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SC20B152
MSc ASTRONOMY & ASTROPHYSICS

Assignment 2

Question

Generate a Hammer-Aitoff map showing the distribution of bright stars (mostly O, and B) from the catalogue of Reed et al. (2003, 2005). The map should be in Galactic coordinates with Galactic longitude of 0 degree occupying the centre of the map.

The stellar data file is attached separately. You may use available standard routines to generate an Aitoff grid.

The location of the stars should be indicated by reasonably big, filled circles. Avoid making the data points too small to the point where it becomes difficult to see.

Plot in the same map the locations of the Large Magellanic Cloud, Small Magellanic Cloud, Andromeda Galaxy using slightly bigger filled ellipses of a different colour. You can get the coordinates of LMC and SMC, and Andromeda from NED (NASA Extragalactic Database) : https://ned.ipac.caltech.edu/

Also plot in that map the locations of all the other dwarf satellite galaxies identified as part of the Local Group of galaxies. The Milky Way and Andromeda are the two most massive, most luminous members of the Local Group. The coordinates of the Local Group galaxies can be found in McConnachie, A.W., 2012, AJ, 144, 4, and on Alan McConnachie's page: https://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/community/nearby/

The Local Group dwarf galaxies should be plotted using filled ellipses of a different colour. All external galaxies should be labelled in the plot. The plot should have a caption that explains what the plot is, and the symbols represent.

Plotting all this data in one map, might make it a bit cluttered, but that is OK. Try to make the plot as aesthetically pleasing as possible. Generating the plot in landscape mode would help. In a single PDF file, submit the (a) code (b) the map.

Additional Challenge: Try to plot the ecliptic on this map, as a moderately thick line. This may involve converting RA, Dec of the Sun for an entire year into Galactic coordinates. The conversion formula is in the lecture slides.

Answer

I will attach the code below for plotting the stellar data, galaxies and ecliptic below. This was performed on python by invoking different packages.

```
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.patches as patches
import numpy as np
from astropy.coordinates import SkyCoord
import astropy.units as u

# Extracting the necessary columns from the csv file which contains all the stellar data
data1 = pd.read_csv('obcat.csv', usecols=['GLONG', 'GLAT'])

# Extract Galactic longitude and latitude
galactic_longitude = data1['GLONG']
galactic_latitude = data1['GLAT']

# Galactic coordinates for Large Megallenic Cloud
galactic_longitude_LMC = -79.534697
galactic_lattitude_LMC  = -32.888347

# Galactic coordinates for Small Megallenic Cloud
galactic_longitude_SMC = -57.203087
galactic_lattitude_SMC = -44.299213

# Galactic coordinates for Andromeda Galaxy
galactic_longitude_Andromeda_Galaxy = 121.174405
galactic_lattitude_Andromeda_Galaxy = -21.572936

# local.csv contains the data for the local group of galaxies
data2 = pd.read_csv('local.csv', usecols=['l', 'b'])

# Galactic coordinates for local group of galaxies
galactic_longitude_local = data2['l']
galactic_latitude_local = data2['b']

# Correct for Galactic longitudes greater than 180 degrees
for i in range(len(galactic_longitude)):
    if galactic_longitude[i] > 180:
```

```
        galactic_longitude[i] -= 360

#plotting the Ecliptic now
ecliptic = SkyCoord(np. linspace(0, 360, 1000), np.zeros(1000), unit = u.deg, frame ='barycentricmeanecliptic')
galactic_ecliptic = ecliptic.galactic

galactic_longitude_sun = galactic_ecliptic.l.radian
galactic_lattitude_sun = galactic_ecliptic.b.radian

# Correcting for Galactic longitudes greater than pi radians for the ecliptic
for i in range(len(galactic_longitude_sun)):
    if galactic_longitude_sun[i] > np.pi:
        galactic_longitude_sun[i] -= 2 * np.pi

# Setting up the Aitoff projection
plt.figure(figsize=(12, 6))
plt.subplot(111, projection="aitoff")
ax = plt.gca()

# Plot the Galactic coordinates of the celestial objects as a scatter plot
plt.scatter(galactic_longitude * 0.0174533, galactic_latitude * 0.0174533,  s=0.7, color='blue', alpha=0.5, label =
'Bright stars (mostly O, and B)')
ax.add_patch(patches.Ellipse((galactic_longitude_LMC * 0.0174533, galactic_lattitude_LMC * 0.0174533),
width=0.1, height=0.09, angle=0, color='purple', alpha=0.8, label='Large Magellanic Cloud(LMC)'))
ax.add_patch(patches.Ellipse((galactic_longitude_SMC * 0.0174533, galactic_lattitude_SMC * 0.0174533),
width=0.07, height=0.07, angle=0, color='limegreen', alpha=1, label='Small Magellanic Cloud(SMC)'))
plt.scatter(galactic_longitude_local * 0.0174533, galactic_latitude_local * 0.0174533,  s=4, color='red', alpha=1,
label='Local Group of Galaxies')
ax.add_patch(patches.Ellipse((galactic_longitude_Andromeda_Galaxy * 0.0174533,
galactic_lattitude_Andromeda_Galaxy * 0.0174533), width=0.25, height=0.2, angle=0, color='aqua', alpha=0.8,
label='Andromeda Galaxy'))

for i in range(len(galactic_longitude_local)):
    ax.add_patch(patches.Ellipse((galactic_longitude_local[i] * 0.0174533, galactic_latitude_local[i] * 0.0174533),
width=0.06, height=0.02, angle=0, color='red', alpha=0.5))

plt.text(galactic_longitude_LMC * 0.0174533 + 0.17, galactic_lattitude_LMC * 0.0174533 , 'LMC', fontsize=9,
color='black', ha='center', va='center')
plt.text(galactic_longitude_SMC * 0.0174533 + 0.17, galactic_lattitude_SMC * 0.0174533, 'SMC', fontsize=9,
color='black', ha='center', va='center')
```

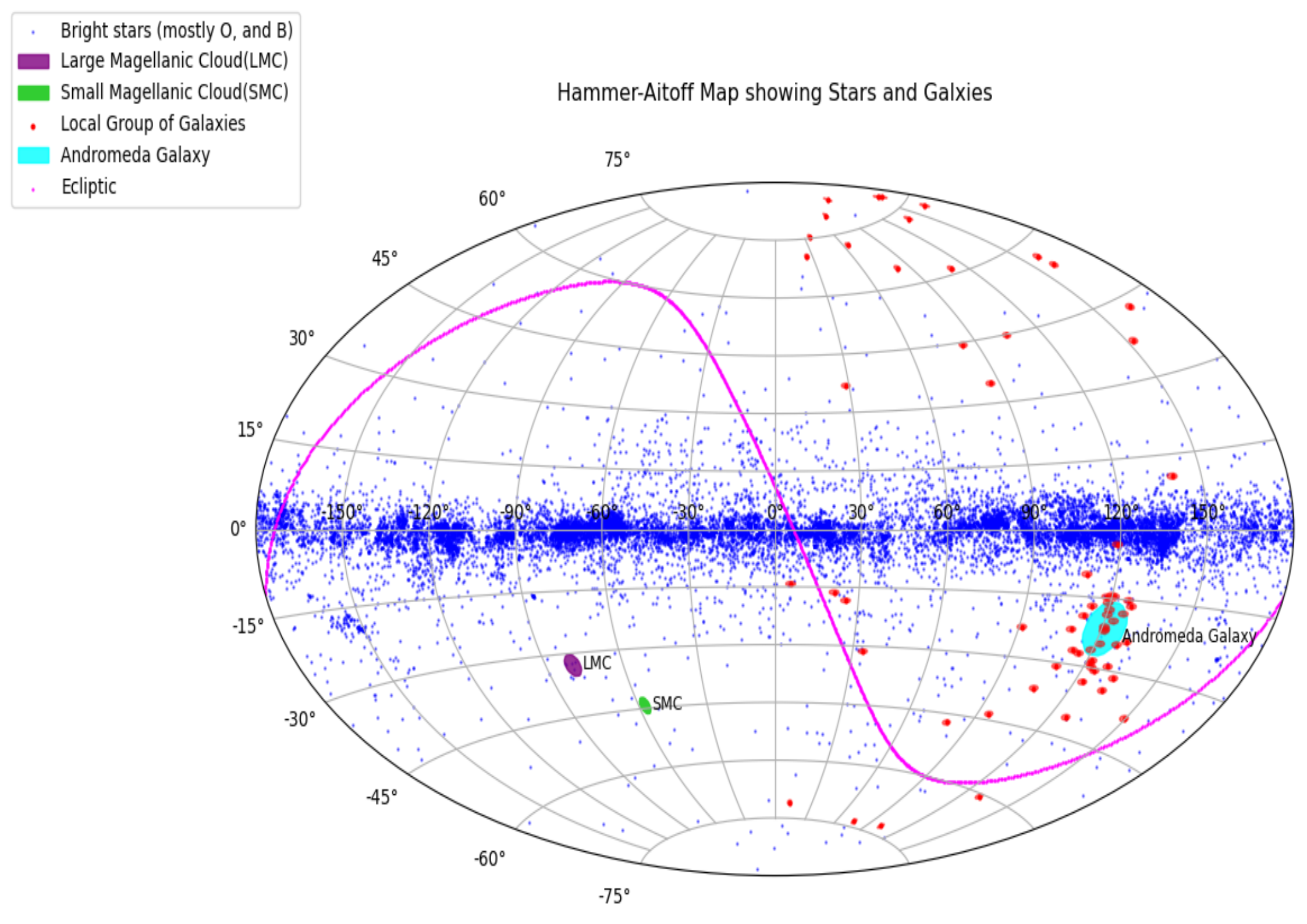
```
plt.text(galactic_longitude_Andromeda_Galaxy * 0.0174533+0.55, galactic_lattitude_Andromeda_Galaxy *
0.0174533 + 0.015, 'Andromeda Galaxy', fontsize=9, color='black', ha='center', va='center')

# Plot the ecliptic as a continuous line with adjusted thickness
plt.scatter(galactic_longitude_sun, galactic_lattitude_sun, color='magenta', alpha=1,s=0.5, label='Ecliptic')

# Customizing the plot
plt.title("Hammer-Aitoff Map showing Stars and Galxies", y=1.1)
plt.grid(True)
plt.legend(loc='lower right', bbox_to_anchor=(0.05, 0.95))

# Displaying the plot
plt.show()
```

The above code produced the following plot.


Bright stars (mostly O, and B)
Large Magellanic Cloud(LMC)
Small Magellanic Cloud(SMC)
Local Group of Galaxies
Andromeda Galaxy
Ecliptic
Hammer-Aitoff Map showing Stars and Galxies
75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
-150°
-120°
-90°
-60°
-30°
0°
30°
60°
90°
120°
150°
LMC
SMC
Andromeda Galaxy