In [1]:
```
#Will need to subtract the flux of the sky, take it of random spots then subtract.
#Will also need magnitudes, reduce standard stars fits images, use exact same aperture photometry with standard
#and then look up their magnitudes. m = -2.5log10(Flux given) - m0, where m0. For standard star, look up its
#magnitude, which is m, then solve for m0. Plug in the new flux with m0, and then solve for magnitude, which we
#graph. Then we have the magnitude in 2 passbands, horizontal axis is color (B-V) which the vertical axis being
#magnitudes. Lamdolt standard stars with websites that come up, select field, chart will come up that has circle
#standard stars and their magnitudes in their passbands. To get B filter, its B-V+V
```

In [2]:
```
from photutils.aperture import CircularAperture
from pathlib import Path
import ccdproc as ccdp
import numpy as np
from photutils.aperture import aperture_photometry
from astropy import units as u
from astropy.coordinates import SkyCoord
from photutils.aperture import SkyCircularAperture
import os
%matplotlib inline
from astropy.io import fits
from astropy import wcs
import math
import matplotlib.pyplot as plt
from astropy.nddata import CCDData
```

In [3]:
```
b_standard = CCDData.read('bstandardreduced.fits')
b_positions_standard = [(272,1268), (627,989), (1623,1311), (906,548)]
b_standard_aperture = CircularAperture(b_positions_standard, r=2)

#b_bkg_standard_positions = [(347,1705), (1723,1673), (1770,520), (390,433), (1071,1071)]
#b_bkg_standard = CircularAperture(b_bkg_standard_positions, r=2)
#b_bkg_standard_table = aperture_photometry(b_standard, b_bkg_standard)
#b_bkg_standard_table['aperture_sum'].info.format = '%.8g'
#b_bkg_standard_fluxes = np.array(b_bkg_standard_table['aperture_sum'])
#b_bkg_standard_fluxes_final = np.average(b_bkg_standard_fluxes)

b_standard_table = aperture_photometry(b_standard, b_standard_aperture)
b_standard_table['aperture_sum'].info.format = '%.8g'
print(b_standard_table)
```

```
 id xcenter ycenter aperture_sum  aperture_sum_err
      pix     pix       adu             adu
--- ------- ------- ------------ ------------------
  1   272.0  1268.0    160129.95  787.2085866068649
  2   627.0   989.0    56038.505  288.7181446152346
  3  1623.0  1311.0    194631.78  975.7481645404863
  4   906.0   548.0     21784.99 107.69712003149557
```

```
WARNING: FITSFixedWarning: RADECSYS= 'FK5 ' / Coordinate reference frame
the RADECSYS keyword is deprecated, use RADESYSa. [astropy.wcs.wcs]
```

In [4]:
```
b_standard_fluxes = np.array(b_standard_table['aperture_sum'])/20.0140
b_m = np.array([(-.290+13.474), (.688+13.512), (.608+12.453), (.679+14.751)])
b_standard_m0 = b_m + 2.5*np.log10(b_standard_fluxes)
b_standard_m0_average = np.average(b_standard_m0)
print(b_standard_m0_average)
```

```
22.95312165554844
```

In [5]:
```
b_data = CCDData.read('bstacked.fits')
positions_data = [(1471, 835), (748, 633), (602,1820), (885, 1763), (1182,491), (1148,732), (206,646), (318,930)
             (249,1910), (427, 2005), (1295,1747), (212,1351), (1149,1545), (1583,57), (689,405),
             (1540,633), (435,122), (203,1003), (728,1528), (1364,999), (1652,521), (1506,177), (1912,266), (12(
             (1559,1240), (1639,1763), (1825,684), (1012,1087), (1506,1576), (1282,1344), (913,1555), (892,1049)
             (1327,1647), (1107,1136), (726,1128), (1199,805), (1489,1676), (1041,1381), (689,1236), (1182,365)
             (1302,1510), (1344,1522), (1377,290), (1195,1472), (1365,208)]
b_data_aperture = CircularAperture(positions_data, r=2)

#b_bkg_data_positions = [(154,1612), (157,519), (1960,1146), (989,505), (1752,1859)]
#b_bkg_data = CircularAperture(b_bkg_data_positions, r=2)
```

```
#b_bkg_data_table = aperture_photometry(b_data, b_bkg_data)
#b_bkg_data_table['aperture_sum'].info.format = '%.8g'
#b_bkg_data_fluxes = np.array(b_bkg_data_table['aperture_sum'])
#b_bkg_data_fluxes_final = np.average(b_bkg_data_fluxes)

b_data_table = aperture_photometry(b_data, b_data_aperture)
b_data_table['aperture_sum'].info.format = '%.8g'  # for consistent table output
print(b_data_table)
```

```
WARNING: FITSFixedWarning: RADECSYS= 'FK5 ' / Coordinate reference frame
the RADECSYS keyword is deprecated, use RADESYSa. [astropy.wcs.wcs]
 id xcenter ycenter aperture_sum  aperture_sum_err
      pix     pix       adu             adu
--- ------- ------- ------------ ------------------
  1  1471.0   835.0    316322.03 1536.3686464418788
  2   748.0   633.0    63138.856  316.6106789935777
  3   602.0  1820.0    66651.669 326.67830096693547
  4   885.0  1763.0    72007.811  364.0919618932548
  5  1182.0   491.0    91872.034  459.4761551510955
  6  1148.0   732.0    108700.15  527.1021153285469
  7   206.0   646.0    126897.73  626.4031920761847
  8   318.0   930.0    57787.517   293.915307654643
  9   249.0  1910.0    112791.19  562.6402747977187
 10   427.0  2005.0    312186.05  1554.931627533925
...     ...     ...          ...                ...
 38  1489.0  1676.0    32405.474 144.50095148723585
 39  1041.0  1381.0    33893.388 169.62666694657844
 40   689.0  1236.0    48311.009 241.17806863541284
 41  1182.0   365.0    29383.083 151.72105637084533
 42   908.0   788.0     44704.68 221.33808569015508
 43  1302.0  1510.0    44573.178  223.4753684430488
 44  1344.0  1522.0    37502.753 184.76904119487577
 45  1377.0   290.0    33371.984 164.11093489583874
 46  1195.0  1472.0    36394.753 181.90848376341222
 47  1365.0   208.0     26796.29 133.31919847383523
Length = 47 rows
```

In [6]:

```
b_data_fluxes = np.array(b_data_table['aperture_sum'])/2700.009
b_data_magnitudes = b_standard_m0_average - 2.5*np.log10(b_data_fluxes)
print(b_data_magnitudes)
```

```
[17.78121108 19.53079292 19.47200711 19.38808566 19.12357636 18.94095931
 18.77290003 19.62694959 18.90084672 17.79550095 19.52953025 19.77900433
 19.85457106 18.02990398 18.88895476 19.4777284  20.10244646 20.10750348
 20.34948052 19.76361179 19.82988647 21.02383746 20.49064498 20.09214318
 20.07464335 20.48152693 20.10365239 20.55590655 20.36142807 20.16229415
 20.29933247 20.36017732 20.2591579  19.90883774 20.28158173 19.96310703
 19.75991702 20.25498873 20.20624724 19.82141942 20.36129127 19.9056522
 19.90885069 20.09637682 20.22307962 20.12893775 20.46134803]
```

In [7]:

```
v_standard = CCDData.read('vstandardreduced.fits')
v_positions_standard = [(272,1268), (627,989), (1623,1311), (906,548)]
v_standard_aperture = CircularAperture(v_positions_standard, r=2)

#v_bkg_standard_positions = [(347,1705), (1723,1673), (1770,520), (390,433), (1071,1071)]
#v_bkg_standard = CircularAperture(v_bkg_standard_positions, r=2)
#v_bkg_standard_table = aperture_photometry(v_standard, v_bkg_standard)
#v_bkg_standard_table['aperture_sum'].info.format = '%.8g'
#v_bkg_standard_fluxes = np.array(v_bkg_standard_table['aperture_sum'])
#v_bkg_standard_fluxes_final = np.average(v_bkg_standard_fluxes)

v_standard_table = aperture_photometry(v_standard, v_standard_aperture)
v_standard_table['aperture_sum'].info.format = '%.8g'
print(v_standard_table)
```

```
WARNING: FITSFixedWarning: RADECSYS= 'FK5 ' / Coordinate reference frame
the RADECSYS keyword is deprecated, use RADESYSa. [astropy.wcs.wcs]
 id xcenter ycenter aperture_sum  aperture_sum_err
      pix     pix       adu             adu
--- ------- ------- ------------ ------------------
  1   272.0  1268.0    135312.86 144.43472141255012
  2   627.0   989.0    158201.97  155.3073932254682
```

```
  3  1623.0  1311.0    311618.36 269.03856583191185
  4   906.0   548.0    45803.528   40.2486210824819
```

In [8]:
```
v_standard_fluxes = np.array(v_standard_table['aperture_sum'])/20.0112
v_m = np.array([(13.474), (13.512), (12.453), (14.751)])
v_standard_m0 = v_m + 2.5*np.log10(v_standard_fluxes)
v_standard_m0_average = np.average(v_standard_m0)
print(v_standard_m0_average)
```

```
23.097487749495215
```

In [9]:
```
v_data = CCDData.read('vstacked.fits')
positions = [(1300, 840), (586, 629), (448, 1824),(715,1764), (1012,491), (986,732), (36,646), (152,926),
             (74,1906), (252,2005), (1129,1751), (46,1356), (987,1549), (1417,62), (523,401),
             (1366,633), (261,122), (41,1003), (556,1528), (1198,999), (1486,521), (1336,177), (1750,266), (110
             (1389,1240), (1472,1763), (1655,684), (842,1083), (1339,1576), (1111,1344), (742,1566), (726,1054)
             (1161,1647), (941,1137), (556,1128), (1033,805), (1319,1676), (871,1381), (522,1236), (1016,369),
             (1136,1514), (1174,1522), (1211,291), (1028,1473), (1198,212)]
v_data_aperture = CircularAperture(positions, r=2)

#v_bkg_data_positions = [(65., 1600.), (70., 186.), (1600., 177.), (1587., 1846.), (740., 1300.)]
#v_bkg_data = CircularAperture(v_bkg_data_positions, r=2)
#v_bkg_data_table = aperture_photometry(v_data, v_bkg_data)
#v_bkg_data_table['aperture_sum'].info.format = '%.8g'
#v_bkg_data_fluxes = np.array(v_bkg_data_table['aperture_sum'])
#v_bkg_data_fluxes_final = np.average(v_bkg_data_fluxes)

v_data_table = aperture_photometry(v_data, v_data_aperture)
v_data_table['aperture_sum'].info.format = '%.8g'  # for consistent table output
print(v_data_table)
```

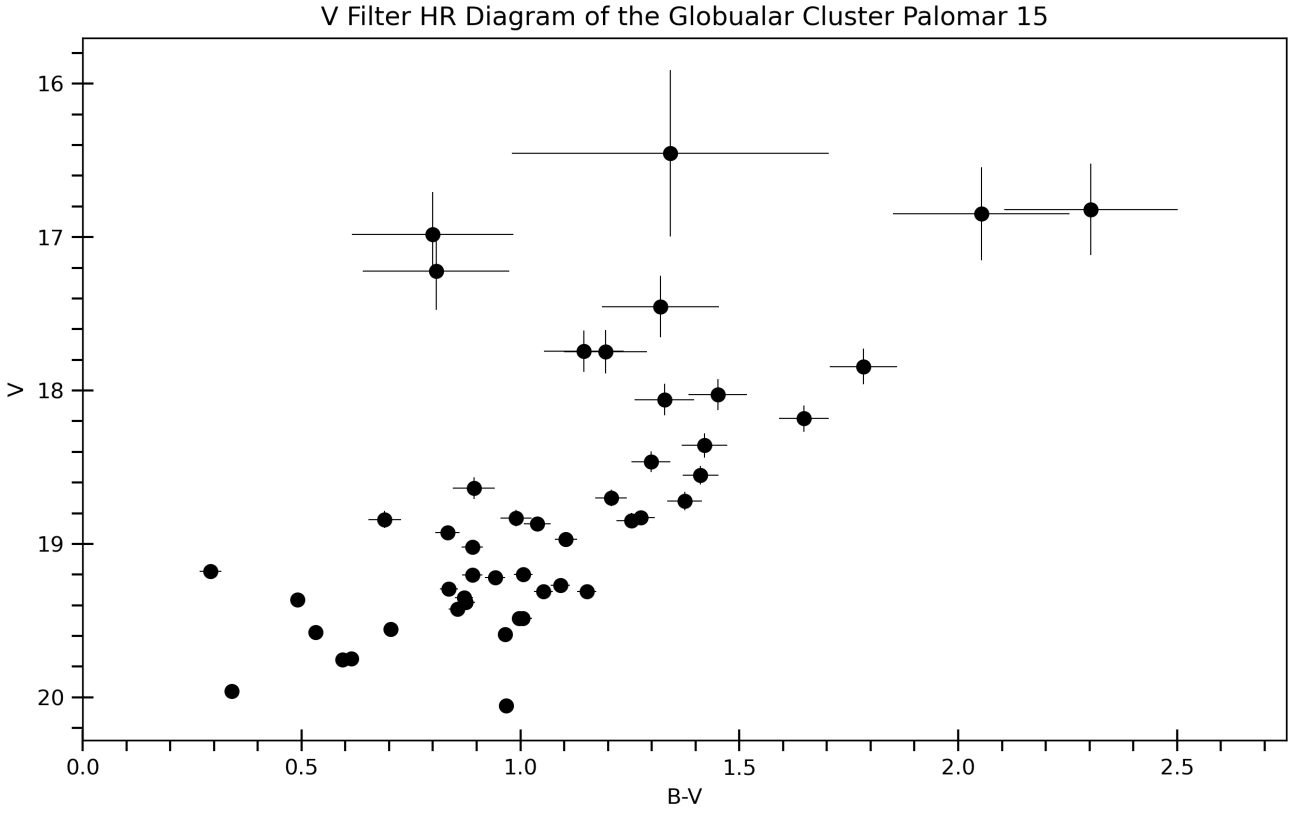
```
WARNING: FITSFixedWarning: RADECSYS= 'FK5 ' / Coordinate reference frame
the RADECSYS keyword is deprecated, use RADESYSa. [astropy.wcs.wcs]
 id xcenter ycenter aperture_sum  aperture_sum_err
      pix     pix       adu             adu
--- ------- ------- ------------ ------------------
  1  1300.0   840.0    502890.42 497.29863038916784
  2   586.0   629.0    90747.894 100.58031167651164
  3   448.0  1824.0    66405.081  67.78716518876365
  4   715.0  1764.0     186489.3 183.72078741193138
  5  1012.0   491.0    583659.15  536.1777358005531
  6   986.0   732.0     248677.7  254.5293666662762
  7    36.0   646.0    325858.63  361.2008451708175
  8   152.0   926.0    227404.78   207.775772114012
  9    74.0  1906.0    569049.59  544.9186061968733
 10   252.0  2005.0    818623.51  976.6289817730859
...     ...     ...          ...                ...
 38  1319.0  1676.0     55264.259  56.01184719997637
 39   871.0  1381.0     65231.758  57.85323774743368
 40   522.0  1236.0     91536.699  96.93355499431603
 41  1016.0   369.0     58990.602 56.415381061472125
 42   742.0   792.0     88578.749  83.52131724756924
 43  1136.0  1514.0     103183.66  96.92943804825317
 44  1174.0  1522.0     101350.96 107.28937919500795
 45  1211.0   291.0     56703.949  55.67864811561655
 46  1028.0  1473.0     59881.961  56.25914625558949
 47  1198.0   212.0     58924.904  60.39980941797377
Length = 47 rows
```

In [10]:
```
v_data_fluxes = np.array(v_data_table['aperture_sum'])/1800.010
v_data_magnitudes = v_standard_m0_average - 2.5*np.log10(v_data_fluxes)
print(v_data_magnitudes)
```

```
[16.98199163 18.84108365 19.18017177 18.05904027 16.82027679 17.74658293
 17.45310196 17.84367605 16.84779976 16.45296452 18.6359862  18.35852065
 19.36364419 17.22256785 17.74386961 18.02701421 18.84868667 19.57524004
 19.75625032 18.46537977 18.1823928  20.05612067 19.48481952 19.20209192
 18.97068791 19.48420644 18.82917166 19.59040622 19.74754372 19.22014339
 19.95919438 19.26899944 19.55504165 19.0188208  19.42496074 18.55175242
 18.92645332 19.37956417 19.19952733 18.83168693 19.30871798 18.86735119
 18.70164768 18.7211054  19.35164177 19.29243502 19.30992784]
```

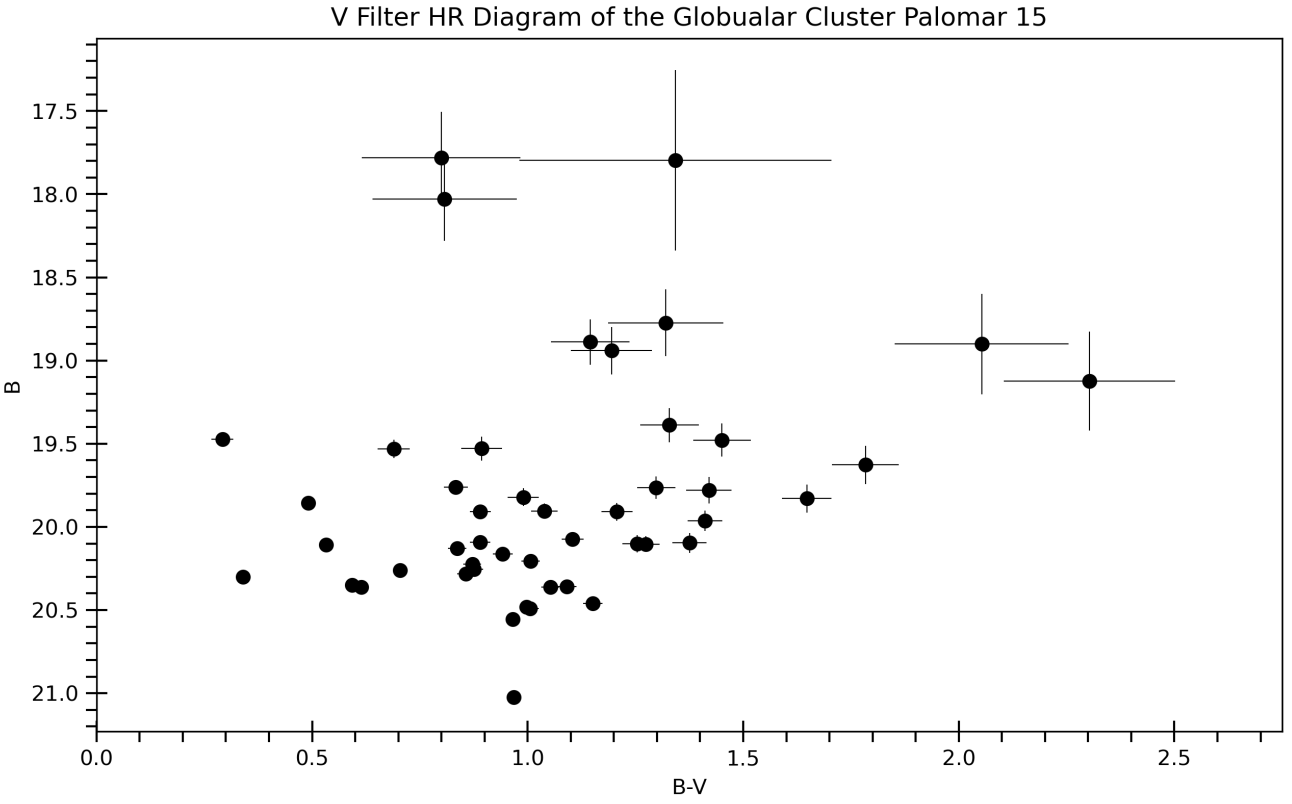
In [11]:
```
yerror = np.array(v_data_table['aperture_sum_err'])/1800.010
xerror = np.array(v_data_table['aperture_sum_err'])/2700.090
x_axis = b_data_magnitudes - v_data_magnitudes
y_axis = v_data_magnitudes
print(x_axis)
fig = plt.figure(figsize=(10, 6), dpi=300)
ax = plt.axes()
plt.errorbar(x_axis,y_axis,xerr=xerror, yerr=yerror, fmt="o", color='black', elinewidth = .5, barsabove = True)
ax.invert_yaxis()
ax.set_xlim([0,2.75])
ax.minorticks_on()
ax.tick_params(which='major', length=10, width=1, direction='inout')
ax.tick_params(which='minor', length=5, width=1)
plt.title('V Filter HR Diagram of the Globualar Cluster Palomar 15')
plt.xlabel('B-V')
plt.ylabel('V')
plt.scatter(x_axis, v_data_magnitudes, color='black', s=1, marker ='.')
plt.savefig('vfiltpal15')
```

```
[0.79921944 0.68970927 0.29183535 1.32904539 2.30329957 1.19437638
 1.31979807 1.78327354 2.05304695 1.34253643 0.89354404 1.42048368
 0.49092687 0.80733613 1.14508514 1.45071418 1.25375979 0.53226345
 0.5932302  1.29823201 1.64749366 0.96771679 1.00582545 0.89005126
 1.10395544 0.99732048 1.27448073 0.96550033 0.61388435 0.94215076
 0.34013809 1.09117789 0.70411625 0.89001694 0.856621   1.41135461
 0.83346369 0.87542456 1.0067199  0.98973249 1.05257329 1.03830101
 1.207203   1.37527142 0.87143785 0.83650274 1.15142018]
```



In [13]:
```
yerror = np.array(v_data_table['aperture_sum_err'])/1800.010
xerror = np.array(v_data_table['aperture_sum_err'])/2700.090
x_axis = b_data_magnitudes - v_data_magnitudes
y_axis = b_data_magnitudes
fig = plt.figure(figsize=(10, 6), dpi=300)
ax = plt.axes()
plt.errorbar(x_axis,y_axis,xerr=xerror, yerr=yerror, fmt="o", color='black', elinewidth = .5, barsabove = True)
ax.invert_yaxis()
ax.set_xlim([0,2.75])
ax.minorticks_on()
ax.tick_params(which='major', length=10, width=1, direction='inout')
ax.tick_params(which='minor', length=5, width=1)
plt.title('V Filter HR Diagram of the Globualar Cluster Palomar 15')
```

```
plt.xlabel('B-V')
plt.ylabel('B')
plt.scatter(x_axis, y_axis, color='black', s=1, marker ='.')
plt.savefig('bfiltpal15')
```



In [ ]: