2MASS Data Collection for Globular Clusters

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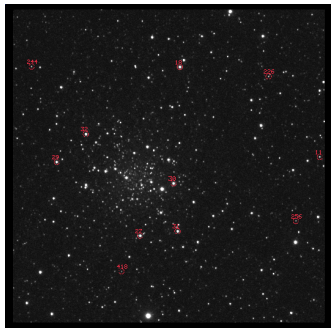
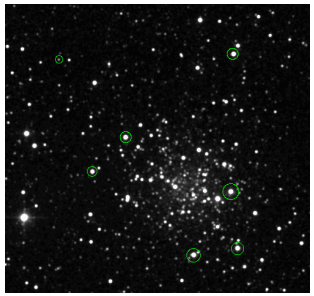
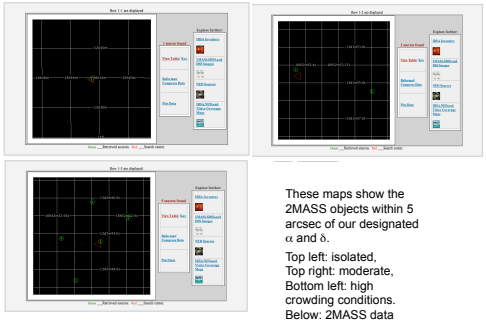


Left image: NGC 6496 from the BGSU 0.5m telescope in the *I* band. Circles mark possible variable stars with identification numbers from Abbas (2011).



Left image: 2MASS *J*-band image of the same cluster, with only the top left quadrant.



These maps show the 2MASS objects within 5 arcsec of our designated α and δ.

Top left: isolated,
Top right: moderate,
Bottom left: high crowding conditions.
Below: 2MASS data table downloaded.

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42   298.407051 18.714378 0.06 0.06 90 19533769+1842517 7.070 0.017 0.024 55517.5 6.153 0.0\
35 0.038 57241.4 5.813 0.009 0.017 45837.4 AAA 111 111 000 666666 14.3 0 0 0.711540 310.363\
 0.9170 0.3400 1.2570
22   298.455879 18.740829 0.06 0.06 90 19534941+1844269 8.058 0.011 0.020 22347.5 7.105 0.\
025 0.029 23818.3 6.863 0.019 0.024 17426.9 AAA 111 111 000 666666 13.3 0 0 0.356311 203.10\
6 0.9530 0.2420 1.1950
497 298.458169 18.773252 0.17 0.17 135 19535020+1846237 16.338 0.148 0.148 10.9 15.785 0.14\
5 0.145 8.0 15.814 9.999 9.999 9.999 BBU 220 110 cc0 060600 7.7 0 0 1.954786 143.766 0.5530\
 -0.029 0.524
65   298.474998 18.784281 0.06 0.06 90 19535399+1847034 7.742 0.017 0.024 29897.2 6.745 0.0\
41 0.044 33182.6 6.478 0.013 0.020 24843.9 AAA 111 111 000 666666 6.9 0 0 0.111880 356.504\
 0.9970 0.2670 1.2640
39   298.483752 18.787989 0.06 0.06 90 19535610+1847167 7.943 0.015 0.023 24844.5 7.078 0.0\
31 0.034 24418.0 6.681 0.013 0.020 20607.2 AAA 111 111 000 666666 7.9 0 0 0.482181 344.417\
 0.8650 0.3970 1.2620
1    298.513037 18.830585 0.06 0.06 90 19540312+1849501 9.737 0.026 0.029 4760.2 9.892 0.0\
28 0.029 2198.4 9.673 0.016 0.018 1369.8 AAA 222 111 000 666666 12.8 0 0 0.462092 258.767\
 .0450 0.0190 0.0640
462 298.584404 18.777515 0.06 0.06 0 19542025+1846390 13.530 0.023 0.026 149.8 13.300 0.031\
 0.032 79.2 13.207 0.025 0.026 50.5 AAA 222 111 000 665566 10.0 0 0 0.331776 260.628 0.2300\
 0.0930 0.3230
116 298.591826 18.868006 0.06 0.06 0 19542203+1852048 8.439 0.019 0.025 16286.6 7.532 0.041\
 0.044 16073.5 7.167 0.015 0.021 13171.0 AAA 111 111 000 666656 11.4 0 0 0.286694 182.928\
 .9070 0.3650 1.2720
6    298.341533 18.830208 0.06 0.06 90 19532196+1849487 7.067 0.031 0.035 53781.1 6.123 0\
.025 0.029 54917.4 5.868 0.025 0.029 42094.0 AAA 111 111 000 666656 9.7 0 0 0.289303 24.670\
 0.9440 0.2550 1.1990
44   298.277922 18.946783 0.06 0.06 90 19530670+1856484 7.003 0.017 0.024 57046.6 6.025 0.0\
59 0.041 60194.9 5.593 0.007 0.016 54227.6 AAA 111 111 000 666656 21.0 0 0 0.459735 102.202\
_0.9780 0.4320 1.4160
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Obtaining Images

Once the clusters that we are studying have been selected, the 2MASS website and database (located at http://irsa.ipac.caltech.edu/applications/2MASS/QL/interactive.html) has images in the fits format, which we can compare to images compiled from our telescope here at Bowling Green. However, the images often do not share the same viewing area, and multiple pictures must be used from the 2MASS site. For example, the image on the top left is a compilation from our telescope, and the image just below it is the relevant segment for one of the four pictures from the database. This image matches the top left corner of our image. Missing sections of data are not an issue, since the 2MASS images overlap each other.

Acquiring coordinates

With the 2MASS images, we can find the right ascension (α) and declination (δ) of variables we have marked in the cluster using the World Coordinate System values displayed by DS9. By finding the marked stars in the 2MASS image by comparing with our image, this will give us approximate coordinates when selected. The x-value and y-value coordinate values of the stars in the 2MASS images were also recorded. For isolated stars, finding the correct coordinates is easy, while for stars near the center of a dense cluster identifying the variable star is difficult. This can cause issues when drawing magnitudes from the 2MASS databases.

2MASS IR Photometry Data

Now that we have the coordinates for the stars that we are interested in, we can supplement our data with more data from 2MASS. Using the Gator portion of the 2MASS site (http://irsa.ipac.caltech.edu/applications/Gator/), we can obtain the J and K-magnitudes recorded by 2MASS along with other data such as error, proximity to the nearest star, and quality of data. Inputting the approximate α and δ will give us a screen similar to the examples in the middle left, and various viewing ranges can be chosen. Beneath this image is a list of data, ordered with respect to the numbers in the image. The data given for our listed variables is transferred to our network. Along with the specific data for the speculated variable stars, we also transferred to the data for the entire cluster, out to 5 to 10 arc minutes. An example of the data strings collected is on the bottom left.

K and J-K comparison

The final step is to graph the relation between the K magnitudes and the J-K values for each possible variable we have found. Graphing these values gives us a form of magnitude and color diagram, akin to the HR diagram. Supermongo is the main program used during this process. We use both sets of data collected, with each star in the cluster shown in blue, and the variables shown larger and in red. Also added to the graph are the error bars for the variables found, linked to their respective points of data. Variables near the top right of the graph indicate Long Period Variable stars at the top of the Red Giant Branch. The other variables my be eclipsing binary systems or other pulsating variables on which light curve analysis is ongoing.