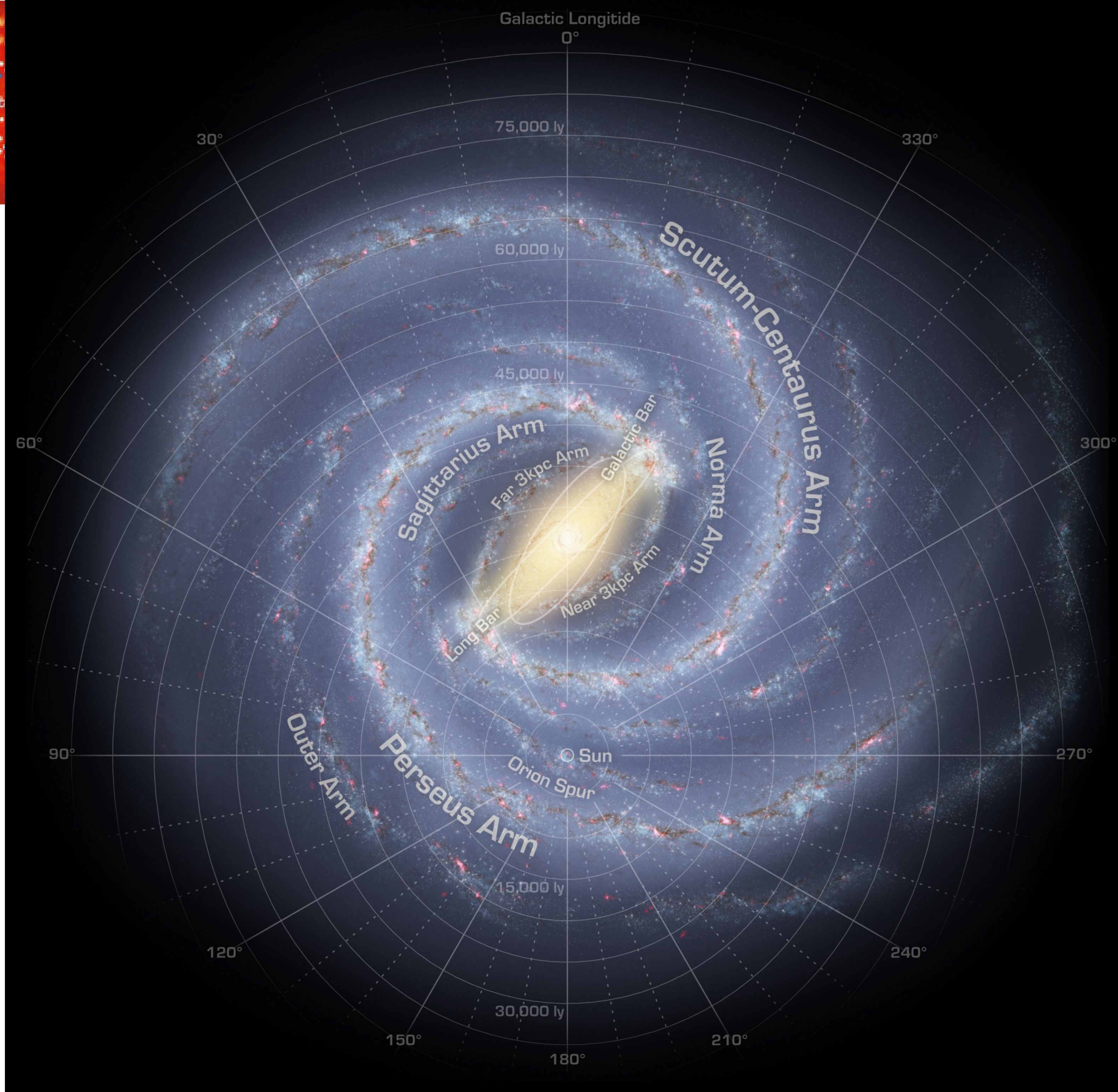

A Roadmap to the Milky Way
(artist's concept)
NASA / JPL-Caltech / R. Hurt (SSC-Caltech)
ssc2008-10a

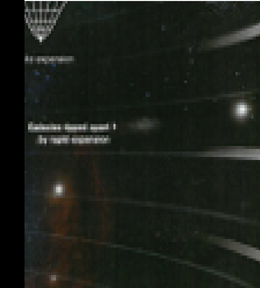


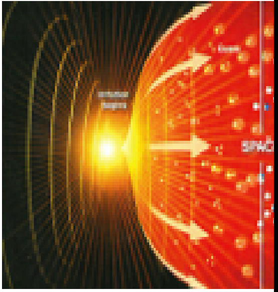


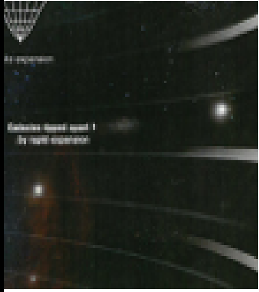
http://www.nature.com/news/galaxy-formation-the-new-milky-way-1.11517#/mw1

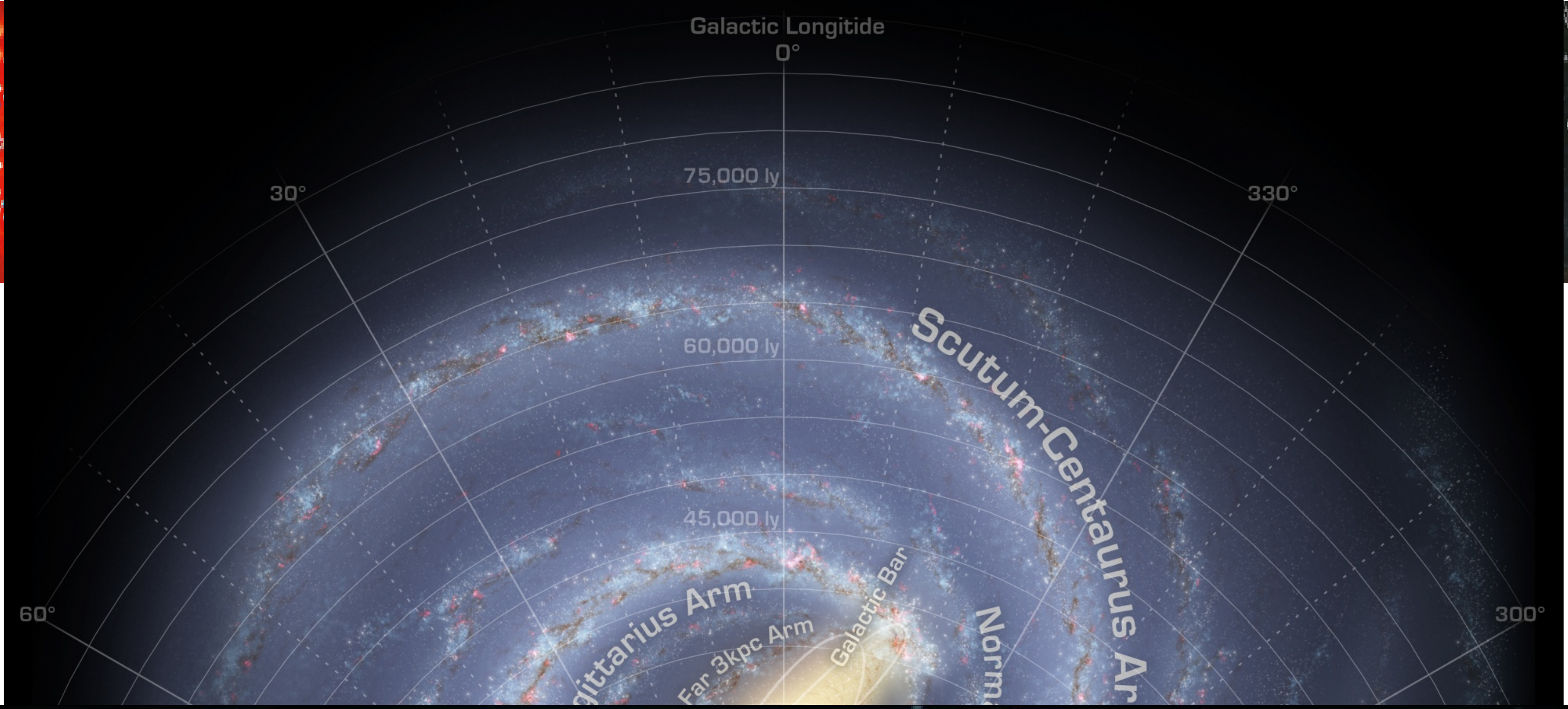


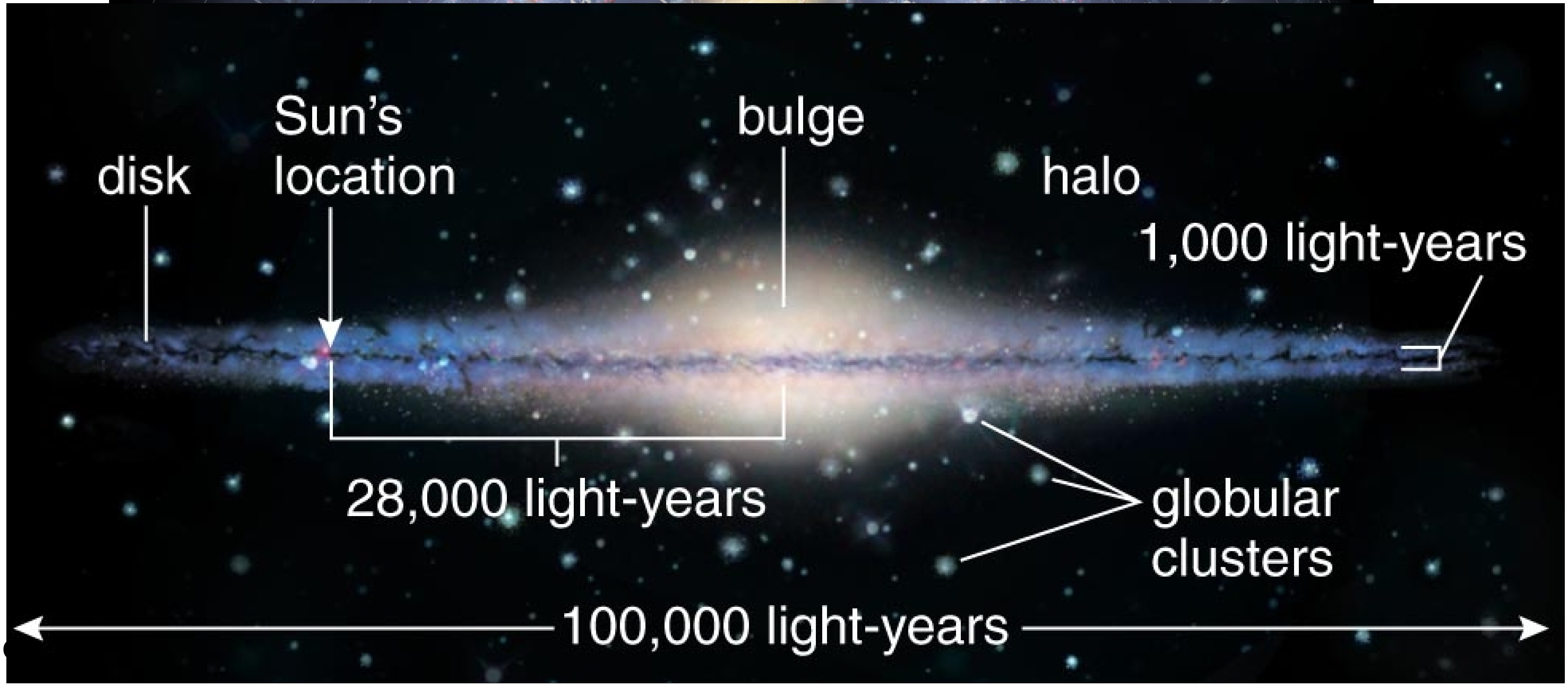

Galactic Longitide
0°
75,000 ly
30°
330°
60,000 ly
Scutum-Centaurus Arm
45,000 ly
Sagittarius Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
60°
300°
Near 3kpc Arm
Long Bar
Outer Arm
Perseus Arm
90°
Sun
Orion Spur
270°
15,000 ly
120°
240°
30,000 ly
150°
210°
180°

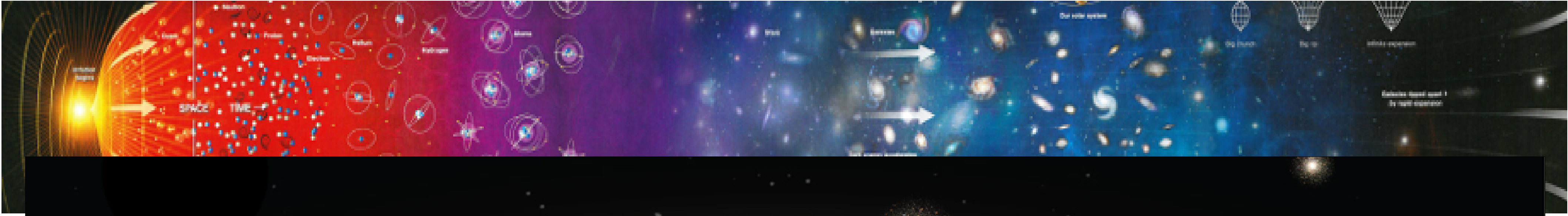


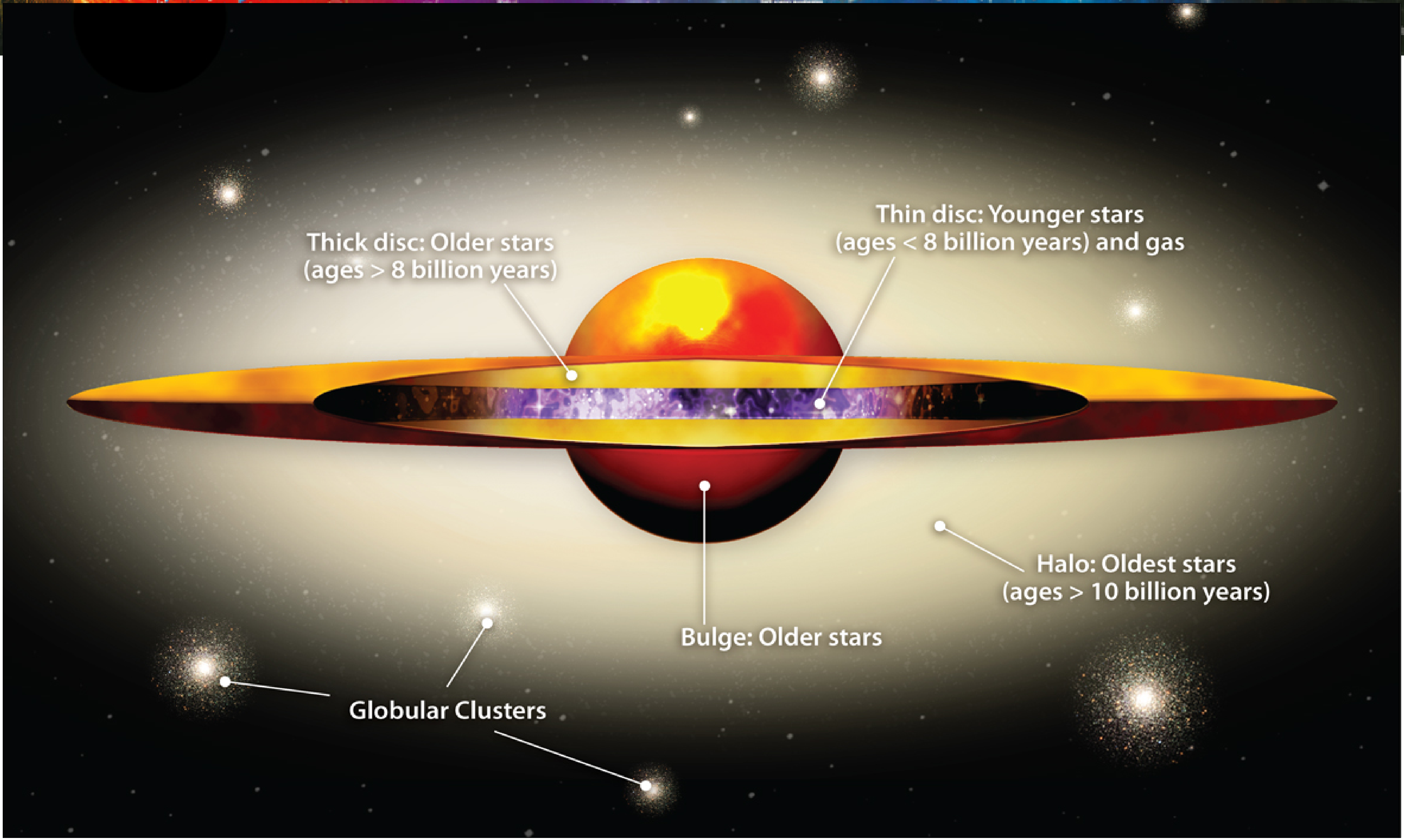


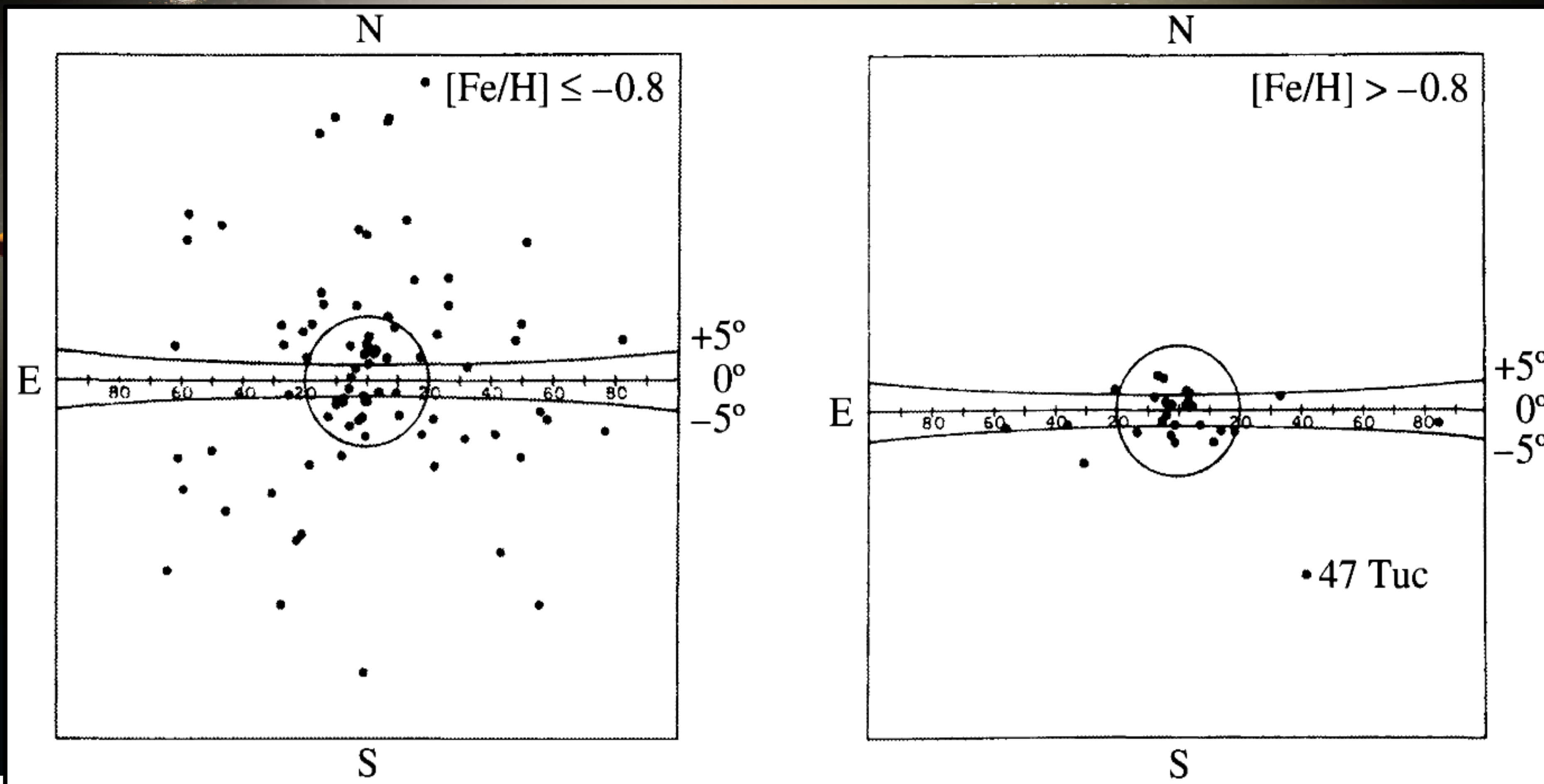



Galactic Longitide
0°
30°
330°
75,000 ly
60,000 ly
45,000 ly
60°
300°
Far 3kpc Arm
Galactic Bar

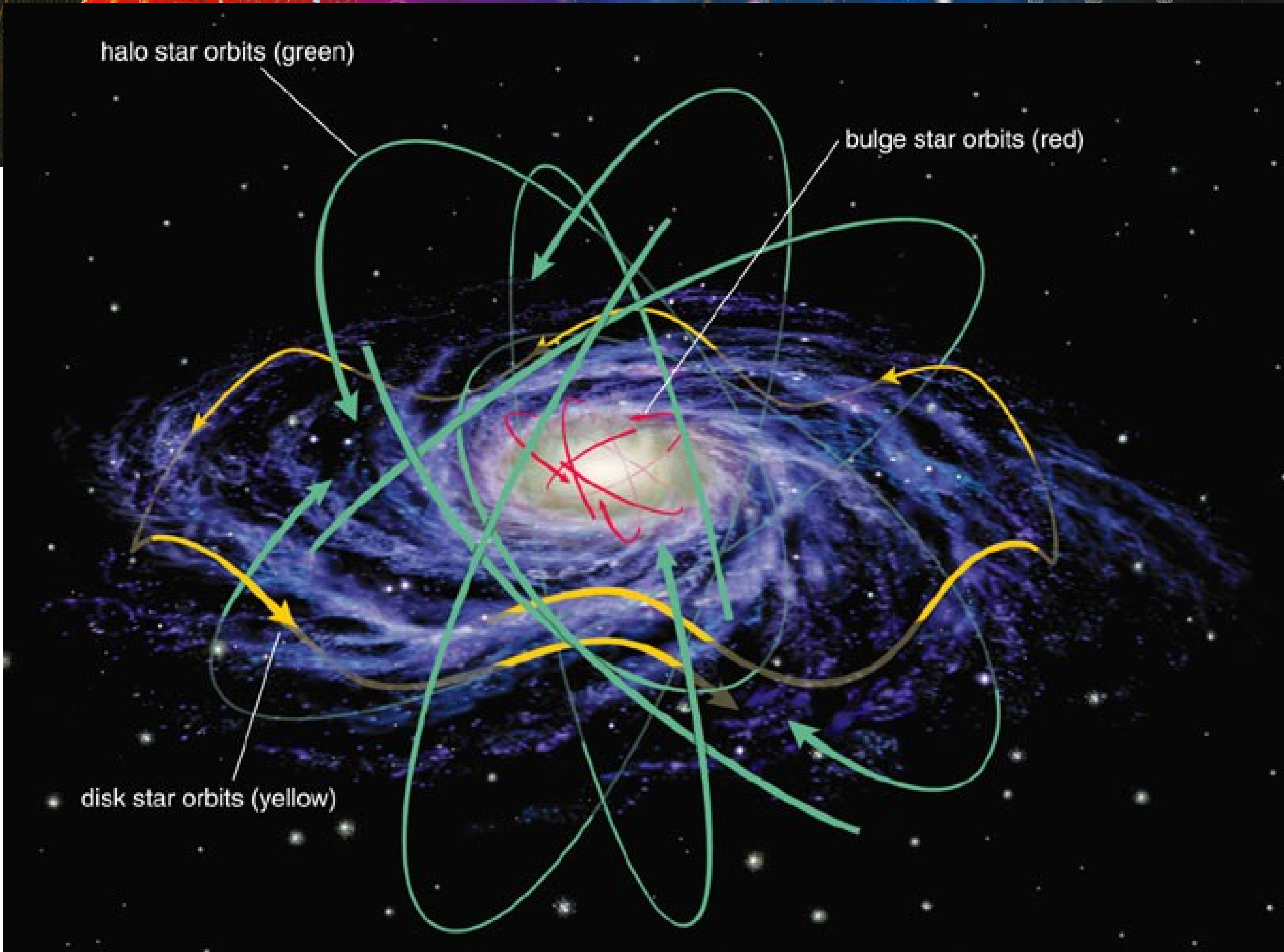

disk
Sun's location
bulge
halo
1,000 light-years
28,000 light-years
globular clusters
100,000 light-years



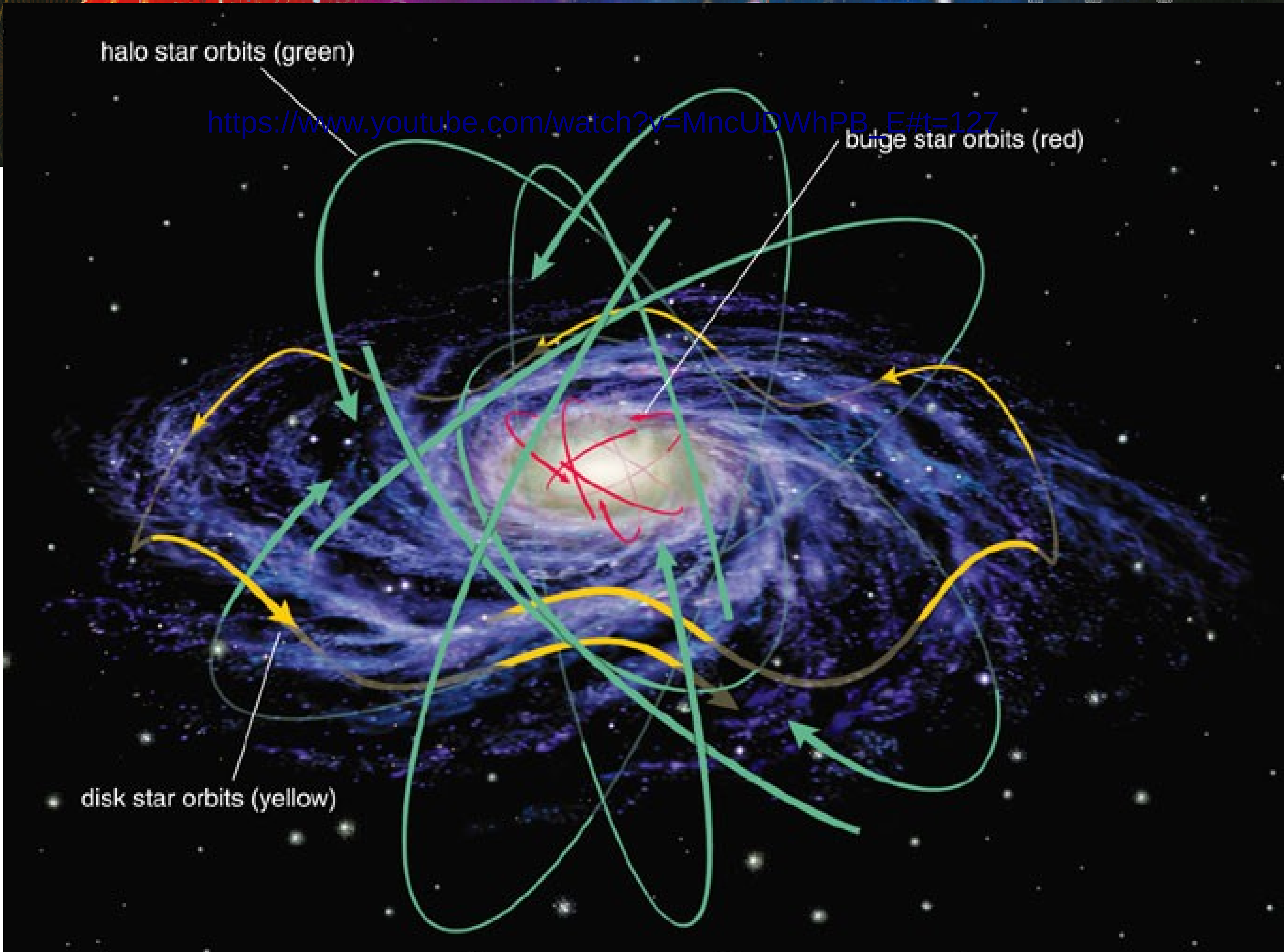

Thick disc: Older stars
(ages > 8 billion years)
Thin disc: Younger stars
(ages < 8 billion years) and gas
Halo: Oldest stars
(ages > 10 billion years)
Bulge: Older stars
Globular Clusters



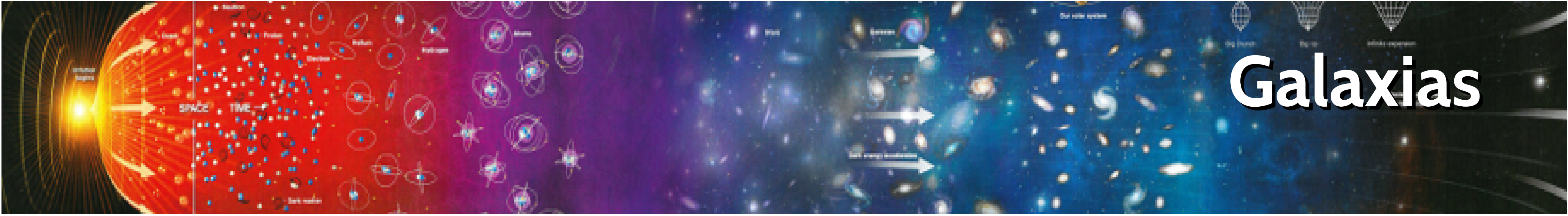
N
[Fe/H] ≤ −0.8
E
+5°
0°
−5°
80
60
40
20
20
40
60
80
S
N
[Fe/H] > −0.8
E
+5°
0°
−5°
80
60
40
20
20
40
60
80
47 Tuc
S


halo star orbits (green)
bulge star orbits (red)
disk star orbits (yellow)

https://www.youtube.com/watch?v=MncUDWhPB_E#t=127



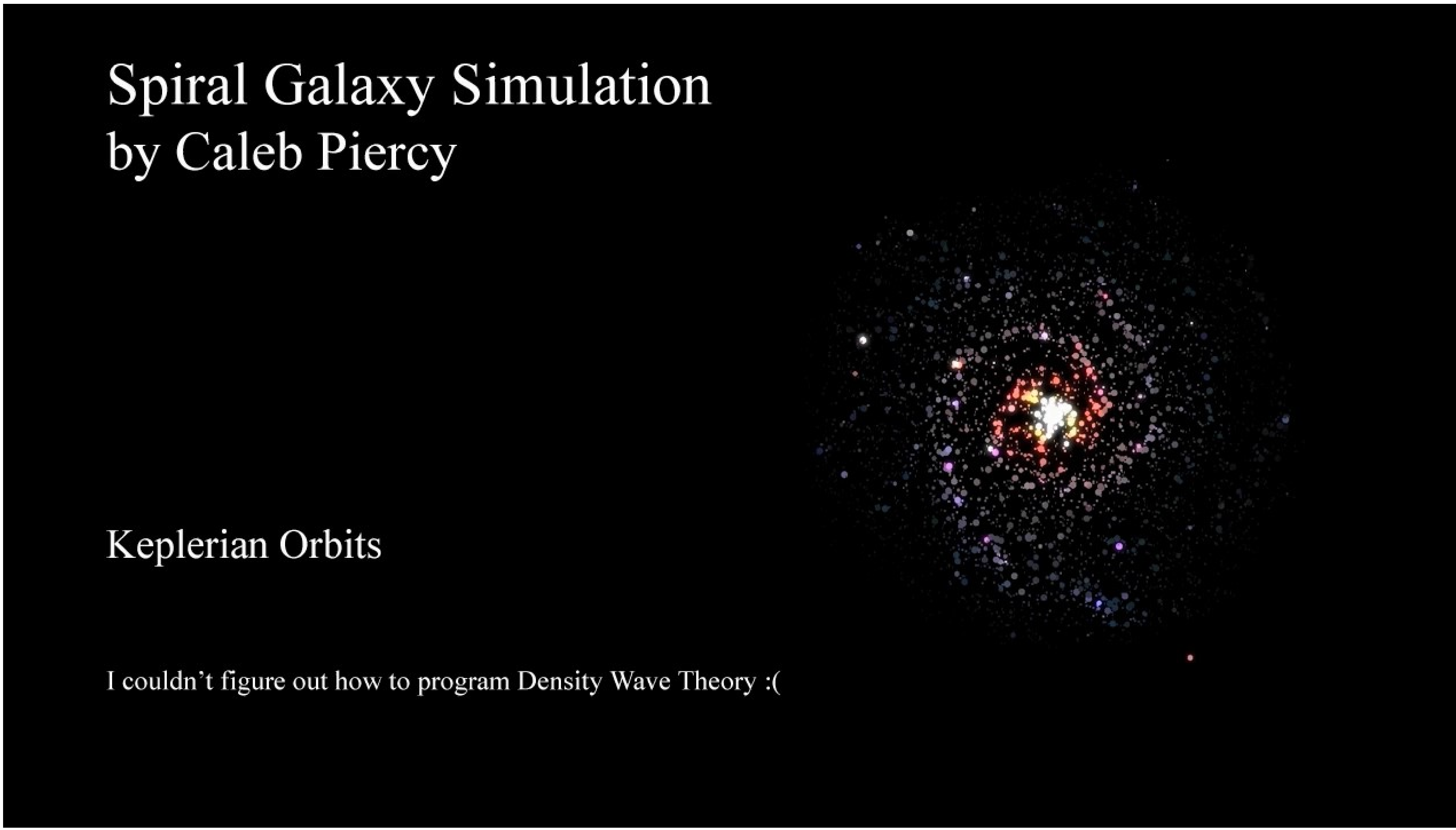
Si Andrómeda fuera más brillante...

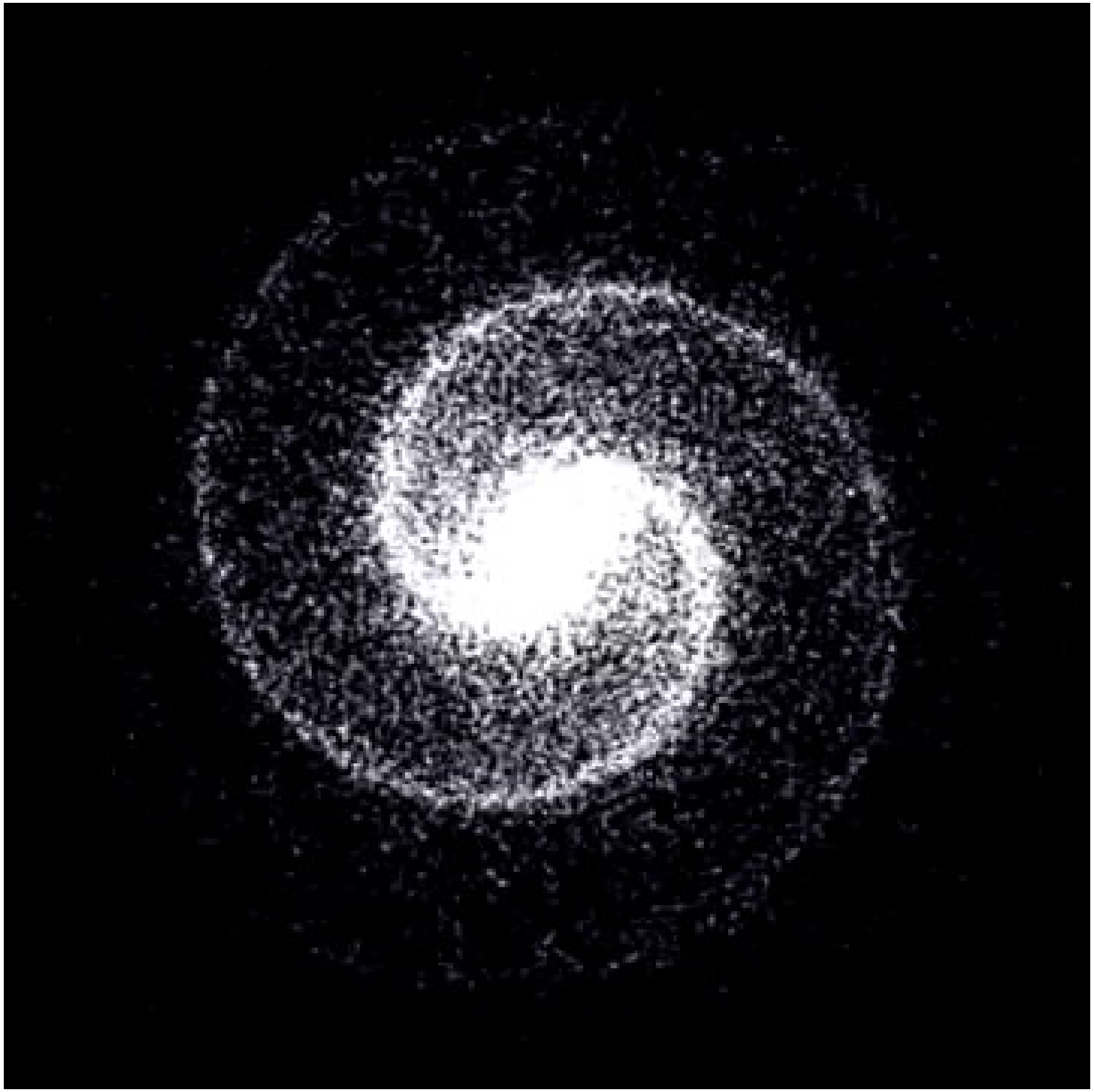


Galaxias

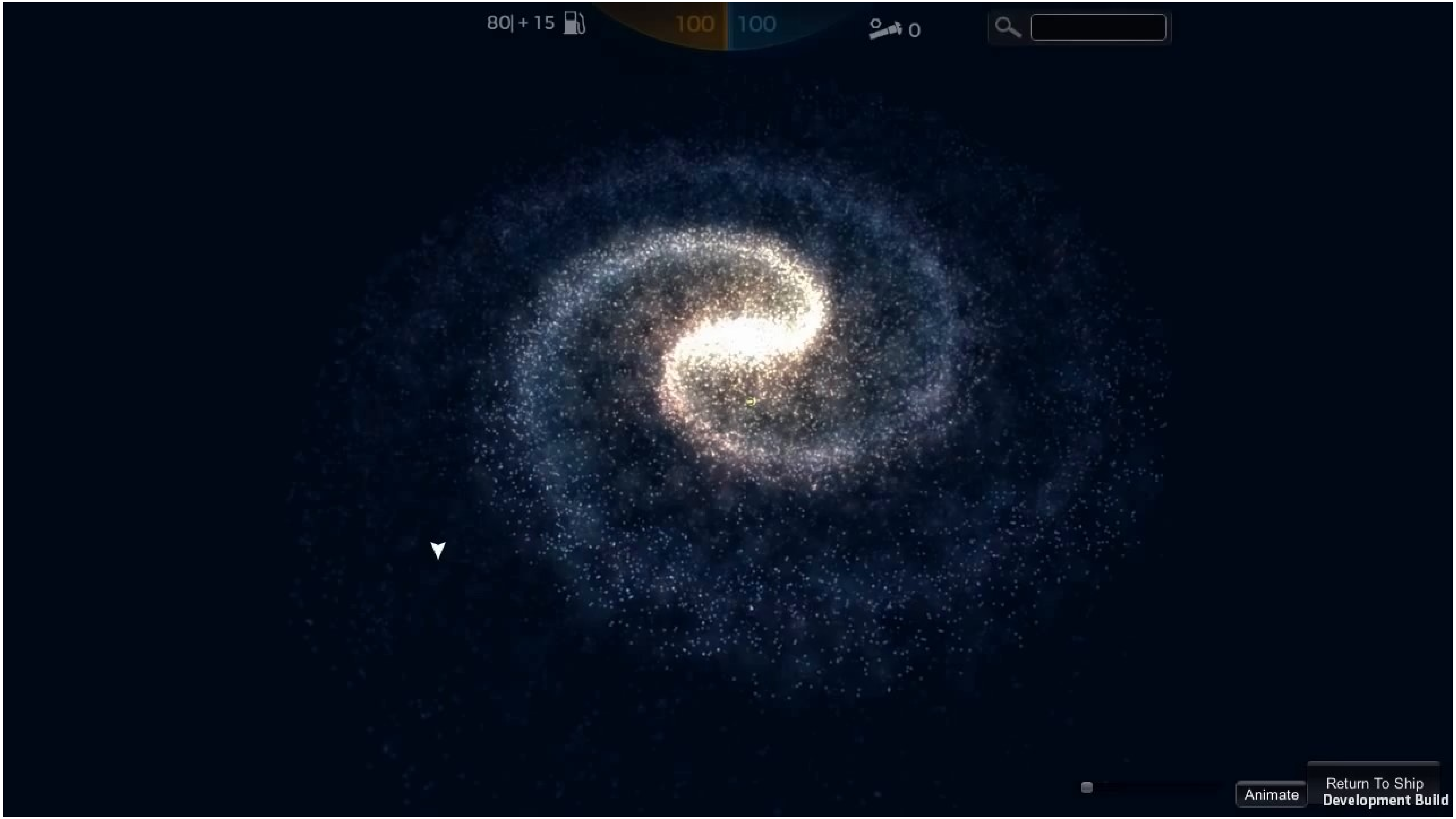
- Una **galaxia es un sistema autogravitatorio que se compone de:**
  - Estrellas
  - Remanentes estelares
  - Un medio interestelar formado por gas y polvo...
  - ... y materia oscura
- **Tamaños:**
  - Enanas (~1000 estrellas, 1000 pc)
  - Gigantes (100000 pc, 10^{14} estrellas)
- Y están separadas por distancias ~Megaparsec

Brazos Espirales → si fuera sólo Kepler



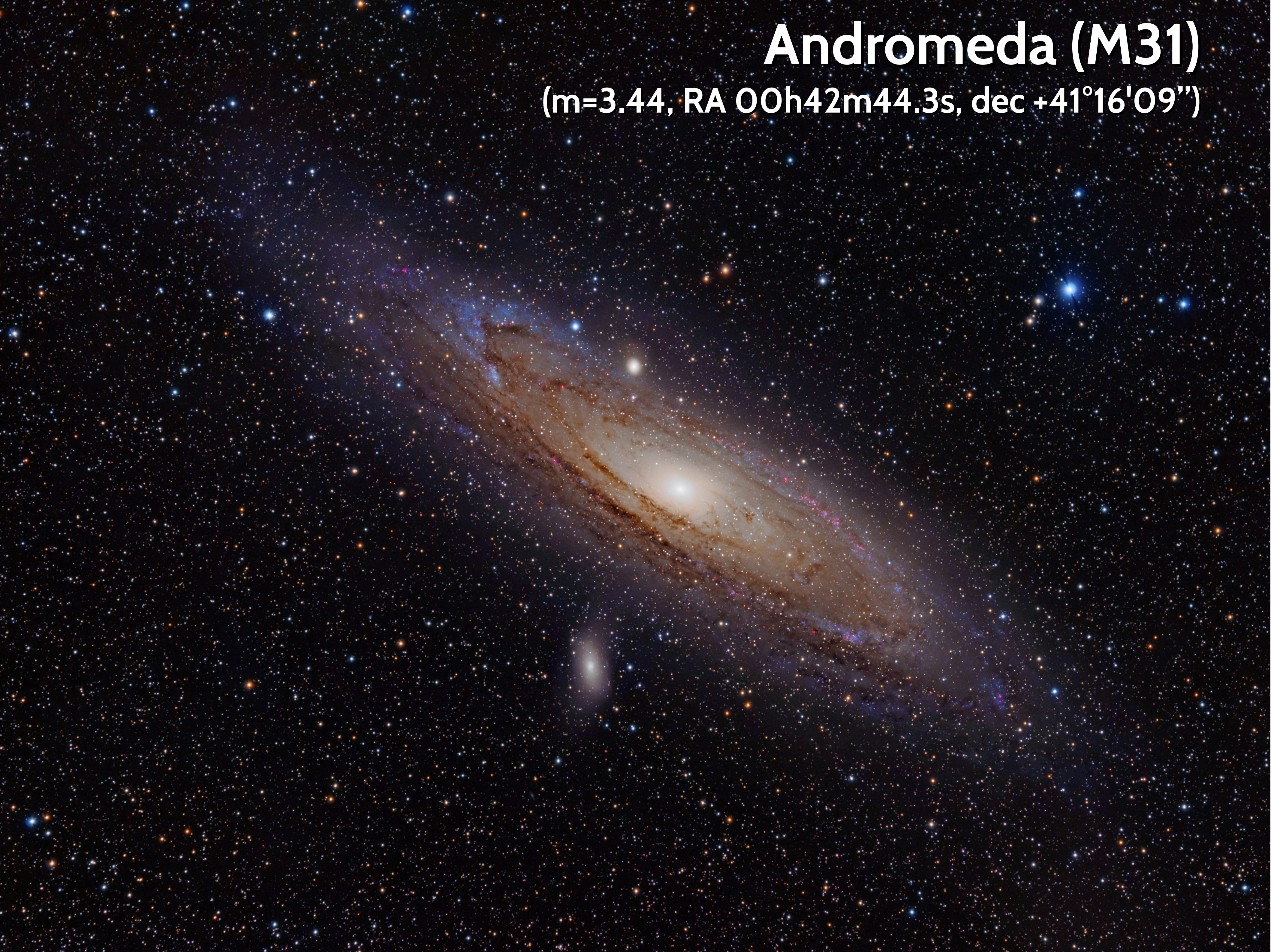


Brazos espirales → atracción entre vecinos



Andromeda (M31)

(m=3.44, RA 00h42m44.3s, dec +41°16'09")



Andromeda (M31)

(m=3.44, RA 00h42m44.3s, dec +41°16'09")

- Ubicada a 780 kpc
- Visible con binoculares (noches sin luna y oscuras a simple vista como una mancha borrosa)
- Es la galaxia más masiva del Grupo Local: $1.5 \times 10^{12}\ M_S$