ex1

March 31, 2025

1 Exercise 1

Make the required imports by the notebook

[2]:
```
import numpy as np
import matplotlib.pyplot as plt
from astropy.io import fits
from astropy.table import Table
from astropy import units as u
plt.ion()
```

[2]:
```
<contextlib.ExitStack at 0x1d6d7b290d0>
```

Create a list with randomly chosen numbers and calculate their mean value using the numpy package.

[3]:
```
a = [23, 56, 2, 4, 3]
b= np.mean(a)
print(b)
```

```
17.6
```

Read the **hst_results_nd.fits** file using astropy and print its columns

[4]:
```
t = Table.read("./data/hst_results_nd.fits")

for c in t.columns:
    print(c)
```

```
Name
RA
DEC
HST_WFC3_F225W
HST_WFC3_F275W
HST_WFC3_F336W
HST_WFC3_F475W
HST_WFC3_F814W
HST_WFC3_F110W
HST_WFC3_F160W
```

Av_Best
Av_Exp
Av_p16
Av_p50
Av_p84
Rv_Best
Rv_Exp
Rv_p16
Rv_p50
Rv_p84
Rv_A_Best
Rv_A_Exp
Rv_A_p16
Rv_A_p50
Rv_A_p84
f_A_Best
f_A_Exp
f_A_p16
f_A_p50
f_A_p84
distance_Best
distance_Exp
distance_p16
distance_p50
distance_p84
radius_Best
radius_Exp
radius_p16
radius_p50
radius_p84
logL_Best
logL_Exp
logL_p16
logL_p50
logL_p84
logg_Best
logg_Exp
logg_p16
logg_p50
logg_p84
mbolmag_Best
mbolmag_Exp
mbolmag_p16
mbolmag_p50
mbolmag_p84
logA_Best
logA_Exp
logA_p16

logA_p50
logA_p84
logT_Best
logT_Exp
logT_p16
logT_p50
logT_p84
M_ini_Best
M_ini_Exp
M_ini_p16
M_ini_p50
M_ini_p84
M_act_Best
M_act_Exp
M_act_p16
M_act_p50
M_act_p84
Z_Best
Z_Exp
Z_p16
Z_p50
Z_p84
logHST_WFC3_F225W_nd_Best
logHST_WFC3_F225W_nd_Exp
logHST_WFC3_F225W_nd_p16
logHST_WFC3_F225W_nd_p50
logHST_WFC3_F225W_nd_p84
logHST_WFC3_F275W_nd_Best
logHST_WFC3_F275W_nd_Exp
logHST_WFC3_F275W_nd_p16
logHST_WFC3_F275W_nd_p50
logHST_WFC3_F275W_nd_p84
logHST_WFC3_F336W_nd_Best
logHST_WFC3_F336W_nd_Exp
logHST_WFC3_F336W_nd_p16
logHST_WFC3_F336W_nd_p50
logHST_WFC3_F336W_nd_p84
logHST_WFC3_F475W_nd_Best
logHST_WFC3_F475W_nd_Exp
logHST_WFC3_F475W_nd_p16
logHST_WFC3_F475W_nd_p50
logHST_WFC3_F475W_nd_p84
logHST_WFC3_F814W_nd_Best
logHST_WFC3_F814W_nd_Exp
logHST_WFC3_F814W_nd_p16
logHST_WFC3_F814W_nd_p50
logHST_WFC3_F814W_nd_p84
logHST_WFC3_F110W_nd_Best

logHST_WFC3_F110W_nd_Exp
logHST_WFC3_F110W_nd_p16
logHST_WFC3_F110W_nd_p50
logHST_WFC3_F110W_nd_p84
logHST_WFC3_F160W_nd_Best
logHST_WFC3_F160W_nd_Exp
logHST_WFC3_F160W_nd_p16
logHST_WFC3_F160W_nd_p50
logHST_WFC3_F160W_nd_p84
logGALEX_FUV_nd_Best
logGALEX_FUV_nd_Exp
logGALEX_FUV_nd_p16
logGALEX_FUV_nd_p50
logGALEX_FUV_nd_p84
logF_QION228_nd_Best
logF_QION228_nd_Exp
logF_QION228_nd_p16
logF_QION228_nd_p50
logF_QION228_nd_p84
logHST_WFC3_F225W_wd_Best
logHST_WFC3_F225W_wd_Exp
logHST_WFC3_F225W_wd_p16
logHST_WFC3_F225W_wd_p50
logHST_WFC3_F225W_wd_p84
logHST_WFC3_F275W_wd_Best
logHST_WFC3_F275W_wd_Exp
logHST_WFC3_F275W_wd_p16
logHST_WFC3_F275W_wd_p50
logHST_WFC3_F275W_wd_p84
logHST_WFC3_F336W_wd_Best
logHST_WFC3_F336W_wd_Exp
logHST_WFC3_F336W_wd_p16
logHST_WFC3_F336W_wd_p50
logHST_WFC3_F336W_wd_p84
logHST_WFC3_F475W_wd_Best
logHST_WFC3_F475W_wd_Exp
logHST_WFC3_F475W_wd_p16
logHST_WFC3_F475W_wd_p50
logHST_WFC3_F475W_wd_p84
logHST_WFC3_F814W_wd_Best
logHST_WFC3_F814W_wd_Exp
logHST_WFC3_F814W_wd_p16
logHST_WFC3_F814W_wd_p50
logHST_WFC3_F814W_wd_p84
logHST_WFC3_F110W_wd_Best
logHST_WFC3_F110W_wd_Exp
logHST_WFC3_F110W_wd_p16
logHST_WFC3_F110W_wd_p50

logHST_WFC3_F110W_wd_p84
logHST_WFC3_F160W_wd_Best
logHST_WFC3_F160W_wd_Exp
logHST_WFC3_F160W_wd_p16
logHST_WFC3_F160W_wd_p50
logHST_WFC3_F160W_wd_p84
logGALEX_FUV_wd_Best
logGALEX_FUV_wd_Exp
logGALEX_FUV_wd_p16
logGALEX_FUV_wd_p50
logGALEX_FUV_wd_p84
logF_QION228_wd_Best
logF_QION228_wd_Exp
logF_QION228_wd_p16
logF_QION228_wd_p50
logF_QION228_wd_p84
symlogHST_WFC3_F225W_wd_bias_Best
symlogHST_WFC3_F225W_wd_bias_Exp
symlogHST_WFC3_F225W_wd_bias_p16
symlogHST_WFC3_F225W_wd_bias_p50
symlogHST_WFC3_F225W_wd_bias_p84
symlogHST_WFC3_F275W_wd_bias_Best
symlogHST_WFC3_F275W_wd_bias_Exp
symlogHST_WFC3_F275W_wd_bias_p16
symlogHST_WFC3_F275W_wd_bias_p50
symlogHST_WFC3_F275W_wd_bias_p84
symlogHST_WFC3_F336W_wd_bias_Best
symlogHST_WFC3_F336W_wd_bias_Exp
symlogHST_WFC3_F336W_wd_bias_p16
symlogHST_WFC3_F336W_wd_bias_p50
symlogHST_WFC3_F336W_wd_bias_p84
symlogHST_WFC3_F475W_wd_bias_Best
symlogHST_WFC3_F475W_wd_bias_Exp
symlogHST_WFC3_F475W_wd_bias_p16
symlogHST_WFC3_F475W_wd_bias_p50
symlogHST_WFC3_F475W_wd_bias_p84
symlogHST_WFC3_F814W_wd_bias_Best
symlogHST_WFC3_F814W_wd_bias_Exp
symlogHST_WFC3_F814W_wd_bias_p16
symlogHST_WFC3_F814W_wd_bias_p50
symlogHST_WFC3_F814W_wd_bias_p84
symlogHST_WFC3_F110W_wd_bias_Best
symlogHST_WFC3_F110W_wd_bias_Exp
symlogHST_WFC3_F110W_wd_bias_p16
symlogHST_WFC3_F110W_wd_bias_p50
symlogHST_WFC3_F110W_wd_bias_p84
symlogHST_WFC3_F160W_wd_bias_Best
symlogHST_WFC3_F160W_wd_bias_Exp

symlogHST_WFC3_F160W_wd_bias_p16
symlogHST_WFC3_F160W_wd_bias_p50
symlogHST_WFC3_F160W_wd_bias_p84
chi2min
Pmax
Pmax_indx
total_log_norm
best_gridsub_tag
reorder_tag
X
Y
F110W_RATE
F110W_RATERR
F110W_VEGA
F110W_STD
F110W_ERR
F110W_CHI
F110W_SNR
F110W_SHARP
F110W_ROUND
F110W_CROWD
F110W_FLAG
F160W_RATE
F160W_RATERR
F160W_VEGA
F160W_STD
F160W_ERR
F160W_CHI
F160W_SNR
F160W_SHARP
F160W_ROUND
F160W_CROWD
F160W_FLAG
F225W_RATE
F225W_RATERR
F225W_VEGA
F225W_STD
F225W_ERR
F225W_CHI
F225W_SNR
F225W_SHARP
F225W_ROUND
F225W_CROWD
F225W_FLAG
F275W_RATE
F275W_RATERR
F275W_VEGA
F275W_STD

```
F275W_ERR
F275W_CHI
F275W_SNR
F275W_SHARP
F275W_ROUND
F275W_CROWD
F275W_FLAG
F336W_RATE
F336W_RATERR
F336W_VEGA
F336W_STD
F336W_ERR
F336W_CHI
F336W_SNR
F336W_SHARP
F336W_ROUND
F336W_CROWD
F336W_FLAG
F475W_RATE
F475W_RATERR
F475W_VEGA
F475W_STD
F475W_ERR
F475W_CHI
F475W_SNR
F475W_SHARP
F475W_ROUND
F475W_CROWD
F475W_FLAG
F814W_RATE
F814W_RATERR
F814W_VEGA
F814W_STD
F814W_ERR
F814W_CHI
F814W_SNR
F814W_SHARP
F814W_ROUND
F814W_CROWD
F814W_FLAG
HST_WFC3_F336W_MD
reliable
```

Select columns from the fits file and store them in the corresponding variables.

[5]:
```
ra = t["RA"]
dec = t["DEC"]
av = t["Av_p50"]
```

```python
age = t["logA_p50"]
mass = t["M_ini_p50"]
temp = t["logT_p50"]
f475w = t["F475W_VEGA"]
f814w = t["F814W_VEGA"]
#t[0].colnames
```

Select **young_stars** to be the stars with age less than *8.5* and **old_stars** to be the stars with age greater than *10*.

Print the size of the two lists of stars.

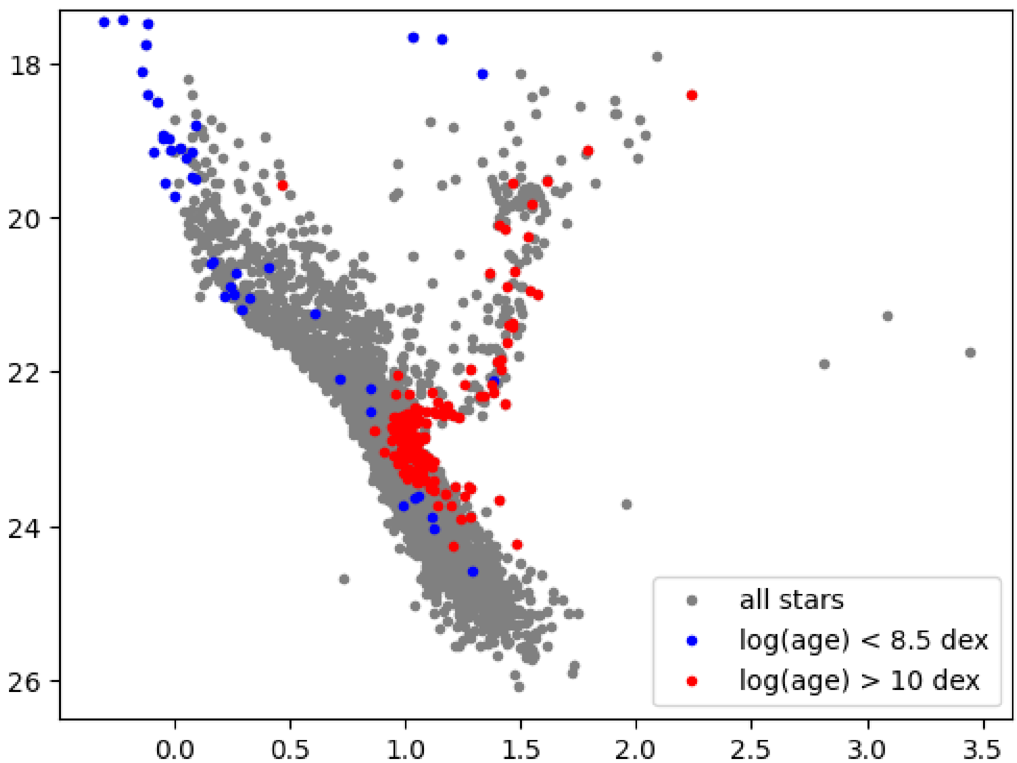
Plot all stars, **young_stars** and **old_stars**, where on the x axis is the difference between the filter 475 and filter 814 (color index) normalized with Vega and on the y axis is the filter 475 normalized with Vega (luminosity in the given filter).

Add a legend.

Save the file to **cmd_by_age.pdf**

[6]:
```python
young_stars = t[age < 8.5]
old_stars = t[age > 10]
print(len(young_stars))
print(len(old_stars))
plt.figure()
plt.plot(f475w - f814w, f475w, '.', color='gray', ls='', label='all stars')
plt.ylim(26.5, 17.3)
plt.plot(young_stars["F475W_VEGA"] - young_stars["F814W_VEGA"],␣
 ↪young_stars["F475W_VEGA"],
         'b.', ls='', label='log(age) < 8.5 dex')
plt.plot(old_stars["F475W_VEGA"] - old_stars["F814W_VEGA"],␣
 ↪old_stars["F475W_VEGA"],
         'r.', ls='', label='log(age) > 10 dex')
plt.legend()
plt.savefig("./dist/cmd_by_age.pdf")
```

```
44
170
```

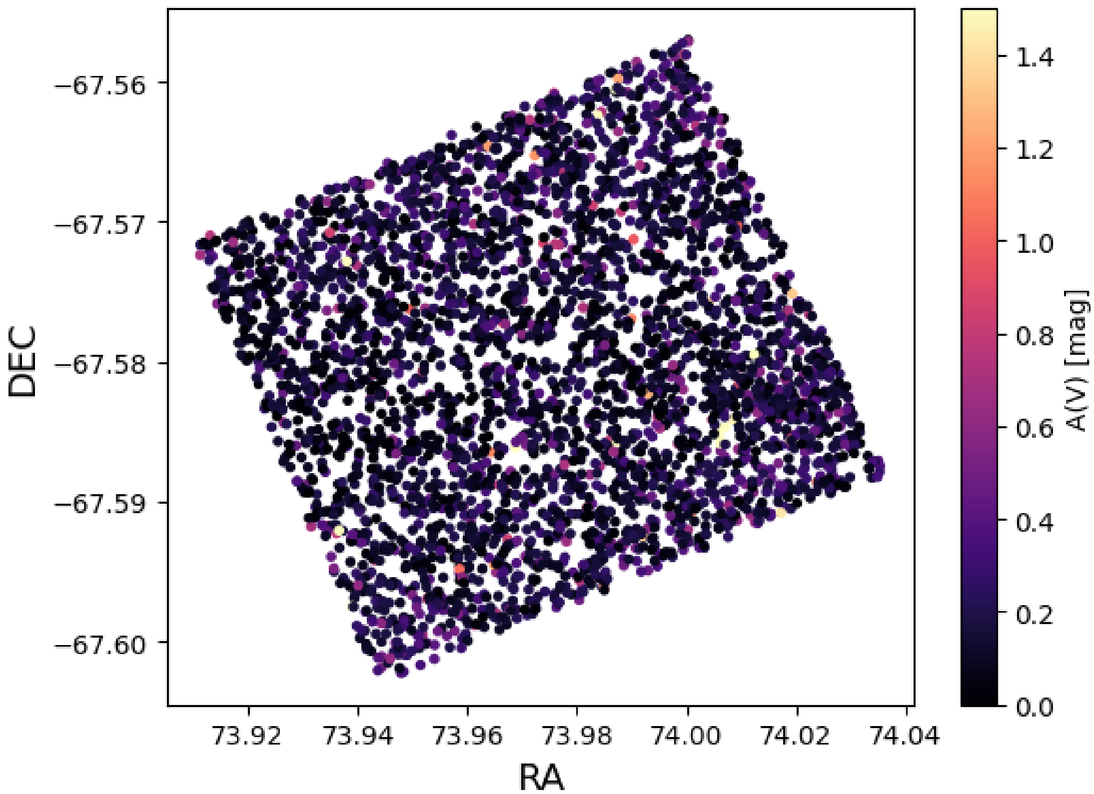


Plot the dust extinction in the square using the RA and DEC coordinates.

For this purpose use scatter plot with a colorbar next to the plot.

Save the file in **lmc_av_spatial.pdf**

[7]:
```
plt.figure()
# A(V) max = 5, -> limit to 1.5
cb = plt.scatter(ra, dec, c=av, marker='.', cmap='magma', vmin=0, vmax=1.5)
plt.colorbar(cb, label='A(V) [mag]')
plt.xlabel("RA", fontsize=14)
plt.ylabel("DEC", fontsize=14)
plt.savefig("./dist/lmc_av_spatial.pdf")
```



Store the predicted distance in the variable **dist**

[9]:
```
dist=t["distance_p50"]
```

Create a histogram of the distances to the stars in kpc. Use 25 bins for the histogram.

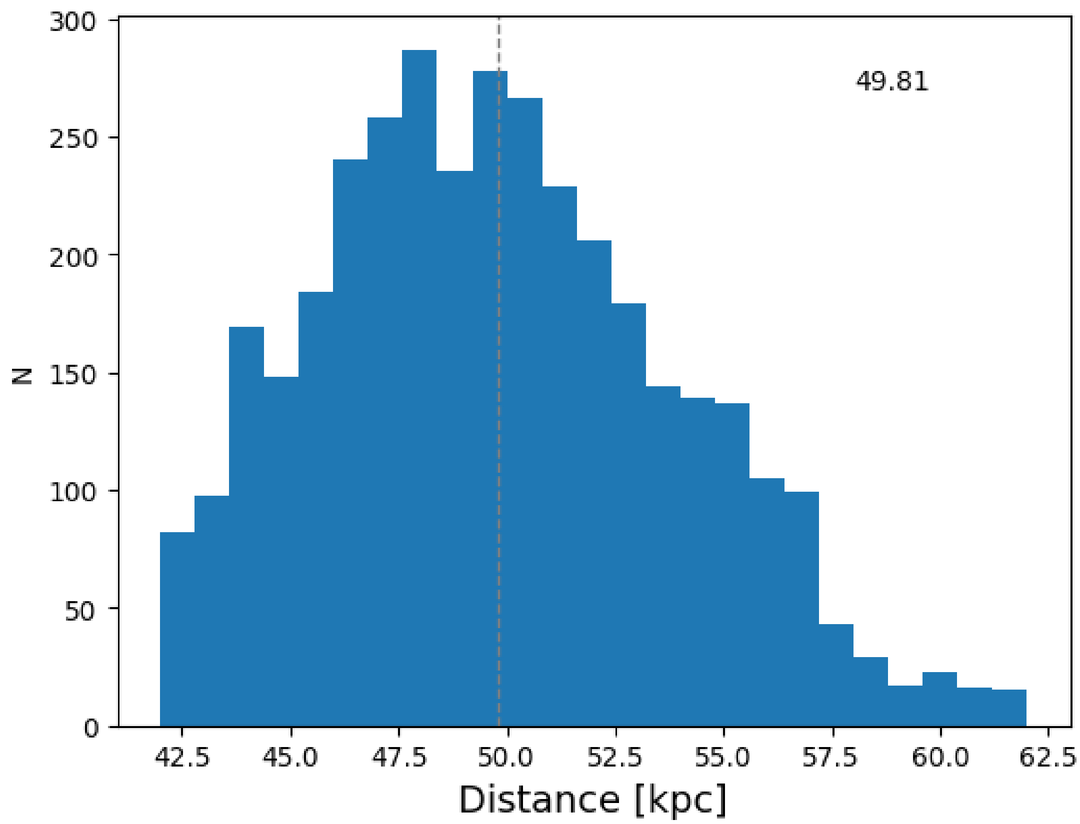
Set the appropriate labels on the x and y axes.

Calculate the mean distance, again in kpc, and plot it as vertical line atop of the histogram.

Save the figure to **lmc_dist_hist.pdf**

[10]:
```
plt.figure()
plt.hist(dist/1000, bins=25)
plt.xlabel("Distance [kpc]", fontsize=14)
plt.ylabel("N")
d_mean = np.mean(dist/1000)
print(d_mean)
plt.axvline(d_mean, color='gray', ls='--', lw=1)
plt.text(58, 270, '%s' % np.around(d_mean, decimals=2))
plt.savefig("./images/lmc_dist_hist.pdf")
```

```
49.806221103883765
```



Read an astropy table with the data from Scylla survey into the variable **cat**.

[13]:
```
f = "./data/hlsp_scylla_hst_wfc3_lmc-04_multi_v1_st.fits"
cat = Table.read(f)
```

Select the 475 and 814 wavelength fluxes normalized to Vega.

[14]:
```
#t[0].colnames
f475 = cat["F475W_VEGA"]
f814 = cat["F814W_VEGA"]
```

Create a Herzprung-Russel diagram by plotting on the x-axis the color index between f475 - f814 and on the y-axis the flux in f475.

Use blue color, no line style and smaller markers on the plot.

Set the limits ti be between $x \in$ *[-3, 6]* and $y \in$ *[30, 17]*.

Note that the y-axis is reversed.

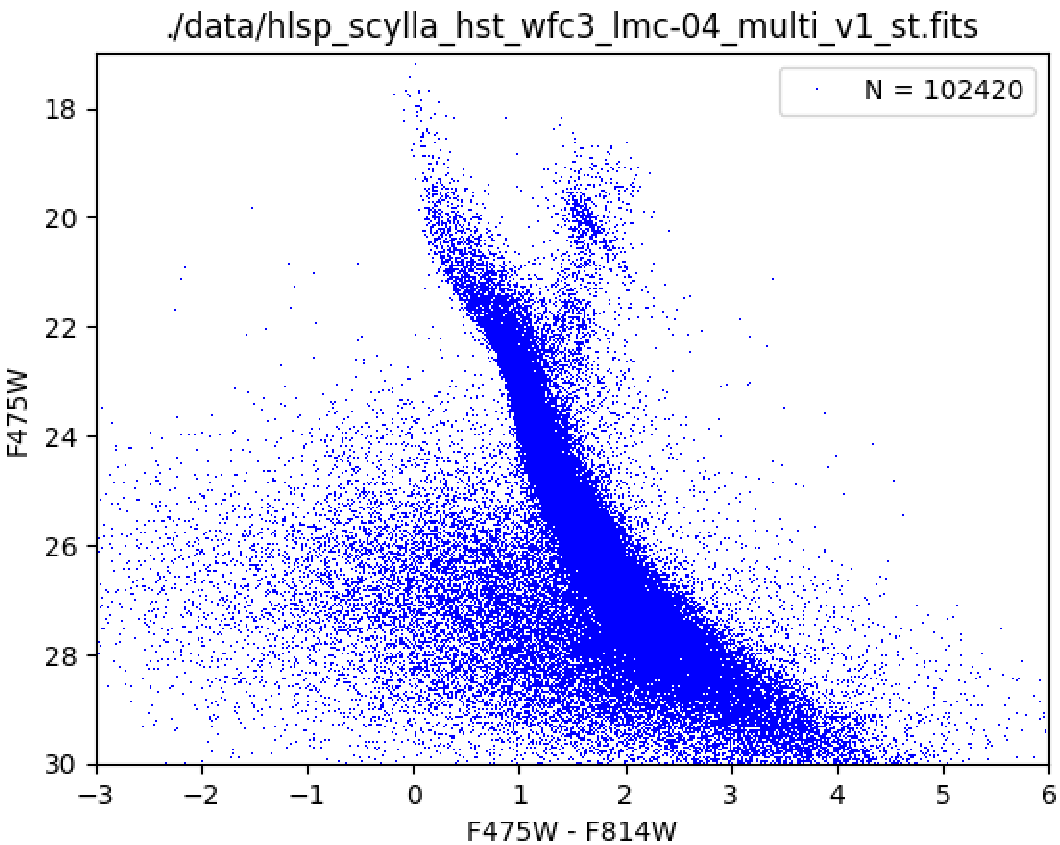
Set the corresponding lables on x and y axes and the title of the figure.

Save the figure to **cmd_lmc4.png**

[15]:

```
col = f475 - f814
mag = f475
n = len(f475)
# TODO: make a correction of n

plt.figure()
plt.plot(col, mag, ',b', ls='', label='N = %s' % n)
plt.legend()
plt.xlim(-3,6)
plt.ylim(30, 17)
plt.xlabel('F475W - F814W')
plt.ylabel('F475W')
plt.title('%s' % f)
plt.savefig("./images/cmd_lmc4.png")
```



[ ]: