Chapter 19

Our Galaxy

Things to know

- Galaxy
- Galactic Disk
- Galactic Bulge
- Galactic Halo
- Cataclysmic Variables
- Intrinsic Variable
- Dark Matter

- Galactic Center
- Spiral Arms
- Spiral Density Waves

Where the stars are

Stars are not distributed randomly in space; rather, they cluster in gargantuan assemblages. These are the galaxies, of which our Milky Way Galaxy is just one among more than nearly a hundred billion others.

Galaxies

A **Galaxy** is a gargantuan collection of stellar and interstellar matter containing stars, gas, dust, neutron stars, black holes all isolated in space and held together by its own gravity. The particular galaxy we happen to inhabit is known as the *Milky Way Galaxy*.

The Milky Way Galaxy

Our Sun lies in a part of the Galaxy known as the **Galactic Disk** an immense, circular, flattened region containing most of our Galaxy's luminous stars and interstellar matter

The Andromeda Galaxy

Our Galaxy, like this one, consists of a circular galactic disk of matter that fattens to a **Galactic Bulge** at the center. The disk and bulge are embedded in a roughly spherical ball of faint old stars known as the **Galactic Halo**.

The First Model of Our Galaxy

In the late eighteenth century, before the distances to any stars were known, the astronomer William Herschel tried to estimate the size and shape of our Galaxy simply by counting how many stars he could see in different directions in the sky.

By assuming the stars were of equal brightness, he concluded that the Galaxy was a somewhat flattened, disk-shaped collection of stars lying in the plane of the Milky Way, with the Sun at its center.

Galactic Center

Most globular clusters reside at great distances—many thousands of parsecs from the Sun. globular clusters map out a truly gigantic, and spherical, volume of space, However, the center of the distribution lies nowhere near our Sun. It is located nearly 8 kpc away from us, in the direction of the constellation Sagittarius

The hub of this collection of matter is the **Galactic Center**. We live in the suburbs of this ensemble, in the Galactic that cuts through the center of the halo.

The Galactic Disk

Based on observations of stars, gas, and dust found within a thousand or so parsecs of the Sun, astronomers estimate that the disk in the vicinity of the Sun is relatively thin "only" 300 pc thick, or about 1/100 of the galactic diameter.

Milky Galaxy’s Central Bulge

The Milky Galaxy’s central bulge is obscuration by interstellar dust makes it difficult to study it’s detailed structure in optical images.

Detailed measurements of the motion of gas and stars in and near the bulge imply that it is football shaped, about half as wide as it is long, with the long axis of the football lying in the galactic plane.

Differences

Aside from their shapes, the three components of the Galaxy (disk, bulge, and halo) have several other properties that distinguish them from one another.

The Halo

The halo contains almost no gas or dust just the opposite of the disk and bulge both in which interstellar matter is common.

All the stars in the Galactic halo are old. The absence of dust and gas in the halo means that no new stars are forming there, and star formation apparently ceased long ago at least 10 billion years in the past, judging from the types of halo stars we now observe

Galactic Bulge

Stars in the Galactic bulge and halo are found to be distinctly redder than stars found in the disk.

The gas density is very high in the inner part of the Galactic bulge, making this region the site of vigorous ongoing star formation, and both very old and very young stars mingle there. The bulge's gas-poor outer regions have properties more similar to those of the halo.

The Galactic Disk

All the bright, blue stars visible in our sky are part of the Galactic disk, as are the young, open star clusters and star-forming regions.

Astronomers often refer to young disk stars as **Population I** stars and to old halo stars as **Population II** stars.

Galactic Motion

As we look around the Galactic disk in different directions, a clear pattern of motion emerges.

Careful study of the data leads to the conclusion that the entire Galactic disk is rotating about the Galactic center.

Differential Rotation

At the Sun's distance of 8 kilopc from the Galactic center, material takes about 225 million years (an interval of time sometimes called **1 Galactic year**) to complete one circuit.

At other distances from the center the rotation period is different (shorter closer to the center, longer at greater distances) that is, the Galactic disk rotates not as a solid object but differentially.

The Disk and Bulge Motion

The old globular clusters in the halo and the faint, reddish individual stars in both the halo and the bulge do not share the disk's well-defined rotation. Their orbital orientations are largely random meaning they move in all directions with their paths filling an entire three-dimensional volume rather than a nearly two-dimensional disk.

The Birth of the Milky Way

The current theory for our Galaxy's evolution, starts from a contracting cloud of pregalactic gas.

When the first galactic stars and globular clusters formed, the gas in our Galaxy had not yet accumulated into a thin disk. Instead, it was spread out over an irregular, and quite extended, region of space.

Mergers

Many astronomers believe that the very first stars formed even earlier, in smaller systems that later merged to create our Galaxy. Probably many more stars were born during the mergers themselves, as interstellar gas clouds collided and began to collapse.

Spin and Flatten

Since those early times, rotation has flattened the gas in our Galaxy into a relatively thin disk. Physically, this process is similar to the flattening of the solar nebula during the formation of the solar system, except on a vastly larger scale.

Halo Motion

The chaotic orbits of the halo stars are also explained by this theory. When the halo developed, the irregularly shaped Galaxy was rotating only very slowly, so there was no strongly preferred direction in which matter tended to move. As a result, halo stars were free to travel along nearly any path once they formed.

Spiral Arms

Radio studies provide the best direct evidence that we live in a spiral galaxy. From far above the disk we could see our Galaxy's **Spiral Arms**, pinwheel-like structures originating close to the Galactic bulge and extending outward throughout much of the Galactic disk.

Where The Stars are Born

The spiral arms in our Galaxy are made up of much more than just interstellar gas and dust they also contain young stellar and prestellar objects, emission nebulae, O- and B-type stars. The spiral arms are the part of the Galactic disk where star formation takes place.

All Wound Up

A central problem facing astronomers trying to understand spiral structure is how that structure persists over long periods of time. We know that the inner parts of the Galactic disk rotate more rapidly than do the outer regions. This differential rotation makes it impossible for any large-scale structure "tied" to the disk material to survive.

Spiral Density Waves

Then how do the Galaxy's spiral arms retain their structure over long periods of time in spite of differential rotation? A leading explanation for the existence of spiral arms holds that they are **Spiral Density Waves** coiled waves of gas compression that move through the Galactic disk, squeezing clouds of interstellar gas and triggering the process of star formation as they go.

Dust in Stars out

The slowly moving spiral density wave is outrun by the faster-moving disk material. As gas enters the arm from behind, the gas is compressed and forms stars. Dust lanes mark the regions of highest-density gas.

The most prominent stars—the bright O- and B-type blue giants—live for only a short time, so young stellar associations, emission nebulae, and open clusters with long main sequences are found only within the arms, near their birth sites, just ahead of the dust lanes.

Self-Propagating Star Formation

An alternative possibility is that the formation of stars drives the waves, instead of the other way around. However, this process, sometimes known as **Self-Propagating Star Formation**, can produce only pieces of spirals, as are seen in some galaxies.

How is The Mass Distributed

If all of the mass of the Galaxy were contained within the edge of the visible structure, Newton's laws of motion predicts that the orbital speed of stars and gas beyond 15 kpc would decrease with increasing distance from the Galactic center. Far from falling off at larger distances, the rotaional speed rises slightly. This implies that the amount of mass in our galaxy continues to grow beyond the visible part of the galaxy