Searching for Variable Stars in the Field of NGC 659

Our Solar Siblings

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Abstract

THIS STUDY utilised data obtained via a remotely controlled telescope to search for variable stars in the field of NGC 659. Analysis was conducted using common astronomical software packages, as well as purpose-written Jython scripts. It was found that two stars have potential periods of 145 and 110 days, however due to the timescale of observations, the accuracy of these values are uncertain. A selection of potential variable stars were uncovered and are currently under further investigation.

Introduction

Variable stars are those which change in brightness, on timescales varying from a few seconds to many years. Variability can be a result of "intrinsic" processes within a star, or "extrinsic" events such as being eclipsed by another object. Variability can be exploited to find exoplanets, determine distances between cosmic objects, and uncover a wealth of other information about the universe.

The monitoring of variable stars was once an extremely labour intensive task, something that advances in telescopes, computers and camera sensors have since changed. There are currently many software packages available to analyse data, yet most methods still involve a certain amount of manual work. This study explored using Jython, an integration of the Python language and Java [1], to directly access the libraries on which graphical user interface programs are built, automating stages of processing.

In an earlier paper [2] observations made on twenty-six nights from 2010 to 2012 were used to designate two stars in the field of open cluster NGC 659 as irregular variables, changing in brightness with no apparent period.

	Star 1	Star2
R.A. (J2000)	01h 44m 37.56s	01h 44m 26.90s
Dec. (J2000)	+60º 49' 53.5"	+60º 44' 35.3"

Through taking a greater volume of measurements in quicker succession, it was expected that more information would be uncovered about the nature of these two stars, and potentially new variables identified.

Method

An image request was made through the LCO online portal

LCO Las Cumbres Observatory

A robotic 1 metre telescope at the Mc Donald Observatory, Texas (left) [3], imaged the field in B, V, R and I filters over four months from 16 Oct. 2015 - 27 Feb. 2016, and a further 3 months from 8 Nov. 2016 - 12 Feb. 2017

Images were imported into Muniwin and basic aperture photometry conducted using the "find variables" feature, to gain an approximate understanding of the nature of any variation

Images were sent through a DAOPhot PSF pipeline to perform accurate photometry

```
#The matching function
def run():

    #Import the target list as a star table
    targetTable = stilts.tread(targetsListPath, "cs

    #Get and iterate over the files that are to be
    fileList = glob.glob(photometryPath)

    for file in fileList:

        try:
            #Create a second table with the test fi
            checkTable = stilts.tread(file, "csv")

            #Perform the match then write result
            table = stilts.tskymatch2(ra1="RA", dec
            table.write(matchingPath + "OUT_" + get

        #Catch any bad files and log them
        except:
            global errorList
            global errorCount
            errorList.append(file)
            errorCount = errorCount+1
```

The JyStilts "tskymatch2" function was called from a Jython script to extract useful data from each photometry file

A second Jython script used the pandas library to calculate magnitudes from photometry counts along with error values.

PERANSO Light Curve and Period Analysis Software

Peranso was used to generate light curves and search for periods.

Discussion

Star 1 and Star 2 appear to be periodic variables, conflicting with other research which describes them as irregular. While our analysis utilised more measurements, working over a shorter timescale makes it possible that these results are not reflective of the true natures of the stars.

The Jython scripts that were developed have already been used by other students involved in the OSS program. Instructions have been written, and modifications made, to improve their functionality on both Windows and Mac operating systems. As this method is further refined, it will likely experience increased uptake.

Ongoing Research

There are still more avenues to be explored in this project. Star 2, while described as very red [2], has not yet been spectrally classified by any study; its spectrum has been obtained, and will be analysed over coming weeks. The stars identified by Muniwin as having a high deviation (residing above the main group in Figure 1) are to be examined further using the aforementioned method. Their variability will be confirmed, and periodicity searched for.

Results

Figure 1 shows the Muniwin "Find Variables" results. The horizontal axis shows the magnitude of each star identified in the field, and the vertical axis a value corresponding to its variation in brightness over the duration of measurements.

Figure 2 and Figure 3 are folded light curves for Star 1 and Star 2, utilising 51 and 59 measurements respectively.

Figure 4 and Figure 5 show period searches conducted on Star 1 and Star 2 using the Lomb-Scargle method [4]. The size of the peak corresponding to a certain number of days along the horizontal axis is an indication of its significance. This analysis yields the most likely period for Star 1 to be 145 days, and for Star 2, 110 days.

Figure 1 – Muniwin Varfind

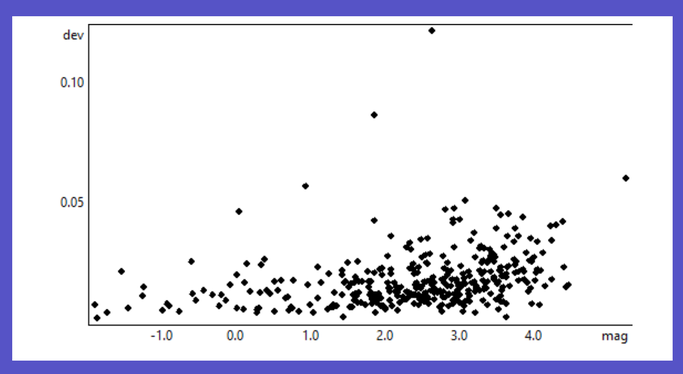


Figure 2 – Light Curve

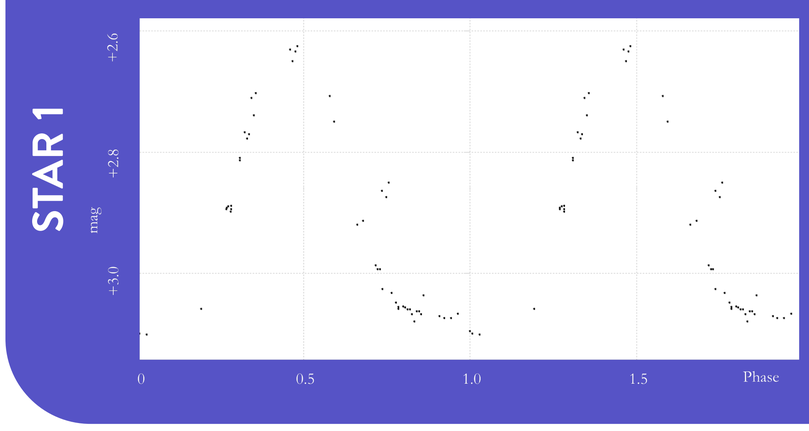


Figure 4 – Lomb-Scargle

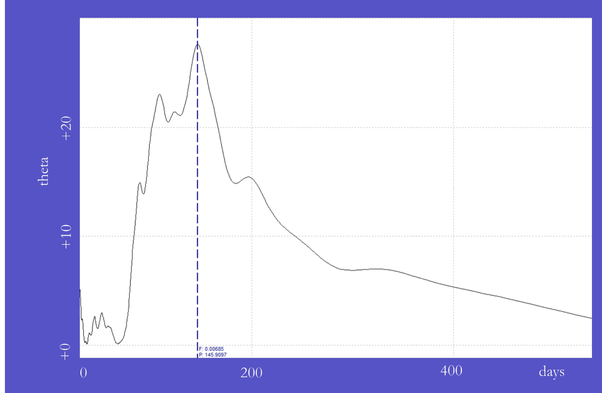


Figure 3 – Light Curve

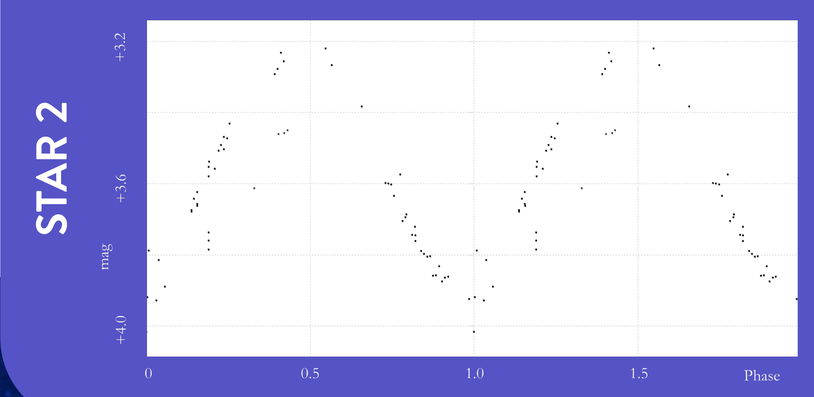
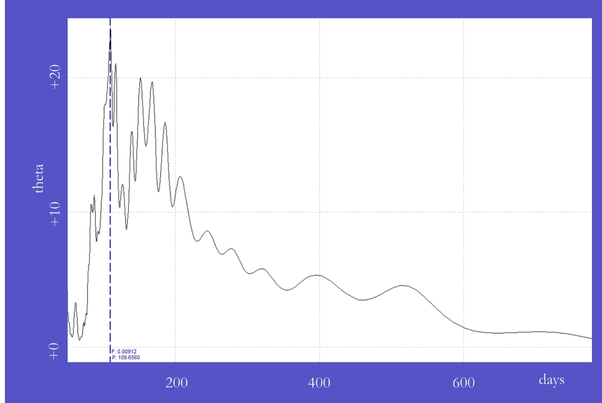


Figure 5 – Lomb-Scargle



[1] Jython. "What is Jython?", viewed 11 June 2017, http://www.jython.org/archive/21/docs/whatis.html
[2] S.P. Souza, "Two New Cool Variable Stars in the Field of NGC 659", *JAAVSO*, vol. 41, 2013.
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