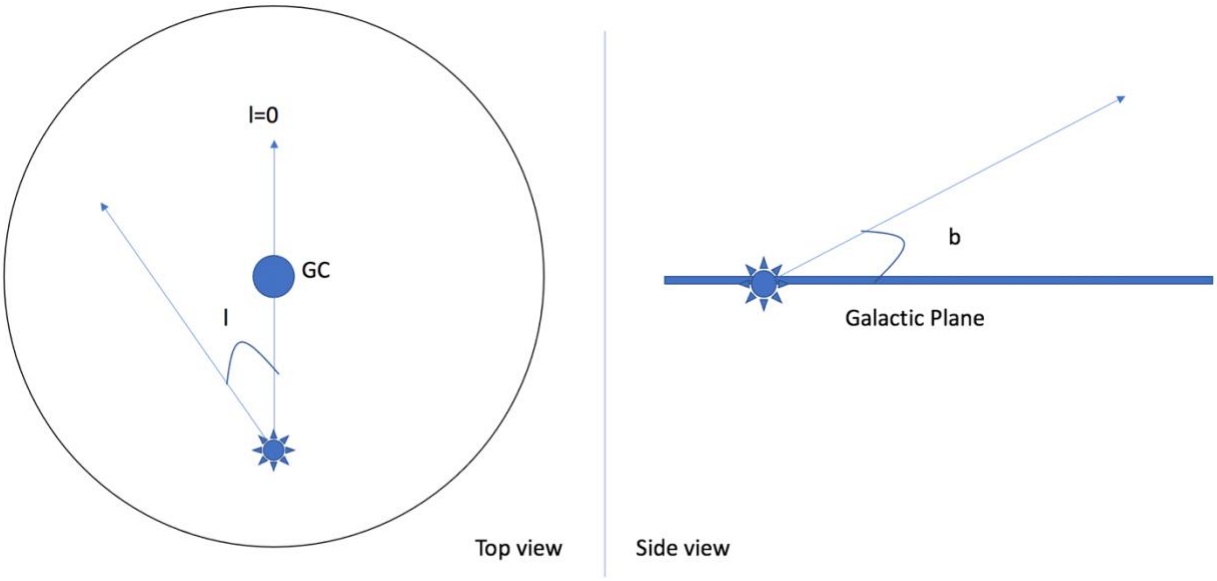
# Mapping the Local Milky Way:

**Background:**

There are a number of coordinate systems we can use to describe the Galaxy. From an observational standpoint, it makes sense to use heliocentric coordinates, as that is where we've made our observations after all! That is, a star's position in space is determined by the ordered triple (d, l, b), where d is the distance to the star as measured from the Sun, l is the longitude, and b is the latitude.

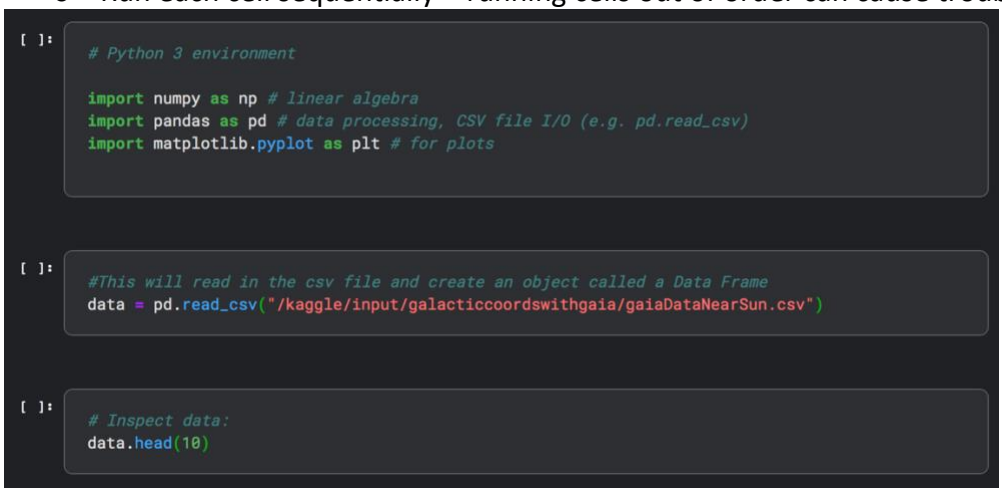



A more natural choice of origin, though, is the Galactic Center (GC). Galactocentric Rectangular Coordinates (X, Y, Z) can be determined via some trigonometry. We'll derive these in today's lab.

**Skills:**

First, we'll need to learn a few new things about python syntax and Kaggle:

- We'll be writing python programs in Kaggle notebooks.
  - Each little block of code is called a cell.
  - Run each cell sequentially – running cells out of order can cause trouble



```
[ ]:
# Python 3 environment

import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import matplotlib.pyplot as plt # for plots

[ ]:
#This will read in the csv file and create an object called a Data Frame
data = pd.read_csv("/kaggle/input/galacticcoordswithgaia/gaiaDataNearSun.csv")

[ ]:
# Inspect data:
data.head(10)
```

- We'll make use of various libraries, which contain useful tools we can use:

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import matplotlib.pyplot as plt # for plots
```

- The pandas library is particularly useful, as it excels in data science contexts.
- To read in data from a file and create a "Data Frame", use the following:

```
#This will read in the csv file and create an object called a Data Frame
data = pd.read_csv("/kaggle/input/galacticcoordswithgaia/gaiaDataNearSun.csv")
```

- To see the first 5 entries in a Data Frame with three columns (a, b, and c), use the .head() method:

```
[12]:
df.head()
```

[12…

| | a | b | c |
|---|---|---|---|
| 0 | 1 | 10 | 1 |
| 1 | 2 | 20 | 4 |
| 2 | 3 | 30 | 9 |
| 3 | 4 | 40 | 16 |
| 4 | 5 | 50 | 25 |

- To access a particular column (in this case the column named c) in a Data Frame, you can code the following:

```
[14]: df.c

[14… 0     1
     1     4
     2     9
     3    16
     4    25
     Name: c, dtype: int64
```

- You can do vector math with each column:

```
[15]: df.a + df.c

[15… 0     2
     1     6
     2    12
     3    20
     4    30
     dtype: int64
```

- You can also apply functions like np.sin() or np.cos() to a column. See the documentation here: https://numpy.org/doc/stable/reference/generated/numpy.sin.html

**Problems:**

1. Derive equations for the Galactocentric Y and Z coordinates in terms of distance, longitude, and latitude. X has already been done for you.

2. In Kaggle, go to the following notebook template that has been created for you: https://www.kaggle.com/code/austinhinkel/galacticcoordstemplate. Click the three dots at the top right and select copy and edit notebook.

3. Using the information above and following the directions in the notebook template, create a map of the Milky Way near the Sun.