UTPA
THE UNIVERSITY OF TEXAS-PAN AMERICAN
Department of Physics and Geology

Astronomy 1402

Laboratory: Milky Way

Equipment Needed	Quantity	Equipment Needed	Quantity
Milky Way galaxy Model	1	Ruler	1

Part 1: Background – Milky Way

1.1 Our Milky Way

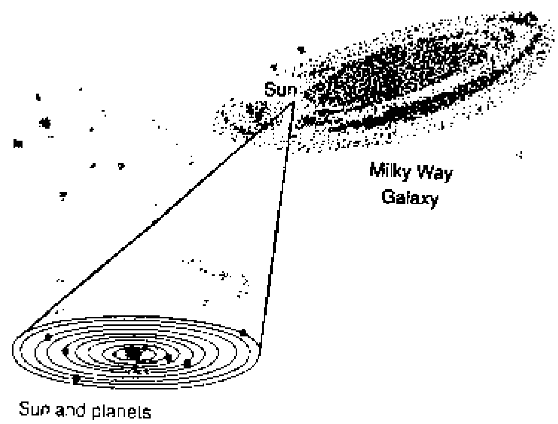

Figure 1.1: Schematic Representation of our Milky Way and of the position of our Solar System within the Milky Way.

A **galaxy** is an enormous group of millions or billions of stars and gas and dust held together by the force of gravity. We live in the **Milky Way Galaxy**, which includes over 200 billion stars plus interstellar gas and dust. Our **Sun** and the solar system are located in one of the great spiral arms of the **Milky Way Galaxy** (see **Figure 1.1**). We cannot photograph our own **galaxy** from the outside, since we are bound to the **Sun**, which is inside the **Milky Way Galaxy**. To figure out what our **galaxy** looks like, we use photographs of distant **galaxies** to help us visualize what our **galaxy** must look like from space.

Our **Milky Way Galaxy** belongs to a typical small **cluster of galaxies** known as the **Local Group**, with about 30 members. By "Local" we mean that the galaxies are within a region 3 million light-years across. Three of these galaxies: 1) our **Milky Way**, 2) Andromeda (M31), and 3) Triangulum (M33) – are **spiral galaxies**. The others are **elliptical galaxies** or **irregular galaxies**.

Spiral galaxies, like our **Milky Way**, have a large amount of gas and dust in a **disk** orbiting the galactic center. Within the **disk** there are brighter extended regions or "**spiral arms**". Fainter stars are also found above and below the **disk** in the spherical region called "**halo**". The oldest stars in our **galaxy** appear to be about 13 billion years old. Today we believe that the universe is full of **galaxies**, perhaps 100 billion of them, having, typically, over 100 billion stars each.

1.2 Classification of Galaxies

Galaxies come in different shapes and sizes. Edwin Hubble first classified them into groups according to their structure, as follows (see **Figure 1.2**):

- **Elliptical galaxies** (**E**) – are egg shaped. They can range from nearly perfect spheres, **E0**, to the flattest, **E7**. Elliptical galaxies tend to contain practically all old stars.
- **Lenticular galaxies (S0)** they present a **disk**, but they appear to lack spiral arms.
- **Spiral galaxies** have large amounts of gas and dust in the **disk**, present spiral arms, and contain young, middle-aged, and old stars. **Spiral galaxies** are divided into two major subcategories.
  - **Ordinary Spiral galaxies** (**S**) - have a bright **disk** where spiral arms wind out from a bulging nucleus. They are further subdivided into **Sa**, **Sb**, and **Sc**, according to the size of the central bulge and how tightly wound the spiral arms are. "**Sa**" **Spiral galaxies** have a larger central bulge and their spiral arms are less winded, "**Sc**" **Spiral galaxies** have a smaller central bulge and their spiral arms are more winded.
  - **Barred Spiral galaxies** (**SB**) – look like **Ordinary spiral galaxies** except that the spiral arms unwind from the ends of a bar-shaped concentration of material.
- **Irregular galaxies** (**Irr**) - have no regular geometric shape. They usually contain gas and dust, mostly bright young stars and clouds of ionized gas, and some old stars.

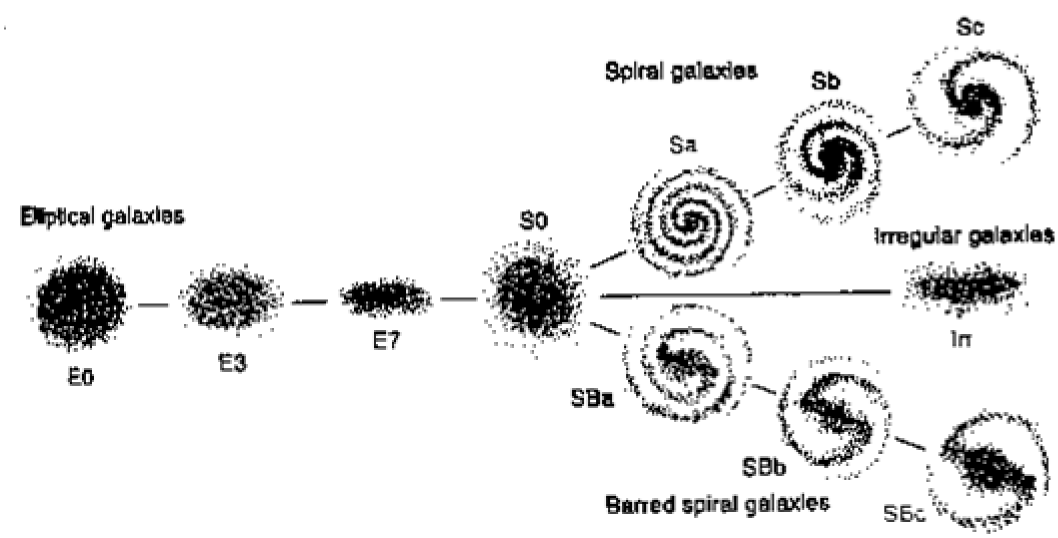

Figure 1.2 "Tuning Fork" Diagram illustrating Hubble's Galaxy Classes

1.3 Galactic Coordinates

Stars can be located in the sky by their **Celestial Coordinates:** that is, by their **Right Ascension** (**RA**) and **Declination** (**Dec**). As we saw in ASTR 1401, these are the equivalent of longitude and latitude on the **Celestial Sphere**. The **Celestial Coordinates** are a convenient system. However, to study our **galaxy,** it is useful to define a set of **Galactic Coordinates**.

The **Galactic Equator** is defined as the circle on the sky that follows the center of the path of stars we call the **Milky Way**. This hazy strip of light is in fact the **disk** of our **galaxy** (see **Figure 1.1**), and the **Galactic Equator** represents the plane of the **disk** (just as the **ecliptic** represents the plane of our **solar system**). **Galactic Longitude**, "***l***", is measured along the **Galactic Equator** from the direction toward the **Galactic Center** and ranges from 0^o to 360^o (see **Figure 3.2**). The constellation of Sagittarius is near 0^o **Galactic Longitude**, Cygnus is near 90^o, Orion is near 180^o, and Vela is near 270^o. **Galactic Latitude**, "***b***", is measured in degrees above or below the galactic equator (see **Figure 3.2**). A star on the galactic equator has $b = 0^o$. A star above the **Galactic Equator** has a positive ***b*** and a star below the **Galactic Equator** has a negative ***b***. Polaris, for example, has a positive **Galactic Latitude**.

By giving the **Galactic Longitude** and **Latitude** of a star, we give its direction in the sky with respect to our **galaxy** (as seen from Earth). If ***l*** and ***b*** are both zero for a star, then the star is located in the direction toward the center of the galaxy. If $l = 180^o$ and $b = 0^o$, then the star is located in the plane of our **galaxy** but in the direction directly away from the center. Note that a **Galactic Latitude** near 0^o means that we are looking along the **Galactic Disk** (from inside the **Galactic Disk**, since our Sun is in the **Galactic Disk**).

Also, note that **Galactic Coordinates** are Earth-centered (just as the **Celestial Coordinates**). That is, the **galactic coordinates** allow us to identify a position in the sky by taking as reference how our **Milky Way** appears in the sky.

Figure 1.3 is a sketch of what our **galaxy** (the **Milky Way**) might look like as seen from another **galaxy**. The spiral arms are shown wrapped around the nucleus at the center. See also the model of the **Milky Way Galaxy** provided. From the position of the Sun it is not possible to see stars in all of the spiral arms because of the interstellar dust that obscures the view (see **Figure 1.1**).

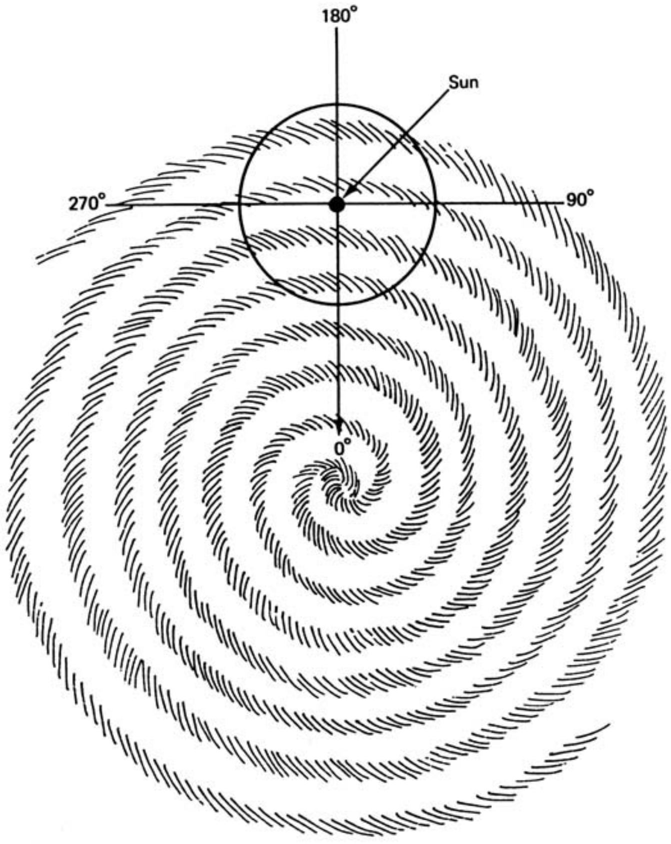

Figure 1.3 Galactic Longitude (Note that the Galactic Longitude is actually Earth-centered).

1.4 Measuring Cosmic Distances

To learn more about galaxies than their shape and color, their distance must be known. This is a challenging task, but distance to galaxies can be measured to an accuracy of within ~ 20%. A useful formula for this is the luminosity–distance formula:

$$\text{Apparent Brightness} = \frac{\text{Luminosity}}{4 \pi r^2}$$

SAFETY REMINDER

- Follow the directions for using the equipment.

THINK SAFETY
ACT SAFELY
BE SAFE!

Part 2: Lab Activity – Milky Way

The purpose of this laboratory activity is to study the structure of our galaxy and to examine the spiral arm near the **Sun**.

2.1 Galaxies and Galaxy Classification

Answer the questions on galaxies and galaxy classification in the **section 3.1**.

2.2 Galactic Coordinates

A. Milky Way Galaxy Model

Using the **Milky Way Galaxy** Model, determine the Galactic Longitude (within 15 degrees) of the astronomical objects listed in **Table 3.1**, and use the results to complete **Table 3.1**.

Note: you may find a ruler useful for estimating the Galactic Longitude with the **Milky Way Galaxy** Model.

B. "O" stars in the Milky Way

Table 2.1 gives the **Galactic Longitude** and **Galactic Latitude** of a number of groups of stars of spectral type O. Plot the positions of these stars on **Figure 3.1**

Galactic Longitude (degrees) *l*	Galactic Latitude (degrees) *b*	Distance (kpc)
1	-2	3.0
7	-3	1.3
13	-2	2.3
14	-1	1.7
19	0	2.0
61	-1	1.8
73	1	2.3
77	0	1.5
78	0	2.0
81	0	1.5
84	-8	1.0
98	-18	0.5
99	5	0.7
104	-2	3.6
110	3	1.0
116	0	2.5
124	2	2.5
135	-3	2.3
137	2	2.1
147	1	0.9
161	-15	0.4
174	0	1.2
174	0	3.8
190	3	1.5
207	-18	0.5
209	0	1.4
286	0	3.3
288	0	1.9
295	-1	2.8
305	5	2.2
344	0	1.4
351	17	0.2
358	-20	3.1

Table 2.1

C. Long-period variable stars (mostly cool giant stars) in the Milky Way

Table 2.2 contains long-period variable stars (variable stars with periods of months or years), within which the majority are cool giant stars. Plot the position of these stars on **Figure 3.2.**

Longitude (degrees) *l*	Latitude (degrees) *b*
113	-13
310	-10
56	-9
158	-37
21	60
144	19
107	71
215	11
282	-3
298	13
77	-80
322	0
326	81
61	52
269	37
91	-5
272	-39
60	-26
124	-55
355	-62
74	48
259	38

Table 2.2

D. Spiral Arms

Plot all the stars in **Table 2.1** on **Figure 3.3** using **Galactic Longitudes** and distances in kilo-parsecs. Notice that these groups of young stars are all located in **spiral arms**. In fact we could use these kinds of objects to trace the spiral pattern. Such objects associated with **spiral arms** are called **spiral tracers**.

2.3 General Questions on the Milky Way

Answer the general questions on the **Milky Way** in **section 3.3**

2.4 Luminosity Distance Formula

Solve the problems in **section 3.4** by using the luminosity distance formula (see **section 1.4**).

Record your results in Part 3 - Lab Report.