Brightness Changes In A Suspected Variable Star

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It was once thought, in the time of Aristotle, four centuries BC, that all the celestial bodies were perfect spheres which revolved around the earth. The earth, then, was the centre of the universe. However Galileo (1564-1642) using telescopes contradicted this. He observed mountains and craters on the moon proving it is not a perfect sphere. His observations paved the way to modern views of the Earth and the universe in which the earth is just one of the nine planets revolving around the sun and in which our solar system is only one of many in our infinite universe[1].

The last several decades have seen an enormous increase in what we know about our solar system and the galaxies beyond. Technological advances such as telescopes and space probes allow us to view distant objects such as the moon or even galaxies beyond our own. The telescope enables us to see a magnified picture of distant objects and to increase the degree of light that reaches our eyes from a faint object such as a fixed star. The Hubble telescope was launched in 1990, and it is in orbit around the earth. It was not launched there to be closer to the stars. Our atmosphere distorts the picture seen through the lens of a telescope. This distortion is similar to what happens when you look up from the bottom of a swimming pool. The Hubble telescope can overcome these distortions as it is located outside of the Earth's atmosphere[2].

Stars are hot bodies of glowing gas that start their life in Nebulae[3]. They vary in size, mass and temperature, diameters ranging from 450x smaller to over 1000x larger than that of the Sun. Some stars have constant brightness whereas others have variable brightness.

[1] http://www.mada.org.il/website/html/eng/4/4552.htm

[2] http://www.mada.org.il/website/html/eng/4/4552.htm

[3] The Ultimate Visual Dictionary of Science, p324

Variable stars are stars that change brightness. The brightness changes of these stars can range from a thousandth of a magnitude to as much as twenty magnitudes over periods of a fraction of a second to years, depending on the type of variable star. The

magnitude system in astronomy[4] is used to measure the brightness of stars. Over 30,000 variable stars are known and catalogued, and many thousands more are suspected to be variable[5]. There are a number of reasons why variable stars change their brightness. Pulsating variables, for example, swell and shrink due to internal forces, while others such as an eclipsing binary will dim when it is eclipsed by a faint companion; and then brightens when the occulting star moves out of the way. The different causes for light variation in variable stars provide the impetus for classifying the stars into various categories.

Variable stars can have different types of behaviour. Variable stars are classified as either intrinsic or extrinsic[6]. Where variability is intrinsic it is caused by physical changes in the star itself such as pulsation or eruption. Pulsating Variables are stars that show periodic expansion and contraction of their surface layers. Pulsations may be radial or non-radial. A radially pulsating star remains in the shape of a sphere, while a star experiencing non-radial pulsations may change from a sphere shape periodically. Eruptive variables, (also known as cataclysmic variables), are stars that have occasional violent outbursts caused by thermonuclear processes either in their surface layers or deep within their interiors. These characteristics can alter the behaviour in a variable star, including brightness (magnitude), distance from earth, mass, and speed at which they are traveling,

In contrast, extrinsic variables are stars where variability is caused by the eclipse of one star by another or by the effects of stellar rotation (*eclipsing binaries and rotating variables*). In the case of eclipsing binaries one or a number of stars eclipse another

[4] Magnitude is a standardized scale for measuring brightness of stars. The magnitude scale is logarithmic such that a magnitude difference of 5 indicates one star is 100 times brighter than the other with which it is compared. The scale starts with the brightest stars at low magnitudes (eg Sirius is the brightest star in the sky and has a magnitude of -1.4). The faintest stars that may be seen with the naked eye are about magnitude 6. Stars that may only be seen from telescopes have magnitudes greater than 6 (rising to approximately +27.5). (McKinnon, David, 2004, Practical Astronomy for years 7, 8 and 9, Using Online Telescopes in Australian Classrooms – Student Workbook, Charles Sturt University, Bathurst)

[5] http://www.aavso.org/vstar/
[6] http://www.aavso.org/vstar/

star. Rotary variables' brightness however is caused by stellar rotation. Rotating stars show small changes in light that may be due to dark or bright spots, or patches on their stellar surfaces ("star spots").

Variable stars need to be systematically observed over decades in order to determine the long-time behaviour of a star. Research on variable stars is important because it provides information about stellar properties, such as mass, radius, luminosity, temperature, internal and external structure, composition, and evolution of objects in our universe. This information can then be used to understand their origin and place in the universe and their relationship with other stellar objects including other stars. This can tell us the approximate distance they are from earth, providing vital information about how our universe has evolved. Professional astronomers have neither the available time nor the unlimited telescope access needed to gather data on the brightness changes of the many thousands of variable stars. Thus it is amateur astronomers utilizing visual, photographic, photoelectric, and now CCD techniques, which are making a real and highly useful contribution to science by observing variable stars and submitting their observations to the AAVSO International Database.

A number of variable stars have received a lot of attention both inside and outside of the astronomical community. Examples include Cepheid Variables, which have played a pivotal role in determining distances to far away galaxies and the age of the universe. Other famous stars include the Mira variables, or the long period variable stars, and eclipsing binaries such as Algol (the demon star) in Perseus.

This project reports a study of brightness changes in a suspected variable star. To study the suspected variable star that I had chosen, a telescope and image processing software would need to be obtained. For these necessities, Associate Professor David McKinnon of Charles Sturt University allowed me access to the computer controlled optical telescope he has in his possession at Bathurst. I was able to gain access to this telescope via a RDP (Remote Desktop Connection) over the internet, and would take images of the star at a specific time each night taking into account weather conditions.

Methodology

The ***purposes/aims*** of this investigation are;

1. to observe a suspected variable star using a remotely controlled telescope;
2. establish whether or not it is a true variable star;

3. if it is a variable star, examine its pattern of changing brightness (magnitude) to establish what type of variable star it is;
4. and forward the gathered data to the AAVSO International Database.

The main ***hypothesis*** is:
Variable stars emit changes in brightness, therefore if the suspected variable star is shown to emit changes in brightness then it may be considered to be a true variable star.

The project has been undertaken with the help of Dr. David McKinnon, who is an Associate Professor of Science Education at Charles Sturt University. The telescope to be used and observatory had been built by him at his home in Bathurst and is available for students at schools around the world to study the solar system and universe. The telescope may be controlled remotely from any personal computer that has installed the necessary StarMX5 software. Professor McKinnon also offered to be a mentor for me on the project. I visited Bathurst during the first term break, and I met Professor McKinnon and inspected the telescope and observed it in operation taking images of stars, planets and distant constellations.

To gain control of the telescope, after installing all the necessary software, one must create a remote desktop connection to the telescope. The software is also used to manipulate the telescope so that it focuses on the desired stellar object in the heavens. There are two cameras on the telescope, with one looking through the telescope lens that can give magnified images of selected stellar objects in the universe, while the other has a wide angle lens and is mounted on top of the telescope to look at the same area of sky as the telescope.

Figure 1 – Bathurst computer controlled telescope

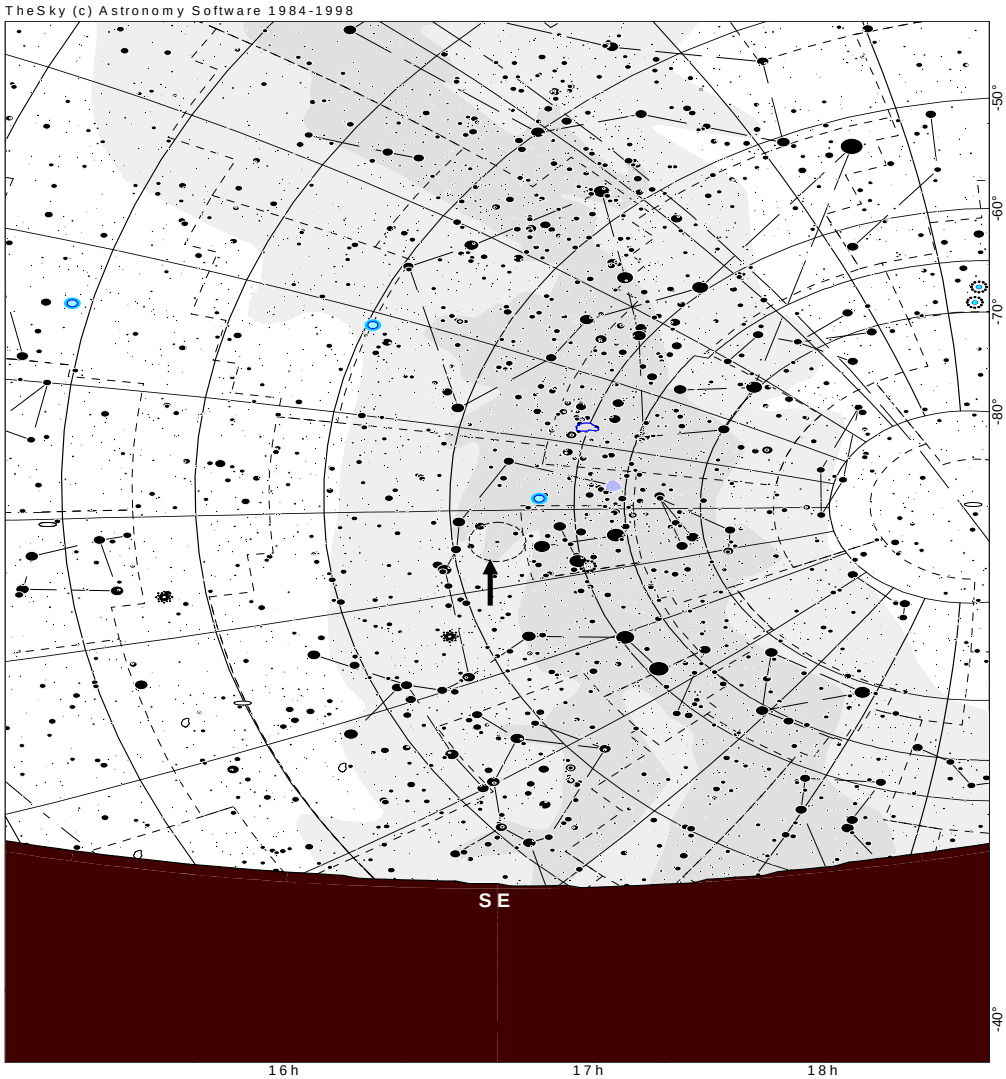
Choosing the suspected variable star for investigation

In choosing the suspected variable star from the many thousands that have been identified it was necessary for the star to meet several conditions:

- The star needed to be at least 20 degrees above the Bathurst night horizon and able to be photographed for a period of 6 weeks.
- A companion non-variable star would be needed to make brightness comparisons
- The star needed to have sufficient brightness so as to be photographed

A number of potential suspected variable stars were examined and one was chosen that met the above conditions. It was named NSV05596 and the companion star was named SAO239920. A diagram of the approximate position of the stars in the nights sky is found in figure 2.

Figure 2 – Diagram of the approximate position of the stars in the night sky – NSV05596 is at the centre of the red circle near the gamma Crucis in the Southern Cross



Controlling the telescope and measuring star magnitude (brightness)

The method used in taking photographic images of the chosen suspected variable star and measuring the brightness was as follows:

Once the connection was made with the computer controlled telescope, certain procedures were followed.

1. "The Sky" software was opened, and the desired stellar object selected.
2. Under the control of the computer, the telescope was slewed to face that stellar object.
3. After slewing the telescope, the "Prime Focus" camera software was opened, and a 2 second photographic image was taken using this program (figure 3)
4. The photo was processed and the magnitude (brightness) of the star was measured by using the software and clicking the computer mouse on the star image.
5. Star magnitudes recorded were transferred to a spreadsheet together with other relevant information such as date & time that the image(s) was recorded.

Figure 3 - Image of Suspected Variable Star (right) and Companion (left)

The software contains a notepad facility which allowed me to chat in real time with Professor McKinnon when I made my observations. It was also through use of that program the he was able to teach me to use the software and make comments and give advice about my use of it (see copies of our conversations in the log book).

Having installed the software necessary to enable me to begin the project, I was able to log onto the Bathurst telescope from my own computer in Sydney at around 8-9pm each night for a period of 6 weeks. Each night when the absence of cloud permitted I was able to capture a photographic image of the chosen suspected variable star and a non-variable star which would be used as a comparison.

Results

27 images were taken over a period of 40 days. In that period it was not possible to take images on 15 nights due to weather conditions. Changes in brightness were measured by calculating the brightness of the Suspected Variable Star and comparing that brightness with that of the companion non-variable star. Results are provided in table 1 which records date and time of image, magnitude (brightness) of the variable star, difference in magnitude of the variable star compared to the companion non-variable star, and lapsed time (in days) of each image calculated from the baseline first image. A graph showing magnitude differences between the suspected variable star and its companion non-variable star is found in figure 4. A graph of the magnitude of the two stars over 27 observations is found in figure 5.

Table 1 – Magnitudes and difference in magnitude of stars NSV05596 and SAO239920, as measured on 27 occasions, together with date and time of observations.

OBS No.	NSV05596 Magnitude	SAO239920 Magnitude	NSV/SAO239920 Magnitude Difference	Lapsed Time (days)	Date	Time
1	8.75	8.69	0.06	0.0000	31-Mar	21.04
2	8.75	8.69	0.06	0.9313	1-Apr	19.25
3	8.67	8.69	-0.02	2.0021	2-Apr	21.07
4	8.65	8.69	-0.04	4.9662	5-Apr	20.10
5	8.69	8.69	0.00	6.0225	6-Apr	21.31
6	8.76	8.69	0.07	7.9739	8-Apr	20.21
7	8.73	8.69	0.04	9.8947	10-Apr	19.27
8	8.66	8.69	-0.03	10.9149	11-Apr	19.56
9	8.68	8.69	-0.01	11.8822	12-Apr	19.09
10	8.69	8.69	0.00	12.9142	13-Apr	19.55
11	8.65	8.69	-0.04	16.9162	17-Apr	19.58
12	8.66	8.69	-0.03	17.9433	18-Apr	20.37
13	8.65	8.69	-0.04	20.9252	21-Apr	20.11
14	8.70	8.69	0.01	21.9203	22-Apr	20.04
15	8.69	8.69	0.00	24.9217	25-Apr	20.06
16	8.66	8.69	-0.03	25.9515	27-Apr	19.49
17	8.69	8.69	0.00	26.9549	28-Apr	19.54
18	8.69	8.69	0.00	28.9597	30-Apr	20.01
19	8.71	8.69	0.02	29.9840	1-May	20.36
20	8.71	8.69	0.02	30.9541	2-May	19.53
21	8.68	8.69	-0.01	32.0145	3-May	21.20
22	8.69	8.69	0.00	33.0033	4-May	21.04
23	8.69	8.69	0.00	33.9593	5-May	19.53

24	8.76	8.69	0.07	37.0233	8-May	21.33
25	8.70	8.69	0.01	37.9628	9-May	20.06
26	8.73	8.69	0.04	38.9836	10-May	20.36
27	8.71	8.69	0.02	39.9954	11-May	20.53

Figure 4

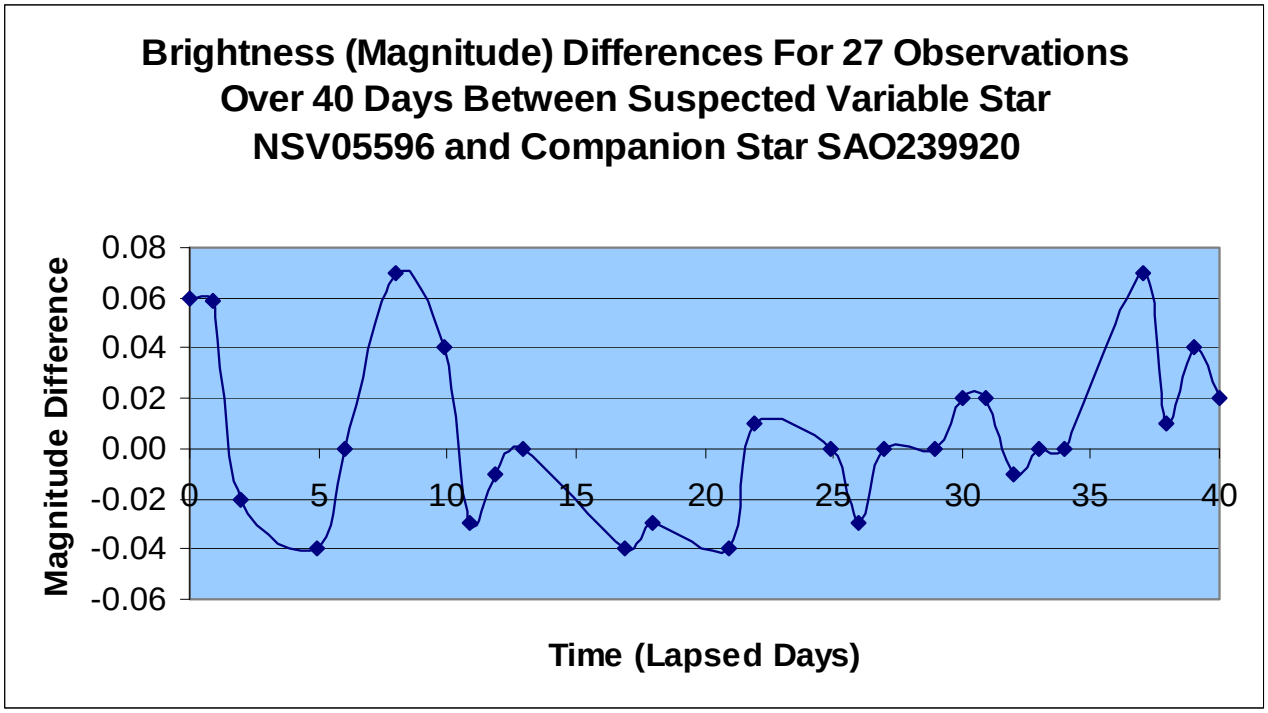
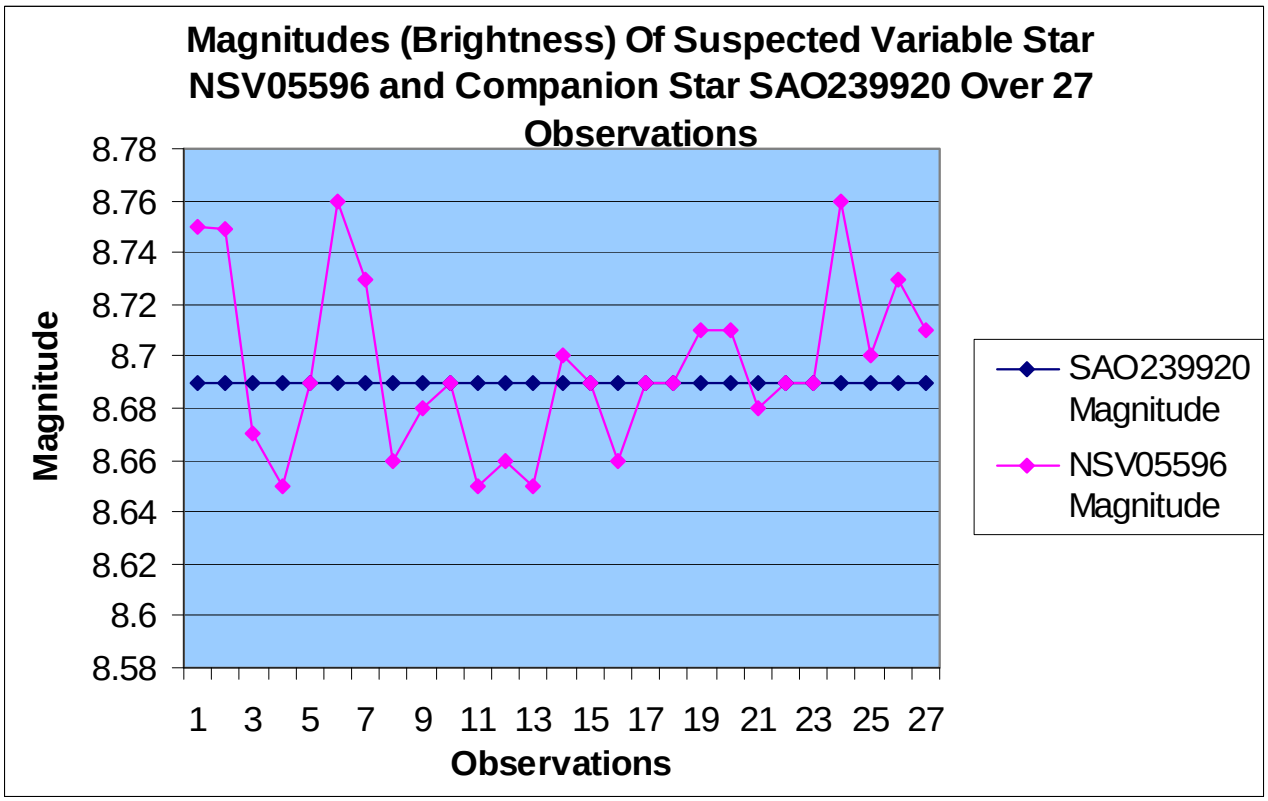


Figure 5



It may be observed from the data and graphs that the suspected variable star did reveal changes in magnitude (brightness) although the pattern of change is quite irregular. Professor McKinnon suggested that an estimate of the accuracy (reliability) of the magnitude measurements made might be calculated by comparng the magnitude measurement recorded from a 2 second photo exposure with that from a 1second exposure. On 9 occasions both 1 and 2 second exposures were taken of the two stars. On 5 of the 9 occasions there were no magnitude differences found between the 1 second and 2 second exposures. On 3 occasions there was a 0.01 difference and on 1 occasion a 0.03 difference. This analysis indicates that magnitude measurement is not entirely accurate.

Discussion

The ***purposes/aims*** of this investigation were;

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The main ***hypothesis*** was:
Variable stars emit changes in brightness, therefore if the suspected variable star is shown to emit changes in brightness then it may be considered to be a true variable star.

With regard to the research purposes 1 and 2, the results support the hypothesis, and it may be concluded that NSV 05596 is a true variable star. Compared with the comparison non-variable star's brightness over time, it varies as much as +0.74 & -0.04 of a magnitude. It is clear however that the brightness changes in NSV05596 are variable but not regular. Changes from day to day are sometimes as little as 0 or 0.01 and as large as 0.08 of a magnitude.

With regard to purpose 3, the type of variable star remains difficult to determine. After examining the pattern of changing brightness and deliberating with Professor McKinnon, I came up with my conclusion via a process of elimination. Firstly, taking into account the trends of brightness and the strength of brightness, it was determined that NSV05596 is most unlikely to be a Pulsating variable star. While it was possible for NSV05596 to have

been an eruptive variable, this was considered unlikely due to the magnitude changes being too small. The most likely possibility therefore was that NSV05596 was a rotating variable star being eclipsed by other stellar objects in orbit around it. Further study will be needed to confirm that conclusion.

There were some limitations to the experiment. These limitations include the marginal inaccuracy of the measurement of magnitude. These marginal inaccuracies could have significant effect on the results and could possibly even change the type of the suspected variable star in relation to the results. Also another limitation to this investigation was the amount of time given to complete it. If there were several more months available, the results would most probably be more accurate and paint a clearer picture of the type of variable star that this study is investigating. Perhaps a trial could be made using a 4 second exposure time rather than the 2 second exposure time used in this study, however, it must be recognised that a 4 second exposure might “drown” the picture in light, which can potentially damage the accuracy of the magnitude readings.

If it was possible for me to undertake the investigation again, I would plan that a time period of perhaps more than three month was available so as to increase the reliability and accuracy of the data. If the star was able to be observed over a longer period of time, more information would be able to be gathered about its characteristics that could possibly change the outcome of the classification of the star.

The investigation has been successful in providing potentially important information about a suspected variable star, and contributing to the further investigation of our universe. That information will now be forwarded to the AAVSO (American Association of Variable Star Observers) database of variable stars.

Acknowledgements

Special thanks are given to Associate Professor David McKinnon who made the remote controlled Bathurst telescope available to me at no cost and who gave freely of his time and expertise in mentoring me throughout the project.

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