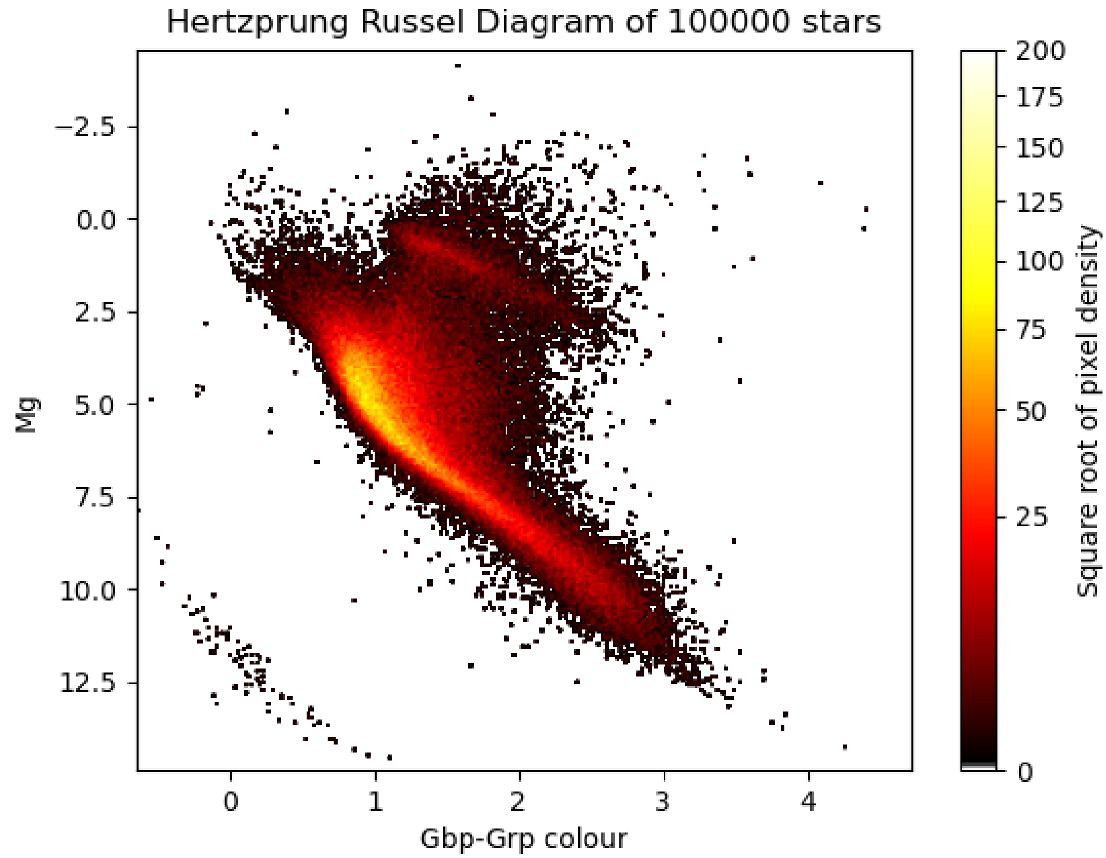

Explanation:

Fig. 1 Graph of Gaia (Gbp-Grp) color vs Gaia G magnitude, as described in (Babusiaux, et al). Star data taken from Gaia DR2 with the specifications from appendix B of (Babusiaux, et al). Color scale is the square root of the number density of stars. The dense, snaking portion of the diagram is the main sequence. Bright and bluer in the bottom left corner are white dwarfs. A smaller number of giant stars are visible in the top and top right, trending red and dim. This diagram was created with data with the specifications from appendix B of (Babusiaux, et al), it might differ from figure 5 of that paper because of the scattering of light by the dust and gas, also known as extinction. Large amounts of dust between the Earth and distant stars distorts the light, leading to dimmer and redder signatures (Babusiaux, et al). The stars trend redder because blue light is absorbed and scattered more by interstellar dust.

Code for Fig. 1

```
import csv
import math
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from scipy.stats import gaussian_kde
```

```
DR2 = pd.read_csv('100k Stars, DR2.csv',sep = ',', names = ['mg','bp_rp'],header = 0)
```

```
import mpl_scatter_density
from matplotlib.colors import LinearSegmentedColormap
```

```
#Plot 100k stars from Gaia DR2
from astropy.visualization import SqrtStretch
from astropy.visualization.mpl_normalize import ImageNormalize
norm = ImageNormalize(vmin=0., vmax=200, stretch=SqrtStretch())
fig = plt.figure()

colormap = LinearSegmentedColormap.from_list('white_viridis', [
    (0, 'white'),
    (0.01, 'black'),
    (0.33, 'red'),
    (0.66, 'yellow'),
    (1, 'white'),
], N=256)

ax = fig.add_subplot(1, 1, 1, projection='scatter_density')
scatter = ax.scatter_density(DR2['bp_rp'], DR2['mg'],norm = norm,cmap=colormap)
plt.xlabel('Gbp-Grp colour')
plt.ylabel('Mg')
ax = plt.gca()
ax.invert_yaxis()
plt.title('HR Diagram, Gaia-DR2')
fig.colorbar(scatter,label = 'Square root of pixel density')
fig.savefig('Gaia DR-2, HR Diagram.png')
```

Attempt at Optional 1:

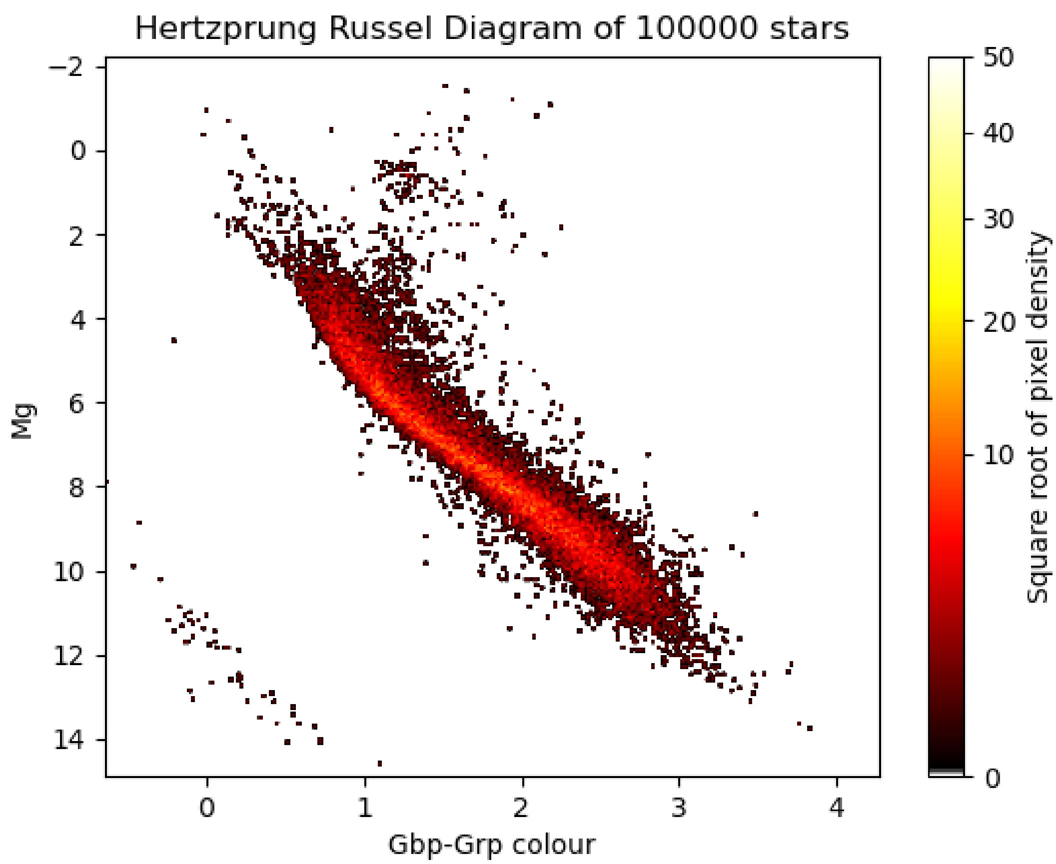

Fig. 2 This plot shows Gaia DR 2 star data with the same filters as Fig. 1 with distance to star < 700 pc. If the distortions in the magnitude and color are caused by interposing gasses, choosing closer stars should reduce the possible amount of gas, (Babusiaux, et al) justified this for stars within ~60 pc. (I attempted to use the reddening maps, but never quite got them working)

Code for Fig. 2

```
#Plot Nearby Stars, aim to reduce redenning
norm = ImageNormalize(vmin=0., vmax=50, stretch=SqrtStretch())
fig = plt.figure()

colormap = LinearSegmentedColormap.from_list('white_viridis', [
    (0, 'white'),
    (0.01, 'black'),
    (0.33, 'red'),
    (0.66, 'yellow'),
    (1, 'white'),
], N=256)

ax = fig.add_subplot(1, 1, 1, projection='scatter_density')
scatter = ax.scatter_density(Data3[(abs(Data3['d']) < 700)&(abs(Data3['b']>0))]['bp_rp'],
                             Data3[(abs(Data3['d']) < 700)&(abs(Data3['b']>0))]['mg'],norm = norm,cmap=colormap)
plt.xlabel('Gbp-Grp colour')
plt.ylabel('Mg')
ax = plt.gca()
ax.invert_yaxis()

plt.title('Hertzprung Russel Diagram of 100000 stars')
fig.colorbar(scatter,label = 'Square root of pixel density')
fig.savefig('Gaia DR-2, distance 700 pc.png')
```

Attempt at Optional 2:

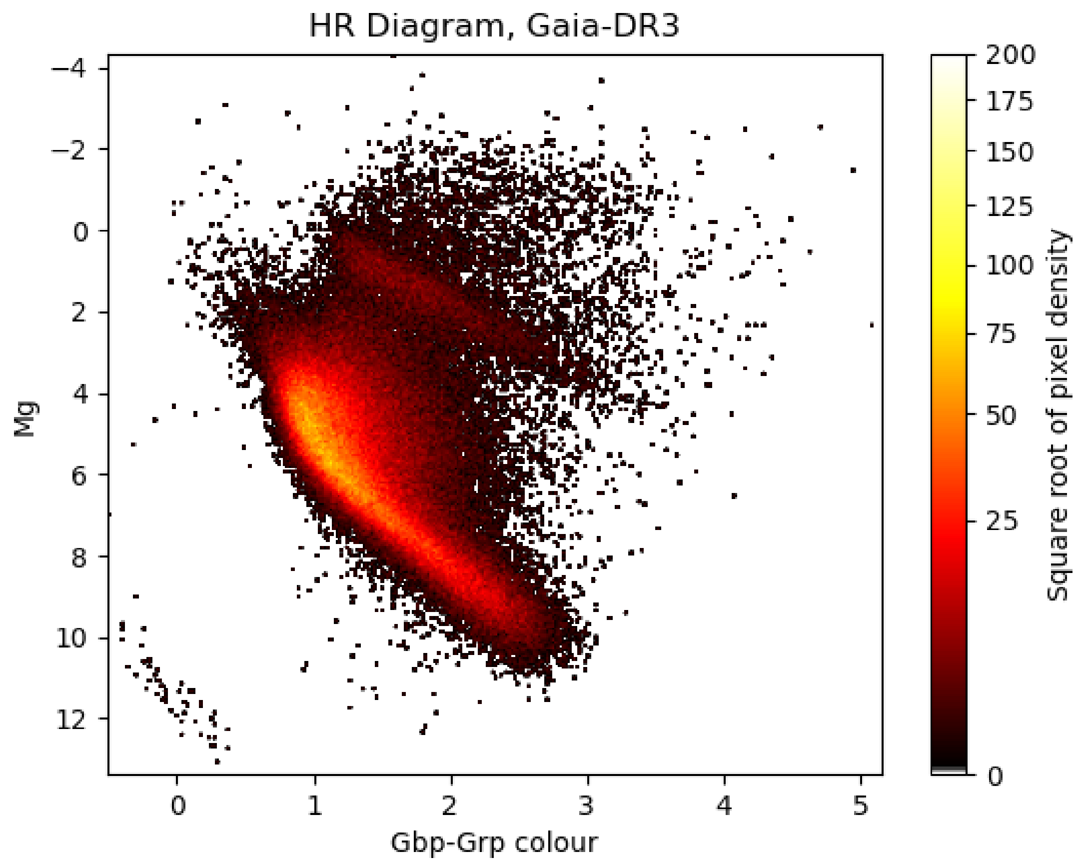

Fig. 3 This plot shows Gaia DR-3 Data with the same filters as Fig 1, taken from the Gaia Data Release 3 instead of 2.

Code for Fig. 3

```
DR3 = pd.read_csv('100k Stars, DR3.csv',sep = ',', names = ['mg','plx','bp_rp','l','b','ID'],header = 0)
```

```
#Plot 100k stars from Gaia DR3
from astropy.visualization import SqrtStretch
from astropy.visualization.mpl_normalize import ImageNormalize
norm = ImageNormalize(vmin=0., vmax=200, stretch=SqrtStretch())
fig = plt.figure()

colormap = LinearSegmentedColormap.from_list('white_viridis', [
    (0, 'white'),
    (0.01, 'black'),
    (0.33, 'red'),
    (0.66, 'yellow'),
    (1, 'white'),
], N=256)

ax = fig.add_subplot(1, 1, 1, projection='scatter_density')
scatter = ax.scatter_density(DR3['bp_rp'], DR3['mg'],norm = norm,cmap=colormap)
plt.xlabel('Gbp-Grp colour')
plt.ylabel('Mg')
ax = plt.gca()
ax.invert_yaxis()
plt.title('HR Diagram, Gaia-DR3')
fig.colorbar(scatter,label = 'Square root of pixel density')
fig.savefig('Gaia DR-3, HR Diagram.png')
```

Attempt at Optional 3:

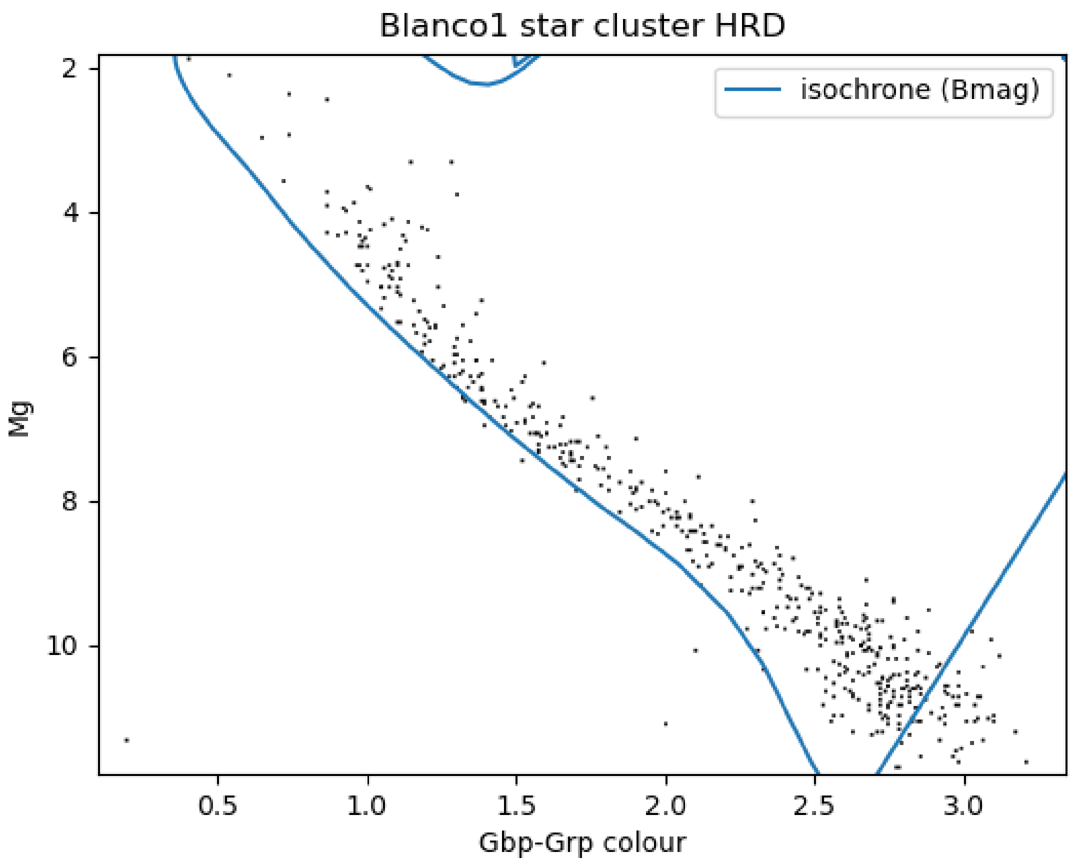

Fig. 4 This plot shows 500 stars from the Gaia DR-2, with the same filters as Fig-1, but from the slice of space corresponding to longitude ~= 73.6$\pm$2, latitude ~= -0.8 $\pm$2, and parallax ~= 4.2$\pm$1. Centerpoint taken from (Babusiaux, et al) table A.3 for the Blanco1 star cluster, I oversized the region the stars in the cluster would be. The cluster Blanco1 has ~ 300 stars, this graph contains stars not in the cluster. (Isochrone magnitude is Bmag, the stars are recorded using Gmag). Isochrone data from (Yang Chen, et al) with Z = 0.17.

Code for Fig. 4

```
Blanco = pd.read_csv('Blanco Cluster.csv',sep = ',', names = ['mg','plx','bp_rp','l','b','source_id','bp'],header = 0)
IF = pd.read_csv('Isochrone Z=0.17.dat', sep = '\s+',header = 0)
```

```
#Plot Blanco1 Cluster, queried from Gaia DR-2, same filtering as Appendix B of paper
#500 stars, Filtering (lon=73.6042+-2),(lat=-0.8388+-2),(plx=4.216+-1)
norm = ImageNormalize(vmin=0., vmax=1, stretch=SqrtStretch())
fig = plt.figure()

colormap = LinearSegmentedColormap.from_list('white_viridis', [
    (0, 'white'),
    (1, 'black'),
], N=256)
al = 10
ax = fig.add_subplot(1, 1, 1, projection='scatter_density')
scatter = ax.scatter_density(Blanco['bp_rp'],
                             Blanco['mg'],norm = norm,cmap=colormap)
plt.plot(IF['Bmag']-IF['Rmag'],IF['Bmag'],label = 'isochrone (Bmag)')
plt.xlabel('Gbp-Grp colour')
plt.ylabel('Mg')
ax = plt.gca()
ax.invert_yaxis()
plt.title('Blanco1 star cluster HRD')
plt.legend()
fig.savefig('Gaia DR-2, Blanco1 Cluster.png')
```

Bibliography:

Gaia Data Release 2 - Observational Hertzsprung-Russell diagrams
Gaia Collaboration, C. Babusiaux, et al.

Yang Chen, Léo Girardi, Alessandro Bressan, Paola Marigo, Mauro Barbieri, Xu Kong, Improving PARSEC models for very low mass stars, *Monthly Notices of the Royal Astronomical Society*, Volume 444, Issue 3, 1 November 2014, Pages 2525–2543, https://doi.org/10.1093/mnras/stu1605