Chapter 14
The Milky Way Galaxy

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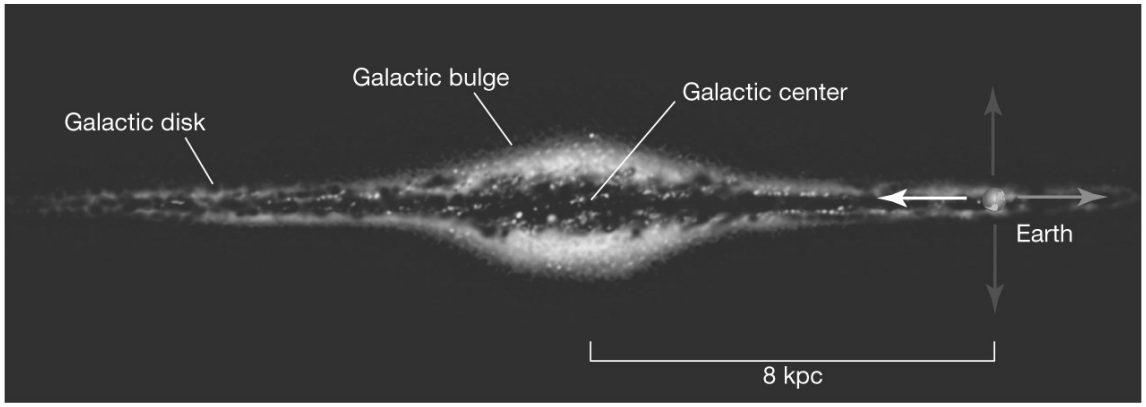
The Galactic Center

14.1 Our Parent Galaxy

From Earth, see few stars when looking out of galaxy (red arrows), many when looking in (blue and white arrows). Milky Way is how our galaxy appears in the night sky (b).



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

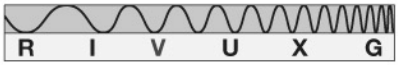
(b) Real image of Milky Way from inside

14.1 Our Parent Galaxy

Our galaxy is a spiral galaxy. Here are two other spiral galaxies, one viewed from the side and the other from the top, which are thought to resemble the Milky Way:

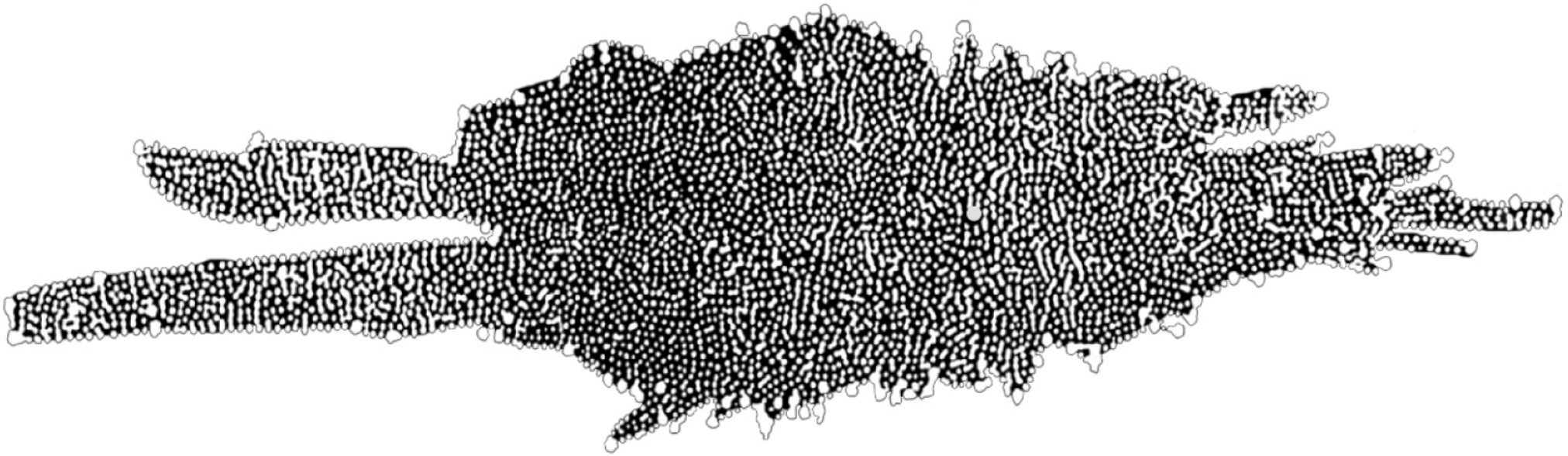
(b)

(c)



14.2 Measuring the Milky Way

One of the first attempts to measure the Milky Way was done by Herschel using visible stars.



Unfortunately, he was not aware that most of the galaxy, particularly the center, is blocked from view by vast clouds of gas and dust.

14.2 Measuring the Milky Way

We have already encountered variable stars –novae, supernovae and related phenomena – these are called cataclysmic variables.

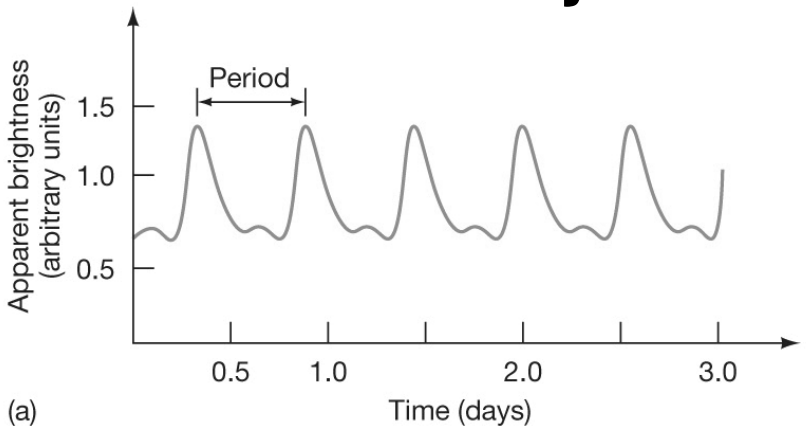
There are other stars whose luminosity varies in a regular way, but much more subtly. These are called intrinsic variables.

Two types of intrinsic variables have been found: RR Lyrae stars, and Cepheids.

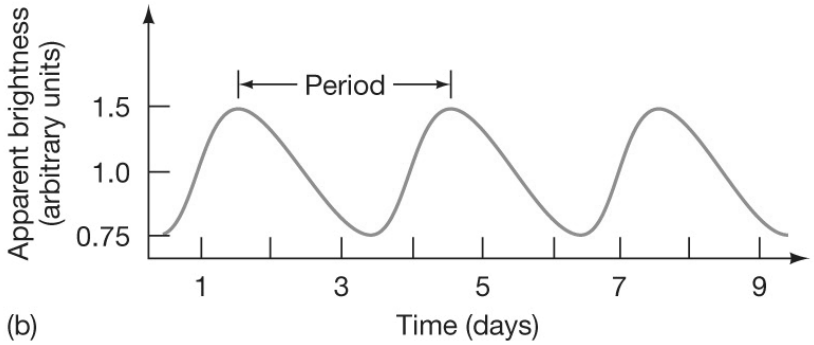
14.2 Measuring the Milky Way

The upper plot is an RR Lyrae star. All such stars have essentially the same luminosity curve, with periods from 0.5 to 1 day.

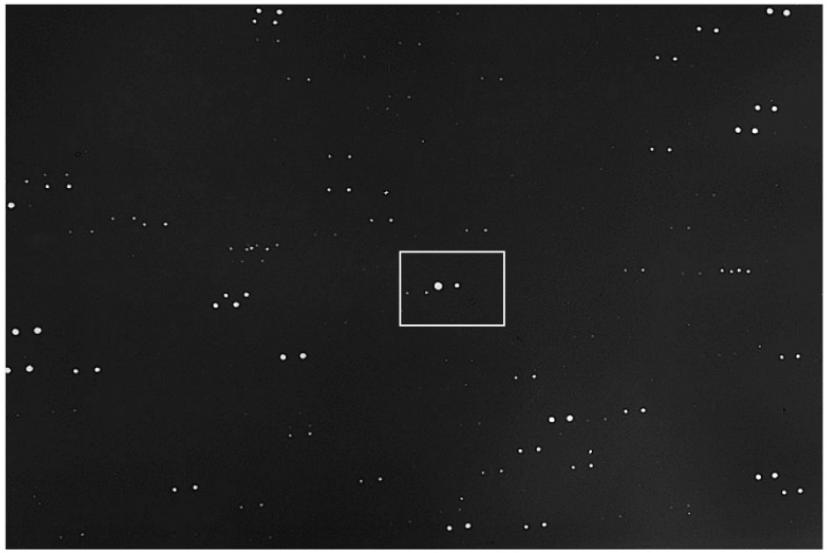
The lower plot is a Cepheid variable; Cepheid periods range from about 1 to 100 days.



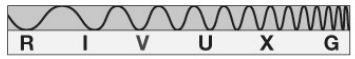
(a)



(b)

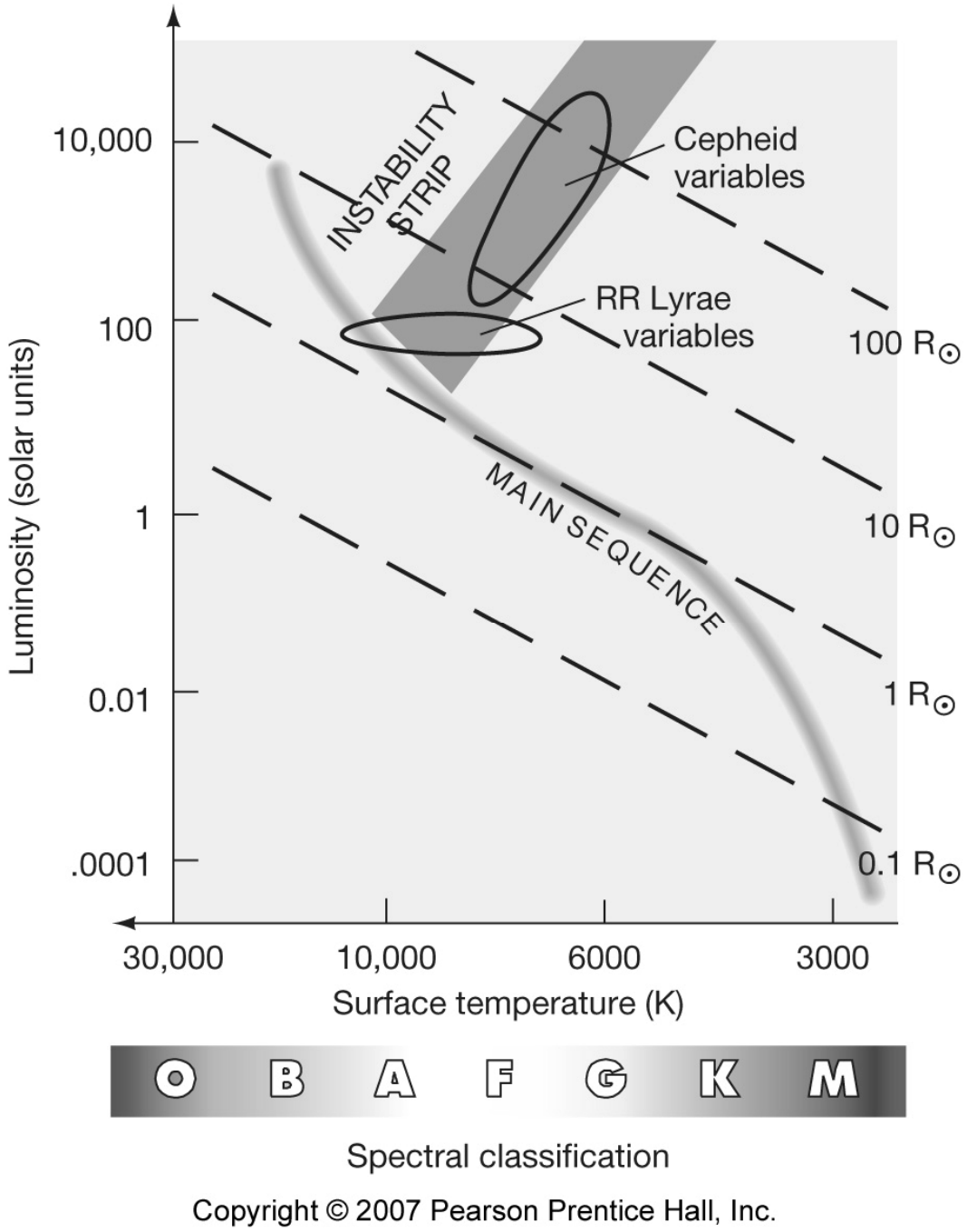


(c)



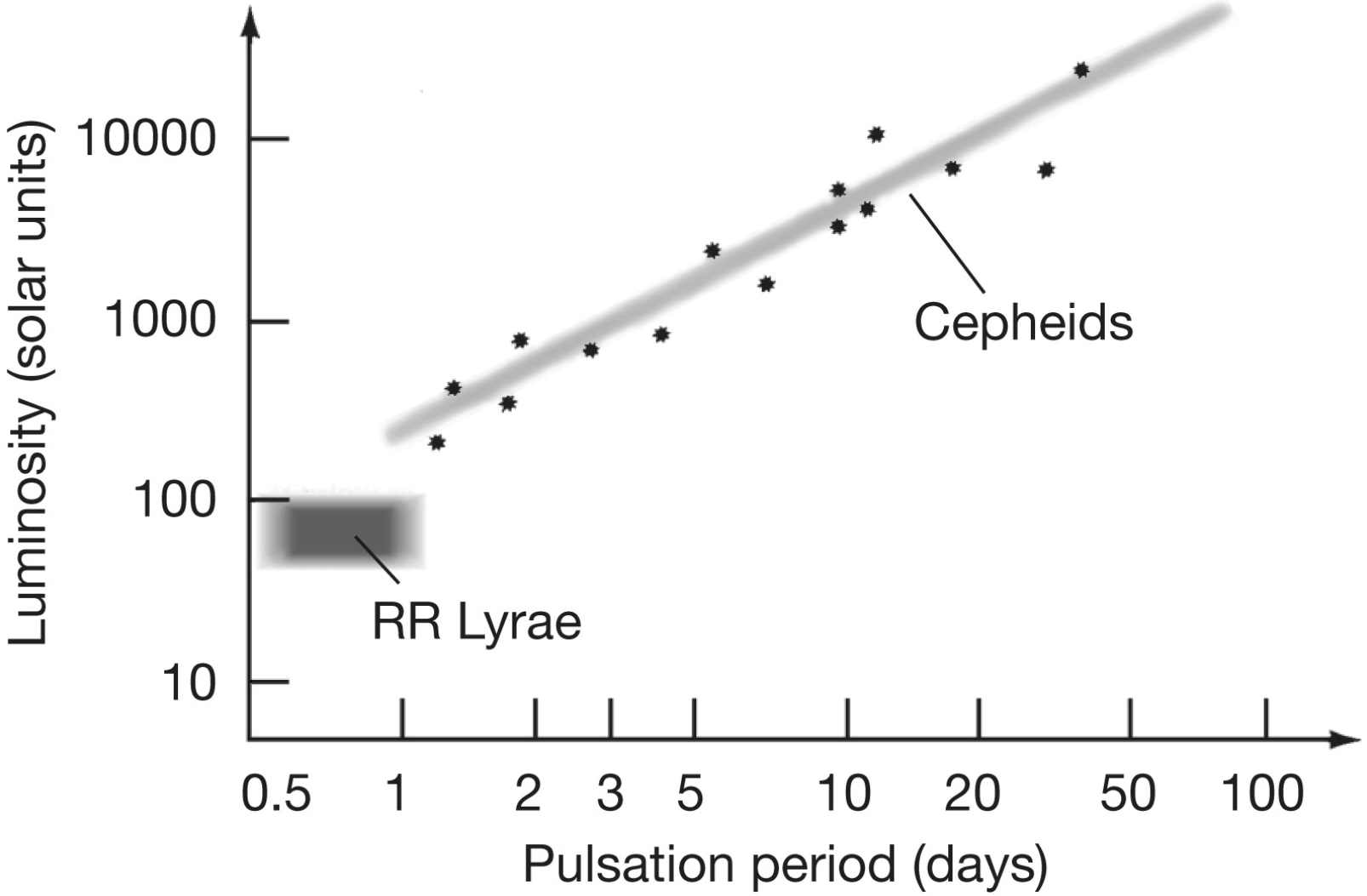
14.2 Measuring the Milky Way

The variability of these stars comes from a dynamic balance between gravity and pressure – they have large oscillations aroun stability.



14.2 Measuring the Milky Way

The usefulness of these stars comes from their period-luminosity relation:



14.2 Measuring the Milky Way

This allows us to measure the distances to these stars.

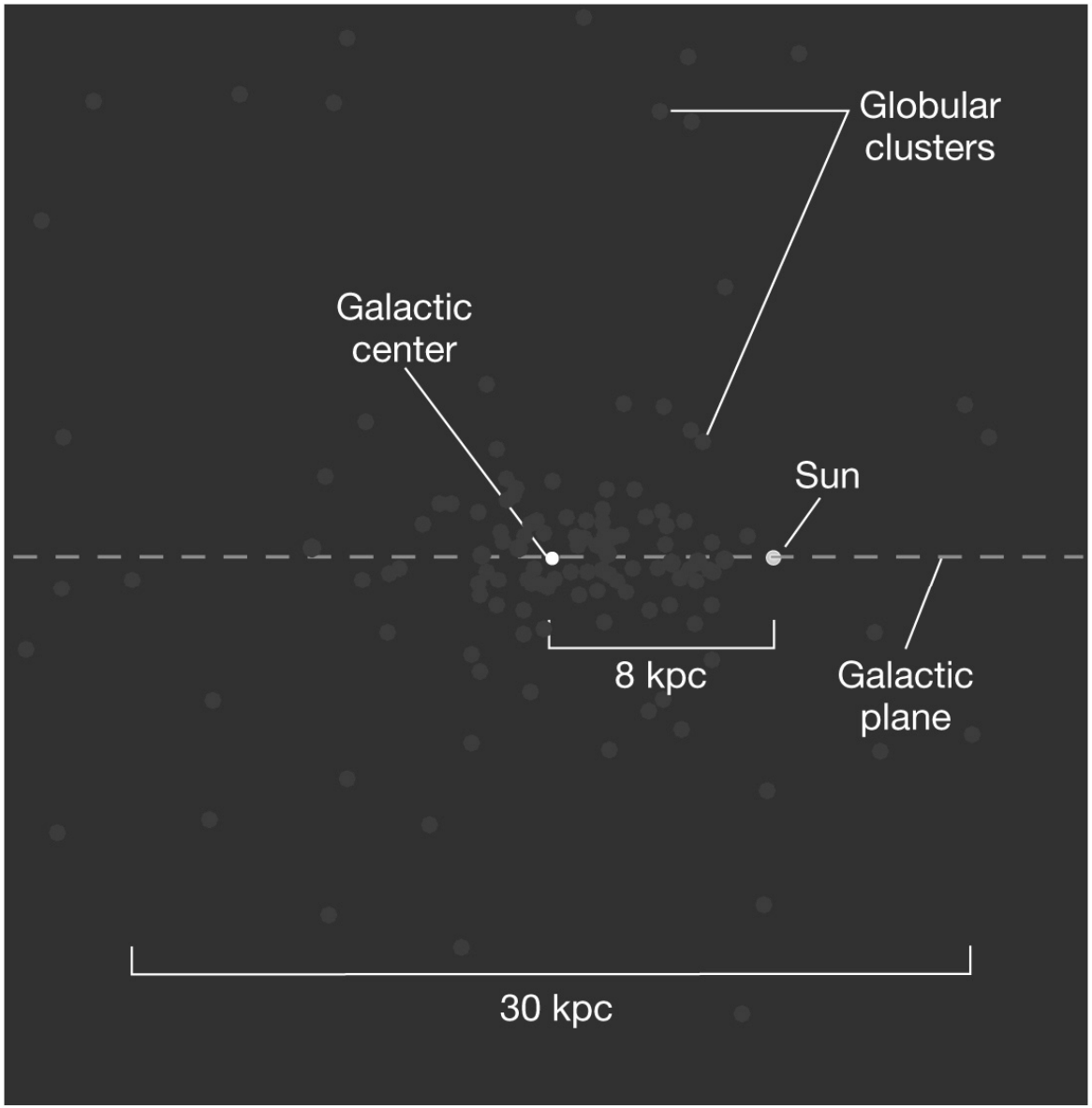
- **RR Lyrae stars all have about the same luminosity; knowing their apparent magnitude allows us to calculate the distance.**

- **Cepheids have a luminosity that is strongly correlated with the period of their oscillations; once the period is measured, the luminosity is known and we can proceed as above.**

14.2 Measuring the Milky Way

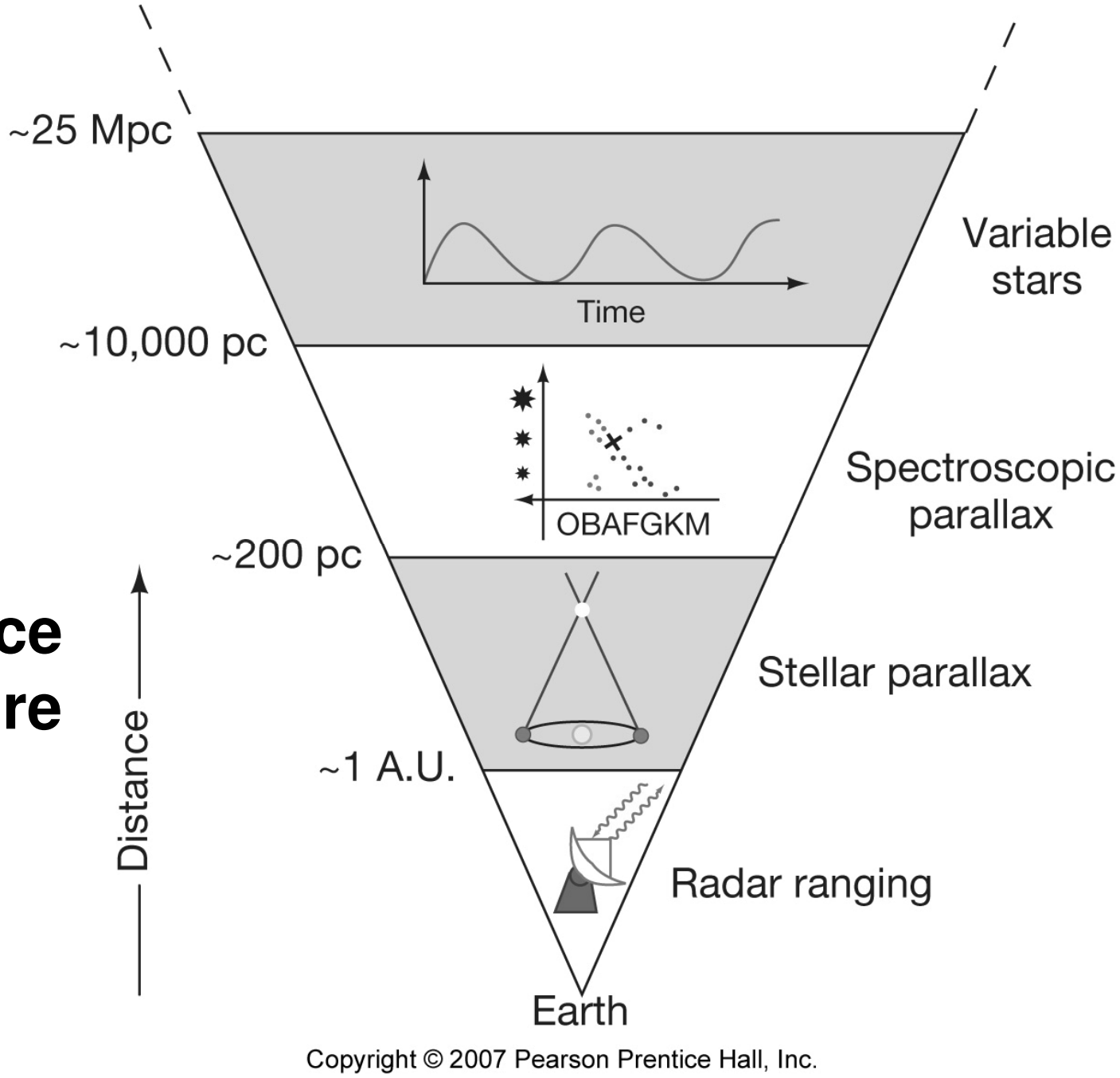
Many RR Lyrae stars are found in globular clusters. These clusters are not all in the plane of the galaxy, so they are not obscured by dust and can be measured.

This yields a much more accurate picture of the extent of our galaxy and our place within it.



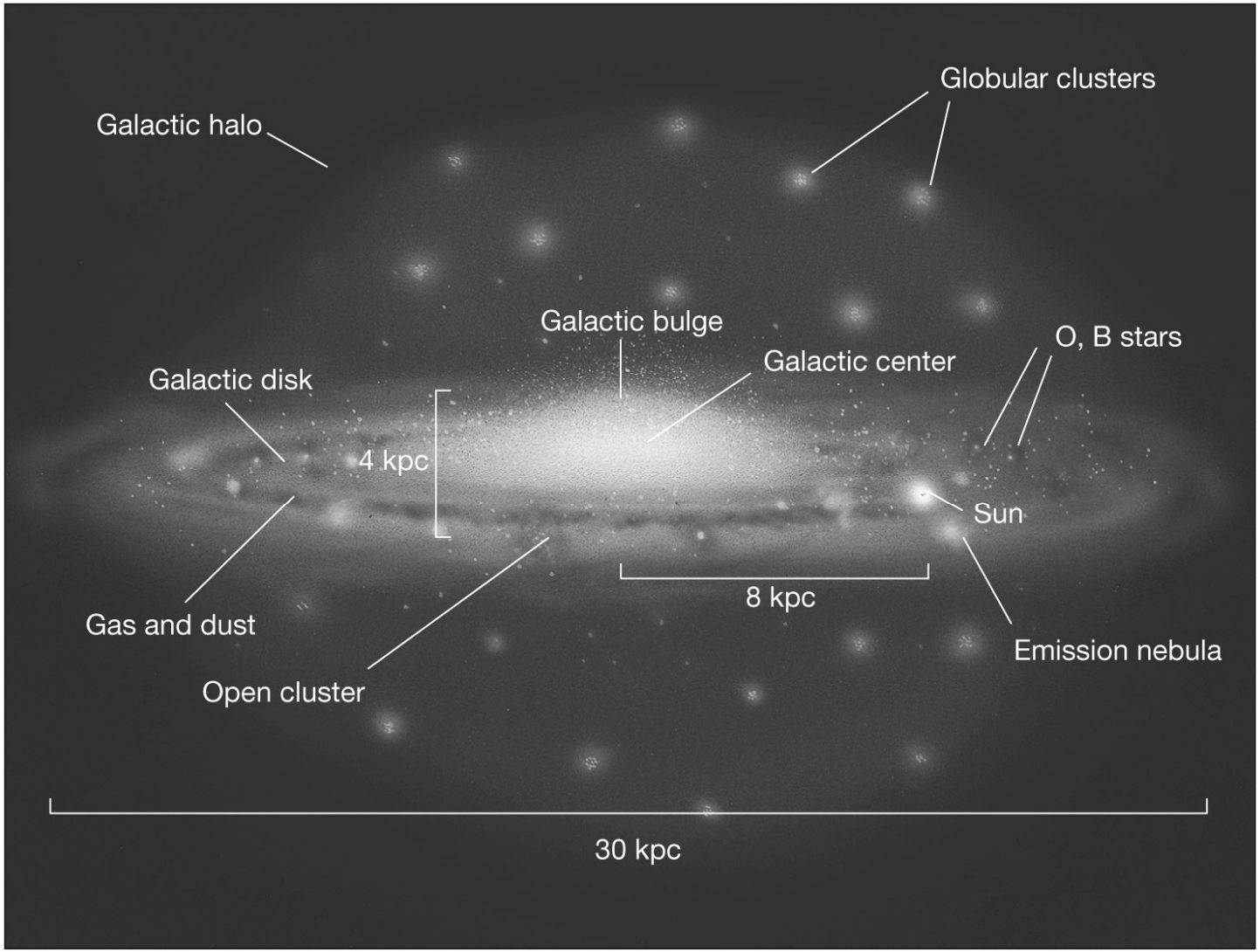
14.2 Measuring the Milky Way

We have now expanded our cosmic distance ladder one more step:



14.3 Galactic Structure

This artist's conception shows the various parts of our galaxy, and the position of our Sun:



14.3 Galactic Structure

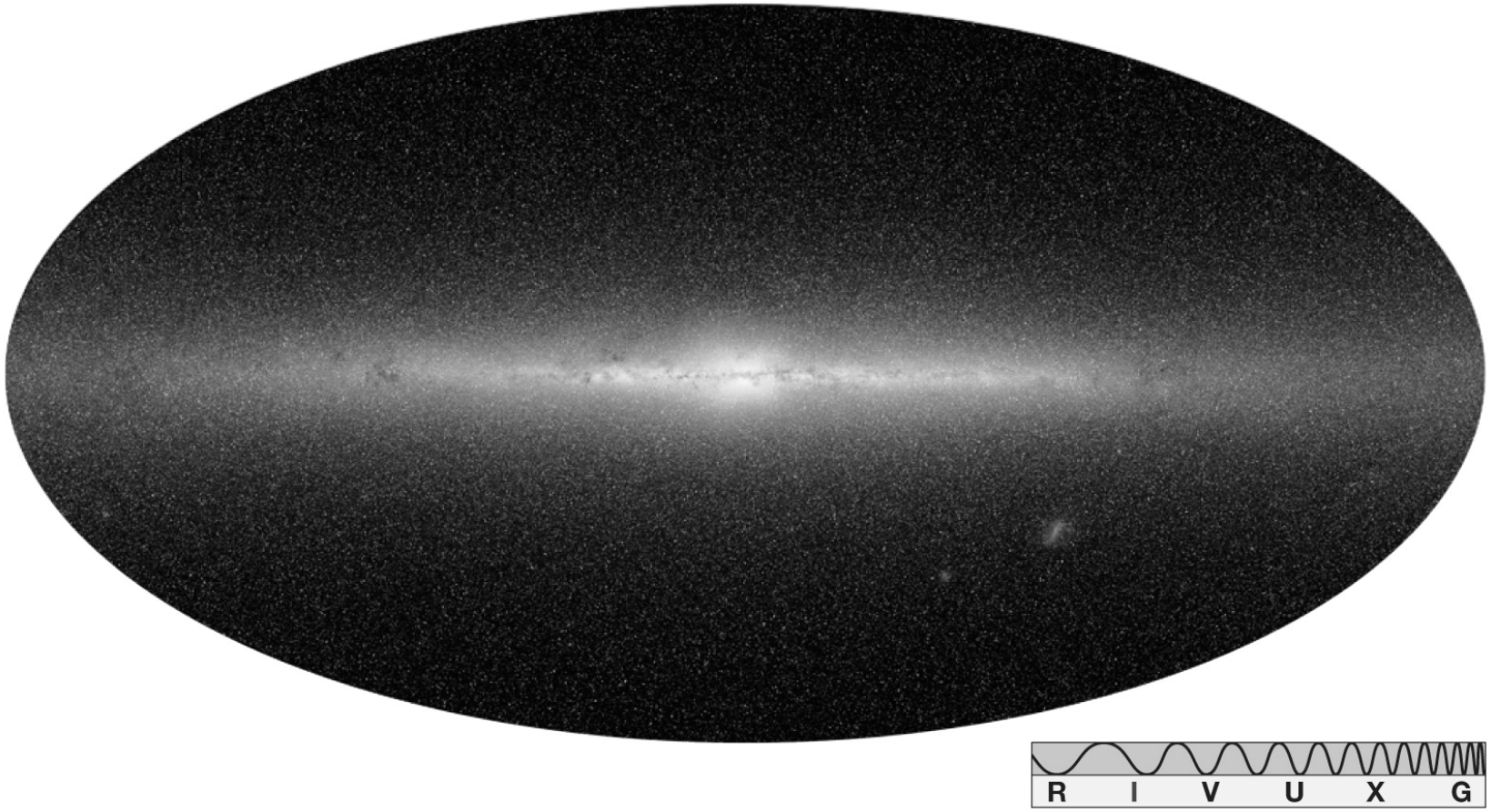
The galactic halo and globular clusters formed very early; the halo is essentially spherical. All the stars in the halo are very old, and there is no gas and dust.

The galactic disk is where the youngest stars are, as well as star formation regions – emission nebulae, large clouds of gas and dust.

Surrounding the galactic center is the galactic bulge, which contains a mix of older and younger stars.

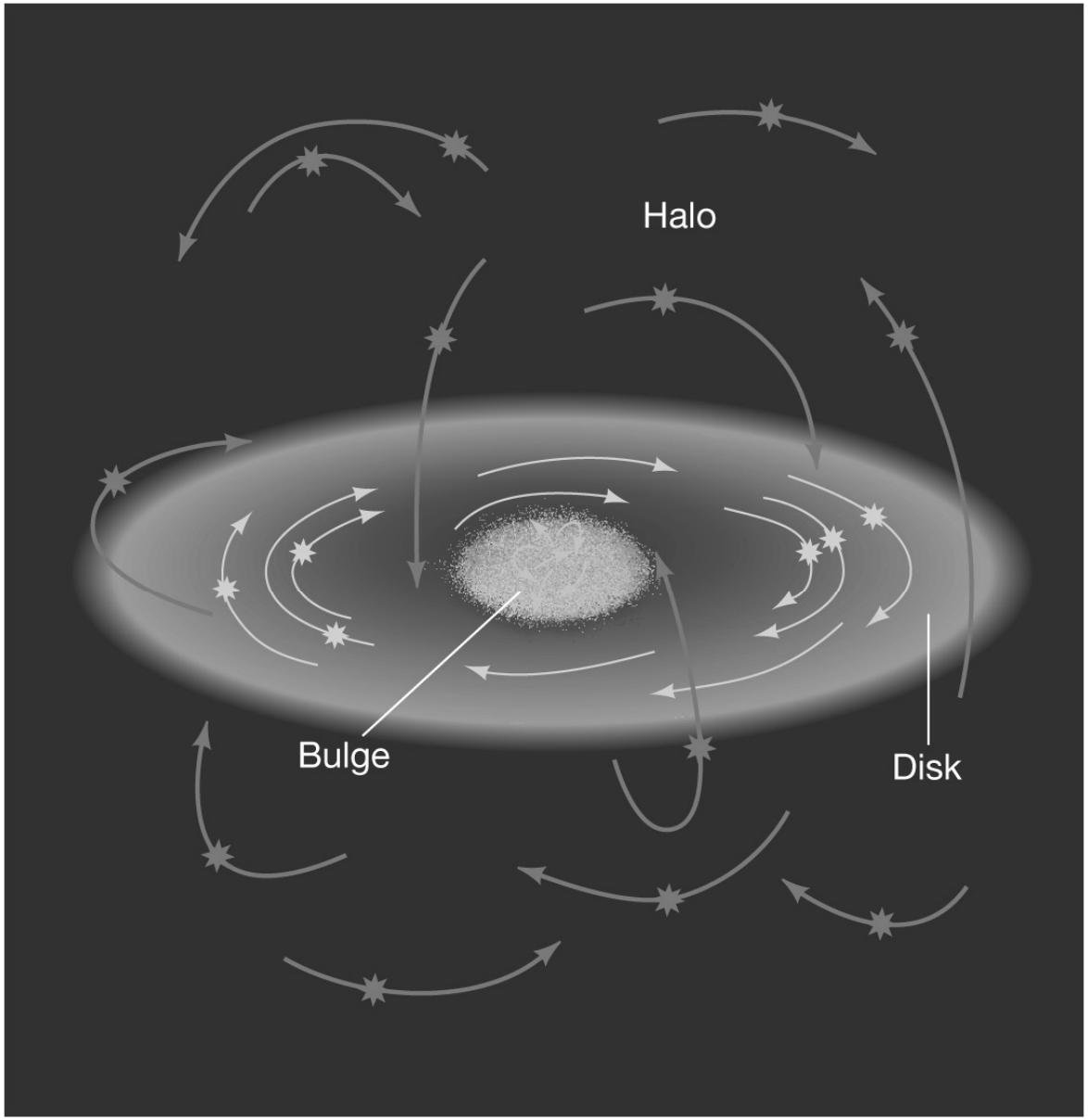
14.3 Galactic Structure

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



14.3 Galactic Structure

Stellar orbits in the disk are in a plane and in the same direction; orbits in the halo and bulge are much more random.



14.4 The Formation of the Milky Way

Any theory of galaxy formation should be able to account for all the properties below:

TABLE 14.1 Overall Properties of the Galactic Disk, Halo, and Bulge

GALACTIC DISK	GALACTIC HALO	GALACTIC BULGE
Highly flattened	roughly spherical—mildly flattened	somewhat flattened—elongated in the plane of the disk (football-shaped)
Contains both young and old stars	contains old stars only	contains both young and old stars; more old stars at greater distances from the center
Contains gas and dust	contains no gas and dust	contains gas and dust, especially in the inner regions
Site of ongoing star formation	no star formation during the last 10 billion years	ongoing star formation in the inner regions
Gas and stars move in circular orbits in the Galactic plane	stars have random orbits in three dimensions	stars have largely random orbits, but with some net rotation about the Galactic center
Spiral arms (Sec. 14.5)	little discernible substructure; globular clusters, tidal streams (Sec. 14.3)	ring of gas and dust near center; central Galactic nucleus (Sec. 14.7)
Overall white coloration, with blue spiral arms	reddish in color	yellow-white

14.4 The Formation of the Milky Way

The formation of the galaxy is believed to be similar to the formation of the solar system, but on a much larger scale: