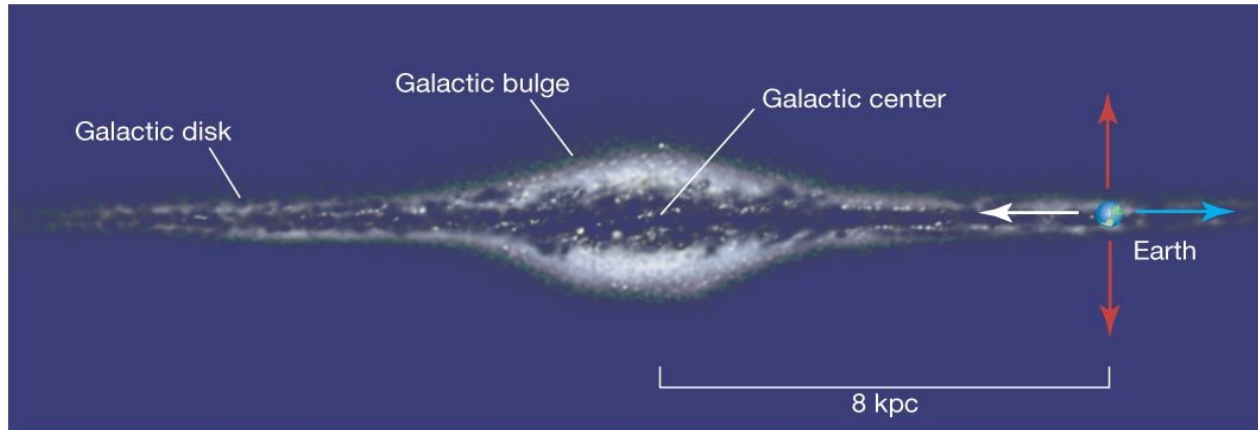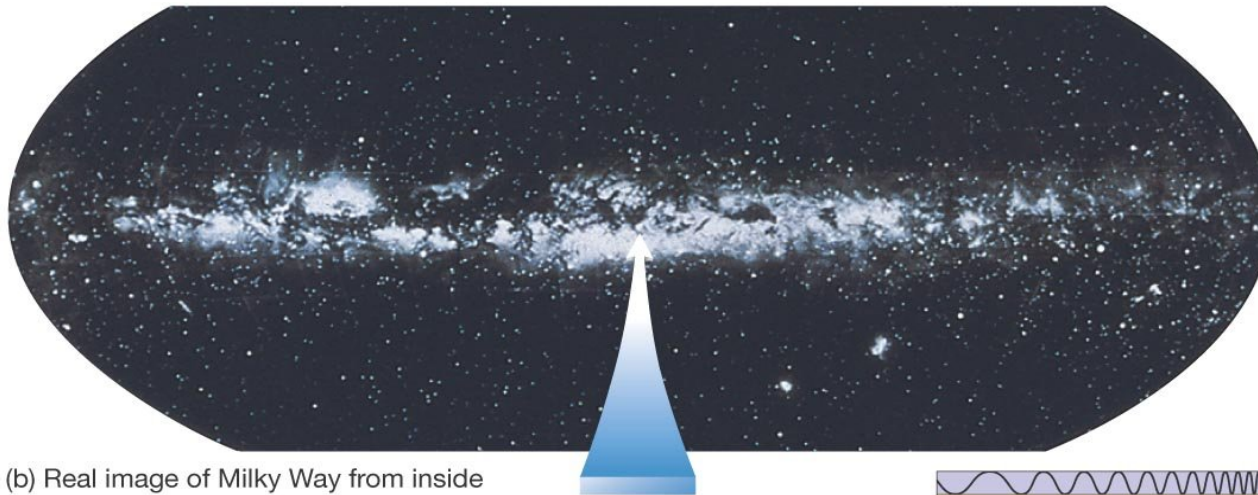# The Milky Way Galaxy

(Ch. 24)

Our Parent Galaxy

Milky Way is what our galaxy appears as in the night sky.
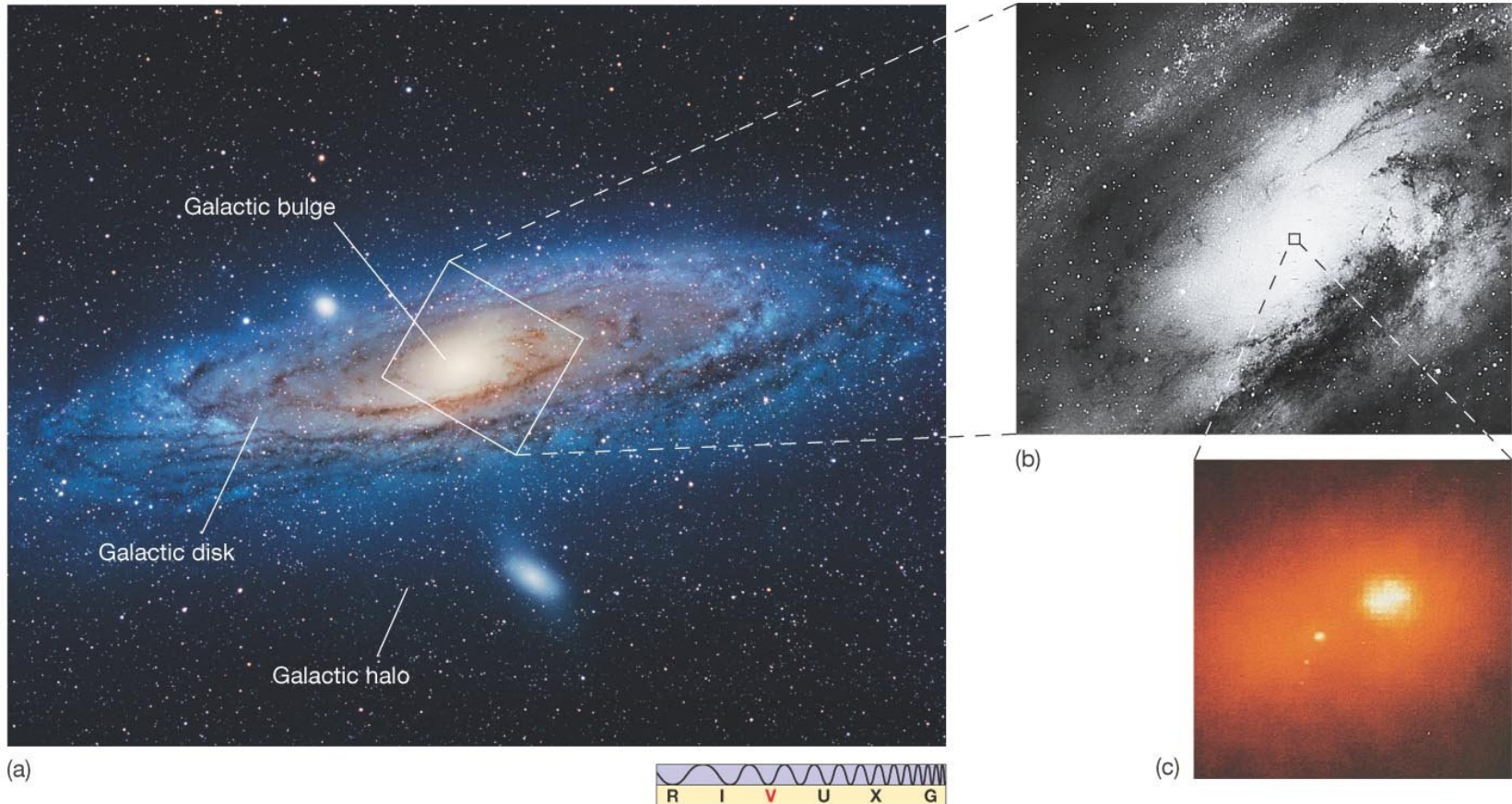

(a) Artist's view of Milky Way from afar

(b) Real image of Milky Way from inside

Our Parent Galaxy

Our galaxy is a spiral galaxy. The Andromeda Galaxy, our closest spiral neighbor, probably resembles the Milky Way fairly closely.

Our Parent Galaxy

Here are two other spiral galaxies, one viewed from the top and the other from the side:

(a)

(b)

R   I   V   U   X   G

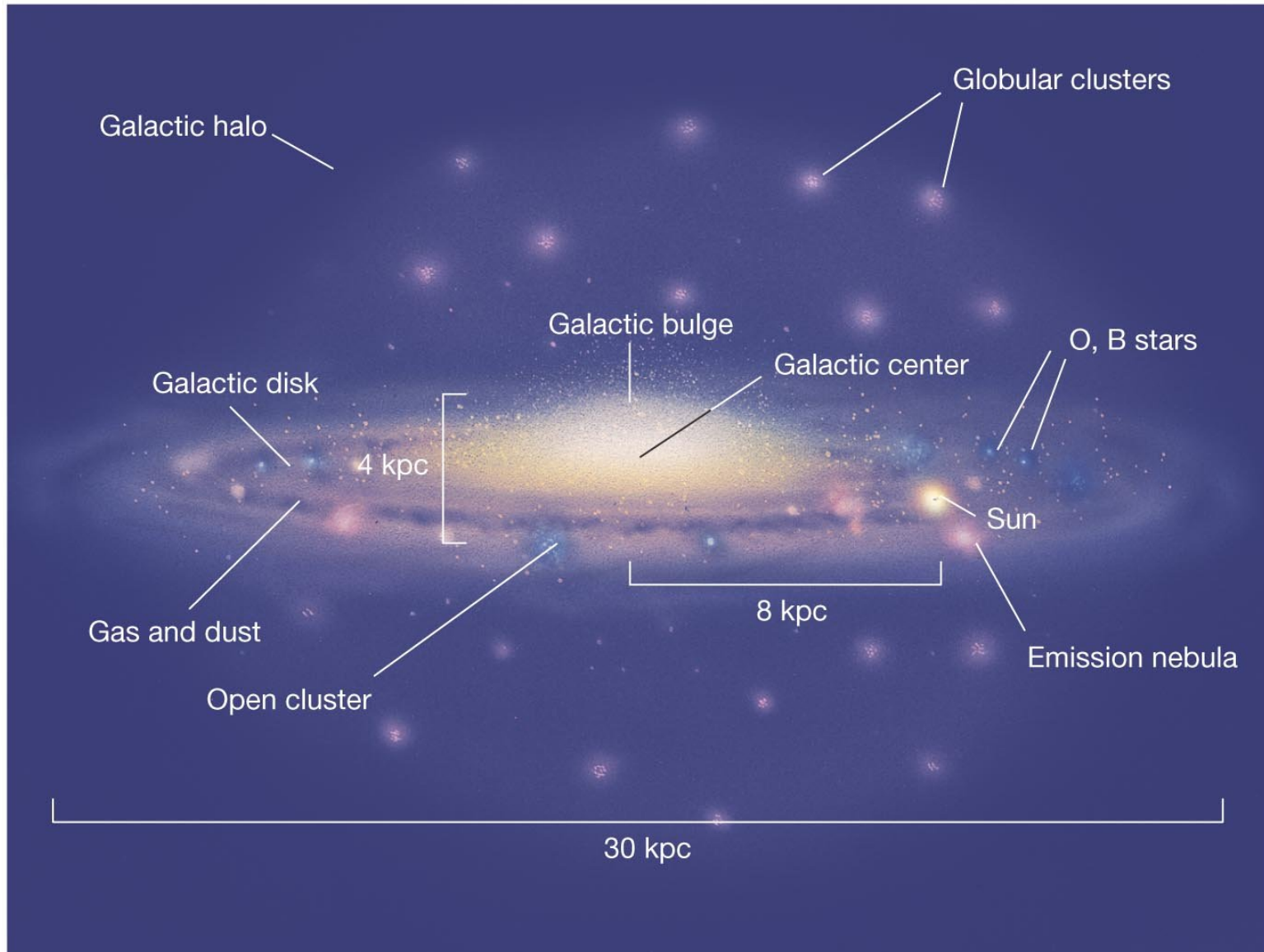**"Face on"**   **"Edge on"**

Our Parent Galaxy

Here is a better twin to the MW, NGC 6744.
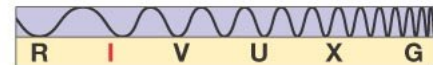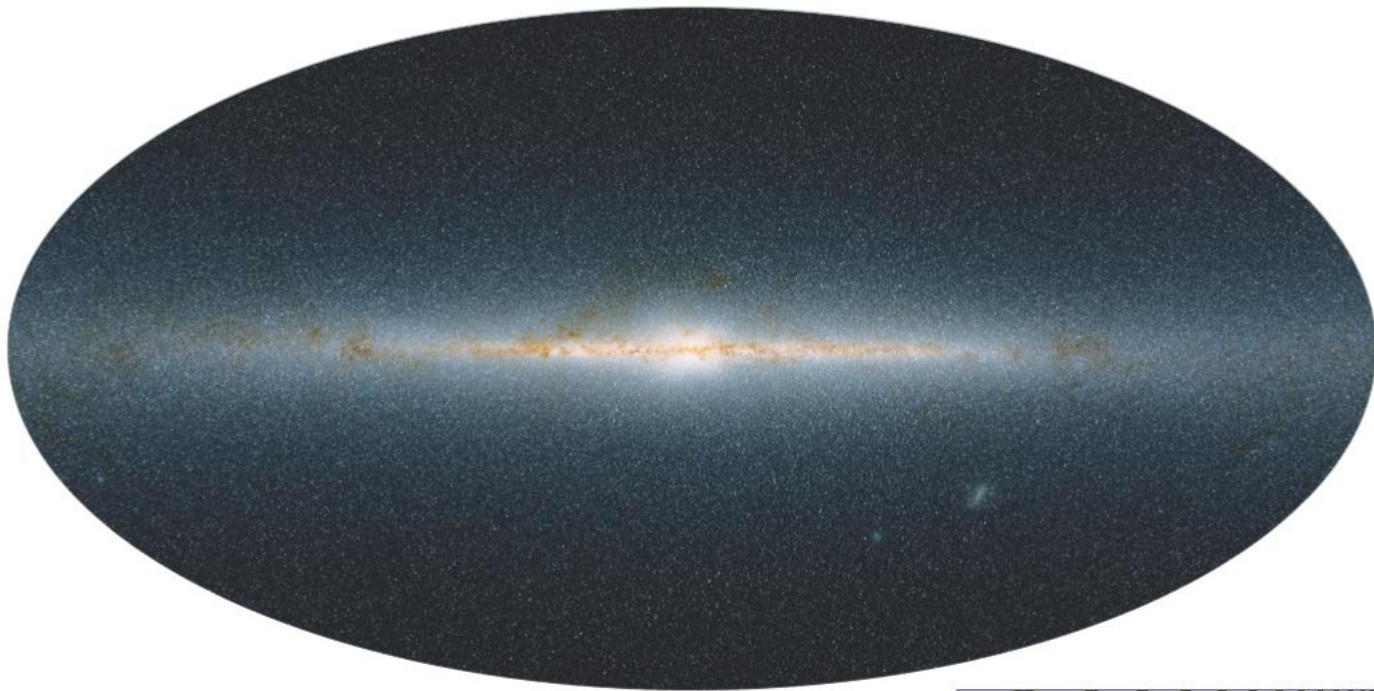Barred, medium-sized bulge, flocculant spiral.

Galactic Structure

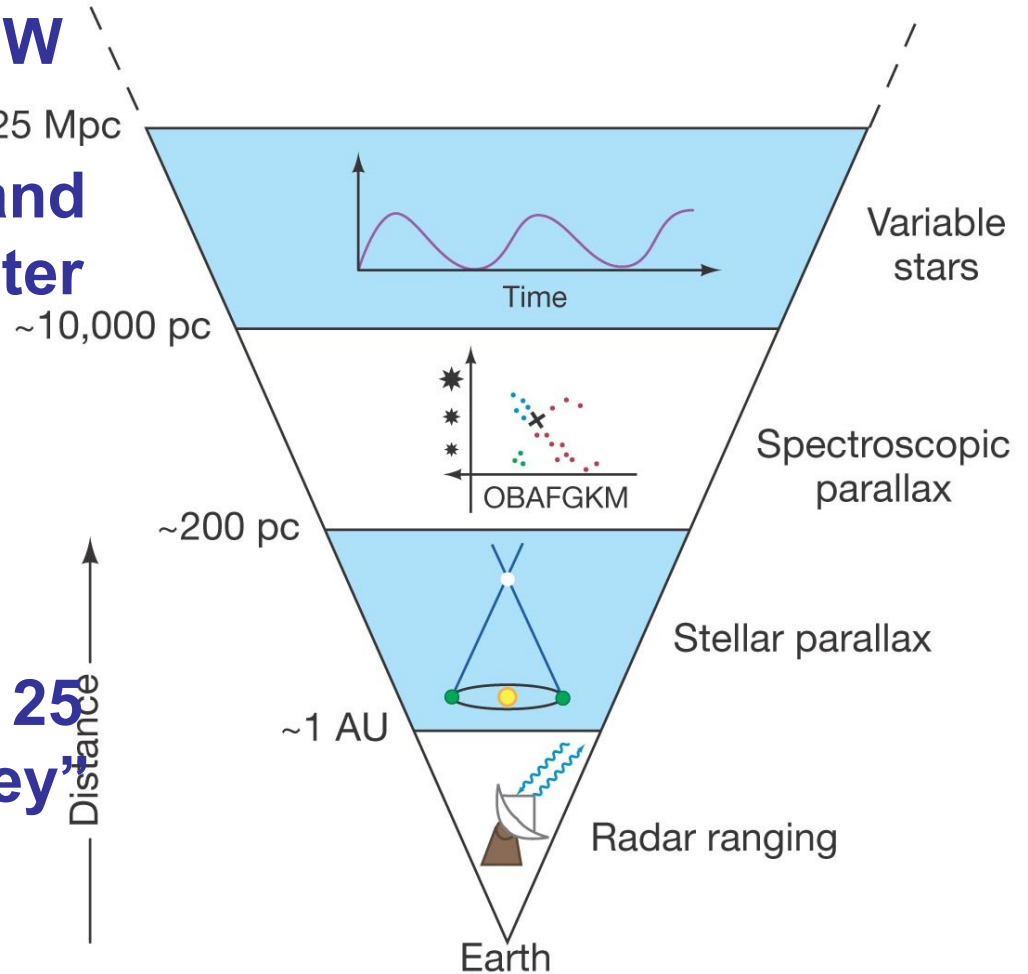## The various parts of our **galaxy:**

Galactic Structure

This **infrared** view of our galaxy shows much more detail of the galactic center than the visible-light view does, as infrared is not absorbed as much by gas and dust.
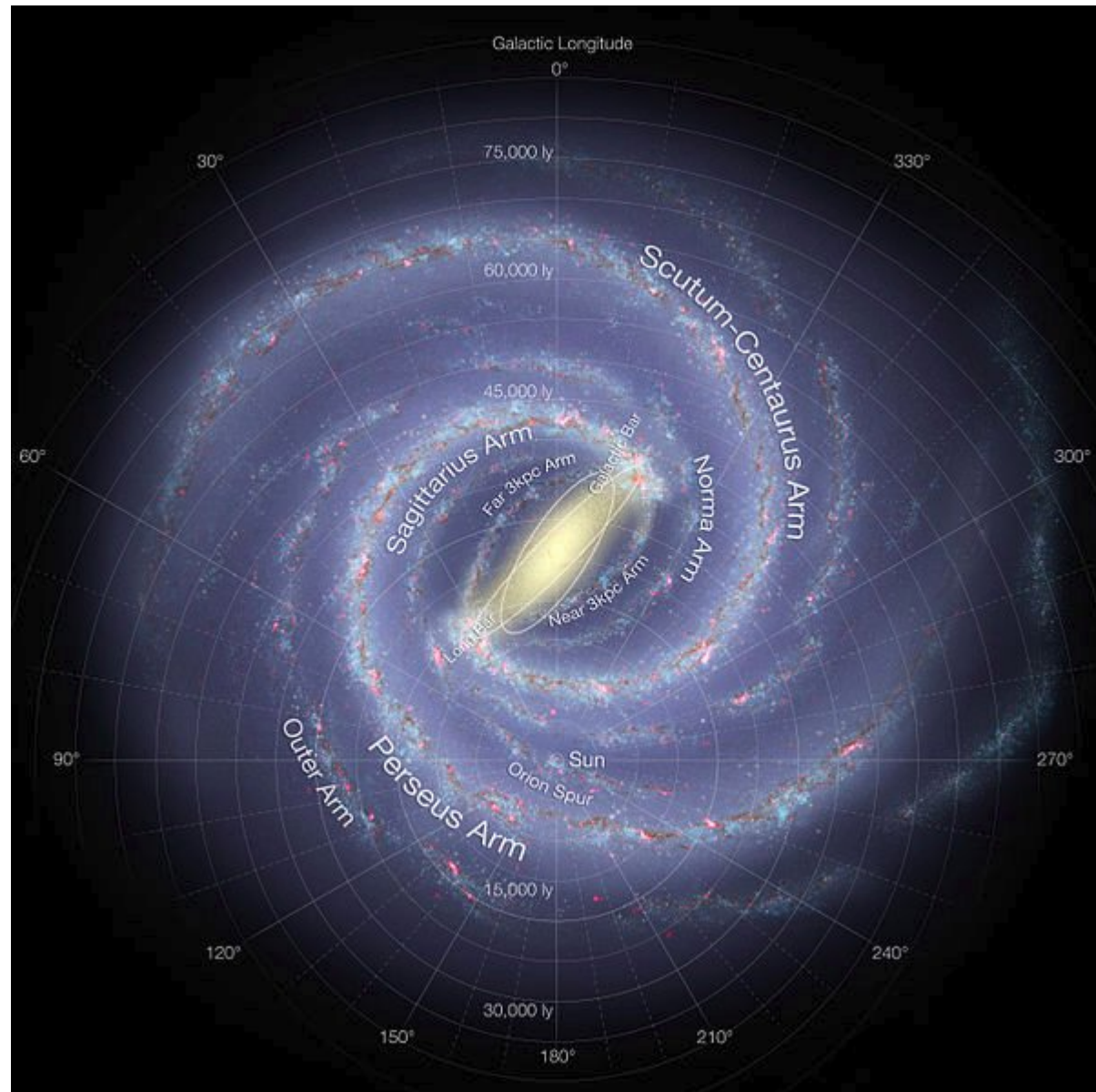
Measuring the Milky Way

We can measure distances to (bright) parts of the MW with many techniques: spec parallax, Cepheid and RR Lyrae variables, cluster sizes, expanding photospheres, moving cluster method, stat parallax, novae, etc, etc.

Finding Cepheids out to 25 Mpc was the original "Key" project for the Hubble Space Telescope.

~25 Mpc

~10,000 pc

Time

Variable stars

OBAFGKM

Spectroscopic parallax

~200 pc

Stellar parallax

~1 AU

Radar ranging

Distance
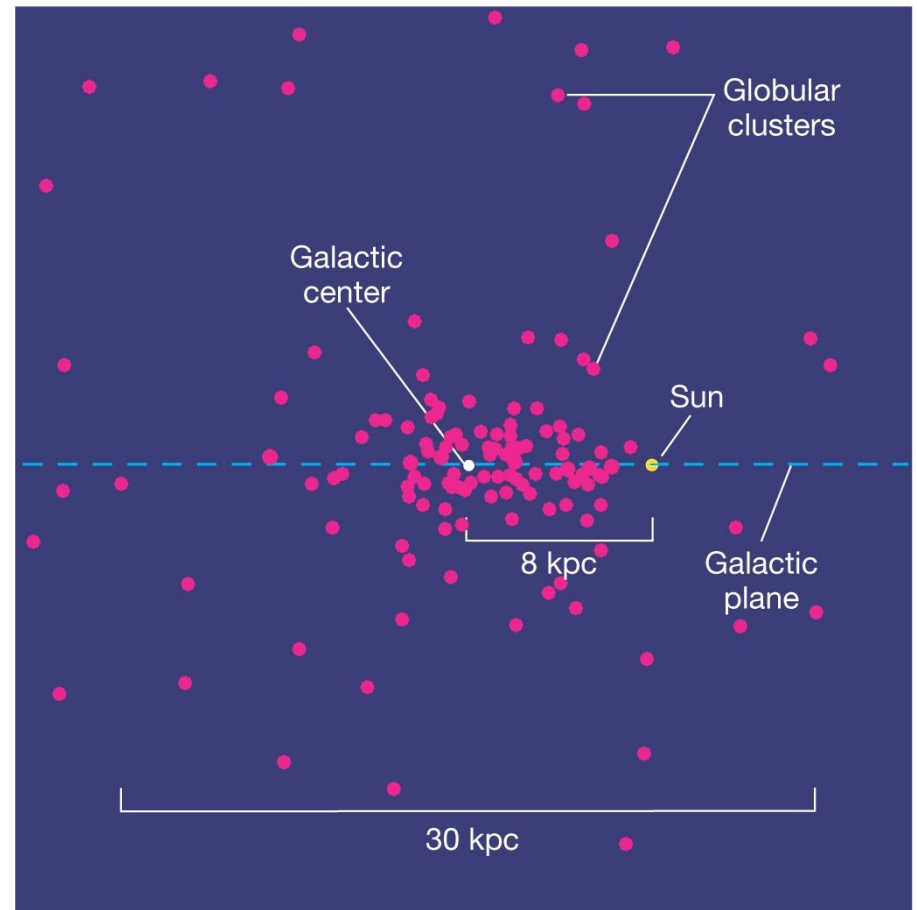
Earth

Measuring the Milky Way

Modern mapping of the M.W. Has relied on a variety of observations, especially 20 cm radio observations of the HI gas.
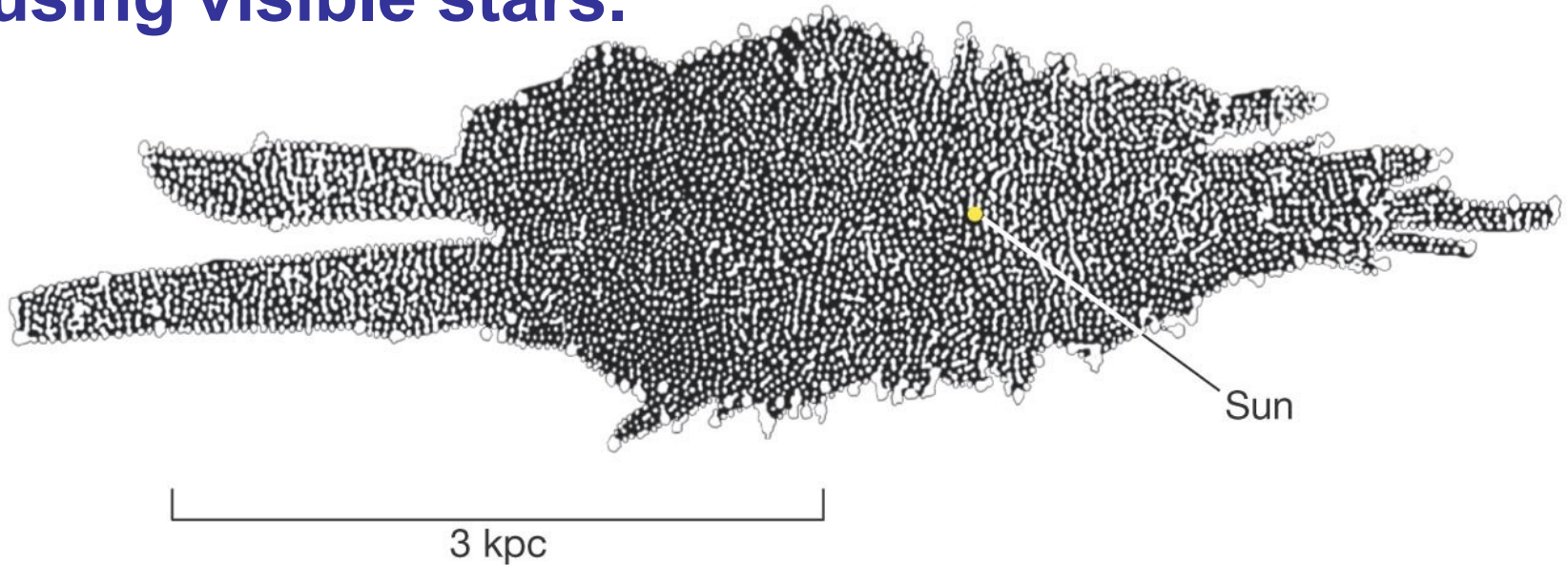
Measuring the Milky Way

Many RR Lyrae stars are found in globular clusters. Harlow Shapley used these to estimate the size of the M.W.

He correctly determined that we were far from the center. But he overestimated the size.

Measuring the Milky Way

One of the first attempts to measure the Milky Way was done by W. Herschel (1738-1822) using visible stars.

Sun

3 kpc

Problems:

1. patchy dust blocked view! (extinction)

2. all stars do not have the same luminosity!!

Measuring the Milky Way

A model based on star brightnesses, types, & motions was done by Jacobus Kapteyn (1850-1922).
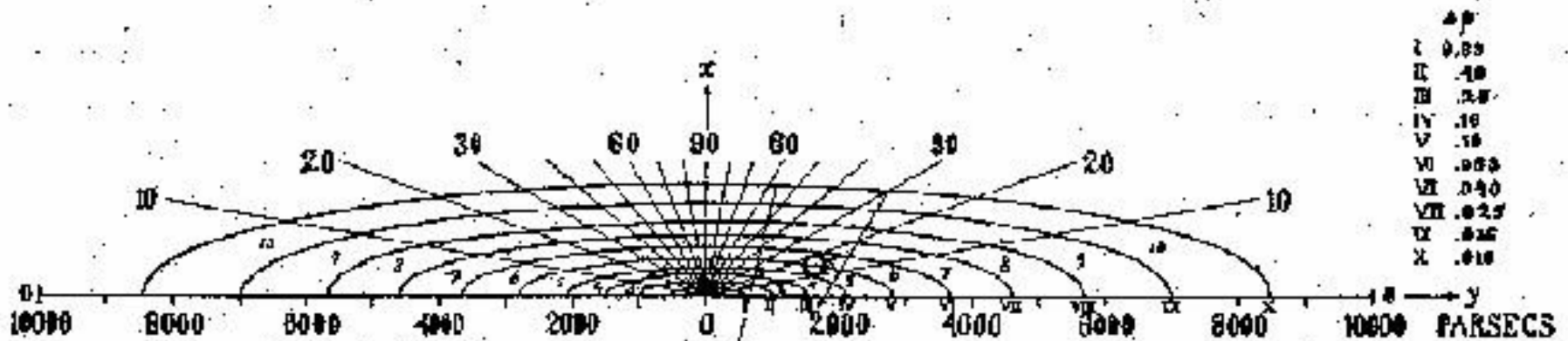

Fig. 1

Still lacked corrections for extinction.
Sun 2000 LY from center.

Kapteyn Universe (circa 1920)
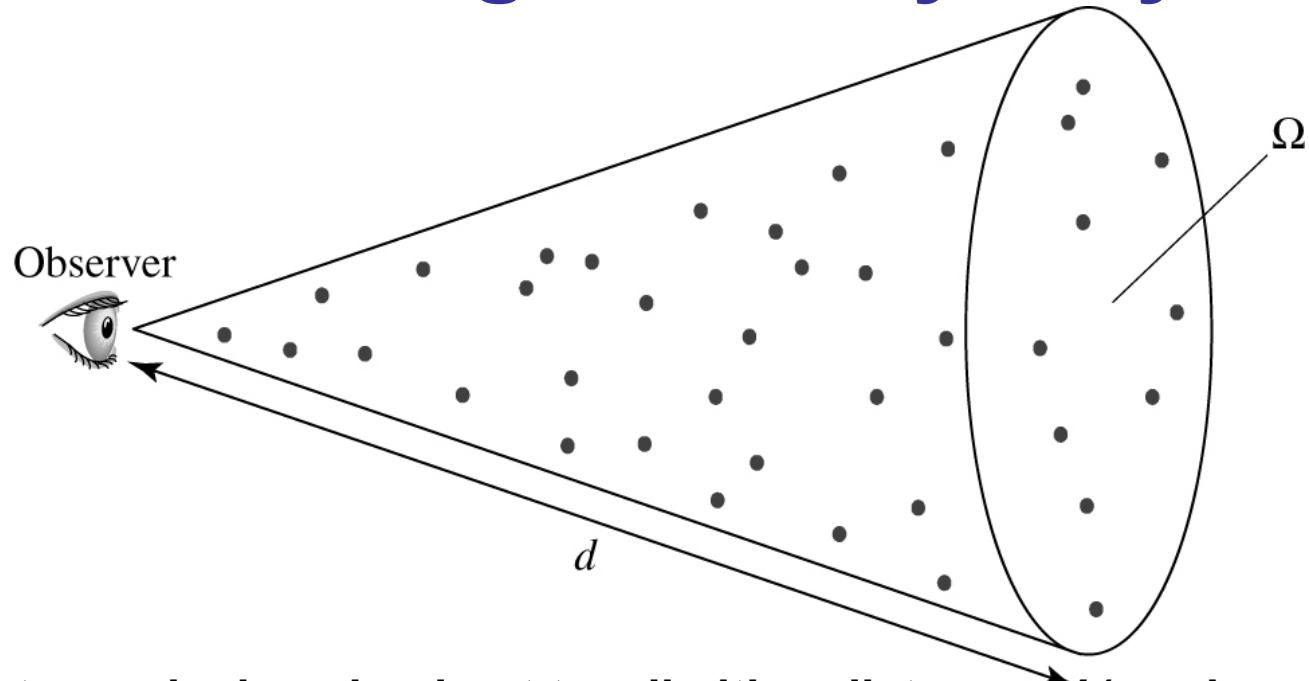
6,500 light years

solar system

30,000 light years

Measuring the Milky Way

Star counts can be imagined out to a limiting distance, *d* (as above). These are integrated stars counts represented by *N*.

However, it is easier to measure magnitudes than distances, so usually star counts are done down to a limiting magnitude (integrated star count, $\overline{N}$), or in magnitude bins (differential star count, *A*).
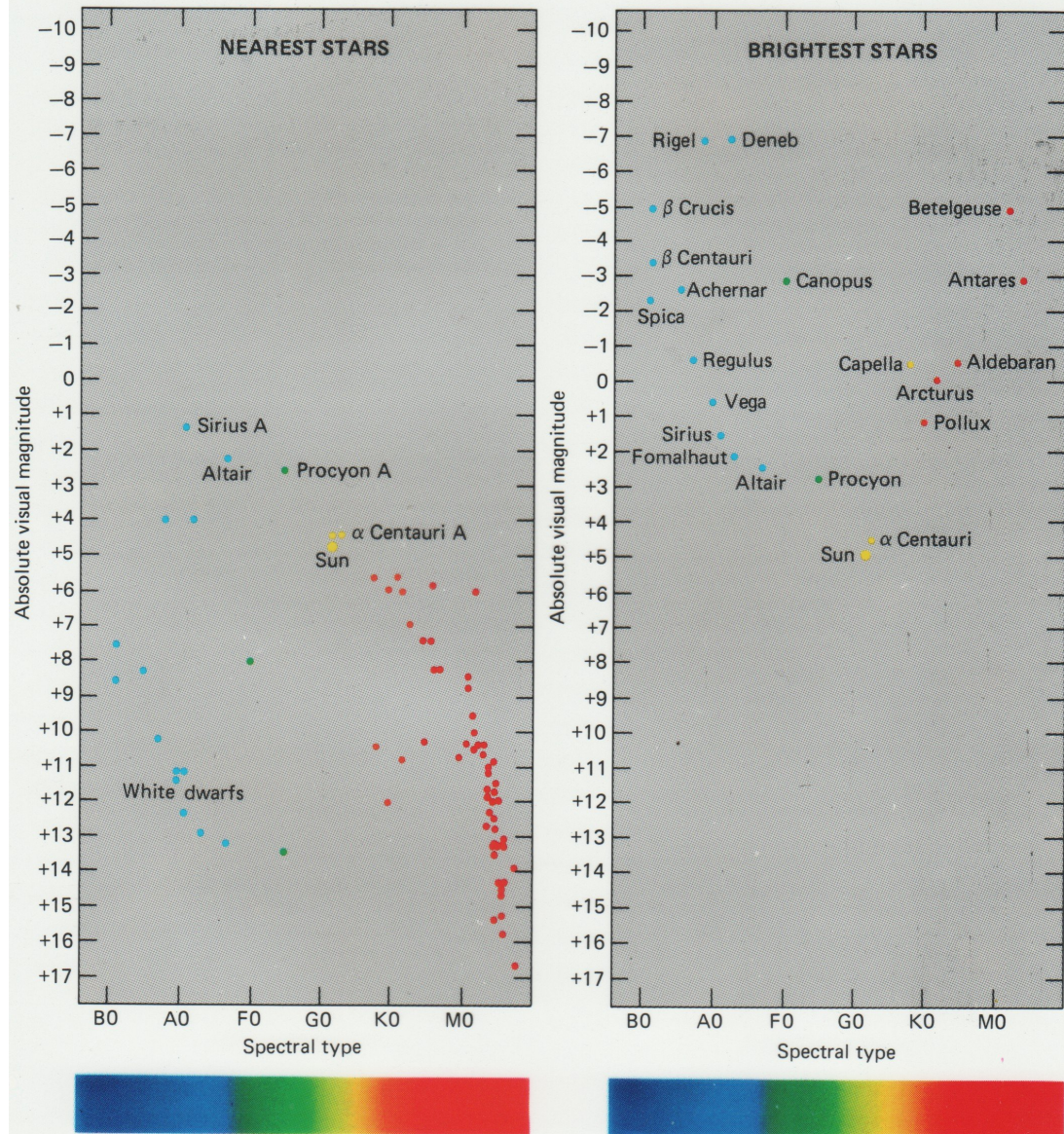
Note that the distance corresponding to a limiting magnitude, *m*, will be greater for more luminous stars (with lower *M*).

Measuring the Milky Way

If we want to use stars to probe the geometry of the MW, we need to know about their demography.
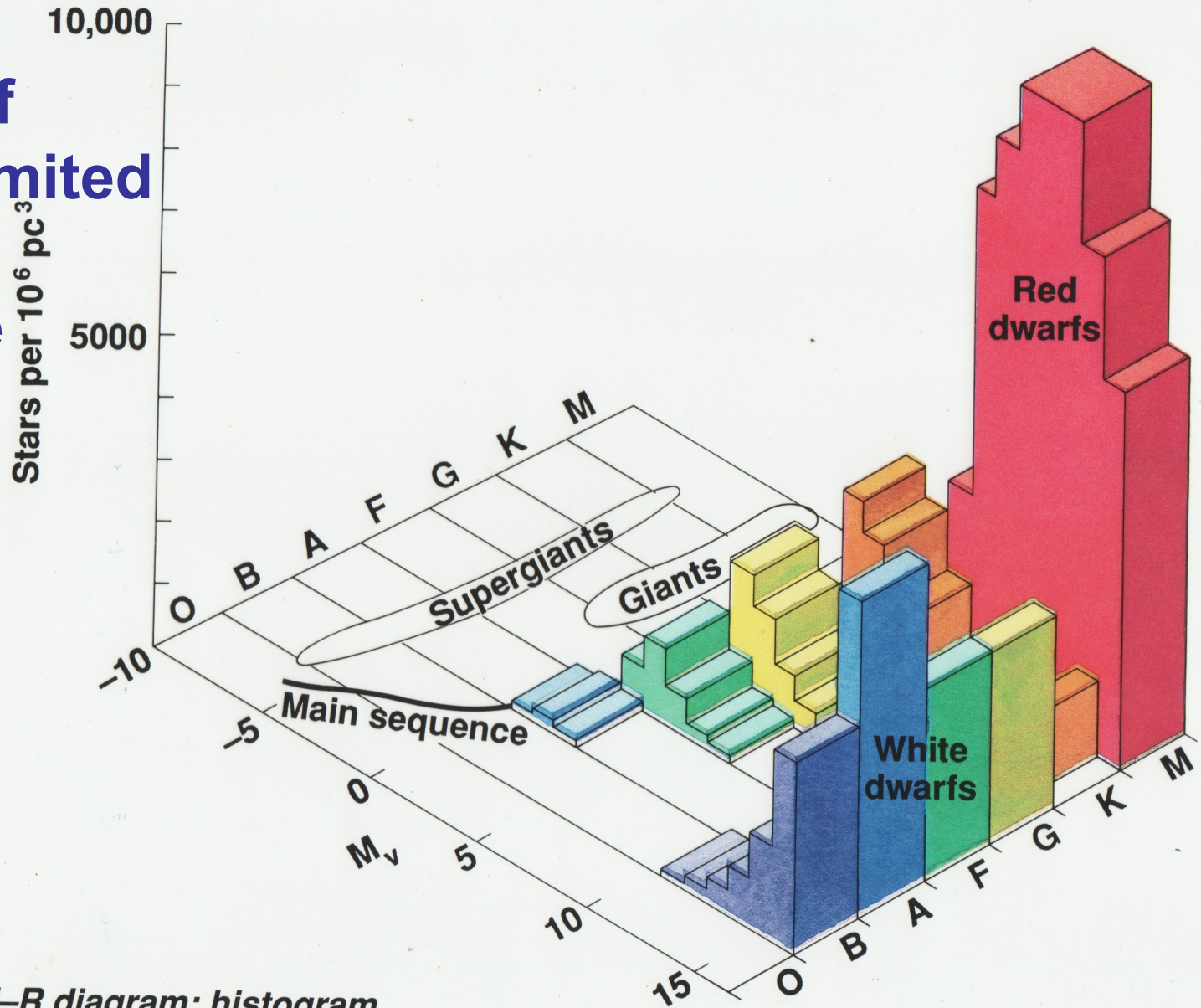
Near stars: faint.
Brightest: luminous.

Measuring the Milky Way

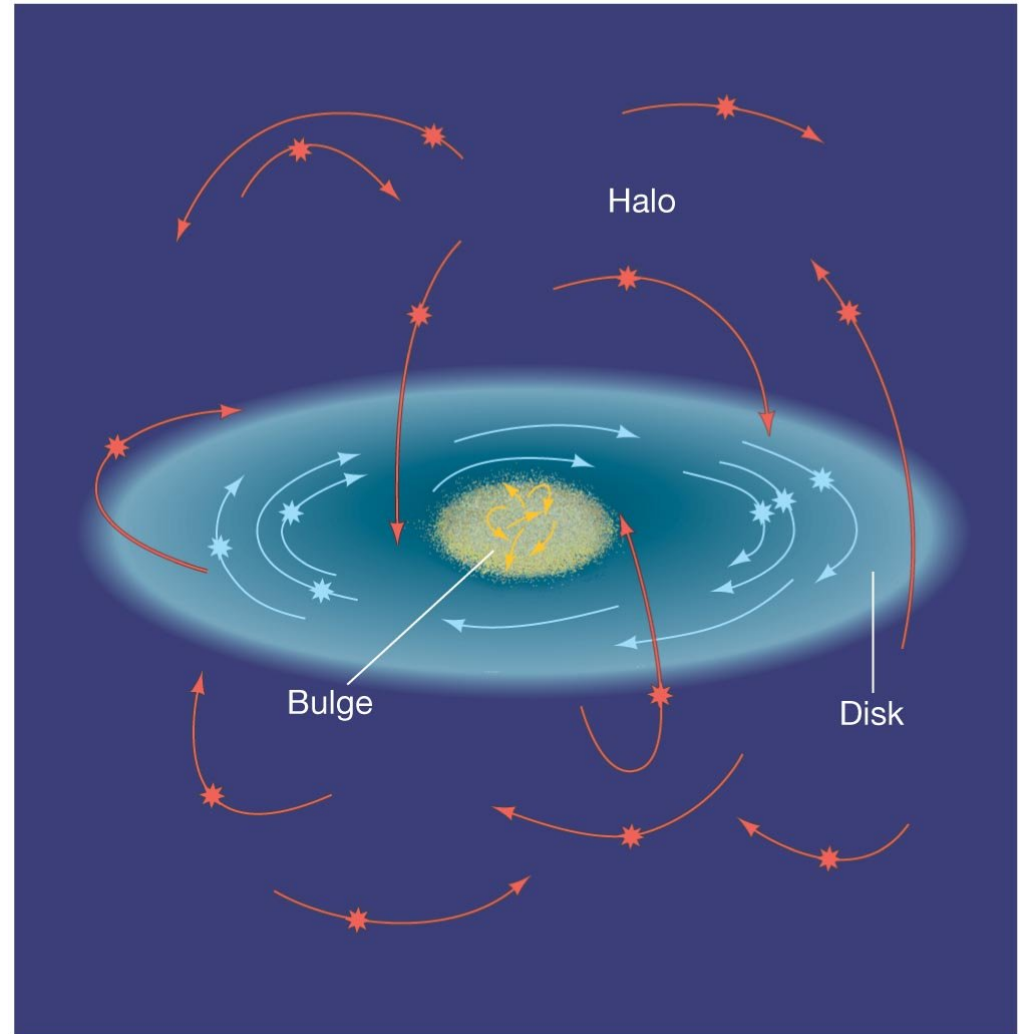**Studies of volume-limited samples reveal the rarity of luminous stars.**

H–R diagram: histogram
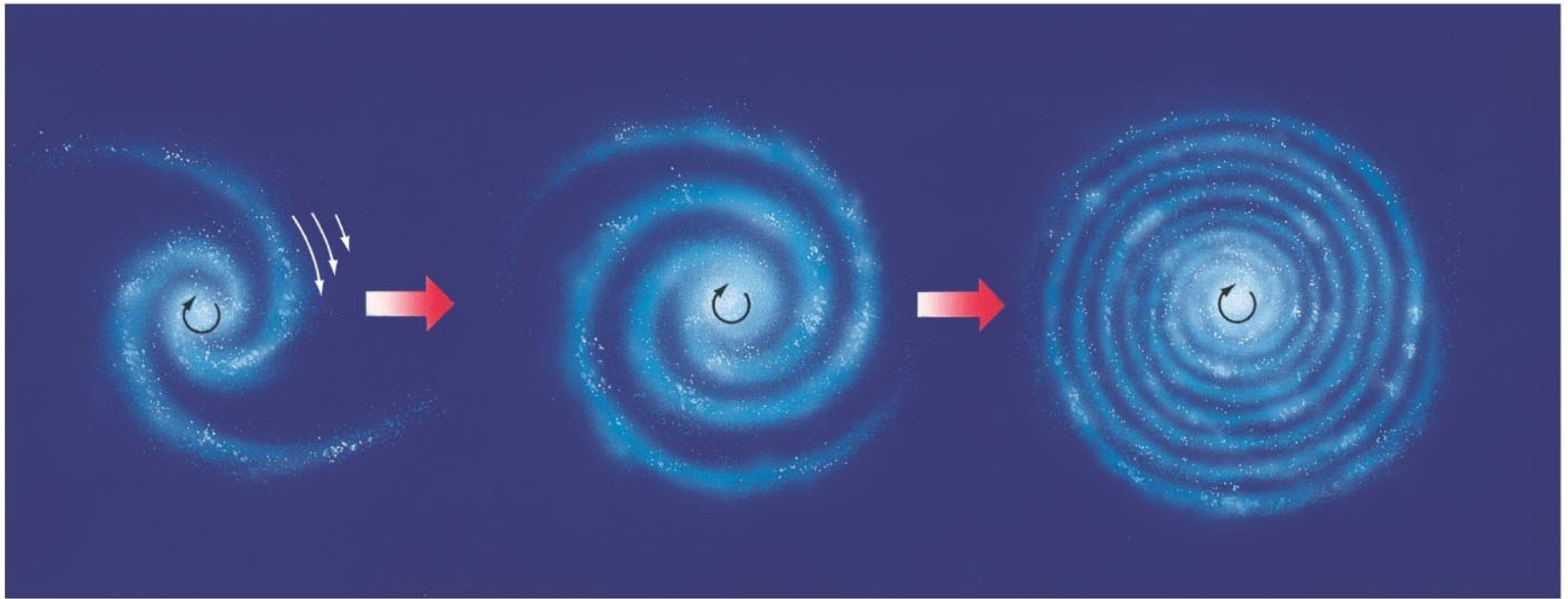
Galactic Structure - kinematics

Stellar orbits in the **disk** move in a common plane (*co-planar*) and in the same direction.

The orbits in the **halo** and **bulge** are much more random (*isotropic*).

Galactic Spiral Arms

**The spiral arms cannot rotate exactly as the stars do; they would "wind up".
(The "winding problem".)**

The speed of the stars is almost constant with radius, so inner stars make it around in less time than outer stars. The period is ~240 Myrs. MW formed ~50 rotations ago.
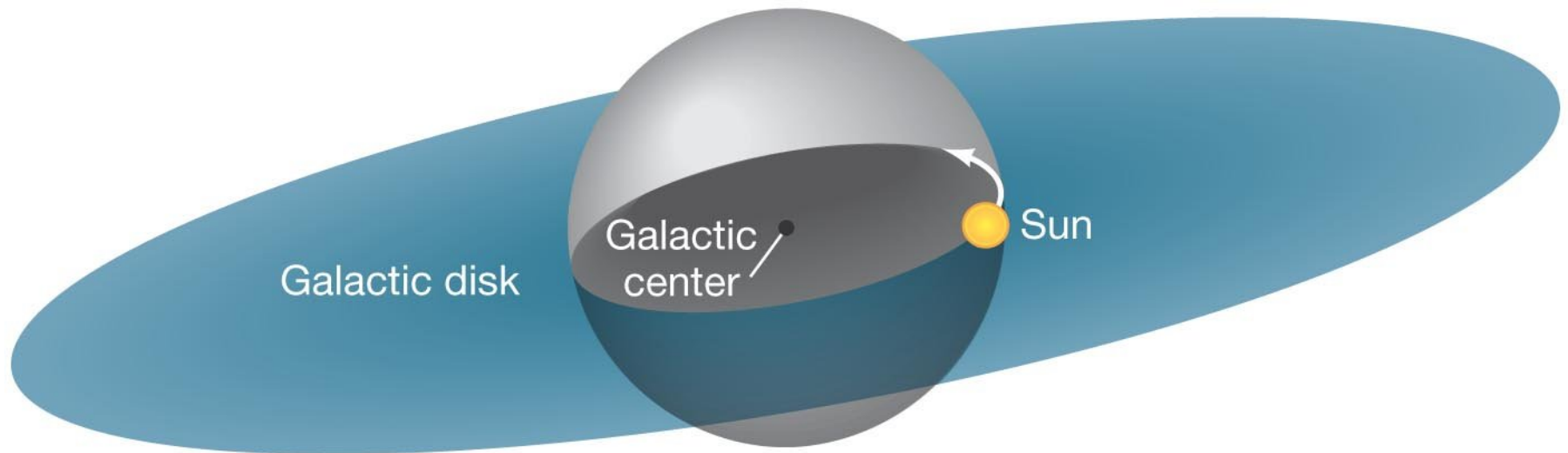
Galactic Spiral Arms

Rather, they appear to be density waves, with stars moving in and out of them such as cars move in and out of a traffic jam:
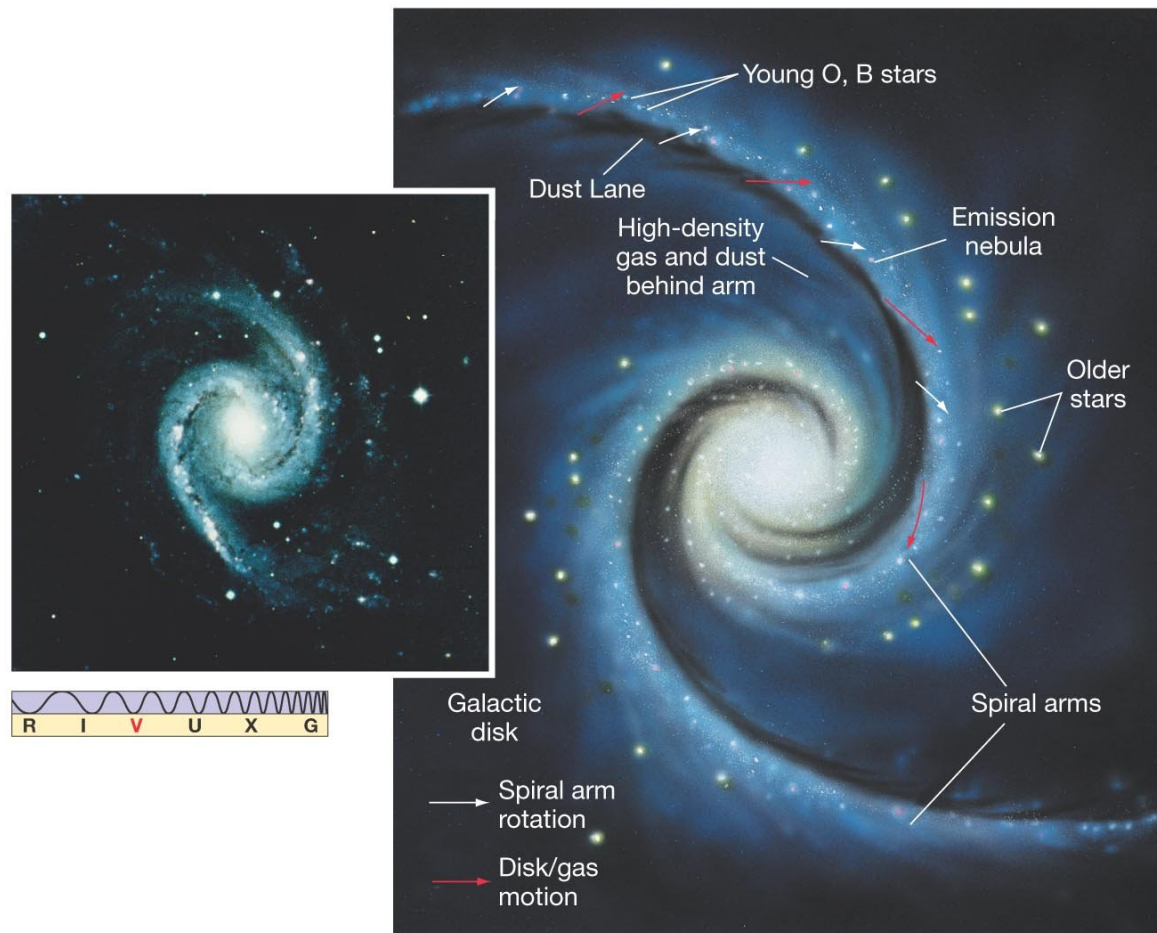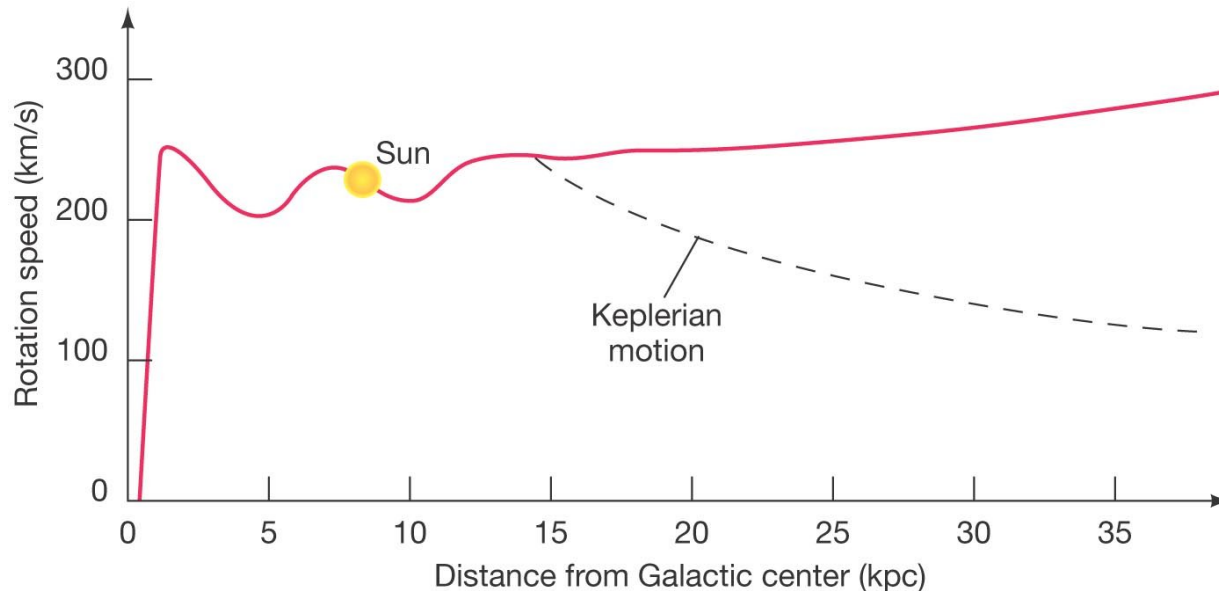
The Mass of the Milky Way Galaxy

The orbital speed of an object depends only on the amount of mass between it and the galactic center:
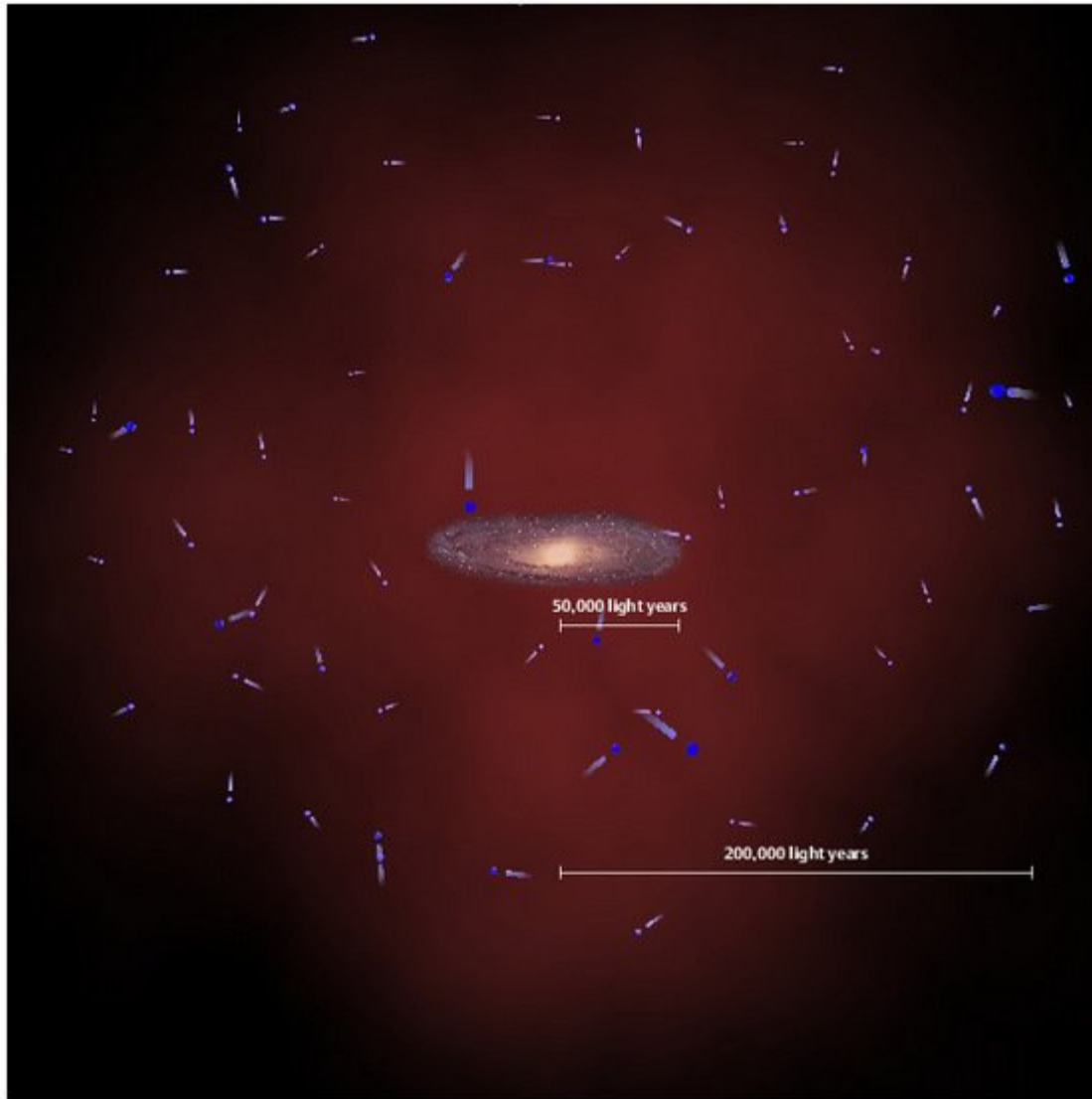
The Mass of the Milky Way Galaxy

Beyond the limits of the visible galaxy, the velocity should diminish with distance, as the dashed curve shows.

It doesn't; more than twice the mass of the galaxy would have to be outside the visible part to reproduce the observed curve.

The Mass of the Milky Way Galaxy

The MW has a dark matter halo.

Candidates:
MACHOS:
  Brown dwarfs
  Red dwarfs
  Stellar black holes
  Neutron stars

WIMPS:
  Axions, neutrinos,
  unknown