Almost everything we see in the night sky belongs to the Milky Way. We see most of the Milky Way as a faint band of light across the sky.

From outside, our Milky Way might very much look like our cosmic neighbor, the Andromeda Galaxy.

First attempt to unveil the structure of the galaxy by William Herschel (1785), based on optical observations.

The structure of our Milky Way is hard to determine because:
1) We are inside.
2) Distance measurements are difficult.
3) Our view towards the center is obscured by gas and dust.
Measuring Distances: The Cepheid Method

- The more luminous a Cepheid variable, the longer its pulsation period.
- Observing the period yields a measure of its luminosity and thus its distance!
- Cepheids allow us to measure the distances to star clusters throughout the Milky Way.

Exploring the Galaxy Using Clusters of Stars

Two types of clusters of stars:
1) Open clusters = young clusters of recently formed stars, within the disk of the Galaxy
2) Globular clusters = old, centrally concentrated clusters of stars; mostly in a halo around the galaxy

Globular Clusters

- Dense clusters of 50,000 – a million stars
- Old (~ 11 billion years), lower-main-sequence stars
- Approx. 200 globular clusters in our Milky Way

Locating the Center of the Milky Way

Distribution of globular clusters is not centered on the sun, but on a location which is heavily obscured from direct (visual) observation.
The Structure of the Milky Way

- Disk
- Nuclear Bulge
- Sun
- Halo
- Open Clusters, O/B Associations
- Globular Clusters

75,000 light years

Stellar Populations

<table>
<thead>
<tr>
<th>Population</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population I</td>
<td>Young stars</td>
<td>Metal rich; located in spiral arms and disk</td>
</tr>
<tr>
<td>Population II</td>
<td>Old stars</td>
<td>Metal poor; located in the halo (globular clusters) and nuclear bulge</td>
</tr>
</tbody>
</table>

The Formation of the Milky Way

Similar process as formation of solar system

Modifications of the Traditional Theory

Recently discovered ring of stars around the Milky Way may be the remnant of a merger.
Infrared View of the Milky Way

Interstellar dust (absorbing optical light) emits mostly infrared.

Near-infrared image

Interstellar dust emits infrared light which is not strongly absorbed, providing a clear view throughout the Milky Way.

Far-infrared image

The Mass of the Milky Way

If all mass was concentrated in the center, the rotation curve would follow a modified version of Kepler's 3rd law.

Rotation Curve = orbital velocity as function of radius.

The Mass of the Milky Way (II)

Total mass in the disk of the Milky Way:
Approx. 200 billion solar masses

Additional mass in an extended halo:
Total: Approx. 1 trillion solar masses

Most (>80%) of the mass is not emitting any radiation:
dark matter!

One of Vera Rubin's important contributions to astrophysics was the collection of conclusive data pointing to the presence of dark matter in galaxies. These data are measurements of the orbital velocities of interstellar matter in galaxies. She studied the variation of these velocities with distance from the center of the galaxy.

It is assumed that matter orbits around the center of a galaxy owing to a centripetal force which is the gravitational attraction of other matter in the galaxy. Assuming all other matter in the galaxy is luminous, astrophysicists cannot account for the centripetal accelerations observed. These can be accounted for, however, if additional matter is present.

Consequently, Rubin's measurements were of fundamental importance as empirical evidence for dark matter. 

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