A Comparision on Photometric Techniques on NGC 6624

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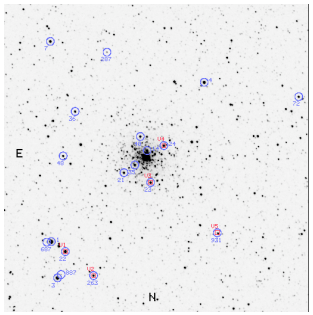
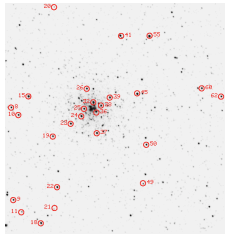
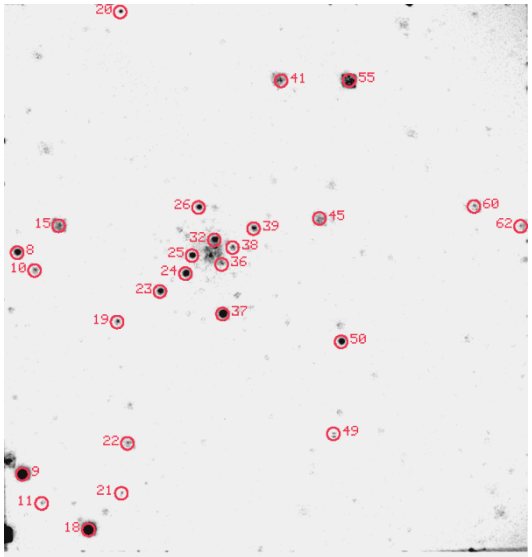




(Upper Left) This is an image in which the previously discovered variables (red squares) and those found using DAOPHOT (blue circles) are marked (Dando et. al, 2009). (Upper Right) Is a similar image, oriented in the same way, in which the variables found using ISIS are marked with red circles. The image of the cluster is cropped to a smaller area because of the way the cluster shifted in the images. A few of the same stars were recognized with both DAOPHOT and ISIS, such as 48 = 8; 4 = 55; 23 = 37. In ISIS, the subtracted digital images allow us to look deeper into the core of the cluster and find potential variable stars.



(Above) The last image ISIS produces for NGC 6624 is a potential variable image. The larger, darker objects, such as 9 and 18, have the largest possibility of being a variable star, while the fainter unmarked blemishes are least likely to be a variable star. This is created by taking all of the subtracted images and combining the absolute values of across all of them. After the potential variable image was created, I used it to determine a lower threshold at which to create light curve files for the various stars. From these files I created the plots on the right and began to classify the LPVs into one of three groups. With the image above I was able to look for variable stars closer to the center of the cluster than previous studies that used photographic plates.

Abstract

Stars that vary brightness and color through time are called variable or pulsating stars. Some of these stars have repeating cycles ranging multiple times a day to almost a year. There are a few ways of finding variable stars, and this comparison was done to support a preliminary data set that was analyzed last fall using one of these techniques. The stars with longer periods, greater than 100 days, have had few studies. This leaves a gap in the understanding of these stars. We collect data on these long period variables (LPVs) in globular star cluster. Previous photographic studies on NGC 6624 have discovered five varible stars. Other works yielded such information as age, composition, and distance, which in turn helps astronomers understand the evolution of the LPVs.

Observations

Over the past year and a half, 51 observations have been taken remotely using the PROMPT 0.4m telescope array on Cerro Tololo in Chile. Using a web interface we requested and downloaded images taken through V-band (green) and I-band (near-infrared) filters. Images were combined by students to remove electronic noise and blemishes.

Processing

In the fall of 2009, a preliminary analysis of the first 21 images was done using DAOPHOT. DAOPHOT is a program that determines the likelihood of stars being variable based on their apparent brightness and searching for individual stars on each image that vary (Stetson, 1987). The present analysis was done using ISIS (Alard, 2000), an image subtraction software that finds variable stars by calculating a difference in flux, or the amount of light that we detect. After the images were calibrated, I used ISIS to trim down and rotate them to a similar orientation. During the rotation step, I encountered a problem with the shortest exposure length images. The rotation program would remove the coldest reading pixels and replace them with a box of 9 pixels in an attempt to eliminate potentially corrupted data. To resolve this problem, I added a uniform amount of counts to each pixel on all of the short exposure images. The next few steps in ISIS created an image of possible variable star by subtracting the nightly images from a reference image and determining the difference in flux. This was all combined into a master image, that was viewed, and then a limit was determined and time and flux difference files were created for the most likely candidates.

Conclusion and Future

With the use of CCD cameras we are building a higher quality electronic database than the photographic plates used in the past. This also allows for a higher level of analysis. The use of both DAOPHOT and ISIS will allow us to better determine the location and period of the LPVs and other variable stars globular clusters, especially in the crowded cluster centers. Data will continue to be taken on NGC 6624 until approximately the end of the year, if enough cycles of the LPVs have been observed. NGC 6624 is just one of the clusters in a survey of about 20 globular cluster looking for LPVs. So far in NGC 6624 we have raise the number of known variables from 5 to approximately 30. Information that is gathered through this research will be made available to the astronomical community as it tries to better understand the evolutionary paths of stars.

References

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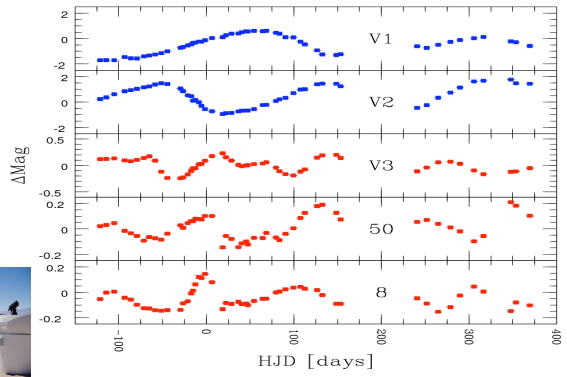

(Above) This is a plot of 5 LPVs that were detected using ISIS. The top three (V1,V2,V3) are part of the five previously found variable stars in NGC 6624(Liller & Liller, 1976). The bottom two are newly identified stars. The blue star diagrams belong to Mira LPVs. Mira variables are classified as having a period >100 days and difference of 2.5 magnitudes. The red plots are semi-regular variables with no true period but a somewhat regular fluctuation in brightness. The graph above was derived from flux differences and using the formula:

$$\Delta Mag = 2.5 \times \log((flux_{dif} + flux_{ref}) / flux_{ref})$$

where the $flux_{ref}$ is determined from the reference image and the $flux_{dif}$ is found by ISIS. This process can not be done for all the variables found by ISIS in the cluster due to the crowding near the center which cause the fluxes to overlap and the resulting ΔMag would be less then what is the true ΔMag.

(Below) The flux plot below compares two of the stars above with three stars in the core of the cluster that were found to be variable. Of these three, 24 is a semi-regular variable; 26 and 32 are irregular with small amplitudes and no discernable period. The maxima and minima in this graph are reversed to the graphs above, because less flux correlates with a fainter object, thus a lower magnitude. The plots of the fluxes have been adjusted to allow for clarity and comparison. Both the top and bottom graphs the Heliocentric Julian Date zero is 2455000.