The Search for Variable Stars in the Globular Cluster M30

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M30 (NGC7099)

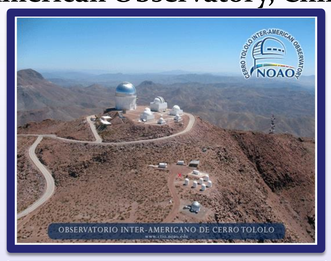
RA: 21h 40.0m DEC: -23° 11'

25,000 Light Years Away

Abstract

Our star – the Sun – has a mostly constant brightness over time. However, some stars – called variable stars - have a consistent pattern of change that occurs over a relatively short time period. Using the PROMPT telescope array in Chile, images of the globular cluster, M30, were collected to be analyzed and new variable star candidates identified so their light curves can be plotted and compared to the known light curves of different types of variable stars. In this way, the variable stars of M30 can be identified and classified with a low error margin. The presence and behavior of these stars in such an old cluster will give us a more complete understanding of stellar evolution and the evolution of our galaxy.

PROMPT C1 – C8 Cerro Tololo Inter-American Observatory, Chile

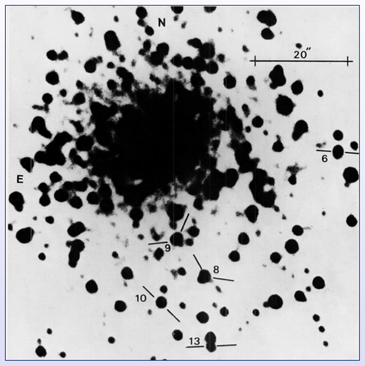


Observations

Using the PROMPT Telescope array in Chile accessed through the Skynet website, about 150 images of M30 were taken over the course of 68 days.

In an image (shown on the right) from a previous survey performed in 1975 by Terzan and Rutily, 5 stars are identified as variable. However, the observational and analytical technology available at the time may have misled them.

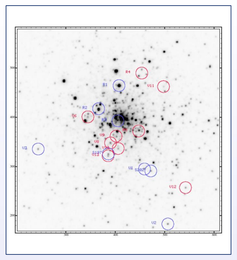
Now, CCD technology produces higher resolution images than 1970's photography.



Terzan & Rutily Image

Processing

1)IRAF: Preparing the Images - A reference star was located on each image allowing all images to be shifted and trimmed to a consistent coordinate frame.

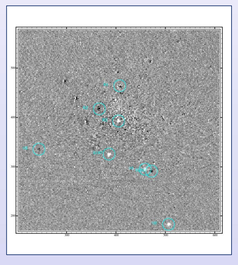


Reference Image

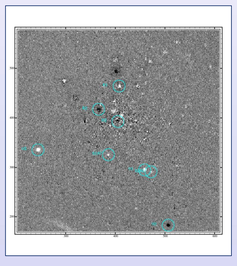
2)ISIS: Subtraction Method – The best images were first stacked to produce a clean reference image as seen below. The program then subtracted the amount of light in each image from the reference leaving only the variation of light from each star. This allowed the variable stars to show their range of variation while any that remained constant subtracted to zero (demonstrated by Subtraction Image 1 & 2 below). The subtracted images were again stacked on top of each other to highlight the variable star candidates creating the Variable Image shown below. These candidates were then measured for brightness on each of the 150 subtraction images to produce a flux vs. time data file.

3)PDM: Obtaining Period Estimates – The program attempted to calculate a light curve at every period and plotted its standard deviation. Periods that produced a small deviation were investigated and period estimates were obtained for use in plotting the light curves.

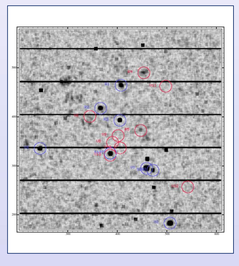
4)SM: Plotting Light Curves – The flux of light over time was given the previously obtained period estimates allowing a pattern of activity to be clearly seen. This pattern of light curve (see below) can then be compared to known light curves of different types of variable stars for classification.



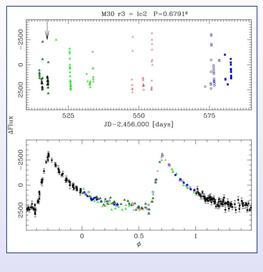
Subtraction Image 1

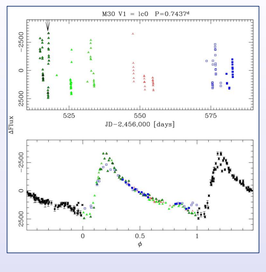


Subtraction Image 2

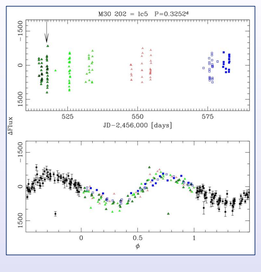


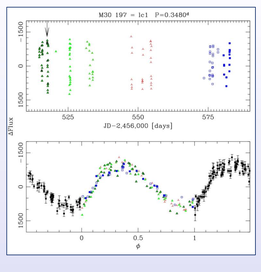
Variable Image



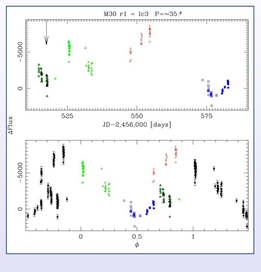


RR Lyrae ab





RR Lyrae c



LPV Mira Irregular

Conclusion

Conclusively, Terzan & Rutily's V1-V3 identifications were confirmed as variable and five new variables were discovered. However, Terzan & Rutily's V5-V13 identifications were not observed to vary within our uncertainties.

The cluster contains four RR Lyrae ab variable stars (periods of 0.4 – 1 day) and three RR Lyrae c variable stars (periods of about 0.1 - 0.4 days). We also discovered the first LPV Irregular variable star (periods of 20 -1000 days) known in M30, although because observations were only taken over the course of about 70 days, its period could not be properly identified.

These light curve patterns match up very well with textbook variable patterns from similar stars, making it relatively easy to identify the types. The statistical analysis of how many stars of each type were found in this cluster given its age is consistent with previously calculated numbers.

References: *Alard, C., 2000, A&A, 144, 363 *Terzan and Rutily, 1975, A&A, 38, 307