



Universidad Nacional de Río Negro

Int. Partículas, Astrofísica & Cosmología - 2017

- **Unidad** 03 – Cosmología
- **Clase** UO3C01 – 13
- **Fecha** 07 Nov 2017
- **Cont** Galaxias
- **Cátedra** Asorey
- **Web** github.com/asoreyh/unrn-ipac
www.facebook.com/fisicareconocida/



Contenidos: un viaje en el tiempo

HOW DID OUR UNIVERSE BEGIN?

In the 20th century the universe became a story—a scientific one. It had always been seen as static and eternal. Then astronomers observed other galaxies flying away from ours, and Einstein's general relativity theory implied space itself was expanding—which meant the universe had once been denser. What had seemed eternal now had a beginning and an end. But what beginning? What end? Those questions are still open.

COSMIC QUESTIONS

Stars, dust and gas—the stuff we can discern—make up less than 5 percent of the universe. Their gravity can't account for how galaxies hold together. Scientists figure about 24 percent of the universe is a mysterious dark matter—perhaps exotic particles formed right after inflation. The rest is dark energy, an unknown energy field or property of space that counters gravity, providing an explanation for observations that the expansion of space is accelerating.

WHAT IS OUR UNIVERSE MADE OF?

The Universe
71.5% Dark energy
24% Dark matter
4% Gas
0.5% Planets and stars

HOW DID OUR UNIVERSE BEGIN?

Infation
In less than a nanosecond a massive energy field inflates space by a factor of a thousand. This fills it with a soup of subatomic particles called quarks.
Age: 10^{-3} milliseconds
Size: Infinitesimal to golf ball

Early building blocks
The universe expands, cools. Quarks clump into protons and neutrons. Electrons begin orbiting blocks of atomic nuclei. Perhaps dark matter forms.
Age: 10^{-2} milliseconds
Size: 0.1 – 1 millionth present size

First nuclei
As the universe continues to cool, the light of hydrogen atoms begins to arise. This light is as far back as our instruments can see.
Age: $.01$ milliseconds
Size: $.01$ to 200 times present size

First atoms, first light
Quarks begin orbiting nuclei, creating atoms. The glow from their infrared radiation is unveiled. This light is as far back as our instruments can see.
Age: $.0009$ years
Size: $.0009$ present size

The "dark ages"
For 300 million years this continues. As electrons begin orbiting nuclei, creating atoms, the glow from their infrared radiation is unveiled. This light is as far back as our instruments can see.
Age: $.0009$ to $.300$ million years
Size: $.0009$ to 0.1 present size

Gravity wins: first stars
Dense gas clouds collapse under their own gravity. Clumps of dark matter form galaxies and stars. Fusion lights up the stars.
Age: $.300$ to $.380$ million years
Size: $.1$ present size

Antigravity wins
After being slowed for billions of years, dark energy overcomes gravity, causing cosmic expansion to accelerate again. The culprit: dark energy. Its nature: unclear.
Age: $.380$ to 10 billion years
Size: $.77$ present size

Today
The universe continues to expand, becoming ever less dense. As a result, fewer new stars and galaxies are forming.
Age: 10 billion years
Size: 13.8 billion years
Our solar system

Dark energy acts

HOW WILL IT END?

Which will win in the end, gravity or antigravity? Is the density of matter enough for gravity to halt or even reverse cosmic expansion, leading to a big crunch? It seems unlikely—especially given the power of dark energy, a kind of antigravity. Perhaps the acceleration in expansion caused by dark energy will trigger a big rip that shreds everything, from galaxies to atoms. If not, the universe may expand for hundreds of billions of years, long after all stars have died.

Big crunch
Big rip
Infinite expansion
Galaxies ripped apart by rapid expansion

Unidad 3 Cosmología
No es lo que se ve
Sino lo que se palpa

WHAT IS THE SHAPE OF OUR UNIVERSE?

Einstein discovered that a star's gravity curves space around it. But is the whole universe curved? Might space close up on itself like a sphere or curve the other way, opening out like a saddle? By studying cosmic background radiation, scientists have found that the universe is poised between the two: just dense enough with just enough gravity to be almost perfectly flat, at least the part we can see. What lies beyond we can't know.

DO WE LIVE IN A MULTIVERSE?

What came before the big bang? Maybe other big bangs. The uncertainty principle holds that even the vacuum of space has density fluctuations. Inflation theory says our universe exploded from such a fluctuation—a random event that, odds are, had happened many times before. Our cosmos may be one in a sea of others just like ours—or nothing like ours. These other cosmos will very likely remain forever inaccessible to observation; their possibilities limited only by our imagination.

Unidad 2 Astrofísica
Cálido y frío

Unidad 1 Partículas 1
todo es relativo

By through the universe on our digital edition

LONDON PHOTOS: ANDREW TAYLOR; GENEVA: SWITZERLAND: ART MONTAGNA DESIGN; SOURCES: CHARLES BENNETT, JOHN HESTER, ANDREW LINSLEY, ANDREW LINSLEY, UNIVERSITY OF CHICAGO; COURTESY OF CERN, NATIONAL GEOGRAPHIC SOCIETY



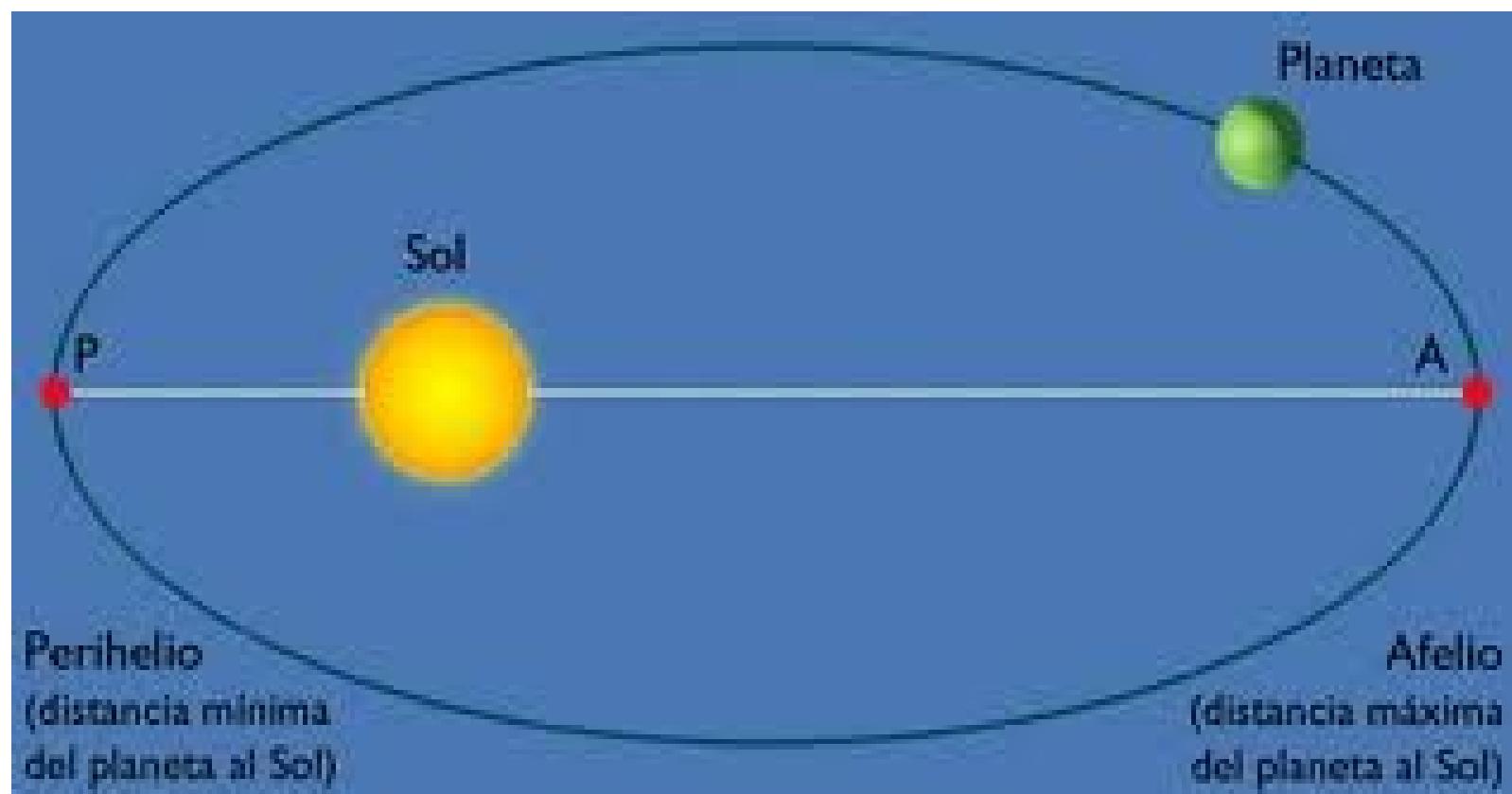
U3: no es lo que se ve, sino lo que se palpa

4 encuentros: del 10/Oct al 31/Oct

- Relatividad General
 - Introducción y conceptos básicos,
 - Modelo de Friedman-Lemaître-Robertson-Walker
 - El error de Einstein
- Modelos del Universo
 - Formación de estructuras
 - Midiendo distancias
 - Corrimiento al rojo
 - El universo en expansión

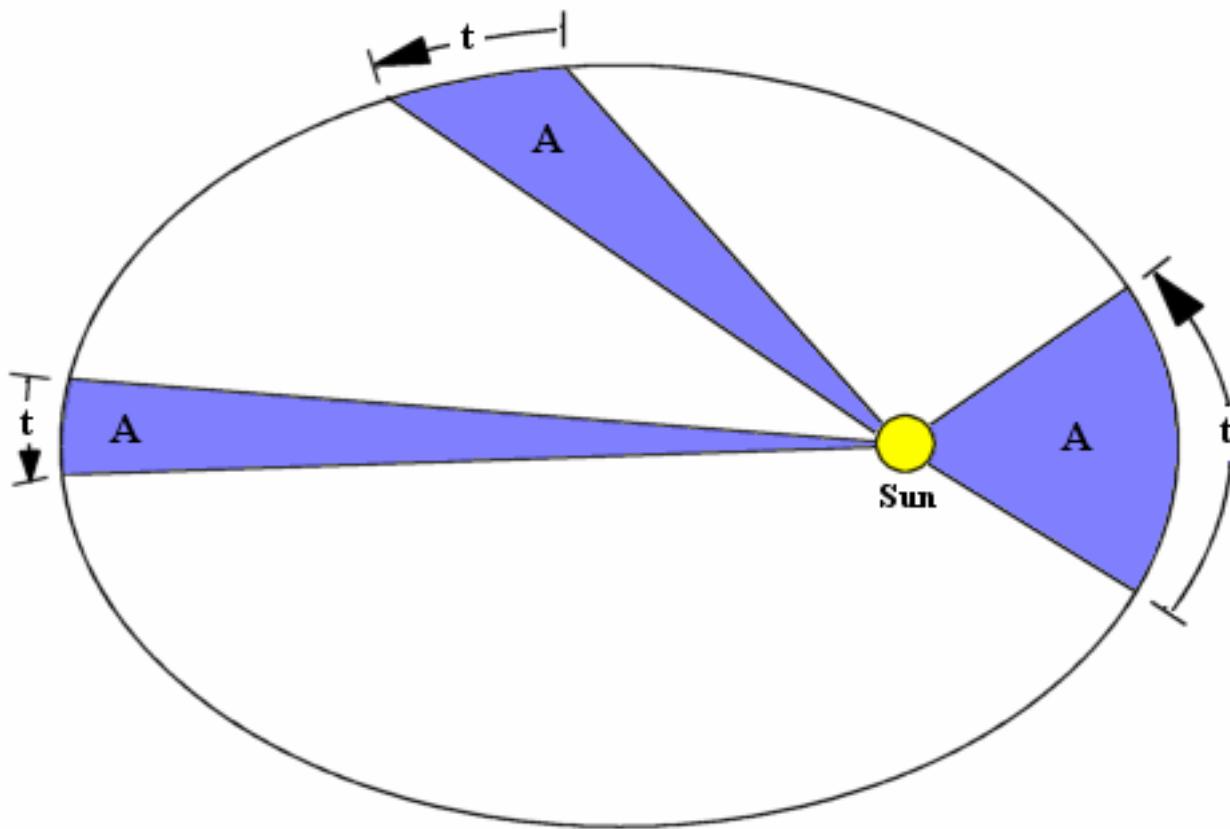
Primera ley: Movimiento cerrado

Primera Ley (1609): Los planetas se desplazan alrededor del Sol describiendo órbitas elípticas. El Sol se sitúa en uno de los focos.



Segunda ley: Conservación Cant. Mov. Angular

Segunda Ley (1609): El radio vector que une el planeta y el Sol barre áreas iguales en tiempos iguales



$$\frac{A}{t} = \text{cte} \Rightarrow \frac{A_1}{t} = \frac{A_2}{t}$$

$$\frac{b_1 \times r_1}{2t} = \frac{b_2 \times r_2}{2t}$$

$$\frac{v_1 t \times r_1}{t} = \frac{v_2 t \times r_2}{t}$$

$$v_1 r_1 = v_2 r_2$$

$$m v_1 r_1 = m v_2 r_2$$

$$\Rightarrow L_1 = L_2 \Rightarrow L = \text{cte}$$

$$\text{y además } v_1 = v_2 \frac{r_2}{r_1}$$

$$\text{Si } r_1 < r_2 \Rightarrow v_1 > v_2$$



Tercera Ley

Tercera Ley (1618): El cuadrado del período orbital (tiempo que tarda en dar una vuelta alrededor del Sol, T) es directamente proporcional al cubo de la distancia media al Sol (a, igual al semieje mayor de la elipse).

$$T^2 = k_{\text{Sol}} a^3$$

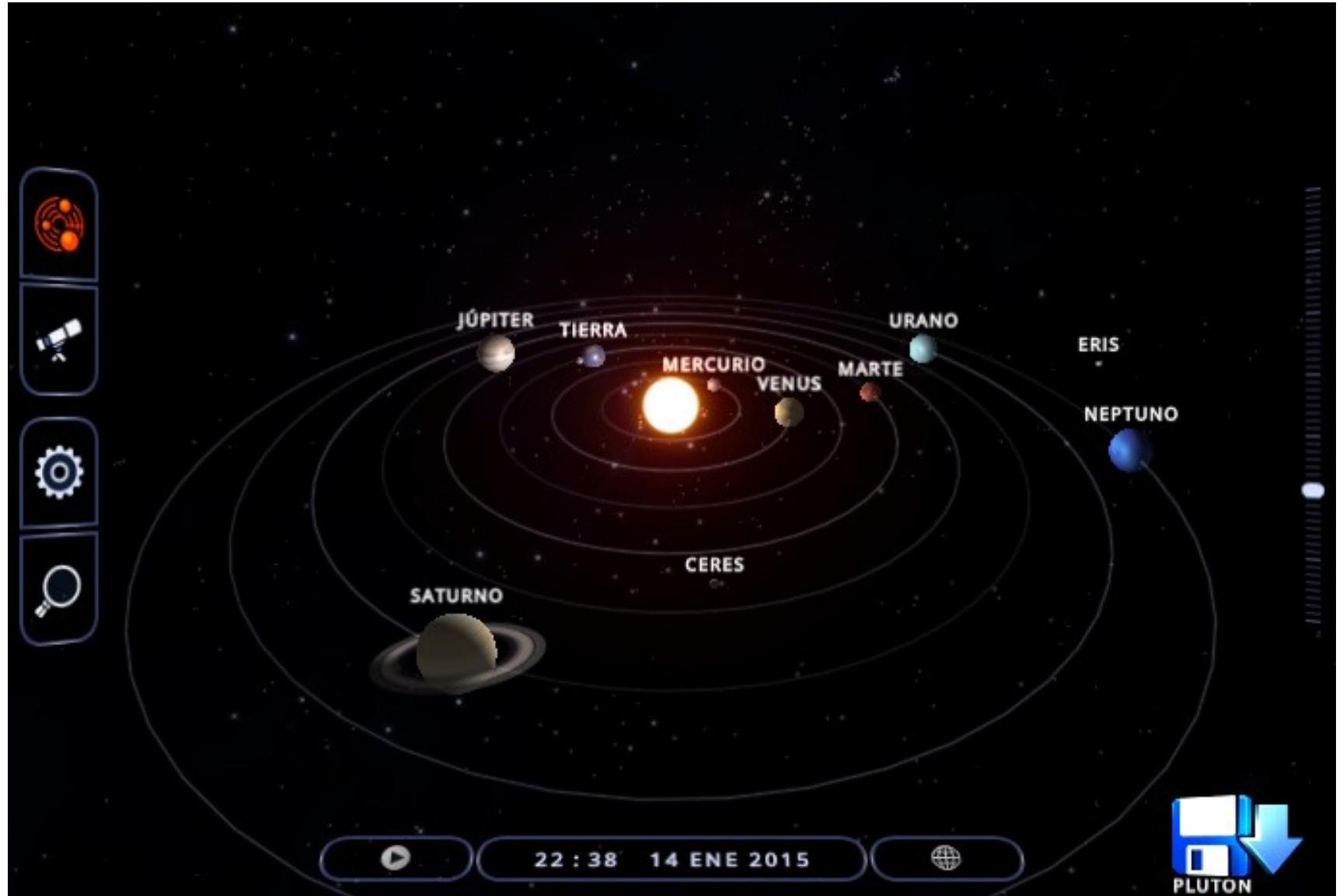
Calcule k_{Sol} y $1/k_{\text{Sol}}$ en unidades del SI (m y s) y en años y unidades astronómicas

$$\frac{T^2}{a^3} = \left(\frac{4\pi^2}{G m_{\text{Sol}}} \right) \equiv k_{\text{Sol}}$$

Recuerde que esta constante sólo depende de la masa del Sol y, por lo tanto, es la misma para TODOS los objetos que orbitan al Sol.

"Solar System Scope"

<https://www.solarsystemscope.com/>



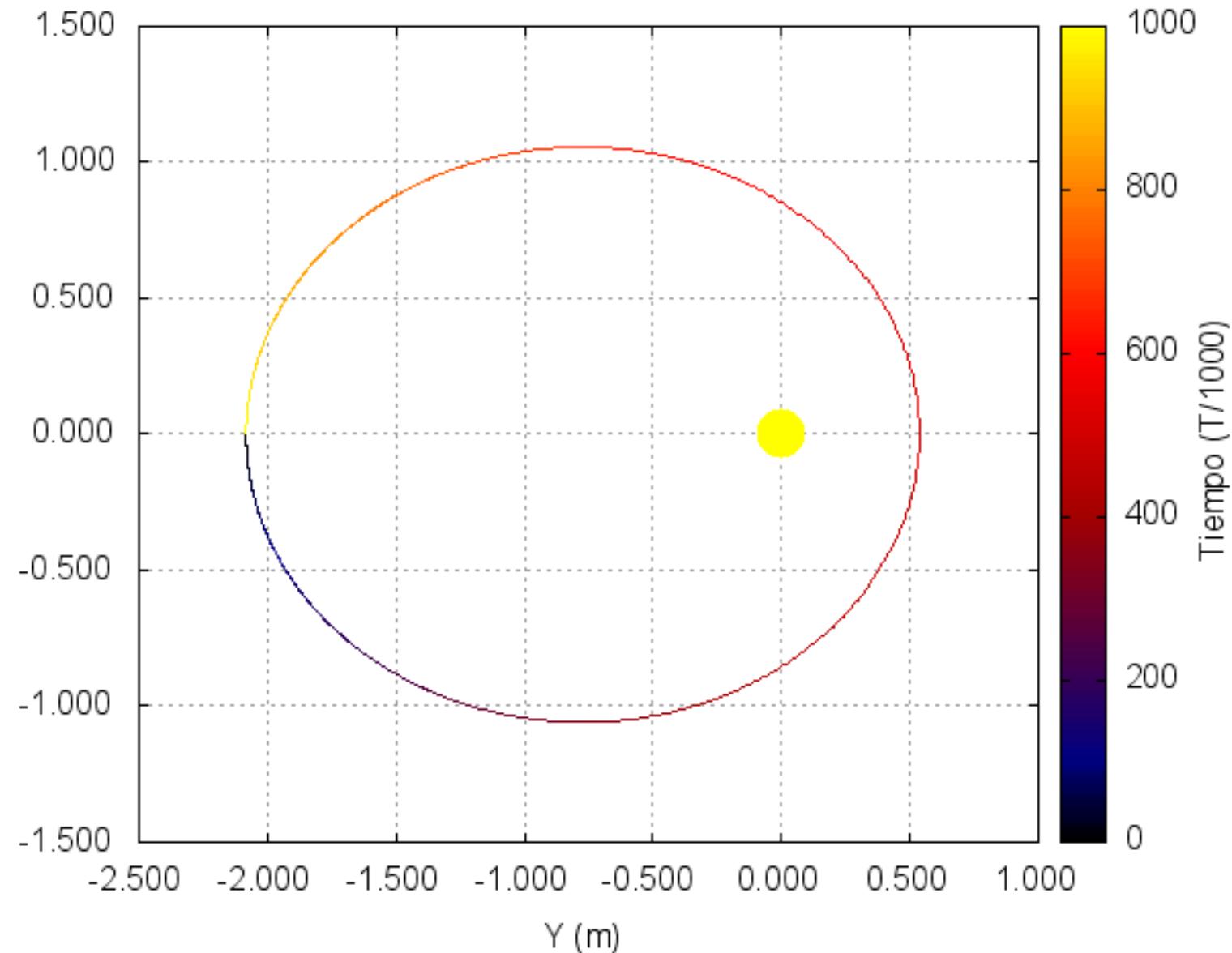


Tercera Ley

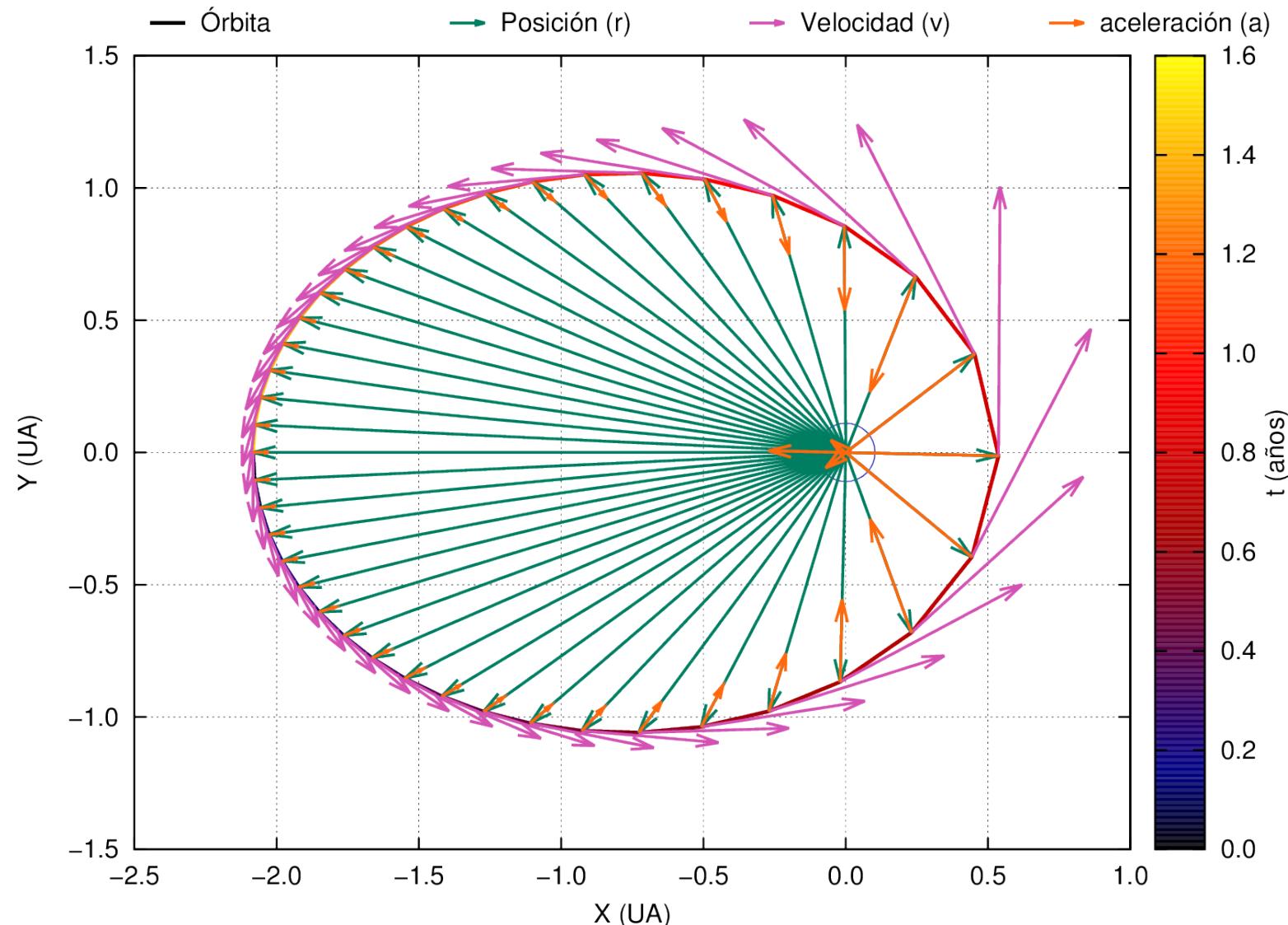
- Y vale para cualquier sistema orbital. Por ejemplo
 - calcule la masa de la Tierra sabiendo que el periodo orbital lunar es de 27,4 días y la distancia media es $a=384800$ km
 - calcule el radio de la órbita de lo sabiendo que su periodo orbital es de 43h y la masa de Júpiter es 1.899×10^{27} kg.

$$\frac{T^2}{a^3} = \left(\frac{4\pi^2}{G m_{\text{central}}} \right)$$

Algo más “tangible”

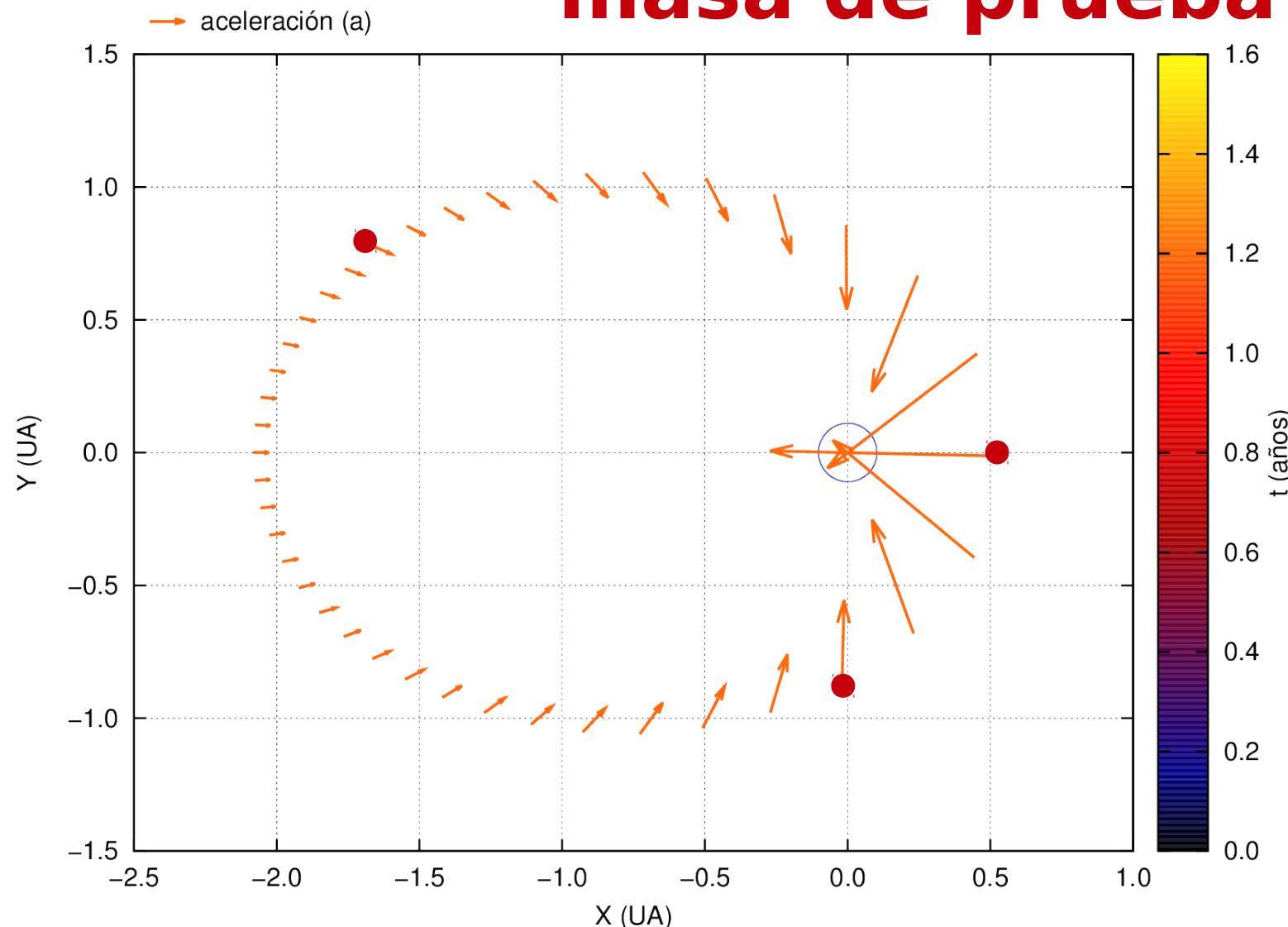


Órbita+posición+velocidad+aceleración



aceleración=Fuerza / masa

masa de prueba





Exoplanetas

<http://exoplanets.org/>

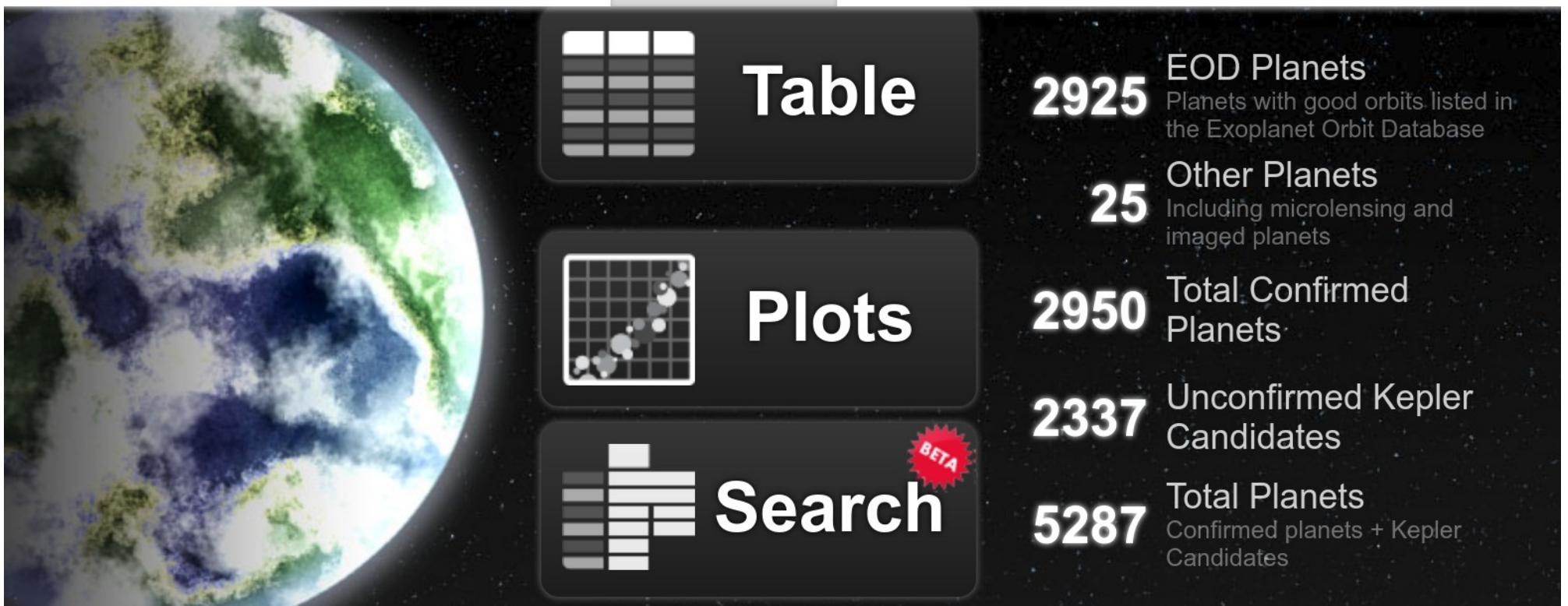
exoplanets.org

Exoplanets
Data Explorer

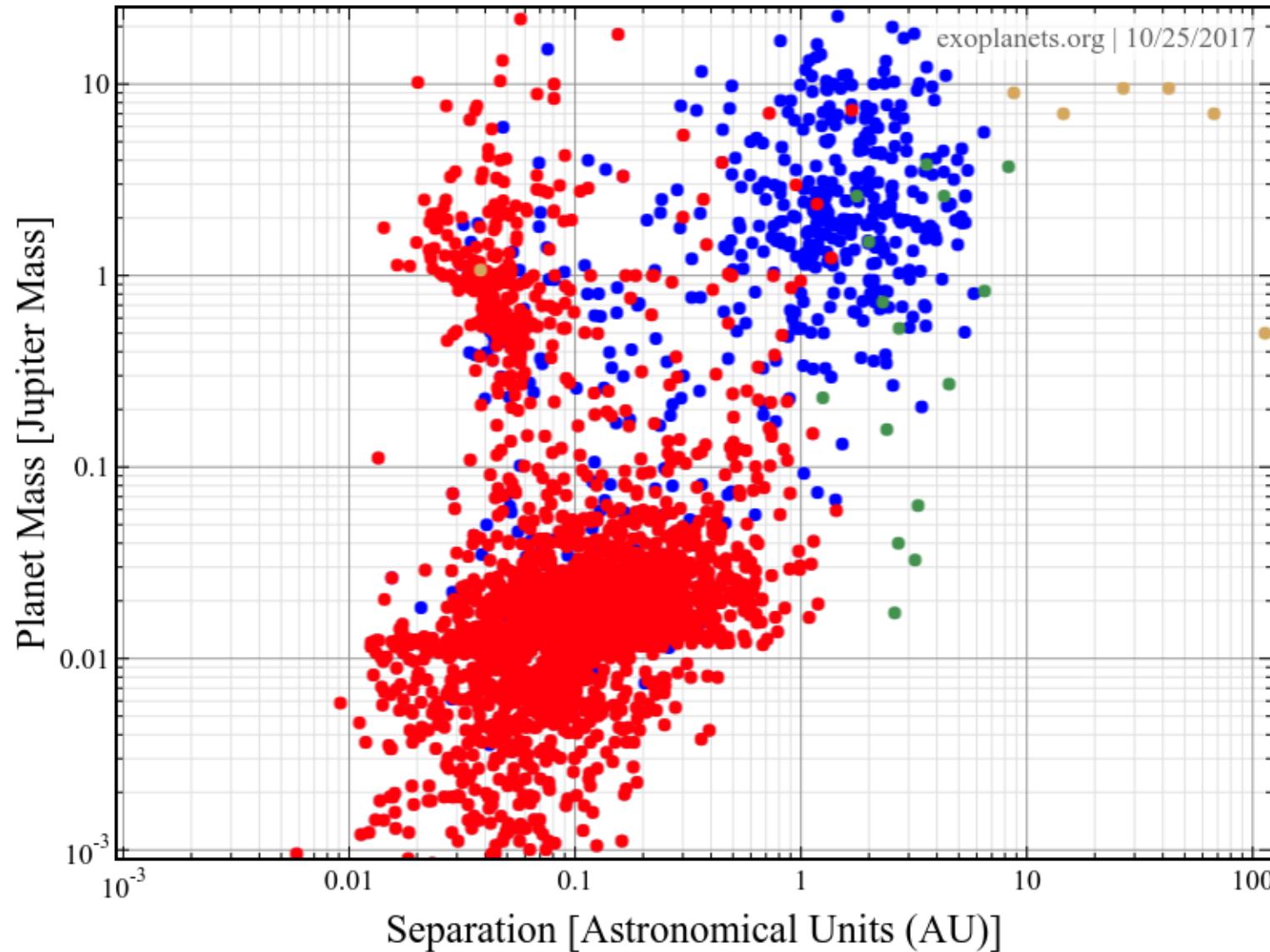
Methodology
and FAQ

Exoplanets
Links

California
Planet Survey



Masa vs separación





Pero si hay otros planetas, hay vida?



- Astrobiología.

astrobiología

De *astro-* y *biología*.

1. f. Rama interdisciplinar de la ciencia cuyo objetivo es el origen, evolución y distribución de vida en el universo fuera de la Tierra.



¿Vida? 18 acepciones

- Gracias rae: tantas palabras y cero contenido... ;-)

vida

Del lat. *vita*.

1. f. Fuerza o actividad esencial mediante la que obra el ser que la posee.
2. f. Energía de los seres orgánicos.
3. f. Hecho de estar vivo. *Le debe la vida a un medicamento.*
4. f. Existencia de seres vivos en un lugar. *No es posible la vida en Marte.*
5. f. Ser vivo. *Hizo nacer la vida en este jardín.*
6. f. Manera de vivir. *Su hija les cambió la vida.*
7. f. Estado o condición a que está sujeta la manera de vivir de una persona. *Vida monacal, de soldado.*
8. f. Actividad que desarrolla una persona o una comunidad. *Vida política, social, sexual.*
9. f. Tiempo que transcurre desde el nacimiento de un ser hasta su muerte o hasta el presente. *Una larga vida.*
10. f. Duración de una cosa. *Un electrodoméstico de vida corta.*
11. f. Narración de los hechos principales de la **vida** de una persona. *Lee vidas de santos.*
12. f. Animación, vitalidad de una persona o de una cosa. *Esta ciudad tiene poca vida nocturna. Es un cuadro con mucha vida.*
13. f. Viveza o ardor, especialmente de los ojos.
14. f. Cosa que origina suma complacencia. *Esta brisa es la vida.*
15. f. Cosa que contribuye o sirve al ser o conservación de otra. *El agua es vida.*
16. f. Conjunto de los bienes necesarios para vivir. *La vida en esta ciudad es muy cara.*
17. f. Existencia después de la muerte.
18. f. Rel. Visión y gozo de Dios en el cielo. *Mejor vida. Vida eterna.*



¿qué es la vida?



Qué es la Vida? E. Schrödinger

- La vida no viola las leyes de la termodinámica, aumentan su complejidad a costa de aumentar la entropía general en los procesos que hacen parte de esta
- La química de la herencia debe basarse en secuencias aperiódicas con la necesidad de una secuencia informativa que debe ser transmitida



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





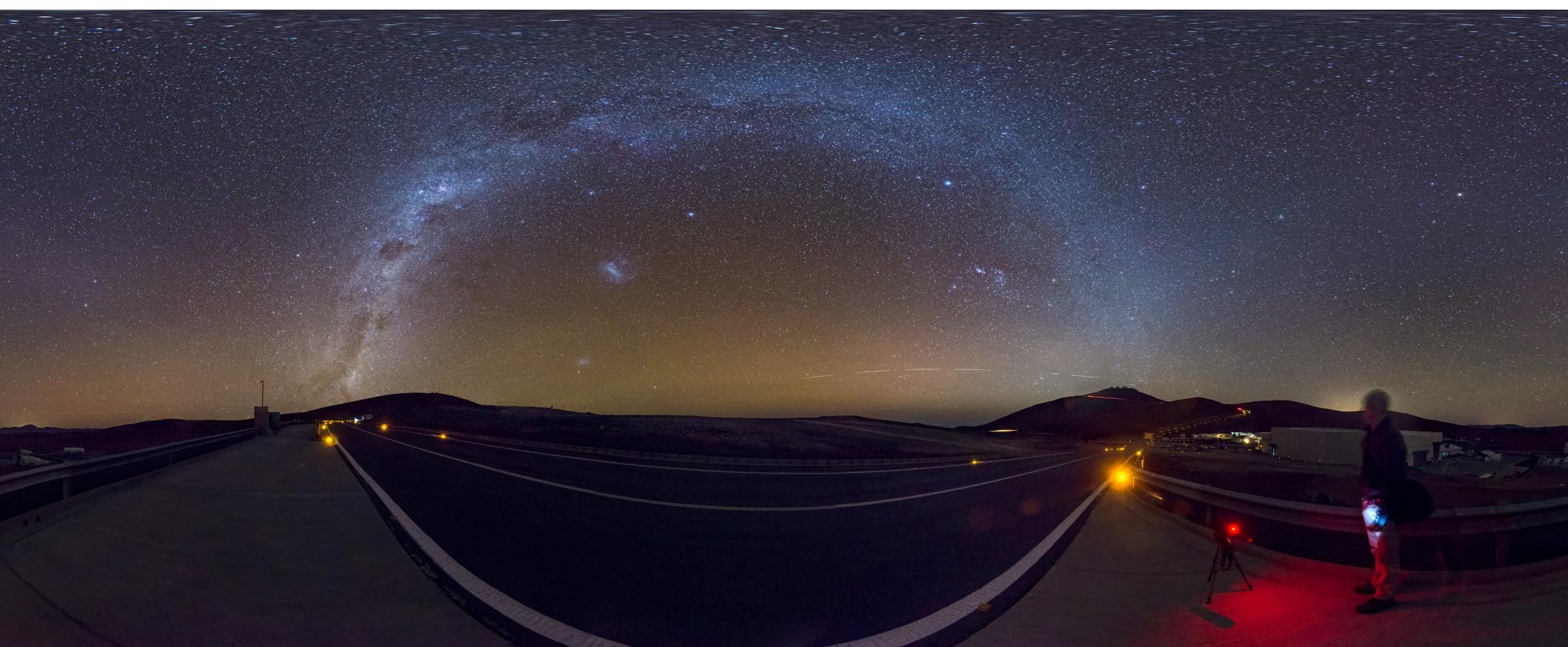
Galaxias

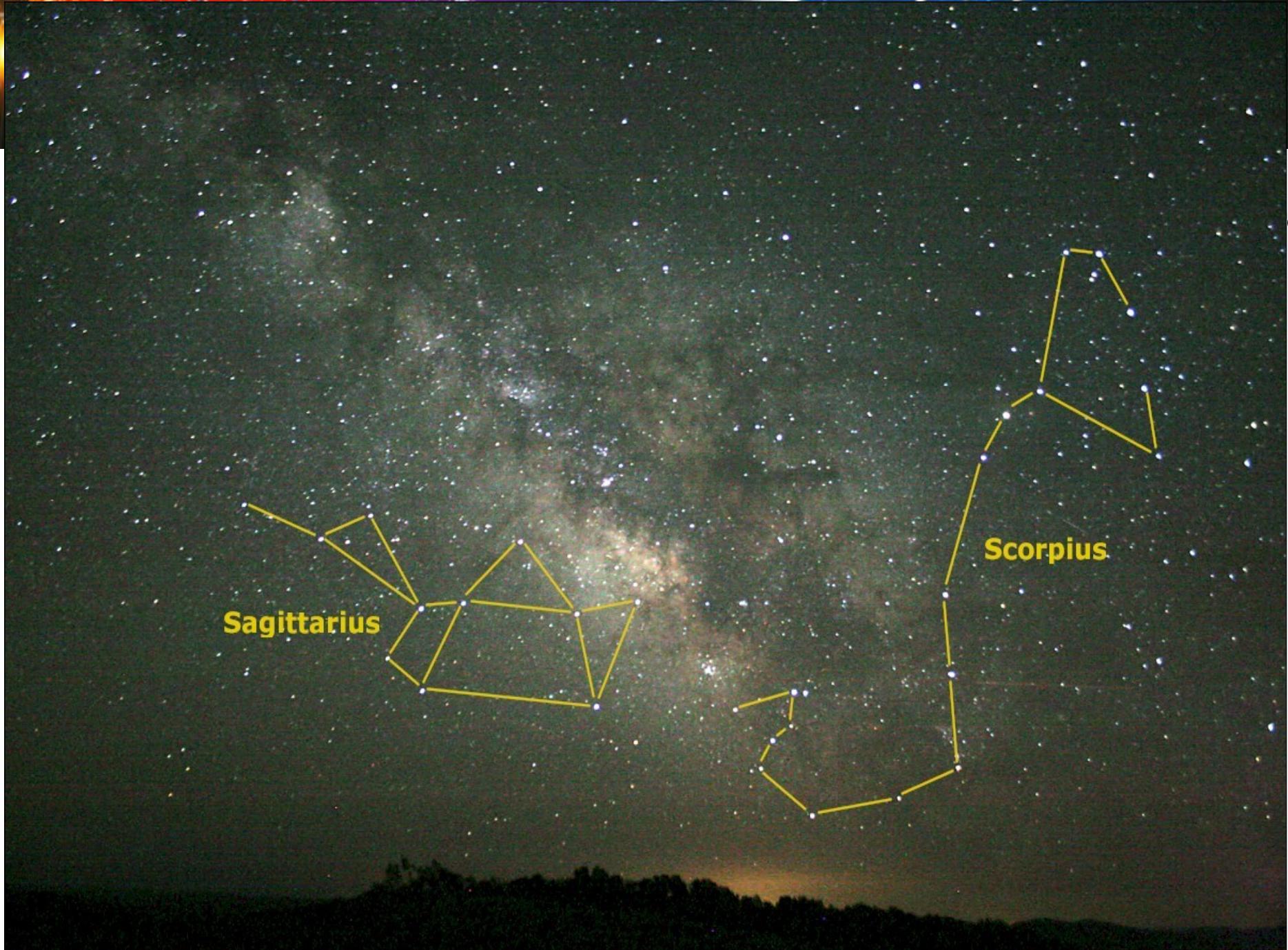
- Una **galaxia** es un sistema autogravitatorio que se compone de:
 - Estrellas
 - Remanentes estelares
 - Un medio interestelar formado por gas y polvo...
 - ... y materia oscura
- **Tamaños:**
 - Enanas (~1000 estrellas, 1000 pc)
 - Gigantes (100000 pc, 10^{14} estrellas)
- Y están separadas por distancias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

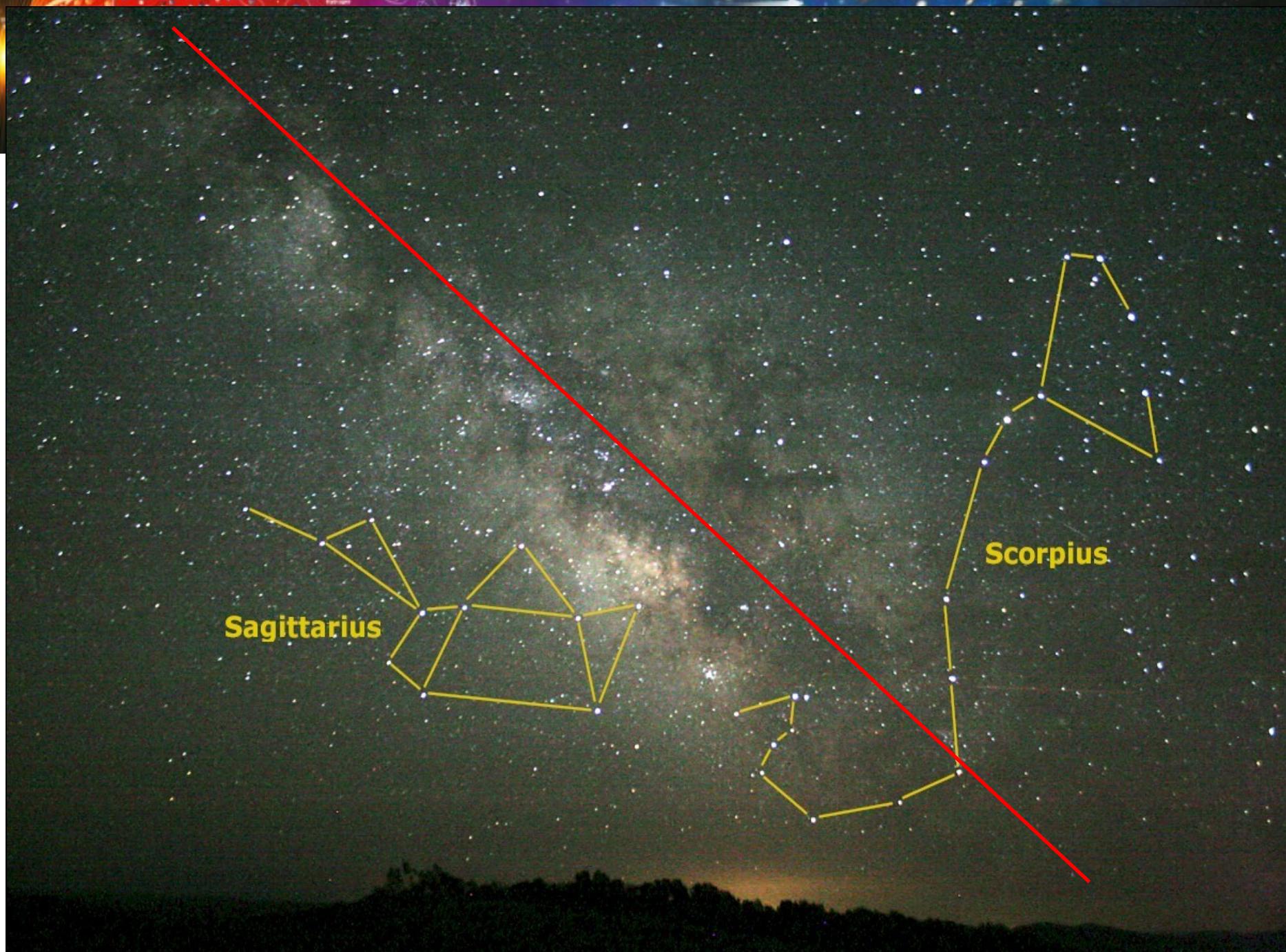




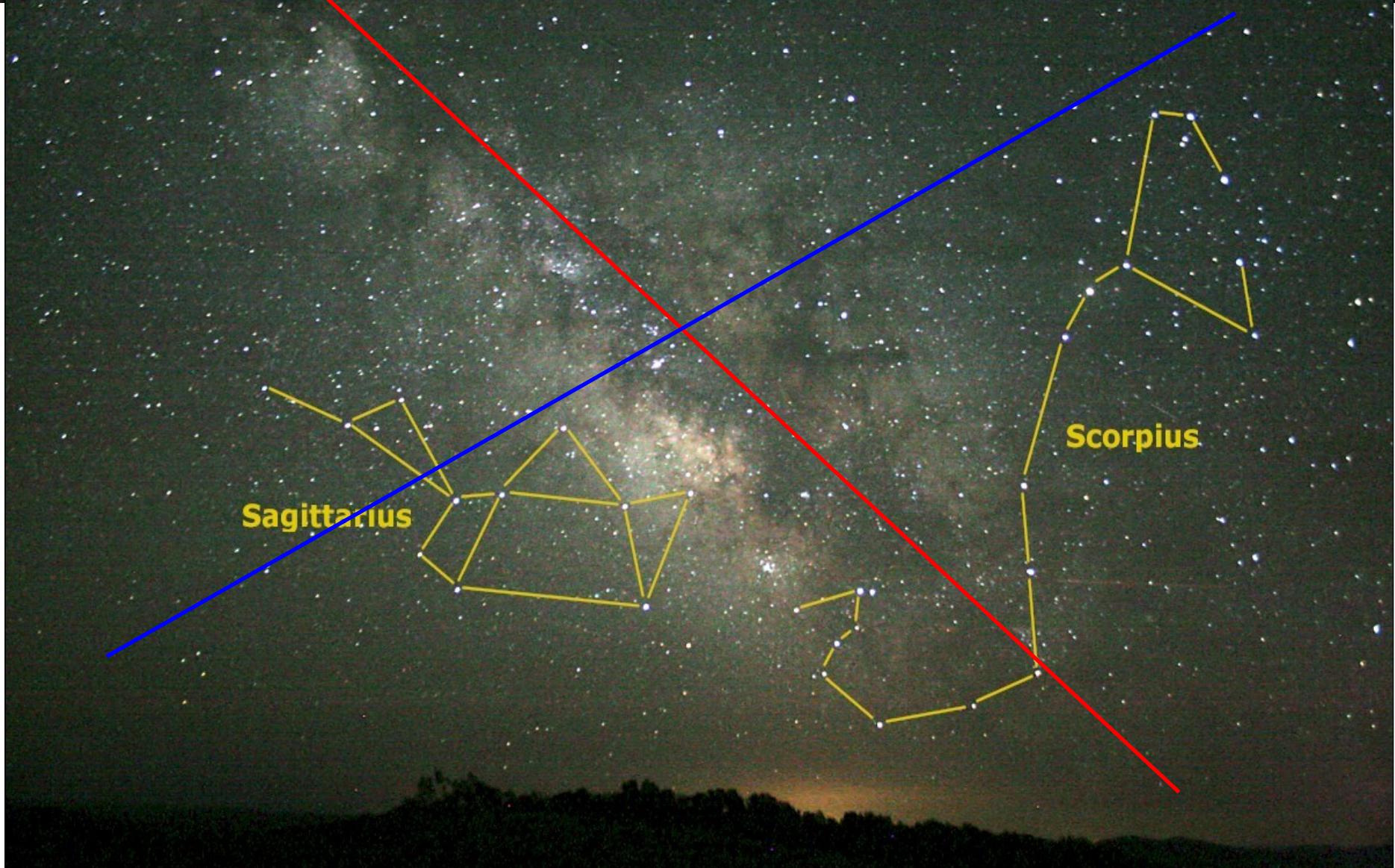
La Vía Láctea desde Cerro Paranal



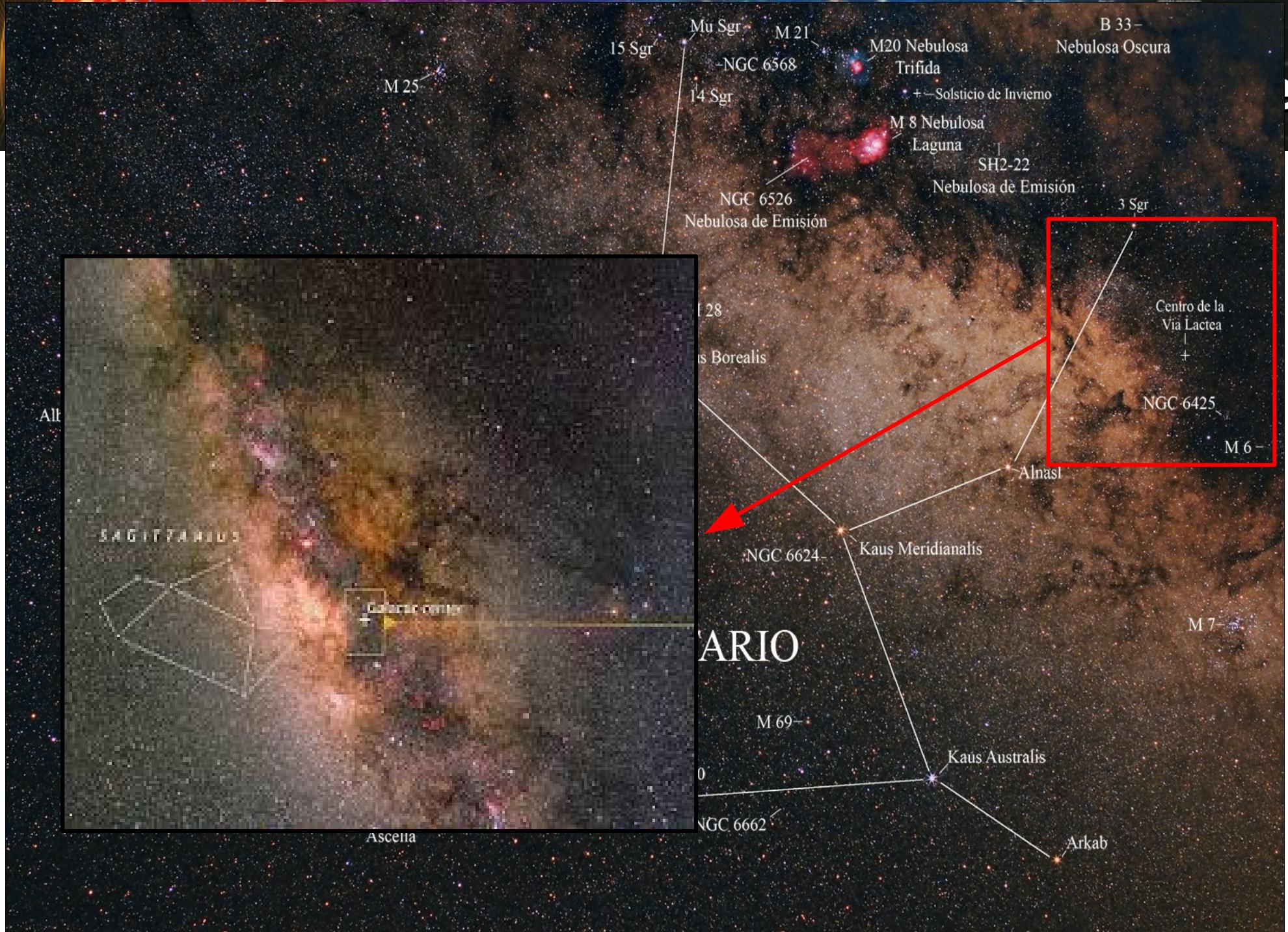


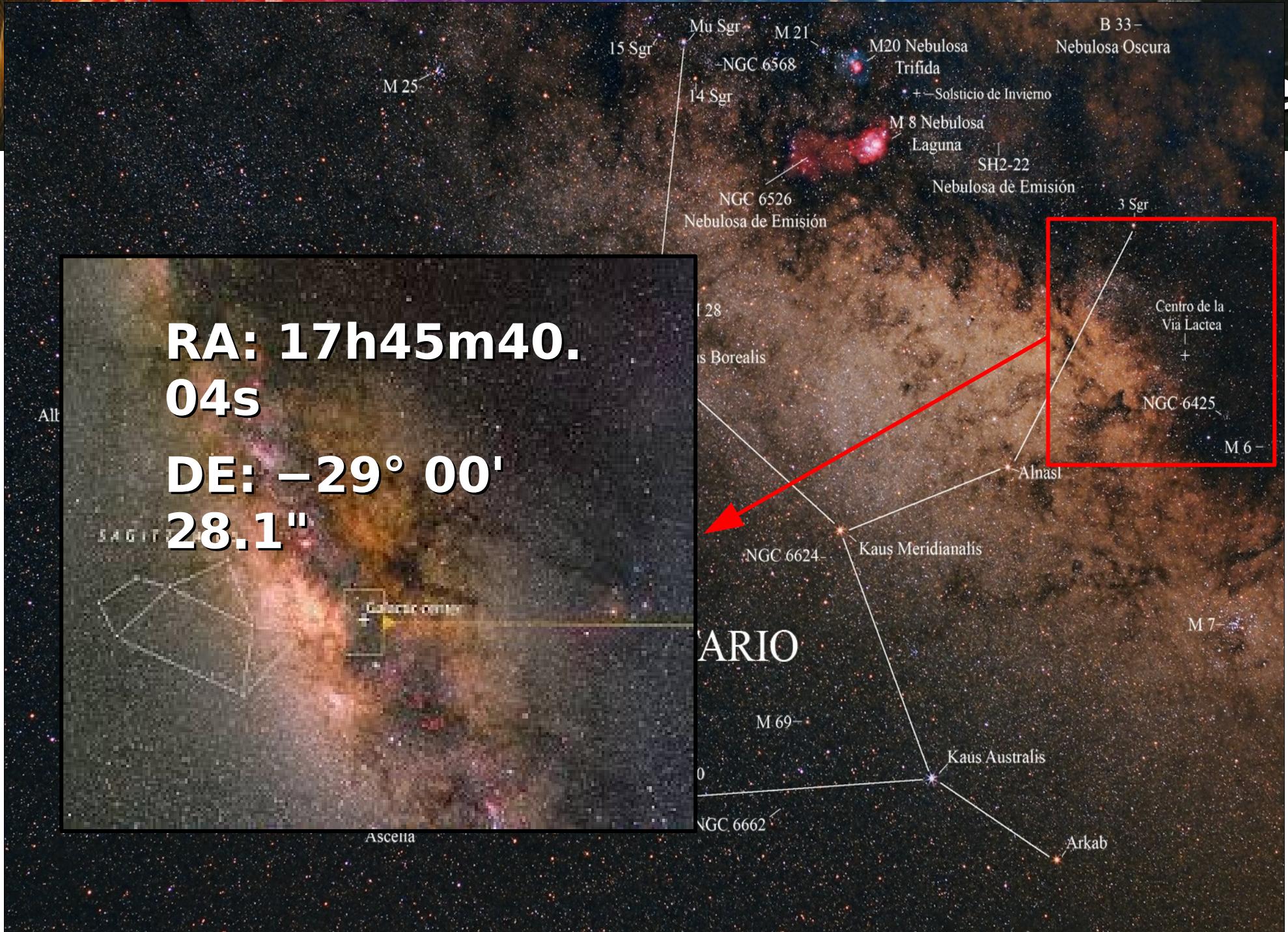


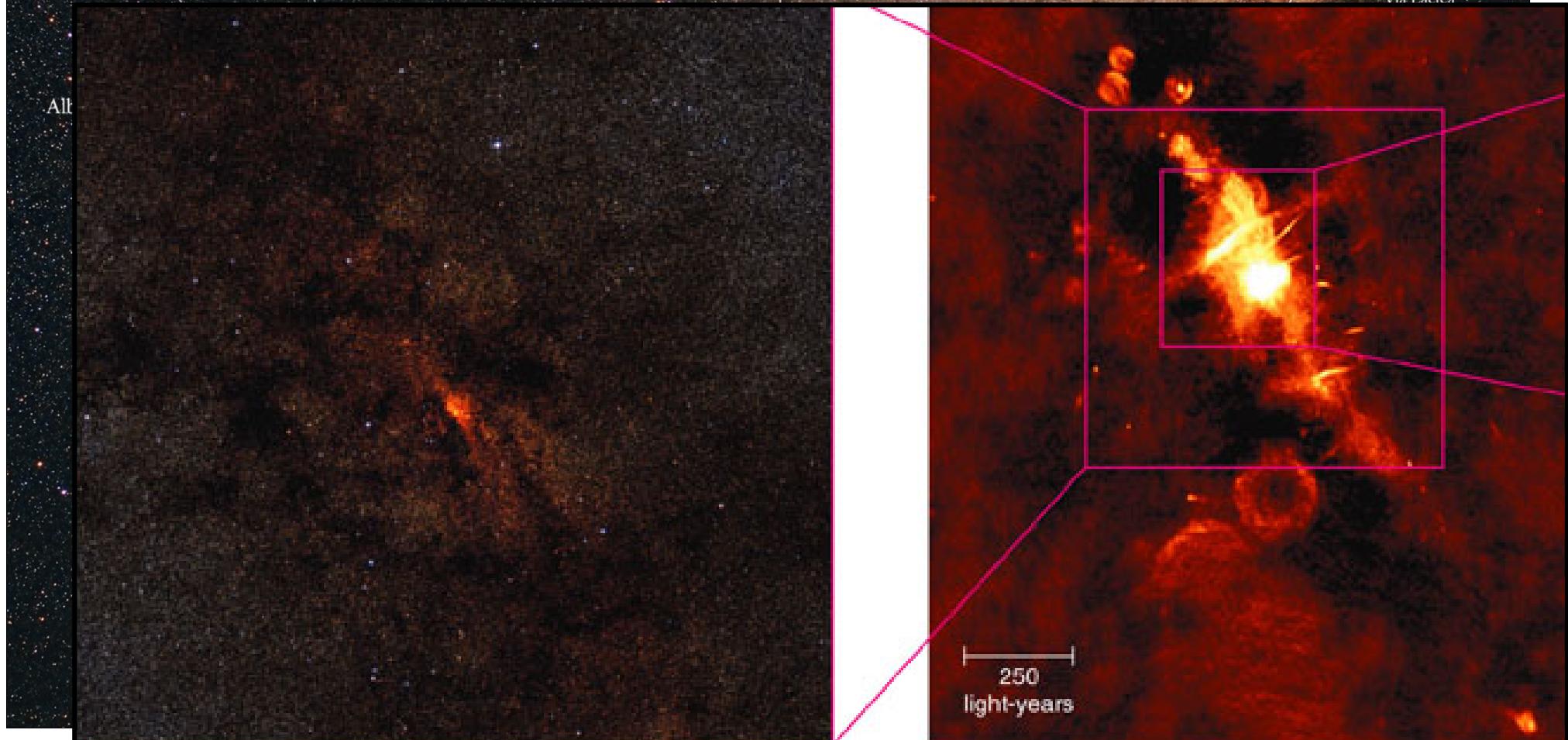
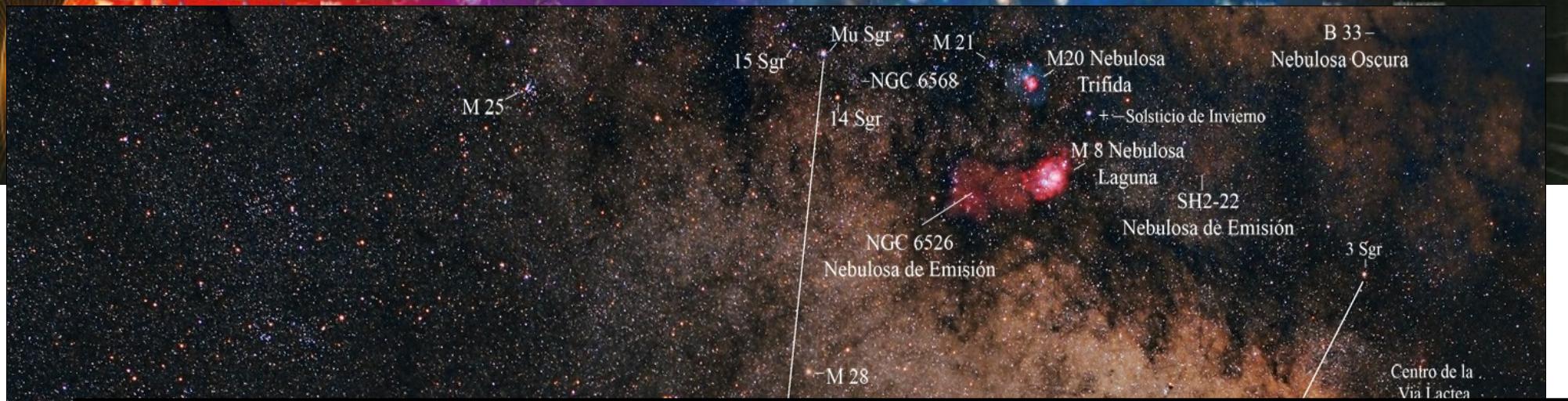
Inclinada $\sim 60^\circ$, respecto del Ecuador Celeste

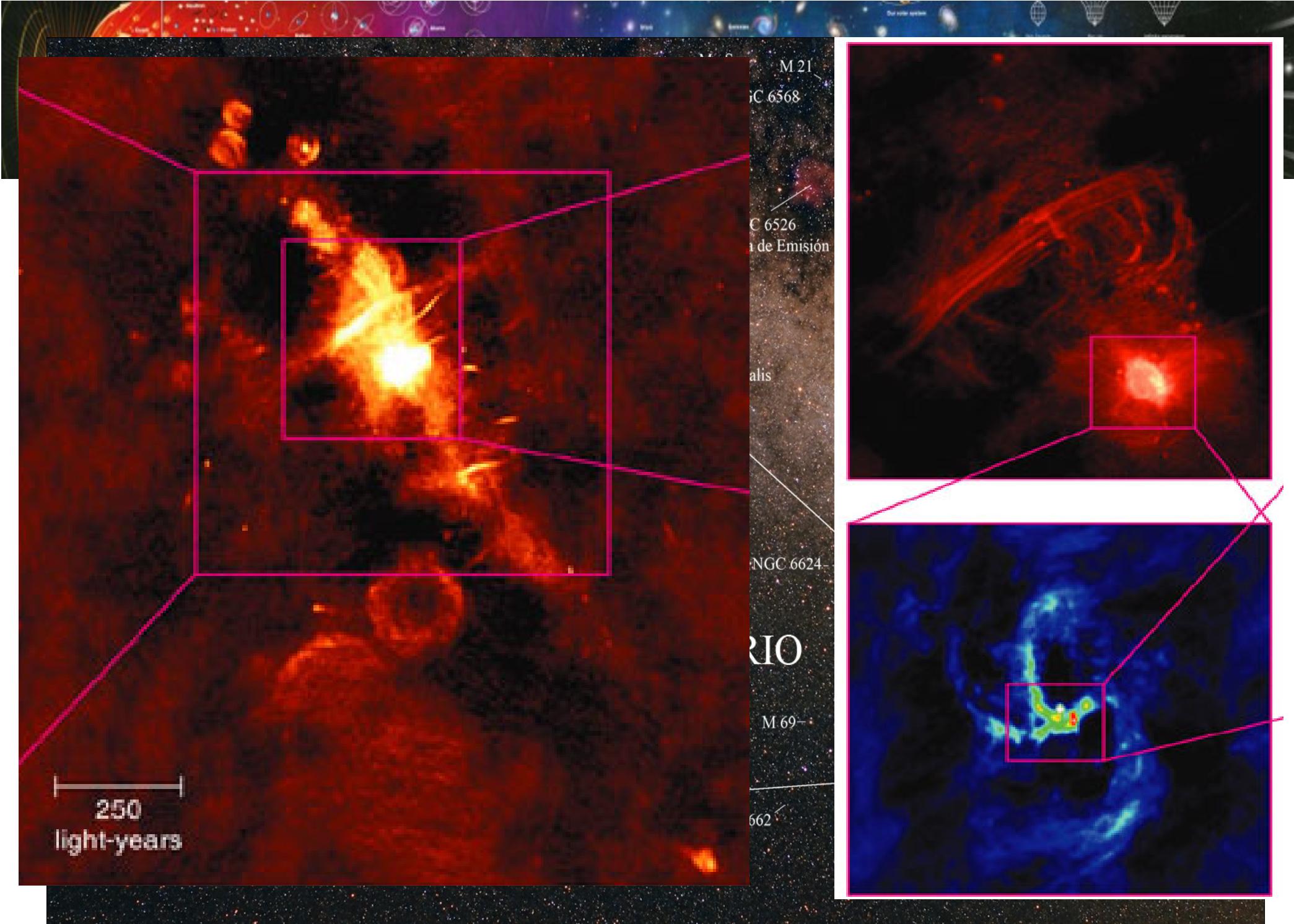


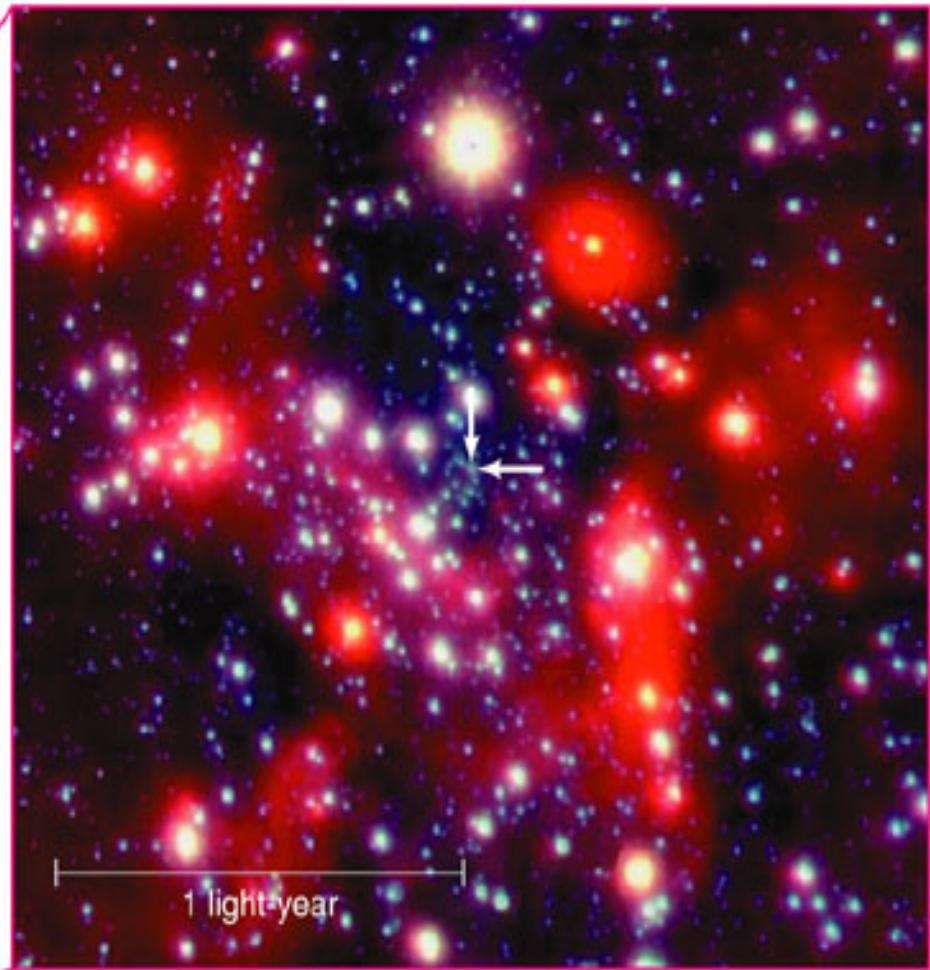
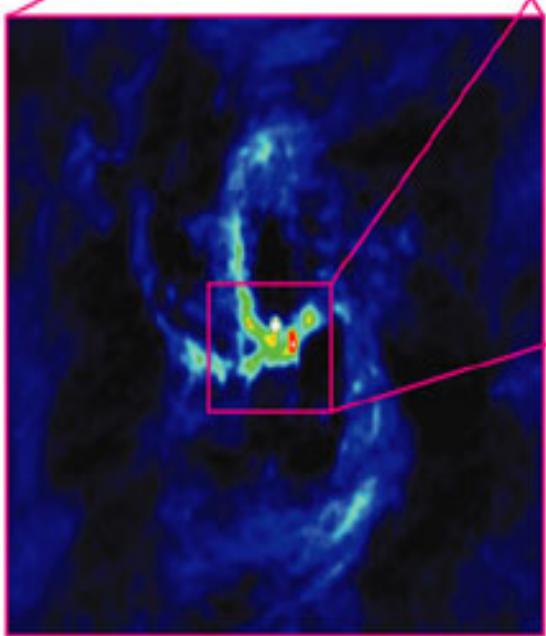
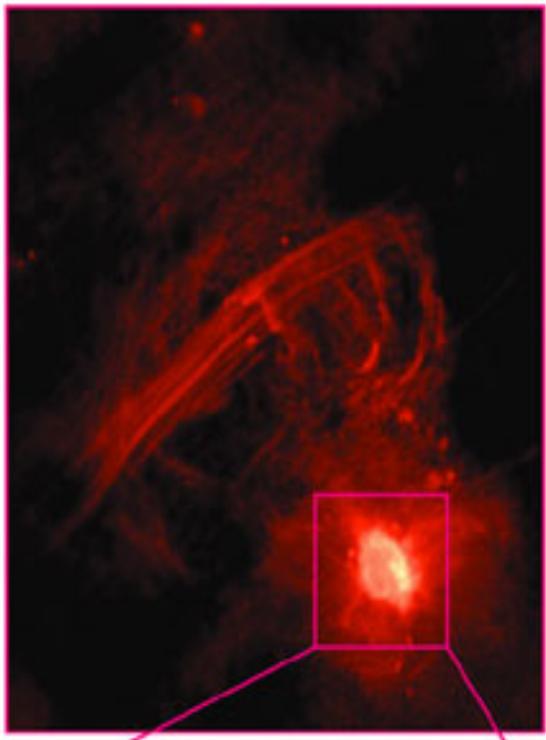


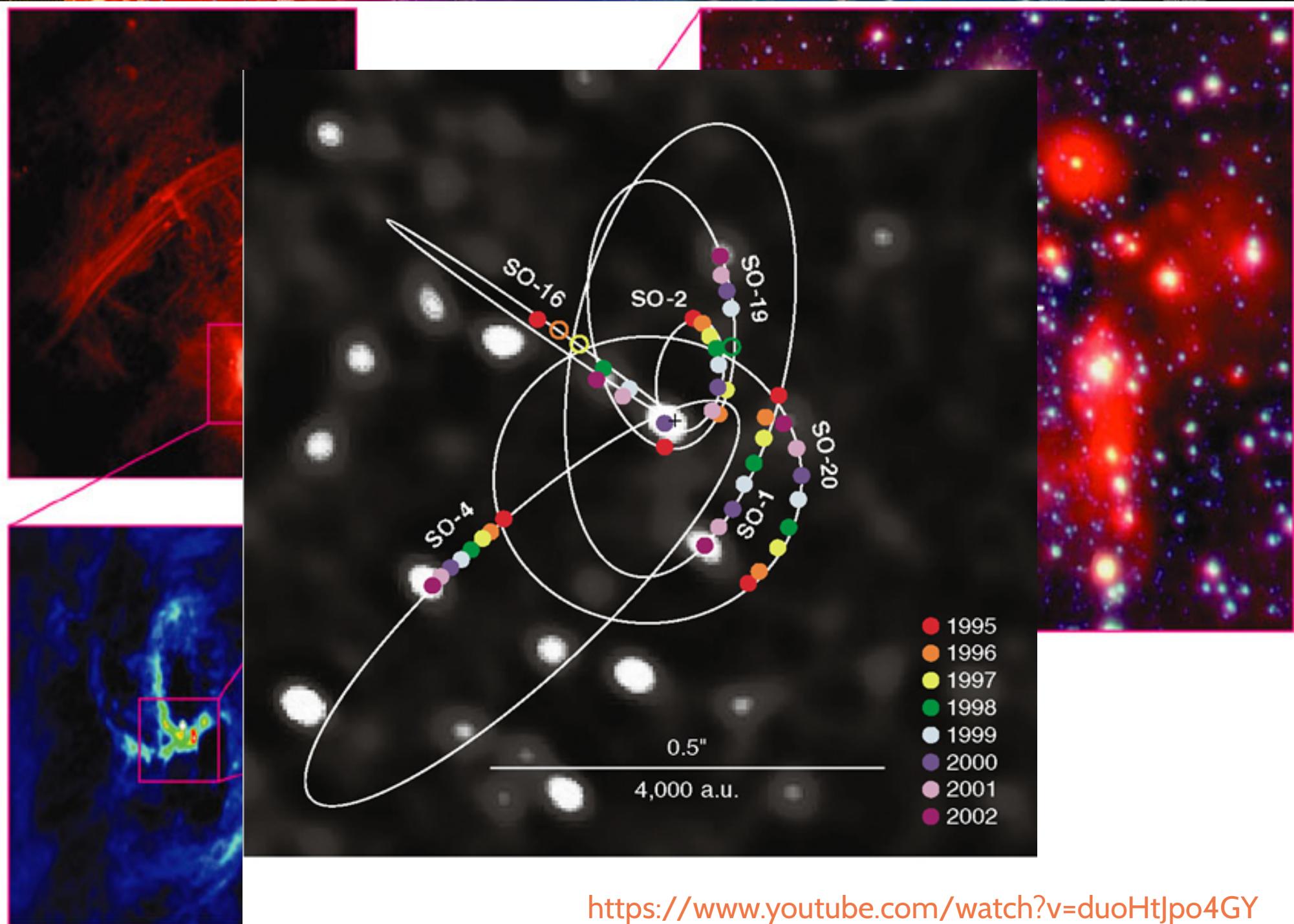












<https://www.youtube.com/watch?v=duoHtJpo4GY>

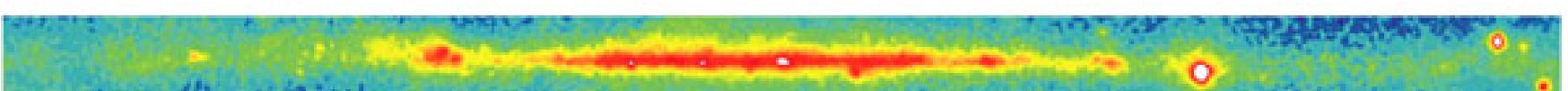
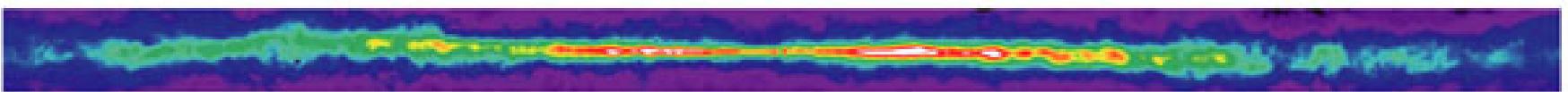


El agujero negro central

Observations with the VLT



¿Y qué forma tiene nuestra galaxia?





d Infrared ($1\text{--}4 \mu\text{m}$) emission from stars that penetrates most interstellar material.



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



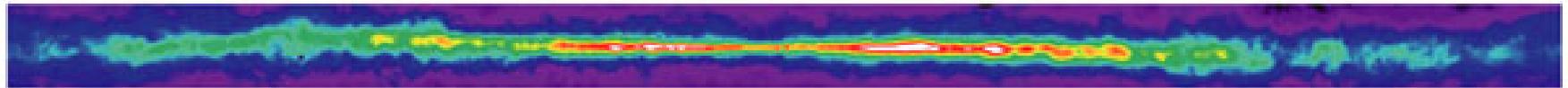
d Infrared (1–4 μm) emission from stars that penetrates most interstellar material.



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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.



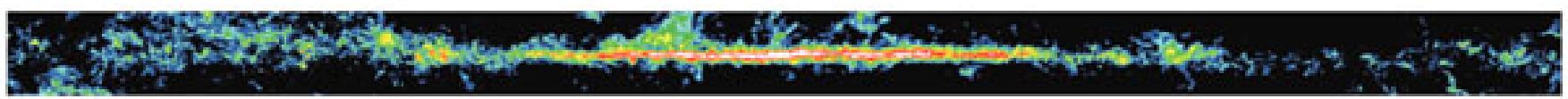
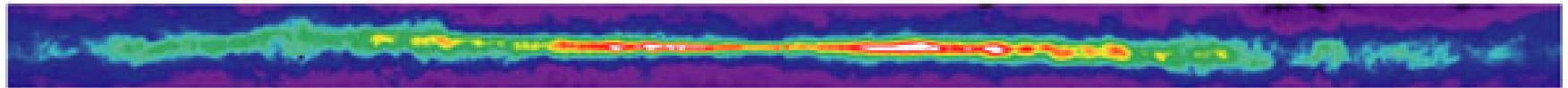
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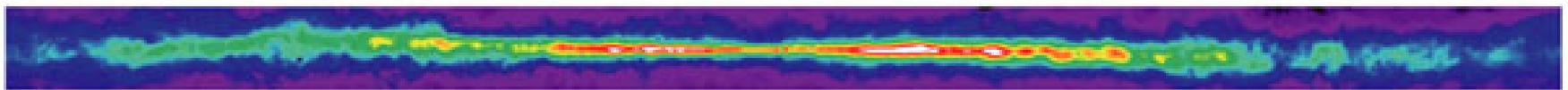
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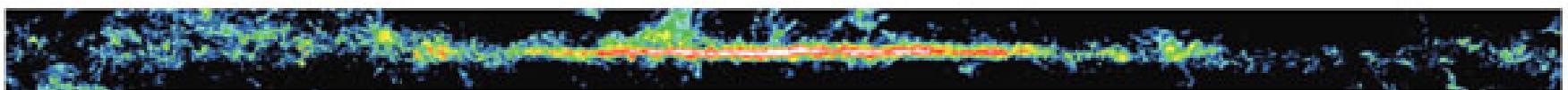
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b Radio emission from carbon monoxide reveals molecular clouds.



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



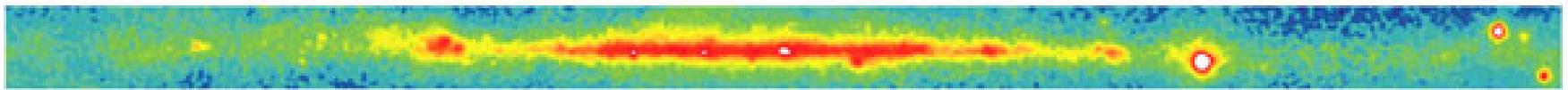
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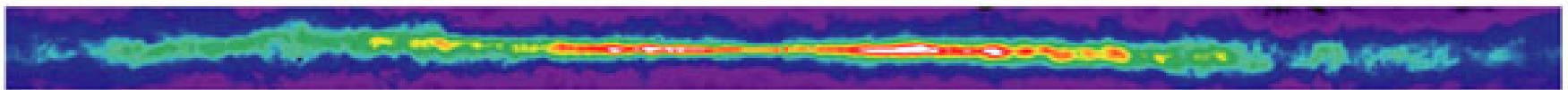
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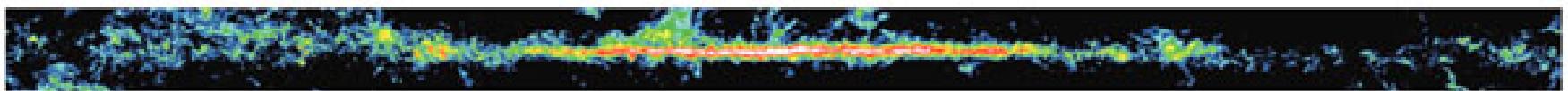
f X-ray emission from hot gas bubbles (diffuse blobs) and X-ray binaries (pointlike sources).



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



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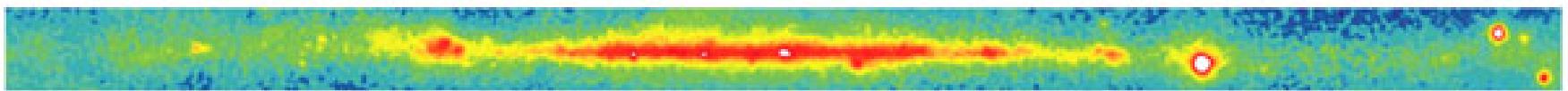
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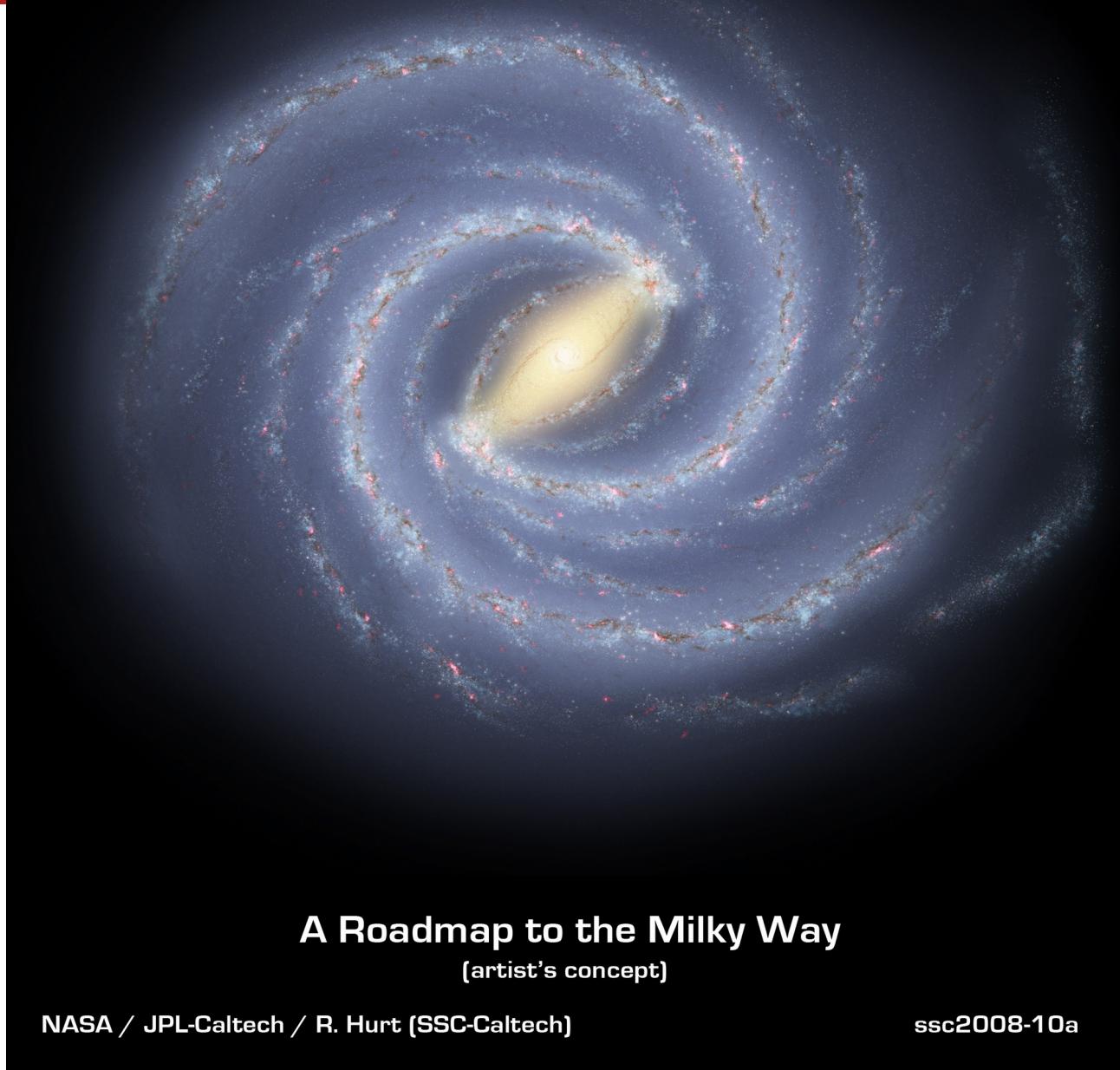


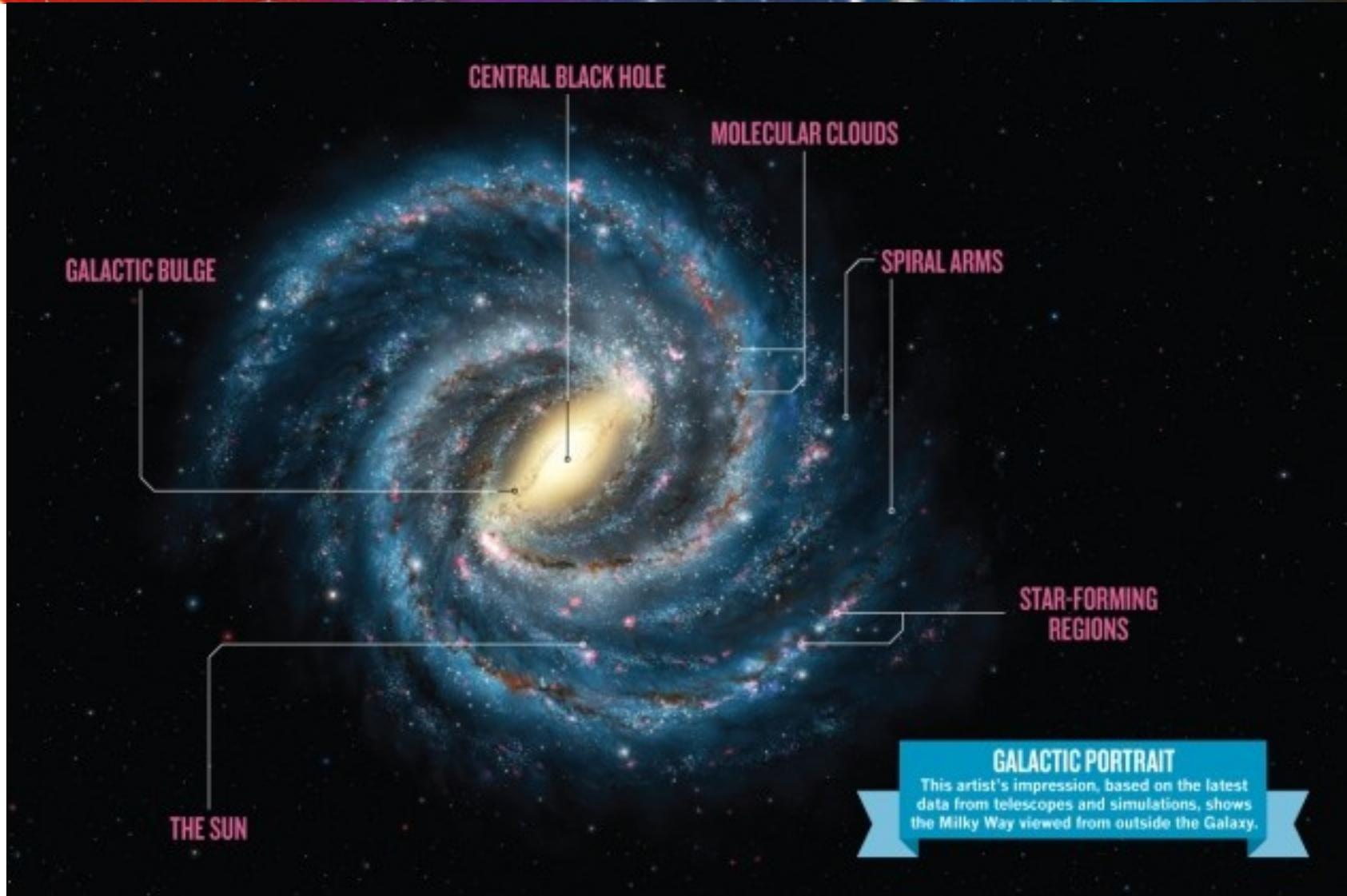
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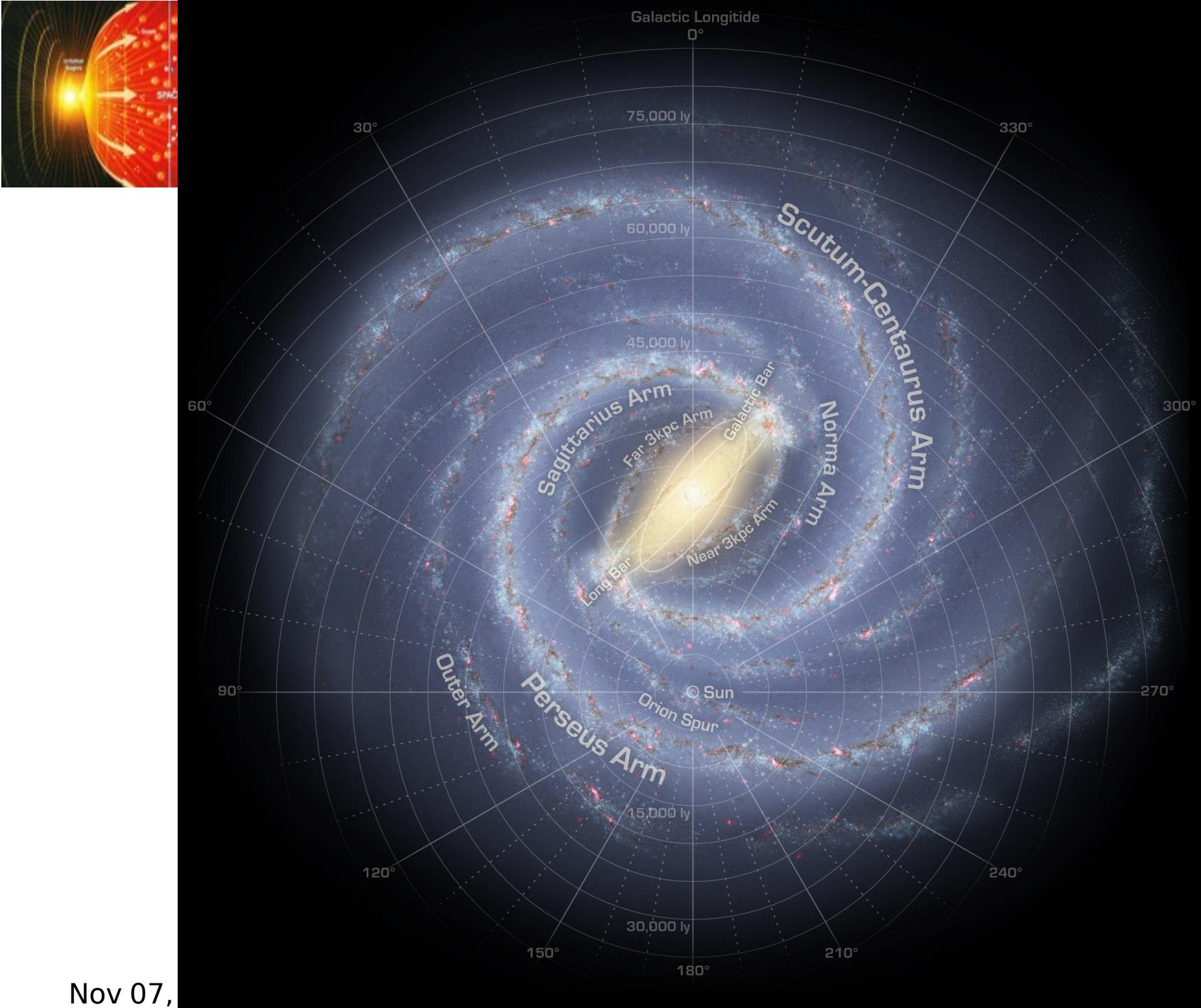


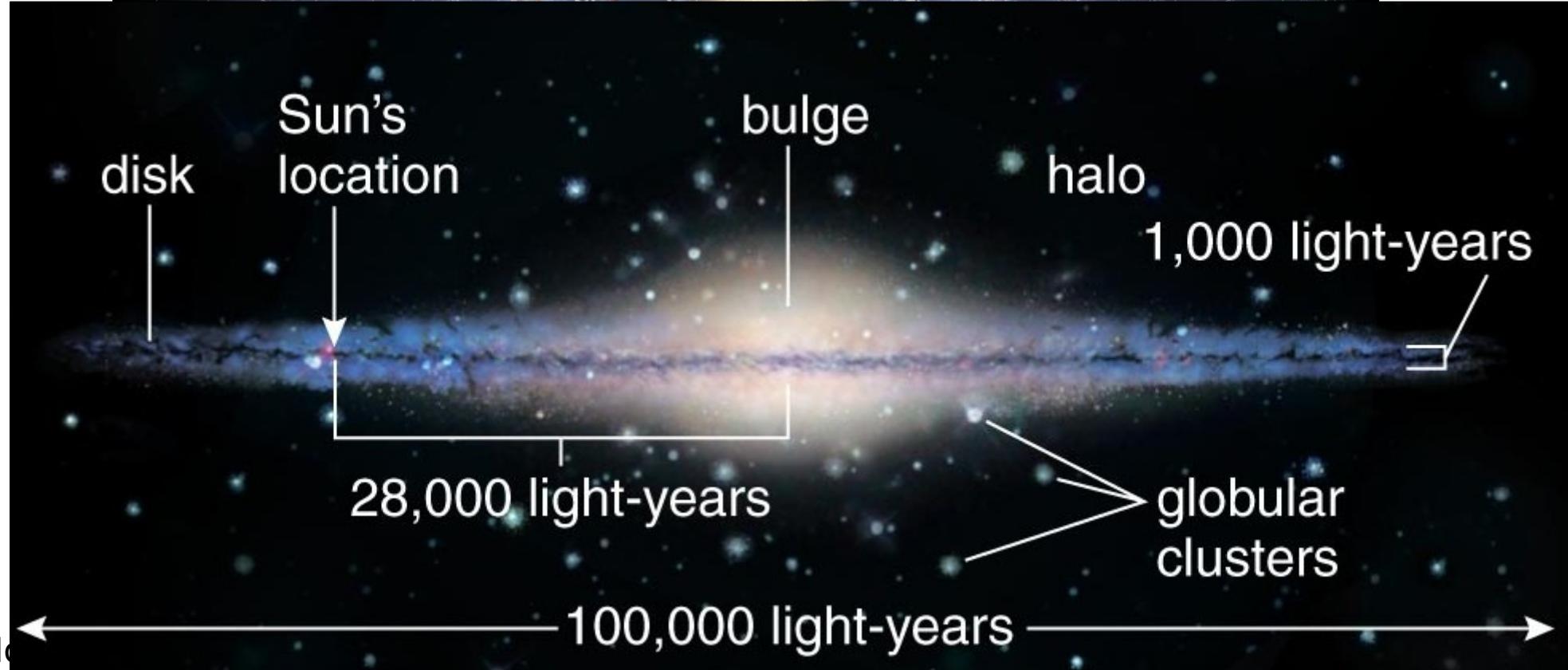
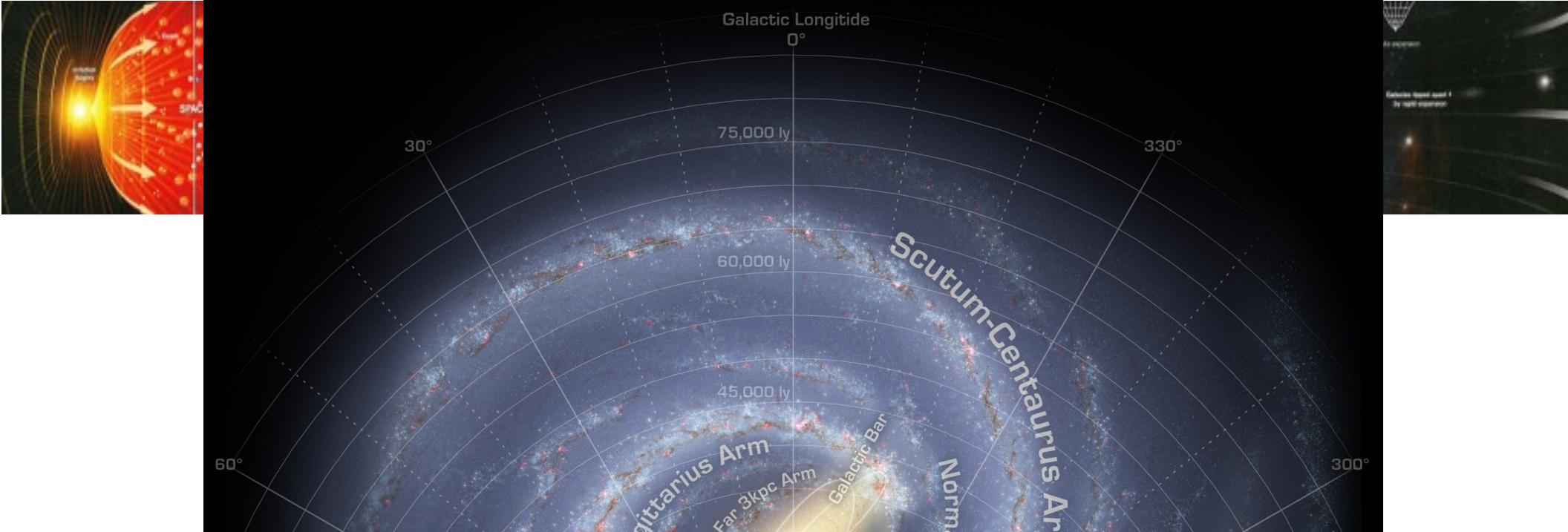
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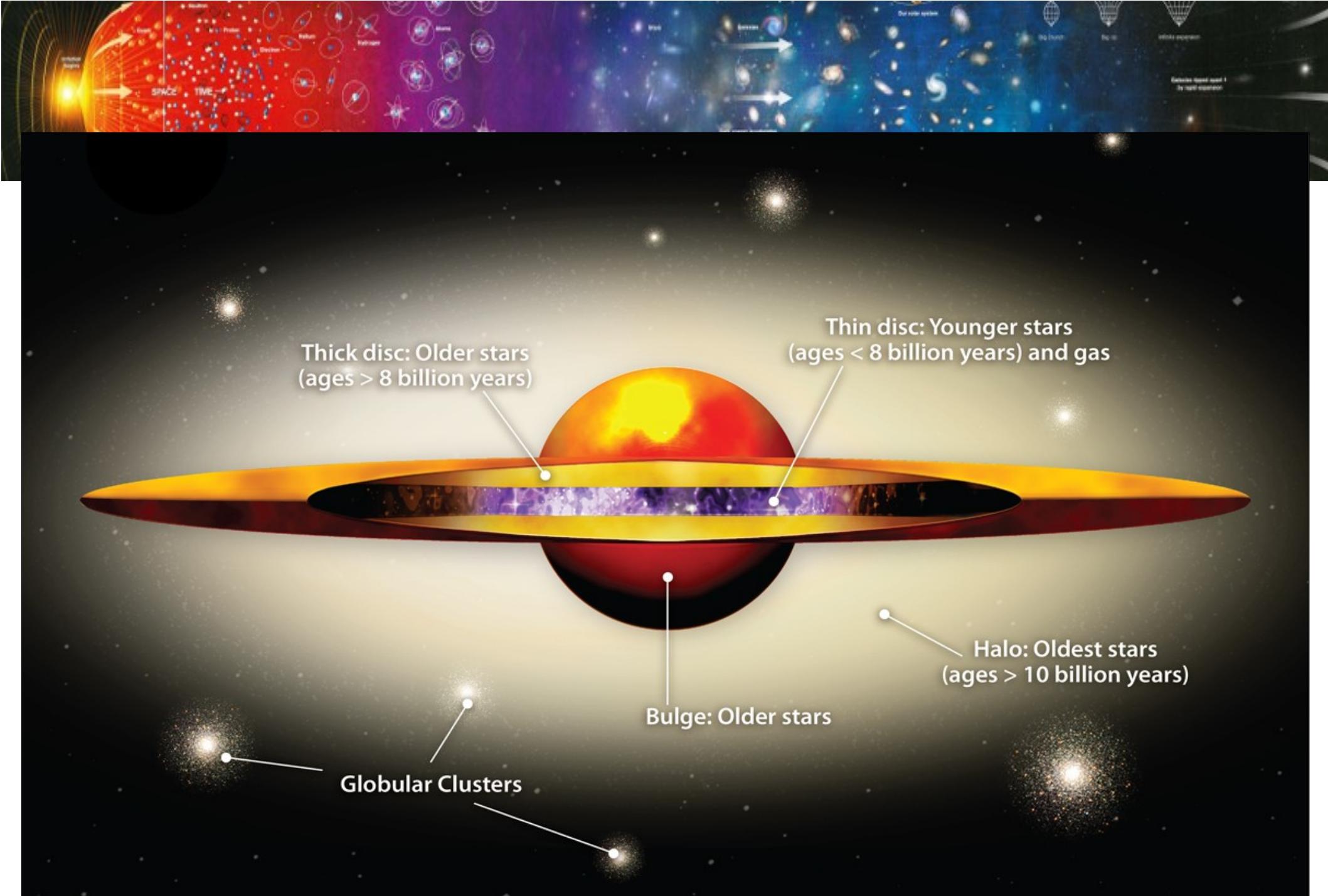
http://en.wikipedia.org/wiki/File:Infrared-visible_light_comparison_of_VISTA's_giga_pixel_view_of_the_centre_of_the_Milky_Way.ogv

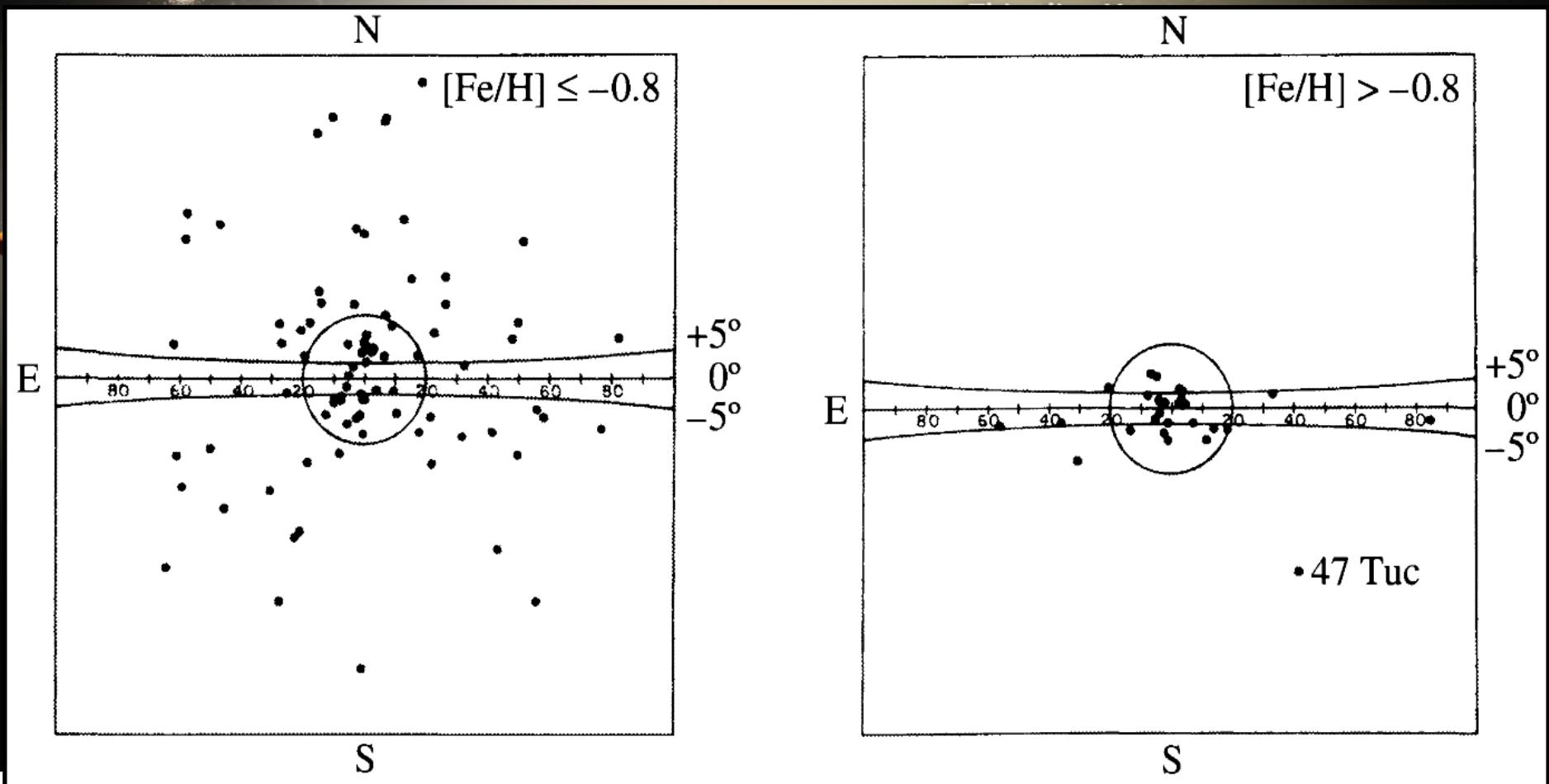






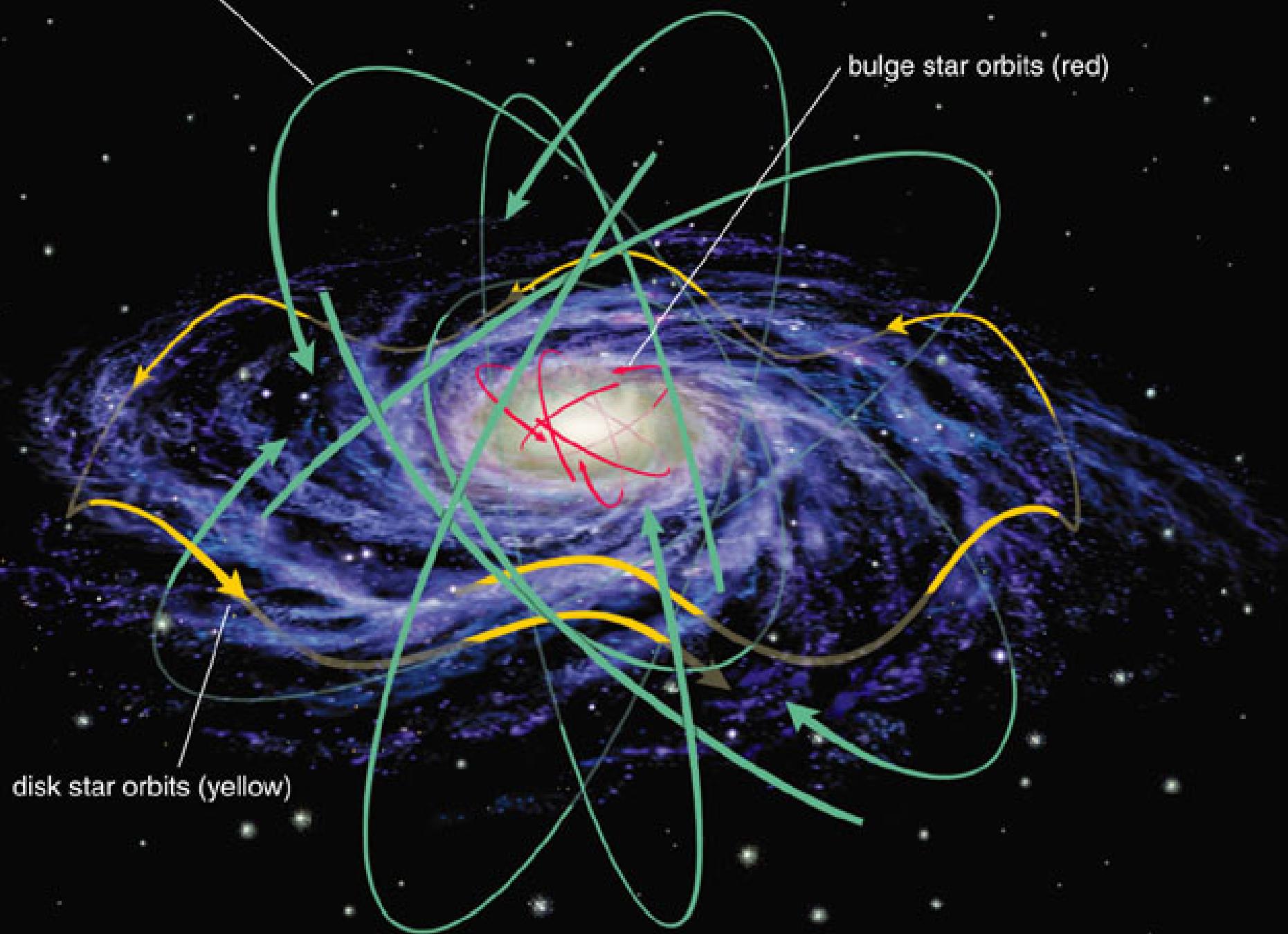






halo star orbits (green)

bulge star orbits (red)



halo star orbits (green)

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

bulge star orbits (red)





Si Andrómeda fuera más brillante...



Brazos Espirales → si fuera sólo Kepler

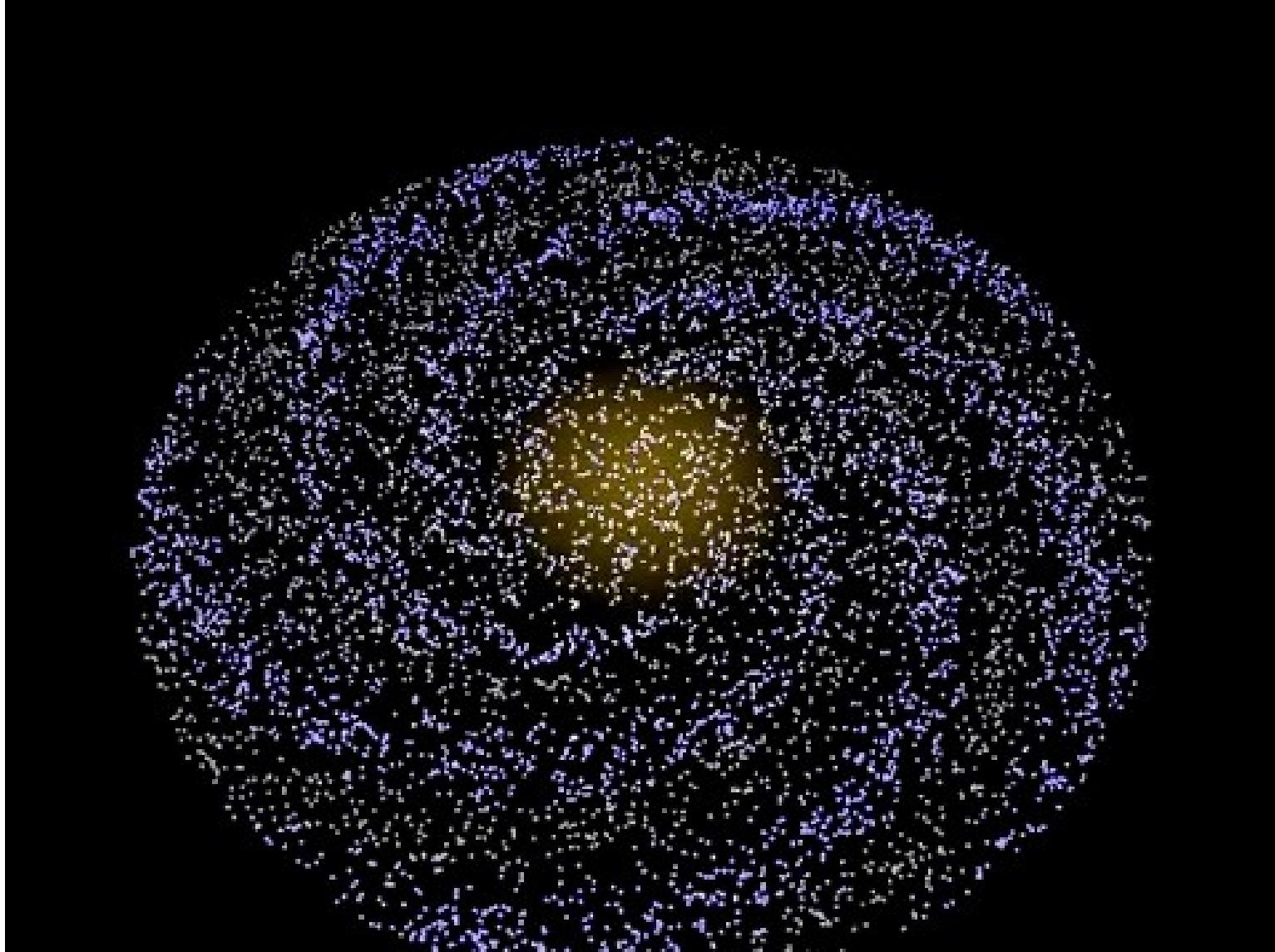
Spiral Galaxy Simulation
by Caleb Piercy

Keplerian Orbits

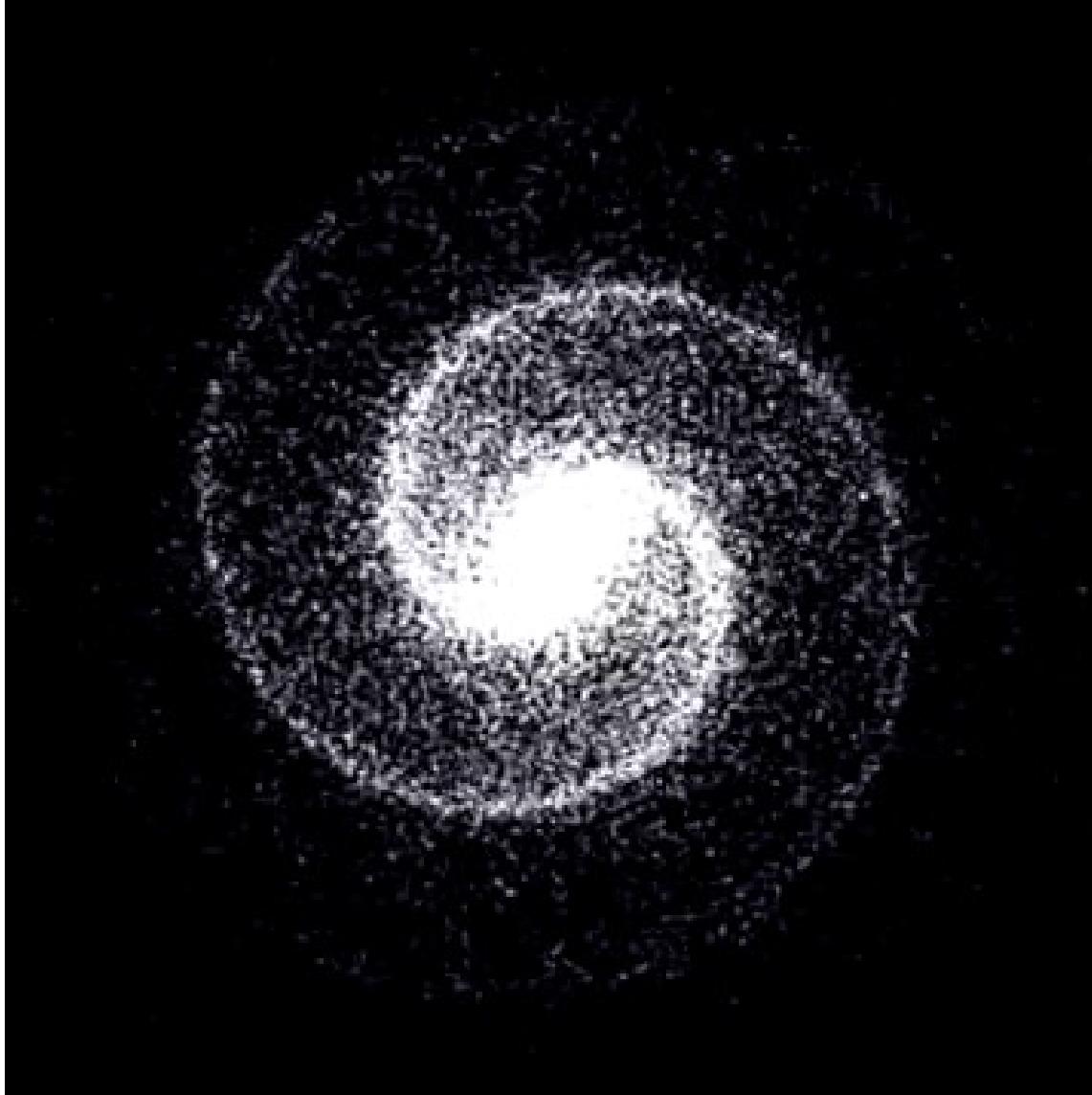
I couldn't figure out how to program Density Wave Theory :(

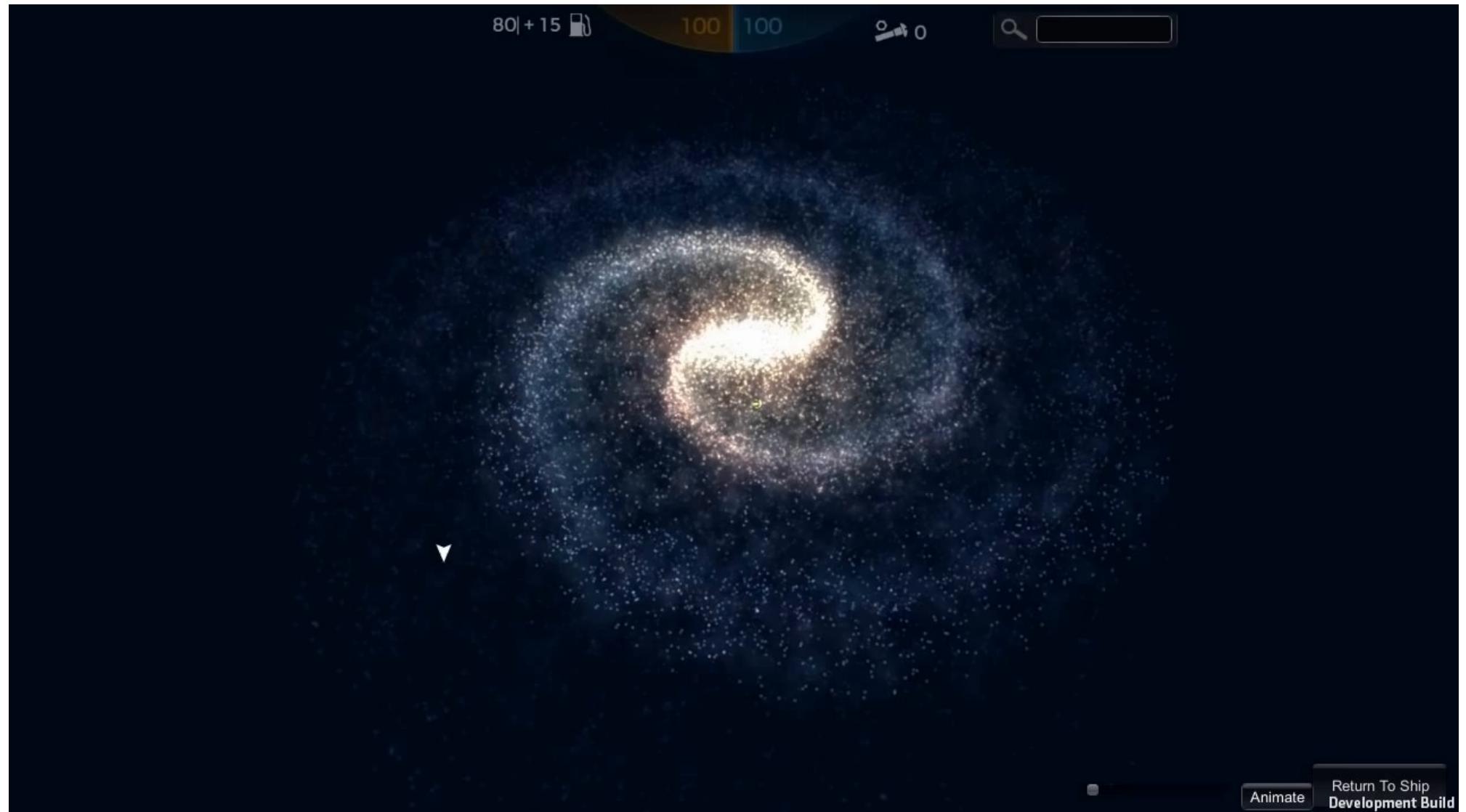


Brazos en espiral



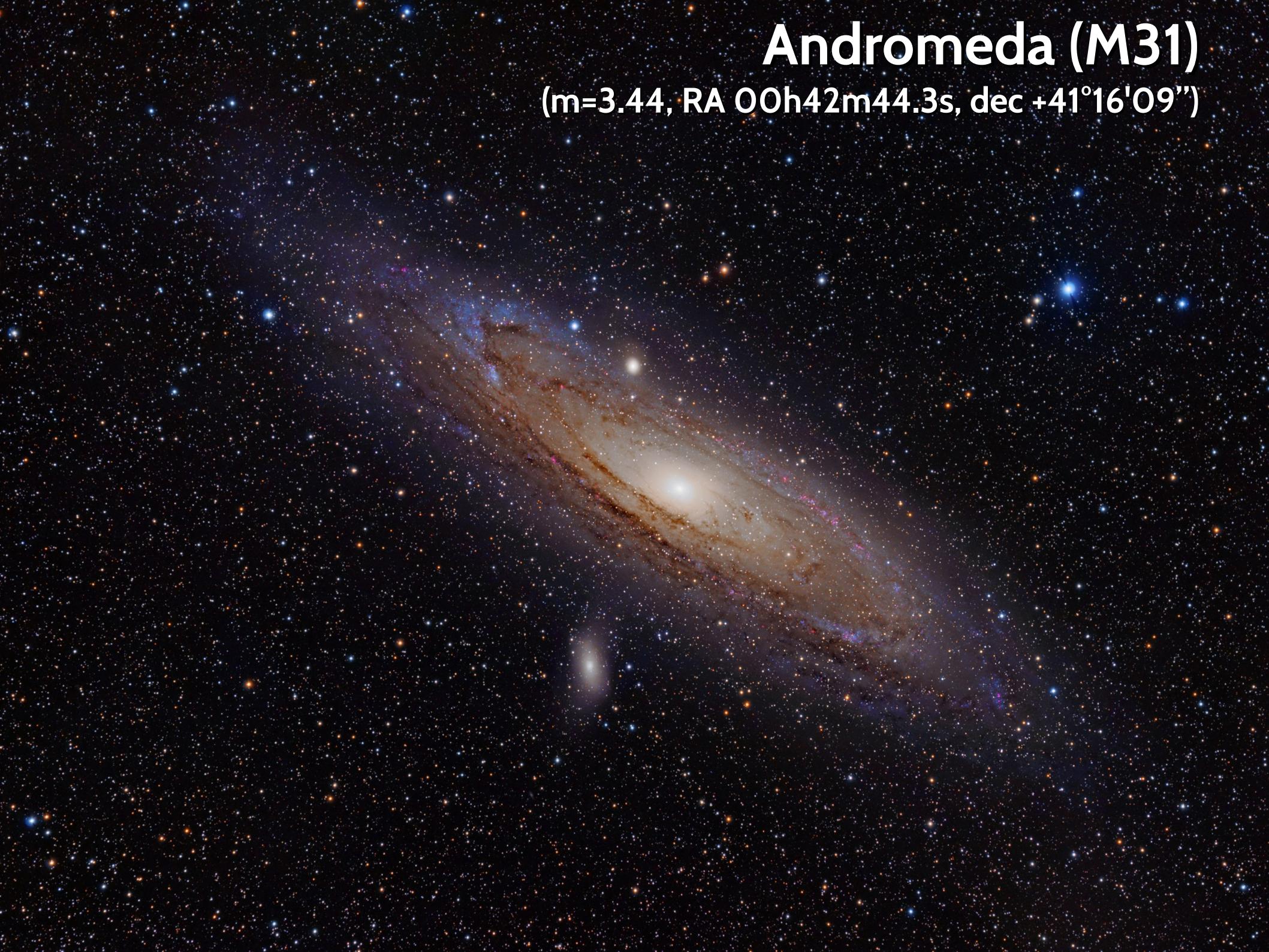
Brazos espirales → atracción entre vecinos





Andromeda (M31)

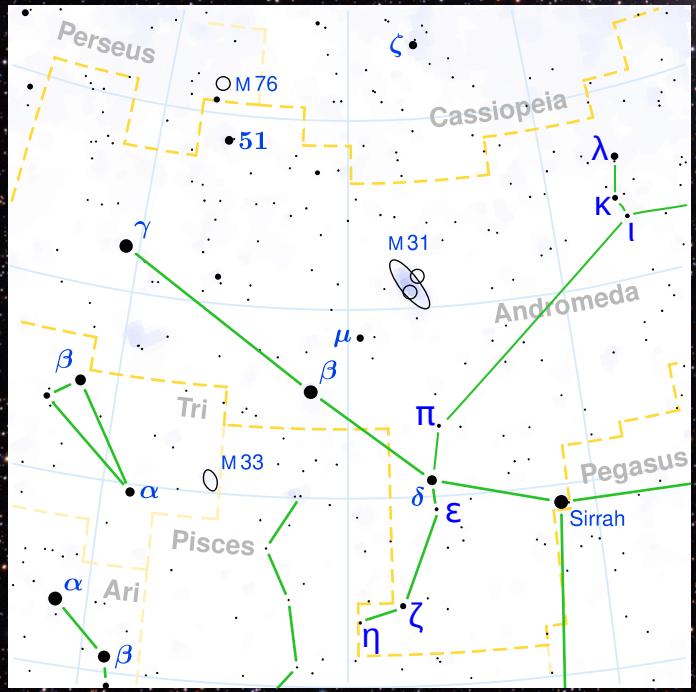
(m=3.44, RA 00h42m44.3s, dec +41°16'09")



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: $1.5 \times 10^{12} M_S$



La Vía Láctea

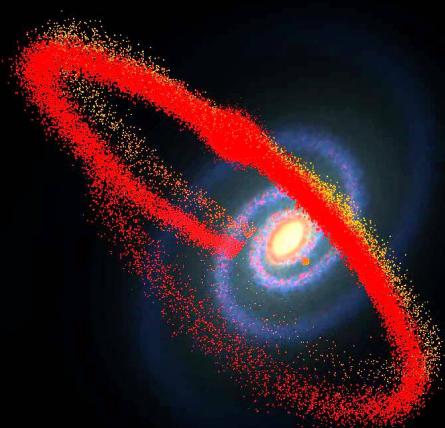


Los satélites de la Vía Láctea

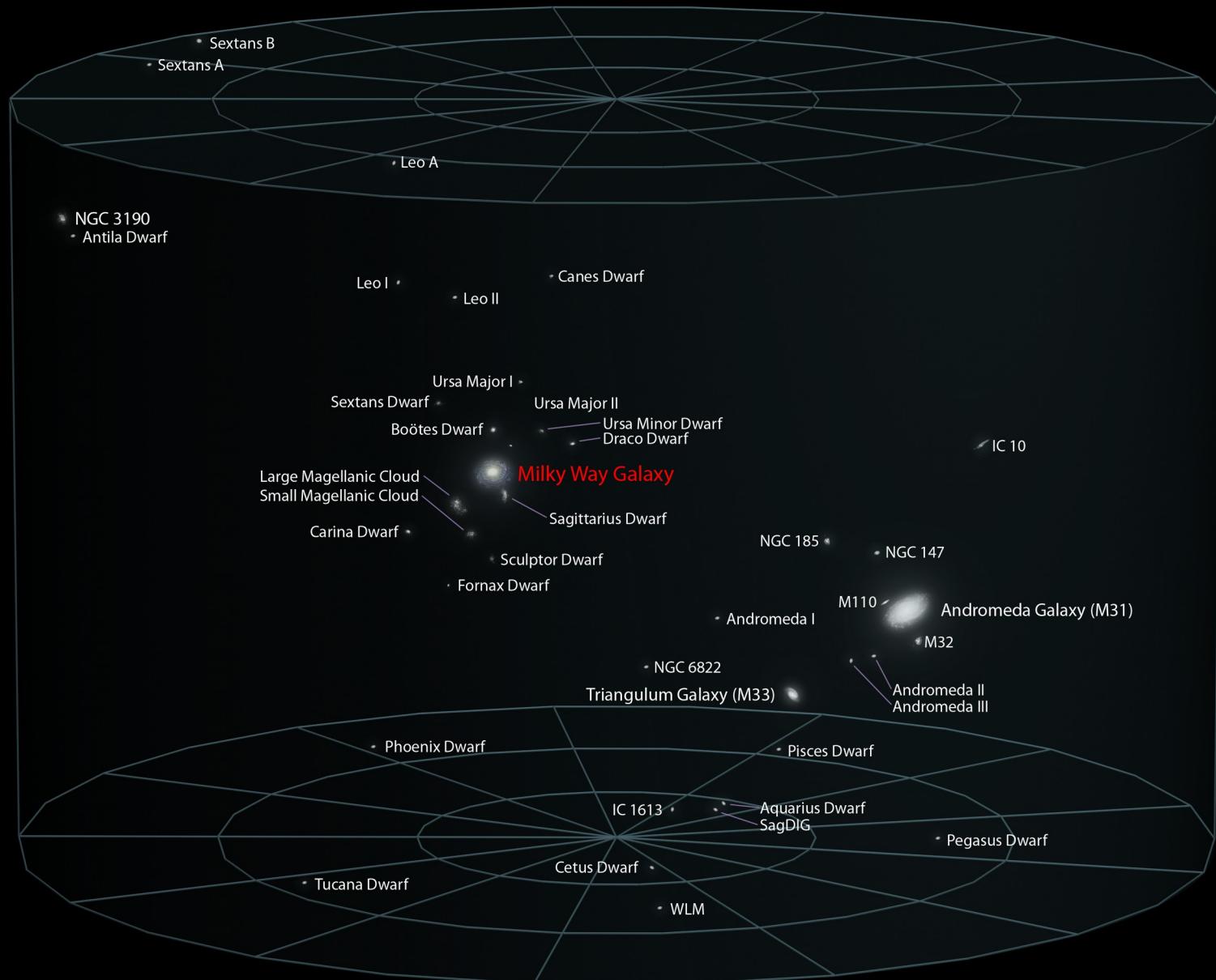


Los satélites de la Vía Láctea

- Subgrupo de la Vía Láctea
 - ~25 galaxias pequeñas unidas gravitatoriamente a la Vía Láctea
 - Nubes de Magallanes son visibles a simple vista, aunque aún no se sabe si son satélites de la Vía Láctea (2006)
 - Galaxia Enana sub-esférica de Sagitario es el mayor satélite conocido

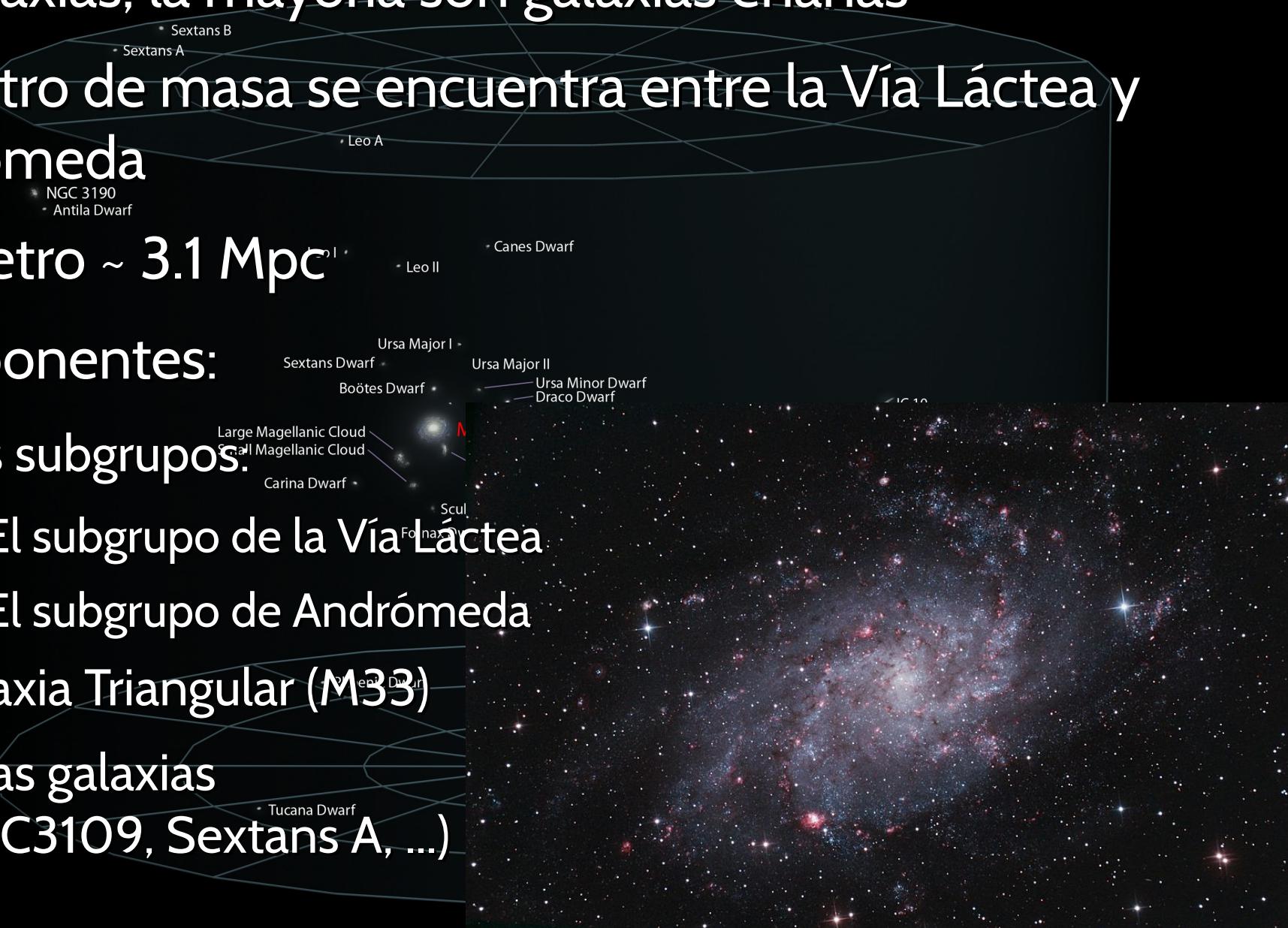


Grupo Local



Grupo Local

- 54 galaxias, la mayoría son galaxias enanas
- El centro de masa se encuentra entre la Vía Láctea y Andrómeda
- Diámetro ~ 3.1 Mpc
- Componentes:
 - Dos subgrupos.
 - El subgrupo de la Vía Láctea
 - El subgrupo de Andrómeda
 - Galaxia Triangular (M33)
 - Otras galaxias (NGC3109, Sextans A, ...)



Supercúmulo de Virgo (o Local)



Supercúmulo de Virgo

Virgo Cluster

M66

- Concentración de galaxias que incluyen al Cúmulo de Virgo y al Grupo Local

35,000,000 ly

Leo I

- Hay millones de supercúmulos como este en el Universo

- 100 grupos de galaxias en 33 Mpc

Local Group

- $\sim 10^{15} M_S$ y $\sim 3 \times 10^{12} L_S$. Se desplaza a ~ 600 km/s hacia el Cúmulo de Norma (Abel3627 \rightarrow Gran Atractor)

40,000,000 ly

Draco Group

SGY

Supercúmulo de Laniakea (2014)

Coma

Centaurus

Virgo

Pisces Perseus

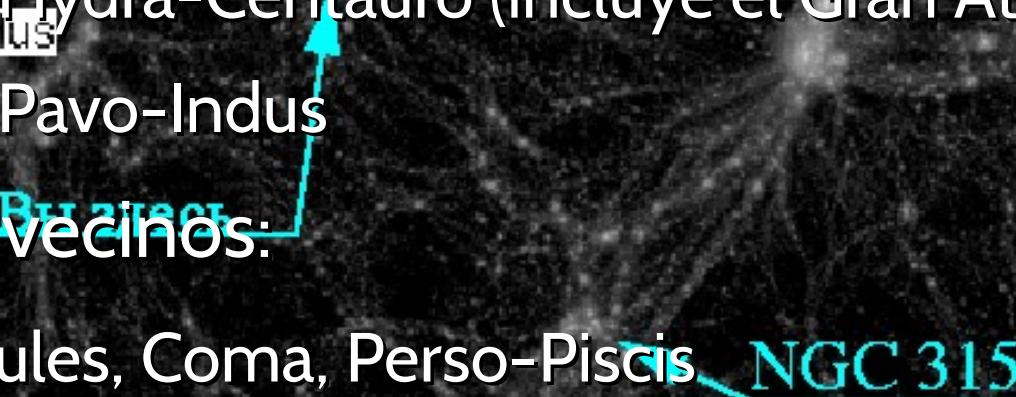
Pavo Indus

Вы здесь

NGC 315

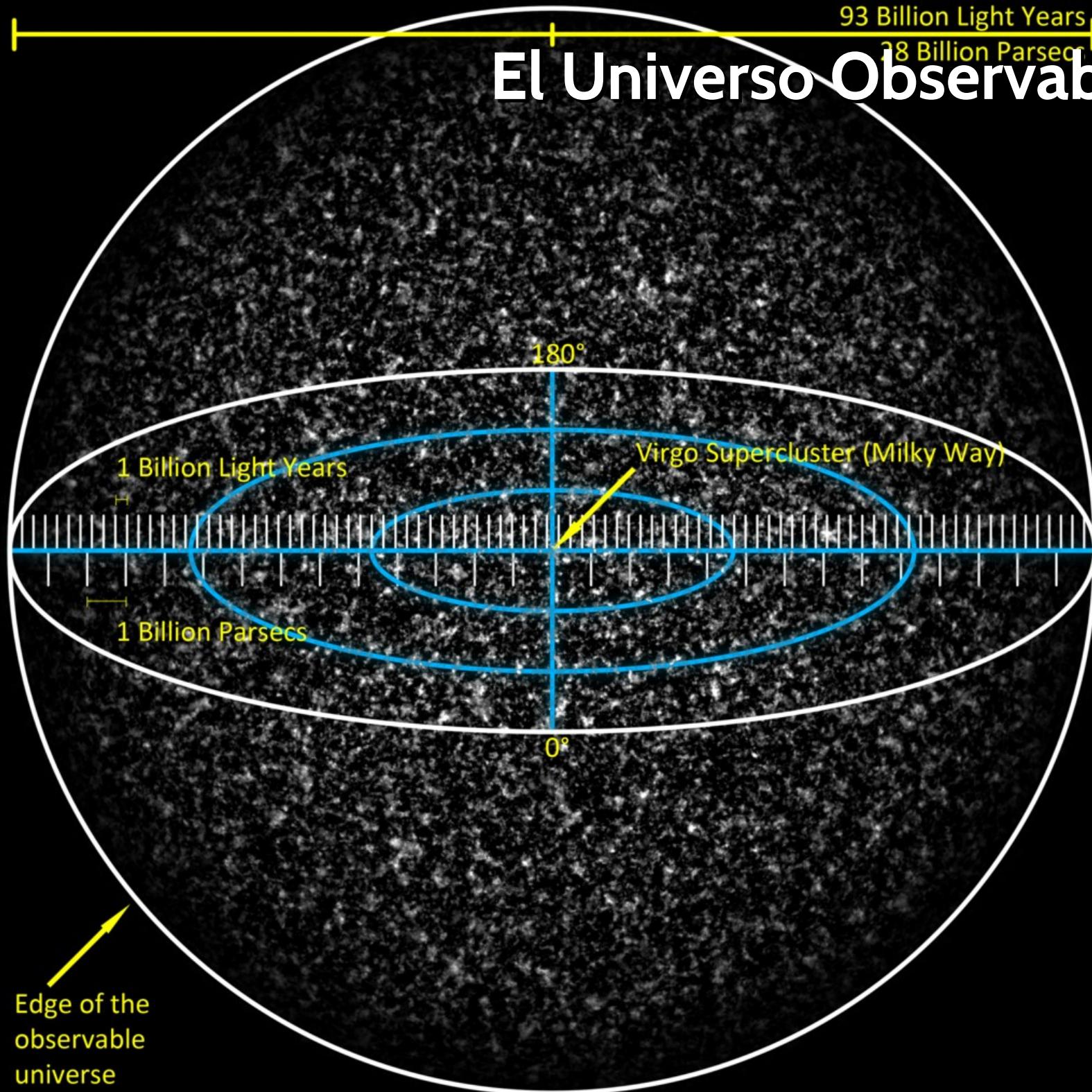
SGX

Supercúmulo de Laniakea (2014)

- Entre 300 y 500 cúmulos de galaxias
- 100000 galaxias en 160 Mpc
- $\sim 10^{17} M_s$ y $\sim 3 \times 10^{12} L_s$.
 - Supercúmulo de Virgo
 - Supercúmulo Hydra-Centauro (incluye el Gran Atractor)
 - Supercúmulo Pavo-Indus
- Supercúmulos vecinos:
 - Shapley, Hercules, Coma, Perso-Piscis 
 - NGC 315

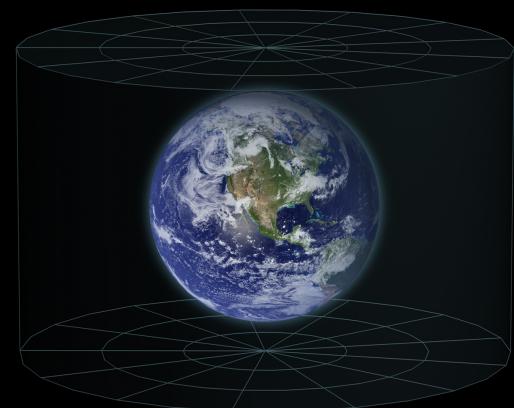
93 Billion Light Years
28 Billion Parsecs

El Universo Observable



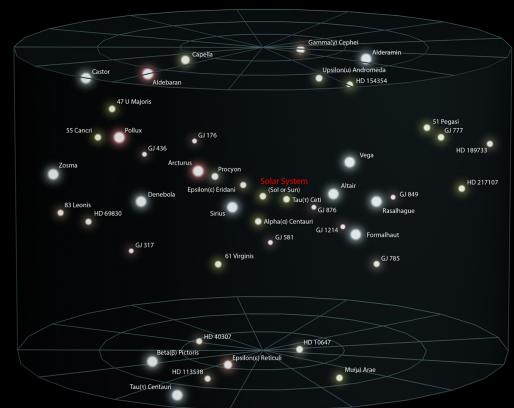
El Universo Observable

Earth

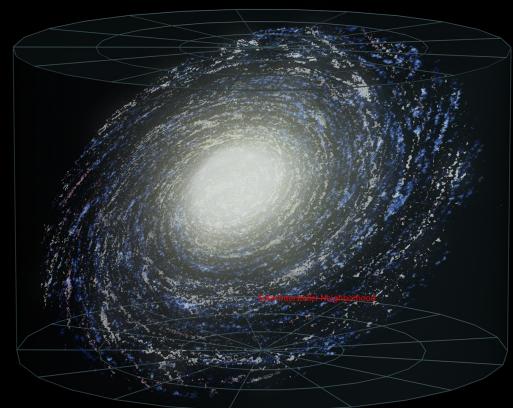


Solar System

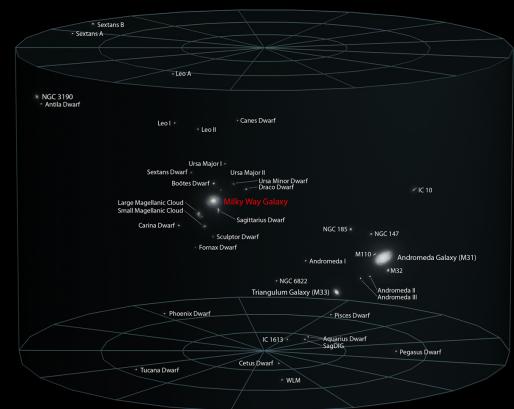
Solar Interstellar Neighborhood



Milky Way Galaxy

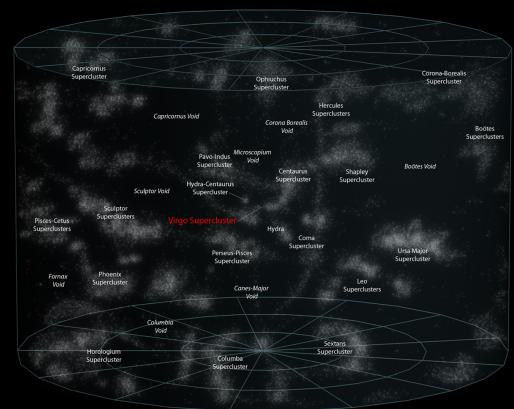


Local Galactic Group



Virgo Supercluster

Local Superclusters



Observable Universe