Galaxies (Structure, Dynamics and Evolution) Programming Assignment - 3

Submitted by

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(a) Does the Galaxy have a morphological center?

Yes, the Galaxy has a morphological center. From the plot of the distribution of the globular clusters seen from the top view (Fig. 1 (b)), and edge on views (Fig. 1 (c) and (d)) it can be seen that the globular clusters are symmetrical around the point ~8kpc from the Sun. The red circle marked in all the plots shows the spherical symmetric distribution of globular cluster near the center of the Galaxy

(b) If it has, then are we at the center of the Galaxy, or displaced from this center?

We are not at the center because the globular clusters are not surrounding us, instead it is surrounding a point at 8 kpc from the Sun. Therefore we are displaced from the center.

(c) Is there any pattern to how globular cluster of different metallicities are distributed within the Galaxy?

Based on the metallicity of the globular clusters plotted as a color map in the edge on view (Fig. 1 (b) and (c)), it can be noted that dark blue colored dots (i.e. higher metallicity globular clusters) and light blue colored dots (i.e. lower metallicity globular clusters) can be found near galactic plane. Whereas at higher heights and far away from Galactic center we can only see lighter blue dots (i.e. metal poor clusters)
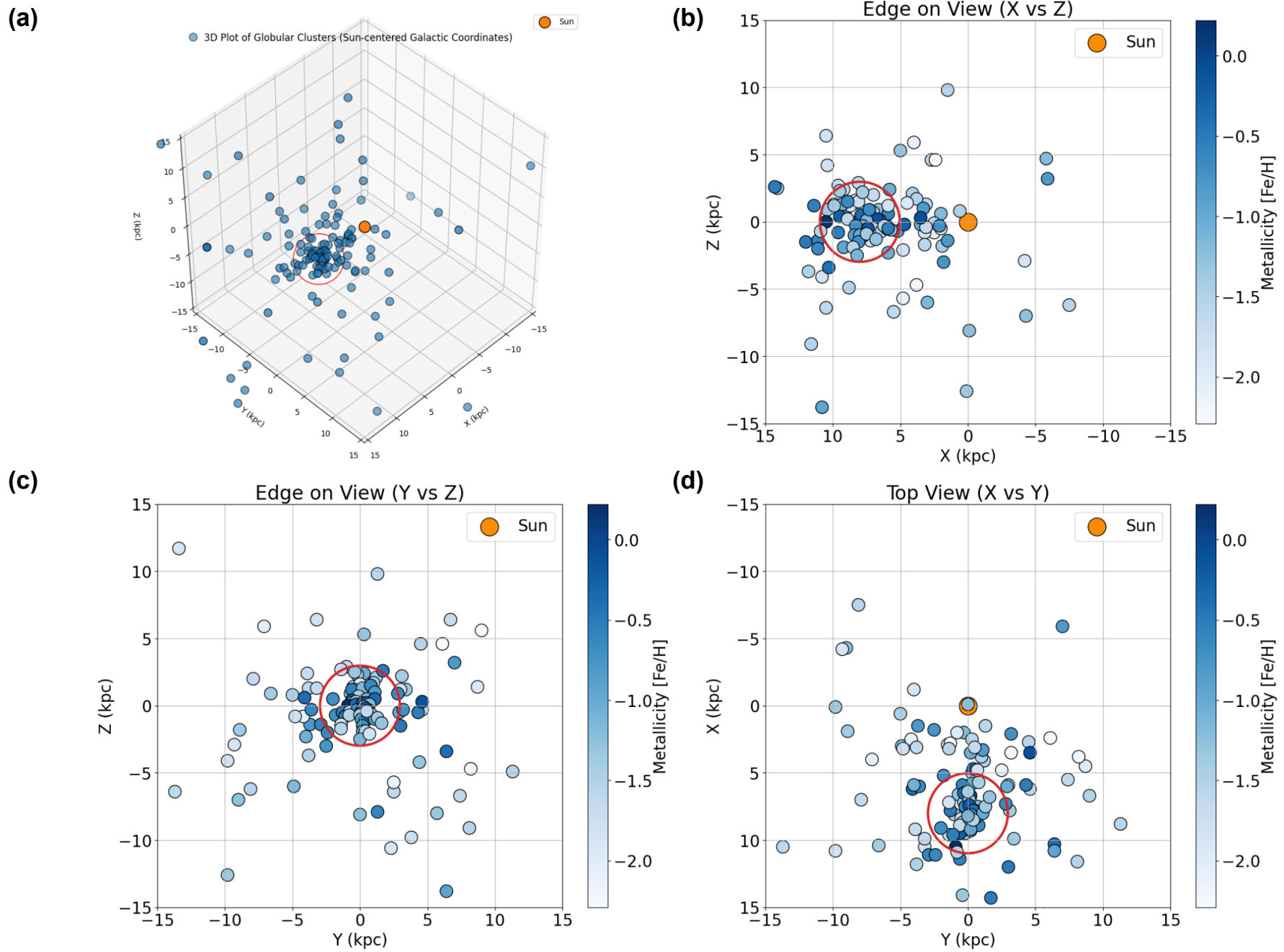
Fig. 1. (a) 3D Distribution of Globular Cluster, (b) and (c) Edge on Views, (d) Top View. X, Y, Z are the positions in the Sun-centered coordinate system; X points toward the Galactic center, Y in the direction of Galactic rotation, Z toward the North Galactic Pole. Metallicity with respect to the Sun is shown in the color map. Red circle is centered on Galactic center.

Program

```python
# Importing Necessary

import numpy as np
import math
import matplotlib.pyplot as plt
from astropy.io import ascii
from mpl_toolkits import mplot3d


# Reading data

data =
ascii.read("https://raw.githubusercontent.com/abrahammathews2000/Dataset_for_Gcol
ab/main/Gal_asg_3/globular_cluster_6Feb_v6.tsv",header_start = 0, data_start = 1,
delimiter = "|")


name = np.array(data["ID"])
X = np.array(data["X"])
Y = np.array(data["Y"])
Z = np.array(data["Z"])
metallicity = np.array(data["[Fe/H]"])


#Plotting the distribution of globular clusters in 2D

fig = plt.figure(figsize = (25,20))
plt.rcParams.update({'font.size': 20})

#plot 1:
plt.subplot(2, 2, 4)
#plt.scatter(0, 8, s = 10000, linewidths=3,facecolors='none', edgecolors='black')
plt.scatter(0,0,color = "darkorange",edgecolors='black',label="Sun",s=500)
plt.scatter(Y,X,c = metallicity,cmap = 'Blues',edgecolors='black',s=250)
cbar= plt.colorbar()
cbar.set_label("Metallicity [Fe/H]", labelpad=+1)

#plt.scatter(8,0, color = 'red', s = 300,label="Center of the Galaxy")
plt.xlim(-15,15)
plt.ylim(15,-15)
plt.xlabel("Y (kpc)")
plt.ylabel("X (kpc)")
plt.title("Top View (X vs Y)")
plt.grid()
plt.scatter(0, 8, s = 10000, linewidths=3,facecolors='none',
edgecolors='tab:red')
#plt.scatter(np.average(Y), np.average(X), s = 10000,
linewidths=3,facecolors='none', edgecolors='black')

plt.legend()

#plot 2:
plt.subplot(2, 2, 2)
```

```python
#plt.scatter(X,Z,c = normalMetallicity)
plt.scatter(0,0,color = "darkorange",edgecolors='black',label="Sun",s=500)
plt.scatter(X,Z,c = metallicity,cmap = 'Blues',edgecolors='black',s=250)

cbar= plt.colorbar()
cbar.set_label("Metallicity [Fe/H]", labelpad=+1)

#plt.scatter(8,0, color = 'red', s = 300,label="Center of the Galaxy")

plt.xlabel("X (kpc)")
plt.ylabel("Z (kpc)")
plt.xlim(15,-15)
plt.ylim(-15,15)
plt.title("Edge on View (X vs Z)")
plt.scatter(8, 0, s = 10000, linewidths=3,facecolors='none',
edgecolors='tab:red')
plt.grid()
plt.legend()

#plot 3:
plt.subplot(2, 2, 3)
#plt.scatter(X,Z,c = normalMetallicity)
plt.scatter(0,0,color = "darkorange",edgecolors='black',label="Sun",s=500)
plt.scatter(Y,Z,c = metallicity,cmap = 'Blues',edgecolors='black',s=250)
cbar= plt.colorbar()
cbar.set_label("Metallicity [Fe/H]", labelpad=+1)

#plt.scatter(8,0, color = 'red', s = 300,label="Center of the Galaxy")

plt.xlabel("Y (kpc)")
plt.ylabel("Z (kpc)")
plt.xlim(-15,15)
plt.ylim(-15,15)
plt.title("Edge on View (Y vs Z)")
plt.grid()
plt.scatter(0, 0, s = 10000, linewidths=3,facecolors='none',
edgecolors='tab:red')

plt.legend()
plt.show()

#Plotting the distribution of globular clusters in 3D

fig = plt.figure(figsize = (10, 10))

plt.style.use('default')
ax = plt.axes(projection='3d')
ax.grid()

ax.scatter(0, 0,0, c = 'tab:orange', edgecolors='black',s = 200,label="Sun")
ax.scatter(X, Y, Z, c = "tab:blue",edgecolors='black', s = 100)
#ax.scatter(8, 0,0, c = 'tab:orange', s = 200,label="Center of the Galaxy")
```

```python
#cbar.set_label("Metallicity [Fe/H]", labelpad=+1)
ax.scatter(8, 0,0, c = 'white', edgecolors='red',s = 4000)

ax.set_title('3D Plot of Globular Clusters (Sun-centered Galactic Coordinates)')

# Set axes label
ax.set_xlabel('X (kpc)', labelpad=20)
ax.set_ylabel('Y (kpc)', labelpad=20)
ax.set_zlabel('Z (kpc)', labelpad=20)
plt.legend()
plt.xlim(-15,15)
plt.ylim(-15,15)
ax.set_zlim(-15,15)
ax.view_init(45,45)
plt.rcParams.update({'font.size': 15})
plt.show()
```