Magnitude Changes in a Suspected Variable Star

Alaina Edwards,
West Kildonan Collegiate Institute
Winnipeg
Manitoba
Canada

As technology advances it allows us to increase our knowledge of different aspects of the world we co-exist in. By using these different technological advances and theories we have the ability to learn more about what we were once unable to explain. One type of study that has benefited immensely from technology is the wide field of astronomy. A number of mechanisms have been developed further to expand the knowledge we have in this field such as telescopes and satellites. Telescopes allow the user to better view an object that is at a distance by magnifying it. This is done by increasing the degree of light that reaches our eyes, to allow us to view objects that aren't easily seen at great distances. One such advancement is the Hipparcos Satellite which was launched on August 8th, 1989. The satellite is responsible for cataloguing suspected variable stars[1]. It is also measured the angle of parallax to determine distances to a large number of stars. These are stars that change their brightness, some over a regulated period of time, others at irregular periods. The Hipparcos Satellite has assisted in cataloguing over 30 000 variable stars, and thousands more which are suspected of being variable.

There are two different types of variable stars: intrinsic and extrinsic. Intrinsic variable stars have light variation caused by physical changes in the star. Intrinsic variable stars are further broken down into two classes, pulsating and eruptive. Pulsating Variables show a periodic expansion and contraction of the star's surface. A star experiencing radical pulsations remains spherical in shape, as opposed to a star with non-radical pulsations may change from a spherical shape periodically. Eruptive Variables, also known as Cataclysmic Variables, are stars that occasionally undergo extreme outbursts caused by thermonuclear processes in either their surface layers or further into the interior of the star.

Extrinsic variable stars can be identified when the variable star's variation is caused by a smaller, darker star passing in front of the suspected variable. Extrinsic variable stars are broken down into two classes as well, eclipsing binary and rotating stars. Eclipsing Binary Stars describe the binary systems of the stars when they have an orbital plane lying near the observer's line-of-sight. The two objects periodically eclipse one another, which causes a decrease in what the observer sees as the

[1] *Variable stars* are stars that change brightness. The changes in brightness 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.

brightness in the system. Lastly, rotating stars, from the extrinsic class, show small changes in light which may be caused by bright or dark spots/patches on their surface. Rotating stars which show variability are commonly found in binary systems.

Flare stars and Irregular variables are two other uncommon types of variable stars. Flare stars are sometimes known as UV Ceti stars. They are intrinsically faint, cool, red, main-sequence stars that tend to have intense outbursts from specific areas on their exterior. It results in an increase in brightness in two or more magnitudes in a short number of seconds. Afterwards there is a decrease to its normal minimum in about 10 to 20 minutes. Irregular variables are stars, including most of the red giants[2], are pulsating variables that show brightness variation with either none or slight periodicity.

Methodology

The purposes and goals of this study are:

1. to observe and record patterns of a suspected variable star, identified by the Hipparcos satellite, using a remotely controlled telescope located in Australia;
2. determine whether it is or is not a true variable star;
3. if it proves to be a true variable star, determine what type of variable star it is by studying its variation in brightness over a period of time;
4. submit collected data and information to the AAVSO International Database.

Variable stars are stars that have a varying brightness and magnitude[3]. Therefore, if the suspected variable star is observed to change in the brightness or magnitude it can be concluded to be a true variable star.

Dr. David McKinnon, an Associate Professor of Science and Education at Charles Sturt Universty, residing in Bathurst, Australia helps students across the world access the stars and other objects in the solar system and universe. Through his remote telescope they can target and observe these objects. The telescope was built by him and resides in his back yard which he has made accessible and available to schools around the world through the Internet. Dr. McKinnon also works both along side, and remotely with students to observe suspected variable stars and to assist in cataloguing them properly. The access and control to his remote telescope is obtainable to any personal computer that has the required StarMX5 software, to measure the brightness using “differential photometry”, installed on

[2] Red Giants are stars that have completed the assumption of hydrogen in their cores and have just left the main sequence.
[3] Magnitude is a logarithmic scale designed to measure the brightness of celestial bodies, commonly stars. The lower the magnitude, the brighter the object, the higher the magnitude, the fainter the object.

it. By creating a remote desktop connection to the telescope, the user can control the telescope through the required software. Two cameras on the telescope provide the user with different views of the same image. One camera looks through the telescope lens, magnifying the image of the desired object(s), while the other camera is placed on top of the telescope to give the user an image through a wide angle lens aiming at the same area of the sky as the telescope.

Figure 1 – Bathurst Computer Controlled Telescope

Choosing the suspected variable star

When choosing the suspected variable star for the investigation, there were several criteria the star had to meet:

- The star was required to be about 45 degrees above the Bathurst night horizon and able to be photographed for a minimum of 4 weeks
- The star needed to be rising around 5:00 pm (in Bathurst) so it would be high enough by 9:00 pm when it was high enough to photograph it
- The magnitude of the suspected variable star needed to be between 9.00 and 10.00 to have adequate brightness to be photographed with a relatively short exposure time
- At least one comparison non-variable star with a magnitude between 9.00 and 10.00 would be needed to make brightness comparisons (two comparison stars are better than one).

Out of several potential candidates for experimentation, one was chosen that met the criteria listed above. It was named SAO 154490. It is recorded to be 109.71 light-years away and is part of the constellation Hydra This suspected variable star had two acceptable comparison stars present in the field of view, GSC 5441:529 and SAO154486.

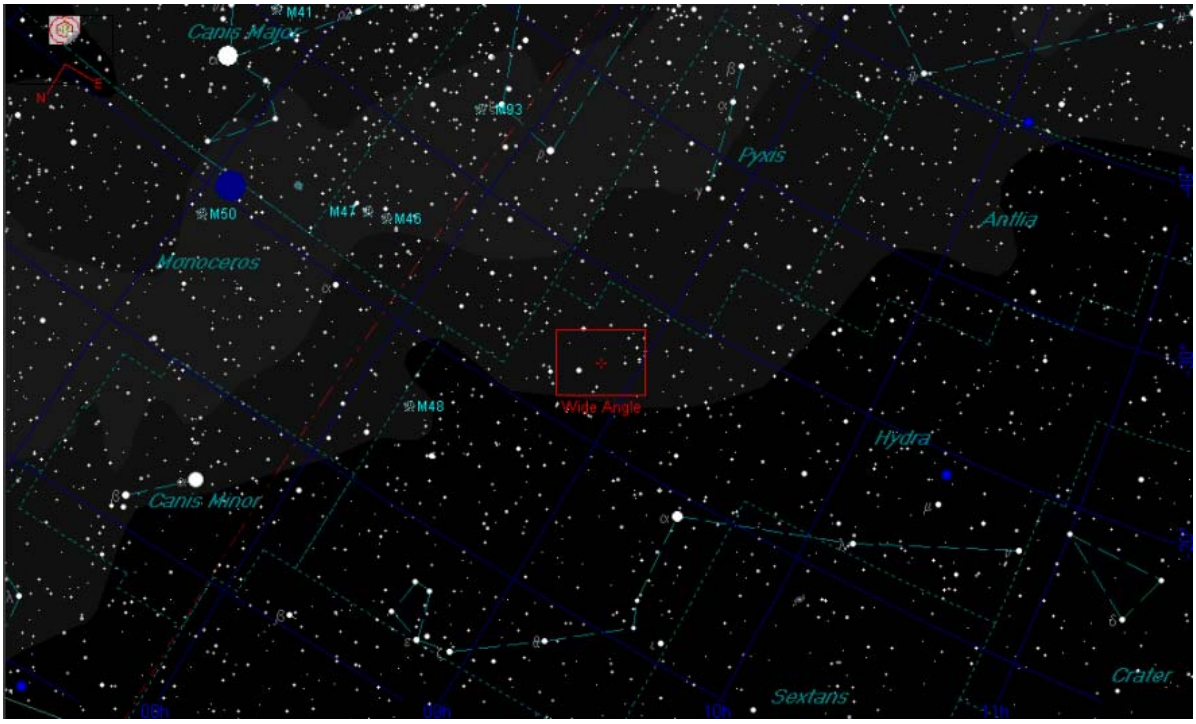

Figure 2 – Image of Hydra, the constellation SAO 154490

Measuring Star magnitude (brightness)

Dr. McKinnon takes digital images of the student's chosen target through his remote telescope in his backyard. Four images are taken at each observation and then forwarded to the student observing the star. The first image is a straight image of the object containing information of the light coming from the objects in the photograph, plus other components derived from the CCD chip and its electronics. The first of these components is the small voltage applied to the CCD chip, which is measured by the bias frame which is a zero second exposure. By subtracting the bias frame from the straight image the effect of the camera's electronics is removed.

The third image sent is the Dark Field image. It has the same exposure of the straight image. This frame is taken because the CCD chip is not at Absolute Zero. Because of this, "thermal electrons" are created inside the CCD chip and these must be removed next. The final image is the Flat Field image. This image is an image of a uniformly illuminated object, for example, a twilight sky or a surface evenly illuminated by lights. This frame is designed to correct for the slight unevenness in sensitivity of each pixel across the CCD array. Once these three frames have been applied to the straight image, the remaining image is ready for the process of Differential Photometry to measure the difference in brightness between the comparison stars and the suspected variable star. This entire process is done through a program called Star MX5. Star MX5 is also used to digitally enhance and

observe stars. Through the program, astronomers are able to view digital images of objects in space and to measure features such as brightness or position.

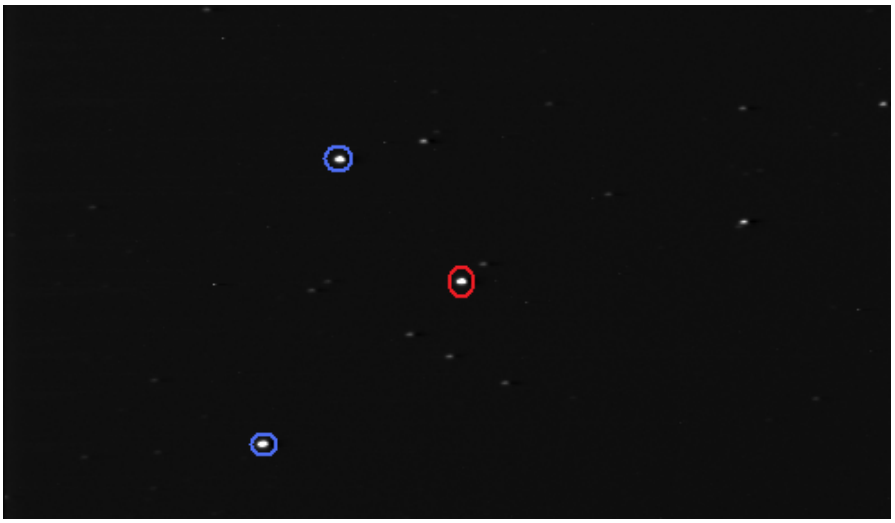

Figure 3 – Image of Suspected Variable Star (circled in red) and Comparison Stars (circled in blue)

Results

A total of 15 images were taken over a period of 55 days. It was not possible to take images on 40 nights due to several conditions, mainly bad weather within that period. Table 1 provides the results for the changes in brightness that were measured compared to the two comparison stars which are non-variable. It also shows records of the date, time and magnitudes of the two comparison stars.

OBS No.	SAO154490 Magnitude	SAO154486 Magnitude	GSC 5441:529 Magnitude	SAO 154490 /SAO154486 Magnitude Difference	SAO 154490 /GSC 5441:529 Magnitude Difference	SAO 154486+ Magnitude Difference	GSC 5441:529+ Magnitude Difference	Date	Time
1	9.69	9.32	9.67	0.38	0.01	9.70	9.68	Mar-13-07	12:18am
2	9.70	9.32	9.67	0.37	0.03	9.69	9.70	Mar-15-07	09:24am
3	9.66	9.32	9.67	0.35	-0.02	9.67	9.65	Mar-30-07	11.22am
4	9.71	9.32	9.67	0.44	-0.01	9.76	9.66	Mar-31-07	12.56am
5	9.67	9.32	9.67	0.33	0.01	9.65	9.68	Apr-01-07	10.43am
6	9.69	9.32	9.67	0.35	0.03	9.67	9.70	Apr-01-07	12.12am
7	9.68	9.32	9.67	0.38	-0.02	9.7	9.65	Apr-04-07	10.09am
8	9.66	9.32	9.67	0.32	0.01	9.64	9.68	Apr-05-07	9.43am
9	9.73	9.32	9.67	0.42	0.04	9.74	9.71	Apr-12-07	10.52am
10	9.69	9.32	9.67	0.39	0.00	9.71	9.67	Apr-13-07	10.32am
11	9.75	9.32	9.67	0.43	0.07	9.75	9.74	Apr-14-07	10.43am
12	9.68	9.32	9.67	0.34	0.02	9.66	9.69	Apr-16-07	9.27am
13	9.76	9.32	9.67	0.44	0.09	9.76	9.76	Apr-17-07	10.00am
14	9.75	9.32	9.67	0.42	0.08	9.74	9.75	May-05-07	9.26am
15	9.69	9.32	9.67	0.34	0.04	9.66	9.71	May-06-07	10.24am

Table 1 – Magnitudes and difference in magnitude of stars SAO 154490 and SAO 154486, and SAO 154490 and GSC 5441:529, as measured on 15 occurrences, simultaneously compared with time and date.

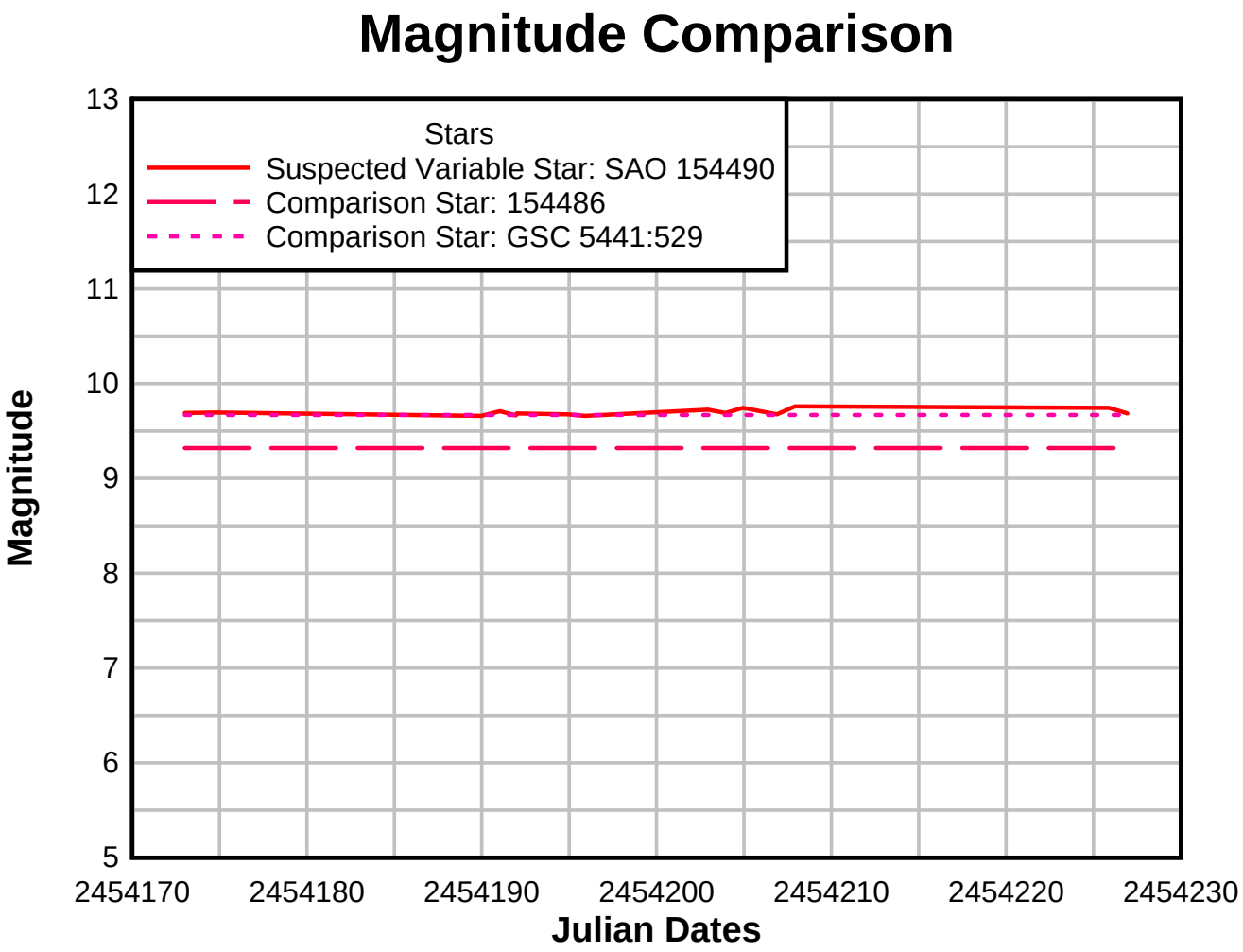

Figure 4: Light Curve

Discussion

The purposes and goals of this analysis were:

1. to observe and record patterns of a suspected variable star using a remotely controlled telescope;
2. to determine whether it is or isn't a true variable star;
3. if it proves to be a true variable star, to determine what type of variable star it is by studying the matter of varying brightness;
4. to submit collected data and information to the AAVSO International Database.

The main hypothesis was:

Variable stars are stars that have a varying brightness and magnitude. Therefore, if the suspected variable star is observed to emit a change in the brightness and magnitude it can be concluded to be a true variable star.

With regard to purposes 1 and 2, and that the main hypothesis states stars can only be catalogued variable if there is a varying brightness and magnitude. Compared with both of the comparison non-variable stars' brightness over time, it is shown that there is hardly any variation in the suspected variable star's magnitude. There is, however, a very minor amount of varying in the results, but there does not appear to be enough information to conclude whether the target, SAO 154490 is or is not variable. Due to the inconclusive data, a final conclusion cannot be determined at this time.

Therefore, the target star will be further analyzed with a similar method that requires a different sized telescope. The telescope will give a larger field of view to find unsaturated comparison stars of similar magnitude to compare the target star's magnitude with. To finalize the data the target star will be further analyzed with a similar method that requires a different sized telescope. This method will use a 400mm refracting telescope mounted on the side of the main 12" telescope. The telescope will give a larger field of view to find unsaturated comparison stars of similar magnitude to compare the target star's magnitude with. This method should increase the statistics, and will give a better idea of the star's variation patterns.

With regard to purpose 3, there cannot be any discussion on the topic as the target was concluded to not be a variable star within the limits of error of measurement.

There were some factors that caused limitations to the experiment. A main limitation was the potential minor inaccuracy when measuring the magnitudes of the stars. It is not likely it has any bearing on the conclusion of this experiment, since even with a minor error in the measurement of the magnitudes, it's not likely the error was that significant. Another limitation that is important to account for are the weather conditions. Since there were days that the star couldn't be photographed, there is an inconsistency in the pattern of observations, amounting to large gaps of time between images. This potentially could cause the observer to miss days where the star's magnitude had a greater or lesser variation. The amount of time available is a third limitation to the experiment. If there were more months available to observe the star, more information could be gathered that could possibly have an effect on the final result of the experiment.

The information obtained by investigating the suspected variable star, SAO 154490 has been successful in providing what is potentially important data. The information will now be forwarded to

the AAVSO (American Association of Variable Star Observers) database of variable stars for cataloguing.

Acknowledgements

Special thanks are given to Associate Professor David McKinnon who assisted me in the investigation of the targeted star by emailing me images of the chosen target and providing his time and knowledge throughout the project. Special thanks are also given to Mr. R. Edwards (a science teacher at West Kildonan Collegiate) who worked with me throughout the project and provided many hours of his time and also information as to how to investigate the star and finalize the write up. Lastly, special thanks are given to Mr. K. Burr (an English teacher at West Kildonan Collegiate) for helping me by peer editing and critiquing the final write up and Mr. D. Edwards for helping me with creating the graphs to include in the final write up.

References

Books

1. McKinnon, David, 2004, Practical Astronomy for years 7, 8, and 9, Using Online Telescopes in Australian Classrooms – Student Workbook, Charles Sturt University, Bathurst.

Websites

1. Variable Stars, http://aavso.org/vstar.
2. From Hipparchus to Hipparcos, http://wwwhip.obspm.fr/hipparcos/SandT/hip-SandT.html
3. Types of Variable Stars, http://www.aavso.org/vstar/types/shtml
4. Variable Star, http://en.wikipedia.org/wiki/Variable_star