

# MILKY WAY

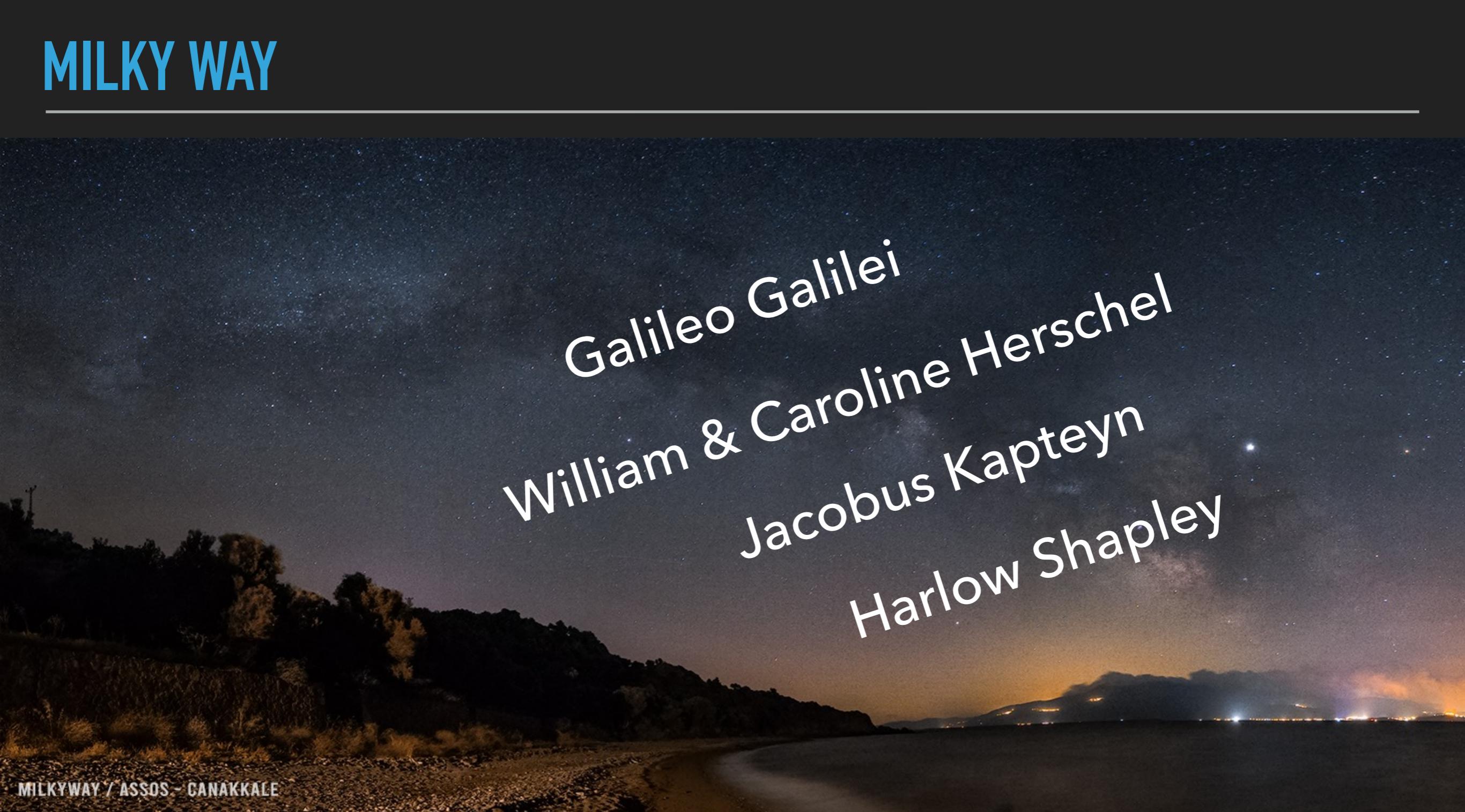
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## ASTROPHYSICS

Dr H.T.Sener

# MILKY WAY

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Galileo Galilei  
William & Caroline Herschel  
Jacobus Kapteyn  
Harlow Shapley

MILKYWAY / ASSOS - CANAKKALE



 @aydinmustafaaa

 @aydinmustafa

# MILKY WAY

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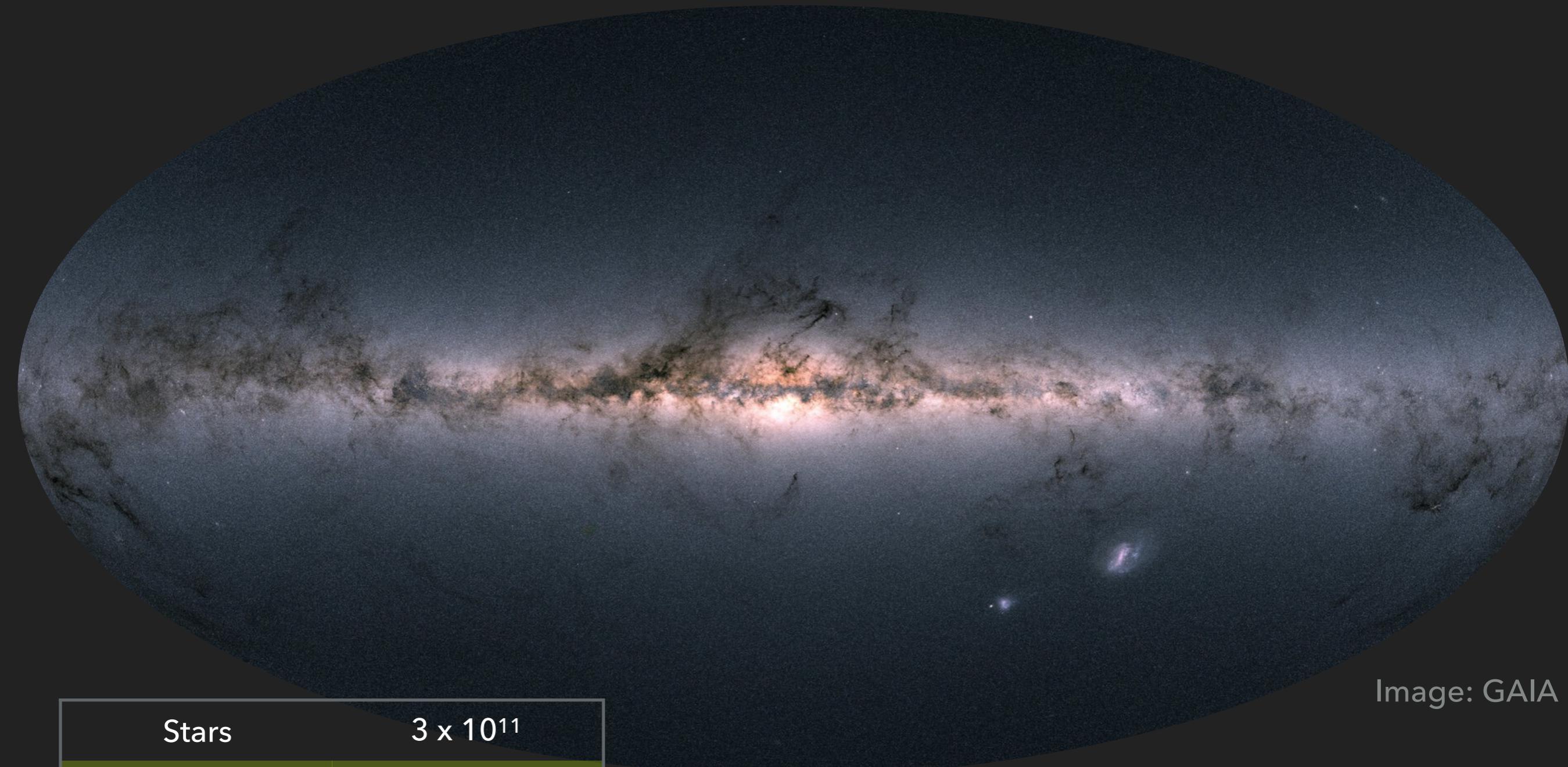


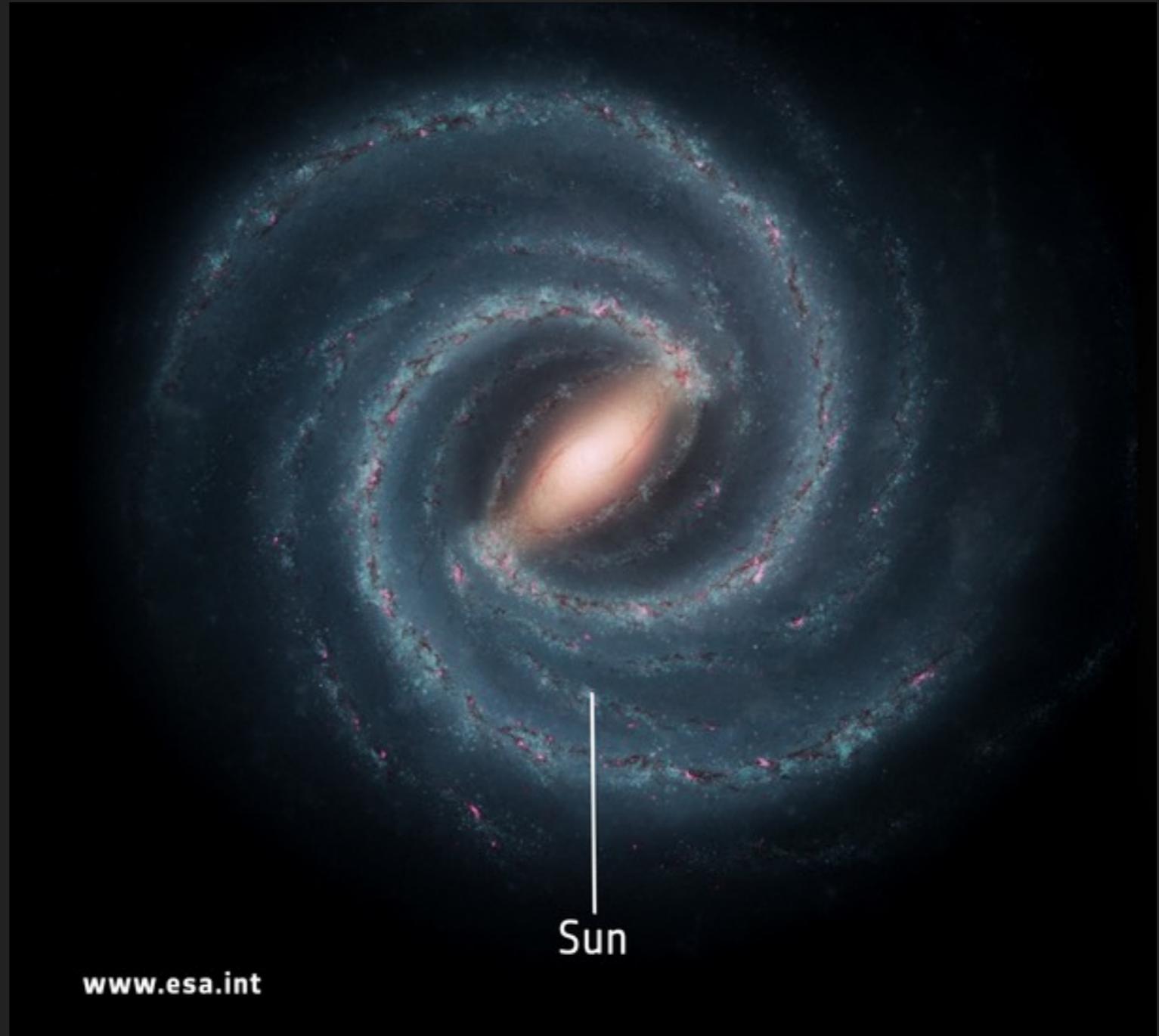
Image: GAIA

Stars	$3 \times 10^{11}$
Planets	$4 \times 10^{11}$
Gas	%20
Diameter	120.000LY
Age	$12.5 \times 10^9$ years

# STRUCTURE

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- ▶ 13 billion year old
- ▶ Barred spiral galaxy
- ▶ A few hundred billion stars

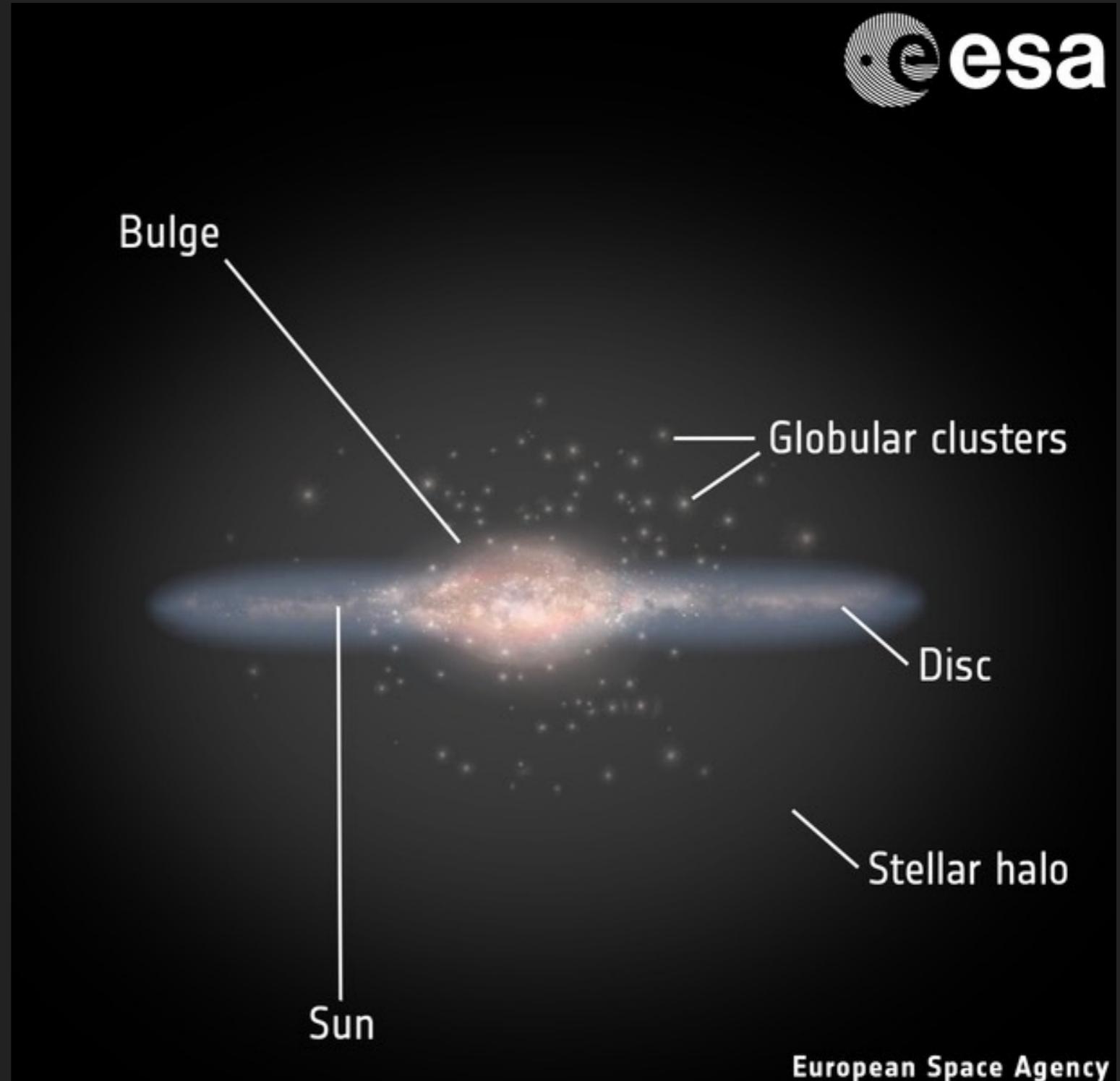


[www.esa.int](http://www.esa.int)

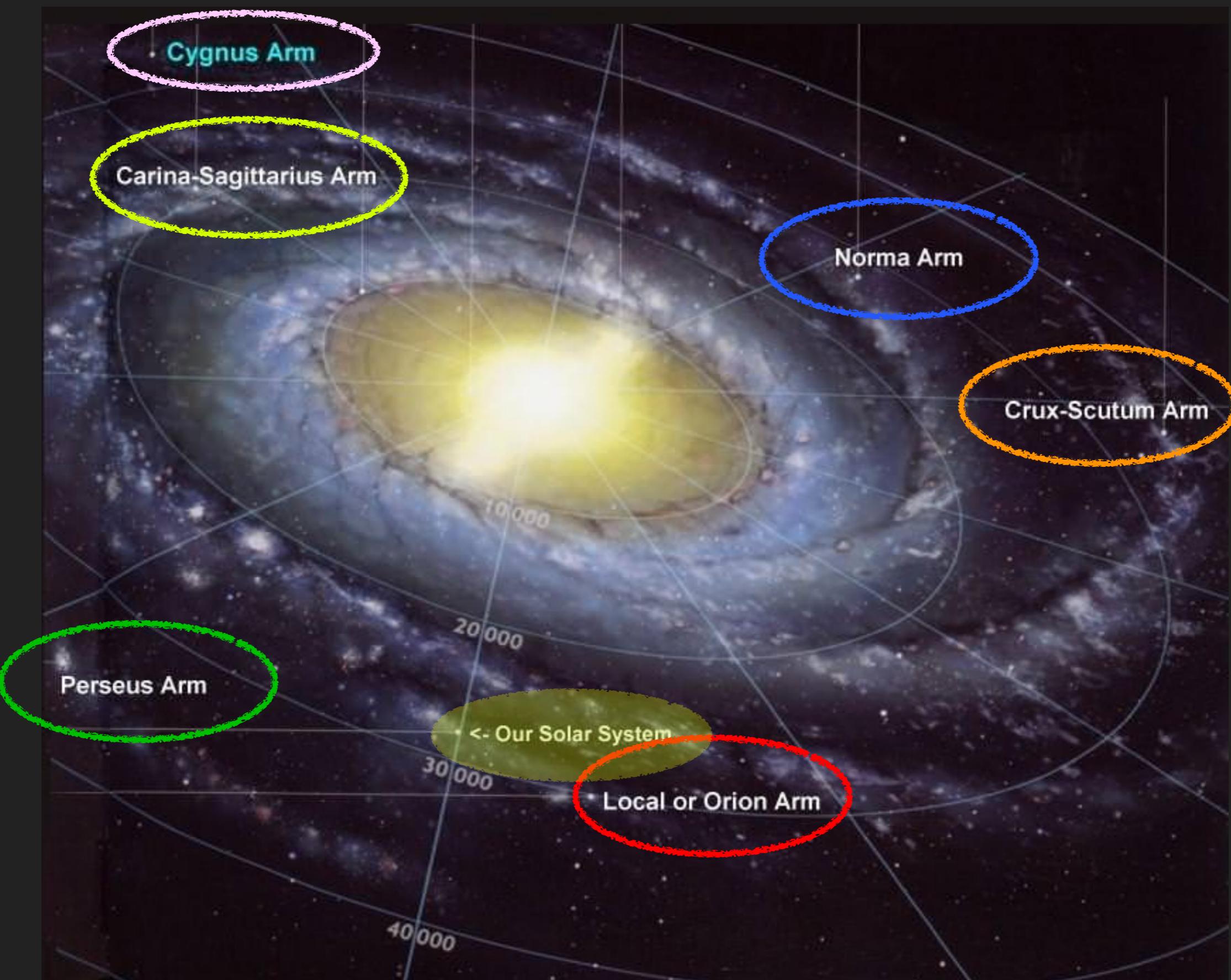
# STRUCTURE

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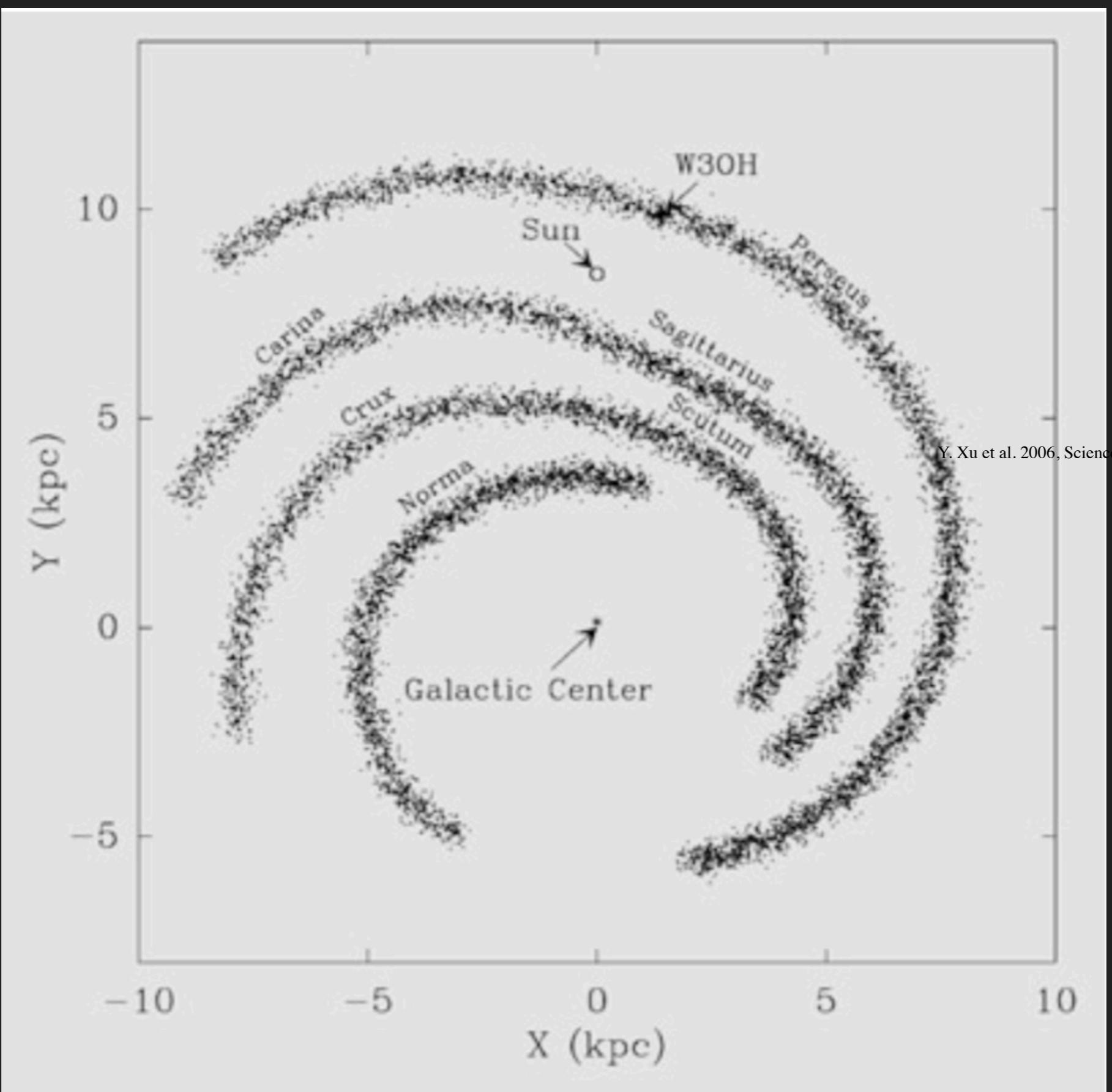
- ▶ Halo:  $1-3 \times 10^9 M_{\odot}$
- ▶ Disc:  $6 \times 10^{10} M_{\odot}$ 
  - ▶ Thin disc: 700 LY
  - ▶ Thick disc: 3.000 LY
- ▶ Bulge:  $10^{10} M_{\odot}$ 
  - 10.000 LY
  - 10 billion stars



# SPIRAL STRUCTURE

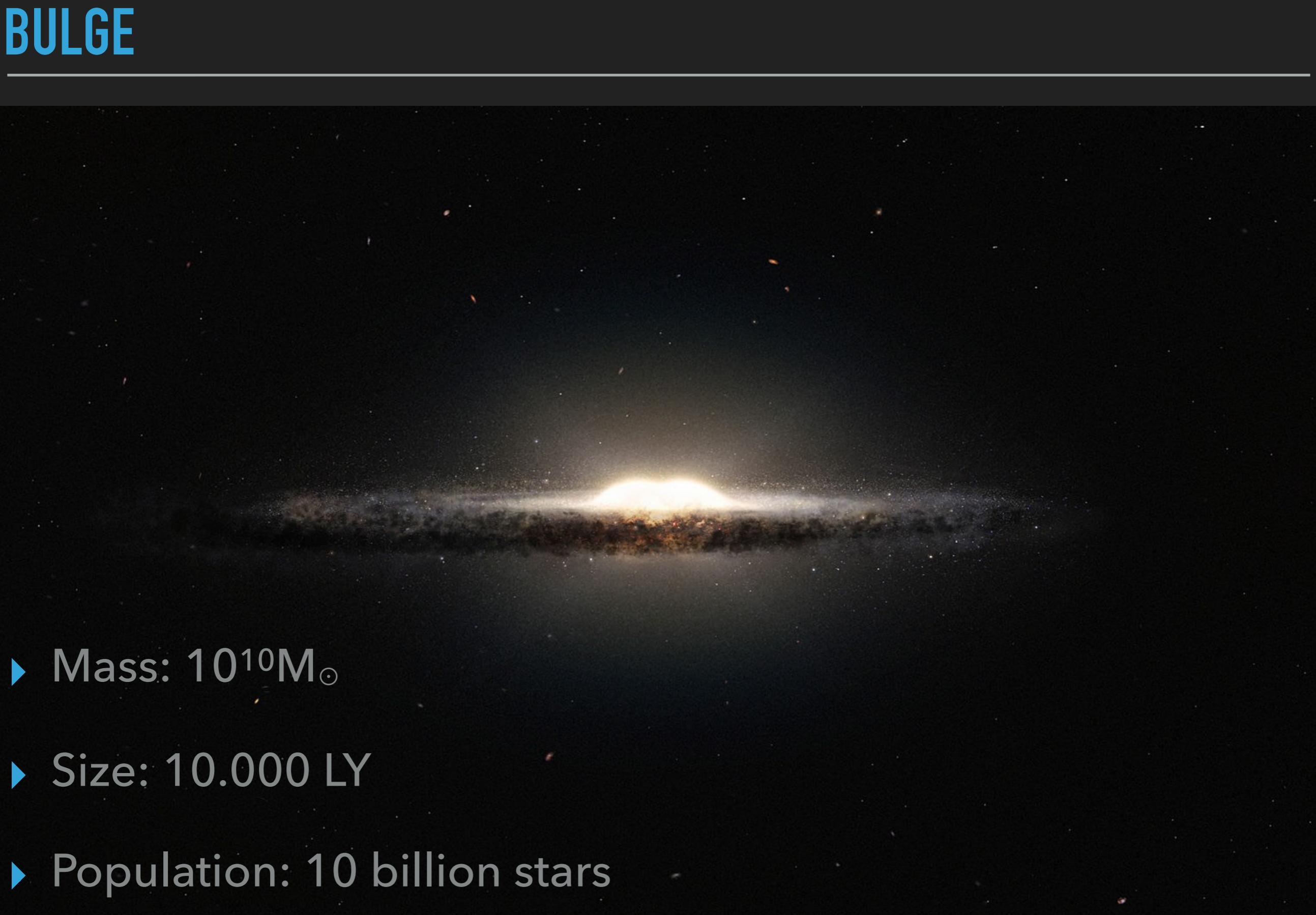


# SPIRAL STRUCTURE

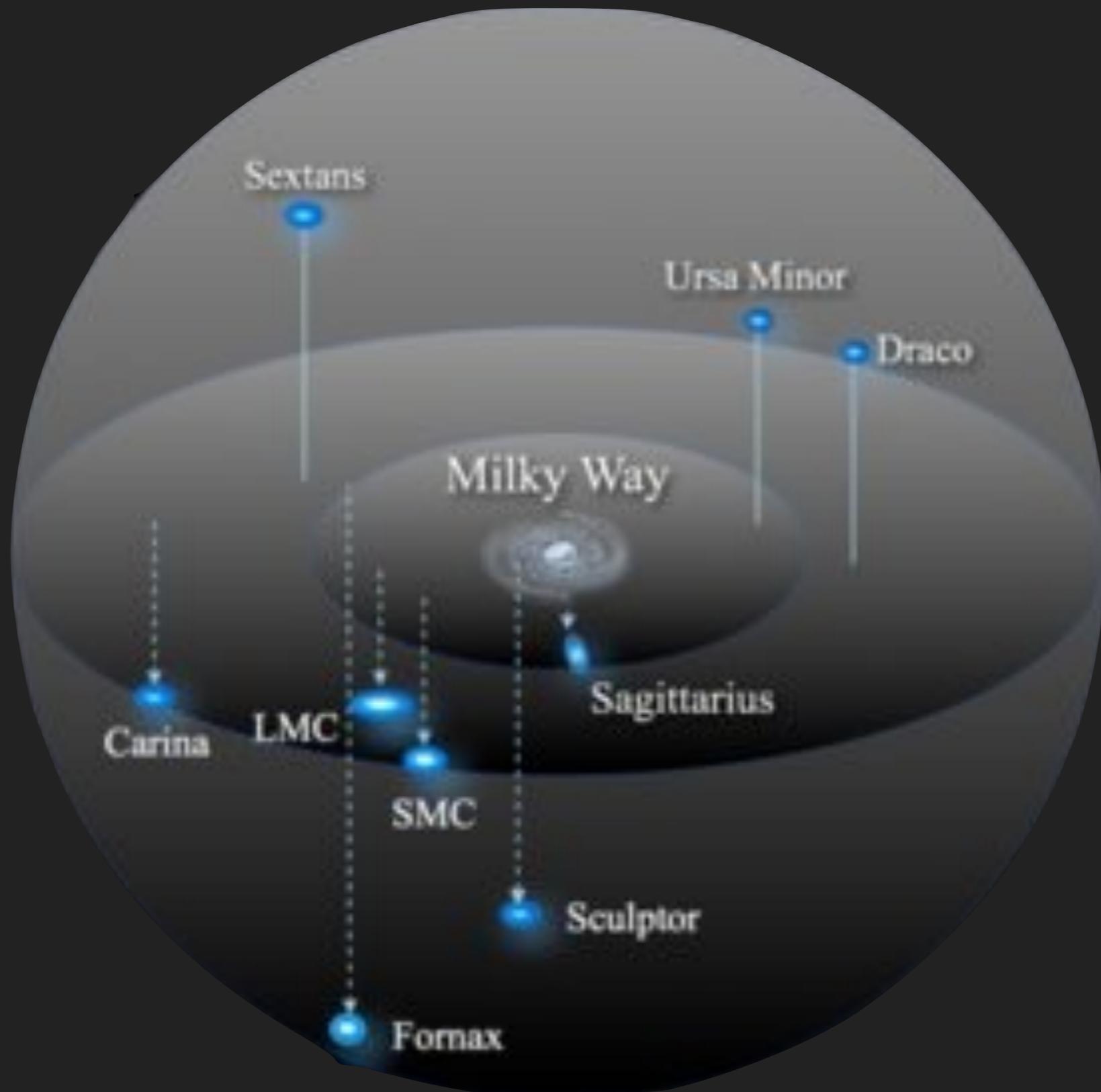


# BULGE

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- ▶ Mass:  $10^{10} M_{\odot}$
- ▶ Size: 10.000 LY
- ▶ Population: 10 billion stars



# LMC & SMC

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- ▶ LMC
- ▶  $d \sim 163.000\text{LY}$
- ▶  $M \sim 10 \text{ billion } M_{\odot}$
- ▶  $R \sim 14000\text{LY}$  (1/100 of MW)
- ▶ Once: barred spiral galaxy
- ▶ Interactions with SMC & MW
- ▶ Now: spiral arms are disrupted

# LMC & SMC

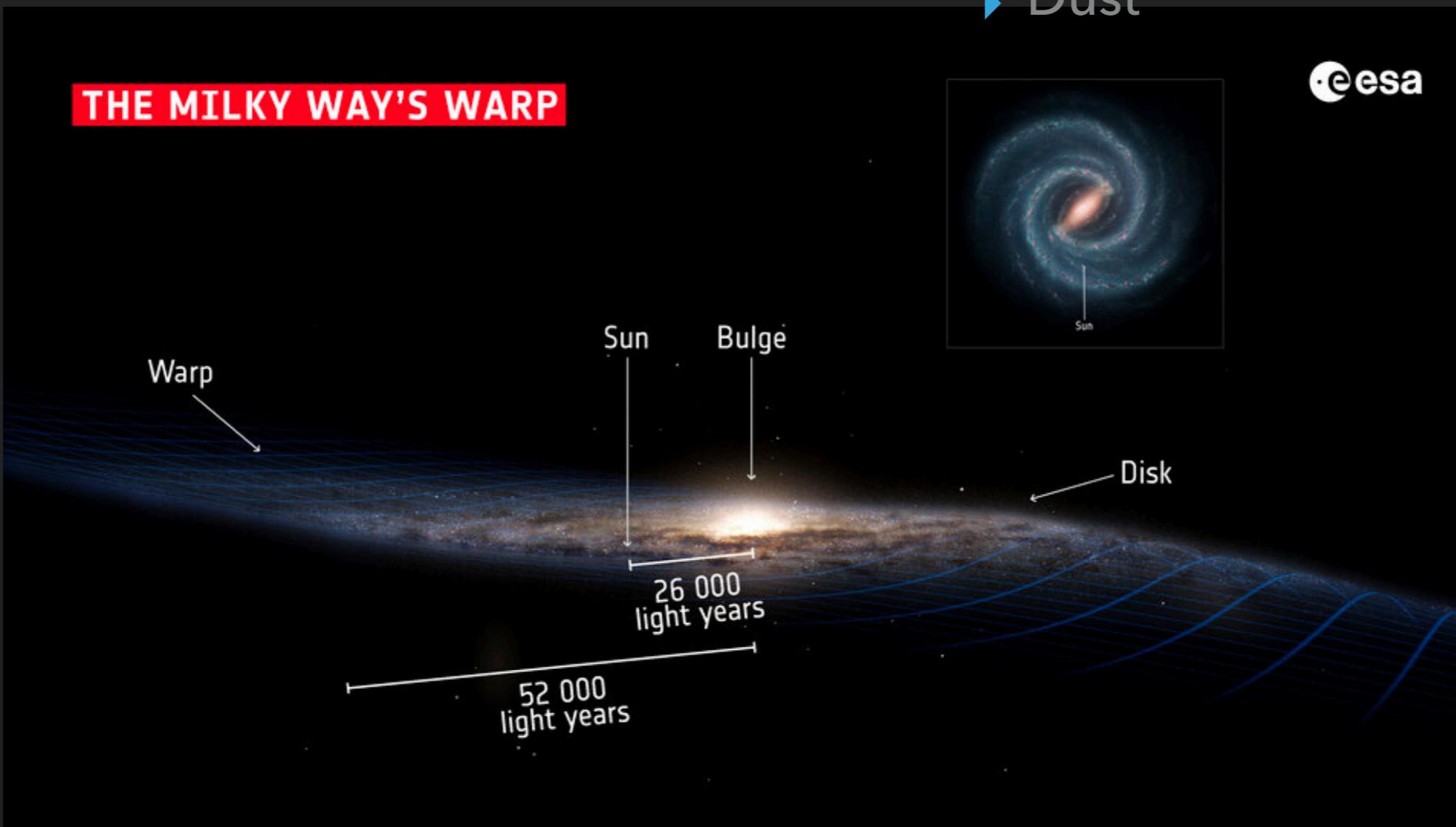
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- ▶ SMC
- ▶  $d \sim 200,000 \text{ LY}$
- ▶  $M \sim 7 \text{ billion } M_{\odot}$
- ▶  $R \sim 7000 \text{ LY}$  (half of LMC)
  
- ▶ Once: barred spiral galaxy
- ▶ Interactions with MW
- ▶ Now: irregular

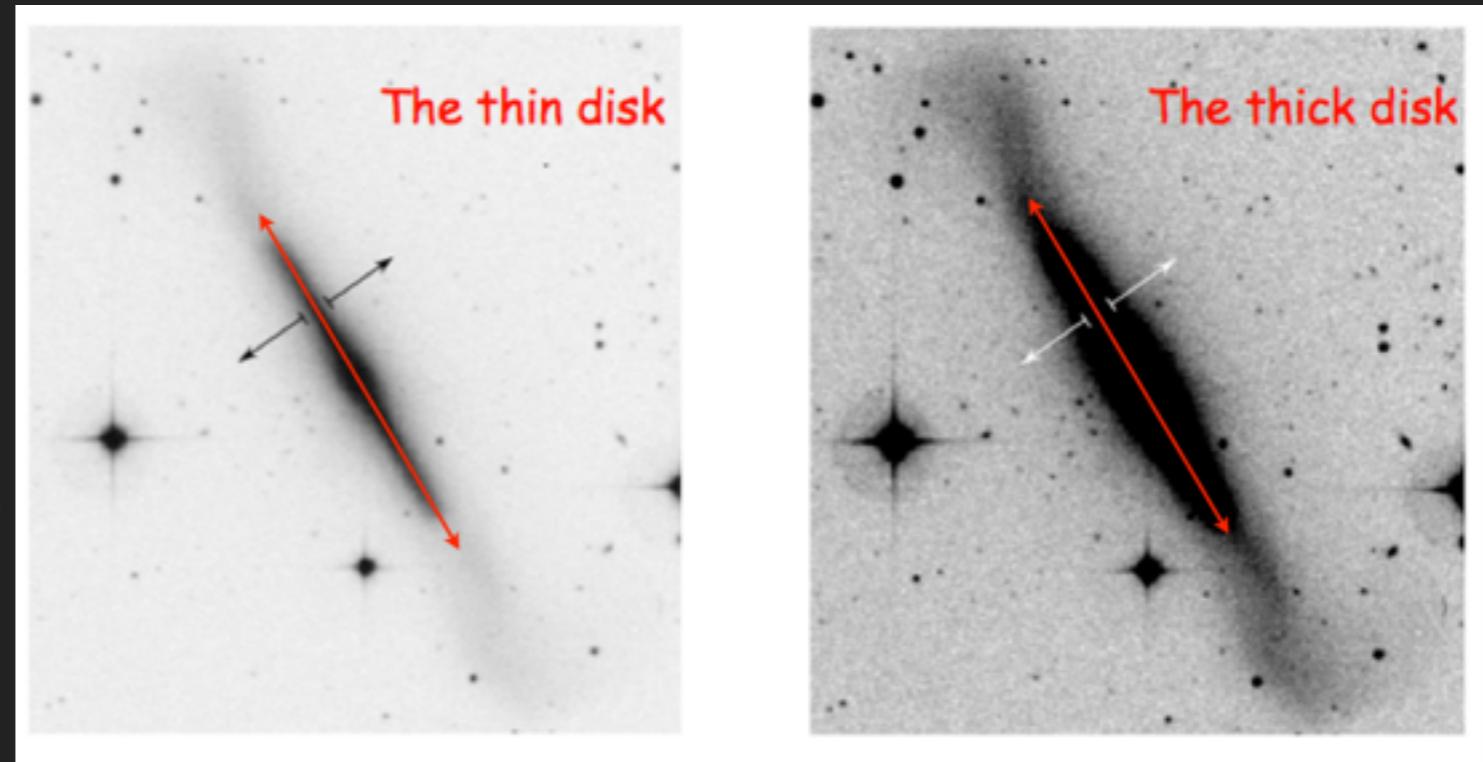
# DISK

- ▶ Not flattened; warped
- ▶  $R \sim 100,000 \text{ LY}$
- ▶ Thickness  $\sim 300 - 1000 \text{ LY}$
- ▶  $P_{\odot} \sim 240 \text{ million year}$
- ▶ Contains:
  - ▶ Spiral arms
  - ▶ Young stars
  - ▶ Cool gas
  - ▶ Dust



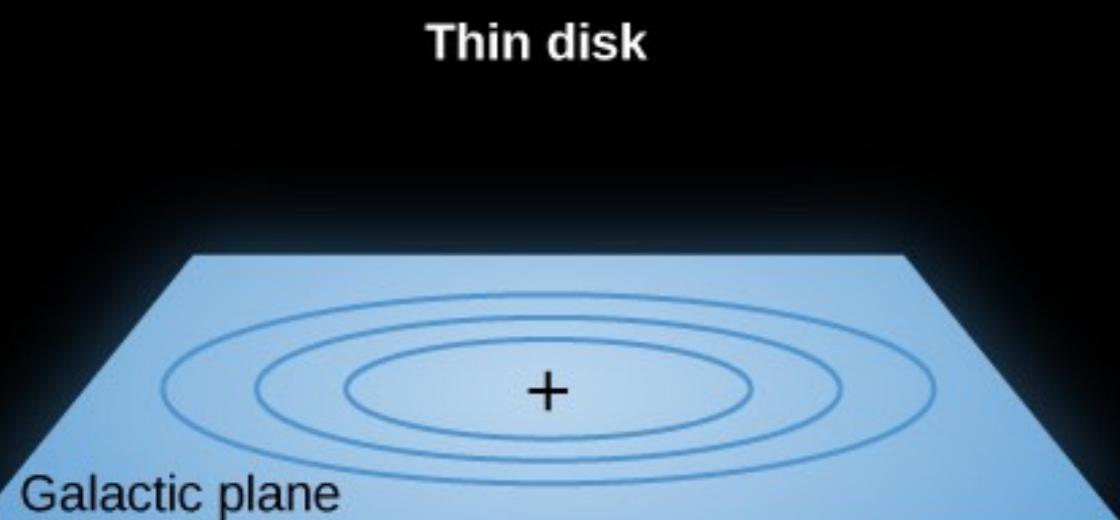
- ▶ Thick Disc:

- ▶ First discovered on edge galaxies
- ▶ Unique for Milky Way ?
- ▶ 2/3 of all disk galaxies have thick disc
- ▶ Height ~1.5 kpc
- ▶ Old Thin Disc:
- ▶ Height ~325pc

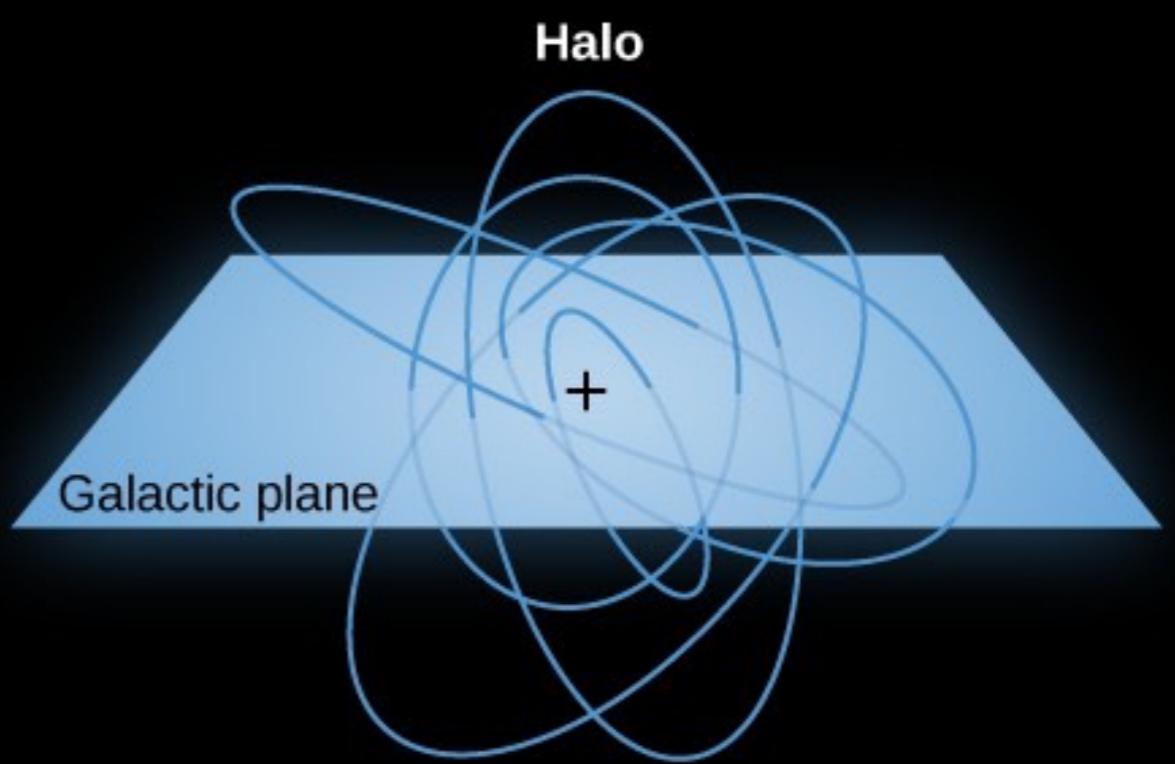


- ▶ Young Thin Disc:

- ▶ Star formation region
- ▶ Height ~100pc



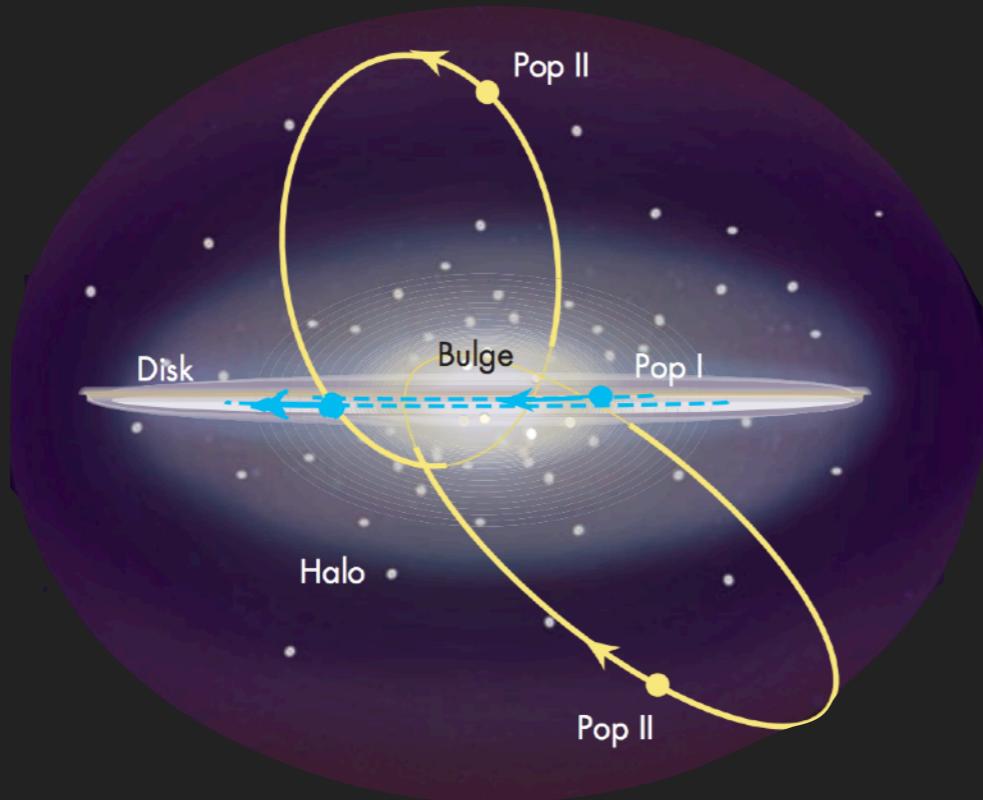
(a)



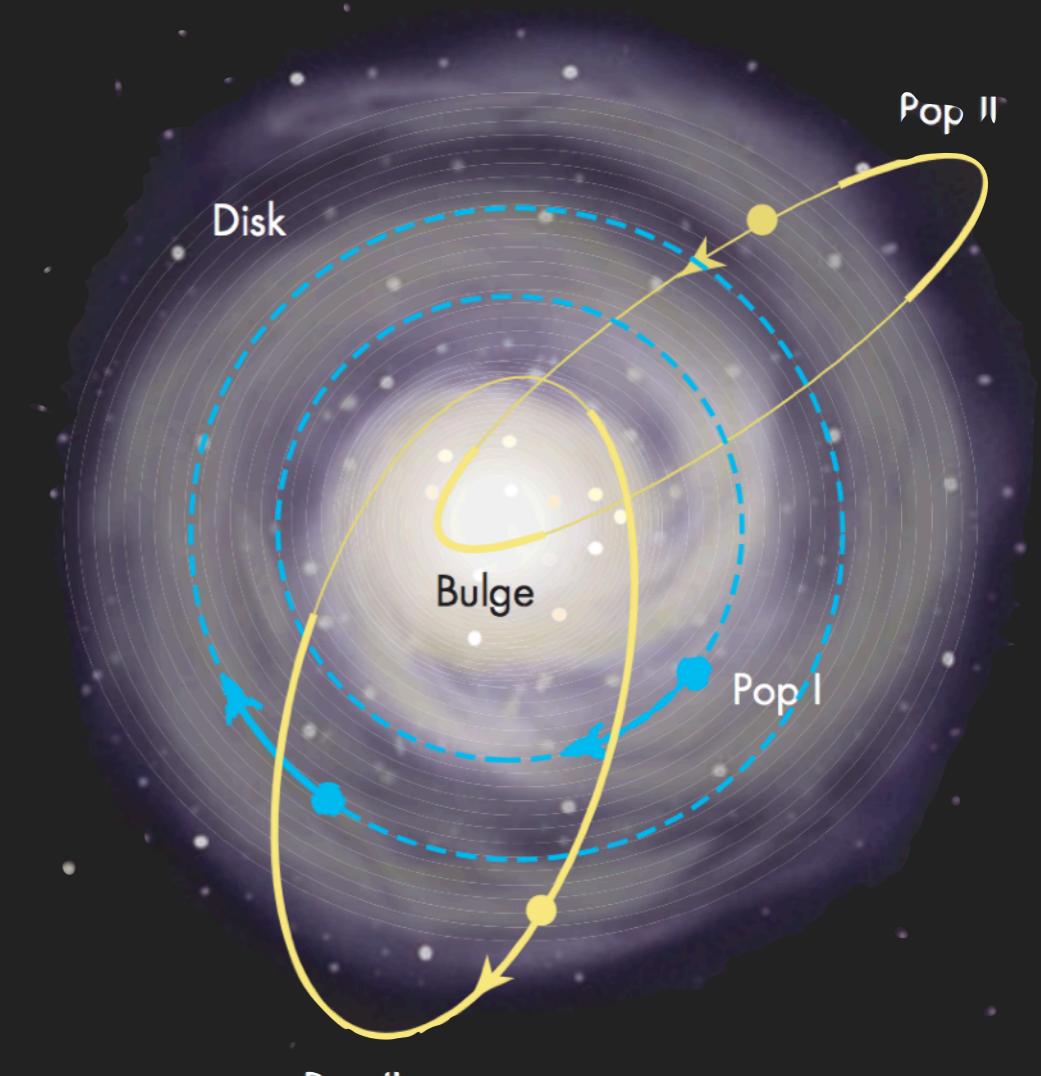
(b)

# POP I & POP II STARS

- ▶ Pop I
- ▶ Sun
- ▶ Luminous
- ▶ Hot
- ▶ Young
- ▶ @Disks & spiral arms of spiral galaxies
- ▶ Made up from previous stars



- ▶ Pop II
- ▶ Globular clusters
- ▶ Nucleus of galaxy
- ▶ Metal-poor
- ▶ Old

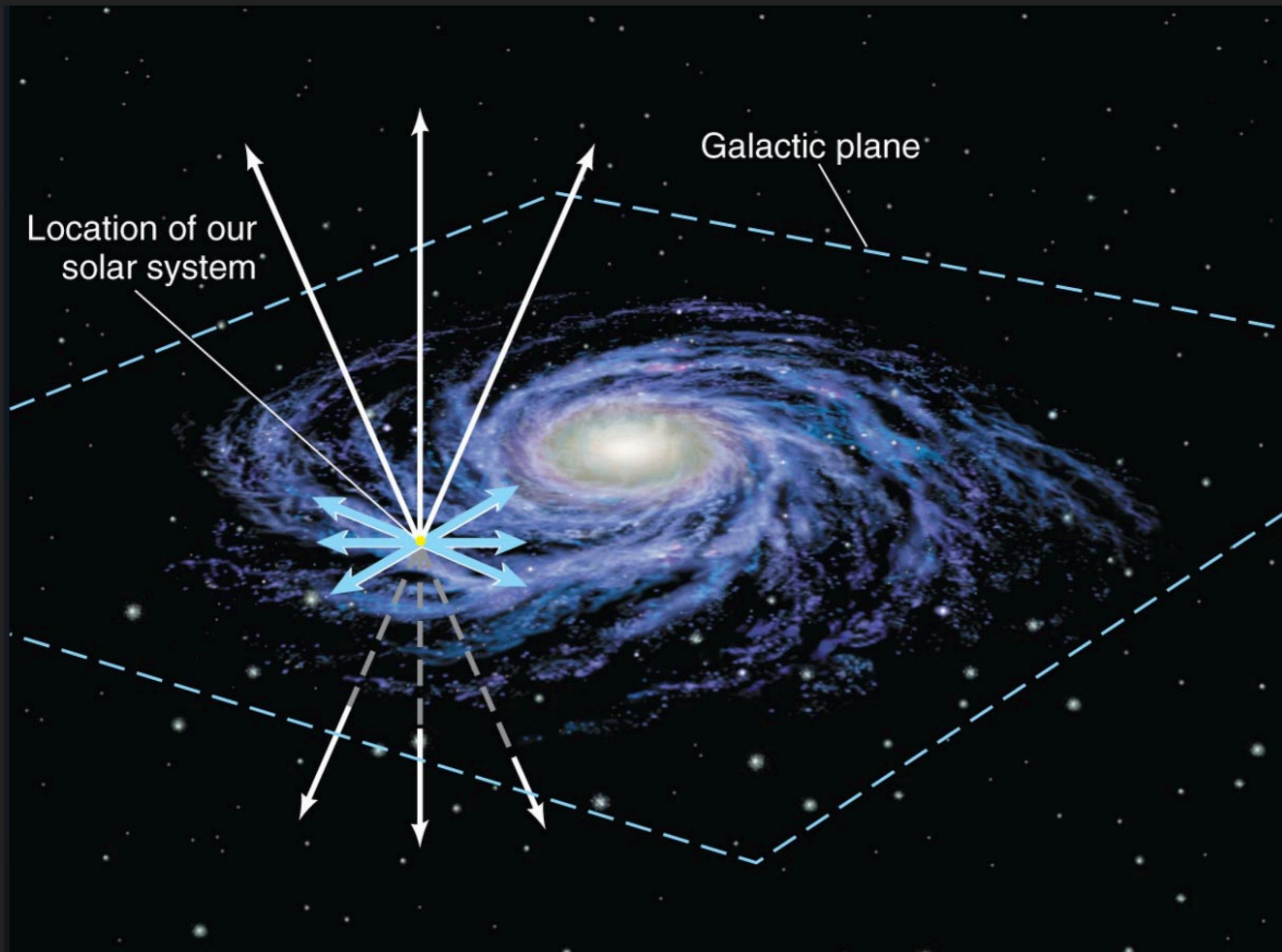


# POP I & II STARS

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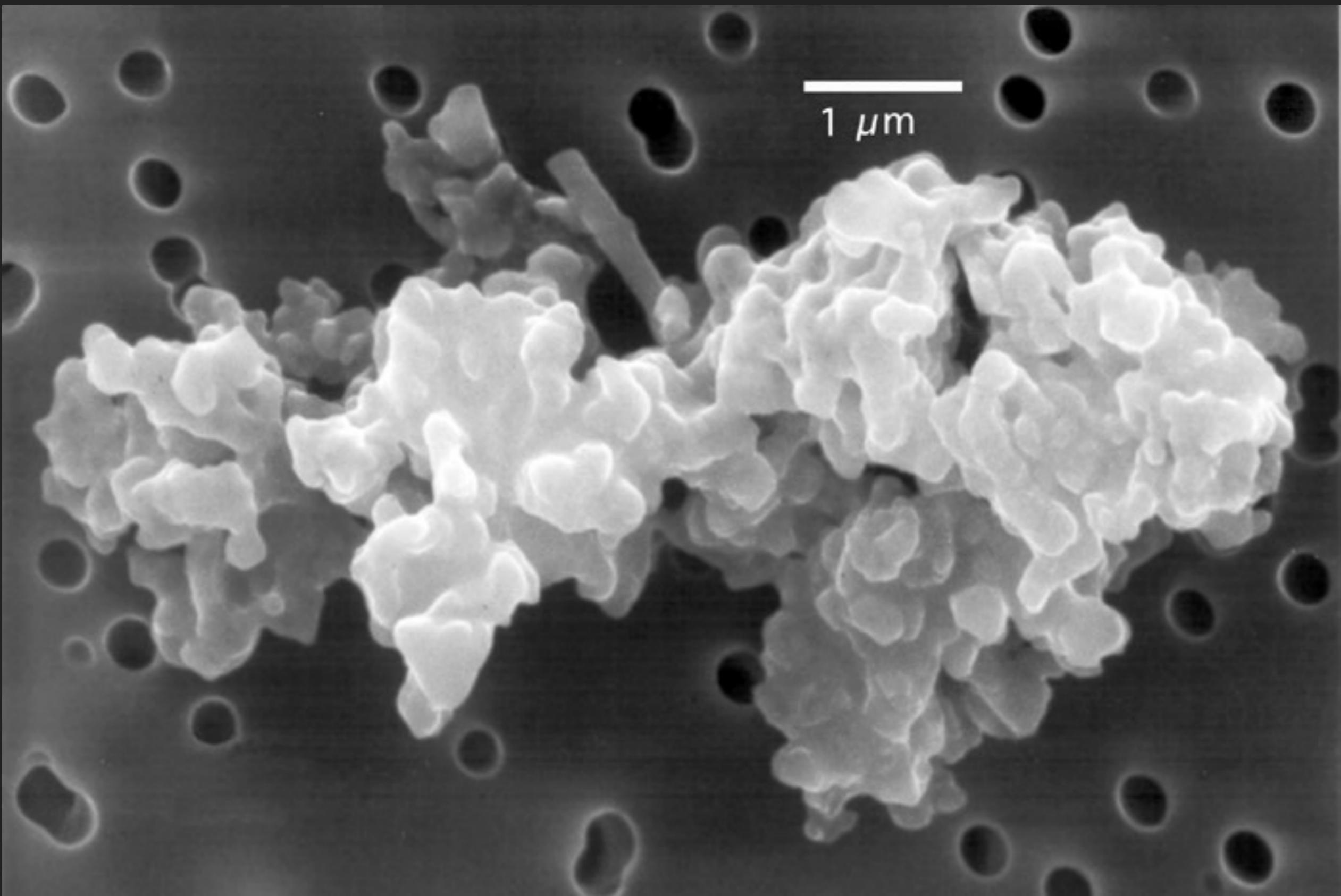
	Pop I	Pop II
Location	Disk & Arms	Bulge, Halo
Age	Young $10^6$ - $10^9$ years	Old $10^{10}$ years
Metallicity	Solar metallicity	Metal-poor
Orbit	Nearly circular	Random Elliptical
Color	Blue	Red
Example	Sun Bright super giants O / B type MS stars Open cluster stars ISM & Molecular Clouds	Stars in Planetary Nebulae RR Lyr type variables Globular cluster stars

# GAS IN THE GALAXY



# INTERSTELLAR GAS & DUST

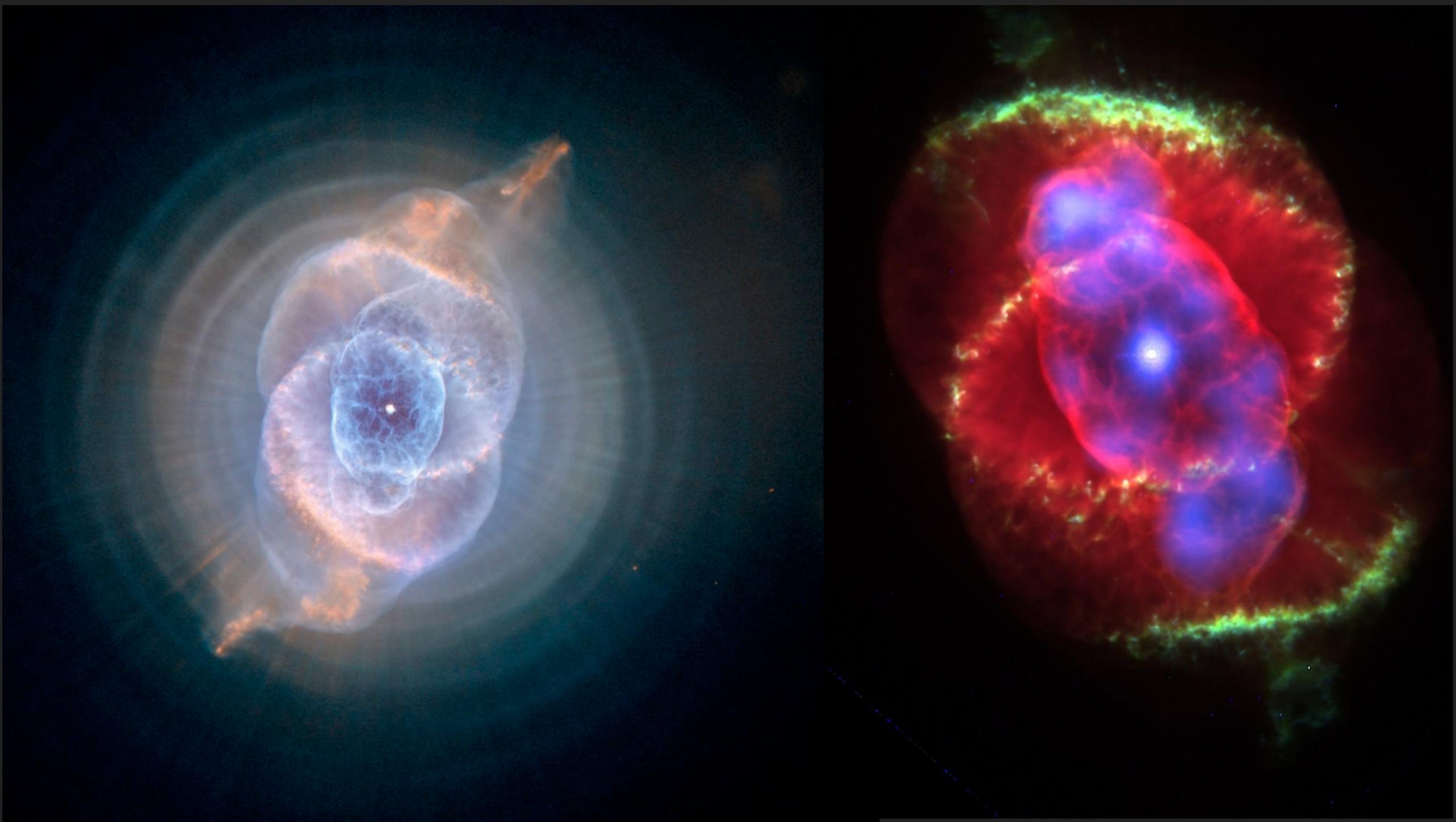
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Donald E. Brownlee, University of Washington, Seattle, and Elmar Jessberger, Institut für Planetologie, Münster, Germany

# CAT'S EYE

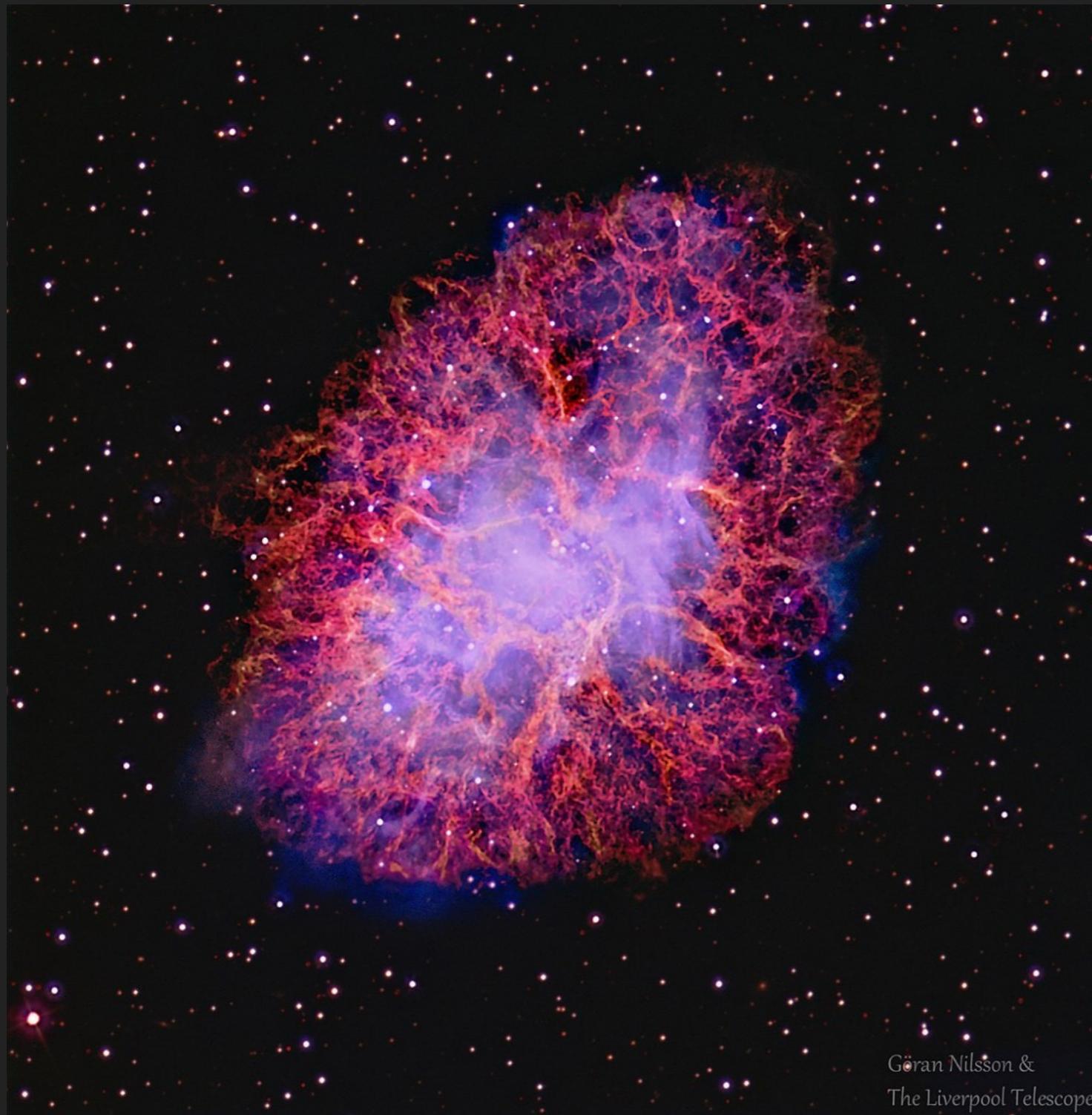
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NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA)

# CRAB NEBULA - M1

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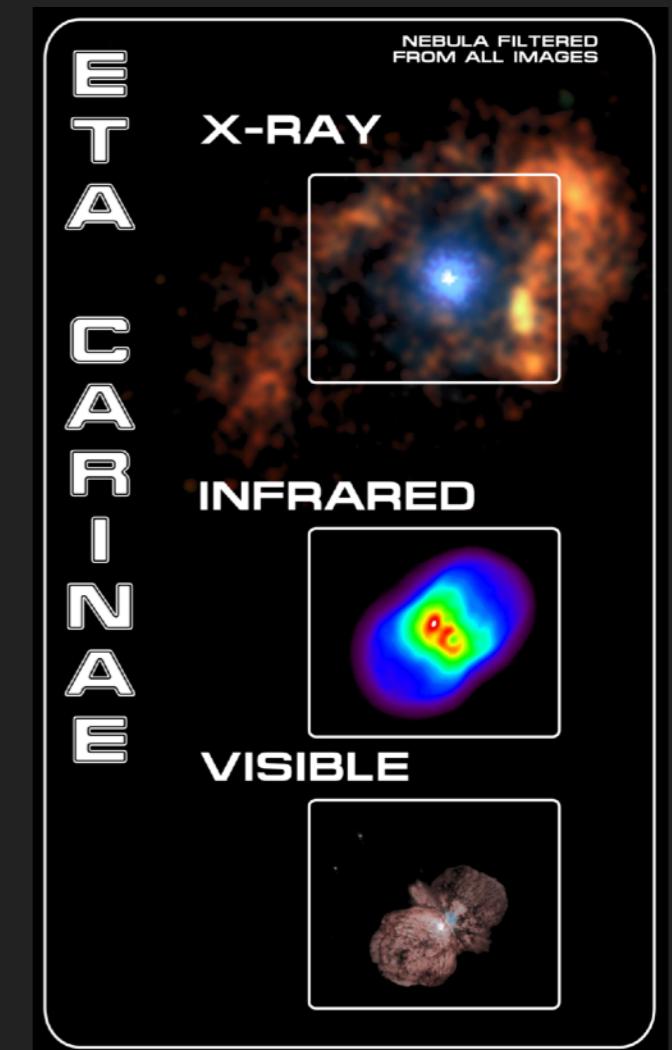
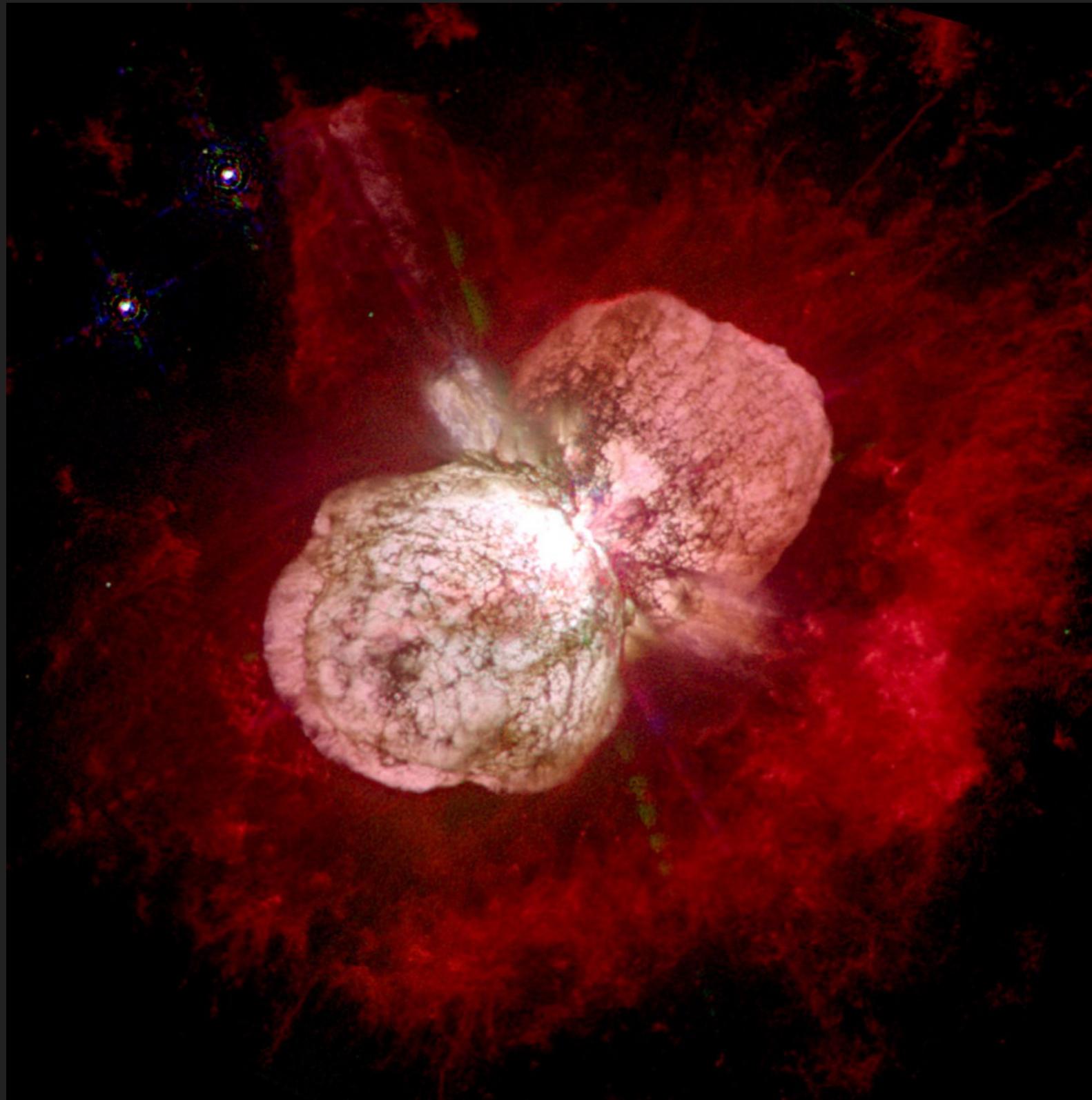


Göran Nilsson &  
The Liverpool Telescope



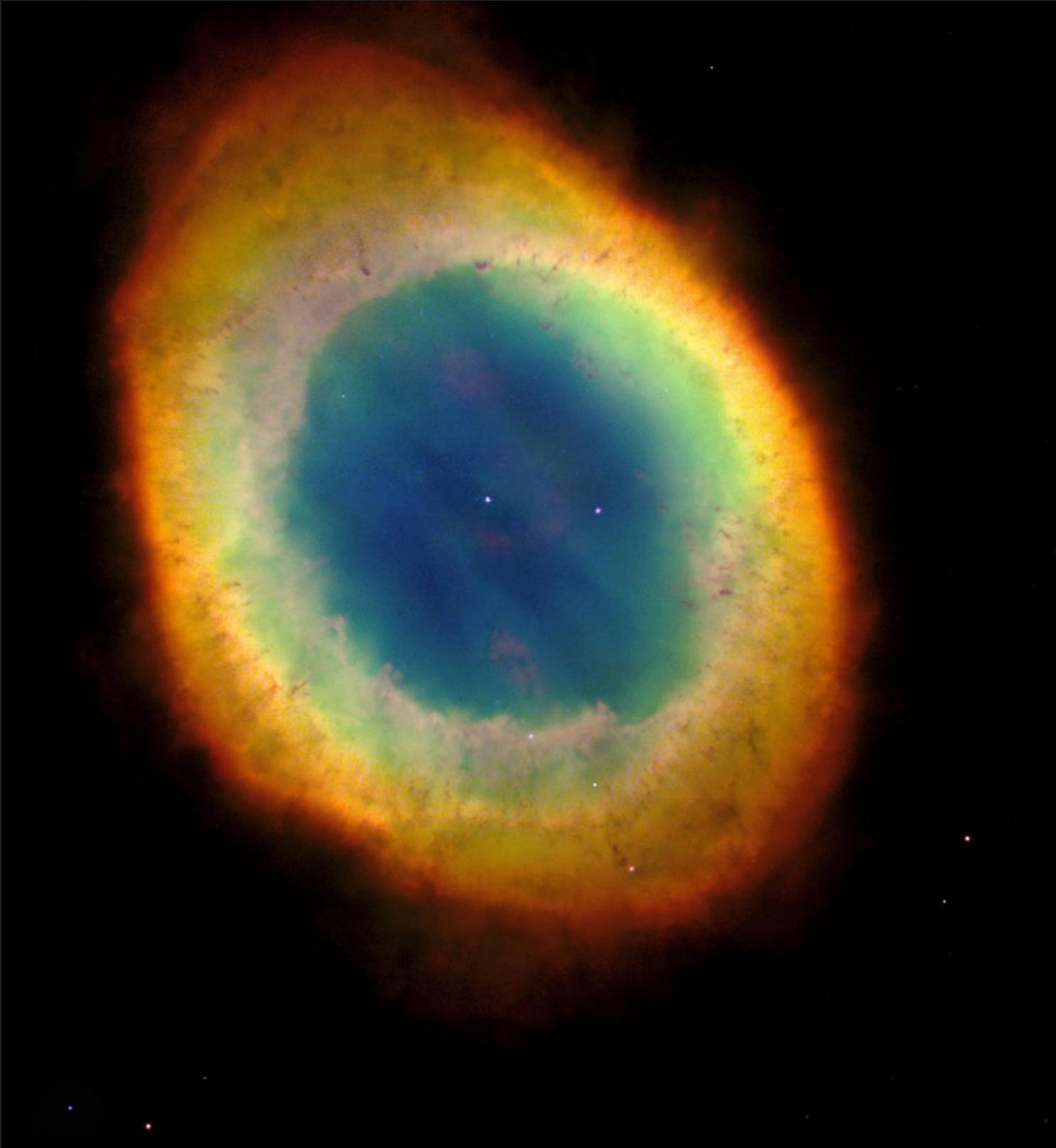
Optical: NASA/HST/ASU/J. Hester et al. X-Ray: NASA/CXC/ASU

# ETA CARINA



# RING NEBULA

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The Hubble Heritage Team (AURA/STScI/NASA)

# HELIX NEBULA

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[www.eso.org](http://www.eso.org)



[www.eso.org](http://www.eso.org)

# DUMBBELL - M27

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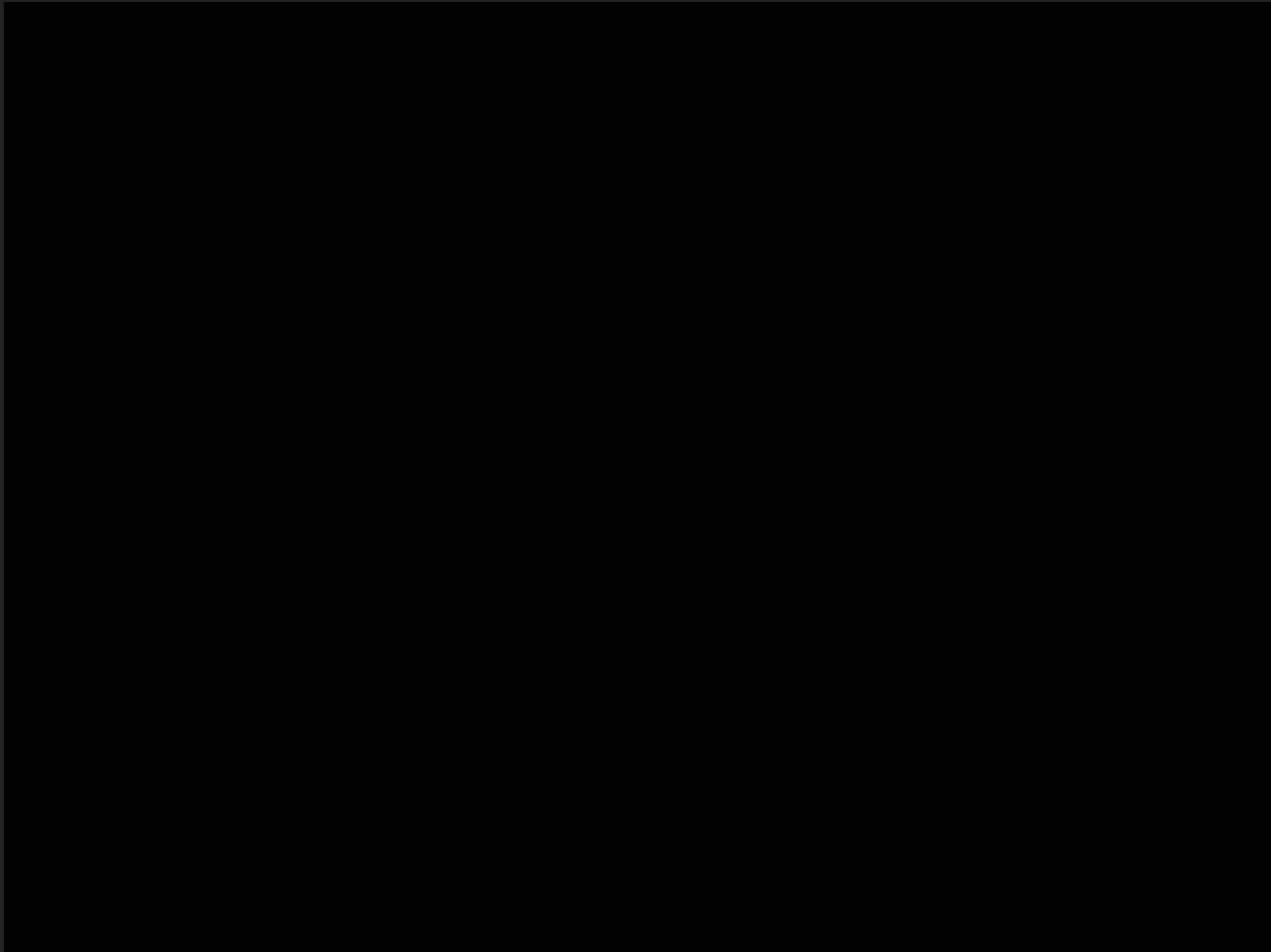
# ORION NEBULA - M42

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# ORION NEBULA - M42

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# HORSE HEAD

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# MULTI WAVELENGTH MILKYWAY

Radio



Infrared



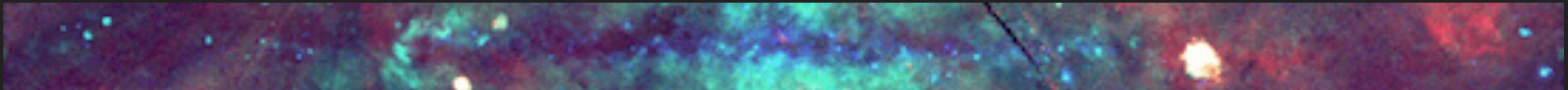
Optical



UV



X-Ray

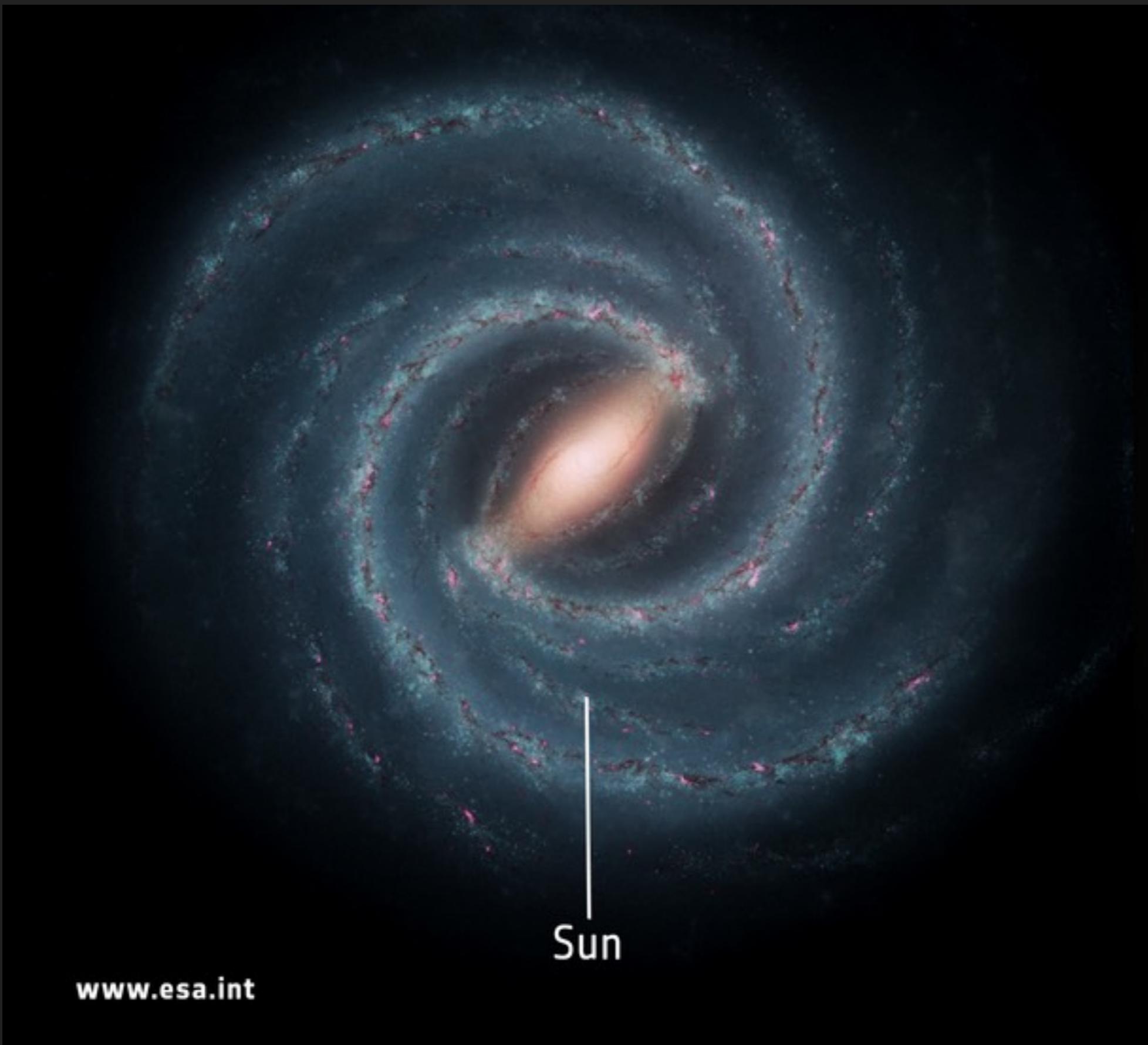


Gamma Ray



# GALACTIC BAR

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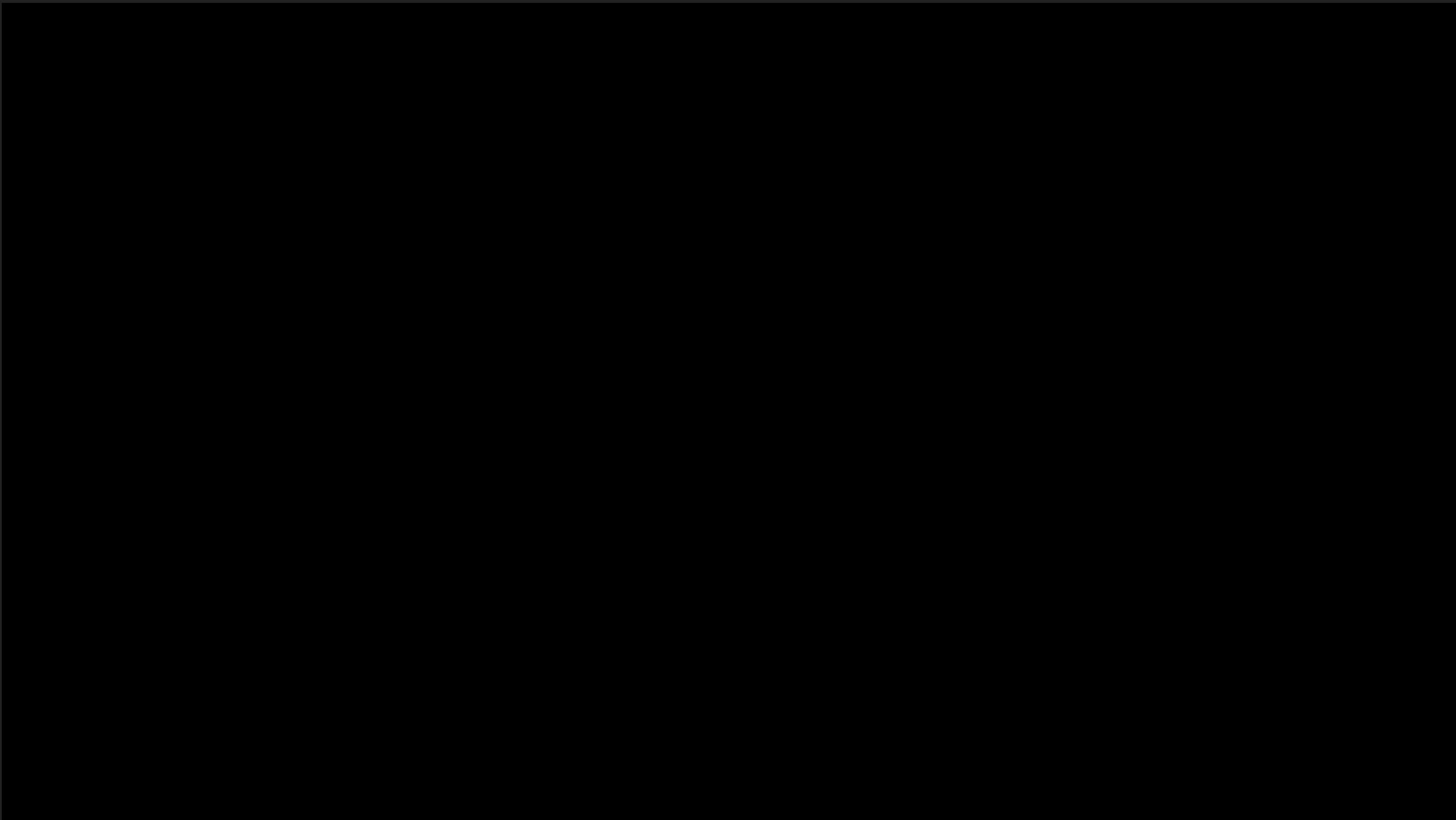
# GALACTIC CENTRE

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- ▶ Rotational centre
- ▶ Sag, Oph, Sco direction
- ▶ Sagittarius A
- ▶ Super-massive black hole:  $4.100 \pm 0.034$  million  $M_{\odot}$
- ▶  $26,700 \pm 1,300$  LY away
- ▶ 10 million stars @ 1pc
- ▶ Red giants & Massive Supergiants & Wolf Rayet stars

# GALACTIC CENTRE

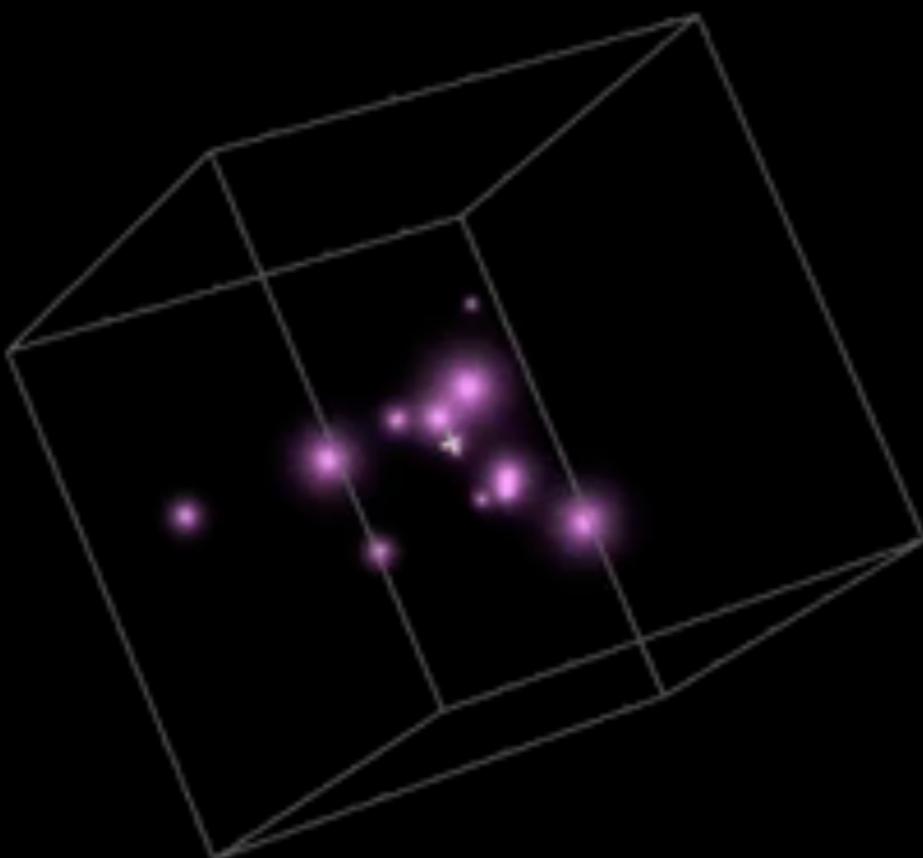
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# SAG A

Year: 1995.0

The Acceleration of Stars Orbiting  
the Milky Way's Central Black Hole



Data: Andrea Ghez, Jessica Lu (UCLA)

Visualization: Dinoj Surendran, Randy Landsberg,

Mark SubbaRao (UChicago / Adler / KICP)



UCLA/Keck Galactic Center Group

# REFERENCES

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- ▶ <https://www.universetoday.com/65343/what-galaxy-is-the-earth-in/>
- ▶ [https://www.researchgate.net/publication/237053797\\_Cold\\_dark\\_matter\\_Controversies\\_on\\_small\\_scales/](https://www.researchgate.net/publication/237053797_Cold_dark_matter_Controversies_on_small_scales/)
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- ▶ <http://spaces.imperial.edu/russell.lavery/ast100/Lectures/Ast100Weekly/Ast100week14.html>
- ▶ <https://courses.lumenlearning.com/astronomy/chapter/the-mass-of-the-galaxy/>
- ▶ <https://youtu.be/xyjqHRNtEto>
- ▶ <https://imagine.gsfc.nasa.gov/science/objects/milkyway2.html>