Department of Physics and Astronomy
University of British Columbia

Astronomy 205
Assignment 1: Due January 21 2019 before class in ASTR205 Box outside Henn 312
Gaia, The Celestial Sphere and the Colour Magnitude Diagram

Download the data files from the course website: gaia_all.npy and near.npy. Both contain Right Ascension (**α**) and Declination (**δ**) (both in degrees), as well as the parallax and parallax error (both in milliarcseconds), apparent g (Gaia) magnitudes, and colours (b – r). In this assignment we will be exploring coordinates on the celestial sphere, the visibility of stars, and the Colour-Magnitude Diagram of the nearby stars.

1. Open the data from the gaia_all.npy file, which contains the 200,000 brightest stars in the Gaia catalog. This data is not perfectly complete, as Gaia has difficulty providing precise astrometry and photometry for the brightest stars, however it far surpasses any other currently existing data, especially at fainter magnitudes.

(a) Plot the **α** vs **δ** data. What features do you notice in the data? What might cause the features you see? Make sure your plots are properly labelled. You can make a simple **α** vs **δ** plot on square axes, or more interestingly you can make a commonly used Mollweide Projection. The following code snippet uses astropy modules to generate one from the **α** vs **δ** arrays. The standard matplotlib Mollweide projection only plots objects with a longitudinal angle between -pi and pi, so this code wraps objects with right ascensions from 180-360 degrees onto the left hand side of the plot.

```
import numpy as np
import matplotlib.pyplot as plt
import astropy.coordinates as coord
import astropy.units as u
ra, dc = coord.Angle(ra*u.deg), coord.Angle(dc*u.deg)
ra = ra.wrap_at(180.*u.degree)
fig = plt.figure(num=1, figsize=(10, 5))
ax = fig.add_subplot(111, projection='mollweide')
ax.scatter(raa.radian, dca.radian, s=0.01, marker='.', color='red')
ax.set_xticklabels(['14h', '16h', '18h', '20h', '22h', '0h', '2h', '4h', '6h', '8h', '10h'])
```

Note: Be careful in copying/pasting the ‘ ’ symbols into your coding environment. Sometimes they don't come through properly.

(b) The unaided human eye can detect objects to a faintness of about V = 6. Plot only the stars that are visible to the naked eye. How many visible stars are there in this data set? Do you have any comments? Plot these brighter stars overtop of the full data set in a different colour and/or marker type.

(c) Which of the visible stars are circumpolar when viewed from Vancouver (latitude=49°)? Plot them over top of the full data set. How many circumpolar stars are visible to the unaided eye from Vancouver?

2. The near.npy file contain all the stars within 100 pc (there are about 592,000 of these). Select out all the stars that are within 50 pc of the Sun. This group of stars should have good Gaia parallaxes.

(a) How many stars are less than 50 pc from the sun?

(b) Plot the Colour-Magnitude Diagram (CMD) in G (this is now the absolute magnitude) vs (b – r) for these stars.

(c) What obvious groupings of stars do you see in this diagram? Indicate them directly on your CMD plot. Can you describe what each group corresponds to?