

ASTR/PHYS 1060: The Universe

Chapter 15: Our Galaxy, the Milky Way

Ch. 16 Reading Assignment due Wednesday!

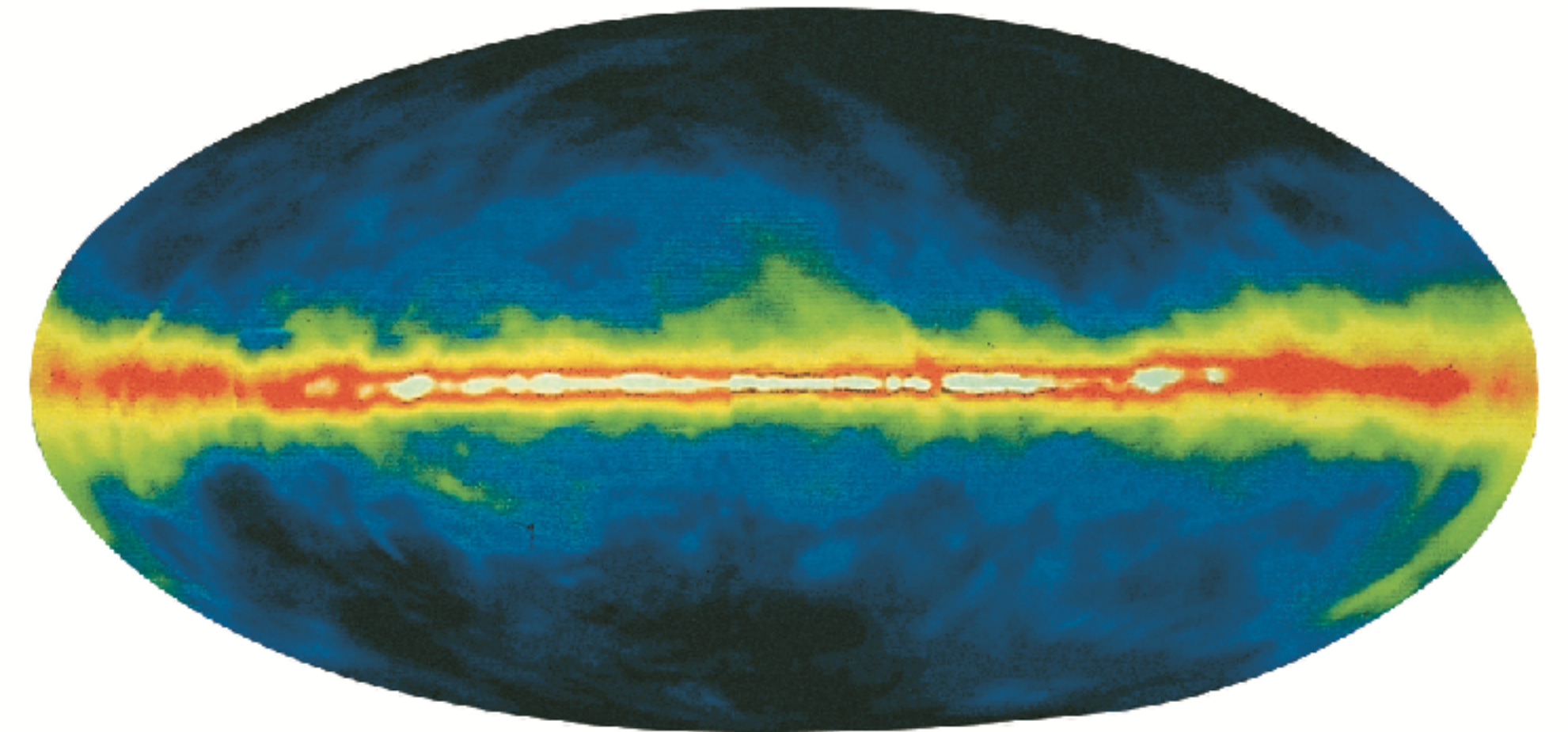
No office hours tomorrow for me

EC write-ups accepted anytime



What type of galaxy do we live in?

Milky Way



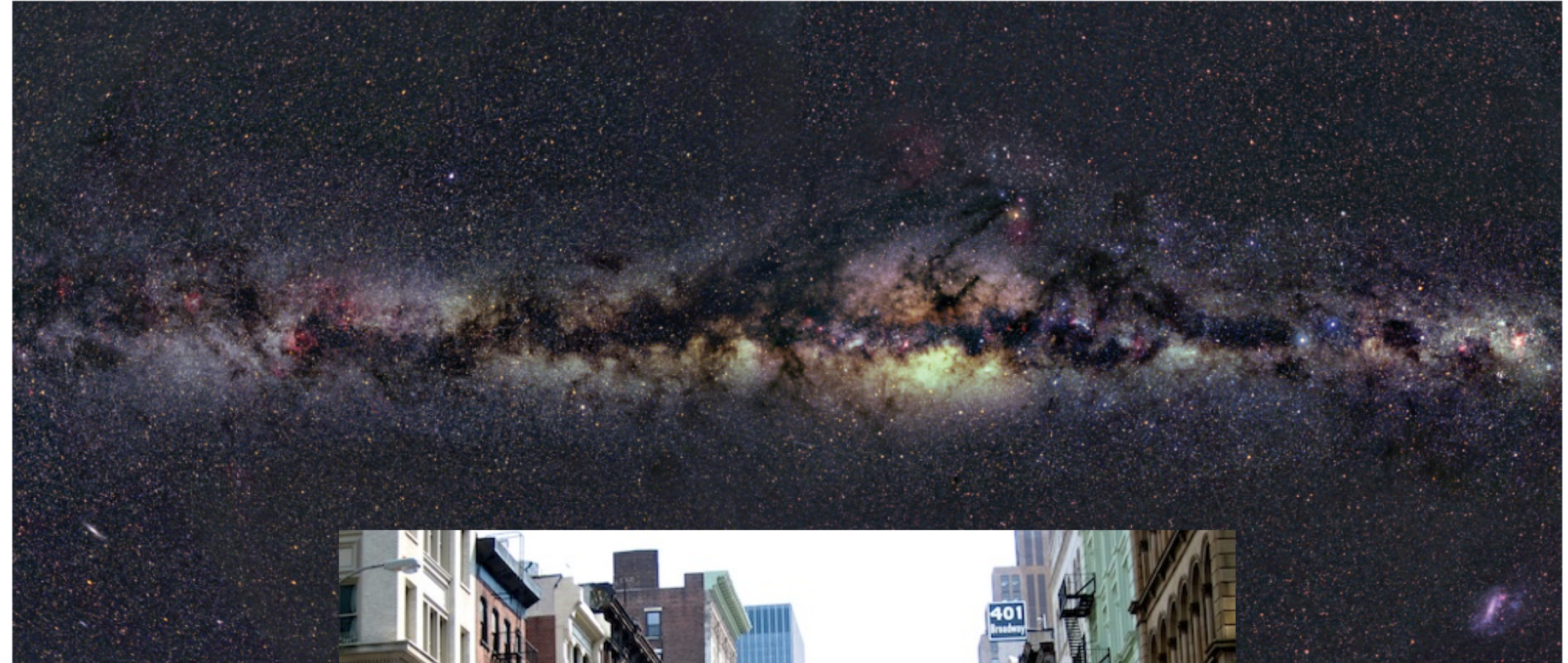
G X U V I R

Edge-on galaxy NGC 891

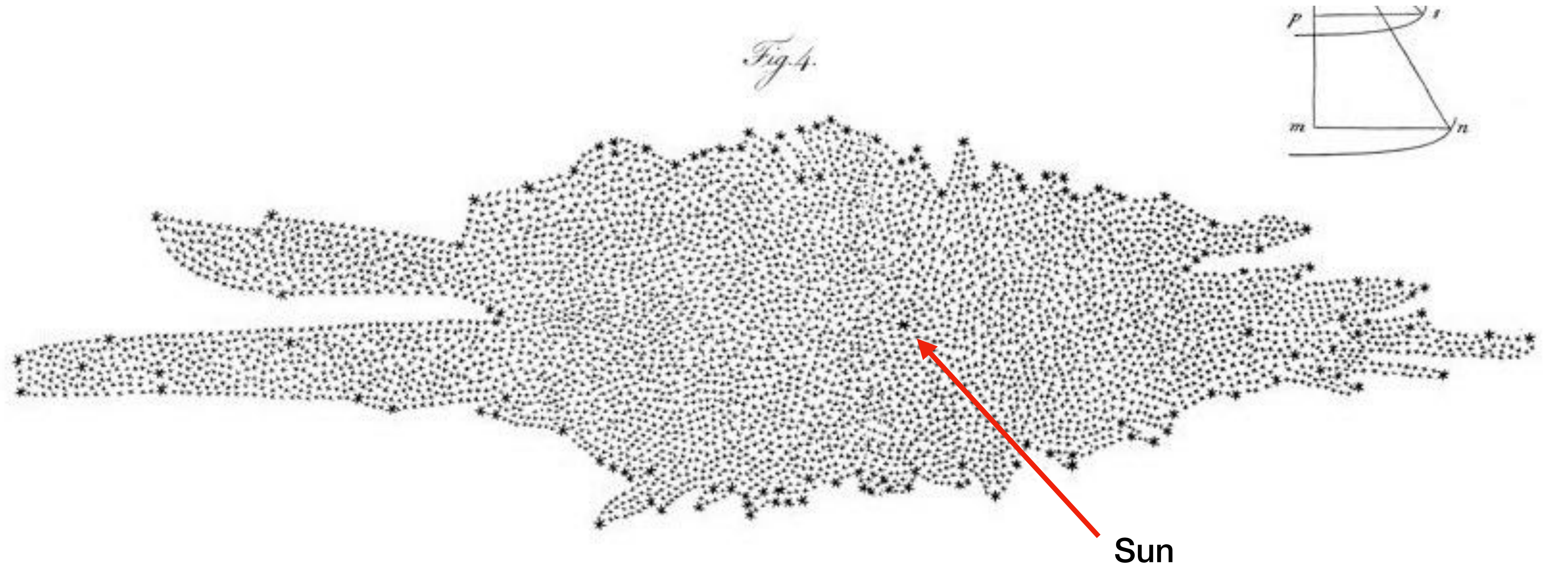


G X U V I R

Can't see the forest for the trees...



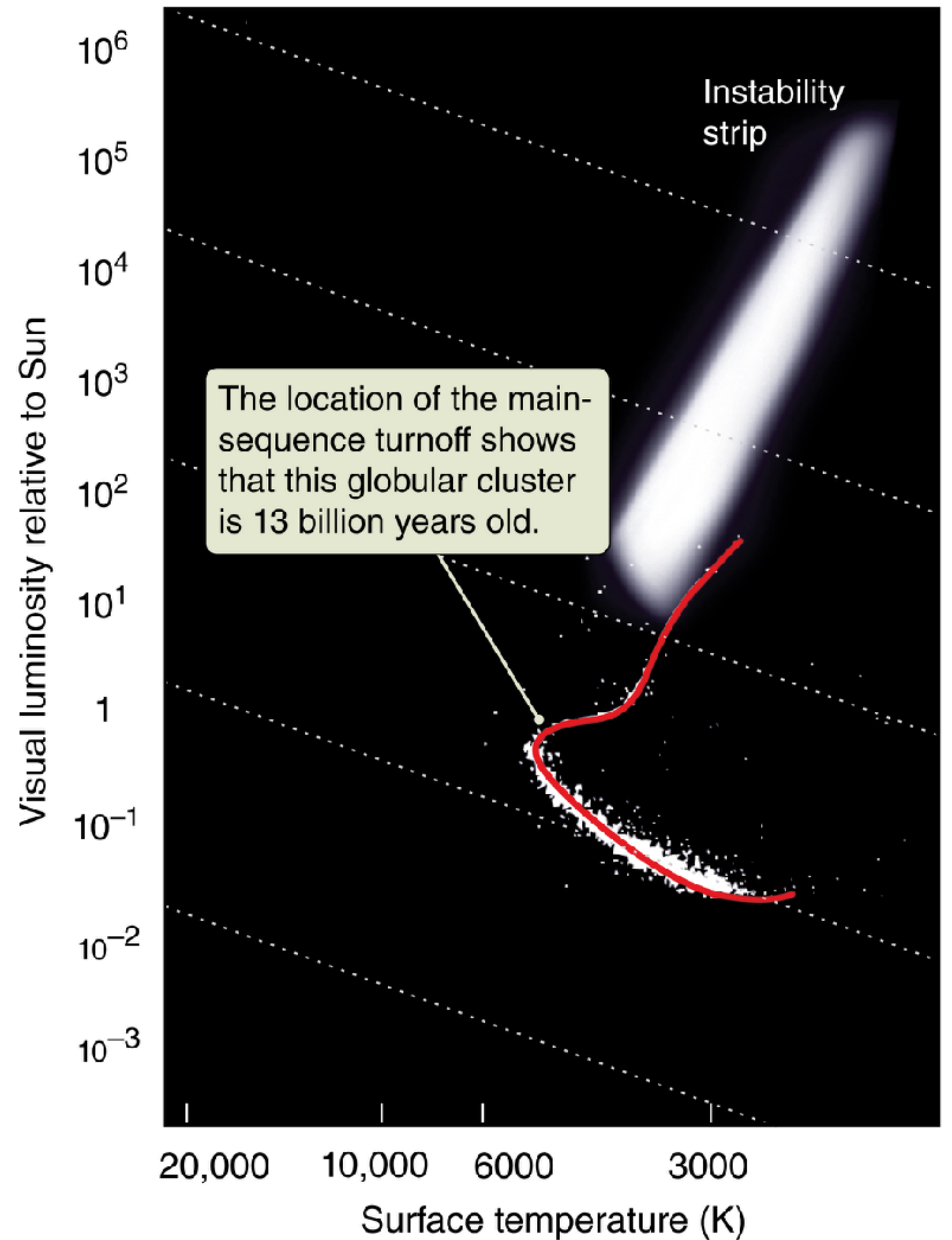
Star counts: William and Caroline Herschel (1785)



Globular Clusters



G X U **V** I R



Globular Clusters



G X U V I R

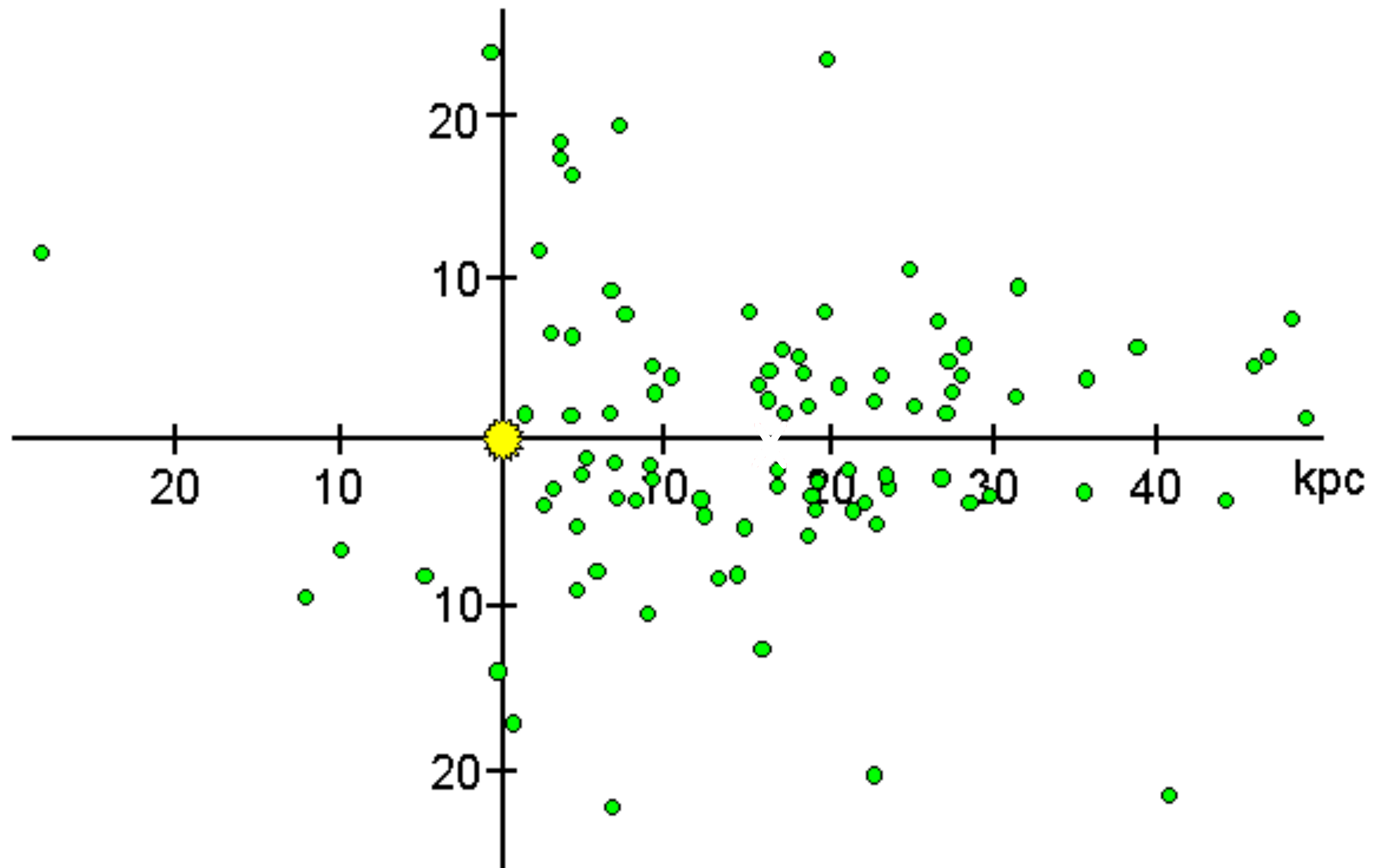
How can we estimate their age?

- A) Average star brightness
- B) Average star color
- C) Location of the MS turnoff in an HR diagram
- D) Location of the Horizontal branch in the HR diagram

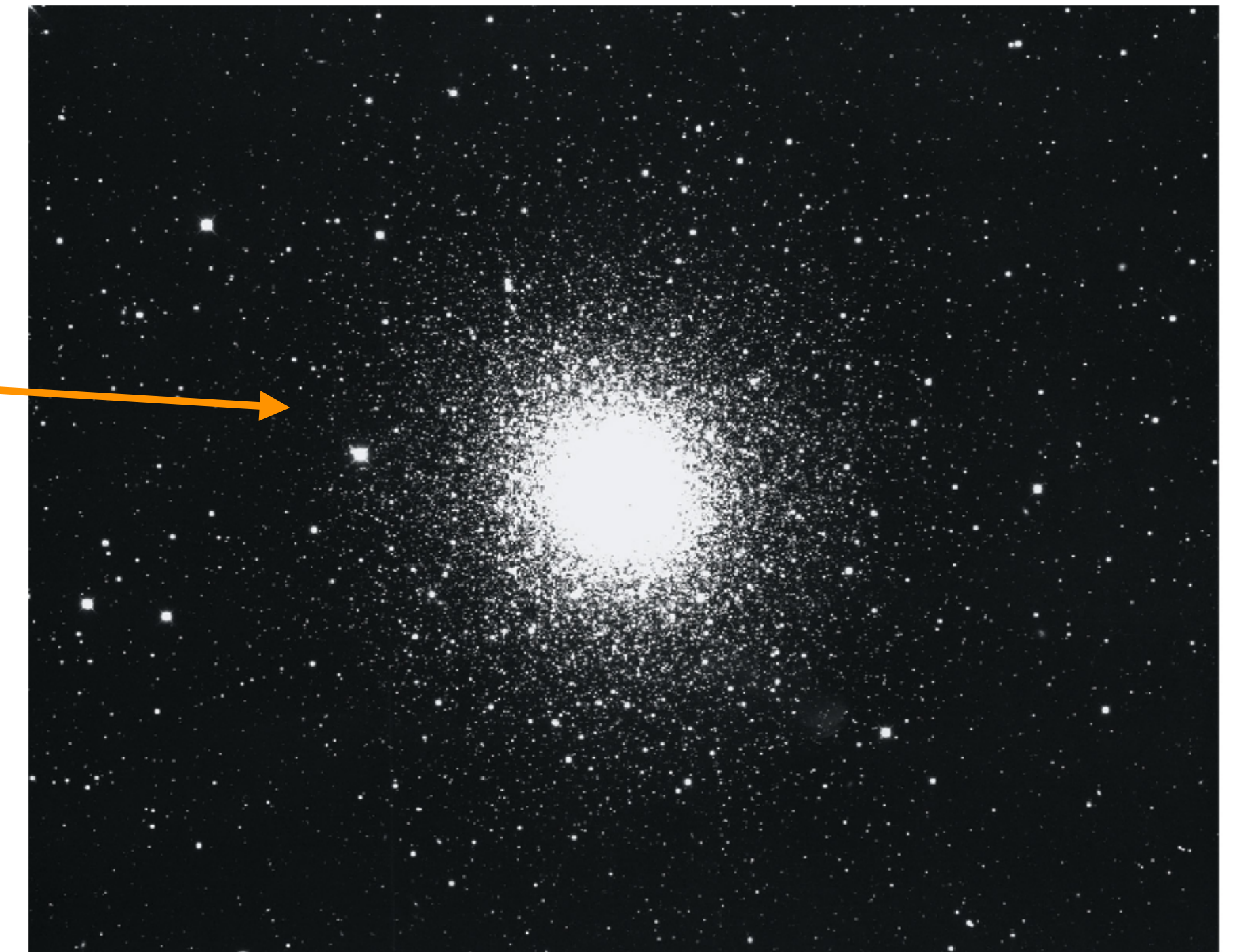
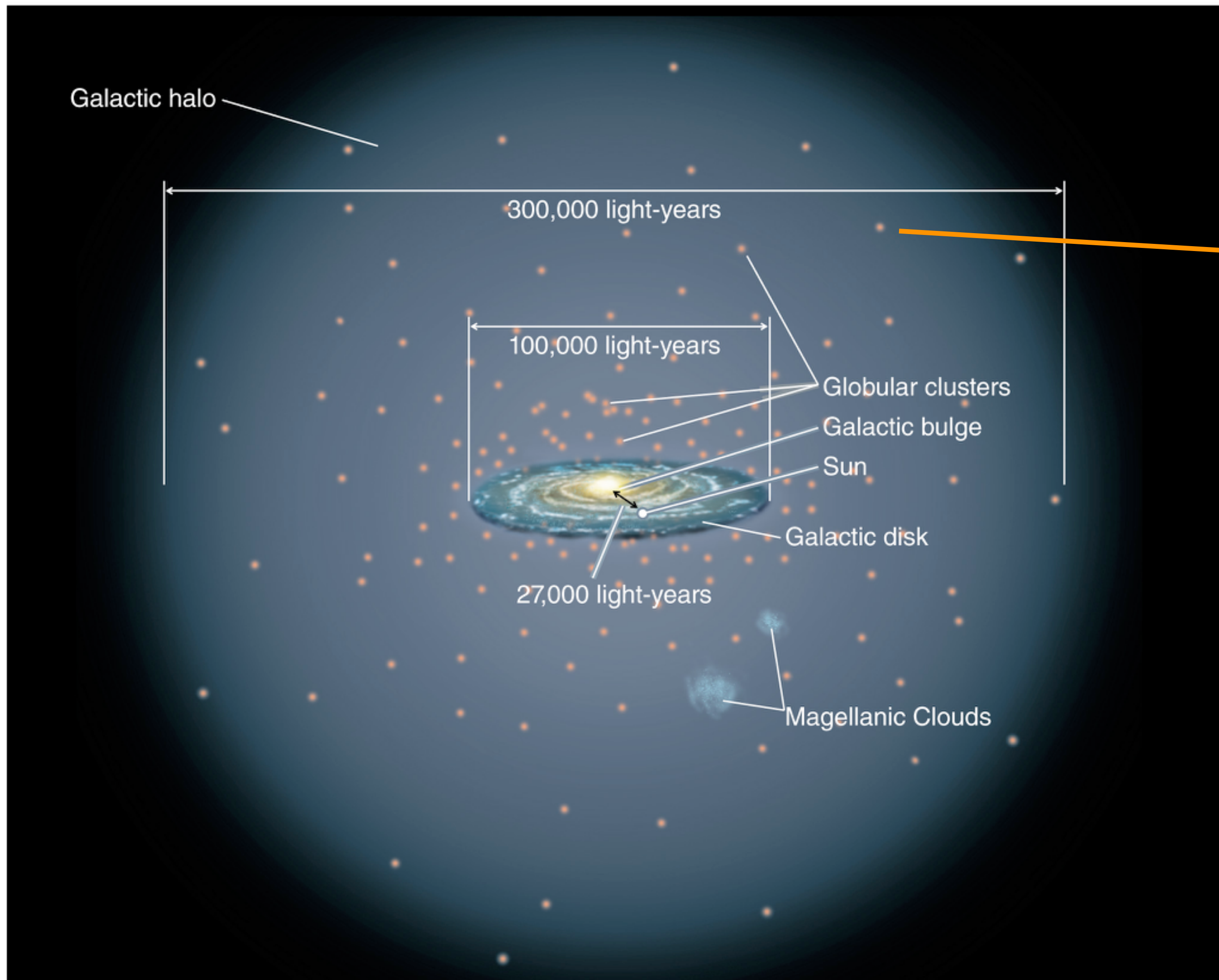
How can we estimate their distance?

- A) Using variable stars (RR Lyrae and Cepheids)
- B) Comparing their apparent sizes
- C) Location of the MS turnoff in an HR diagram
- D) Location of the Horizontal branch in the HR diagram

Shapley's Globular Cluster Distribution



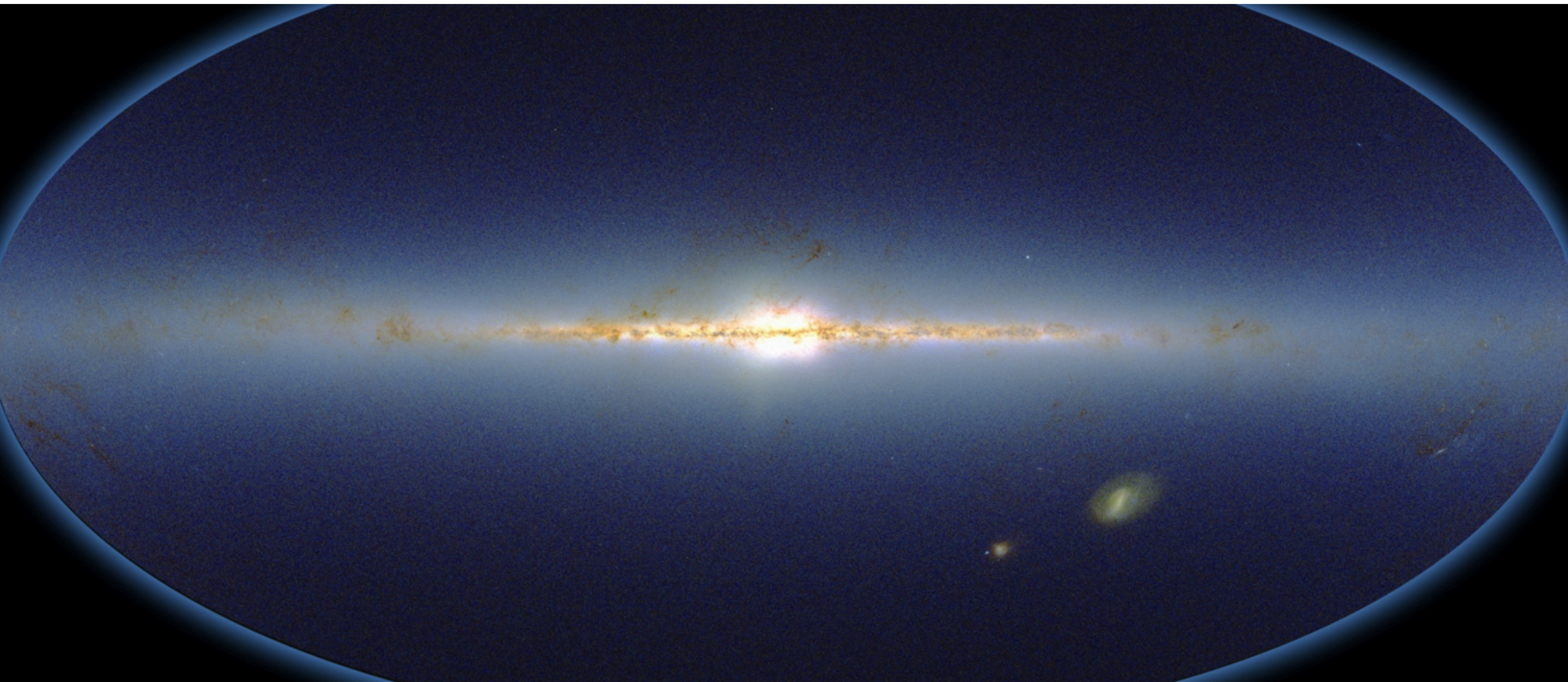
Globular clusters revealed the scale of the MW



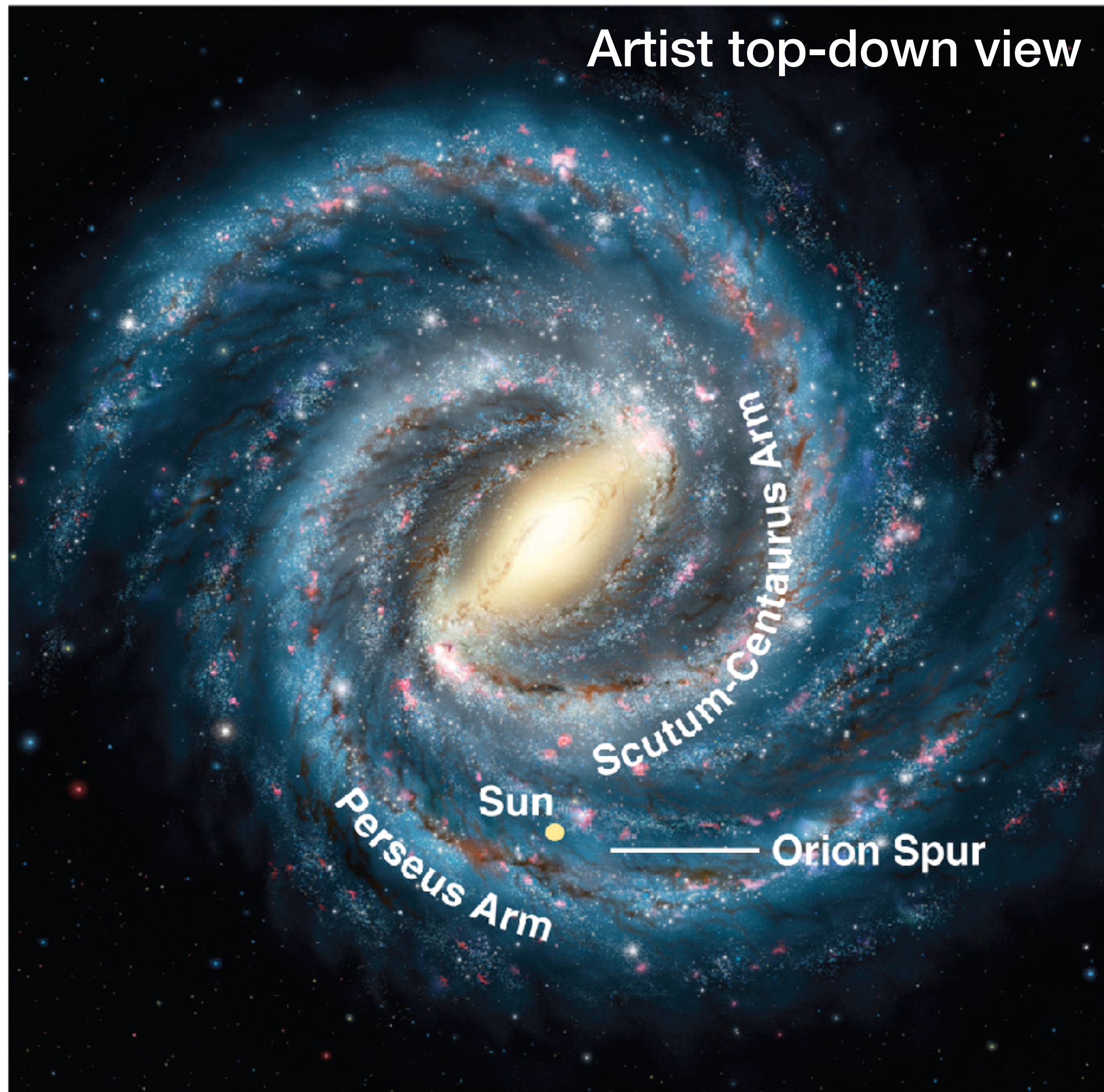
G X U V I R

Variable stars like Cepheids (called RR Lyrae stars) were used to estimate the distance to globular clusters, which were assumed to be distributed uniformly around the center of the MW

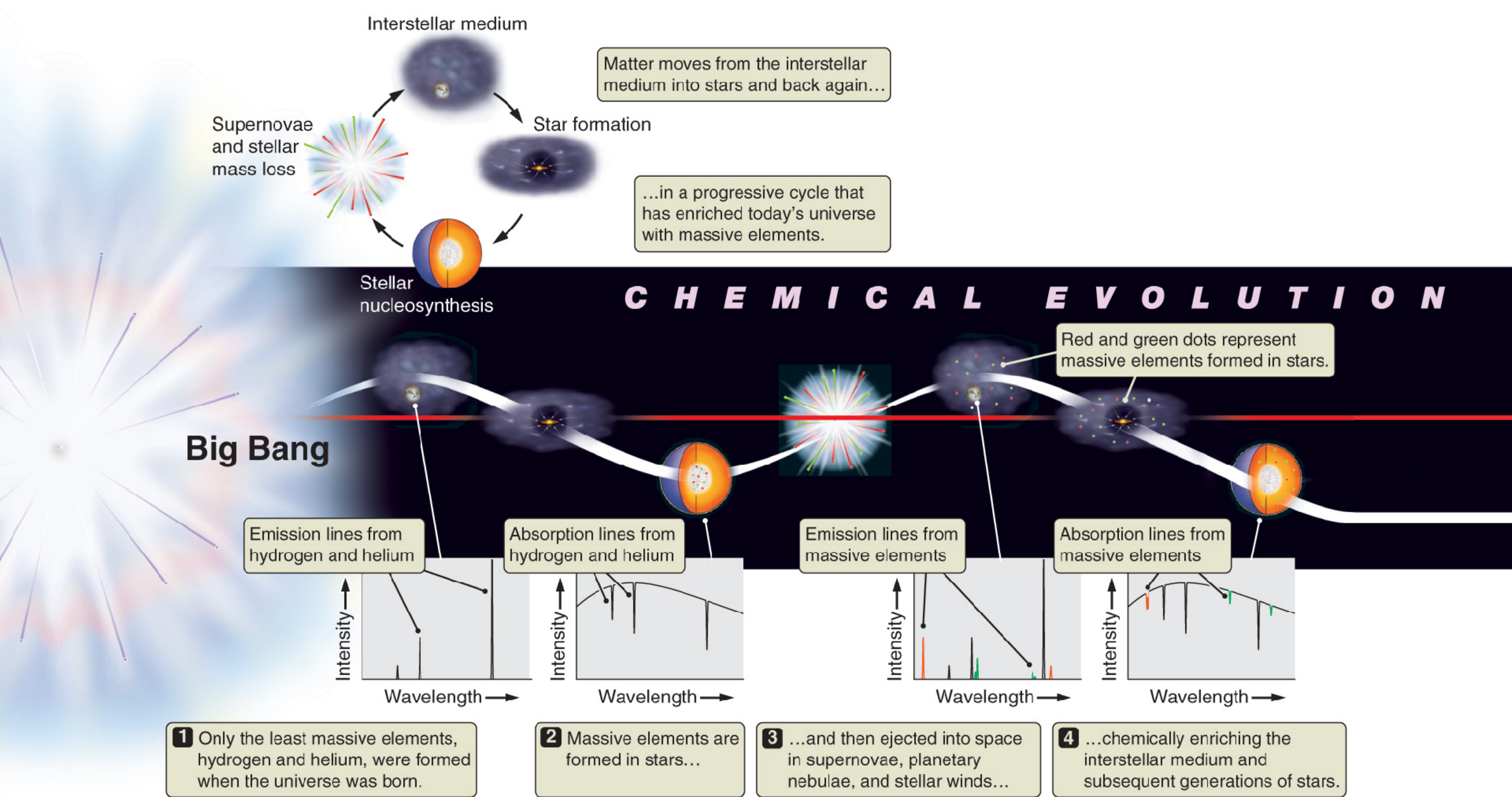
2MASS infrared all sky survey



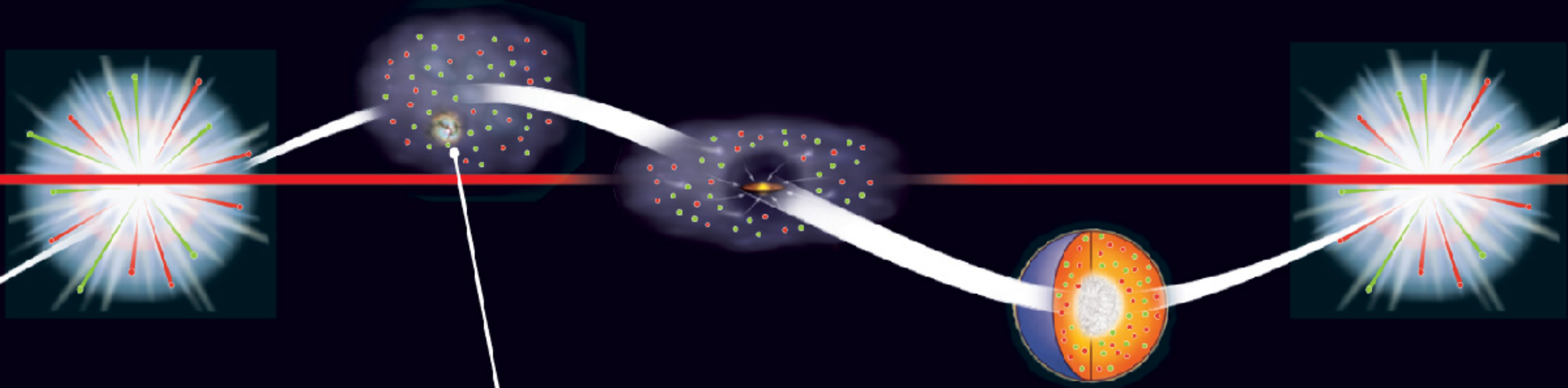
Definitely a disk galaxy, but the arms aren't obvious



G X U V I R



O F T H E M I L K Y W A Y

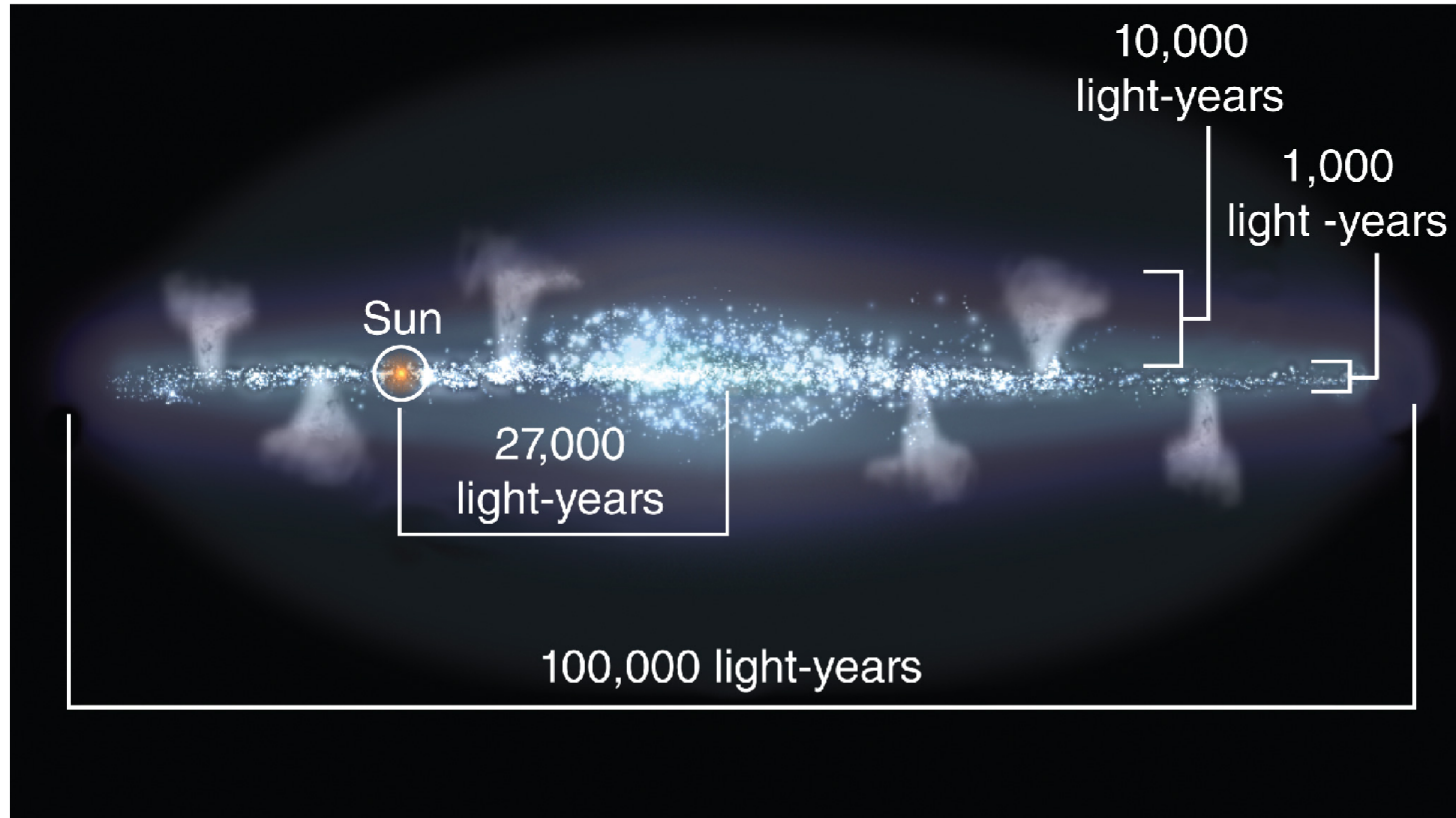


5 With each subsequent generation of stars, the amount of massive elements in the universe has increased.

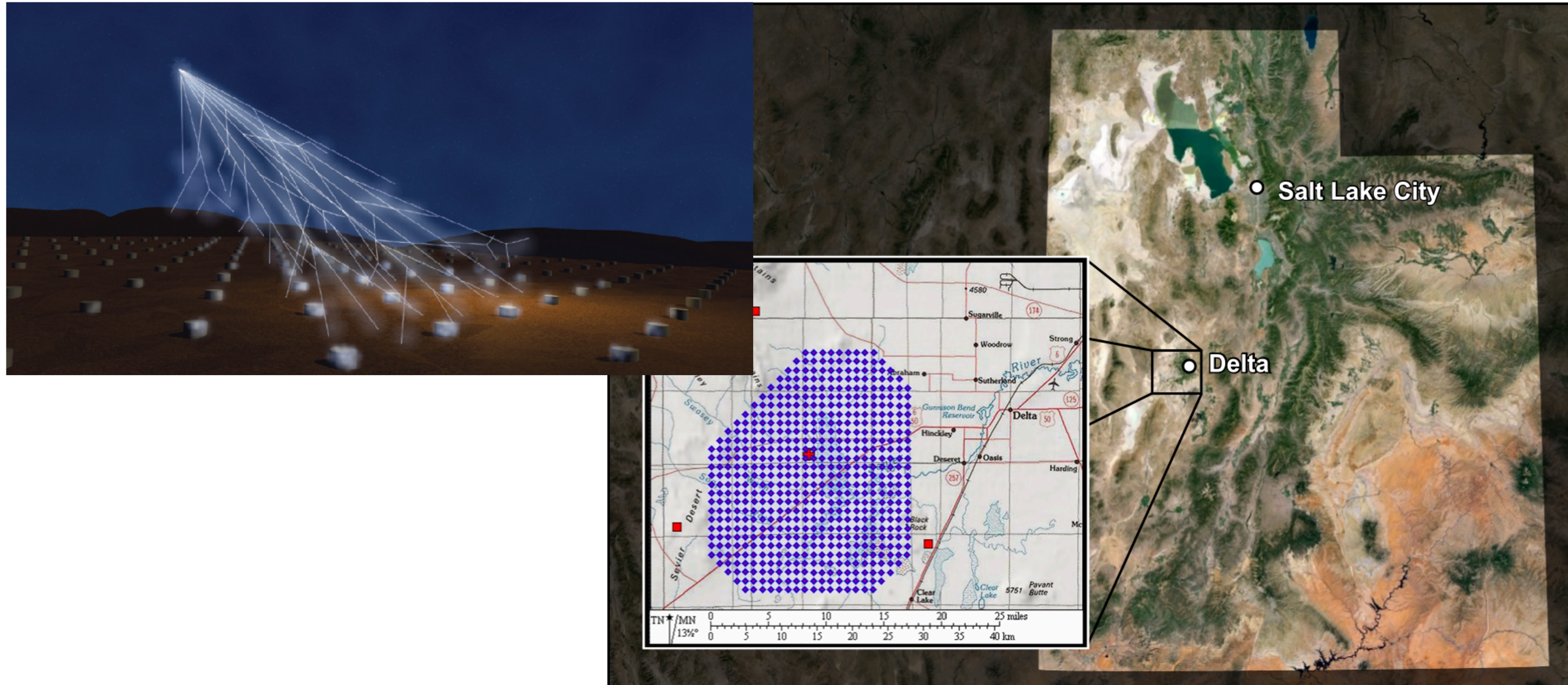
6 Evidence of progressive chemical enrichment is found in interstellar emission from massive elements...

7 ...and in the strength of massive-element absorption lines in spectra of stars formed in different places and at different times.

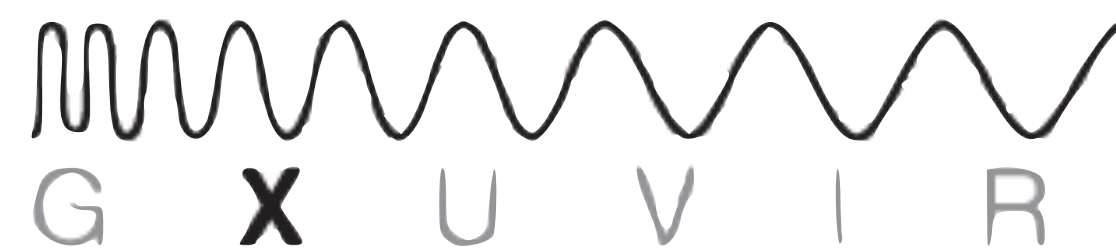
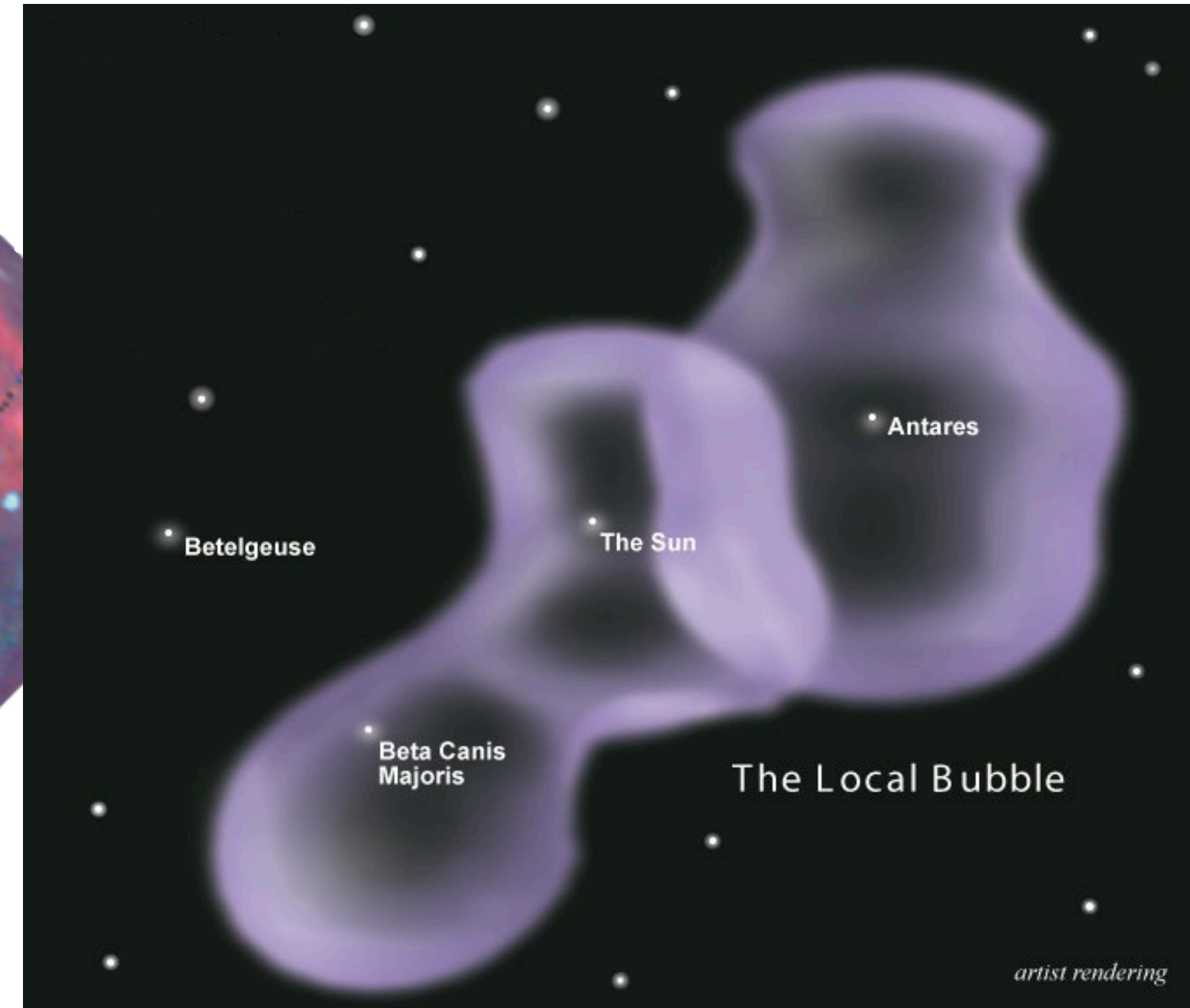
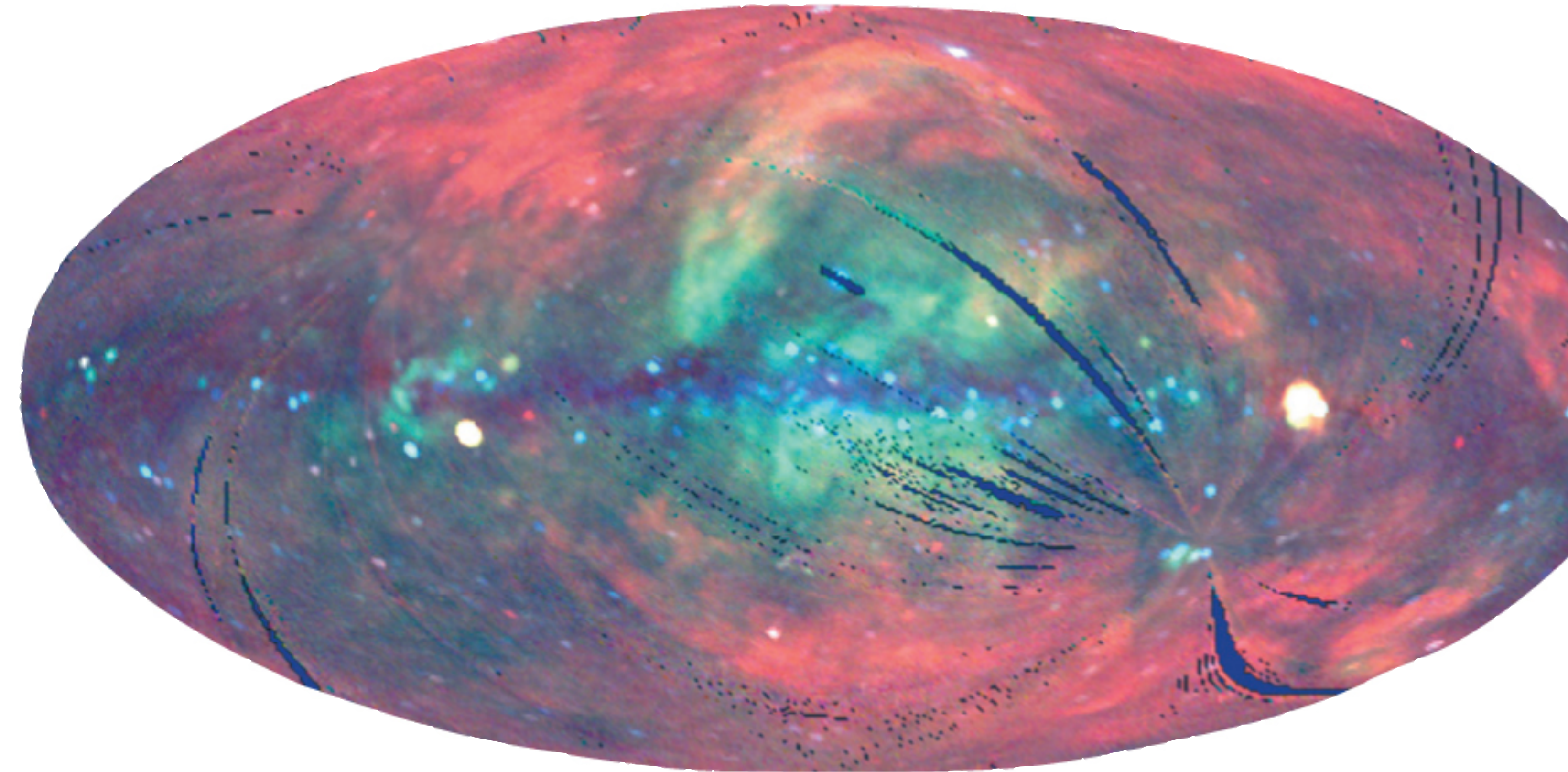
Supernovae shape and “enrich” the MW



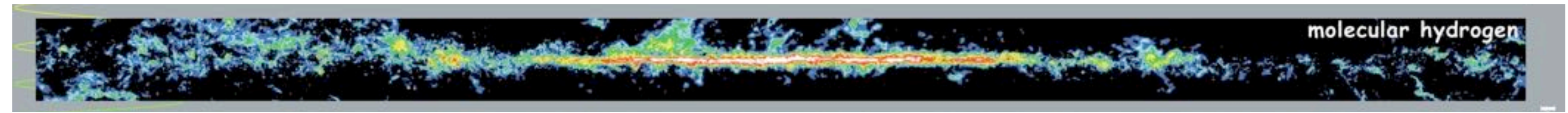
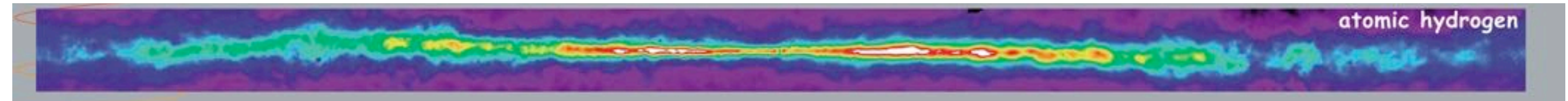
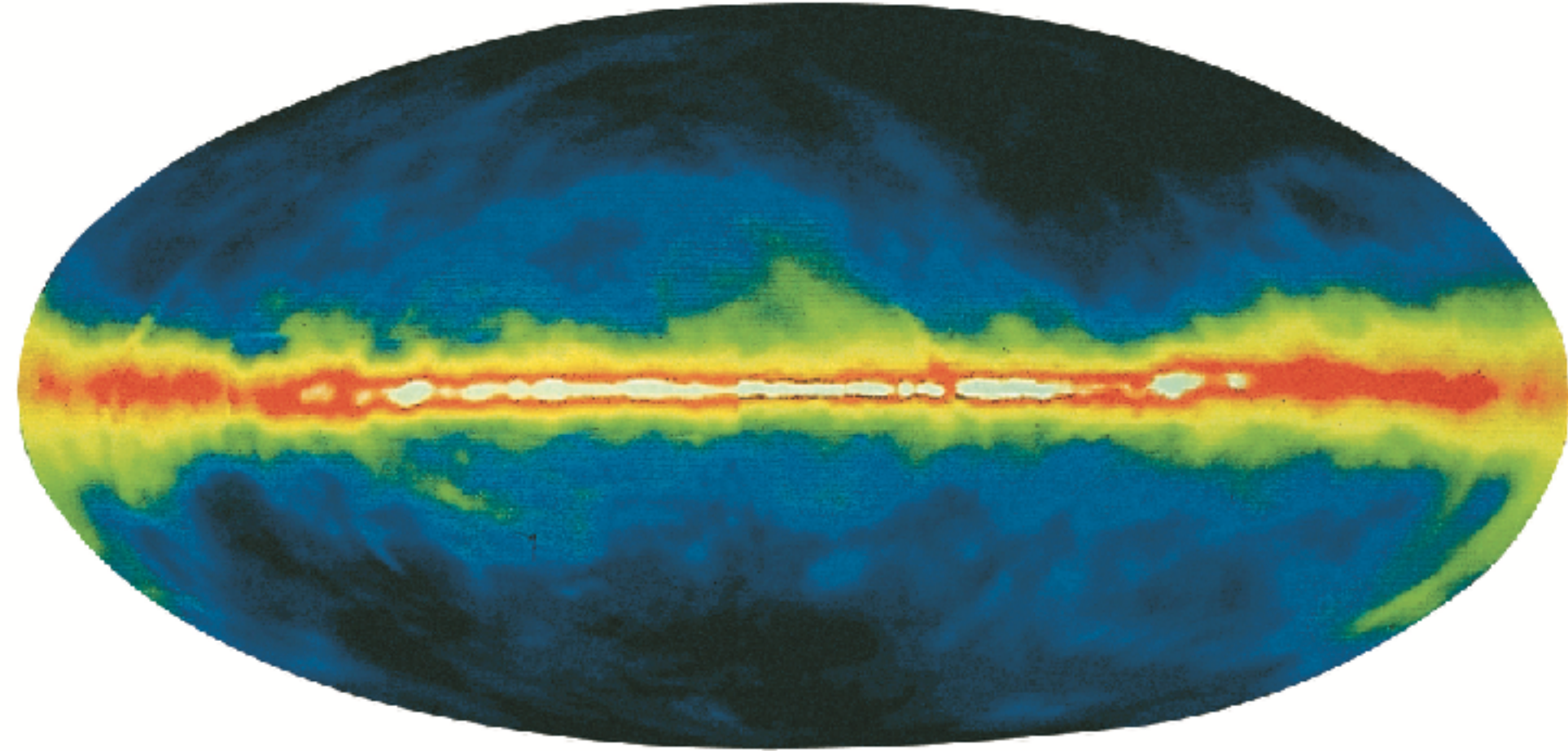
Supernovae (among others) accelerate cosmic rays



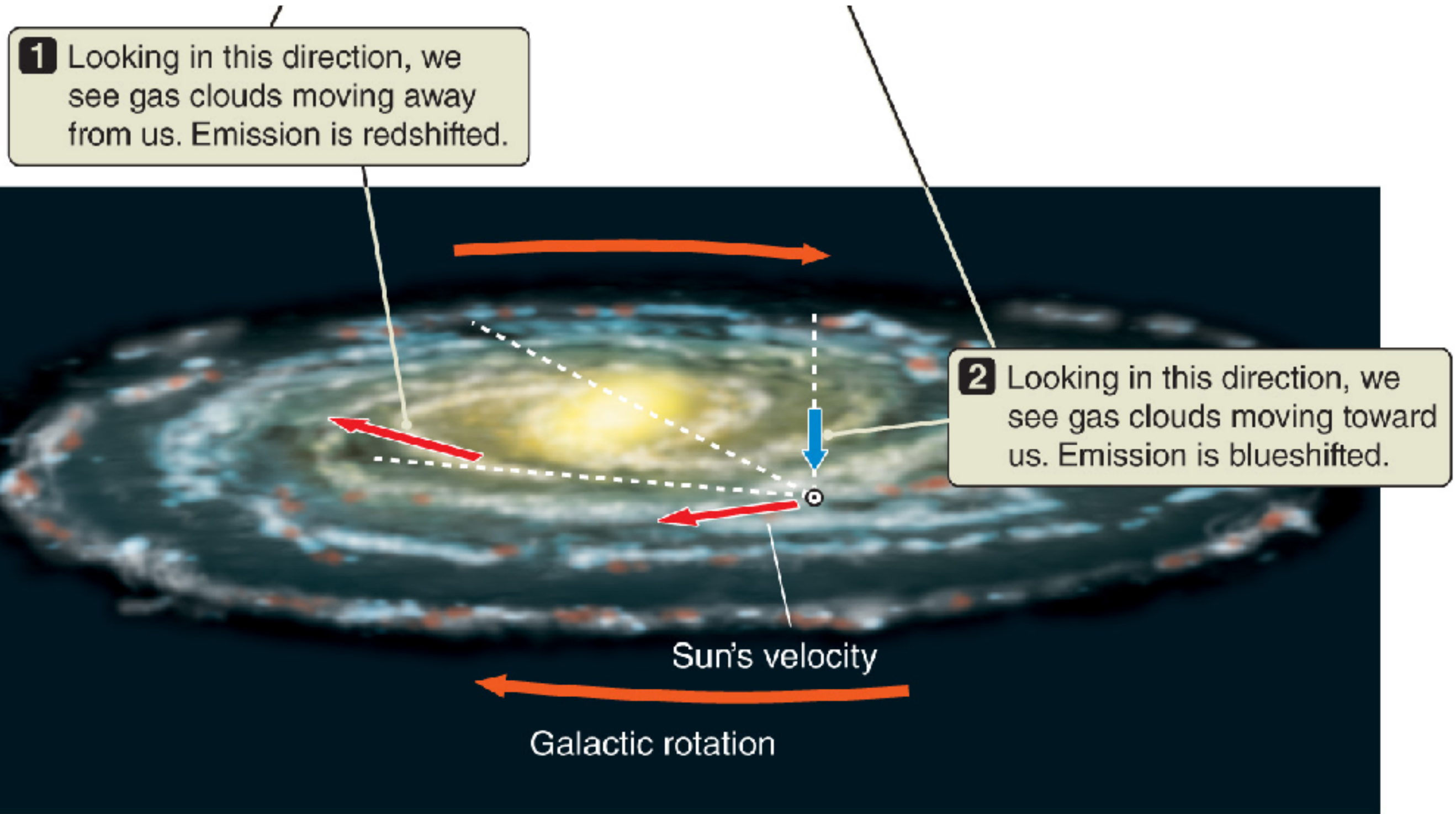
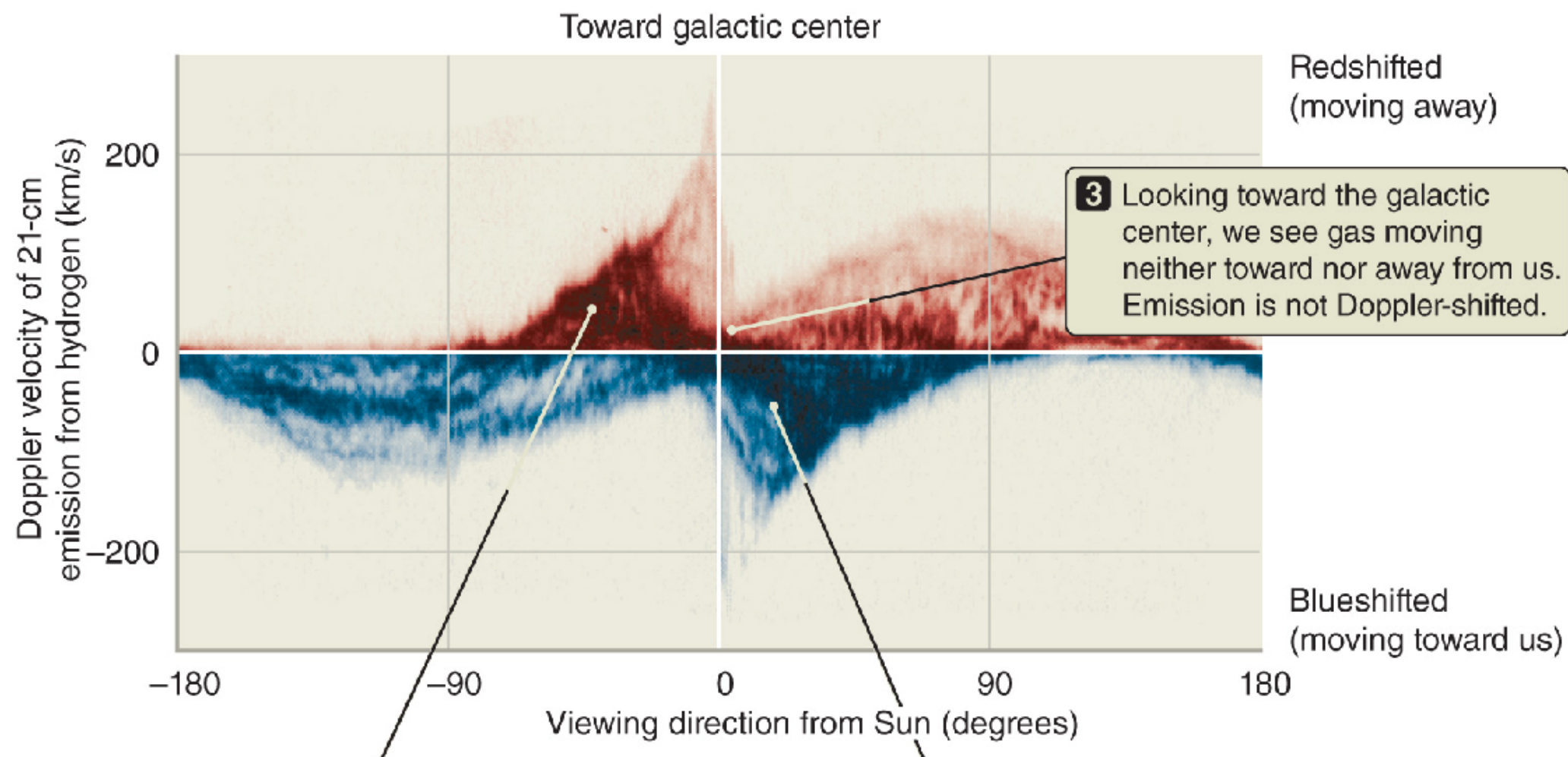
Supernovae heat the MW's gas



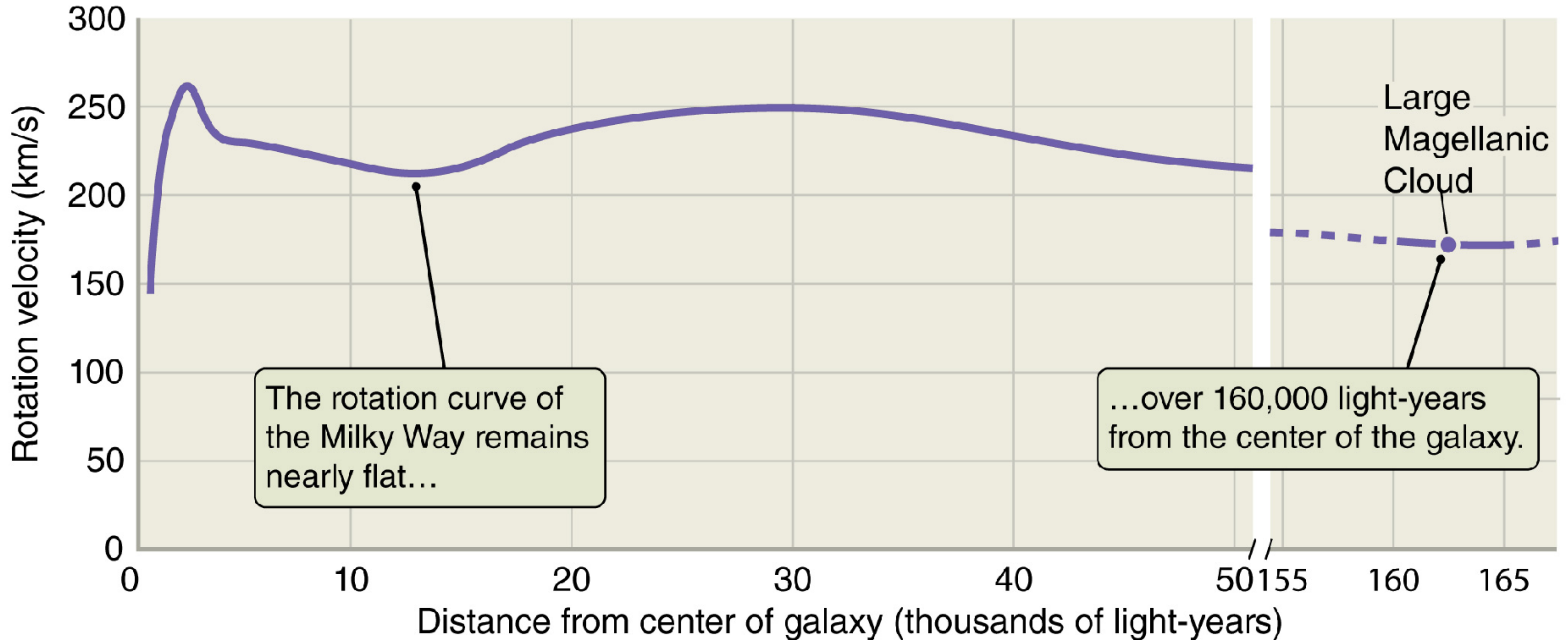
Cool (neutral and molecular) gas lie in a thin plane



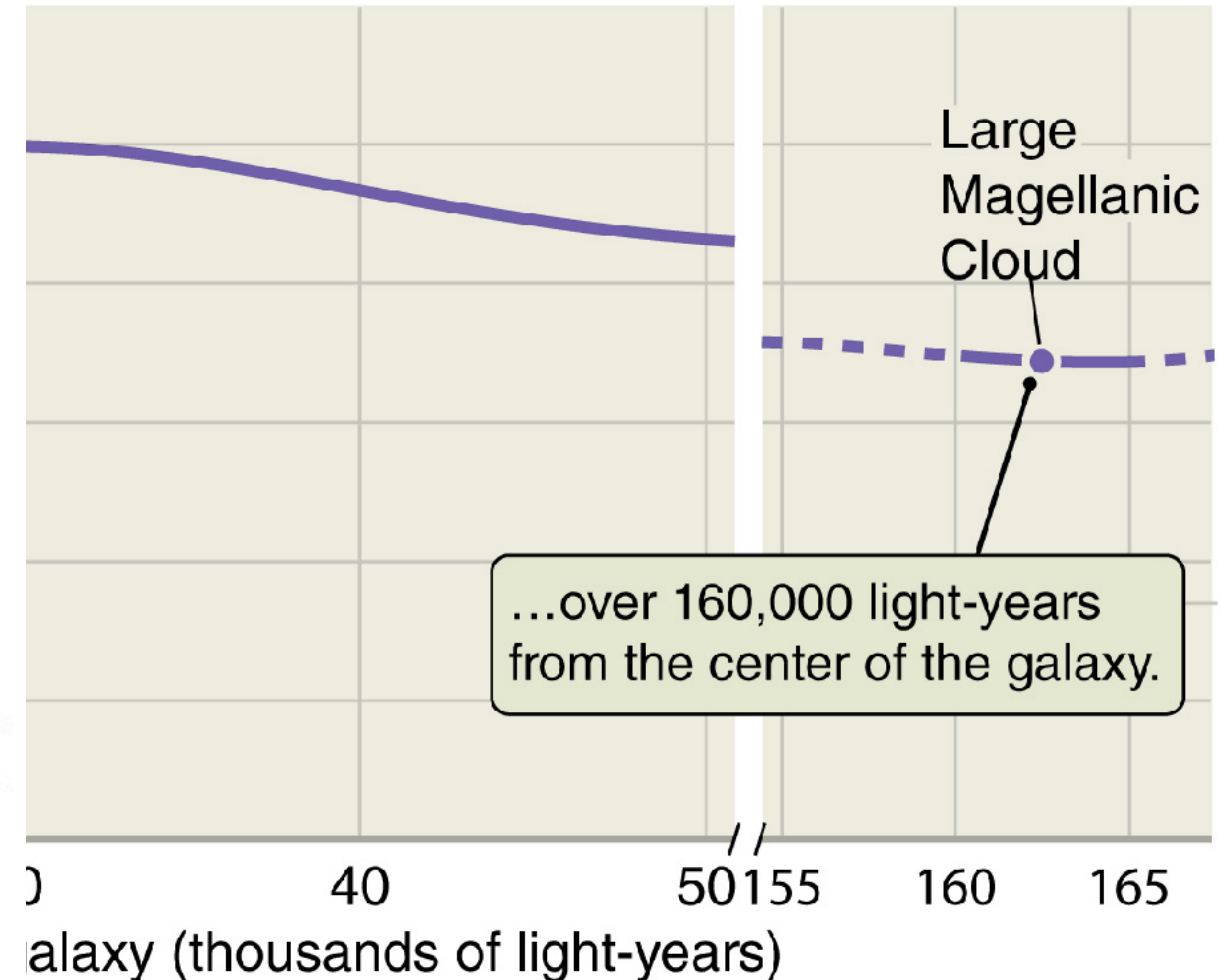
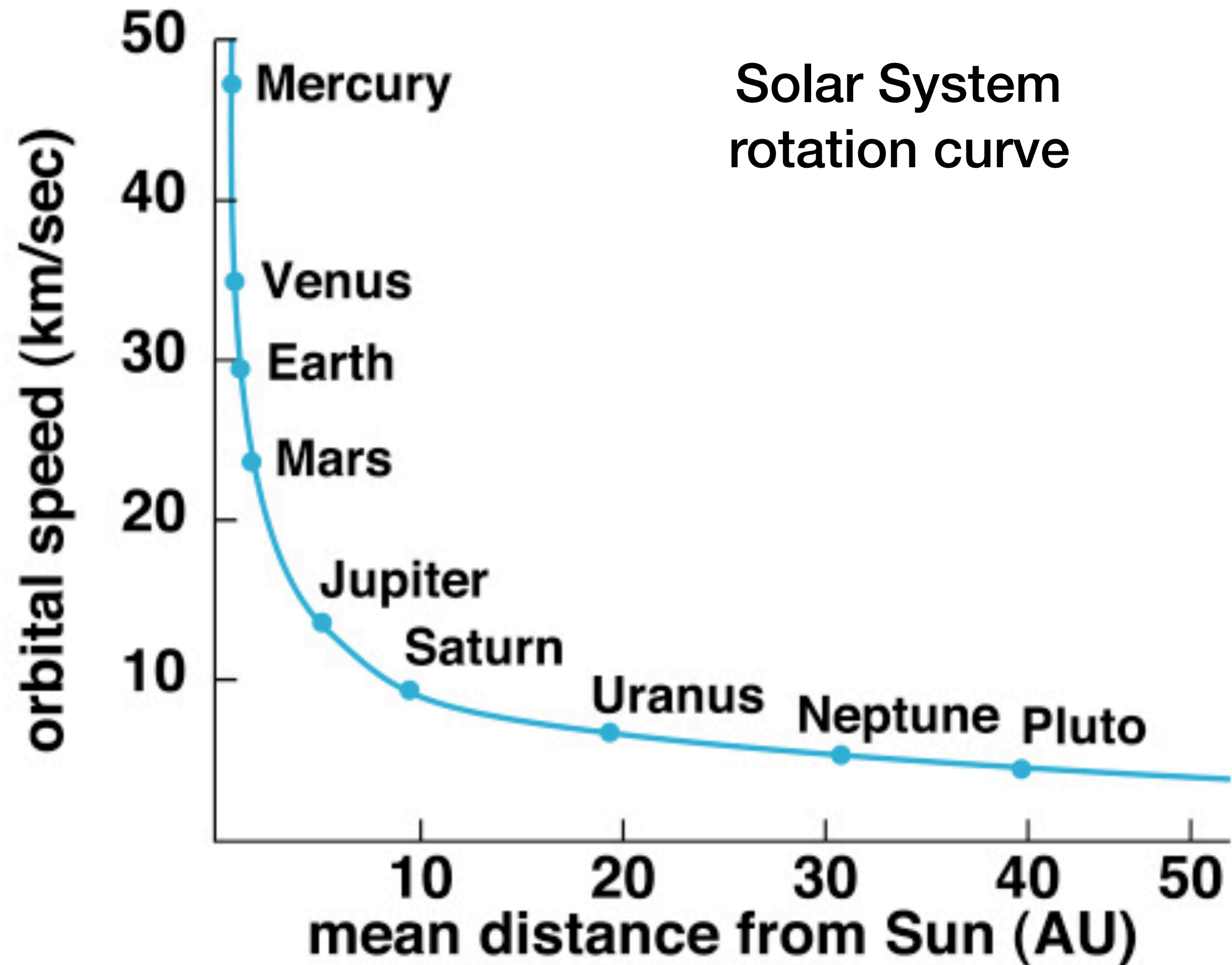
G X U V I R



MW rotation curve \rightarrow dark matter



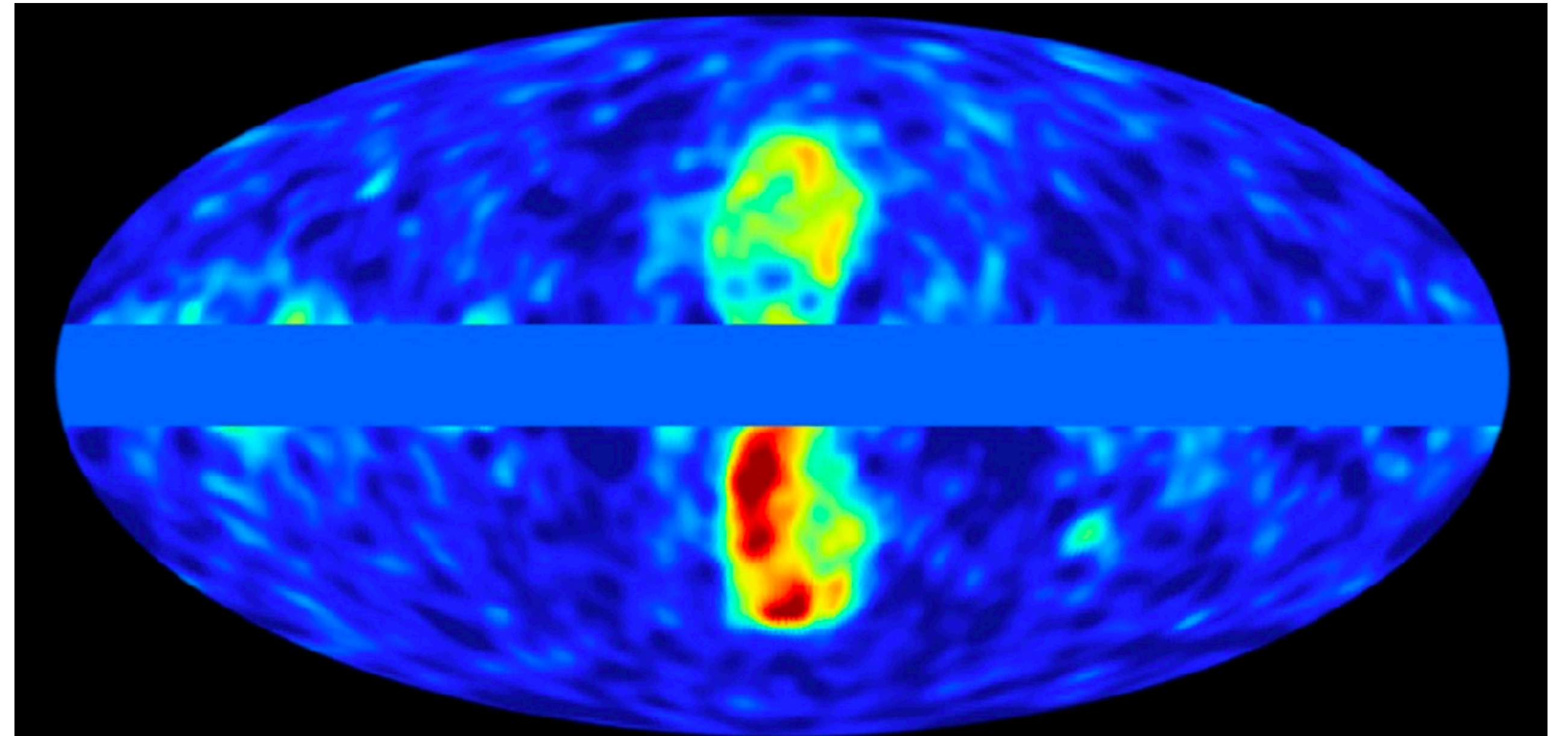
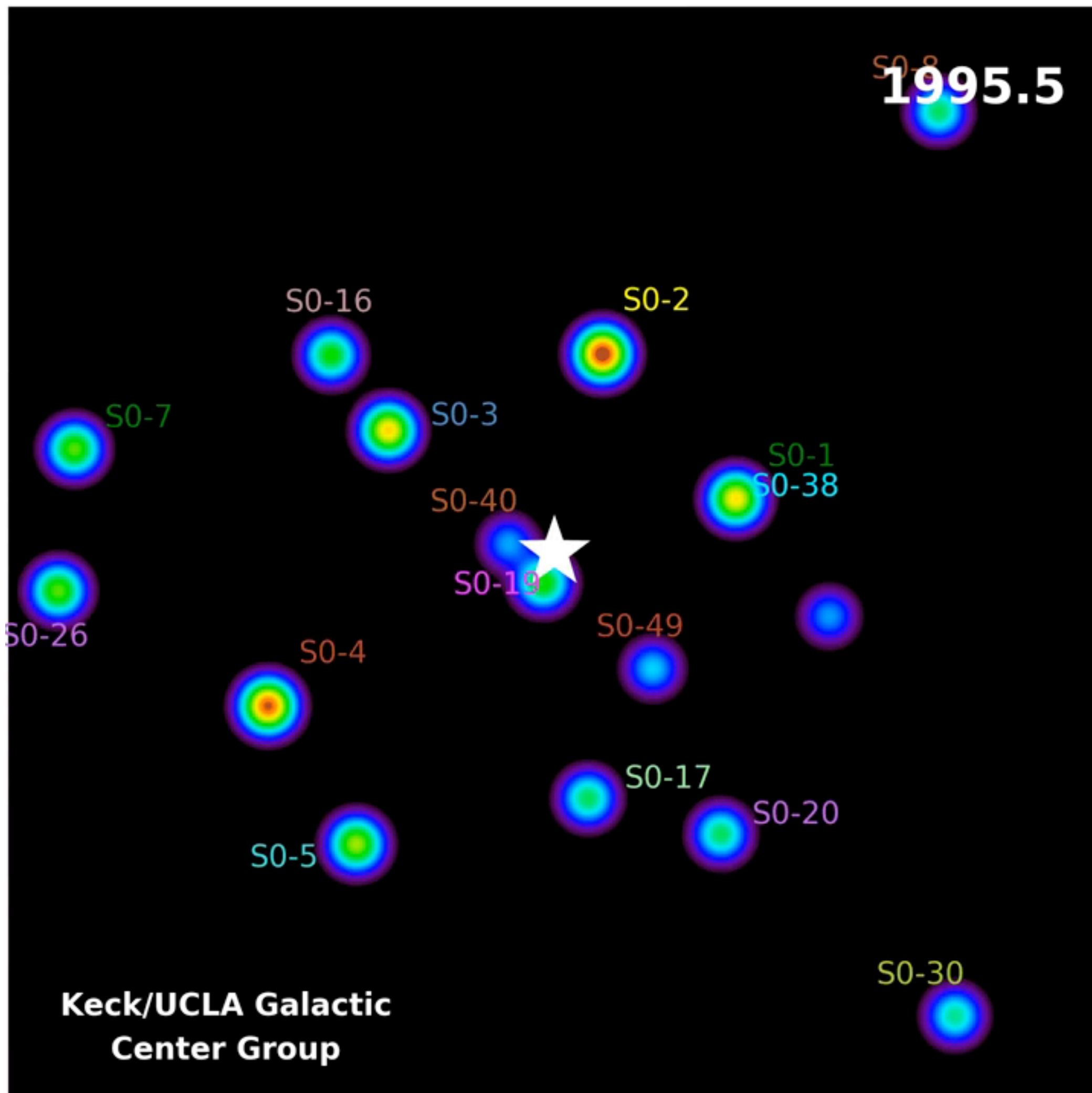
MW rotation curve \rightarrow dark matter



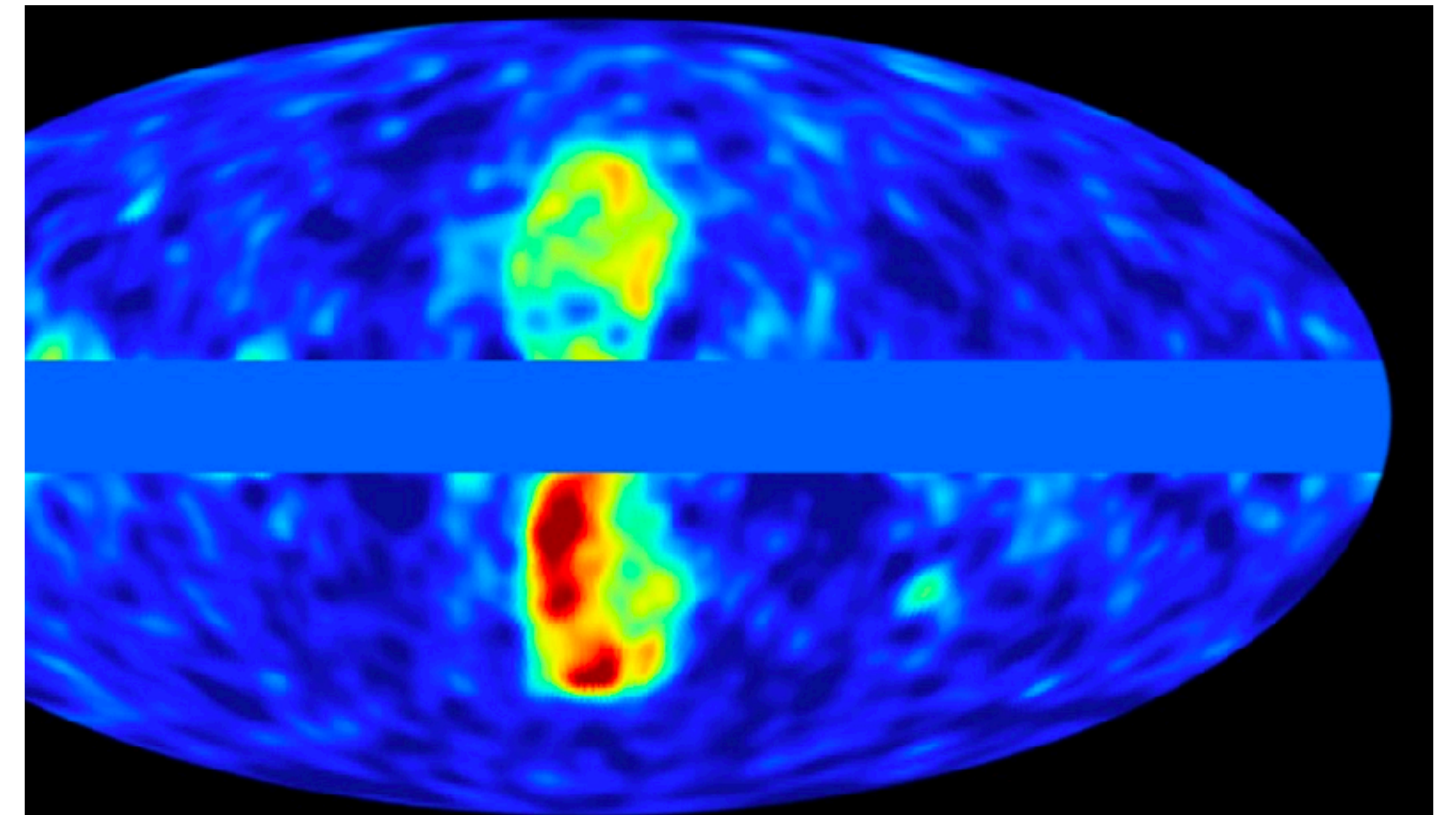
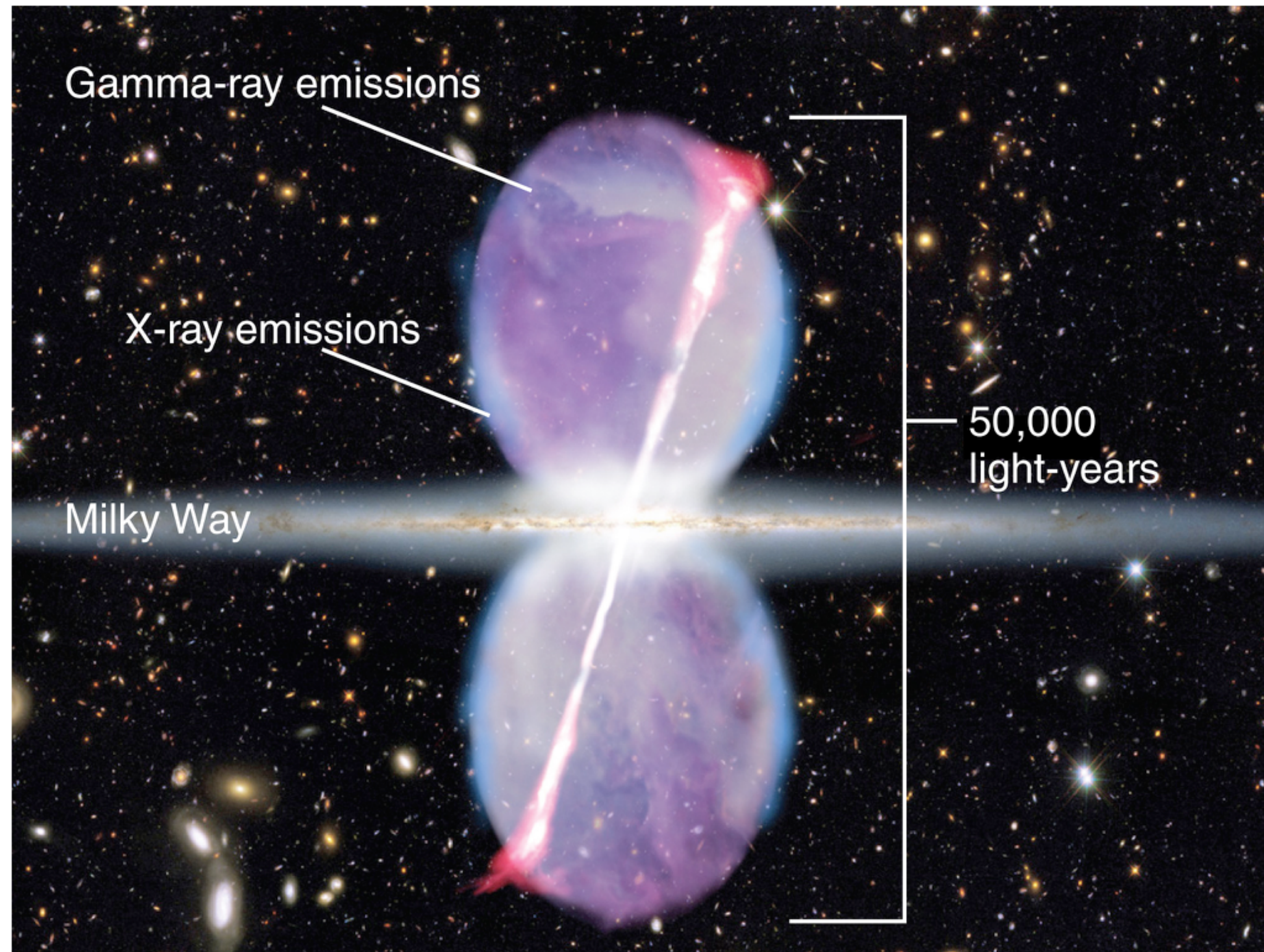
(b)

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MW's supermassive black hole



MW's supermassive black hole

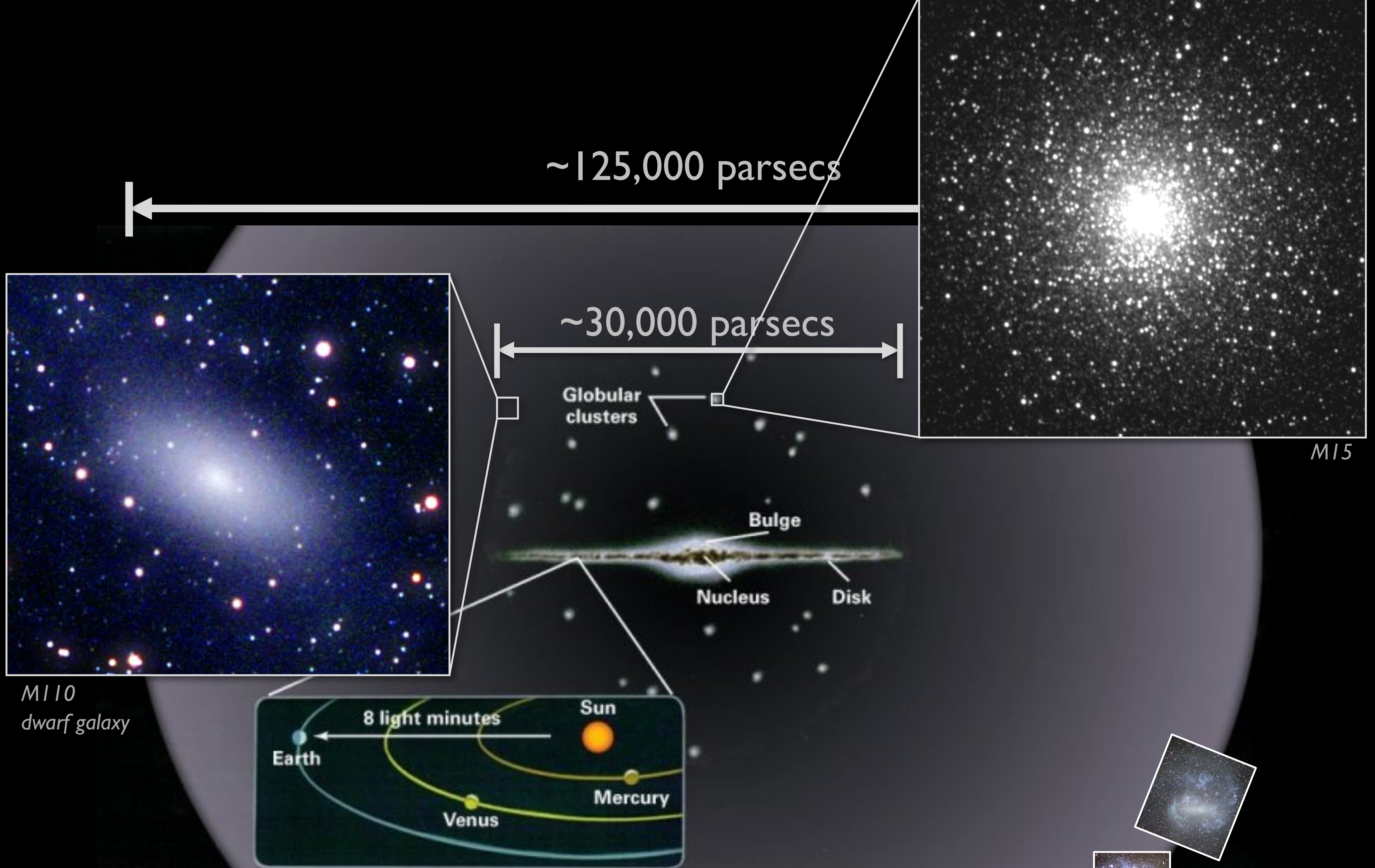


quiet now, but was active not that long ago
(a few million years)

$z=30.0$

Computer simulation of the formation of a Milky Way-like galaxy





~125,000 parsecs

~30,000 parsecs

Globular clusters

Bulge

Nucleus

Disk

8 light minutes

Sun

Earth

Venus

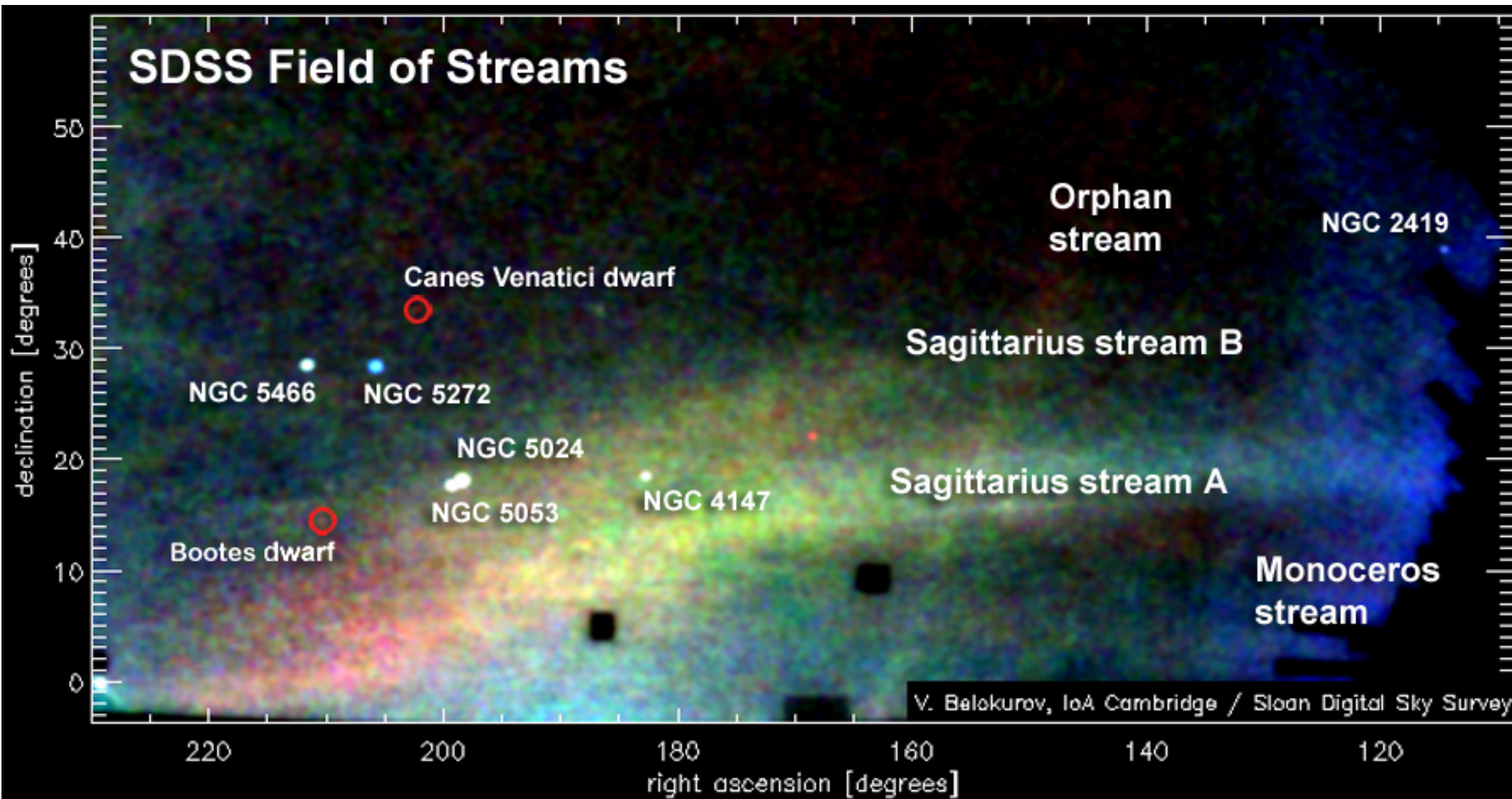
Mercury

M15

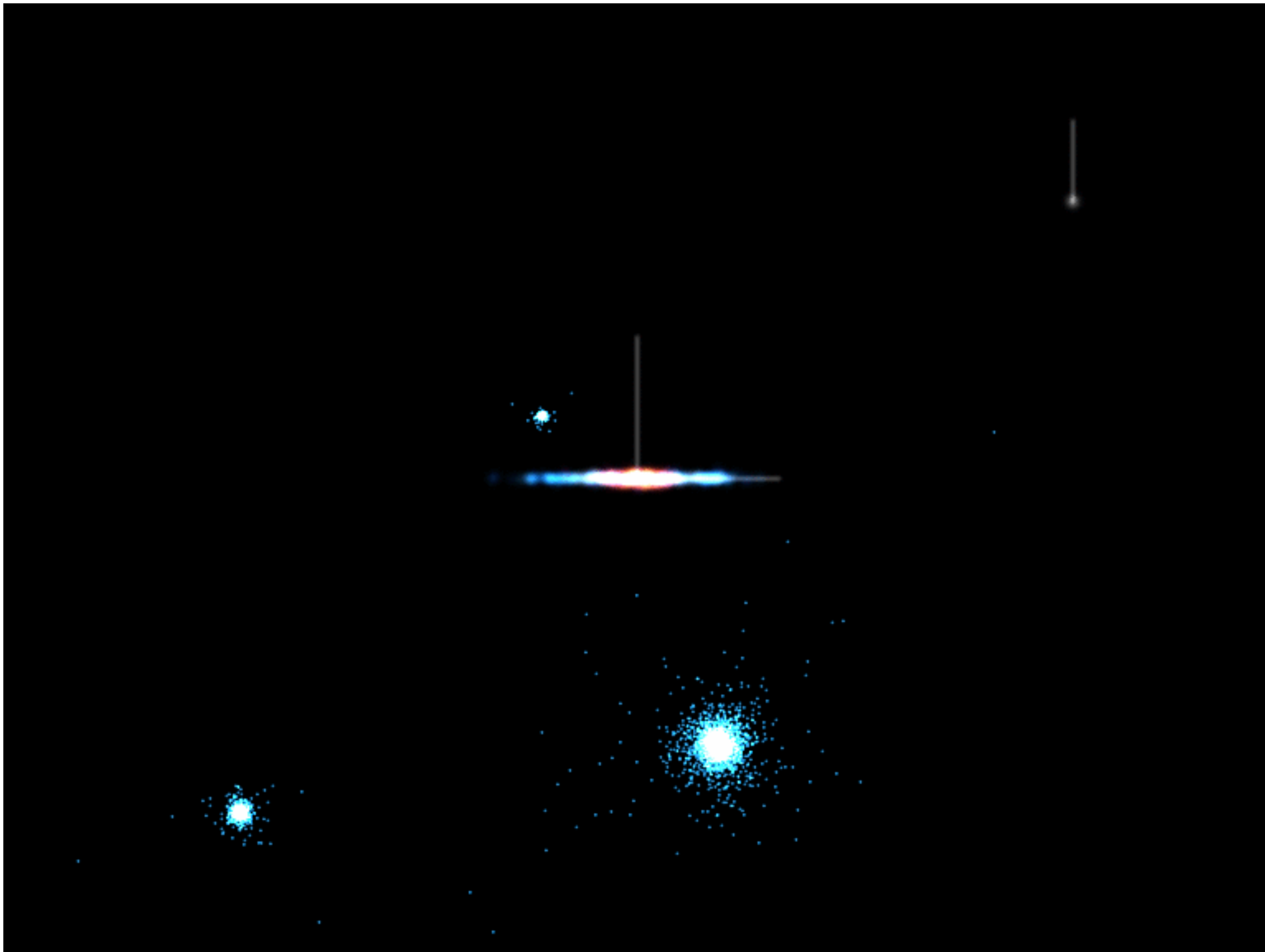
M110
dwarf galaxy

Magellanic Clouds
(not to size scale)

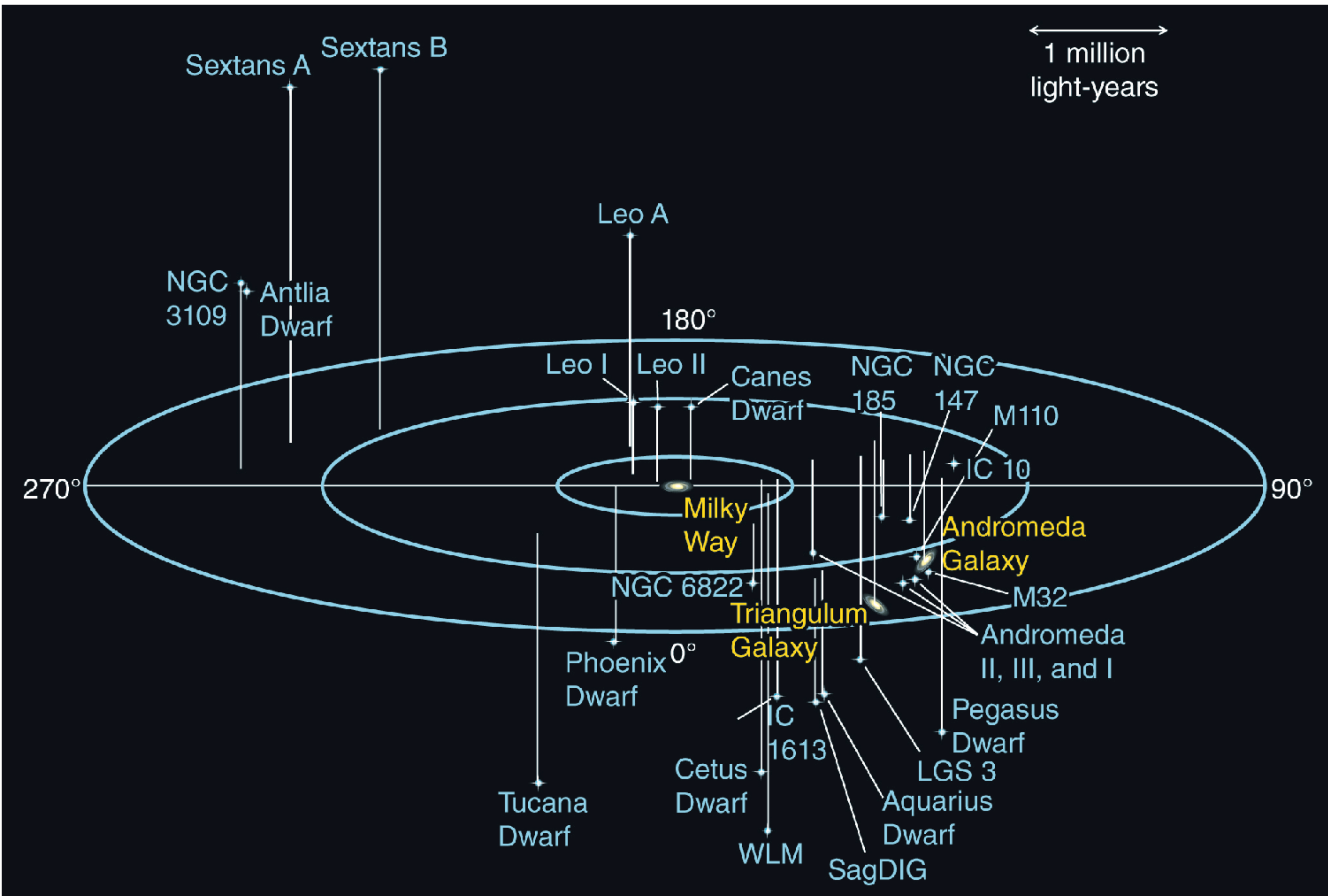
Small galaxies get shredded into the halo



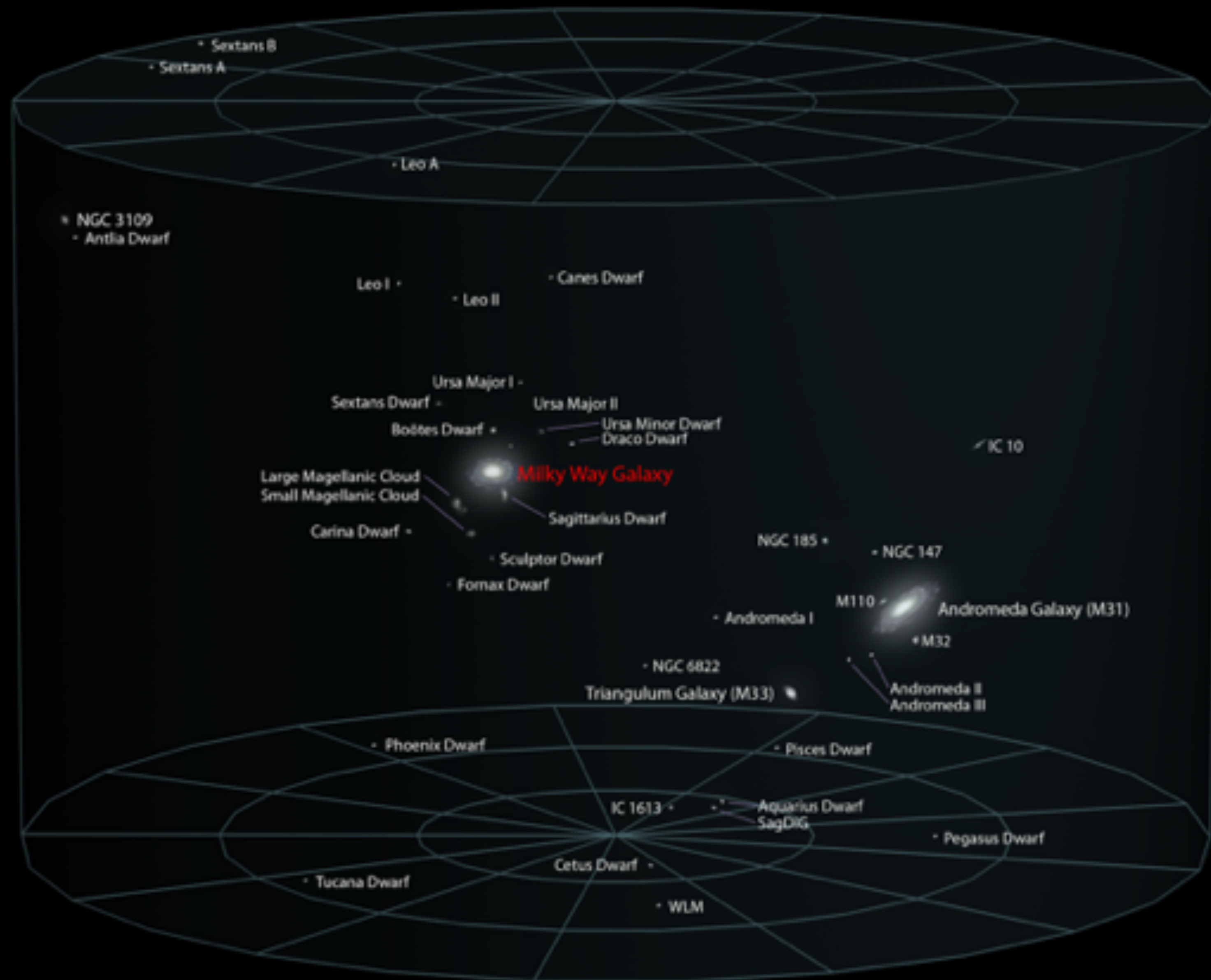
Small galaxies get shredded into the halo



Our place in the local universe



LOCAL GALACTIC GROUP








*Andromeda
Galaxy
(M31)*

*Milky Way
Galaxy*



In 3.75 billion years

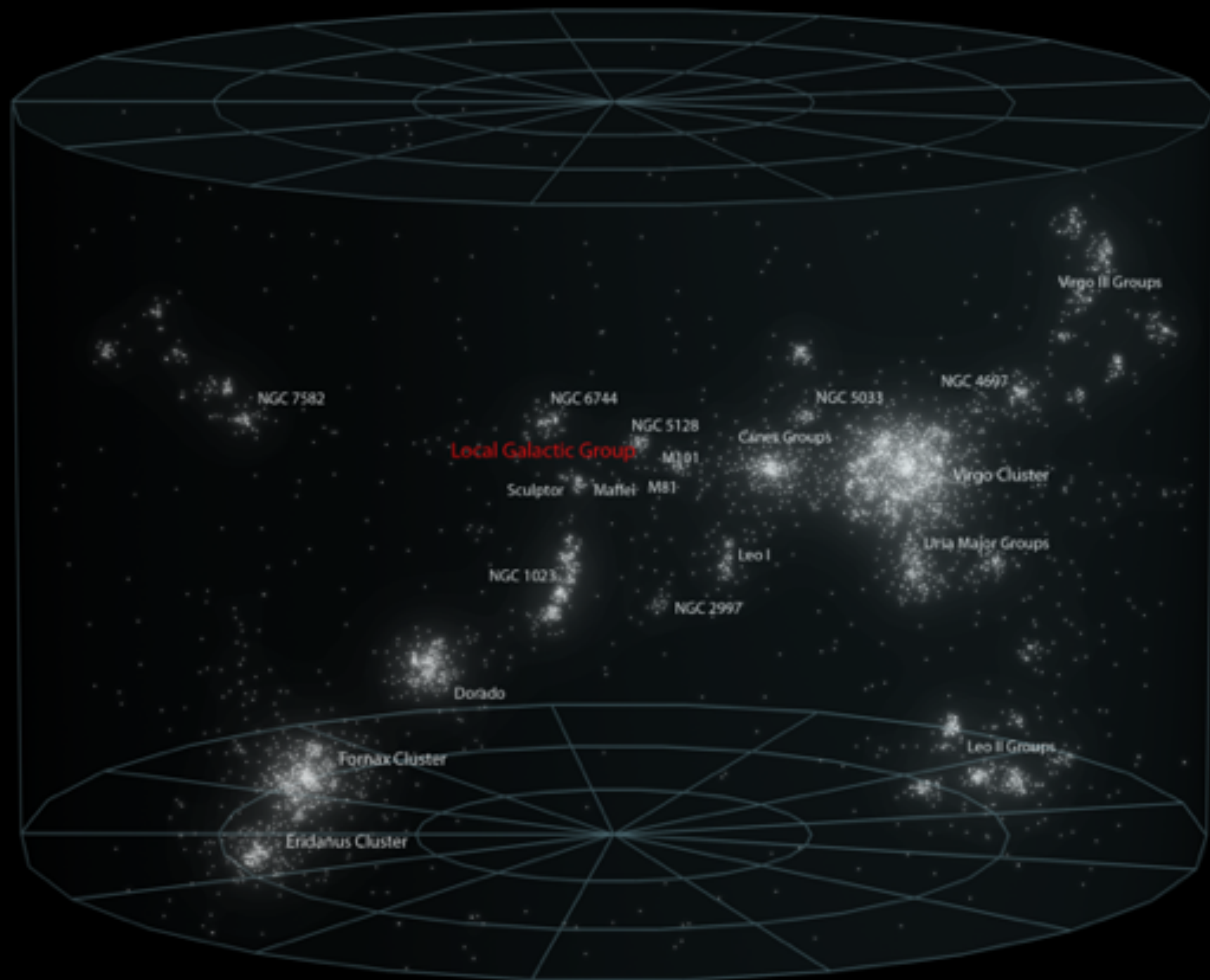
A composite image showing the Milky Way galaxy in the foreground and the Andromeda galaxy in the background. The Milky Way is depicted as a bright, multi-colored band of stars and dust stretching across the sky. The Andromeda galaxy is shown as a distinct, bright, elliptical galaxy in the distance. The background is a dark, star-filled sky. At the bottom of the image, there is a black silhouette of a mountain range.

In 4 billion years

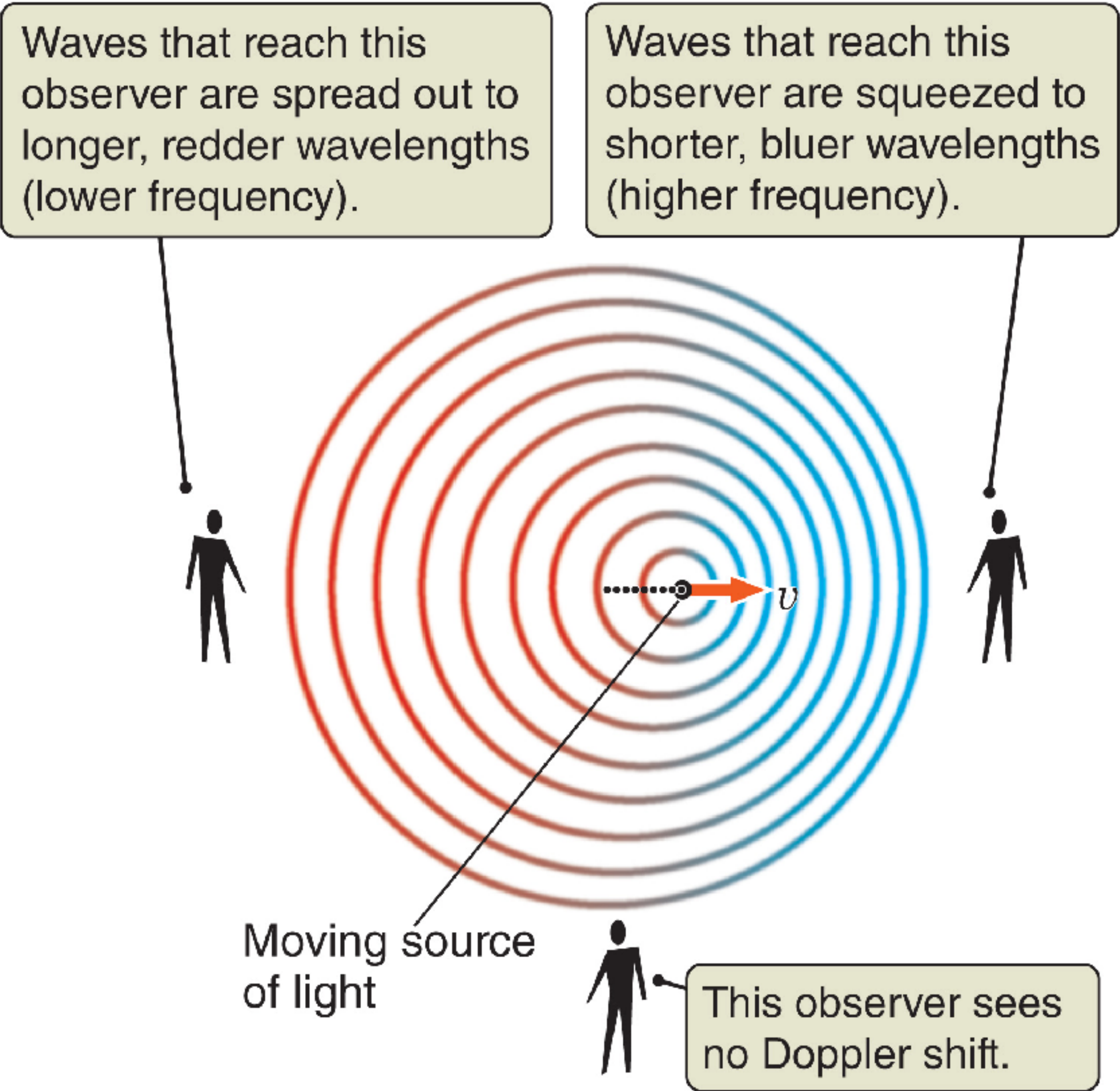
A night sky filled with stars, with a very bright star in the upper left quadrant. The bottom of the image shows a dark silhouette of a landscape with various peaks and structures. The text "In 6 billion years" is overlaid in the lower-left area.

In 6 billion years

VIRGO SUPERCLUSTER



But how are galaxies moving?



Doppler Shift of Light

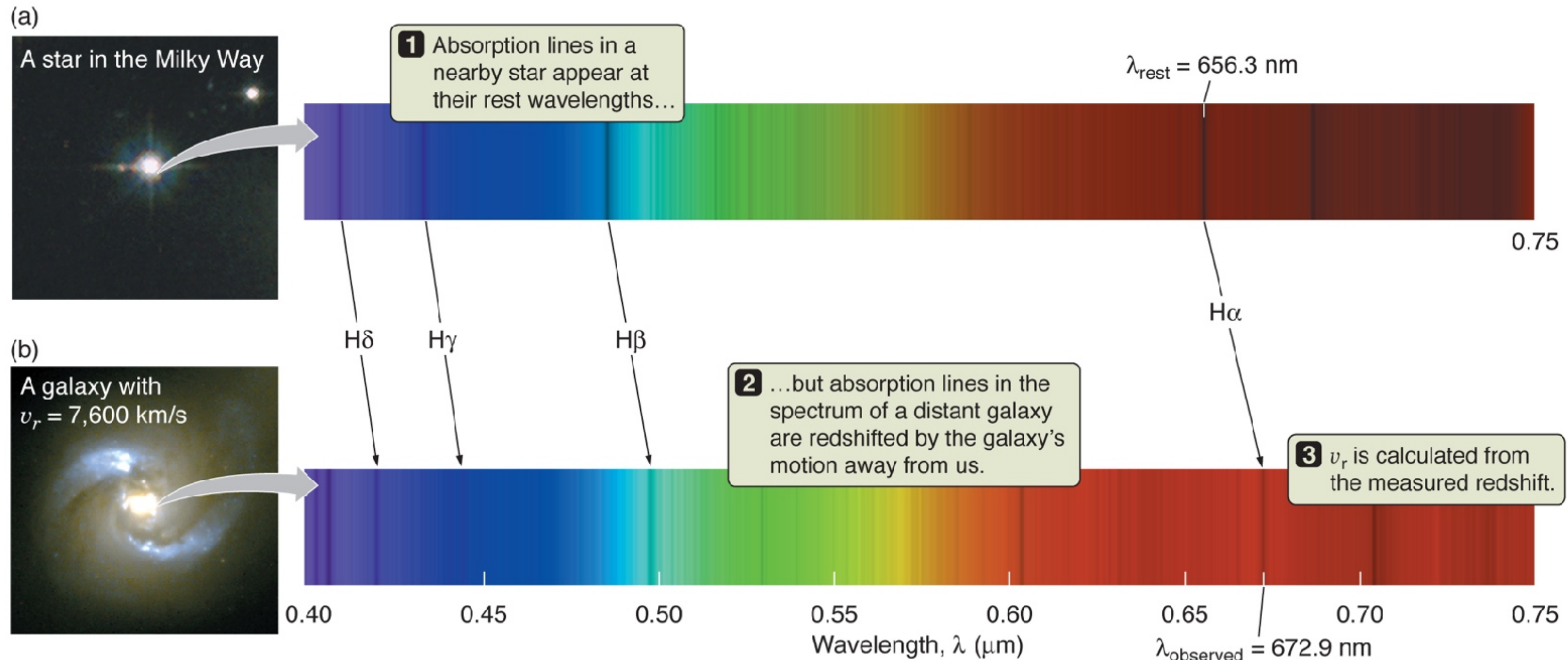


$$\frac{\lambda_{observed} - \lambda_{emitted}}{\lambda_{emitted}} = \frac{v}{c}$$

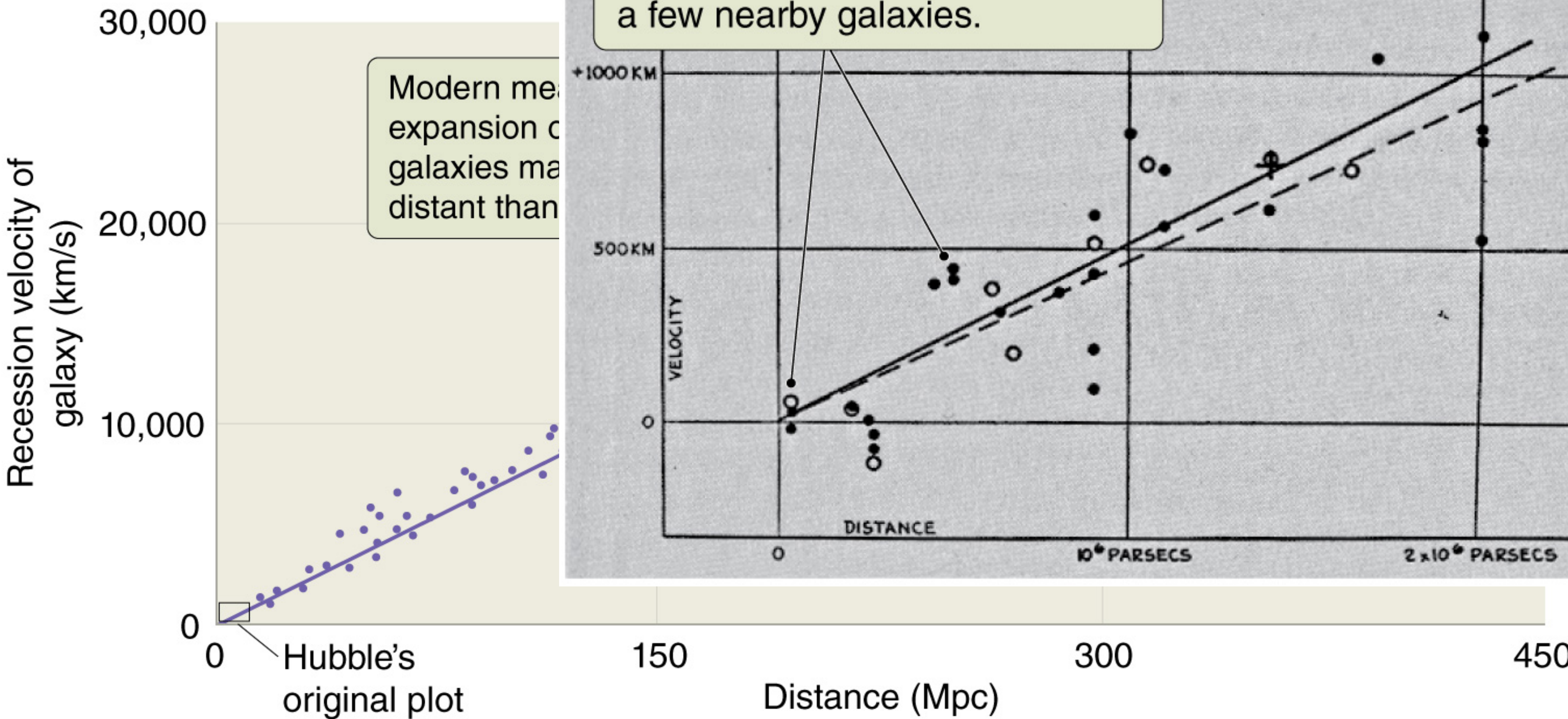
Which spectrum is moving away from us the fastest?

Almost all galaxies are moving away from us.

$$\frac{\lambda_{observed} - \lambda_{emitted}}{\lambda_{emitted}} = \frac{v}{c}$$



Hubble's Law



We live in an expanding “balloon universe”

