

Proof of Standard Stars

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Table of Contents

Abstract/ Introduction.....	Pg. 3
Background.....	Pg. 4
Process.....	Pg. 5
Conclusion.....	Pg. 8
Works Cited.....	Pg. 9

Abstract

In doing this research, I hoped to show that a selection of listed standard stars used in a project involving the Andromeda Galaxy (M31) were, in fact, standard. I had never seen any data reference for the standards in the subrasters for the fields of the galaxy, and intended to investigate, looking at ten stars in field 14 of M31. A standard star is a star whose magnitude stays fairly constant over time and is used as a comparison towards the calculation of a target's magnitude. They are used to detect variable stars, black holes, quasars, novas and super novas, polar systems, etc.

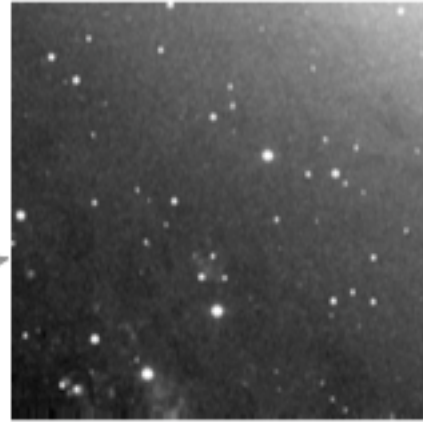
The magnitudes for each of the stars in each picture, or epoch, were calculated by isolating one star and using the other nine stars as standards to compare to. This was done for each star in fifty selected epochs. I then made a graph for each of the stars and plotted their magnitude over time. Using these graphs, I was able to determine if the stars stayed within their given error range and therefore show them to be standard stars.

Introduction

Originally, my project idea was to find a new variable star in the Andromeda galaxy (also known as M31) based on my theory that more variables would be located near the outer edge of a galaxy, as this is where new stars are formed. This proved very difficult to do, with an incredible amount of data, and during a discussion about the project, Mr. Jeff Adkins made a statement that he had never seen actual data on the standard stars, and I was unable to find a data reference, so I decided that I would show that these listed standards were actually standard. I selected field 14 of M31, which contains about ten standards. The reason why I needed a field with more standards in it is because the more standard stars you have, the more accurate your calculations for magnitude will be and therefore your data is more reliable.

Background

The pictures used in this project were taken by Travis A. Rector and George H. Jacoby at the Kitt Peak National Observatory in Arizona. The telescopes used were the KPNO 0.9-meter, MDM 1.3-meter and KPNO 2.1-meter telescopes. The pictures of the Andromeda Galaxy (M31) were taken periodically across about nine years (1995-2004). However, there is a gap in each year where no pictures were taken and this is due to the fact that M31 is not visible from Earth from late January to late June. The pictures were taken for a nova search lab to be used in classrooms. The pictures were actually taken of the galaxy as a whole. Each picture of the galaxy was divided into 16 subrasters, or fields, in order to make locating novas easier for the students who would participate in this lab. I used these same pictures to look at a selection of the listed standard stars in the galaxy.



1

Above is a picture of the entire Andromeda Galaxy (M31). Above and to the right is the field that I selected to test, field 14.

A standard star is a star whose magnitude stays fairly constant over time. In other words, it shows very little variation. Standard stars are given an error range, because no star can stay perfectly constant as well as the possibility for random measurement error when then calculations for its magnitude were made. This error range is usually not higher than a 0.1 magnitude variation. For example, if a standard star has an average magnitude of 16.5 ± 0.08 , then that star is still considered constant as its magnitude can change from 0.08 above the average or below 0.08 below the average.

Standard stars are used as comparison to calculate the magnitudes of variable stars, planets, quasars, novas, etc. There are thousands of standard stars- that way, no matter where your target is, you have access to a standard somewhere within the vicinity of your target. Though there are an abundance of standard stars that we know of, there are many others out there that we have not tested. The more standards we have at our disposal, the more accurate our calculations will be when looking at a variable, or black hole, or anything else really. Standard stars are essential in the research of other objects in space. We use them in determining magnitude, and by determining magnitude, we can find out how far away the target is, what it could possibly be made of, and we can make a very close estimate as to how big it is. As you can see, standards are very important, and we all need to be able to trust them and rely on them. That is why I feel that my research is influential and important.

¹ <http://www.obspm.fr/messier/Pics/More/m31caltech.jpg>

The stars that I selected to test all have about the same average magnitude and similar error ranges. They are as follows:

subrafter #14 standard stars

star #	my #	magnitude	error
50	1	16.56	±0.08
51	2	15.13	±0.08
52	3	15.92	±0.09
53	4	16.13	±0.08
54	5	14	±0.08
55	6	16.14	±0.07
56	7	17.18	±0.07
57	8	15.15	±0.06
58	9	16.5	±0.08
59	10	16.18	±0.08

Process

To collect the data on each standard star in field 14, I used a program called Image J to look at about fifty pictures based on dates, or epochs, of the field and used an aperture tool to get the brightness count of each standard star. Some of the pictures had to be skipped or disregarded because they contained bad pixels or because some of the target stars were cut out on the edge of the picture. I then pasted the data onto a spreadsheet, using Microsoft Excel, for fifty different sheets (one for each epoch, or date, observed). I then calculated the log of the brightness count ($\log(B_1)$) and then took that number and

divided it by the brightness count ($\log\left(\frac{B_1}{B_1}\right)$) in other words comparing the star to itself. If

the data was correct, the result of this calculation should be zero. I then calculated the log of the brightness count divided by the brightness count of each of the other nine standards

($\log\left(\frac{B_1}{B_2}\right); \log\left(\frac{B_1}{B_3}\right) \dots \log\left(\frac{B_1}{B_9}\right)$). In other words, I took one star and used it as a target,

and then used the other nine stars as standards.

I put my results for the tests in a table, like this:

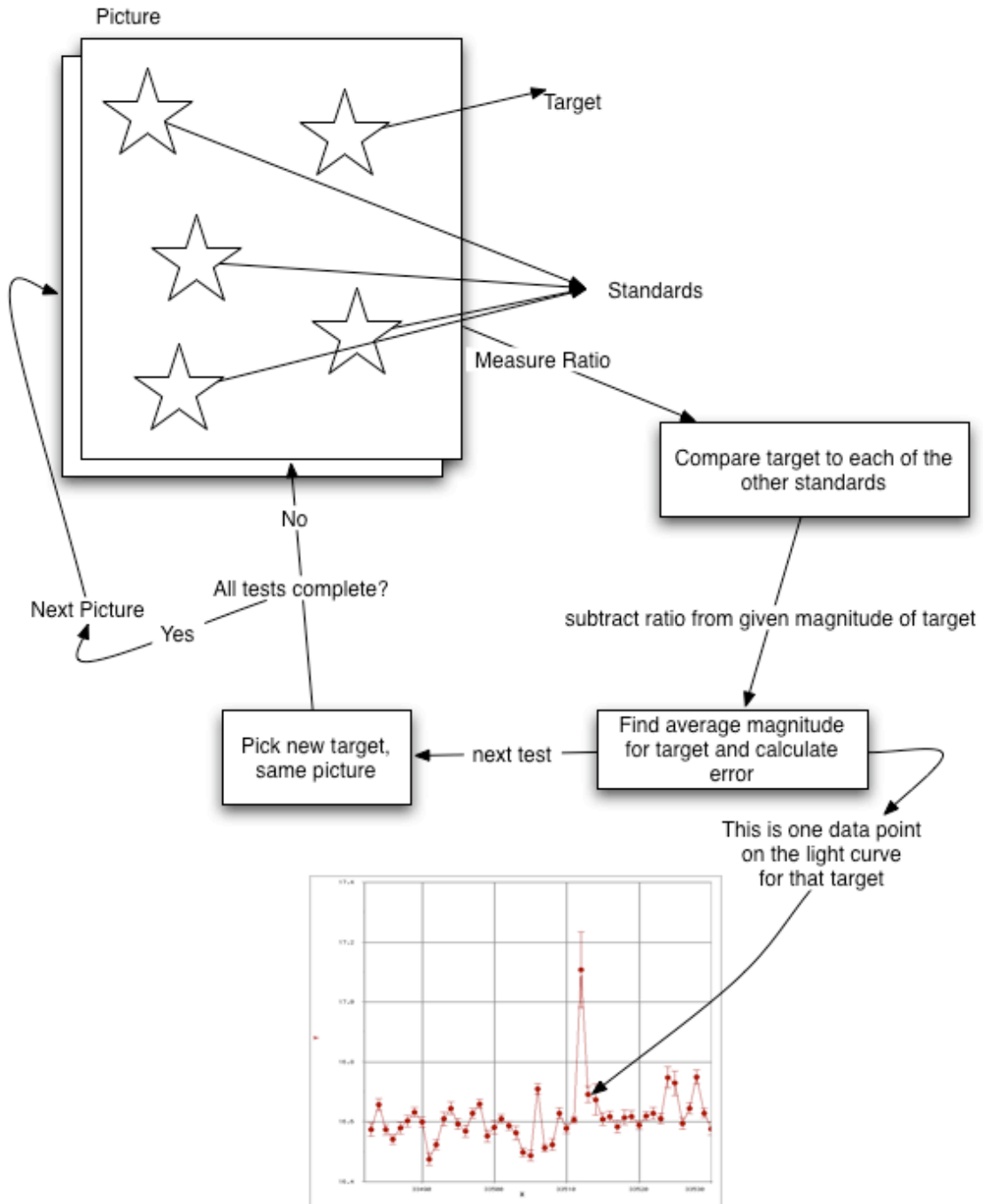
test 1	test 2	test 3	test 4	test 5
0	0.553710078	0.237816476	0.182675653	1.022276757
-0.553710078	0	0.315893602	0.371034425	0.468566679
-0.237816476	0.315893602	0	0.055140823	0.784460281
-0.182675653	0.371034425	0.055140823	0	0.839601104
-1.022276757	0.468566679	0.784460281	0.839601104	0
-0.189971438	0.36373864	0.047845038	0.007295785	0.832305319
0.115780295	0.669490374	0.353596772	0.298455949	1.138057053
-0.562584932	0.008874854	0.324768456	0.379909279	0.459691825
0.015344651	0.569054729	0.253161127	0.198020304	1.037621408
-0.112567707	0.441142371	0.125248769	0.070107946	0.90970905
test 6	test 7	test 8	test 9	test 10
0.189971438	0.115780295	0.562584932	0.015344651	0.112567707
-0.36373864	0.669490374	0.008874854	0.569054729	0.441142371
0.047845038	0.353596772	0.324768456	0.253161127	0.125248769
0.007295785	0.298455949	0.379909279	0.198020304	0.070107946
0.832305319	1.138057053	0.459691825	1.037621408	-0.90970905
0	0.305751734	0.372613494	0.205316089	0.077403731
0.305751734	0	0.678365228	0.100435645	0.228348002
0.372613494	0.678365228	0	0.577929583	0.450017225
0.205316089	0.100435645	0.577929583	0	0.127912358
0.077403731	0.228348002	0.450017225	0.127912358	0

(This example of my data was taken from the first epoch.)

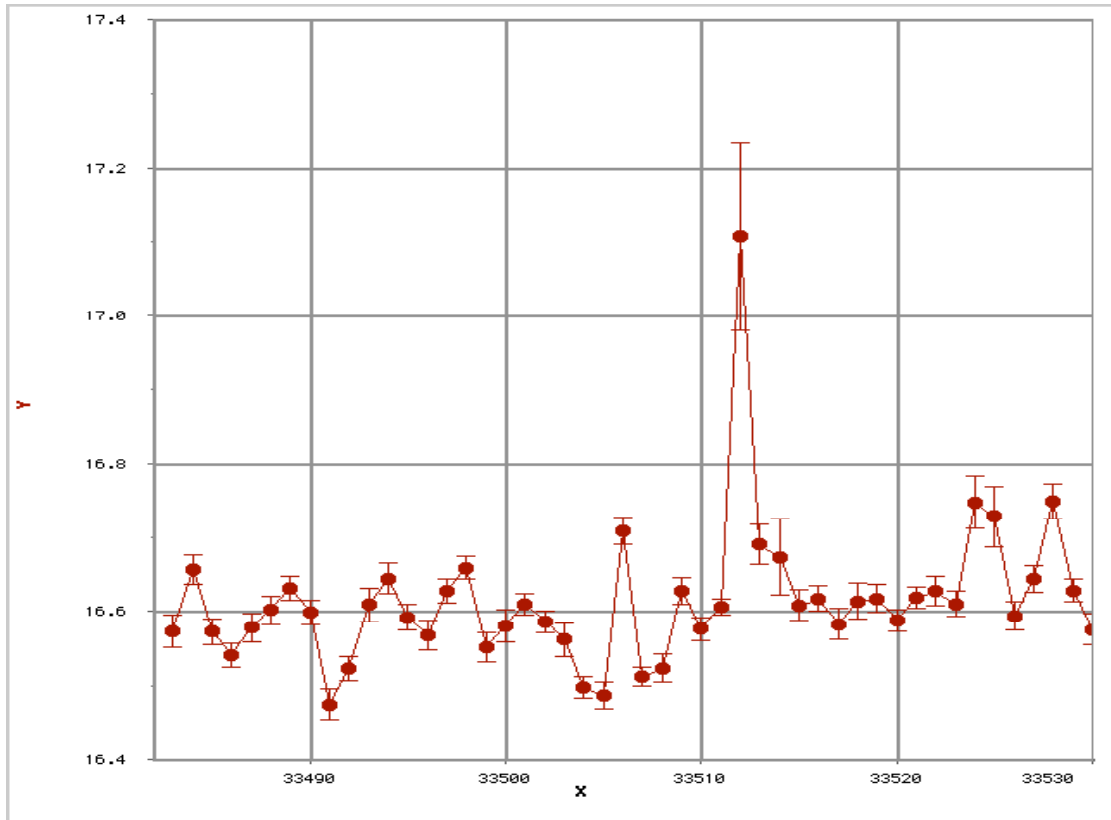
I then took the given magnitude of one of the standards and subtracted the numbers calculated in the previous step ($mag - \log\left(\frac{B_1}{B_2}\right); mag - \log\left(\frac{B_1}{B_3}\right) \dots mag - \log\left(\frac{B_1}{B_9}\right)$). I then took the average of these results and got that the magnitude for star 1 in epoch 01 is 16.573. However, in order to make it accurate, I still needed to include the standard error of the mean for this star in this epoch. To do this, I took the standard deviation of the average magnitude and divided the result by the square root of the number of measurements used in the average. For my calculations, this would be $\sqrt{9}=3$. So my error for the magnitude of star 1 in epoch one came out to be ± 0.043 . This was all done

for each standard in each epoch. To better explain these instructions, I have included a flow chart on the following page.

Steps for each test:



Once I had the average magnitudes and the errors for each standard in each epoch, I then made a graph for each of the ten stars and plotted their calculated magnitudes and error bars over time. Here is an example of one of my graphs:



As you can see, star 1's light curve is relatively steady; its variations are within its published error range. Each of the points on the graph shows very small errors as well. The stray point at the top of the graph is a point that was off in every one of my graphs. That point is from epoch 31 and there must have been some interference in the picture. (This is something else that could be looked into.) I did attempt to re-measure the brightness counts for the standards in that picture, but I still got the same obscurity.

Conclusion

All of my graphs showed that the standards that I tested from field 14 are all standard. Most of the stars stayed fairly constant. According to my calculations, star 3 (or listed 52) surpassed the given range for its error. I believe that a further observance of this star may lead to a better conclusion for it. However, this star's graph showed nearly a flat line, so again I suggest further observance. As I mentioned with the example of one of my graphs, there was one obscure point in every graph and it was all from the same epoch (epoch 31). Because I got the same result after attempting to re-measure the brightness counts for that same epoch, it leads me to believe that there is some sort of interference in the picture itself. I have calculated errors for all these standards, save for one, lay within the given errors, therefore showing nearly every one of these standard.

Works Cited:

Malin, David. Digital image. [Andromeda Galaxy]. CalTech. 22 Feb. 2006

<<http://www.obspm.fr/messier/pics/More/M31caltech.com>>.

Rector, Travis. Digital images. [Field 14 of the Andromeda Galaxy]. Kitt Peak National Observatory, AZ.

Data collected through the images of Field 14 of the Andromeda Galaxy sponsored by the website <http://www.noao.edu/outreach/tlrbs> for the use of a nova search lab for students.

Rector, Travis. "Cosmic Easter Eggs." Introduction. Nova Search Lab. 2000.