Lab 3

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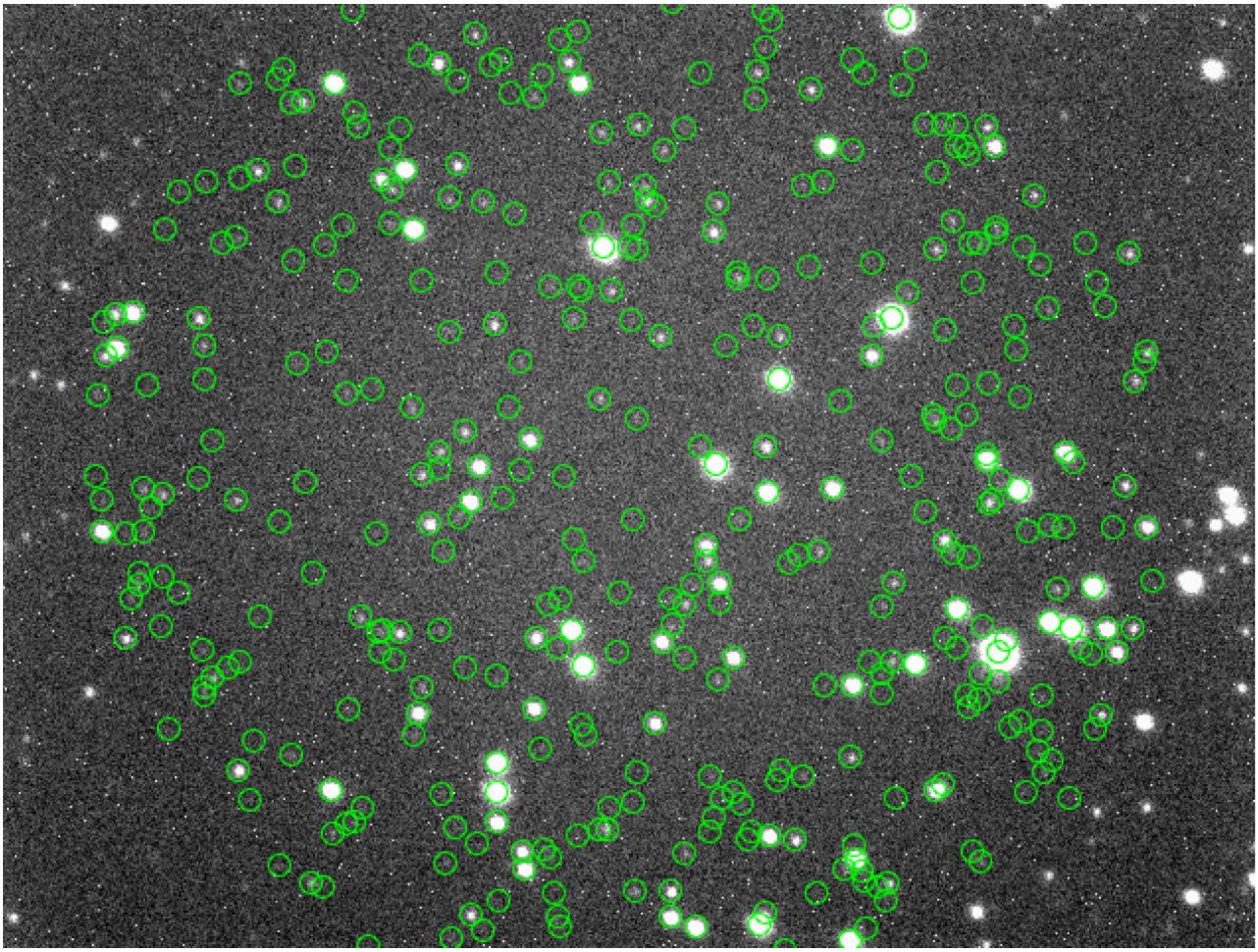
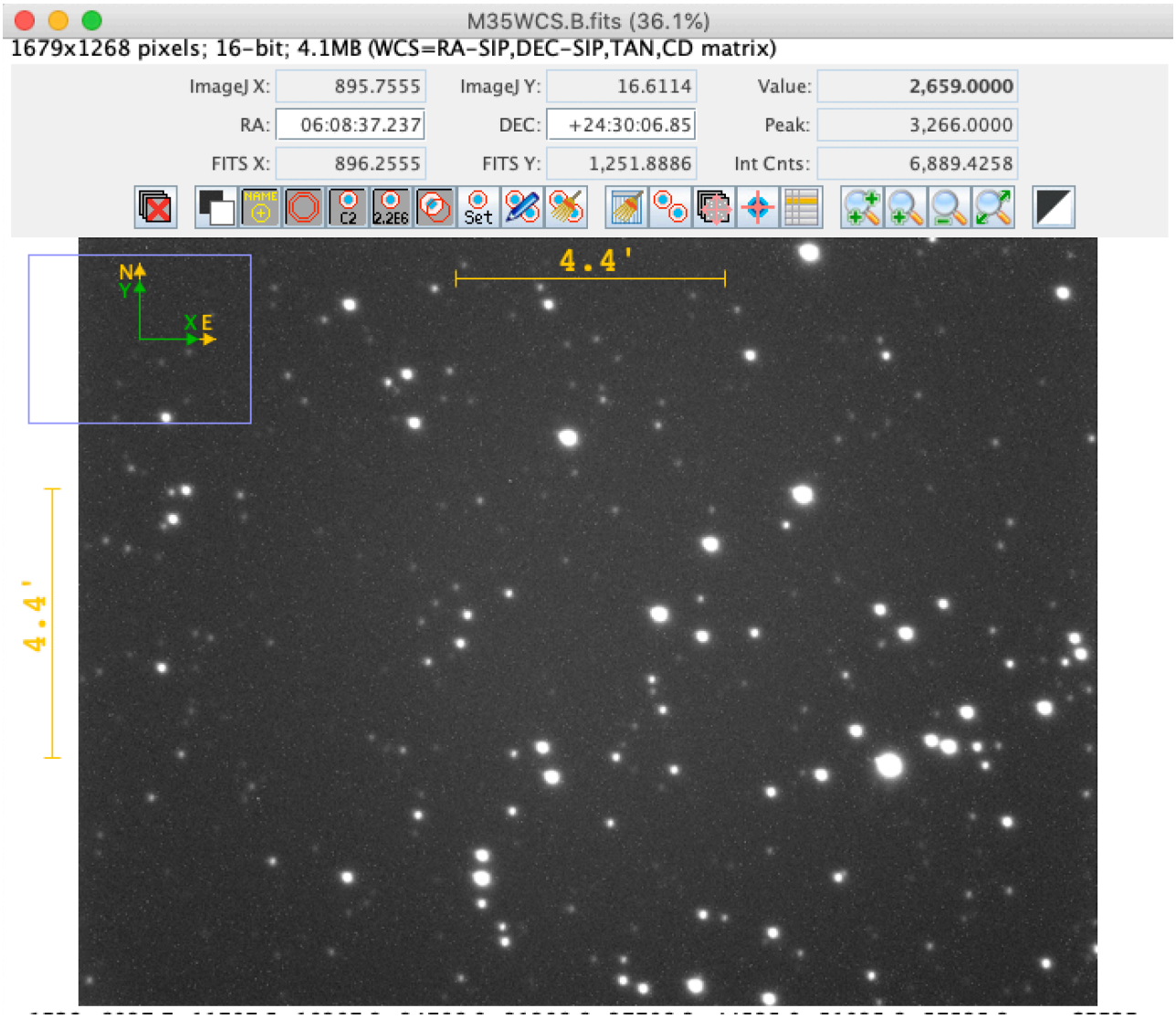
HR Diagram

HR Diagrams were constructed from observations of open clusters in B and R filters. The clusters observed were selected based on monthly recommendations from SkyMaps.com. The observations were made on 2/27/2020 and 2/28/2020 with the UWM 14" telescope and CCD camera. Astrometry.net was used to obtain astrometric solutions for each image. DS9 was used initially to assess the images and match stars to USNO UCAC4 catalog data. This same catalog data was used to create reference HR diagrams to compare to the created diagrams.



AstroImageJ (AIJ) was used extensively to calibrate the images with bias, dark and flat field images. AIJ also created a Seeing Profile where the FWHM was found to be 9.18 pixels or 5.49 arcsec. AIJ's Multi-Aperature functionality was used to select stars to analyze and plot on the diagram.

A pair of images from each cluster in each filter was then analyzed and flux measurements taken.



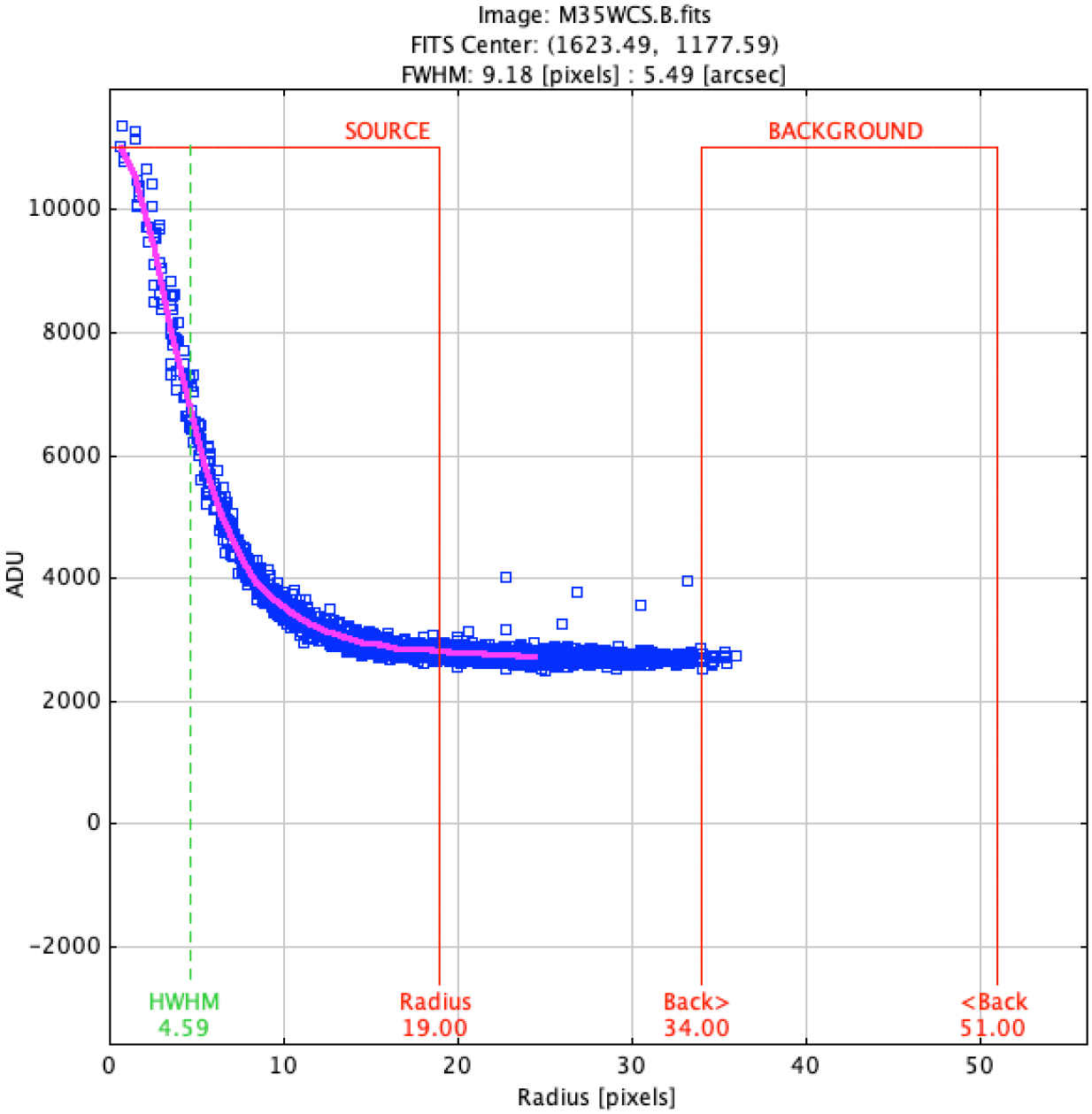
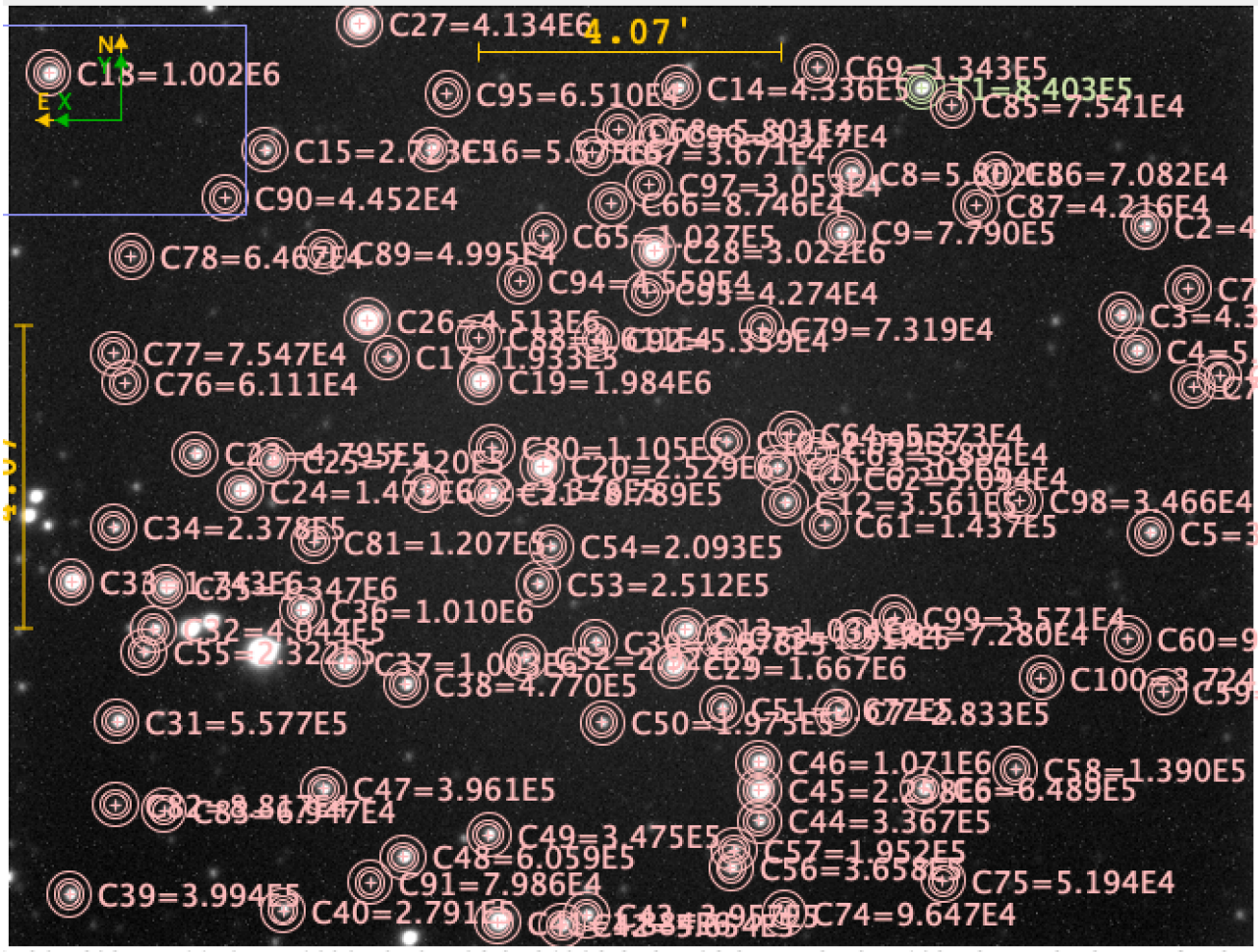


Image: M35WCS.B.fits
FITS Center: (1623.49, 1177.59)
FWHM: 9.18 [pixels] : 5.49 [arcsec]
SOURCE
BACKGROUND
ADU
10000
8000
6000
4000
2000
0
-2000
HWHM
4.59
Radius
19.00
Back>
34.00
<Back
51.00
0
10
20
30
40
50
Radius [pixels]


C27=4.134E6
4.07'
N
E
C13=1.002E6
C95=6.510E4
C14=4.336E5
C69=1.343E5
C85=7.541E4
C15=2.723E5
C90=4.452E4
C97=3.053E4
C8=5.802E5
C86=7.082E4
C66=8.746E4
C87=4.216E4
C65=1.027E5
C9=7.790E5
C78=6.467E4
C89=4.995E4
C28=3.022E6
C94=4.559E4
C95=4.274E4
C26=4.513E6
C79=7.319E4
C77=7.547E4
C17=1.933E5
C76=6.111E4
C19=1.984E6
C80=1.105E5
C20=2.529E6
C24=1.472E6
C12=3.561E5
C98=3.466E4
C34=2.378E5
C61=1.437E5
C81=1.207E5
C54=2.093E5
C53=2.512E5
C36=1.010E6
C99=3.571E4
C55=2.322E5
C29=1.667E6
C38=4.770E5
C31=5.577E5
C50=1.975E5
C46=1.071E6
C58=1.390E5
C47=3.961E5
C45=2.238E6
C44=3.367E5
C49=3.475E5
C48=6.059E5
C57=1.952E5
C56=3.658E5
C91=7.986E4
C75=5.194E4
C39=3.994E5
C40=2.791E5
C74=9.647E4

	Label	Col_1	Col_2
9	CCD-TEMP	-2.168183	-1.881263
10	EXPTIME	60.000000	60.000000
11	RAOBJ2K	NaN	NaN
12	DECOBJ2K	NaN	NaN
13	rel_flux_T1	0.025555	0.025464
14	rel_flux_C2	0.007653	0.006098
15	rel_flux_C3	0.003408	0.002805
16	rel_flux_C4	0.010567	0.008594
17	rel_flux_C5	0.004363	0.003959
18	rel_flux_C6	0.008083	0.007150
19	rel_flux_C7	0.001634	0.001277
20	rel_flux_C8	0.002558	0.002085
21	rel_flux_C9	0.003539	0.002800
22	rel_flux_C10	0.001516	0.001453
23	rel_flux_C11	0.011280	0.008923
24	rel_flux_C12	0.001135	0.001029
25	rel_flux_C13	0.002186	0.001864
26	rel_flux_C14	0.010719	0.007907
27	rel_flux_C15	0.001391	0.001218

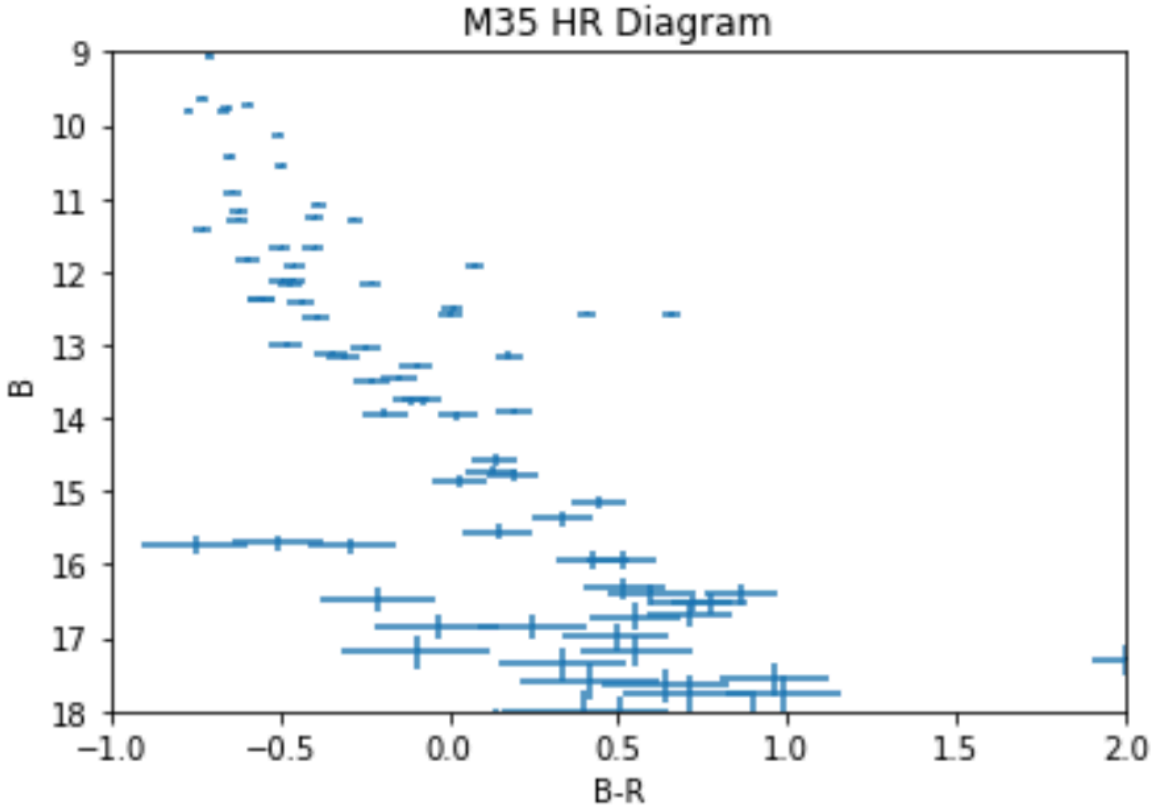
The output file was then read into Phython and the data plotted on in an HR diagram.

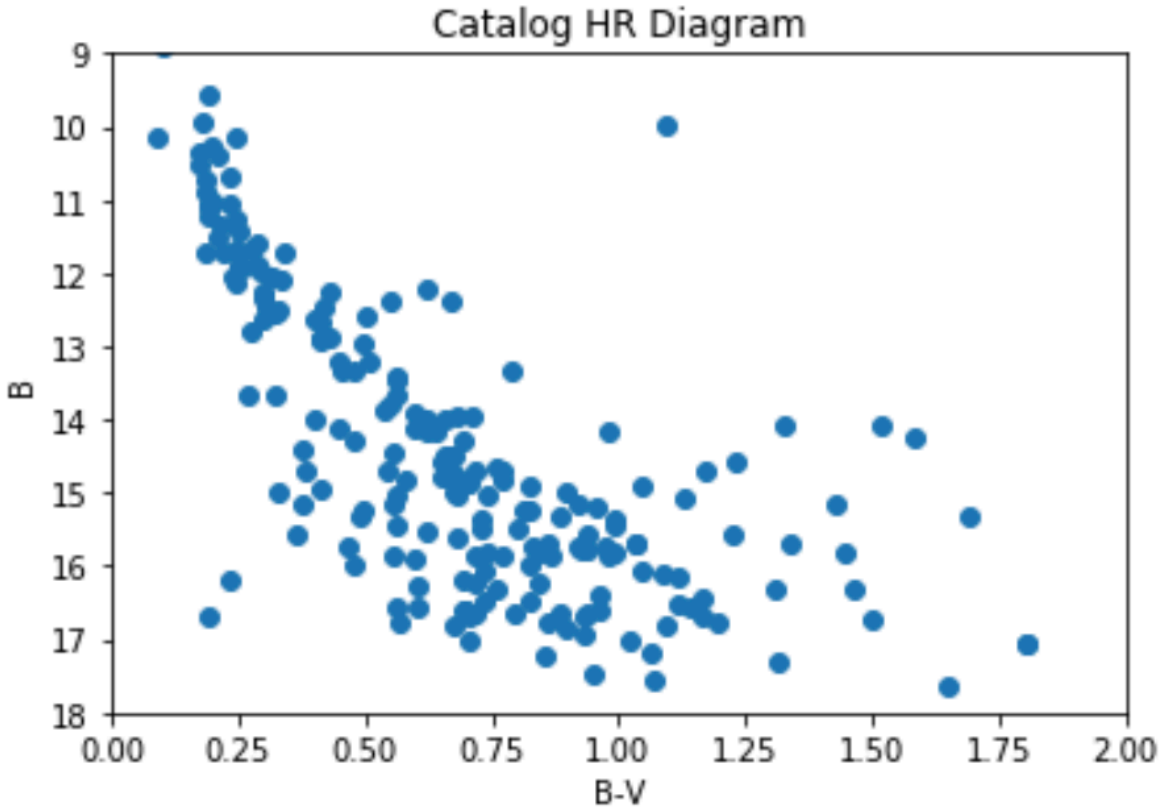
Color Index

The color index, $B - R$, was calculated as follow:

$$B - R = -2.5log_{10}(f_B/f_R)$$

M35


M35 HR Diagram
B
B-R
9
10
11
12
13
14
15
16
17
18
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0


Catalog HR Diagram
B
B-V
9
10
11
12
13
14
15
16
17
18
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

Python code

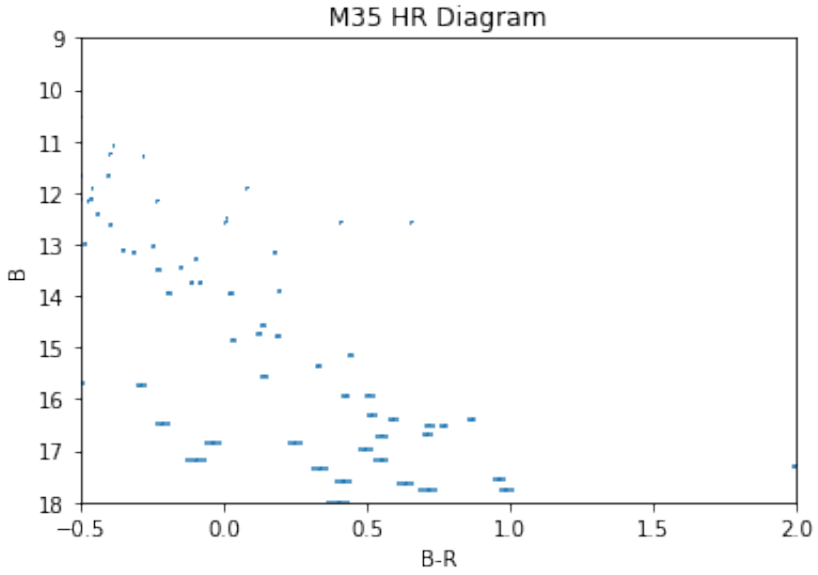
In [1]:
```
from astropy.io import fits
from os import walk
from matplotlib import pyplot as plt

import numpy as np
from scipy import stats

```

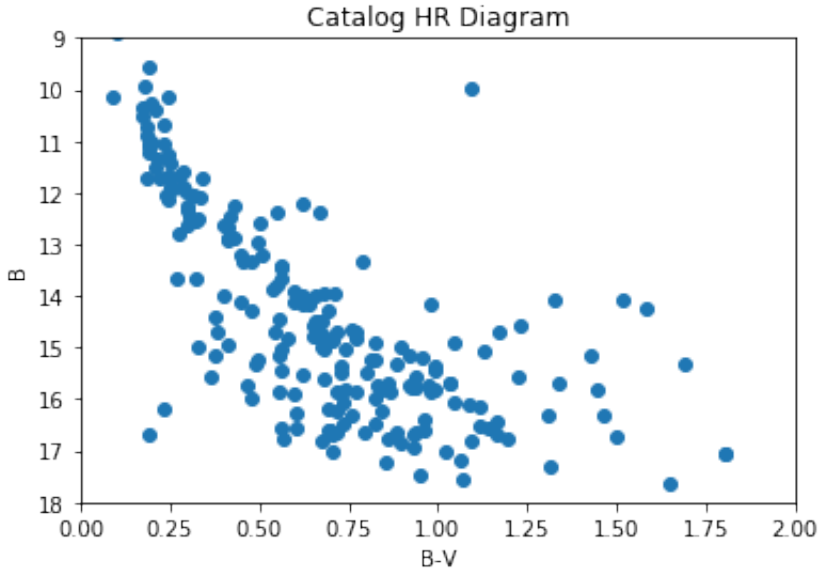
In [2]:
```
data = np.genfromtxt(fname="Measurements_transposed.tsv", delimiter=

#print(data.shape)  # (200,100)
#print(data)

cata = np.genfromtxt(fname="M35Catalog.tsv", delimiter="\t", skip_he

print("Catalog data shows",cata.shape[0],"stars in this field.")
```

```
Catalog data shows 410 stars in this field.
```

In [3]:
```
b_vArray = -2.5*np.log(data[13:112,2]/data[13:112,3])
XErrArray = (data[113:212,2]/data[13:112,3])
MagArray = -2.5*np.log(data[13:112,2])
YErrArray = (data[113:212,2]/data[13:112,2])
#plt.scatter(b_vArray,MagArray)
plt.errorbar(b_vArray,MagArray,xerr=XErrArray, yerr=YErrArray, fmt='
#print(YErrArray, XErrArray),
plt.gca().invert_yaxis()
plt.xlim(-.5,2)
plt.ylim(18,9)
plt.title("M35 HR Diagram")
plt.xlabel("B-R")
plt.ylabel("B")
plt.savefig('Lab3_M35_HR.png')
plt.show()

b_vArray = (cata[:,13]-cata[:,14])
MagArray = (cata[:,13])
plt.scatter(b_vArray,MagArray)
plt.gca().invert_yaxis()
plt.ylim(18,9)
plt.xlim(0,2)
plt.title("Catalog HR Diagram")
plt.xlabel("B-V")
plt.ylabel("B")
plt.savefig('Lab3_Catalog_HR.png')
```

```
27 plt.show()
```

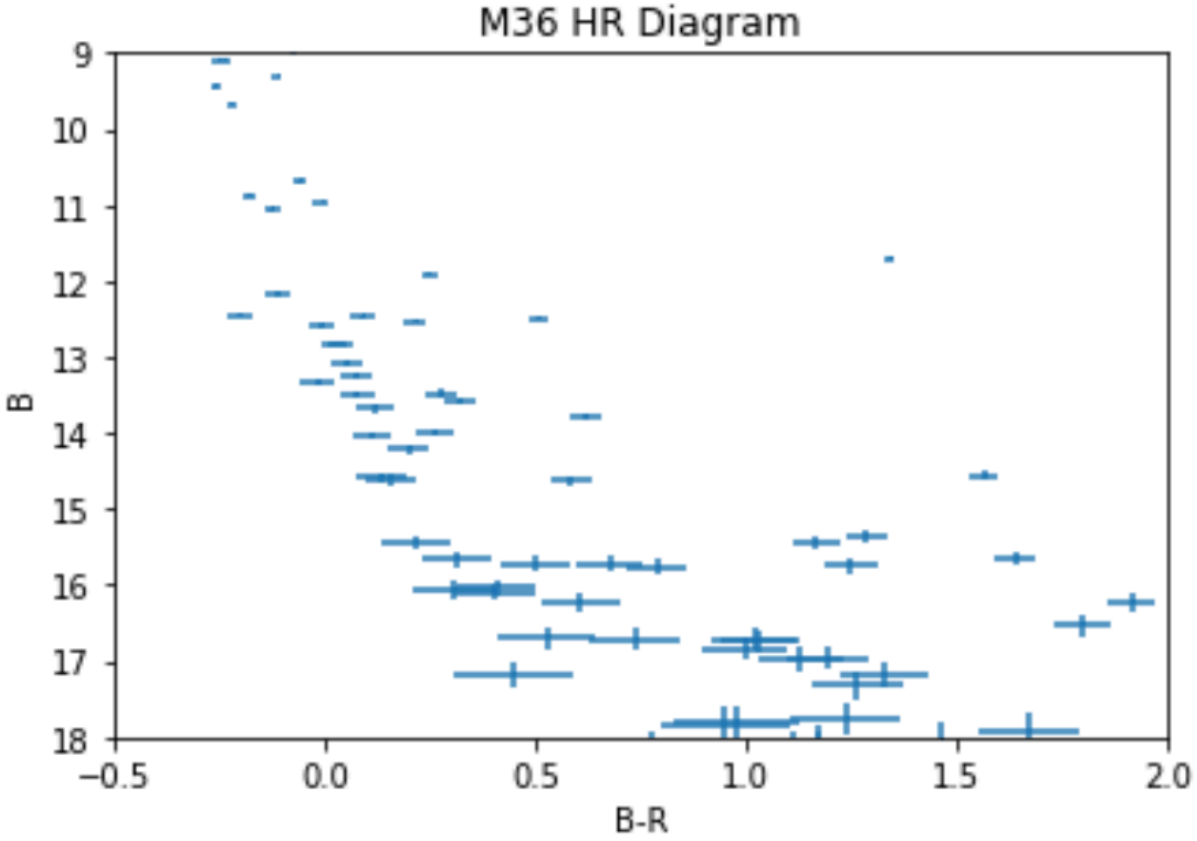


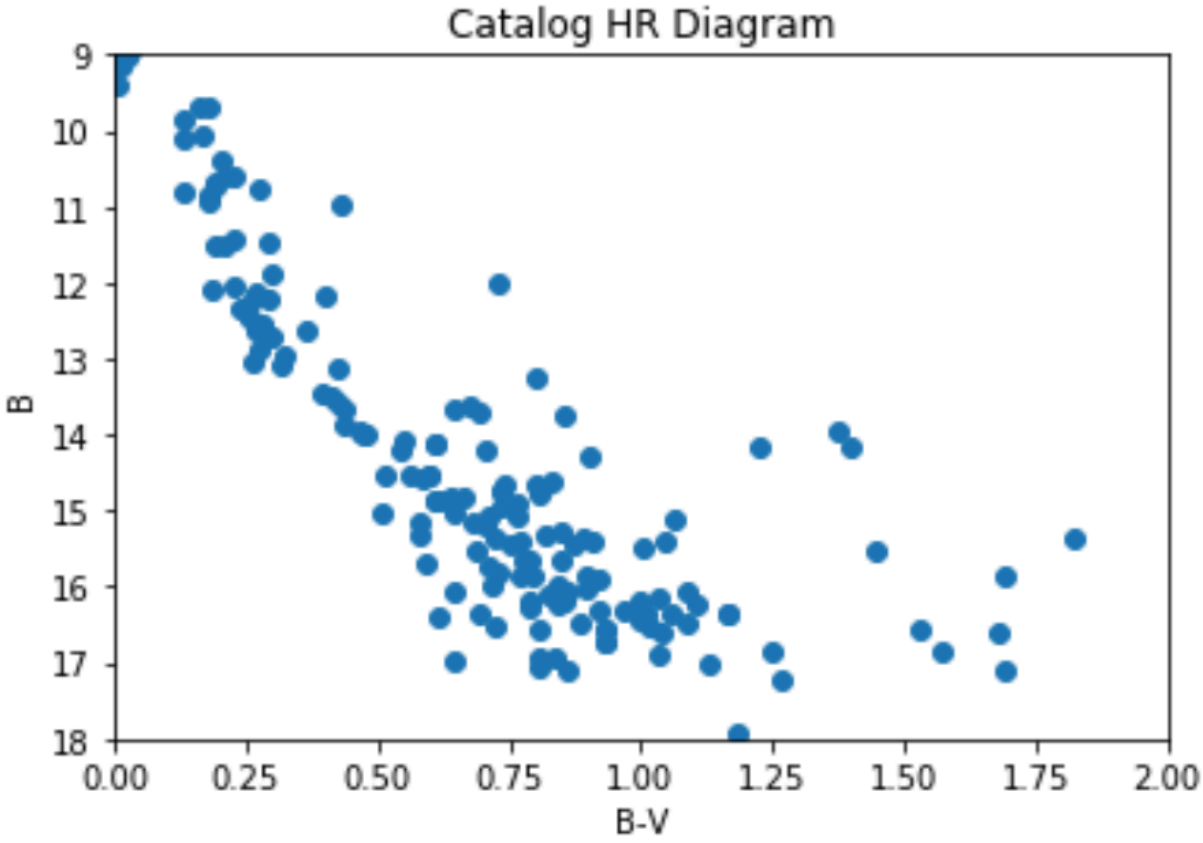


Other HR Diagrams

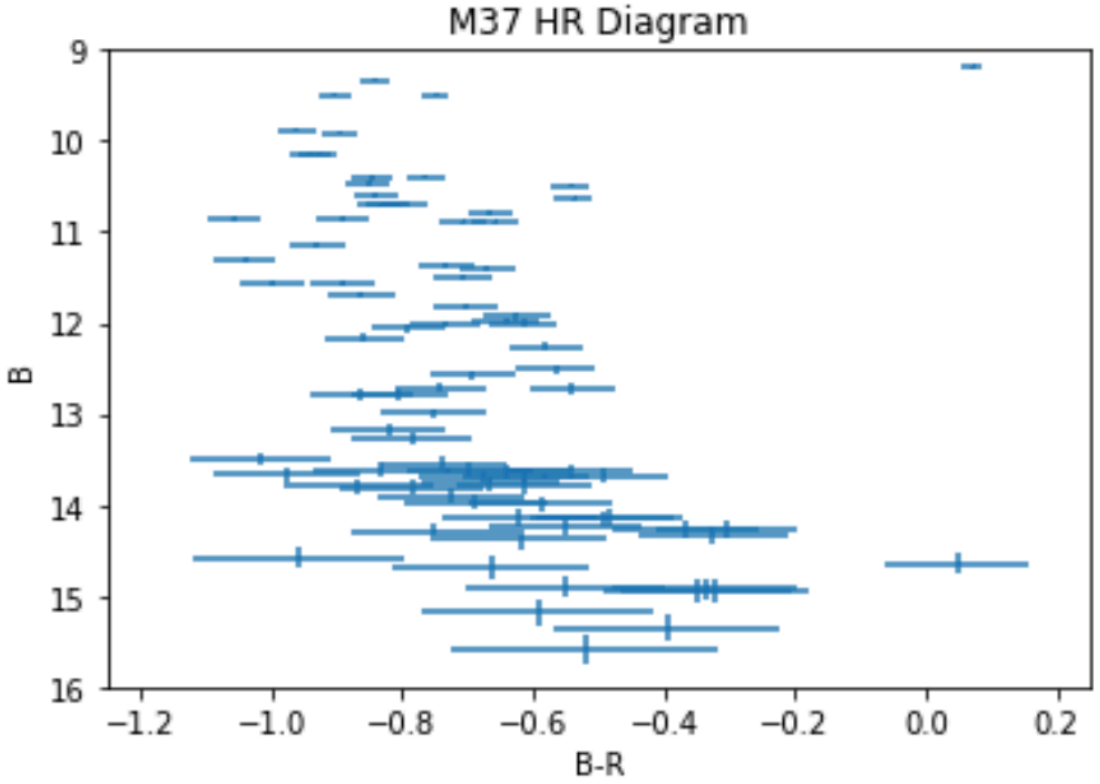
Six other clusters were also analyzed with varying results.

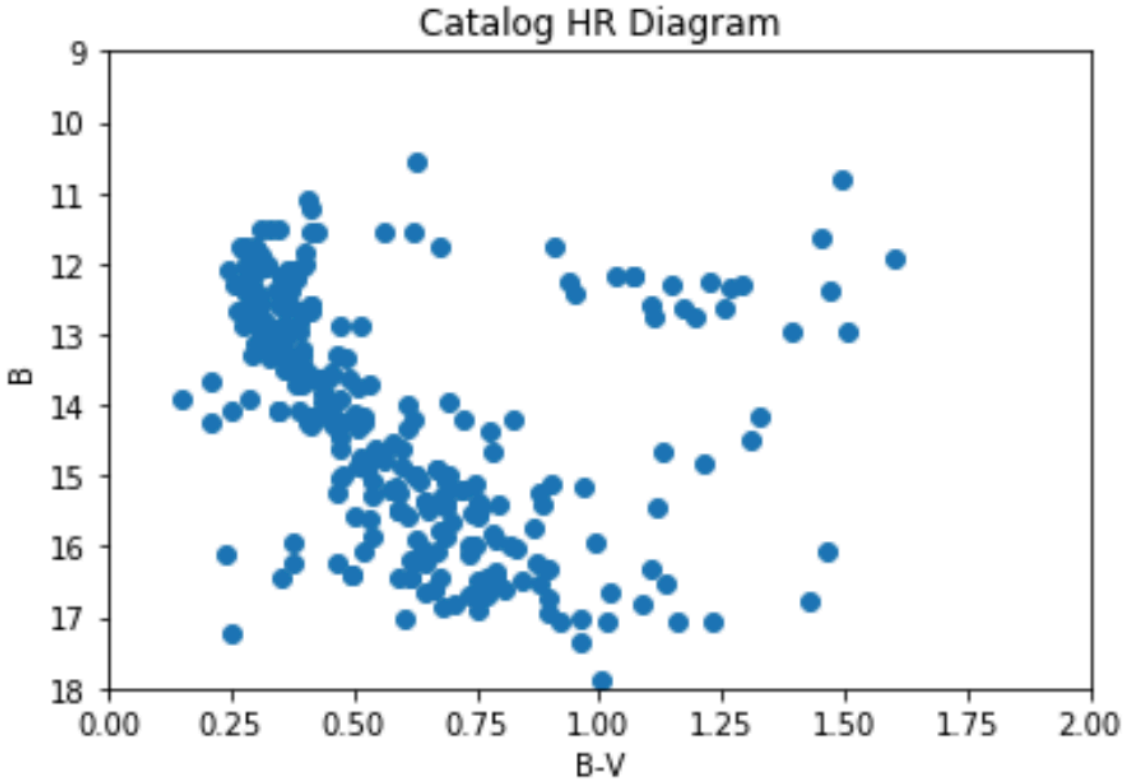
M36


M36 HR Diagram
B
B-R
9
10
11
12
13
14
15
16
17
18
−0.5
0.0
0.5
1.0
1.5
2.0

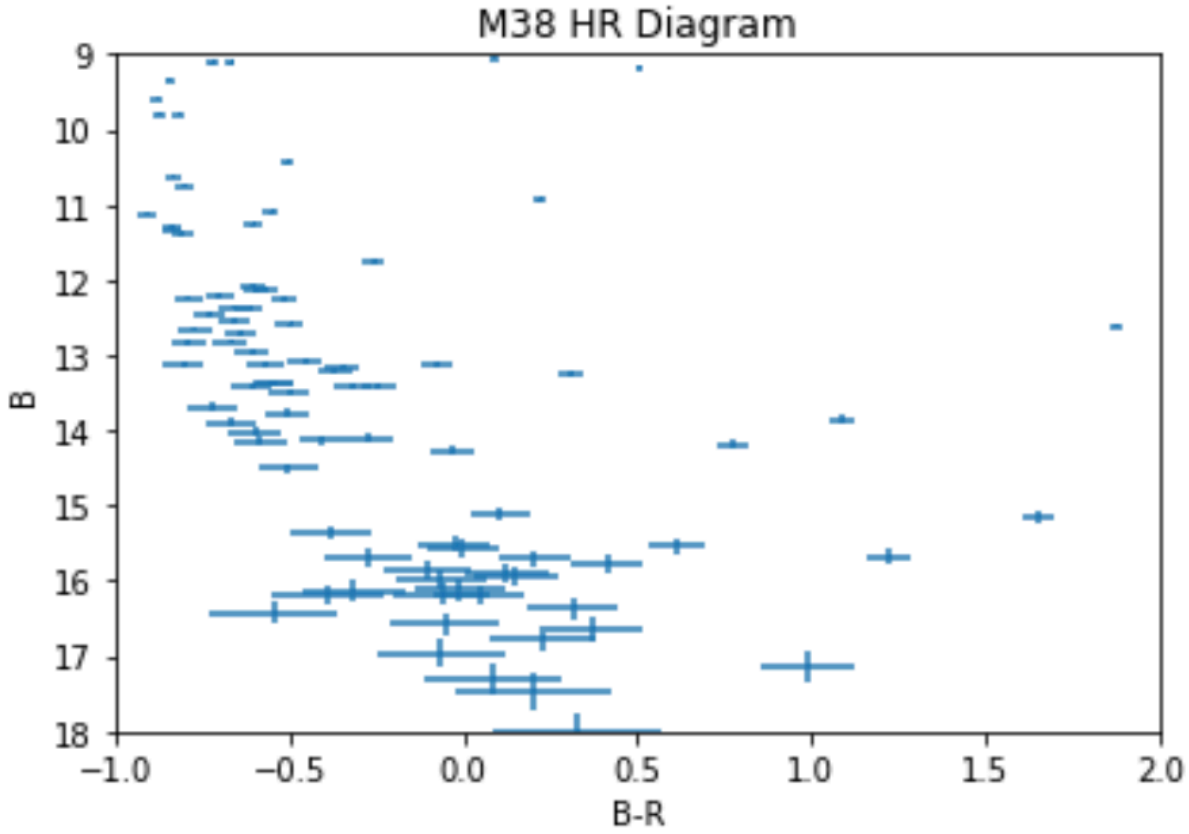

Catalog HR Diagram
B
B-V
9
10
11
12
13
14
15
16
17
18
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

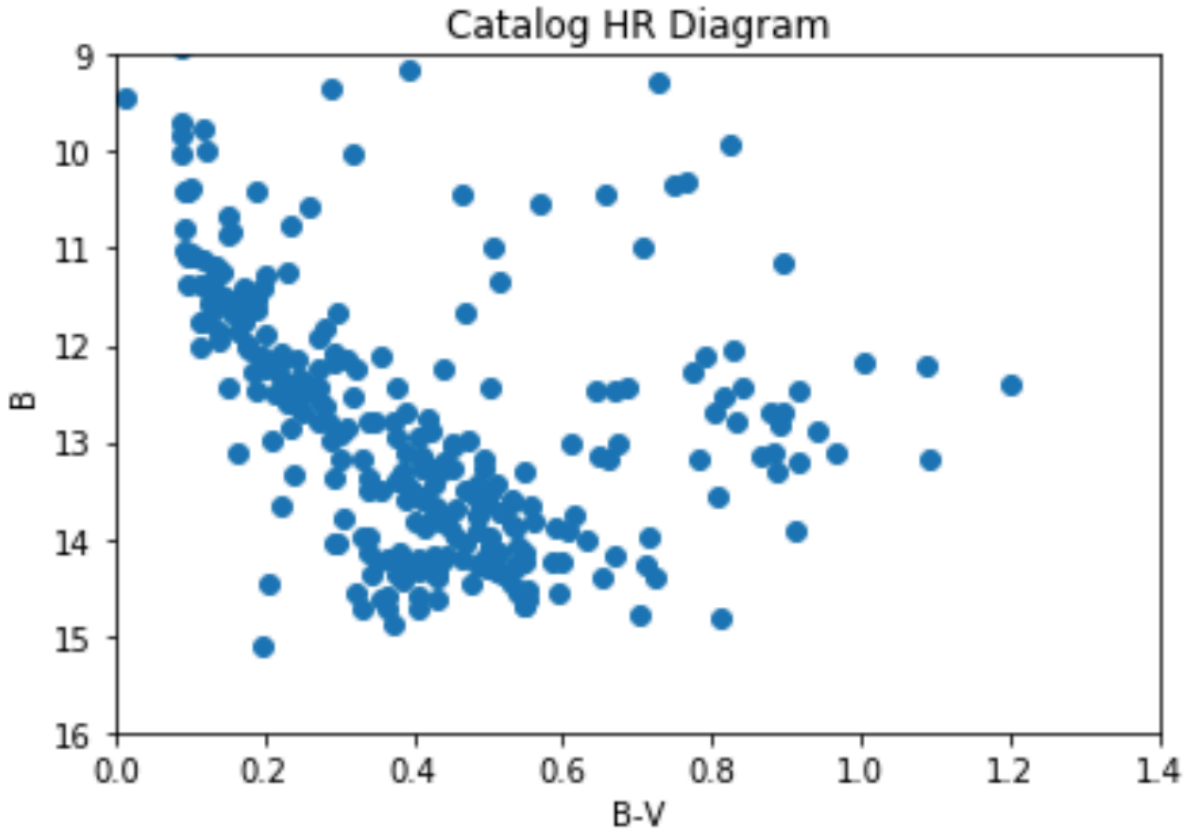
M37


M37 HR Diagram
B
B-R
9
10
11
12
13
14
15
16
−1.2
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
0.2

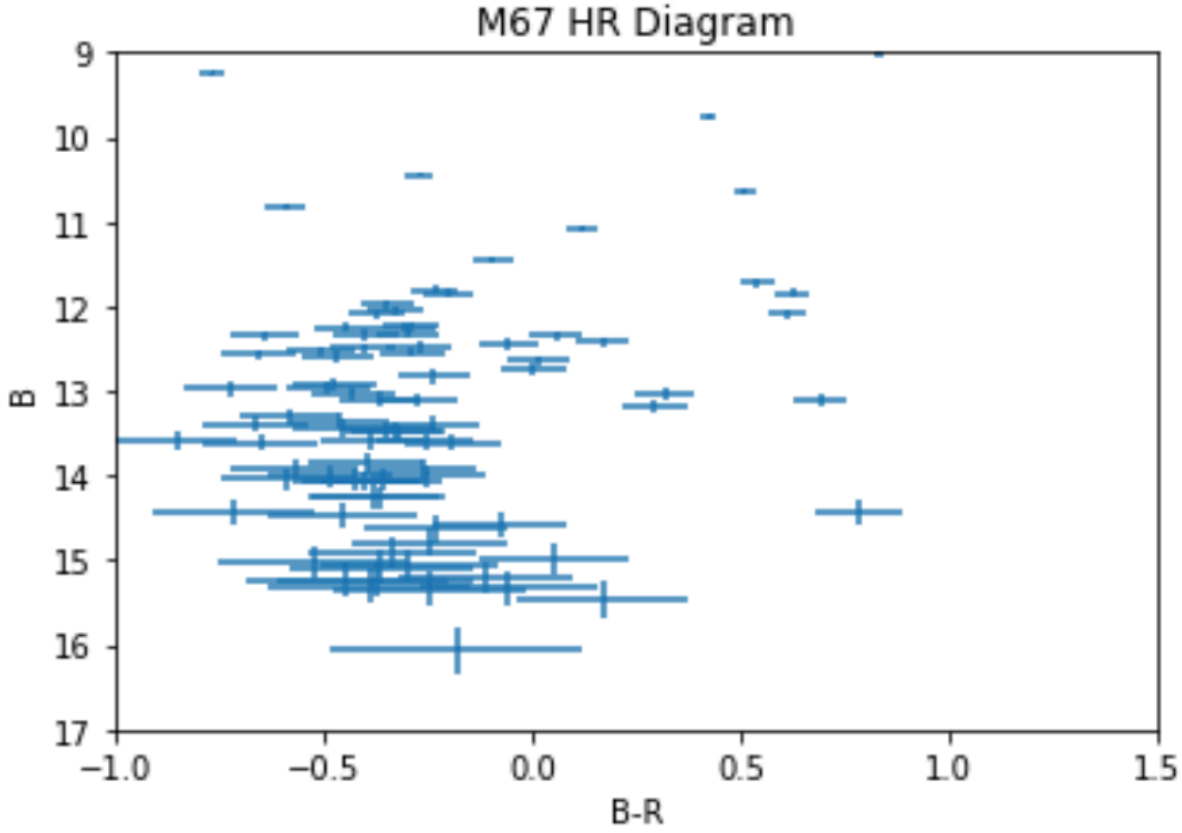

Catalog HR Diagram
B
B-V
9
10
11
12
13
14
15
16
17
18
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

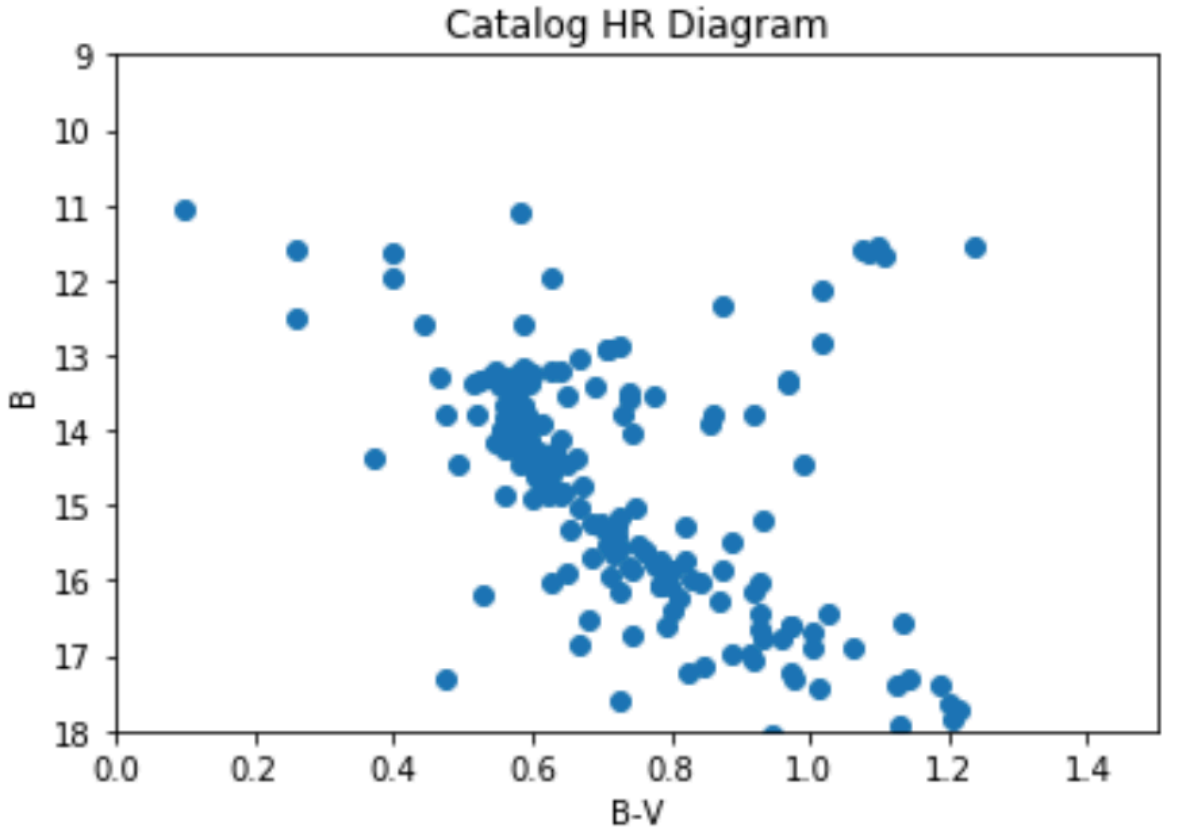
M38


M38 HR Diagram
B
B-R
9
10
11
12
13
14
15
16
17
18
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0

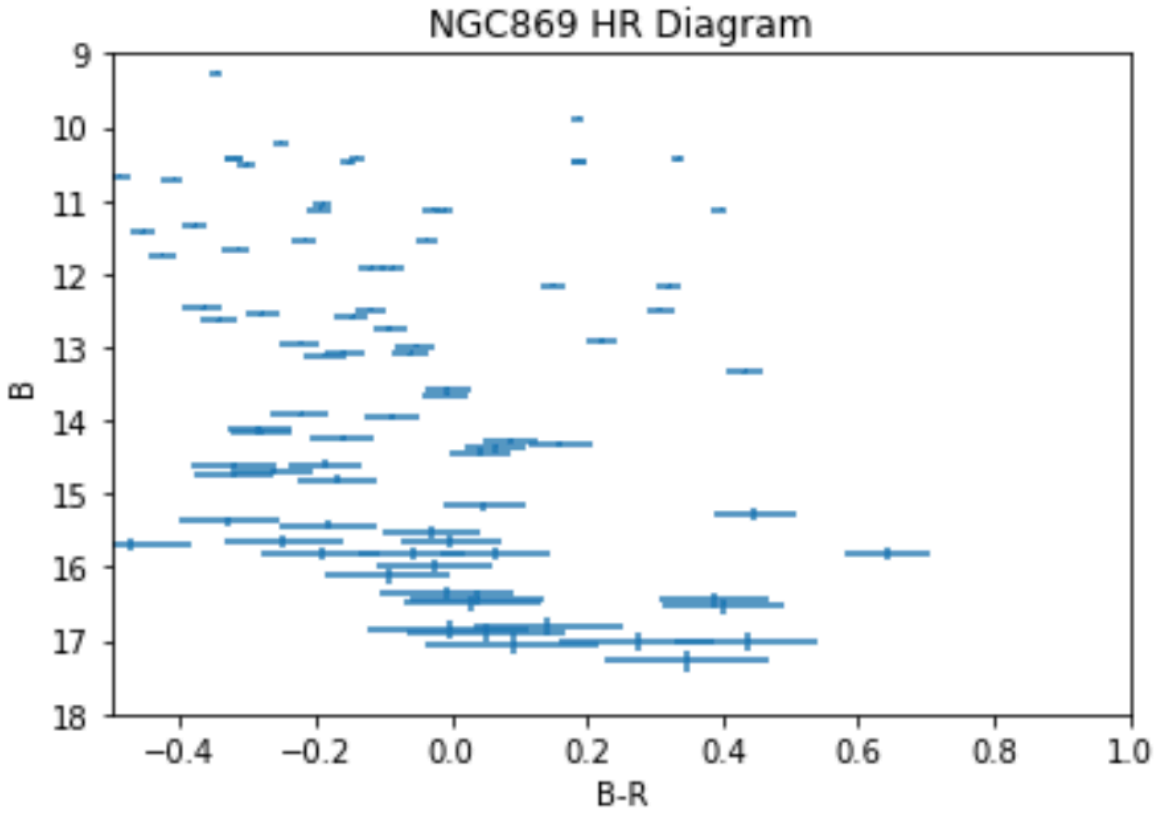

Catalog HR Diagram
B
B-V
9
10
11
12
13
14
15
16
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4

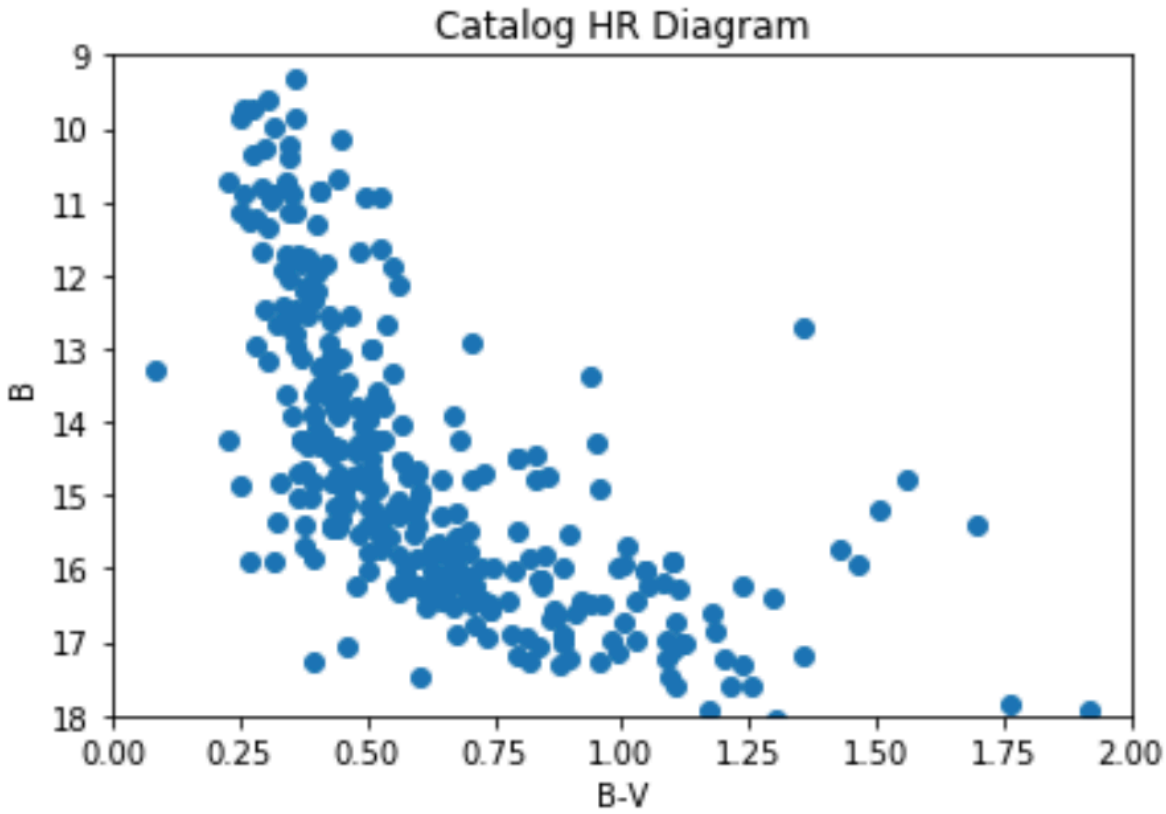
M67


M67 HR Diagram
B
B-R
9
10
11
12
13
14
15
16
17
−1.0
−0.5
0.0
0.5
1.0
1.5

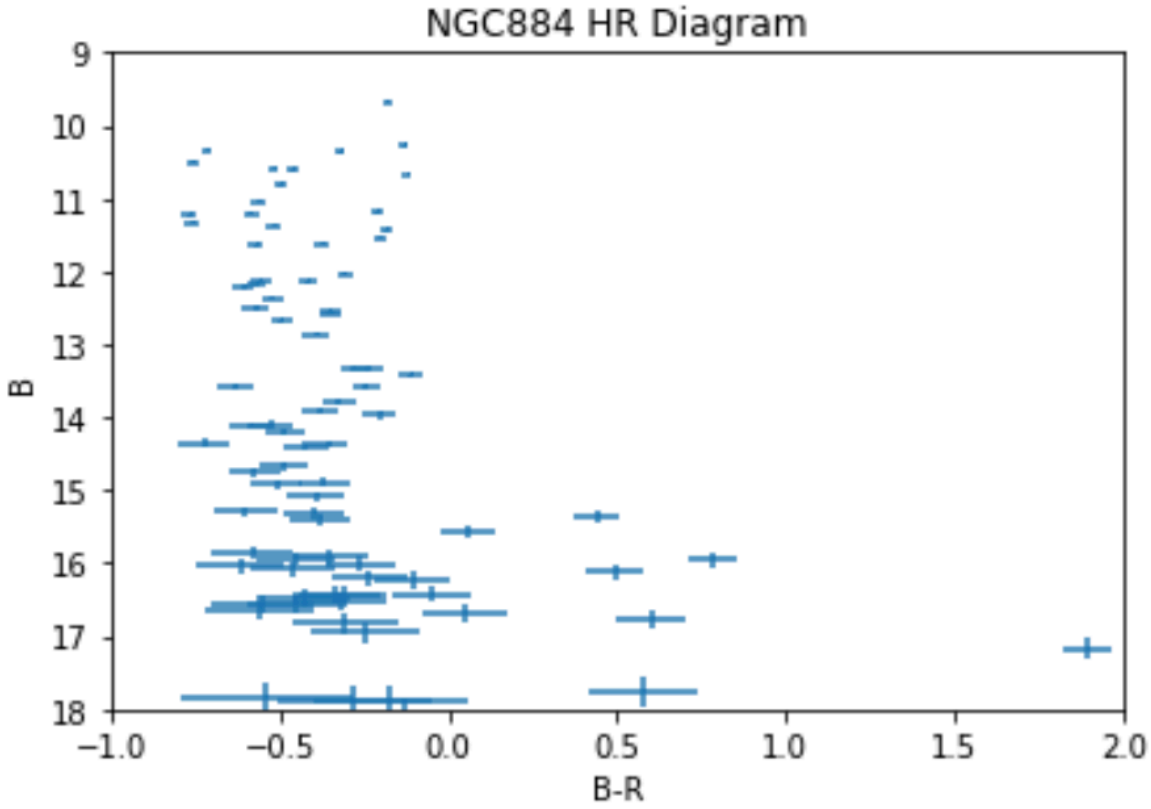

Catalog HR Diagram
B
B-V
9
10
11
12
13
14
15
16
17
18
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4

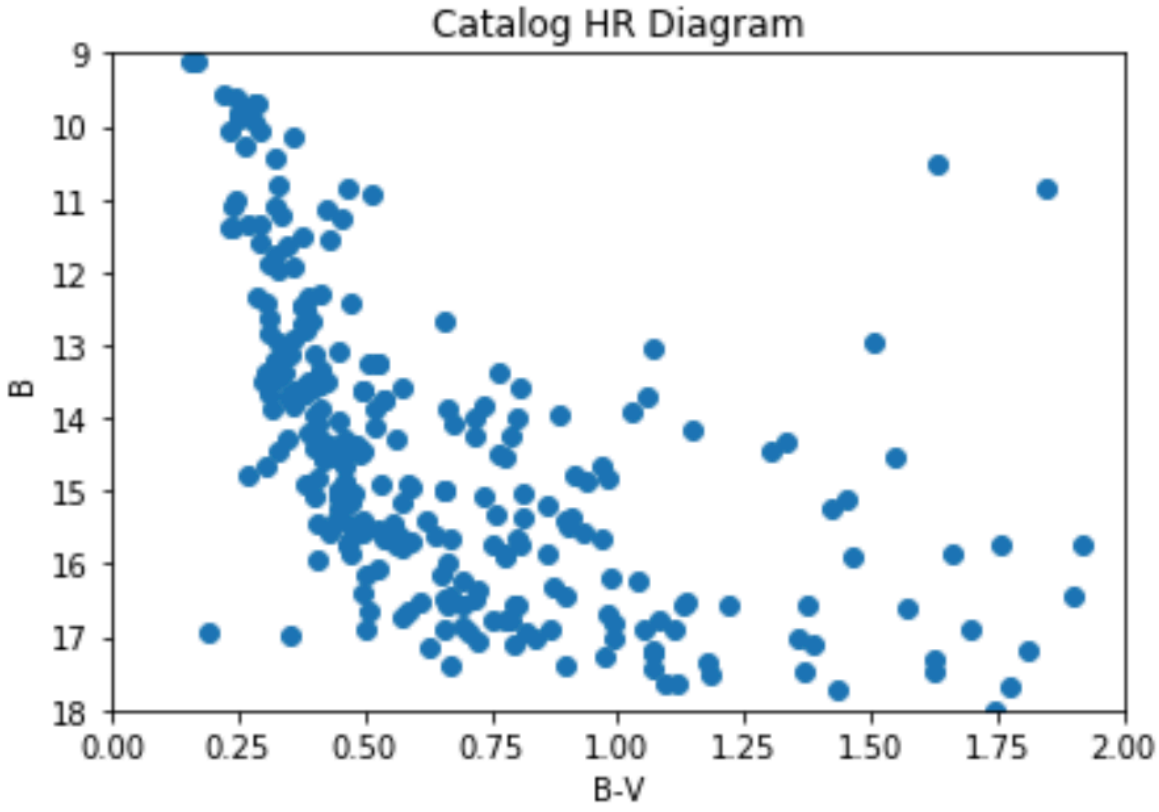
NGC 869


NGC869 HR Diagram
B
B-R
9
10
11
12
13
14
15
16
17
18
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
1.0


Catalog HR Diagram
B
B-V
9
10
11
12
13
14
15
16
17
18
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

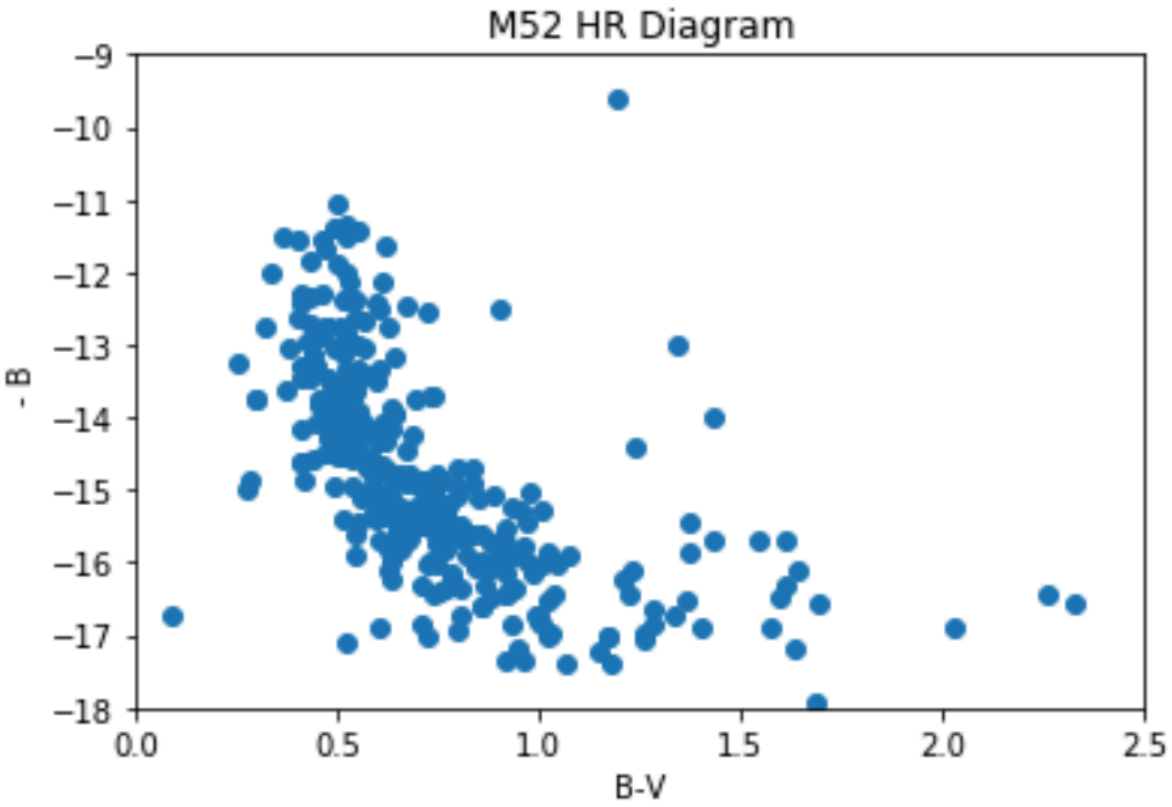
NGC 884


NGC884 HR Diagram
B
B-R
9
10
11
12
13
14
15
16
17
18
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0


Catalog HR Diagram
B
B-V
9
10
11
12
13
14
15
16
17
18
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

As an excercise and for reference purposes, an HR Diagram was generated from catalog data.

M52



In [ ]:
```
1
```