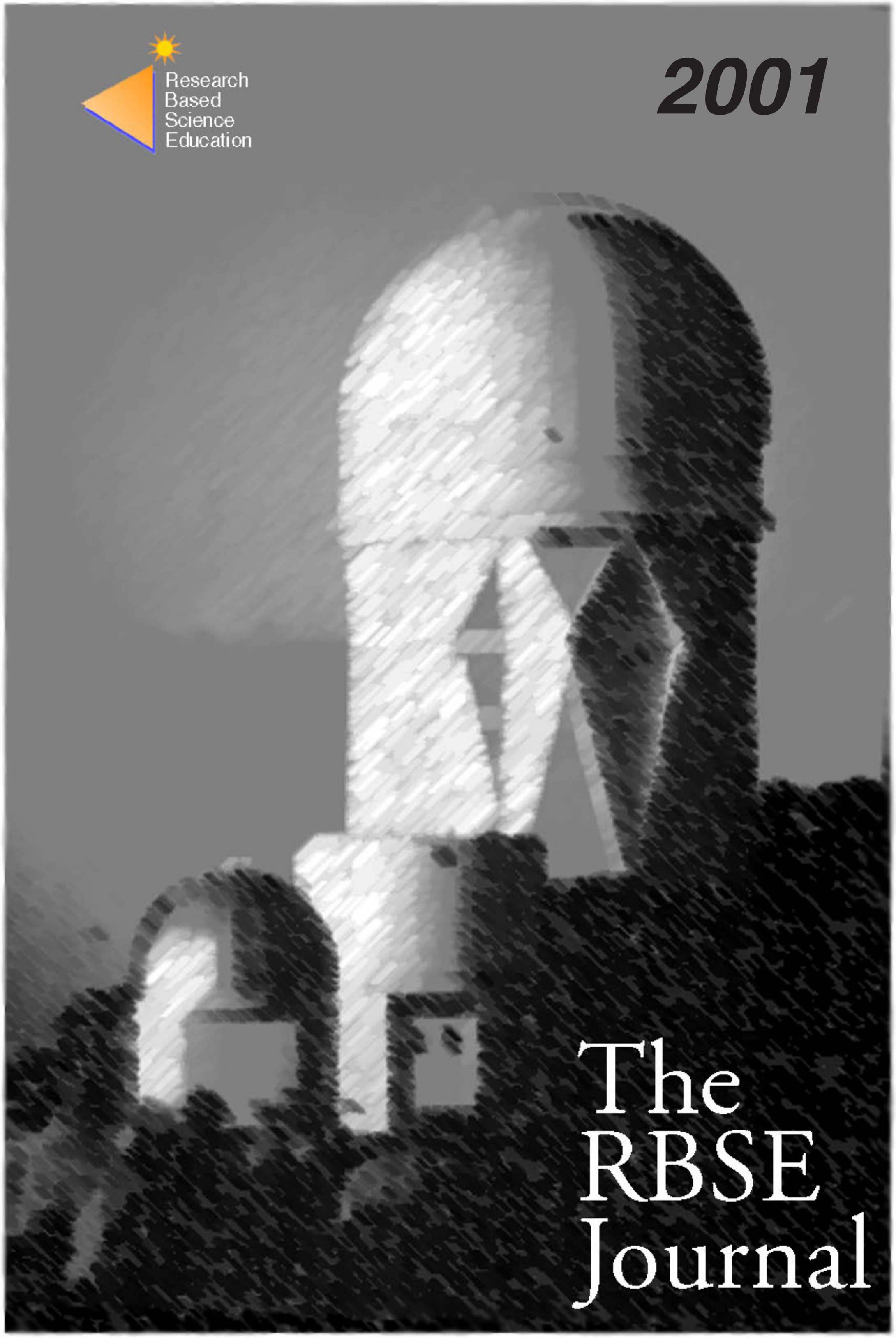

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The "Use of Astronomy in Research Based Science Education" (RBSE) is a Teacher Enhancement Program funded by the National Science Foundation. It consists of a four-week summer workshop for middle and high school teachers interested in incorporating astronomy research within their science classes. RBSE extends the experience to the classroom with materials, datasets, support and mentors during the academic year. The RBSE Journal is an annual publication intended to present the research of students participating in the RBSE program.

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The Area of Sunspots vs. Precipitation on Earth

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Abstract

Sunspots, large darkened spots covering the Sun's surface, are always present on the sun, covering its surface from small to great areas. Sunspots range in area from anywhere from very small to the size of Earth, and rotate with the suns movement. These sunspots can last anywhere from a few hours to a few months.

Since sunspots are formed by magnetic fluctuations in the suns magnetic field, a correlation between the number of sunspots on the sun and the weather on earth is theoretically possible. Since weather on Earth has a relationship with the planet's magnetic field, a relationship between the Sun's magnetic field, and that of Earth is a noteworthy possibility. The amount of sunspots was determined by taking the area of certain sunspot groups in KPVT solar images, then continuing to add up all the area values for the solar image to get a total.

After analyzing the available data, our outcome was indecisive. Our hypothesis that the number of sunspots would affect the weather on earth went unproved because of data complications. Only having solar images from the past two years proved to hinder the outcome of the project.

Purpose

The original purpose of Eric and Jesse's project was to determine if sunspots and the fluctuation in their area had any affect on the weather here on earth. The Scion Image program was used to collect data on sunspots and their area for the months of May and January in 2000 and 1999.

Hypothesis

The sunspots will have a long term, not short term, effect on the weather and climate on earth, specifically: precipitation.

Procedure

The Kitt Peak Vacuum tube Telescope(KPVT) supplied the data on a CD for us to view. The CD contained images of the sun from 1999 and 2000. They also included examples which were not utilized in our project. The CD was loaded onto a PC and special macros, which had been previously loaded, were used to view these FITS images. Eric and Jesse then chose four months to analyze. The months chosen were January and May of 1999 and 2000. The months contained images for almost all days in each month.

When attempting to extract data from the images, a filter, or density slice, was put on so the program could better analyze the sunspots. The filter made the darker spots on the sun, which were the sunspots, red. Then a box was drawn around the spot or group of spots and the letter A was pressed. The data automatically appeared in a box to the left of the screen. For spots close to the side of the sun, a different tool was utilized for the box tool overlapped the end of the sun and was not able to read the sunspot area. The data was then transferred to Microsoft Excel and formulas were written to establish one box as a total area box.

Controls and Error Analysis

Unfortunately, an enormous amount of error crippled the results of the project. Since weather is effected by so many factors, determining the effect of only sunspots on the weather was a near impossible task. Certain Earth-climate phenomena like; El Nino, jet streams, and other factors all have certain effects on the precipitation and weather in general.

A more technical aspect that could have generated error in the sunspot project is the variation in the solar images used. Many solar images had to be ignored because of disturbances in the actual picture. These disturbances made the density slice impossible, and the data was not salvageable from those particular solar images. Also, some solar images were only mildly affected by the poor photography job, and were used in the project, which could add error to the overall result. The sunspots that were located near the edge of the solar image also could have added to the overall error generated in producing this project. The Scion Image program has a hard time calculating area of sunspots near the edge of the image, and oftentimes gives areas that seemed absolutely absurd. This erroneous data was removed from the lab as much as possible, but many of these errors could have slipped into the final conclusive results.

Data

The following chart shows example data regarding; the individual area of the sunspot groups on a particular solar image, the date that the solar image was taken on, the total area of the sunspots on each solar image, and the total

1999
Data

Date	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Total Area
1-Jan	4.11E+09	4.53E+08	3.92E+07						4.6E+09
2-Jan	3.17E+09	3.94E+08	1.25E+08						3.69E+09
3-Jan	1.30E+08	3.83E+08	5.95E+09						6.46E+09
4-Jan	4.70E+08	1.11E+08	3.40E+08						9.21E+08
5-Jan	7.12E+08	1.08E+07	2.02E+08						9.25E+08
6-Jan	3.89E+07	5.66E+08	4.49E+07						6.5E+08
7-Jan	5.06E+08	6.53E+07	4.57E+00						5.71E+08
8-Jan	1.16E+08	6.38E+07	4.26E+08						6.06E+08
9-Jan	2.07E+08	7.23E+07	2.93E+08						5.72E+08

combined sunspot area for all the solar images analyzed for the months taken. The months that were analyzed were January and May, of the years 1999, and for the year 2000.

Analysis

After looking at both the total sunspot areas from the sunspot spreadsheet, and analyzing the data from weather archives on the Internet, the project determined no definite relationship between the total are of sunspots and weather, climate, or precipitation on Earth. The total combined area of sunspots did not vary greatly over the two years that we took data for, and the precipitation level only varied by about and inch or two overall. No unusual weather phenomena occurred during the duration of time that the project analyzed, and no noteworthy disturbances in the sun took place either. The data that was gathered was inconclusive regarding the hypothesis. To successfully complete this project, data spanning centuries would be needed, to get a broader view of the sunspot cycle, and to help rule out the other weather phenomena like El Nino. Unfortunately only two years of solar images were available, and as a result the project was crippled.

Conclusions

Unfortunately, the group was not able to collect enough data to form a conclusion on whether sunspots have a significant impact on the weather here on earth. Dr. Goldberg informed the pair that they would need approximately a century's worth of data to form any conclusion. The data they were able to obtain was also, at times, incomplete or inaccurate. Dr. Goldberg also informed the group on other factors concerning weather that they would have to take into consideration, like; El Nino, and the jet streams, which is information that the group simply did not have the resources to analyze. While no conclusive data was produced, the attempt at relating sunspots to weather was a positive experience, which improved skills in astronomy computer programs like Scion Image. There were past solar images available to use in the project that would have made the results more successful, but due to the time restraints on the project, and the restrictions present of the equipment used in analyzing the data, more solar images just could not be accessed. Because of the tedious and time-consuming nature of taking the area for individual sunspots and recording it all in a spreadsheet, the desired results were not achieved, but the project was not a complete failure, as the small amount of data proved no relationship between precipitation and sunspots, and was overall, a good learning experience.

The Life of a Sunspot

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Abstract

The area of the sunspots and sunspot groups were observed over a period of time. A correlation was to be found between the area of the sunspots and their position on the surface of the sun. It was predicted that as the sunspot moved around the sun, it would decrease in size. The RBSE research on the Scion image program was used to collect the sunspot data. The Internet was also used to gather background information regarding sunspots. Data were gathered using the RBSE research program to find a relationship between the area and location of the sunspot. It was concluded that the area of sunspots fluctuated over the period of time that they were observed. They did, however, reduce in size overall during that period of time.

Introduction

The research project that has been completed concerned the correlation between the area of a sunspot or sunspot group and its position on the surface of the sun. Data were collected using the RBSE research. The relationship between these two factors was then determined using the data that were gathered. This topic was chosen because it was noticed that the size of a sunspot changed over a period of time. The way in which each sunspot changed was of interest and the relationship between its area compared to it location on the surface of the sun needed to be researched.

Problem/Question

What is the relationship between the area of a sunspot or sunspot group and its location on the surface of the sun?

Hypothesis

It is predicted that as a sunspot moves across the sun, it will gradually decrease in size. It will continue to get smaller until the spot can no longer be seen from the side of the sun that is being viewed.

Materials

The RBSE research on the Scion Image program was used to collect the majority of all data. This program allowed me to track the life, area, and location of two different sunspots or sunspot groups. The Internet was also used to gather background information about sunspots.

Variables

The first variable was the location of each sunspot or sunspot group on the surface of the sun. The second variable was the area of each sunspot or sunspot group.

Procedure

First, I logged on to the RBSE program and got into the KPVT data folder. I then went into the 2000 intensity folder. I then opened up several files in order to observe a particular sunspot or sunspot group over a period of time. I then recorded the coordinates and area of the observed sunspot or sunspot pattern for each day. I then compared my data in order to find some correlation between the location of a sunspot and its area. I then put all of my data into graph form.

Data

Series 1	Series 2
2-1-00 Area: 262,000,000 sq km X-Coordinate: 459 Y-Coordinate: 460	3-8-00 Area: 1,310,000,000 sq km X-Coordinate: 516 Y-Coordinate: 478
2-2-00 Area: 262,000,000 sq km X-Coordinate: 554 Y-Coordinate: 460	3-9-00 Area: 925,000,000 sq km X-Coordinate: 587 Y-Coordinate: 491
2-3-00 Area: 286,000,000 sq km X-Coordinate: 645 Y-Coordinate: 464	3-10-00 Area: 722,000,000 sq km X-Coordinate: 673 Y-Coordinate: 492
2-4-00 Area: 226,000,000 sq km X-Coordinate: 727 Y-Coordinate: 467	3-11-00 Area: 1,070,000,000 sq km X-Coordinate: 746 Y-Coordinate: 507
2-5-00 Area: 237,000,000 sq km X-Coordinate: 779 Y-Coordinate: 471	3-12-00 Area: 956,000,000 sq km X-Coordinate: 800 Y-Coordinate: 514

Conclusions

The area of each sunspot fluctuated over a period of time. Their area often began larger than it was when its life could no longer be observed. As the sunspots moved, their area first became smaller than when they began. Then, it gradually increased in size before it shrank down again. My hypothesis was correct because the area of the sunspots did decrease over the time that they were observed.

Correlation of Radio Emissions and X-rays from the Sun

Katie Cronin, Mara Siegel, Linda Spinelli, Jessica Fullagar and Alex Cullen
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Teacher: Margaret Holzer, RBSE '00

Abstract

We observed OVSA (Owens Valley Solar Array) radio data in conjunction with the NOAA (National Oceanic and Atmospheric Association) x-ray data to discover any possible relationship between radio waves and x-ray waves that sunspots emit. Five months of data was collected and analyzed in hopes of proving that a direct correlation was present between the two. We discovered that the greater the emission of x-ray waves, the greater the fluctuation of the radio waves.

Background Information

The sun, for thousands of years ancient cultures and peoples have marveled over this massive ball of fire. Numerous fables and stories have been made up to account for the mysterious nature of the sun. The Greeks said it was a god driving a chariot across the sky. Centuries later, scientists believed that the sun revolved around the earth. It was also believed that the sun was perfect and unchanging made entirely of ether. This was a widely accepted truth that did not interfere with the church's views. The thirst for new truth evoked by the enlightenment yielded real answers through the research of scientists such as Brahe, Kepler and Galileo. We now know the sun is far from perfect. Violent eruptions and storms plague the sun's photosphere along with wind, flares and sunspots which Galileo first bore witness to. When a radio wave is emitted it appears on a graph as a spike, the correlating soft x-ray is shown as a gradual hill. The "Soup Analogy" helps to explain the complicated relationship between the x-ray emissions and radio-wave emissions. The gas stove turning on is like the spike in the radio emission graph because it occurs quickly in a sort of blast. The spike is similar to the sudden rush of heat. The lump of the soft x-rays similar to the act of heating up soup it slowly takes time to heat up and then cool down. (See diagram1.1) Sunspots are formed when the oppositely charged magnetic fields interact. They can create flares, which are emitted into space. As the helmet streamers, surrounding the sunspot pull away the inner loops of charged particles interlock with the outer loops and cause the outer loops to switch direction and form new streamers. Eventually two new flares will form. (See diagram 1.2) The sun also emits radio waves. The goal of our research is to study the relationship between x-rays from flares and solar radio waves.

Purpose

The purpose of our research was to use data from OVSA that was collected over a five-month time period, and analyze the data for relationships among the solar events, radio waves, and x-rays.

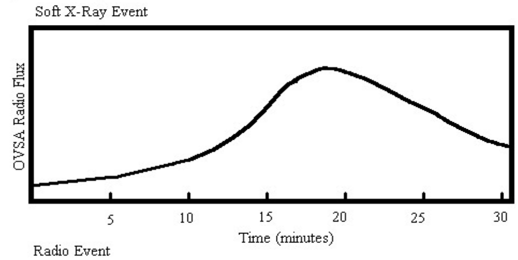
Procedure

To begin, background research was gathered to aid us in our understanding of sunspots. Our research was done during the solar max of the 11-year cycle. The Internet enabled us to have vast amounts information at our disposal. The OVSA (Owens's Valley Solar Array) web page has a telescope array that is on from 1545 UT till 2400 UT, which translates to 11:45 am to 8:00pm; the hours of daylight. The array currently consists of two large, 27-meter antennas, and three smaller, 2-meter antennas. From this site we were able to gather radio data from which we extracted the radio fluctuations. The x-ray events come from the NOAA site came from a solar event page. After both OVSA and x-ray data were collected we took the times that the x-rays occurred and matched them to the graphs from the OVSA hoping to find fluctuations. The data that matched up was then plotted on the graph (diagram 1.3). Some difficulties occurred in the data collection when there was: broken data, missing data, missing regions and other various obstacles.

Data analysis

For the logarithmic graphs above the x-rays have rated by classes. In descending order from strongest to weakest are as follows: the X class of x-ray is the strongest of the four. Preceding it is the M x-ray class, which can cause a rather large radio flux. The most abundant of the classes is the C x-ray type; a majority of our data consisted of C x-rays, and the B x-ray class, which is the weakest of the classes. (See 1.3) The spreadsheet displays what date an x-ray radio event correlation occurred and the particulars on how long the event lasted, the max and radio fluxes. (See 1.4) A majority of the data is complete but as with everything, there are some minor gaps that can be compensated for with using the averages.

Diagram 1.1



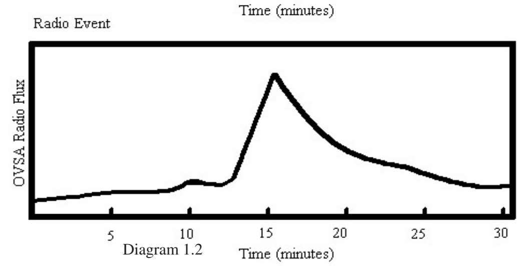


Diagram 1.2

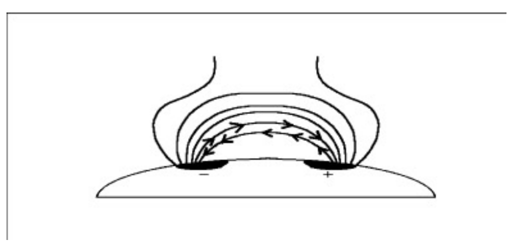
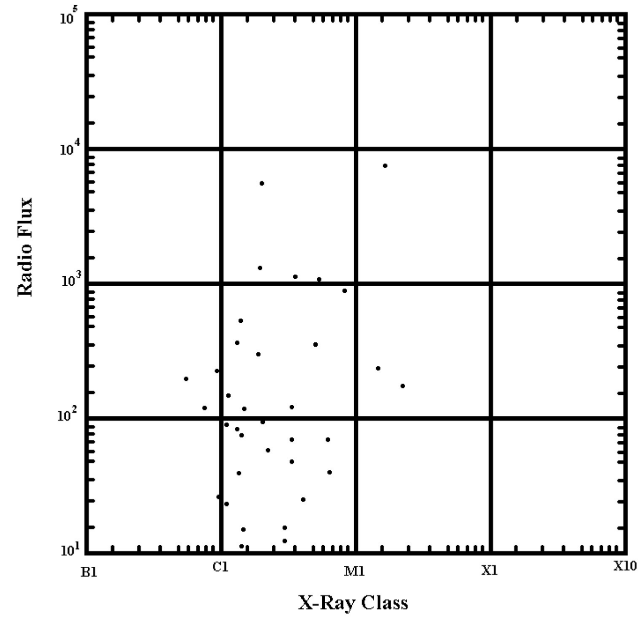


Diagram 1.3



Conclusions

From our data and analysis we can conclude that when a large x-ray i.e. a B.7 or higher is emitted form the sun there is a flux in the radiographs. There is a direct connection in between the amount of the radio flux and the intensity of the x-ray. Still we believe that more research is necessary to completely confirm our findings.

Acknowledgements

We would like to thank Dr. Dale E. Gary, Associate Professor of Physics from the New Jersey Institute of Technology (NJIT) for providing us with the guidance and background information for our research.

We would also like to thank Margaret Holzer, for helping evaluate research findings and organizing meetings with Dr. Gary.

References

http://www.ovsa.njit.edu/
gopher://sec.noaa.gov/11/indices/event/

How Sunspots Group

Thomas M. I. Rodgers and Michael P. Johnston
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Teacher: Carl Katsu, RBSE '00

Abstract

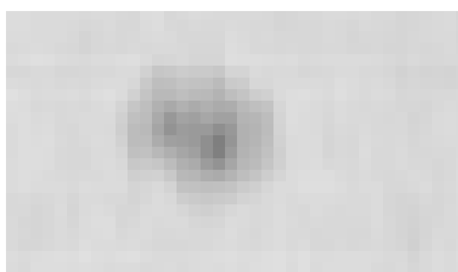
My partner and I are researching our hypothesis of how sunspots group. Naturally we assumed that the larger sunspots would be closer together just because of their size. Therefore, causing them to be closer than their smaller counterparts. My partner and I know that sunspots are caused by magnetic fields. We assumed that the larger fields would be closer together, thinking that the large magnetic fields would pull in or "swallow" the weaker fields. Therefore, causing larger sunspots to be closer than their smaller counterparts.

Introduction

Sunspots are cooler surfaces of the sun that appear darker and will last for about a week. These spots will appear in-groups ranging upward towards 100, and will stay for around 2 months. George Ellery Hale realized that magnetic fields were the cause of the spots. He found that the fields were up to 1000 times stronger then the sun's average field. In 1843, German astronomer Heinrich Schwabe noticed that every 11 years the sunspot count would flourish. He noticed that the spots would appear around 35 degrees above and below the sun's equator and would work their way towards the center of the sun to within five degrees of the equator.

Data and Analysis

My partner and I collected our data from Scion Image, which is a program that has already images and data from previous years. By taking one image from the beginning and end of every month we set a certain size limit of 3.14e8 that would classify whether the sunspot was large or small. By splitting up the months of data that had to be analyzed we were able to draw a conclusion, which is that the larger spots group more than smaller spots. After looking at many months of data and taking the measurements of the sunspot images my partner and I saw that the larger sunspots either paired up or were single. The smaller sunspots developed in-groups of 3-4 and would either become one large sunspot or two slightly smaller sunspots as they progressed over the surface.



Two smaller sunspots forming into a larger one as seen with the Scion Image computer program.

Conclusions

In conclusion, my partner and I found that larger sunspots group more than the smaller ones which agreed with our hypothesis.

Evolution of Solar Active Regions

Michael Conrad
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Teachers: Travis Stagg, RBSE '99, and Ivan Ferron

Abstract

The goal of this project is to map magnetic active regions of the sun. During the course of my investigation, I have learned a lot about the sun and how active regions appear. The program that was used in this study is called Image J. It is a graphics program that can display magnetogram images of the solar disk and analyze active regions as they evolve over time. We found that all active regions tend to "diffuse" radially outward as they age. In a few cases, we observed unique characteristics of behavior in the evolution of an active region.

Introduction

An active region is a "spot" on the sun that is caused by the sun's magnetic field. They are often viewed as sunspots in filtered intensity images of the sun. It is very important to understand how active regions behave because of their influence on all other solar phenomenon. By understanding how they evolve, we may further our understanding of the sun.

Methods

The project used Image J to look at daily magnetogram images from the Kitt Peak Solar Vacuum Telescope. It first required a consecutive date period, dates that are in a row and contain an active region on the solar disk image during each day. Then you had to beware about the consecutive date period because the dates may be interrupted one day because of bad weather or it was a cloudy day. Then you had to decide which active region candidate to study. Once decided, you needed to create a region of interest (ROI) box, by holding the shift key to make it a perfect square, while centered the active region. Using interpolation, the image was scaled to 2 x 2, which smoothed the image. You do this step because the active region will not be big enough to study well. Making the region bigger and clearer, it was easier to see the small detail. On the next date, by clicking on edit, you use the "restore selection" command and centered the active region. This process restores the same size ROI box, so you can make a stack. All the images had to be the same size in order to make a stack. You repeat this process, collecting enlarged ROI windows, until the end of the date span or until the active region disappeared or came to close to the limb of the disc. Occasionally the data became distorted by the "line of sight" of the telescope. Since parts of the image are distorted by the " line of sight", the active region may become slanted on the last date and you would not be able to see how it turns out. After completing the scaling process, you convert the images to a stack, which can then be played like a flipbook movie by controlled animation rates, allowing for time elapse study of them.

Many dates were examined during the course of this study. The data the project used started in the year 1981, and ended in the year 1984. These dates were chosen because every eleven years the sun becomes very active. In this three-year span, a time of high activity, many different shapes and sizes of the active regions were witnessed. One of the best examples included the circular spinning of an active region [see Figure 2]. Other researchers may already have documented similar events. The spinning occasionally took place in both the north and south hemispheres of the sun.

Results

Out of the regions that have been analyzed, some have appeared one day and disappear the next. This happens because the active region begins to "diffuse" outward, weaken and disappear. This can happen over the course of a day or several days. The example below shows the typical diffusion of an active region (see Figure 1). The next example illustrates the "spinning" action of an active region (see Figure 2). It could be this happens because of the differential rotation rate of the sun. If the spinning takes place in a clockwise motion, it was usually in the Southern Hemisphere. If the spinning is in a counter-clockwise motion, it usually indicated that it resides in the Northern Hemisphere. I have not seen any other regular motions or actions that have taken

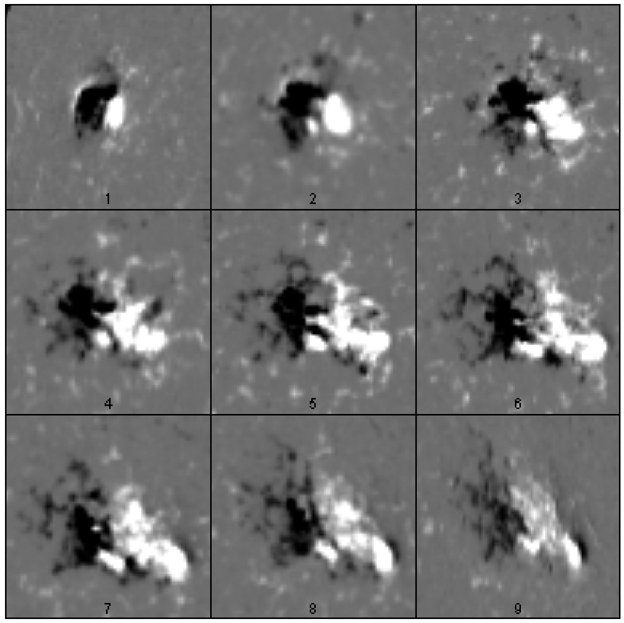

Figure 1: Regular "diffusion" of active region (typical)

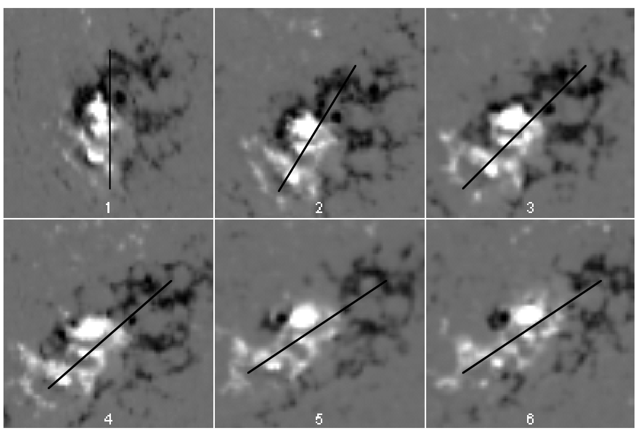

Figure 2: Samples of "spinning" active regions

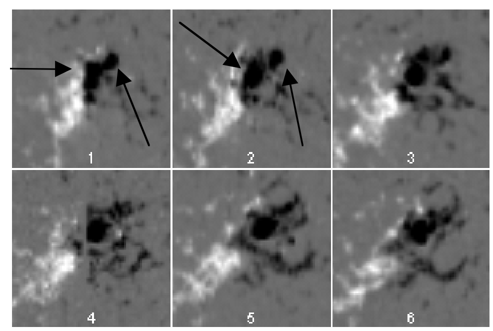

Figure 3: "Splitting" active region

place over the course of my study.

Only on one occasion did I see a sunspot appear to split in two (see Figure 3). This active region formed on January 17, 1981. On January 18, 1981, the active region began to split in two. The active region later formed two separate regions. I believe that this occurred because the way the sun rotates. The active regions then became one active region again. It is unclear what caused one to end before the other. Later, on January 22, 1981, the primary active region ended. The arrows show where the active region split. At this point in my study, it is evident that the evolution of these regions is dependent upon the rotation of material around it. The diffusion could be a result of the region being pulled apart until the magnetic lines can no longer hold it together.

Conclusions

In conclusion, after studying many dates, I have come to believe that the spinning of the active region takes place because the way the sun rotates. The observed data supports the conclusion that the evolution of these regions is dependent upon the rotation of material around it. Differential rotation of the sun contributes to the observed active region behaviors. During the discoveries I have made, I have learned a lot about how an active region appears. It took a lot of hard work to find out answers to questions I had about active regions. An active region may well have as many observable as unobservable characteristics.

Sunspot Variations During Solar Minimums and Maximums

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Abstract

Every twenty-two years, sunspot occurrences cycle from a maximum, to a minimum, and then back to a maximum. Currently there is a solar maximum, in which the number of occurring sunspots increases drastically. In order to find a relation between the area of sunspots during solar maximums and minimums, each occurring sunspot was tracked and its area and longevity were measured. It was found that during solar maximum, sunspots have a considerably larger area than during a solar minimum. However, the longevity remained constant.

Purpose

The purpose of this study is to determine a relationship between sunspot area and longevity during a solar maximum and minimum.

Hypothesis

The sunspots that occur during a solar maximum will have consistently larger areas and less longevity than sunspots occurring during a solar minimum.

Procedure

The first step taken was to gather sunspot images from the NOAO web site and use Scion Image to track the life of a sunspot. The solar latitude and longitude, area in pixels, adjusted area, and actual area in km^2 of these images were then recorded. Once all the information had been collected, all the data was placed in a spreadsheet in Microsoft Excel. The solar maximum data and the solar minimum data were compared to help form a conclusion.

Error Analysis

The largest error that occurred was corrupted data. This occurred on days when the weather was too cloudy to get accurate data from the sun.

Data

The data shown below is a collection of example data during 1995, 1999, and 2000. The column labeled area is measured in pixels, yet this measurement of area does not take into consideration the curvature of the sun. The next column, labeled adjusted area, is also measured in pixels, however it does take into consideration the curvature of the sun. The following column is based on the adjusted area and measured in km^2.

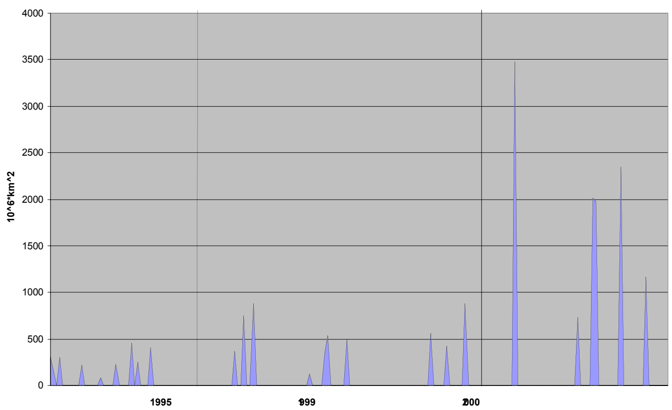
Analysis

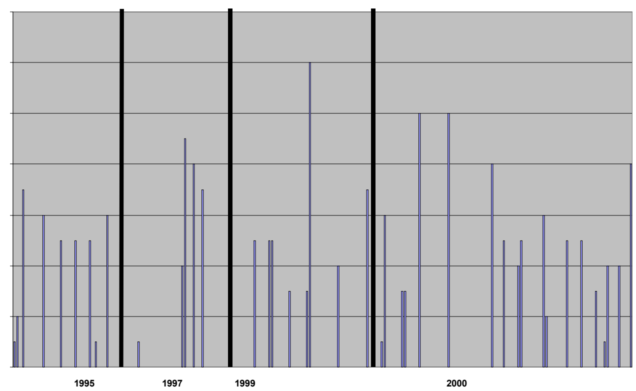
After viewing all the collected data, the average adjusted area of each sunspot was calculated. Through careful observation, any anomalies will be minimized, which allow for a clearer picture of any apparent trends. The highest sunspot area in 1995 is 247 pixels or roughly 6.57*10^8 km^2, while in 1999 and 2000 the largest sunspot is 2070 pixels or 5.5*10^9 km^2 (see chart 2). The sunspot longevity is based on the days that the sunspot was visible (see chart 1).

Conclusions

The data shows that the solar maximum and minimum affect a sunspot's area. The sunspots that were observed during the solar maximum had large, almost gigantic areas. Most of these areas ranged from hundreds to thousands of adjusted pixels. The sunspot areas recorded during the solar minimum were not as large. These areas ranged from high tens to low hundreds. Therefore, sunspots have a larger area during a solar

Start Date	End Date	Latitude	Longitude	Area	Adj. Area	Area (km^2)	Average	Day
950201	950208	-13	-48.8	116	242	6.44*10^8	112	7
950202	950208	-13.2	-33.7	115	139	3.69*10^8		
950203	950208	-12.7	-19.9	90	96	2.56*10^8		
950204	950208	-12.9	-6.8	130	132	3.5*10^8		
950205	950208	-13.1	7.4	45	46	1.2*10^8		
950206	950208	-13	19.2	103	110	2.92*10^8		
950208	950208	-12.5	48.5	17	25	6.74*10^7		
990202	990208	-25.2	-47.3	42	65	1.71*10^8	48	5
990203	990208	-25.2	-34.6	89	112	2.77*10^8		
990206	990208	-26.4	7.5	36	39	1.02*10^8		
990207	990208	-26.4	29.2	13	15	3.92*10^7		
990208	990208	-26.6	3.5	7	9	2.35*10^7		
000104	000108	-15.3	14.2	188	203	5.35*10^8	205.2	5
000104	000108	11	7.6	191	192	5.2*10^8		
000105	000108	11	16.9	145	157	4.14*10^8		
000105	000108	-15.4	33.2	166	202	5.35* !0^8		
000106	000108	10.7	29.7	92	110	2.91*10^8		
000106	000108	-15.5	45.6	135	195	5.19*10^8		





maximum than during a solar minimum.

However, when interpreting the data no such relation was found when dealing with longevity of sunspots. It appears that sunspots last the same amount of time during a maximum and minimum. However, to draw a truly accurate conclusion more data would need to be studied over a longer period of time.

Bibliography

Sunpots : http://es.rice.edu/ES/humsoc/Galileo/Things/sunspots.html
ScienceRules.com - Space News and lots more: http://www.sunspotcycle.com
Science @ NASA : http://www.science,nasa.gov
FTP directory /kpvt/daily/medres/ at ftp.noao.edu

Investigation of the Correction Constant for the Wolf Equation for Sunspot Calculations

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Abstract

Is there a mathematical constant to correct solar images viewed on a computer screen? In my research I am calculating a mathematical constant to figure my sunspot data more accurate. In order to reach a mathematical constant I will count sunspots for every day each month in the year 1999. After calculating all the observed sunspots I use the Wolf Equation, which is an equation that will calculate the average number of sunspots for each day in a month (10g+s). When I have calculated the average for each day I will find the average number of sunspots for that month by dividing the average day by the number of days there are in that month. I continue this procedure for each month in 1999. Next I will add each months calculated k constant and divide by 12 to reach an overall yearly average. This will then give me a mathematical constant to use with any sunspot data to make them more accurate.

Finally to prove my k constant was usable I calculated sunspots for twelve days in the year 2000. I calculated these sunspots exactly like I did in 1999. I then used the Wolf Equation but then multiplied my k constant to prove my mathematical constant to be accurate. I expect my k constant to be very reliable and make my observed data more accurate. After all my data and calculations I discovered my k constant to be accurate. Finally I figured the percent error to show the difference between my data using my k constant and the actual sunspot data, which will be graphed. In my research I have proven that there is a mathematical constant to correct solar images for sunspots when viewed on a computer screen.

Introduction

Is there a mathematical constant (k) that corrects solar images for sunspots when viewed on a computer screen? I am attempting to prove whether or not there is a mathematical constant or k constant, which is a mathematical correction for degraded images displayed on a computer screen, that corrects calculations of solar sunspot images using the Wolf Equation. I have calculated sunspots of an image throughout the year of 1999 and discovered a mathematical constant to make my calculations more accurate. Throughout my research I have proven that there is a mathematical constant or k constant that corrects the calculations of solar images.

Procedure

Beginning in the middle of November to the end of December I counted and recorded the number of groups and single sunspots displayed on a computer screen. I calculated sunspots for each day in every month of 1999. After completing a months worth of data I used the Wolf Equation (10g+s), which gave me x, I then will add each days average together and divide by how many days there are. After finding the average I will look up and record the actual number of sunspots for that month. Next I will use the formula n/x (n=actual and x=observed) to calculate the average number of sunspots for that month. I continued this procedure for each month in the year 1999 and graphed my calculations compared to the actual calculations. To view the sunspot pictures I logged into scion imaging where the pictures were loaded and sent from the National Optical Astronomy Observatory located atop Kitt Peak, Arizona. After completing a years worth of data I added every months average together and divided by twelve to achieve a mathematical (k) constant that will correct my calculations and make them more accurate.

I put my k constant to the test and viewed twelve solar days in the year 2000. I viewed these days just as I viewed every day for each month in 1999 using the Wolf Equation. I then used the formula k (10g+s), k being my constant. I used this formula for each of those twelve days and then compared my results to the actual results to find out if my k constant was any good. To find the actual results for each single day I went to the website http://sidc.oma.be/index.php3. After comparing the actual and the observed I discovered if my k constant was accurate enough. My last procedure was to discover the percent error between my calculations and the actual

Wolf formula: **N = 10g + s**

Solar Date	groups	sunspots	Number
990101	2	16	36
990102	2	19	39
990103	1	18	28
990104	4	18	58
990105	5	19	69
990106	2	15	35
990107	4	13	53
990108	5	20	70
990109	4	11	51
990111	0	2	2
990112	4	15	55
990113	2	15	35
990114	2	14	34
990115	3	20	50
990117	4	17	57
990118	4	19	59
990122	4	20	60
990123	5	19	69
990126	1	3	13
990129	0	2	2
990131	0	4	4

Actual Monthly Average: 62
Observed Monthly Average: 42

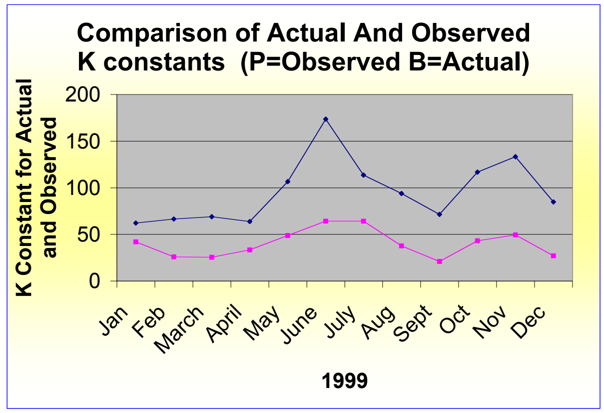
Calculation of *k* constant value for the month of January:

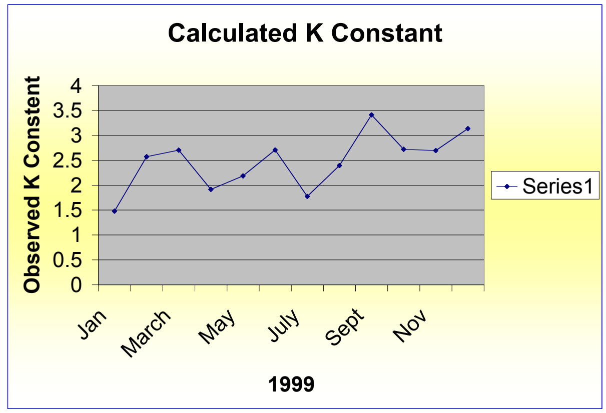
Formula: k = N/x

Where: N = actual monthly value
x = observed monthly values

k =1.4762

The data sheet of January in the year 1999 is an example of the recorded sunspot calculation data using the Wolf and K Constant Equation.





calculations. To figure the percent error I divided the actual sunspot number for each day by my observed sunspot number for each day then multiplied by one hundred (A/O*100). I have graphed all my results during this project to prove my theory and to show the difference between my calculations and the correct calculations.

Results

The k constant through calculating sunspots for scion imaging is determined to be 2.4732.I have proven that there is mathematical correction that corrects the accuracy of solar sunspot images. Throughout my research I have discovered a k constant, which corrects the calculations between my observed and the actual number of sunspots throughout the year of 1999. I also figured the percent error between the two calculations. My results using my k constant have been graphed to show the close comparison between my observed sunspot calculations and the actual sunspot calculations.

Discussion

Throughout my research and observation I have not only discovered a mathematical constant that corrects solar images but I have proven that with close observation and data collection you can discover a k constant that will make your calculations closer to the actual calculations. I used a computer to reach all my data and math to figure the average number of sunspots and the percent error. I noticed in my research that my observations were close to the actual calculations and my percent error proves that. The k constant is important in sunspot data collection because now other students, teachers, scientists etc. can use the Wolf Equation correctly (k*10g+s) in order to achieve accurate sunspot results viewed on a computer screen.

Conclusions

Is there a mathematical (k) constant that corrects solar images for sunspots when viewed on a computer screen? Yes, there is a mathematical constant, which corrects solar images. Not ever will there be a k constant that is the same because of degraded pictures and how close the observer calculates their data. I have calculated and recorded a lot of data in my research project using sunspot data in the year of 1999, the Wolf Equation, the k equation, and the percent error equation. I answered my question and was able to prove my results with graphs showing correlations between my results and the actual results. I have learned that a k constant exists and I can calculate my results more accurately using it.

The Search for Recurring Novae in M31

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Abstract

Photographs of M31, the Andromeda Galaxy, were taken at the Kitt Peak National Observatory between 1995 and 2000 with the 0.9 meter telescope. Using Scion Image software, nineteen epochs for each of the sixteen subrasters were observed. The right ascension (RA) and declination (Dec) of each of the novae located were recorded and compared to historical data to determine if the duration between successive nova events of the same star could be estimated. No novae have been previously reported within a radius of 5 and 10 arcseconds of the novae identified in this study.

Purpose

The question that was researched was whether or not novae in M31 had previously exploded as documented by the professional literature.

Procedure

Scion Image Software and macros developed by the RBSE program were used to locate novae in M31. This program allowed for the nineteen available photographs of each subraster to be animated in sequence. When the photographs were stacked, the stars that blinked were considered to be novae. The RA and Dec were recorded for each nova. Also the magnitude was recorded from each of the images.

From the magnitudes of the ten novae that were located, light curves were developed using Microsoft Excel 2000. The light curve and duration of a nova could be used to determine the size of the exploded object, although this information was not ultimately used in our study.

Using the acquired data, the Simbad database was consulted to search professional journal articles for historical information of each object that was identified. This information was then compared to the data taken from the Kitt Peak images to determine if it was possible to find the duration between explosions. We searched for previously reported objects within a radius of 5 and 10 arcseconds of the RA and Dec of these ten novae.

Controls and Error Analysis

Several controls were used in these procedures. While a nova may be of such duration that it is only visible in one epoch, this study only considered images recorded in a minimum of two epochs. Objects that moved across the subraster were also dismissed as comets, asteroids or mistakes in the data. Images too close to the edge of outer subrasters were not included because of poor data quality.

Some error may occur due to the clarity of the pictures. These differences, caused by "seeing" may be due to cloud cover or atmospheric instability. Due to large gaps of time between some images, certain light curves obtained had shapes different from the generally expected shape for a nova. This error is not central to the theme of the project.

When a nova was located, the contrast was adjusted from the maximum to the minimum to ensure that the nova was not visible in the epoch after it "disappeared." Occasionally, dim images were perceived when this adjustment was made, and more data was collected.

Data

R.A. Dec	5 arcseconds	10 arcseconds
00:42:19.10 +41:16:14.1	1 object reported 00 42 19.36 +41 16 16.2 **ShAl 54**: nova reported by Sharov in 1998.	1 object reported 00 42 19.36 +41 16 16.2 **ShAl 54**: nova reported by Sharov in 1998.
00:42:30.08 +41:16:31.1	0 objects reported	1 object reported 00 42 30.7 +41 16 28 **Ford M31 43**: emission object
00:42:31.77 +41:14:39.5	0 objects reported	0 objects reported
00:42:33.07 +41:16:59.4	0 objects reported	2 objects reported 00 42 33.48 +41 17 02 **PFJ93 31**: x-ray source reported in 1993 00 42 33.2 +41 16 50 **Ford M31 41**: emission object reported in 1978.
00:42:36.92 +41:16:56.1	1 object reported 00 42 37.07 +41 16 56.8 Nova **ShAl 62** reported by Sharov in 1998.	2 objects reported 00 42 37.07 +41 16 56.8 Nova **ShAl 62** reported by Sharov in 1998. 00 42 36.35 +41 16 57.3 Planetary nebula **Ford M31 39** reported in 1989
00:42:46.33 +41:14:46.1	1 object reported 00 42 46.6 +41 14 50 **EQ J0042+4114**: nova reported by Modjaz in 1998	1 object reported 00 42 46.6 +41 14 50 **EQ J0042+4114**: nova reported by Modjaz in 1998
00:42:50.25 +41:07:47.0	0 objects reported	0 objects reported
00:43:06.68 +41:18:07.5	0 objects reported	1 object reported 00 43 06.1 +41 18 07 **C84 95**: a strong x-ray source reported in 1984.
00:43:12.39 +41:21:48.9	0 objects reported	1 object reported 00 43 12.8 +41 21 40.9 **Ford M31 502**: planetary nebula reported in 1989.
00:43:28.46 +41:26:40.6	0 objects reported	0 objects reported

Analysis

Ten novae were identified and located. A search of objects within 5 and 10 arcseconds of the RA and Dec of these objects indicates that three had been previously reported in the literature by Sharov and Modjaz. These novae were reported at the times the epochs were taken.

Conclusions

Objects reported within the areas studied did not indicate novae outside the epoch periods, but planetary nebulae and x-ray sources. This indicates that either insufficient time has elapsed for these novae to recur or that the information has not been reported in the literature.

References

SIMBAD Astronomical Database http://simbad.harvard.edu/sim-fid.pl

CDS Bibliographic Service http://cdsweb.u-strasbg.fr/

The Use of Novae to Determine the Spiral Structure Near the Core of the Andromeda Galaxy

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Abstract

The purpose of this research is to locate the spiral structure within the core of the Andromeda Galaxy using the coordinates of novae.

Images were taken using the 0.9-meter telescope at Kitt Peak National Observatory in Nevada. The images are stacked and flipped rapidly to find the novae. This is done using the NIH Image and SCION Image programs. All novae are plotted on a single image to highlight the spiral arms and structure into the core.

Purpose

The problem to be addressed in this research is to map the spiral structure near the core of the M31, Andromeda Galaxy, to determine if the galaxy has a barred spiral structure.

Background

Novae originate in binary star systems; systems where two stars orbit each other. In nova-producing systems, there is a white dwarf closely orbiting a companion red giant. The dwarf star is the dense core of an older red giant that has pushed away its outer layers of gas.

The two stars are in a tight enough orbit that the white dwarf has a stronger gravitational pull on the outer gas layers of the red giant than does the giant's own core. Hydrogen gas is pulled toward the small star and forms an accretion disk, or ring, around the star. As the layer of gas gets thicker, it settles onto the dwarf star's surface. By the time about 100 earth masses have been transferred, the base of the layer of hydrogen reaches millions of degrees and 10,000 times the density of water. Suddenly, the hydrogen begins to fuse. In a few seconds, the temperature raises to 100 million degrees. The temperature grows hot enough to force the gas to expand. The collected hydrogen is thrown from the star, creating a nova. The shell swells and cools, causing the nova to fade.

Procedure

Novae are found on images of the core of M31 provided by the National Optical Astronomy Observatory through the Use of Astronomy in Research-Based Science Education Program. There are 20 images from September 1995 to November 2000. The images are divided into 16 sections for easier use. The center four sections (6, 7, 10, 11) were used for this study. The SCION Image Program is used to stack on section of the images chronologically and flip rapidly between the images. Any star that appears in one image and not in the previous image is considered to be a possible nova.

The location of each nova is then plotted on a large image of M31 to allow study of the distribution of the novae. Novae are compared with their position relative to the others to determine where the greatest concentration of novae lies.

Data

The table contains the location of all 94 novae in right ascension and declination, and if novae were found during this research.

RA	DEC	
00:42:13.56	41:19:28.7	
00:42:17.89	41:21:51.6	*
00:42:18.37	41:21:53.7	*
00:42:19.31	41:16:16.5	
00:42:19.68	41:16:08.3	
00:42:19.78	41:14:08.4	
00:42:20.65	41:10:37.6	
00:42:21.03	41:10:38.6	*
00:42:21.76	41:12:16.5	
00:42:22.17	41:11:31.7	
00:42:22.24	41:12:17.2	
00:42:22.60	41:11:32.3	*
00:42:26.46	41:16:56.6	
00:42:26.58	41:16:57.6	*
00:42:26.88	41:19:25.3	*
00:42:27.61	41:11:07.1	*
00:42:27.85	41:11:07.1	
00:42:29.10	41:13:36.0	
00:42:30.37	41:16:34.2	
00:42:32.05	41:14:41.7	
00:42:34.36	41:15:50.3	*
00:42:34.67	41:15:50.3	*
00:42:35.63	41:15:43.4	*
00:42:36.11	41:15:44.1	*
00:42:36.60	41:14:05.4	*
00:42:37.01	41:16:56.3	
00:42:37.37	41:20:52.9	
00:42:37.44	41:13:28.0	*
00:42:37.80	41:13:29.4	*
00:42:38.41	41:13:58.4	
00:42:38.47	41:11:24.8	*
00:42:38.59	41:14:19.7	*
00:42:38.71	41:11:25.5	*
00:42:38.83	41:13:46.4	*
00:42:38.89	41:13:59.3	*
00:42:39.01	41:16:58.3	*
00:42:39.13	41:13:47.8	*
00:42:39.59	41:09:04.0	
00:42:40.14	41:15:46.7	
00:42:40.28	41:14:45.6	*
00:42:40.36	41:18:10.2	
00:42:40.40	41:17:33.0	
00:42:40.40	41:20:59.2	*
00:42:41.18	41:12:00.2	*
00:42:41.21	41:12:00.4	
00:42:41.92	41:16:40.2	
00:42:42.07	41:12:18.0	

RA	DEC	
00:42:42.14	41:15:10.8	
00:42:42.15	41:12:17.2	*
00:42:42.57	41:12:18.6	*
00:42:43.10	41:16:04.1	
00:42:43.27	41:14:15.9	
00:42:43.29	41:14:16.3	*
00:42:43.48	41:14:17.0	*
00:42:43.82	41:11:31.5	
00:42:43.82	41:16:52.4	
00:42:43.90	41:12:05.0	*
00:42:44.02	41:11:32.3	*
00:42:44.19	41:17:07.7	
00:42:44.50	41:11:33.0	*
00:42:44.56	41:20:40.8	*
00:42:45.16	41:15:31.6	
00:42:46.59	41:14:49.5	
00:42:46.66	41:11:08.2	
00:42:46.73	41:18:14.4	
00:42:46.73	41:12:51.8	*
00:42:47.00	41:14:50.2	*
00:42:47.76	41:16:54.7	
00:42:48.79	41:17:21.4	*
00:42:49.64	41:15:05.8	
00:42:49.91	41:16:48.5	
00:42:52.31	41:16:21.9	
00:42:56.63	41:12:55.8	
00:42:57.05	41:09:18.1	
00:42:57.90	41:18:17.9	*
00:43:01.28	41:17:41.2	*
00:43:01.82	41:15:38.5	
00:43:02.66	41:18:41.8	*
00:43:02.92	41:23:02.0	
00:43:03.78	41:16:03.9	
00:43:03.99	41:17:08.5	*
00:43:04.41	41:19:35.9	
00:43:04.89	41:18:41.4	
00:43:05.34	41:14:59.3	
00:43:06.12	41:13:41.3	
00:43:06.80	41:17:58.1	
00:43:06.96	41:18:09.9	
00:43:07.37	41:17:56.8	*
00:43:07.49	41:18:11.1	*
00:43:08.34	41:16:40.2	
00:43:08.64	41:19:58.7	*
00:43:09.97	41:19:19.2	*
00:43:10.03	41:20:26.6	*
00:43:12.53	41:21:49.7	

* not previously found

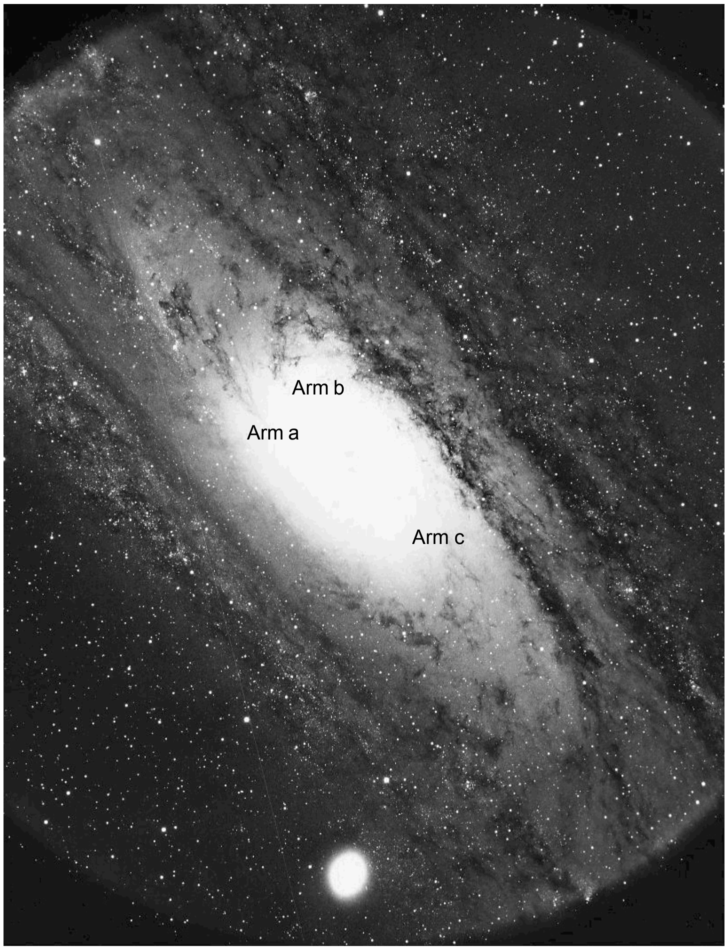
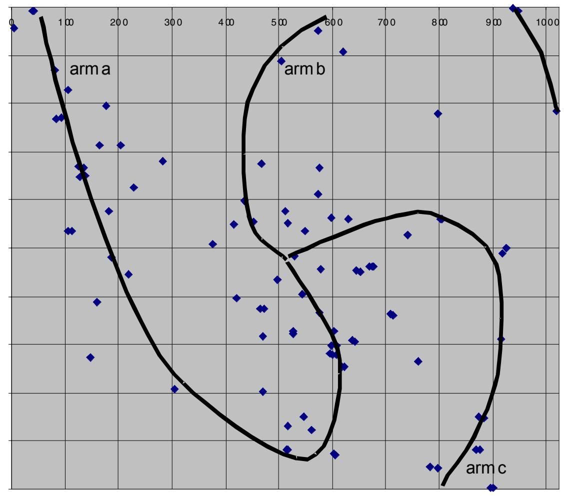


Image of Andromeda Galaxy.
(figure 1)



Possible Spiral Structure near the core of the Andromeda Galaxy
as Indicated by Location of Novae.
(figure 2)

Analysis

Location of each nova is plotted on an image using Microsoft Excel. Novae are analyzed to find spiral structure. Possible spiral pattern was located visually. Any spiral is compared to an image of the outer portion of M31 to determine if the spiral near the core is of the same direction and on the same plane.

Conclusions

Forty-four new novae were discovered in the Andromeda Galaxy. Previously located and newly located novae were graphed and analyzed. The suggested pattern near the core in relation to existing spiral structure beyond the core is shown in figures 1-2.

Acknowledgements

I would like to thank Dr. Travis Rector for his development of the procedures used to locate the novae and determine their magnitude. I would also like to thank my teacher, Tom Gehringer, for all of his help in making this research possible.

References

Bizony, M. T. The space Encyclopedia E.P. Dutton, New York, 1960
Chartrand, Mark R., Alfred P. Knopf, New York, 1998.
Rector, Dr. Travis, RBSE Nova Search Information. National Optical Astronomy Observatories, 1999.
Seeds, Michael A., Foundations of Astronomy Wadsworth 1997
Shipman, Harry L., The Restless Universe Houghton Mifflin, 1978.

Magnitudes of Novae in M31

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Abstract

A nova search was conducted using images of the Andromeda Galaxy taken at Kitt Peak National Observatory by a 0.9-meter telescope over a period of 4 years. Novae are stars that show a sudden, dramatic in increase in brightness. A total of 26 novae were found but only 17 were used because the others had a short duration and there was insufficient data to form adequate light curves. 71% of the novae had a slow decrease of magnitude after they reached maximum brightness, while the other 29% had a rapid decrease after reaching maximum brightness. The highest daily magnitude decrease was .103, and the lowest .006. The daily magnitude decrease is the average of the magnitudes recorded for every epoch that the star was nova. Twelve novae lasted less than 400 days but 5 lasted longer than 400 days before returning to normal. In fact 2 out of the 5 lasted more than 600 days. Nova # 11 lasted 730 and # 13 lasted 850 days! These results has led us to the belief that it, along with the other 4 stars may not be novae.

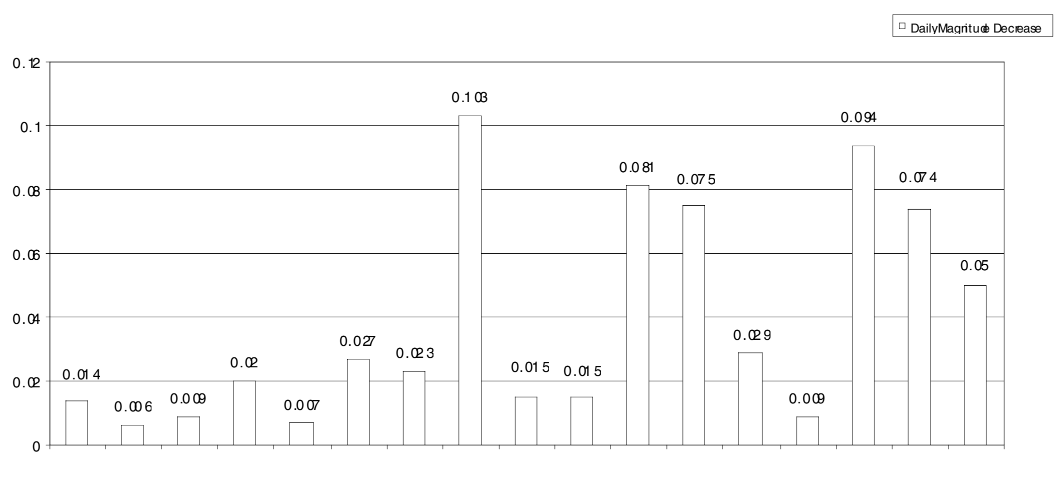
Purpose

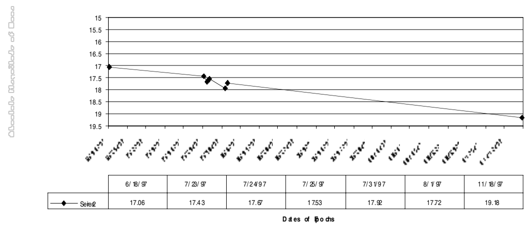
The purpose of this project is to find novae in the Andromeda Galaxy (M31) and measure the rate of decrease after the novae reach maximum brightness. Other studies have shown that the brightest novae decrease in magnitude more rapidly than dimmer novae.

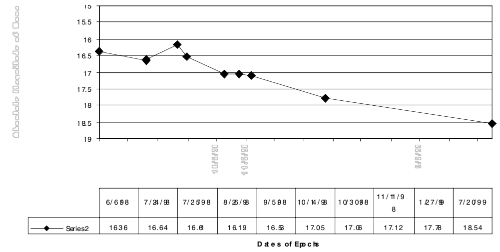
Procedure

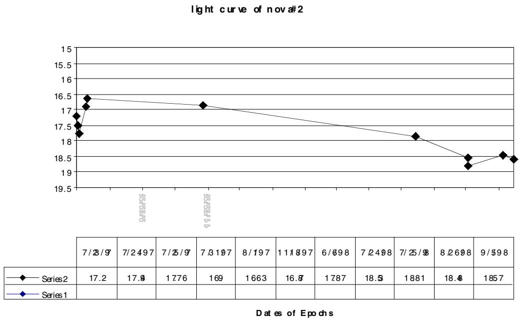
A nova search was conducted using images of the Andromeda Galaxy taken at Kitt Peak by a professional astronomer during a period of four years. These images, along with Scion Image were on the RBSE CD-ROM. Scion Image, an image-processing program, was used for locating the novae and measuring their magnitudes. With the help of the Subraster booklet, three stars with known magnitudes were chosen and their magnitudes recorded on to the epochs in which the novae were found. We measured the novae's magnitude in each epoch by comparing it to the known magnitudes in the Subraster booklet. This information was recorded on Novae Data Sheets and, using Microsoft Excel, line graphs were made with the magnitudes so the light curves of each nova could be observed. A daily magnitude decrease was calculated for each nova.

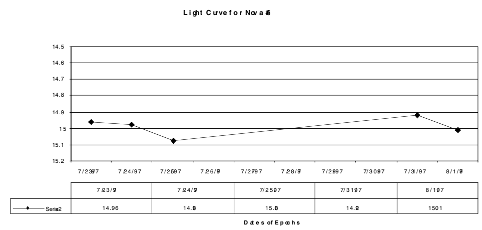
Analysis

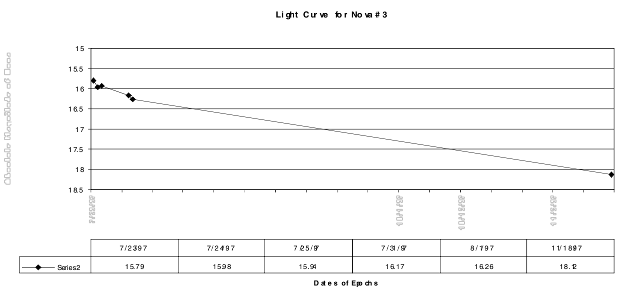


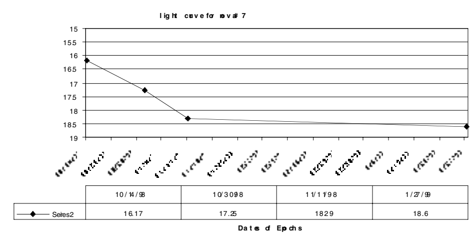


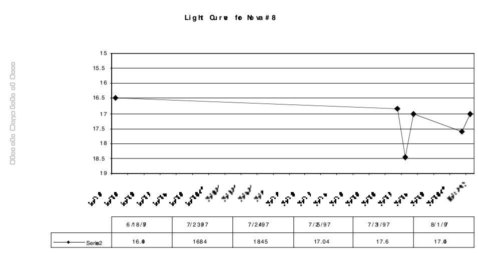












Conclusions

A total of twenty-three novae were found but only seventeen were graphed because the other six didn't appear in enough epochs to make light-curves. Of the novae studied, the brightest novae had a more rapid daily decrease than the dimmer novae, this result was also obtained by other researchers. Results showed that the average novae had a rapid increase of magnitude followed by a slow, smooth decrease. There were several light curves that didn't look like the ones of most novae. They could have possibly been other objects or it could have simply been bad data.

Bibliography

Discovering the Cosmos, Bless, R.C., University Science Books, 1996, Sausalito, CA.

Astronomy Today, Chaisson/McMillan, Prentice-Hall, Inc., 1999, 1996, 1993. Upper Saddle River, NJ.

Voyages Through the Universe, Fraknoi, A., Morrison. D., and Wolff, S., Harcourt, Inc., 2000, 1997. Orlando, FL.

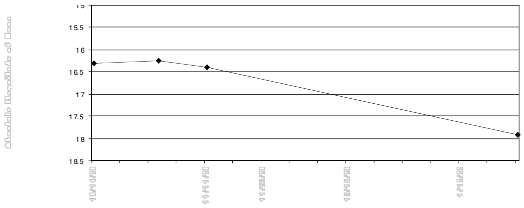
A Search for Novae in the bulge of M31, Rector, T.A., et al. RBSE Nova Search Team, NOAO. 2000

A Search for Novae in the Andromeda Galaxy—Year Two Results, Phelps, K., Provenzano, C., and the Nova Search 2000 Research Group. RBSE Journal 2000

The Correlation of the Location of Novae in the Andromeda Galaxy with Respect to the Duration of their Light Curves, Harriger,M., RBSE Journal 2000.

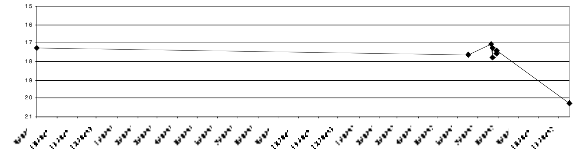
The Search for Novae in the M31 Galaxy, Nascenzi, B., RBSE Journal 2000.

Astronomy Magazine, Neon Nova, David Bruning, 1993



	10/14/98	10/30/98	11/11/98	1/27/99
Series2	16.3	16.26	16.4	17.91

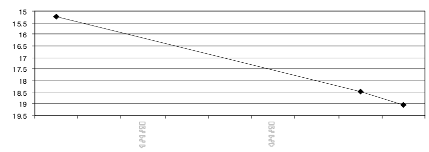
Dates of Epochs



	9/3/95	6/18/97	7/23/97	7/24/97	7/25/97	7/31/97	8/1/97	11/18/97
Series2	17.25	17.62	17.03	17.8	17.8	17.8	17.43	20.24

Dates of Epochs

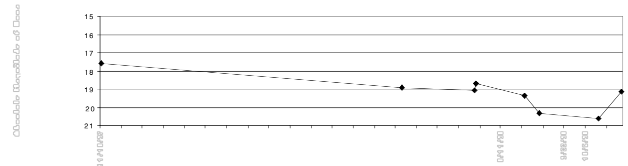
Light Curve for Nova# 10



	11/18/97	6/6/98	7/24/98
Series2	15.22	18.44	19.02

Dates of Epochs

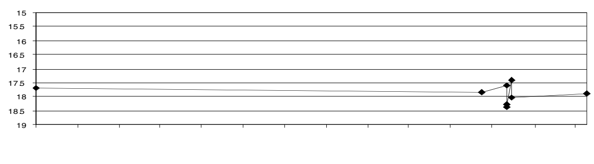
Light Curve for Nova# 15



	11/18/97	6/6/98	7/24/98	7/25/98	8/25/98	9/5/98	10/14/98	10/30/98
Series2	17.59	18.92	19.05	18.68	19.34	20.31	20.66	19.14

Dates of Epochs

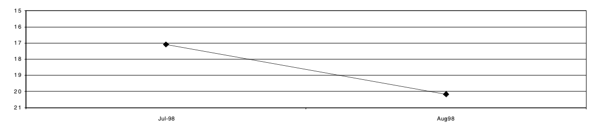
Light Curve for Nova# 11



	9/3/95	6/18/97	7/23/97	7/24/97	7/25/97	7/31/97	8/1/97	11/18/97
Series2	17.7	17.82	17.62	18.35	18.28	17.42	18.04	17.89

Dates of Epochs

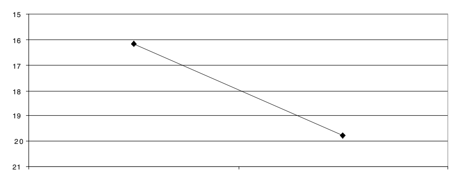
Light Curve for Nova# 16



	7/25/98	8/26/98
Series2	17.09	20.17

Dates of Epochs

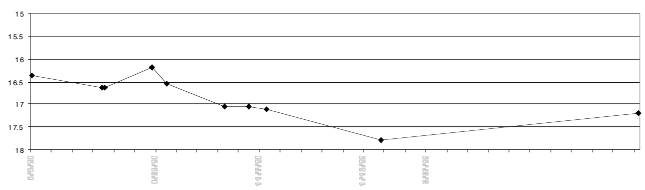
Light Curve for Nova# 12



	6/6/98	7/24/98
Series2	16.19	19.79

Dates of Epochs

Light Curve for Nova# 14



	6/6/98	7/24/98	7/25/98	8/25/98	9/5/98	10/14/98	10/30/98	11/11/98	1/27/99	7/20/99
Series2	16.36	16.64	16.62	16.19	16.53	17.05	17.06	17.12	17.78	17.2

Dates of Epochs

Data Sheet

Novae # 1

Located in Subraster # 6
First visible in epoch # 2 Disappears after # 8
Location: X coordinate 43.00 Y coordinate 9.00
RA: 00:43:12.38 Dec: +41:21:49.3

Epoch #	2	3	4	5	6
Magnitude:	17.06	17.43	17.67	17.53	17.92

Epoch #	7	8
Magnitude:	17.72	19.18

Novae # 2

Located in Subraster # 14
First visible in epoch # 3 Disappears after # 13
Location: X coordinate 409.00 Y coordinate 222.00
RA: 00:42:50.37 Dec: +41:07:47.8

Epoch #	3	4	5	6	7	8
Magnitude:	17.20	17.49	17.76	16.90	16.63	16.87

Epoch #	9	10	11	12	13
Magnitude:	17.87	18.53	18.81	18.48	18.54

Novae # 3

Located in Subraster # 11
First visible in epoch # 3 Disappears after # 8
Location: X coordinate 201.00 Y coordinate 126.00
RA: 00:42:31.93 Dec +41:07:47.8

Epoch #	3	4	5	6	7	8
Magnitude:	15.79	15.98	15.94	16.17	16.26	18.12

Novae # 4

Located in Subraster # 6
First visible in epoch # 9 Disappears after # 18
Location: X coordinate 135.00 Y coordinate 332.00
RA: 00:43:06.84 Dec +41:18:09.4

Epoch #	9	10	11	12	13	14
Magnitude:	17.13	15.85	16.04	16.04	16.32	17.02

Epoch #	15	16	17	18
Magnitude:	17.42	17.28	17.93	19.22

Novae # 5

Located in Subraster # 5
First visible in epoch # 9 Disappears after # 18
Location: X coordinate 287.00 Y coordinate 19.00
RA: 00:4 3:28.58 Dec +41:21:42.5

Epoch #	9	10	11	12	13	14
Magnitude:	16.36	16.64	16.61	16.19	16.53	17.05

Epoch #	15	16	17	18
Magnitude:	17.06	17.12	17.18	18.54

Novae # 6

Located in Subraster # 10
First visible in epoch # 3 Disappears after # 7
Location: X coordinate 193.00 Y coordinate 6.00
RA: 00:43:03.41 Dec +41:16:03.8

Epoch #	3	4	5	6	7
Magnitude:	14.96	14.98	15.08	14.92	15.01

Novae # 7

Located in Subraster # 11
First visible in epoch # 14 Disappears after # 17
Location: X coordinate 365.00 Y coordinate 406.00
RA: 00:42:19.6 Dec +41:11:58.7

Epoch #	14	15	16	17
Magnitude:	16.17	17.25	18.29	18.60

Novae # 8

Located in Subraster # 16
First visible in epoch # 2 Disappears after # 7
Location: X coordinate 80.00 Y coordinate 182.00
RA: 00:42:08.36 Dec +4:08:15.7

Epoch #	2	3	4	5	6	7
Magnitude:	16.49	16.84	18.45	17.04	17.06	17.04

Novae # 9

Located in Subraster # 10
First visible in epoch # 14 Disappears after # 17
Location: X coordinate 472.00 Y coordinate 116.00
RA: 00:42:46.58 Dec +41:14:48.2

Epoch #	14	15	16	17
Magnitude:	16.30	16.26	16.40	17.91

Novae # 10

Located in Subraster #10
First visible in epoch # 8 Disappears after # 10
Location: X coordinate 162.00 Y coordinate 101.00
RA: 00:43:05.22 Dec +41:15:38.7

Epoch #	8	9	10
Magnitude:	15.22	18.44	19.02

Novae # 11

Located in Subraster # 12
First visible in epoch # 1 Disappears after # 8
Location: X coordinate 431.00 Y coordinate 43.00
RA: 00:41:47.24 Dec +41:15:38.7

Epoch #	1	2	3	4	5
Magnitude:	17.70	17.82	17.62	18.35	18.28

Epoch #	6	7	8
Magnitude:	17.42	18.04	17.89

Novae # 12

Located in Subraster # 10
First visible in epoch # 9 Disappears after # 10
Location: X coordinate 109.00 Y coordinate 196.00
RA: 00:43:08.48 Dec +41:13:54.4

Epoch #	9	10
Magnitude:	16.19	19.79

Novae # 13

Located in Subraster # 5
First visible in epoch # 1 Disappears after # 8
Location: X coordinate 372.00 Y coordinate 24.00
RA: 00:43:23.5 Dec +41:21:40.1

Epoch #	1	2	3	4	5
Magnitude:	17.25	17.62	17.03	17.80	17.26

Epoch #	6	7	8
Magnitude:	17.54	17.45	20.24

Novae # 14

Located in Subraster # 5
First visible in epoch # 8 Disappears after # 15
Location: X coordinate 469.00 Y coordinate 83.00
RA: 00:43:17.66 Dec +41:20:59.7

Epoch #	8	9	10	11	12
Magnitude:	17.59	18.92	19.05	18.68	19.34

Epoch #	13	14	15
Magnitude:	20.31	20.66	19.14

Novae # 15

Located in Subraster # 9
First visible in epoch # 11 Disappears after # 12
Location: X coordinate 371.00 Y coordinate 33.00
RA: 00:43:23.58 Dec +41:15:45.3

Epoch #	11	12
Magnitude:	17.15	20.17

Novae # 16

Located in Subraster # 7
First visible in epoch # 10 Disappears after # 12
Location: X coordinate118.00 Y coordinate 441.00
RA: 00:42:34.04 Dec +41:16:56.7

Epoch #	10	11	12
Magnitude:	16.40	15.67	18.04

Novae # 17

Located in Subraster #9
First visible in epoch #11 Disappears after #12
Location: X coordinate 452.00 Y coordinate 224.00
RA: 00:43:18.69 Dec +41:13:35.3

Epoch #	11	12
Magnitude:	18.07	19.91

Novae in the Andromeda Galaxy

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Abstract

While searching in the Andromeda Galaxy with Scion Image, we found seventeen possible novae and verified fourteen of them. We hypothesized that more novae occur near the core of the Andromeda Galaxy, where the stars are older and more crowded, rather than near the perimeter, where the stars are younger. We believe that we were correct in our prediction, since we found twelve likely (ten verified) novae in the four subrasters nearest the center of the Andromeda Galaxy, yet found only five likely (four verified) novae in the outer twelve subrasters.

Purpose

The purpose of this research was to determine where in the Andromeda Galaxy there are the most novae.

Hypothesis

We predicted that more novae occur near the core of the Andromeda Galaxy, rather than near the edge.

Procedures

To find novae, we used 16 images (fields, or subrasters) of different parts of the Andromeda galaxy taken from the RBSE CD-ROM. We loaded the Nova Search Macro in Scion / NIH Image, and then chose "Make Stack For Blinking" from the Special menu. We made it display all nineteen epochs (dates) of a particular subraster, and then animated it. We determined possible novae by looking for stars that 'blinked,' and then recorded their Field, Epoch, X Coordinate, and Y Coordinate. After we had found as many possible novae as we could (all twenty-eight of them), we made light curves of all the novae. To make a light curve, we would get the frame that the nova first appeared on (using "Import FITS"), recording the magnitudes of two known stars, and then measured the magnitude of the possible nova. We did this for each nova's epochs. Using Microsoft Excel, we made the light curves by plotting the data as a line graph and inverting the Y-axis. We took out all of the possible novae that didn't have nova-like light curves. We determined that a nova would have a light curve that started bright, but gradually became dimmer and dimmer without ever going back up to its original brightness before disappearing completely.

Conclusions

Originally, we hypothesized that more novae occur near the core of the Andromeda Galaxy, rather than near the edge. This hypothesis turned out to be correct. The data proved this since there were twelve likely (ten verified) novae in the four subrasters nearest the center of the Andromeda Galaxy, but only five likely (four verified) novae in the outer twelve subrasters. We verified these novae by their light curves. For example, Nova 14's magnitudes were 16.66, 17.28, 18.31, and 19.91; it starts out relatively bright, but gets dimmer and dimmer. We could rule out "novae" that got dimmer and brighter and dimmer and brighter, or 'novae' that zigzagged all over the place.

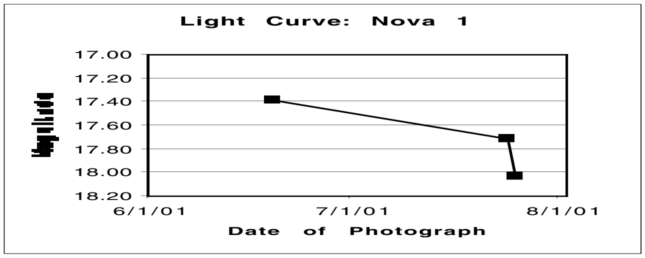
Several things could have caused errors in the recording of our data. The most common source of errors is human misjudgment. If the data gatherers mistakenly thought a nova was a non-nova, or vice-versa, then that could slightly skew the results. Hopefully, we cut down on that by using as close to the same standards as possible for determining each nova. In addition, the measuring of magnitudes and coordinates of novae could be false because of clicking off the center of the nova, though the software should account for that in most cases. Lastly, if a nova was too close to the edge of the picture, its apparent magnitude would be affected, or its magnitude couldn't be measured.

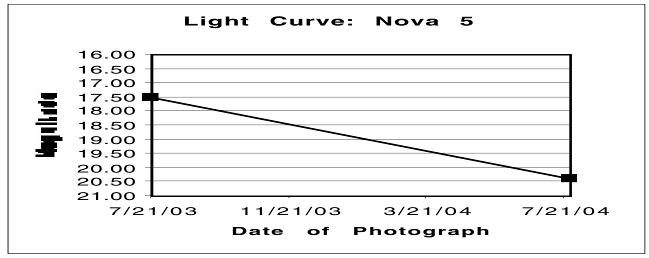
Data, Tables, and Graphs

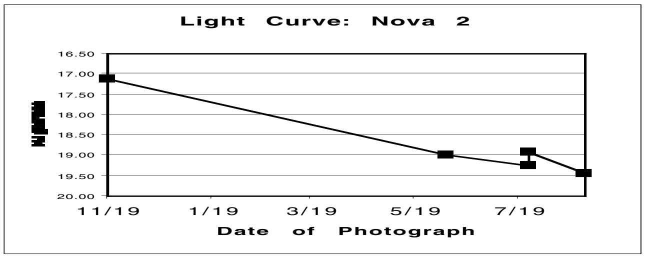
Novae w/ subraster, epoch, & magnitude measurements.								
Nova	Field	Epoch	X	Y	RA	DEC	Magnitude	Date
1	5	2	372	25	00:43:23.5	+41:21:39.2	17.39	6/19/01
1	5	3					17.71	7/24/01
1	5	4					18.03	7/25/01
2	5	8	467	83	00:43:17.8	+41:20:59.9	17.13	11/19/01
2	5	9					18.97	6/7/02
2	5	10					19.24	7/25/02
2	5	11					18.93	7/26/02
2	5	12					19.43	8/27/02
3	6	2	43	9	00:43:12.4	+41:21:50.3	Edge	
4	6	10	135	332	00:43:06.9	+41:18:10.4	15.58	7/25/02
4	6	11					15.08	7/26/02
4	6	12					15.74	8/27/02
4	6	13					16.28	9/6/02
4	6	14					17.13	10/15/02
5	6	18	177	206	00:43:04.3	+41:19:36.2	17.50	7/21/03
5	6	19					20.40	7/25/04
6	7	3	412	499	00:42:19.3	+41:16:16.8	15.78	7/24/01
6	7	4					15.90	7/25/01
6	7	5					15.77	7/26/01
6	7	6					16.02	8/1/01
6	7	7					15.97	8/2/01
6	7	8					18.06	11/19/01
6	7	9					19.35	6/7/02
7	7	10	119	440	00:42:37.0	+41:16:56.9	16.42	7/25/02
7	7	11					15.61	7/26/02
7	7	12					18.36	8/27/02
8	7	10	228	473	00:42:30.4	+41:16:34.5	15.76	7/25/02
8	7	11					15.51	7/26/02
8	7	12					16.45	8/27/02
8	7	13					16.41	9/6/02
8	7	14					18.17	10/15/02
9	10	3	193	5	00:43:03.4	+41:16:04.5	Edge	
10	10	8	161	100	00:43:05.3	+41:14:59.9	15.26	11/19/01
10	10	9					18.37	6/7/02
10	10	10					19.05	7/25/02
11	10	14	472	115	00:42:46.5	+41:14:49.7	16.33	10/15/02
11	10	15					16.61	10/31/02
11	10	16					16.42	11/12/02
11	10	17					17.66	1/28/03
12	11	2	404	176	00:42:19.8	+41:14:08.2	17.90	6/19/01
12	11	3					18.77	7/24/01
13	11	3	200	126	00:42:32.1	+41:14:42.2	15.80	7/24/01
		4					16.00	7/25/01
		5					15.93	7/26/01
		6					16.21	8/1/01
		7					16.14	8/2/01
		8					18.14	11/19/01
		9					20.48	6/7/02
14	11	14	365	405	00:42:22.1	+41:11:32.3	16.66	10/15/02
		15					17.28	10/31/02
		16					18.31	11/12/02
		17					19.91	1/28/03
15	14	3	409	222	00:42:50.3	+41:07:48.4	16.95	7/24/01
		4					17.24	7/25/01
		5					17.63	7/26/01
16	15	12	511	226	00:42:13.3	+41:07:45.7	Edge	
17	15	13	171	472	00:42:33.8	+41:04:58.3	13.48	9/6/02
		14					16.66	10/15/02
		15					18.21	10/31/02
		16					22.40	11/12/02

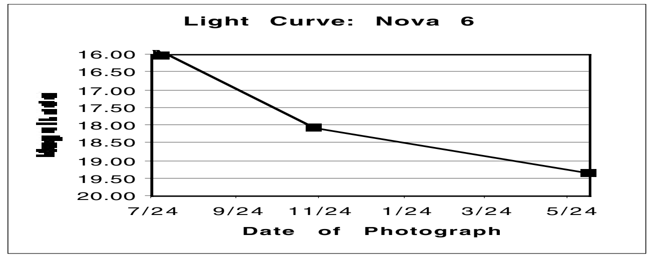
References

"Kit Peak National Observatory M31 Data." RBSE CD-ROM version 5.5. RBSE Nova Search Team. National Optical Astronomy Observatories. 2000.


Light Curve: Nova 1
17.00 17.20 17.40 17.60 17.80 18.00 18.20
6/1/01 7/1/01 8/1/01
Date of Photograph


Light Curve: Nova 5
16.00 16.50 17.00 17.50 18.00 18.50 19.00 19.50 20.00 20.50 21.00
7/21/03 11/21/03 3/21/04 7/21/04
Date of Photograph


Light Curve: Nova 2
16.50 17.00 17.50 18.00 18.50 19.00 19.50 20.00
11/19 1/19 3/19 5/19 7/19
Date of Photograph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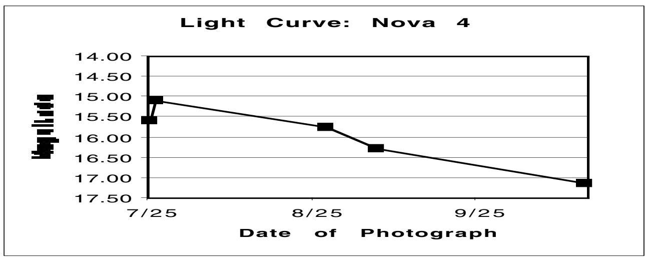
7/24 9/24 11/24 1/24 3/24 5/24
Date of Photograph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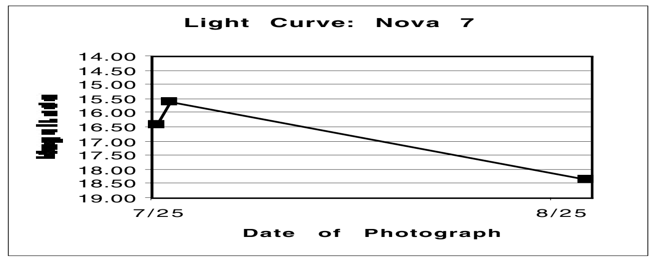
7/25 8/25 9/25
Date of Photograph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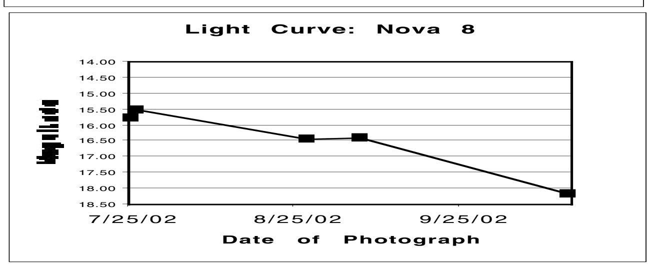
7/25 8/25
Date of Photograph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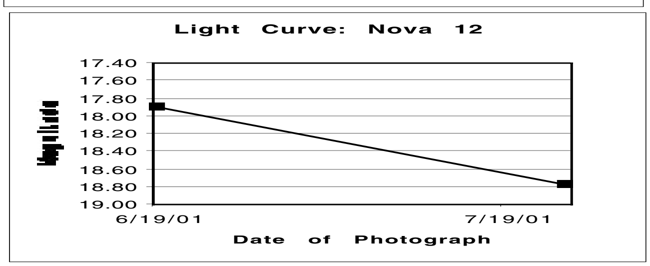
7/25/02 8/25/02 9/25/02
Date of Photograph


Light Curve: Nova 12
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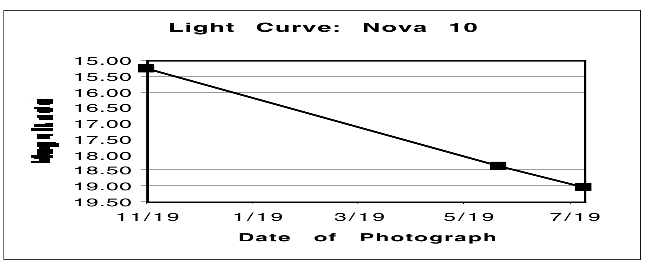
6/19/01 7/19/01
Date of Photograph


Light Curve: Nova 10
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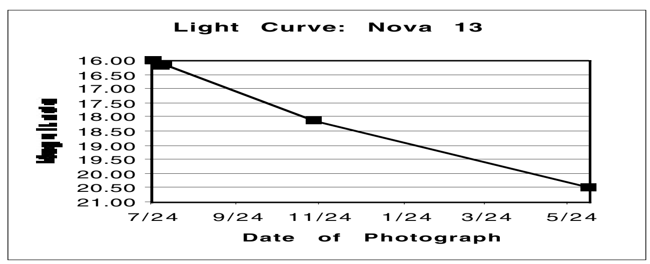
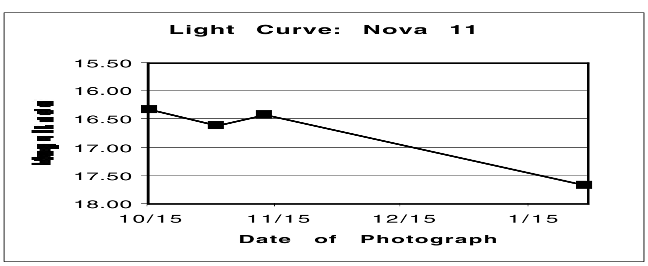
11/19 1/19 3/19 5/19 7/19
Date of Photograph


Light Curve: Nova 13
16.00 16.50 17.00 17.50 18.00 18.50 19.00 19.50 20.00 20.50 21.00
7/24 9/24 11/24 1/24 3/24 5/24
Date of Photograph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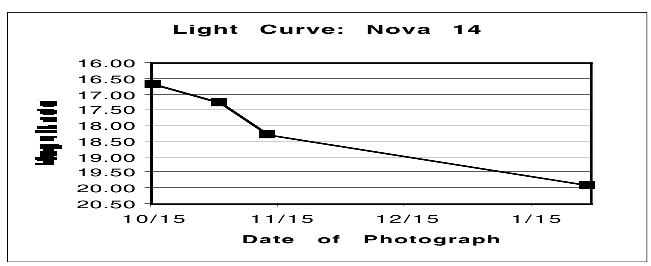
15.50 16.00 16.50 17.00 17.50 18.00
10/15 11/15 12/15 1/15
Date of Photograph


Light Curve: Nova 14
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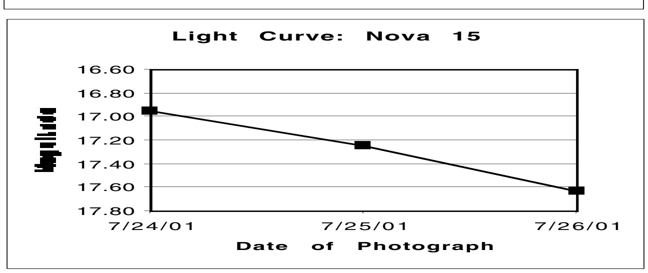
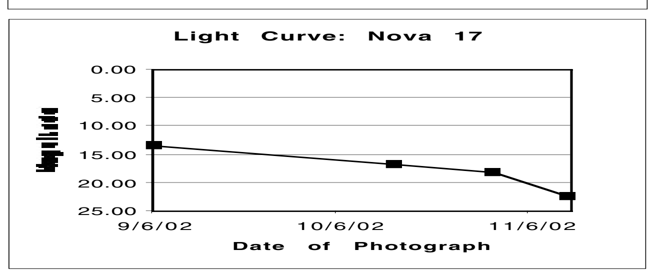
10/15 11/15 12/15 1/15
Date of Photograph


Light Curve: Nova 15
16.60 16.80 17.00 17.20 17.40 17.60 17.80
7/24/01 7/25/01 7/26/01
Date of Photograph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0.00 5.00 10.00 15.00 20.00 25.00
9/6/02 10/6/02 11/6/02
Date of Photograph

Do Novae Repeat? A Study of Novae Discovered in M31 Between the Years 1980-2000

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Round Valley High School, Springerville, AZ
Teacher: Richard Spitzer, RBSE '00

Abstract

Students in the astronomy class at Round Valley High School wondered if novae repeat. We looked at the M31 Galaxy using Scion Image to find all of the Novae we could. We looked for novae between 1995 and the year 2000 by stacking images and animating them. To proceed with our project on finding repeating novae, we then compared the information we had found with the information of Robin Ciardullo, et al. in their July 1987 paper and their 1990 paper. This was how we began to discover whether novae repeat or not. From these comparisons we found five novae that were close and two that were within seven arcseconds in both RA and Dec.

We then checked Ciardullo's field stars with the RBSE field stars, many of which were supposed to be the same. We found 11 stars that averaged about five arc seconds apart. We also noticed that the Ciardullo novae were mostly along the major axis of M31, while about half of our novae were along the minor axis. In conclusion, we think there's a good chance that novae in the Andromeda Galaxy repeat, but because of differences in image orientation it may be difficult to prove.

Background

In scientific studies today, it is somewhat rare to have high school students work on a serious research project. Our astronomy class brainstormed for about three days to determine what kind of astronomical project we would do. We decided on a project that would help us verify whether novae in the M31 Andromeda Galaxy repeated over a period of time.

To make this project feasible we used information from two sources. Our teacher, Mr. Spitzer, participated in the Research Based Science in Education (RBSE) project sponsored by the National Science Foundation. He helped take one set of images of the M31 galaxy, epoch 19. We then had access to 20 epochs taken between 1995 and 2000.

The Andromeda Galaxy, also referred to as M31, is only 2.2 million light years away, making it one of the closest spiral galaxies to the Milky Way. Andromeda is a type Sb and should contain regular novae. (1) Astronomers have been recording novae since Edwin Hubble (2).

"Nova," the Latin word, which by definition means, "new star," is a perfect description of the nova phenomenon. Realistically they have been there for a while. They just recently have been visible to earth. Novae occur with binary stars, in which one has evolved into a white dwarf, while its companion is becoming a red giant. In the "classical" nova, orbiting gaseous material falls on the white dwarf, causing a nuclear reaction on the star's surface and brightening the star. It then becomes what we call "Nova". According to nova theory, this should happen repeatedly. (1)

We used Scion Image to look for novae and had help from Dr. Rector, astronomer at NOAO (National Optical Astronomy Observatory). We also had information (3) and images that were brought to classroom by Mr. Spitzer, our teacher, who spent a month on Kit Peak. We used many Internet sites including www.noao.edu, fuse.pha.jhu.edu/support/tools/precess.html, and several research papers, especially Ciardullo (4) to find novae found in the past.

Methods

We looked at the M31 galaxy using Scion Image to find all the novae we could. First, we divided M31 into 16 fields.

We searched in fields 1-16, and through the date's 9/3/95-10/15/00, arranged in epochs 1-20. Once we thought we had found a nova, we zoomed in on the image to determine if it was an actual nova, artifact or a variable star. Once we decided it was a nova, we took the x and y coordinates, the epoch it was in, and the right ascension (RA) and declination (DEC) coordinates. We used the dates between epochs to tell if there was enough time in between them for it to be a real nova, and each suspected nova confirmed by at least two classmates. We also made sure we

Novae Discovered or Confirmed by Round Valley High Astronomy Class

Names	Field	Epoch	Date	X coord	Y coord	RA Location	DEC location
None	1						
None	2						
Ethan 1	3	1	9/3/95	470	487	00:42:15.78	41:22:13.4
Ethan 2	3	1-3	9/3/95-7/23/97	433	408	00:42:18.01	41:23:07.2
Ethan 3	3	19	7/20/00	70	324	00:42:39.92	41:24:04.3
Danny 1	4	2	6/18/97	116	340	00:42.06.25	41:23:53.4
Danny 2	4	8	11/18/97	254	479	00:41:57.92	41:22:18.8
Danny 3	4	8	11/18/97	397	135	00:42:41.29	41:26:13.0
Cora 1	5	2-7	6/18/97-8/1/97	372	24	00:43:23.24	41:21:37.3
Cora 2	5	9-17	6/6/98-1/27/99	287	19	00:43:28.37	41:21:40.7
Cora 3	5	8-15	11/18/97	467	83	00:43:17.75	41:20:59.9
Michelle 1	6	9-19	6/6/98	135	332	00:43:06.59	41:18:10.4
Michelle 2	6	1	9/3/95	112	464	00:43:08.28	41:16:40.0
Michelle 3	6	19-20	7/17/00-9/15/00	505	111	00:42:44.56	41:20:40.8
Michelle 4	6	2	6/18/97	82	132	00:43:10.09	41:20:26.6
Michelle 5	6	2-7	6/18/97-8/1/97	43	11	00:43:12.80	41:21:50.9
Michelle 6	6	18	7/20/99	170	202	00:43:04.78	41:19:38.9
MLF 1	7	9	6/6/98	285	221	00:42:26.95	41:19:25.8
MLF 2	7	14-17	10/14/98-1/27/99	112	94	00:42:37.40	41:20:52.2
MLF 3	7	3-8	7/23/97-11/18/97	411	499	00:42:19.35	41:16:16.6
MLF 4	7	1	9/3/95	62	387	00:42:40.42	41:17:32.8
MLF 5	7	10-11	7/24/97-7/25/97	118	441	00:42:37.04	41:16:56.1
MLF 6	7	10-13	7/24/98-9/5/98	228	473	00:42:30.40	41:16:34.3
MLF 7	7	20	9/15/00	202	104	00:42:31.97	41:20:45.4
Tim 1	8	1	9/3/95	194.0	202.0	00:42:01.54	41:19:38.9
Tim 2	8	2	6/18/97	175.0	121.0	00:42:02.69	41:20:34.0
Tim 3	8	9	6/6/98	23.0	421.0	00:42:11.86	41:17:09.9
Tim 4	8	8	11/18/97	189.0	352.0	00:42:01.84	41:17:56.8
Tim 5	8	4	7/24/97	406.0	150.0	00:41:48.75	41:20:14.3
Tim 6	8	17	1/27/99	31.0	388.0	00:42:11.37	41:17:32.3
Tim 7	8	18	7/20/99	62.0	442.0	00:42:09.50	41:16:55.6
Tim 8	8	5	7/25/97	95.0	369.0	00:42:07.51	41:17:45.3
Tim 9	8	20	9/15/00	409.0	182.0	00:41:48.57	41:19:52.5
Tim 10	8	20	9/15/00	140.0	420.0	00:42:04.70	41:17:09.9
Scott 1	9	11	7/25/98	371.0	33.0	00:43:23.56	41:15:45.5
Scott 2	9	11	7/25/98	453.0	224.0	00:43:18.63	41:13:35.4
Scott 3	9	20	10/15/00	395.0	426.0	00:43:22.13	41:13:35.4
Scott 4	9	11	7/25/98	94.0	409.0	00:43:40.30	41:11:29.3
Scott 5	9	18	7/20/99	233.0	385.0	00:43:31.90	41:11:45.7
Steven 1	10	13-16	9/5/98-11/11/98	471.0	115.0	00:42:46.63	41:14:49.5
Steven 2	10	20	10/15/00	498.0	174.0	00:42:45.00	41:14:09.4
Steven 3	10	18-19	7/20/99-7/17/00	421.0	91.0	00:42:49.66	41:15:05.8
Steven 4	10	18	7/20/99	219.0	43.0	00:43:01.85	41:15:38.5

Steven 5	10	8	11/18/97	161.0	100.0	00:43:05.35	41:14:59.7
Steven 6	10	9	6/6/98	109.0	196.0	00:43:08.48	41:13:54.4
Steven 7	10	3-7	7/23/97-8/1/97	193.0	6.0	00:43:03.42	41:16:03.6
Steven 8	10	19-20	7/17/00-10/15/00	469.0	288.0	00:42:46.75	41:12:51.8
Steven 9	10	11	7/25/98	91.0	168.0	00:43:09.57	41:14:13.4
Steven 10	10	1	9/3/95	470.0	440.0	00:42:46.70	41:11:08.3
Steven 11	10	10	7/24/98	71.0	125.0	00:43:10.78	41:14:42.7
Emera 1	11	3-8	7/23-11/18/97	201	126	00:42:32.01	41:14:42.2
Emera 2	11	8	11/18/97	371	340	00:42:21.75	41:12:16.6
Emera 3	11	5	7/25/97	287	445	00:42:26.82	41:11:05.1
Emera 4	11	17	1/27/99	6	406	00:42:43.78	41:11:31.6
Emera 5	11	1	9/3/95	249	223	00:42:29.11	41:13:36.2
Gabe 1	12	20	10/15/00	24	91	00:41:58.37	41:15:04.5
Gabe 2	12	20	10/15/00	247	93	00:41:58.09	41:15:04.7
Monica 1	12	20	10/15/00	390	251	00:41:49.71	41:13:17.2
Monica 2	12	2	6/18/97	169	387	00:42:35.00	41:11:44.6
Mitch 1	13	20	9/15/00	186.0	501.0	00:43:34.75	41:04:38.2
Shayne 1	14	6	7/31/97	408.0	220.0	00:42:50.42	41:07:48.5
Rose 1	15	13-18	9/5/98-7/20/99	171	471	00:42:33.87	41:04:58.8
Rose 2	15	12-18	8/26/98-7/20/99	508	226	00:42:13.54	41:07:45.4
Denea 1	16	2-7	6/18-8/1/97	80	182	00:42:08.42	41:08:15.6

marked all found novae on an image of M31. We then looked at past novae that have been reported and checked if our nova had been found before, or if we had found a nova no one else has found. We also looked for novae reported by Ben Nascenzi (5) and Matt Harriger (6) in The RBSE Journal for 2000. If we didn't find a nova in one of those papers, then we listed it unconfirmed.

Artifacts and novae can be confusing at times. The pixels used with a nova should be many shades of color, having an abstract shape. Artifacts are mostly darker shades and they are most often found as perfect squares. The observer should zoom in on the object, as much as they can to see the pixels in a larger view. Artifacts are often found around the edges of the screen where light has flooded the pixels. If the observer is not careful he or she can mistakenly take an artifact as a real nova.

To compare novae and see if they were repeating, we first compared RA and DEC coordinates with novae found by Robin Ciardullo, et al. in their July 1987 paper (4) and their 1990 paper (7). In order to do this we had to first change the RA and DEC coordinates from 1975 coordinates to 2000 coordinates. We used a website recommended by Dr. Travis Rector that changes the coordinates into 2000 coordinates so we could compare and look for the repeating novae. Dr. Rector told us that in order for the novae to be repeating, they had to be very close in their RA and DEC coordinates. So, to confirm if the novae were repeating, we decided they had to be less than five seconds from each other. This helped limit the amount of error in our conclusions.

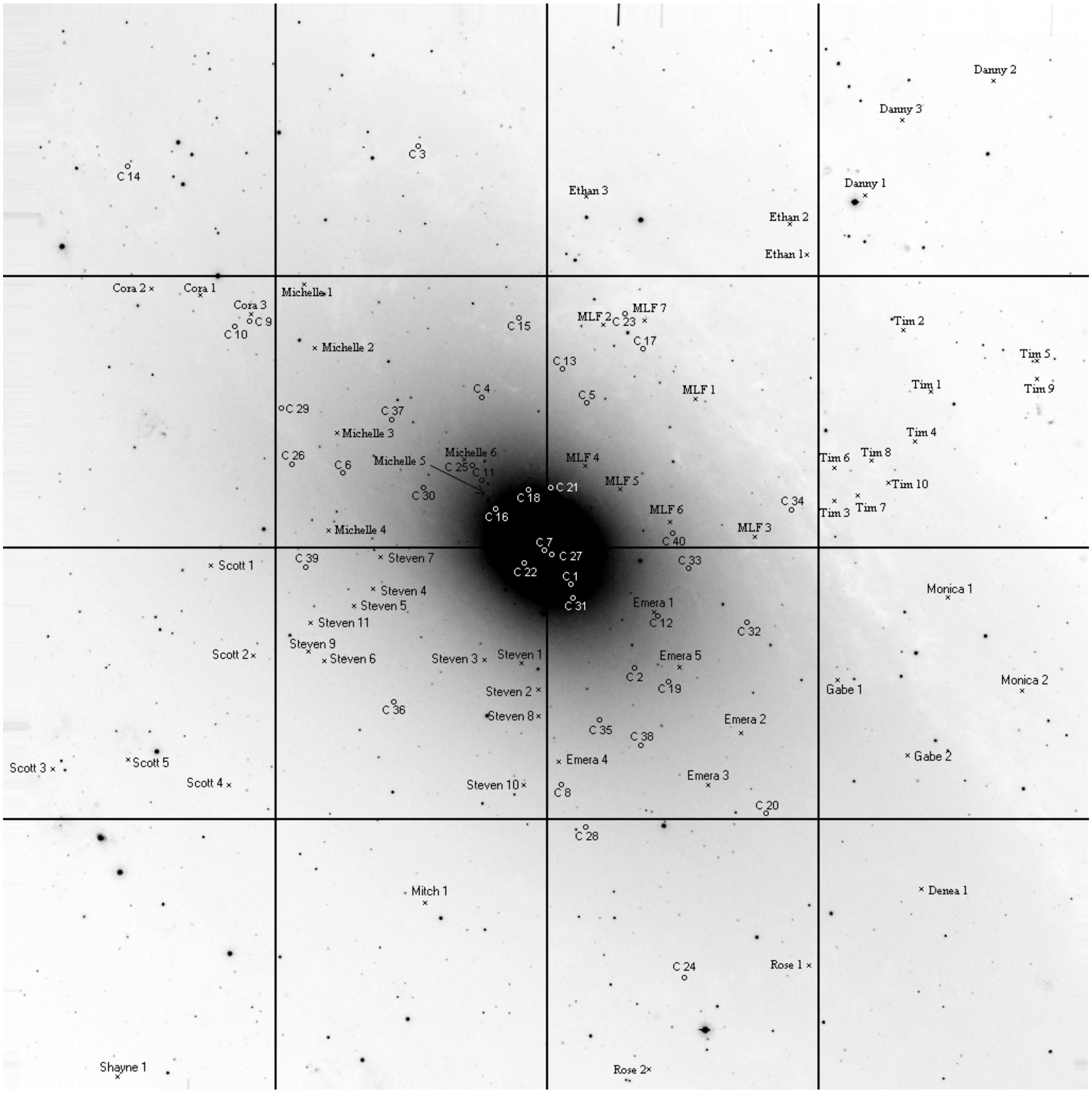
We compared Ciardullo's field stars with the RBSE field stars to determine if a margin of error existed between their positions. Many of the positions of the field stars should be the same. We used this to determine if our repeating nova candidates did indeed pair up with Ciardullo's novas when this positional margin of error was taken into account. After doing this we plotted Ciardullo's novae with our own, compiling it all on one map.

Conclusions

We found two of the Ciardullo novae (4,7) were extremely close to being repeating novae. They were each within seven arc seconds close to past novae on the major axis. We found five novae within 5 seconds of Ciardullo novae. Since RA is measured in units different from DEC, we changed the RA coordinates by using the formula: 1 second RA =15 (cos (DEC)). This allows for closer, more accurate measurements.

We plotted the Ciardullo novae with our own discovered novae and we found that the Ciardullo novae were almost entirely located on the major axis of the M31 Galaxy, while about 50% of our discovered novae

Location of Novae discovered by Round Valley astronomy class as compared to Ciardullo Novae:



were found on the minor axis. An astronomer suggested that this is possibly due to the angle at which the photos of M31 were taken.

We then checked Ciardullo's field stars with the RBSE field stars to determine if any positional errors or movement had occurred. This comparison yielded an average difference of about five arc seconds, which could account for the deviation in the positions of our repeater candidates as compared to their Ciardullo counterparts. If there are more than 11 of the same field stars in our data, then the average displacement of the two sets of images may be much greater than 5 arc seconds. We can say that there is a good possibility that the closest novae we discovered do repeat since the difference between our field stars and Ciardullo's field stars is at least five arc seconds and this positional error may indeed account for the positional differences between our repeater candidates and Ciardullo's novae.

References

1. Pasachoff, Jay H.; ASTRONOMY: From The Earth To The Universe; Harcourt Brace College Publishers; 1998.
2. Hubble, Edwin; "A Spiral Nebula As A Stellar System, Messier 31"; American Astronomical Society; 1929.

Previously Discovered Novae Not Confirmed by Round Valley (5)				
Field	Epoch	Date	X	Y
1	10-11	7/24/98-7/25/98	453	59
5	17-18	1/27/99-7/20/99	167	129
6	16-17	11/11/98-1/27/99	126	449
6	9-11	6/6/98-7/25/98	134	358
6	12-18	8/26/98-7/20/99	376	494
6	14-17	10/14/98-1/27/99	416	454
6	11	7/25/98	451	444
6	11	7/25/98	510	424
6	11	7/25/98	481	425
6	11	7/25/98	466	327
6	11	7/25/98	468	402

Ciardullo coordinates from 1987 & 1990 Precessed into 2000 coordinates (4,7)			
Nova	Year	__RA	__DEC
1	1982	00 42 42.76	+41 15 14.4
2	1982	00 42 35.04	+41 13 21.5
3	1982	00 42 58.72	+41 24 31.3
4	1982	00 42 51.69	+41 19 04.3
5	1982	00 42 40.07	+41 19 12.4
6	1982	00 43 08.22	+41 17 32.2
7	1983	00 42 44.47	+41 16 01.4
8	1983	00 42 42.95	+41 11 31.7
9	1983	00 43 18.25	+41 20 55.2
10	1983	00 43 20.46	+41 20 50.2
11	1983	00 42 50.78	+41 17 36.4
12	1983	00 42 32.64	+41 14 36.5
13	1983	00 42 42.17	+41 19 32.4
14	1983	00 43 31.59	+41 24 16.1
15	1984	00 42 46.18	+41 20 35.4
16	1984	00 42 49.08	+41 17 01.4
17	1984	00 42 32.96	+41 20 20.5
18	1984	00 42 46.17	+41 17 19.9
19	1985	00 42 29.83	+41 13 11.5
20	1985	00 42 18.19	+41 10 21.6
21	1985	00 42 44.57	+41 17 34.4
22	1985	00 42 46.67	+41 15 40.4
23	1985	00 42 34.86	+41 21 01.5
24	1985	00 42 27.80	+41 07 10.5
25	1985	00 42 51.19	+41 17 43.4
26	1985	00 43 13.43	+41 18 13.2
27	1985	00 42 44.67	+41 15 53.4
28	1985	00 42 40.04	+41 10 07.4
29	1986	00 43 14.14	+41 18 39.2
30	1986	00 42 57.60	+41 17 20.3
31	1986	00 42 41.36	+41 14 39.4
32	1986	00 42 21.31	+41 14 29.5
33	1986	00 42 29.13	+41 15 32.5
34	1986	00 42 15.51	+41 16 45.6
35	1986	00 42 36.54	+41 12 26.4
36	1988	00 43 02.39	+41 12 55.3
37	1988	00 43 02.71	+41 18 41.3
38	1988	00 42 34.33	+41 12 15.5
39	1988	00 43 12.82	+41 15 44.2
40	1988	00 42 29.44	+41 17 01.5

References (cont.)

3. Rector, T.A. et al.; “A search for Novae in the Bulge of M31”; NOAO; www.nova.educ/outreach/rhse/nova.html; 2000.
4. Ciardullo, Robin; “The Spiral Distribution And Population Of Novae In M31”; The Astrophysical Journal, 318: 520-530; July 15, 1987.
5. Nascenzi, Ben; “The Search for the Novae in the M31 Galaxy”; The RBSE Journal, p.30-31; Cranston East High School; Cranston, RI; 2000.
6. Harriger, Matt; “The Correlation of the Location of Novae in the Andromeda Galaxy with Respect to the Duration of their Light Curves”; The RBSE Journal, p.26-28; Harry A. Burke High School, Omaha, NE; 2000.
7. Ciardullo, Robin; “The Ha Light Curves of Novae in M31”; The Astrophysical Journal, 356: 472-482; June 20, 1990.

Possible Repeating Novae

Name	RA	Dec	RA off	Converted RA to arcsecs	Dec off	Years
				15 * cos(41° 1")		apart
	d° m' s"	d° m' s"	d° m' s"	d° m' s"	d° m' s"	
Emera 4	00:42:43.83	41:11:31.5				
Nova 8	00:42:42.89	41:11:31.7	0.94"	0' 10.6"	0' 0.2"	16
Cora 3	00:43:17.75	41:20:59.9				
Nova 9	00:43:18.25	41:20:55.2	0' .5"	0' 5.65"	0' 4.7"	14
Emera 1	00:42:32.01	41:14:42.2				
Nova 12	00:42:32.6	41:14:36.5	0' .59"	0' 6.67"	0' 5.7"	14
Michelle 3	00:42:44.56	41:20:40.8				
Nova 15	00:42:46.18	41:20:35.4	0' 1.62"	0' 18.31"	0' 5.4"	11
MLF 4	00:42:40.42	41:17:32.8				
Nova 21	00:42:44.57	41:17:34.4	4.15"	0' 46.90"	0' 1.6"	10
Unconfirmed Rector, et al (3) Novae that are also close						
Nova 1	00:42:42.76	41:15:14.4				
#19 in list	00:42:42.12	41:15:10.7	0' 0.64"	0' 7.2"	0' 3.7"	15
Nova 7	00:42:44.47	41:16:01.4				
#20 in list	00:42:43.10	41:16:04.1	0' 1.37"	0' 15.48"	0' 2.7"	15

Field Star Comparison

Ciardullo Field Stars	RBSE Field Stars	Location Difference RA	RA Arc Secs	Dec
Star 1	Star 110	-0.22	-2.5	-3.5
Star 3	Star 107	-0.11	-1.2	-1.8
Star 8	Star 97	-0.02	-0.2	-0.1
Star 12	Star 87	-1.6	-18.1	0.02
Star 15	Star 93	-0.09	-1.0	1.1
Star 17	Star 94	0.03	0.3	-1
Star 27	Star 85	0.6	6.8	0.4
Star 51	Star 73	0.03	0.4	0.3
Star 52	Star 22	2.16	24.4	2.5
Star 55	Star 20	0.16	1.8	13.6
Star 63	Star 18	0.01	0.1	-1.9
Average			5.2	2.4

CHS Nova Project

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Teacher: Margaret Holzer, RBSE '00

Abstract

Our group searched the Andromeda Galaxy (another name is M31) to locate novae. The sixteen subrasters had data collected once in 1995, and then in 1997, data was collected continuously for approximately three years. Epoch 1 was collected on September 3, 1995. Epoch 2 was collected on June 18, 1997, and the collection ran until Epoch 18, which was collected on July 20, 1999. This area was checked for stars that showed a difference in magnitude. These magnitudes were recorded and then used to create light curves for each nova. The light curves of the nova in the same subraster had similar patterns and cycles.

Purpose

The purpose of our research paper was to locate all the novae, measure the magnitudes, create light curves and plot the novae locations on a star atlas. Once plotted on the atlas we would look at the data, and determine if there was a direct relationship with the subraster and the type of nova that was contained within that subraster. The length of life, the nova's magnitude, and how quickly the pattern repeats itself identify different types of nova.

Introduction

A nova is a type of variable star. Its magnitude seems to change as it is being viewed. The magnitude of a star is its brightness. Its increasing magnitude is because of nuclear explosions on the star. This change in brightness is a repeating event. When the change of brightness is charted against time, the resulting graph is called a "light curve." This tool is used to identify variable stars, which a nova is. We are doing this research project on the novae of the M31 galaxy.

Hypothesis

There is a connection between the magnitude and light curve of a nova and it's location in M31 because the novas in the same subraster have similar patterns, ranges, and cycles.

Procedure

1) The subrasters were chosen according to availability of data and location in the galaxy. 2) The entire collection of nova in each subraster was located and its location and magnitudes were recorded using the stars whose magnitudes have been already found. 3) The atlas of the Andromeda Galaxy was found via the Internet, on which all of the subrasters were located and labeled on the star atlas. 4) The light curves were created with the data from the magnitudes.

Analysis

After studying the data collected, we came to several conclusions. The first novae in both subrasters nine and twelve had inconclusive data, and therefore no information could be taken out of those. Novae two and three in subraster six also had too many breaks in their data to draw any conclusions from those either. In subraster twelve, novae two and three were at a low point of their cycle when they began to be recorded. Then they suddenly brightened as the cycle of life began, and finally dimmed again. In subraster six, novae one and four are very dim and their magnitude does not change that much. The second nova that was found in subraster nine was captured in full cycle. Its magnitude is low and then decreases for a very little amount of time and the increases again. Nova one of both subrasters one and six look very much alike. Both of their magnitudes do not change much, and they look very similar. One possibility is that these particular novae are on the corners of their subrasters, and therefore it might be the same nova.

Light Curve Data

Time (Days)	Nova #1 Magnitudes	Nova #2 Magnitudes	Nova #3 Magnitudes	Nova #4 Magnitudes	Subraster #6
1	20.08	25.58	21.87	20.27	
654	22.2		24.69	27.09	
689	20.19	23.35	22.44	21.06	
690	19.76	22.34	22.32	20.38	
691	18.82	21.52	20.52	19.43	
697	22.4	30.11	25.03	21.34	
698	19.69	22.72	21.86	19.51	
807	21.39	24.47		21.12	
1007	22.3	28.93	29.85	25.2	
1055	19.12		25.88	18.97	
1056	19.31			20.44	
1088	21.11	32.67	30.81	25.28	
1098	19.22	35.09	24.62		
1137	19.28		26.35	22.06	
1153	20.05		30.48	22.2	
1165	18.96	26.68	28.4	22.09	
1242	21.38		35.89	28.47	
1416	18.58		24.31	20.86	

Time (Days)	Nova #1 Magnitudes	Nova #2 Magnitudes	Subraster #9
1		19.51	
654		19.83	
689		19.62	
690		19.91	
691		19.81	
697		19.95	
698	21.34	19.84	
807	20.18	19.56	
1007		20.05	
1055	23.78	20.59	
1056	21.88	19.59	
1088		19.96	
1098	20.95	19.67	
1137		19.77	
1153	24.71	19.86	
1165	24.02	19.86	
1242		19.86	
1416		20.32	

Time (Days)	Nova #1 Magnitudes	Nova #2 Magnitudes	Nova #3 Magnitudes	Subraster #12
1	17.4	17.25	17.44	
654		17.33	17.35	
689		17.23		
690				
691		17.34		
697	17.51	17.45		
698	17.58	17.33		
807		17.26	17.59	
1007		17.13	17.35	
1055	17.31	15.17	17.28	
1056		17.23	15.02	
1088		17.31	17.18	
1098	17.4	17.29	17.34	
1137	17.33	17.25	17.3	
1153		17.22	17.23	
1165		17.27	17.48	
1242		17.27	17.27	
1416		17.23	17.3	

Time (Days)	Nova #1 Magnitudes	Subraster #1
1	20.84	
654		
689	7.27	
690	21.71	
691	21.98	
697	20.84	
698	20.88	
807	20.52	
1007	22.14	
1055	22.68	
1056	19.62	
1088	20.37	
1098	21.36	
1137	20.21	
1153	19.76	
1165	21.98	
1242	21.21	
1416		

Control & Error Analysis

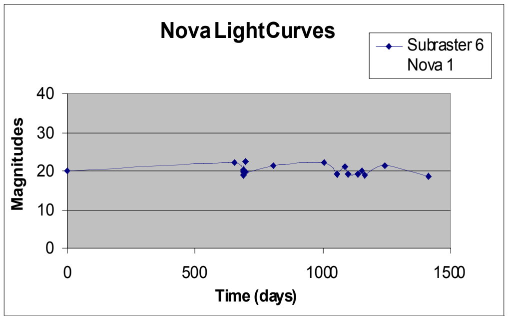
1) There were macro errors to begin with. 2) Some of the novae were to close to the edges of the maps in the epochs. 3) For some subrasters, it was not possible to locate the correct portion of atlas. 4) In the original program there were many errors, and research could not be done there were so many. When the second edition came, some of the errors were corrected, but others still remained in the program.

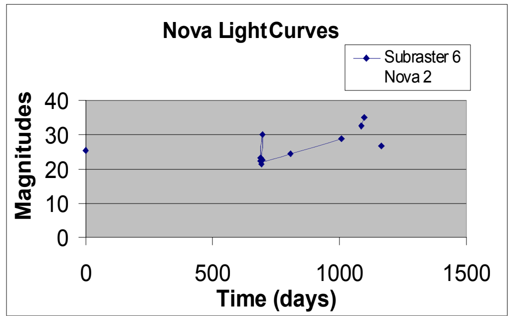
Conclusions

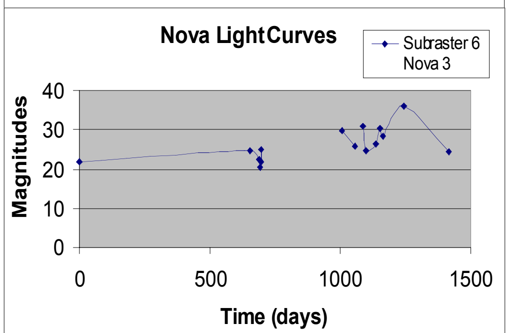
Based on our research, we concluded that while the novae in each subraster were similar, there was no distinction between the novae based upon location as a distinguishing factor. However, the similarities were interesting. The light curves of each nova in one subraster, looking at the data, are almost the same. The novae fade and brighten near the same dates. This shows that the novae in each subraster have similar cycles, perhaps having similar origin, creating the similar cycles.

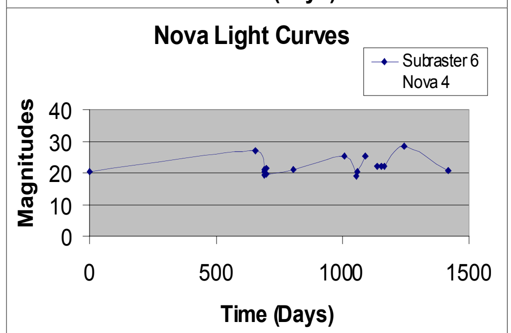
Extensions

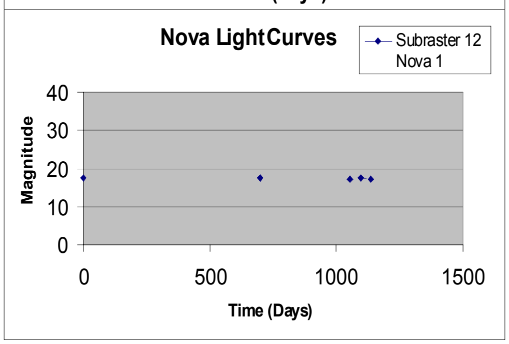
There are many other studies we could have conducted from the data we collected. A search for more novae in the galaxy could have been conducted, using the Scion Image Software. A connection between a nova and its neighboring nova could have been researched, using cycles. Also the cycles of specific nova could have been more closely looked at to find abnormalities or similar cycles in different novae, using the light curves from all of the found nova in M31.

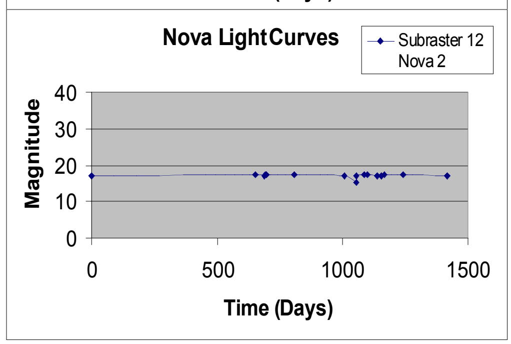


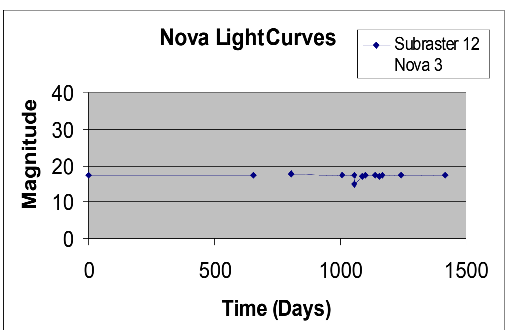


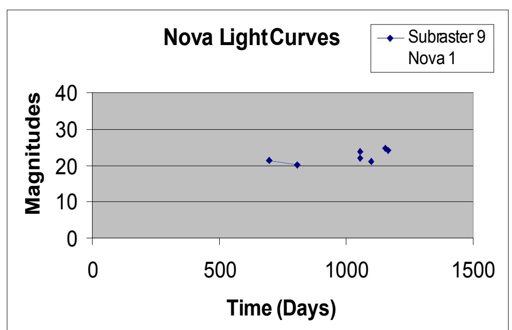


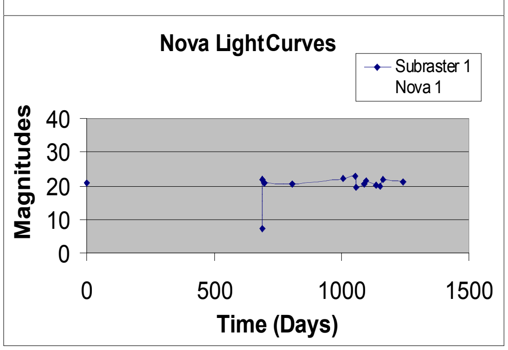


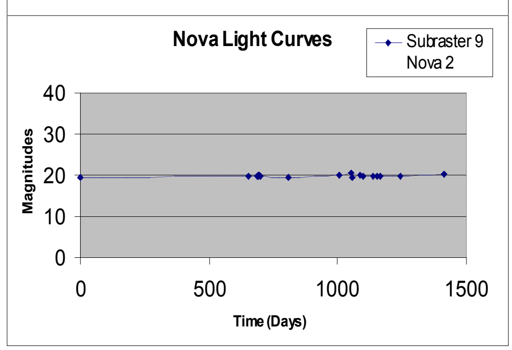












Bibliography

Clark, David H., Superstars. New York: McGraw-Hill Book Company, 1984.
North, John, Astronomy and Cosmology. New York: W.W. Norton & Company, 1995.
“Nova and Supernova,” Microsoft® Encarta® 98 Encyclopedia ©. 1993-1997, Microsoft Corporation. CD-ROM.

A Search for Novae in the Andromeda Galaxy - Year Three

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Teacher: Ardis Maciolek, RBSE '98

Purpose

The purpose of this year's Nova Search project was to analyze new and existing observational data for new novae, continue observations of any novae that may have continued into the latest set of observational data, and to organize and verify the novae found in the past two years.

Procedures

This year, we were provided with two new epochs of data, and improved macros for novae analysis. All the old novae data were redone, and higher standards for results were set than in past years. Many new novae were discovered, and all the information was compiled into a single database. A new numbering system was given to identify when the nova was discovered.

Data Tables

The new data table contains more information than past years, and all old novae were reanalyzed to meet these standards. The table consists of 13 columns, detailed below.

Nova	Number to identify individual novae. Format is YY-###.
SR	Subraster.
Epoch	Epoch.
X & Y	X/Y position in image.
Scale	Scale used.
RA	Right Ascension. Format is 00h:m:s.
Dec	Declination. Format is d:m:s.
SS Used	Standard stars used.
SS Err	Standard star error.
Im Err	Image error.
Comb. Err	Combined image/standard star error.
Mag	Magnitude.

The new numbering system was implemented primarily to distinguish novae discovered in past years from novae discovered this year. The X/Y and scale were used only to locate the nova in the image. The image error was found by calculating all the magnitudes for the standard stars used, and recording the variance.

Data

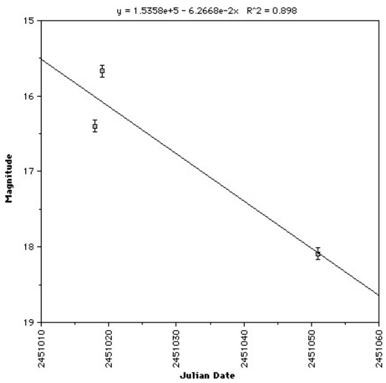
All data from past years were reanalyzed and recalculated using the latest set of macros and observational data. This year, we discovered a total of 25+ (21 fully analyzed and included in data table) new novae, 5 of which had a duration of 2 or more epochs. Of those 5, we identified 4 to be Type NB and 1 to be Type NA.

Data Revisions

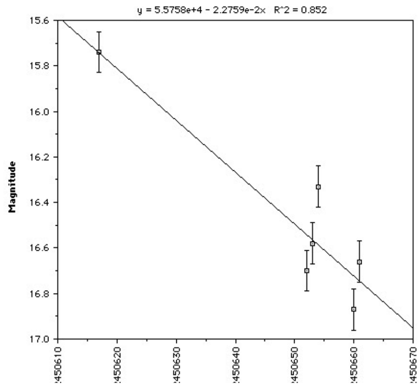
While verifying our data from past years before adding it into the new database, we discovered that several novae continued into the new epochs we were given. We also were able to find several novae which continued beyond what was previously thought. Light curves have been recalculated and included for these.

Analysis

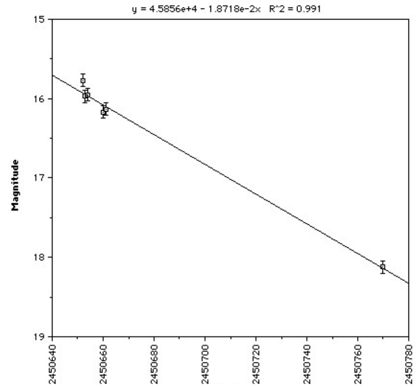
The observational data were analyzed using NIH Image and the Nova Search macros provided on the RBSE CD-ROM. All novae were mapped on an image of M31 using the GNU Image Manipulation Program (GIMP). Light curves were graphed for all new major novae (spanning more than a single epoch) and for previously discovered novae which were found to exist in more epochs.



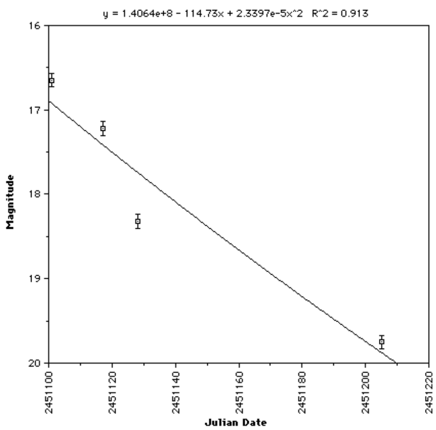
Nova #99-020



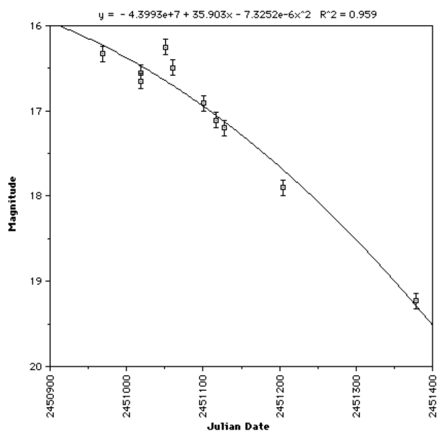
Nova #00-022



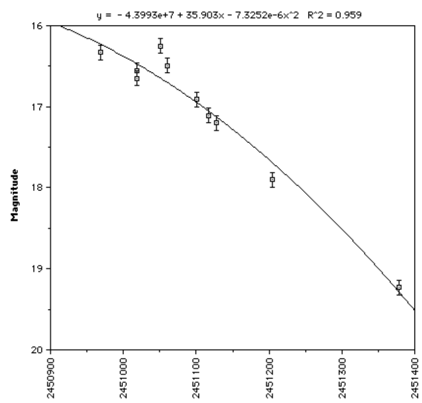
Nova #00-022



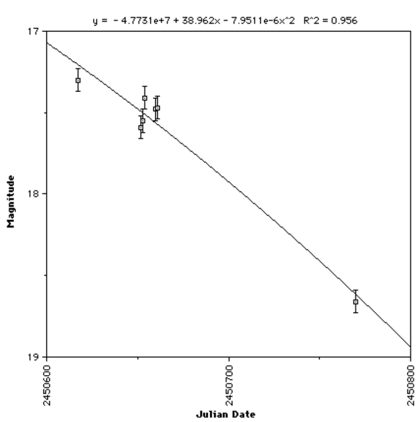
Nova #01-024

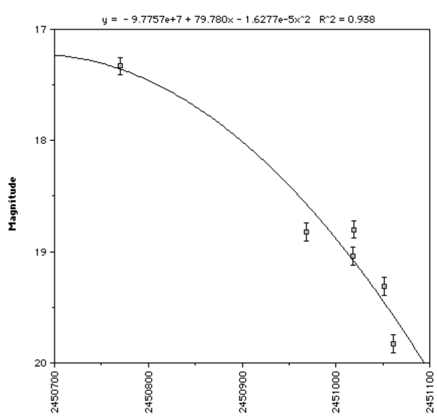


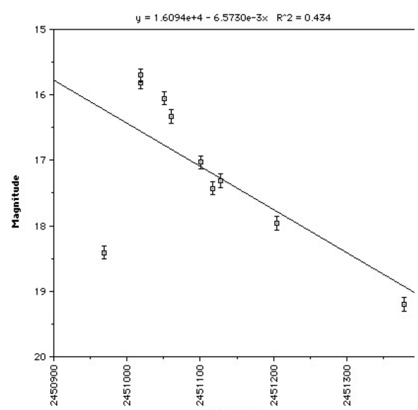
Nova #01-025



Nova #01-030







Nova	RA	Dec	Type
99-007	00:42:36.95	+41:16:55.5	NA
01-097	00:42:40.05	+41:15:46.0	NB
99-017	00:42:31.98	+41:14:41.3	NB
99-020	00:42:22.10	+41:11:30.8	NB
00-022	00:43:28.58	+41:21:42.5	NB
01-024	00:43:23.47	+41:21:09.9	NB
01-025	00:43:17.71	+41:20:59.4	NB
01-030	00:43:06.86	+41:18:09.4	NB

\Conclusions

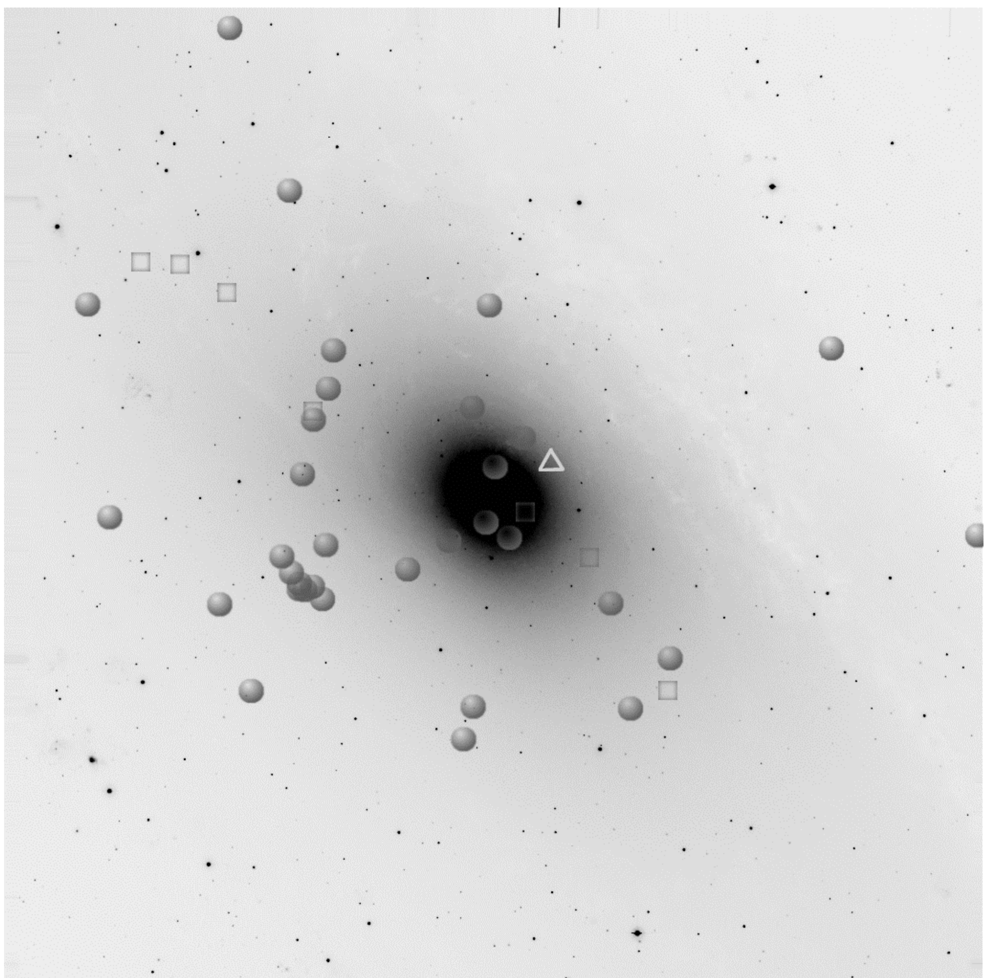
The pattern of distribution for Type NB novae has become more apparent, as can be seen in the map. Novae which occur in only one epoch seem to be clustered together in many places, suggesting some sort of connection. Our full report will be on our web page in June, which can be found at:

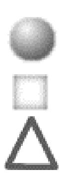
http://north.gp.k12.mi.us/~maciola/webpages/studentprojects.htm

Nova	SR	Epoch	X	Y	Scale	RA (00h:m:s)	Dec (d:m:s	SS Used	SS Err	Im Err	Comb. Err	Mag
00-022	5	9	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.03	0.05	16
00-022	5	10	287	19	0-400	43:28.58	41:21:42.5	11,12,16	0.05	0.07	0.07	16
00-022	5	11	287	19	0-400	43:28.58	41:21:42.5	11,12,16	0.05	0	0.05	16
00-022	5	12	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.05	0.06	1
00-022	5	13	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.02	0.05	16
00-022	5	14	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.04	0.06	16
00-022	5	15	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.02	0.05	17
00-022	5	16	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.02	0.05	17
00-022	5	17	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.03	0.05	17
00-022	5	18	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.01	0.05	1
00-022	5	19	287	19	0-400	43:28.58	41:21:42.5	10,11,14	0.05	0.15	0.12	1
00-023	5	17	174	111	100-200	43:35.40	41:20:39.6	10,12,13	0.05	0.04	0.06	17
00-025	6	18	177	206	0-1000	43:04.32	41:19:35.3	18,19,21	0.05	0.01	0.05	1
00-027	10	18	421	91	0-1000	42:49.59	41:15:05.0	67,73,74	0.05	0.09	0.08	16
00-028	10	18	220	43	0-1000	43:01.75	41:15:37.9	67,73,74	0.05	0.09	0.08	14
00-029	11	18	92	159	0-1000	42:38.53	41:14:18.4	97,103,104	0.07	0.11	0.10	16
00-031	15	13	171	472	0-325	42:33.77	41:04:57.4	105,106	0.09	0	0.09	14
00-031	15	14	171	472	0-325	42:33.77	41:04:57.4	105,106	0.09	0	0.09	16
00-031	15	15	171	472	0-325	42:33.77	41:04:57.4	105,106	0.09	0	0.09	16
00-031	15	16	171	472	0-325	42:33.77	41:04:57.4	105,106	0.09	0	0.09	17
00-031	15	17	171	472	0-325	42:33.77	41:04:57.4	105,106	0.09	0	0.09	18
01-001	1	11	474	45	0-325	43:17.29	41:27:13.4	1,2,5	0.06	0.04	0.07	18
01-024	5	2	371	24	0-450	43:23.47	41:21:09.9	10,11,14	0.05	0.04	0.06	1
01-024	5	3	371	24	0-450	43:23.47	41:21:09.9	10,11,14	0.05	0.06	0.07	17
01-024	5	4	371	24	0-450	43:23.47	41:21:09.9	10,11,14	0.05	0.05	0.06	17
01-024	5	5	371	24	0-450	43:23.47	41:21:09.9	10,11,14	0.05	0.05	0.06	17
01-024	5	6	371	24	0-450	43:23.47	41:21:09.9	10,11,14	0.05	0.05	0.06	17
01-024	5	7	371	24	0-450	43:23.47	41:21:09.9	10,11,14	0.05	0.04	0.06	17
01-024	5	8	371	24	0-450	43:23.47	41:21:09.9	10,11,14	0.05	0.04	0.06	18
01-025	5	8	467	83	0-200	43:17.71	41:20:59.4	11,12,13,16	0.05	0.06	0.07	17
01-025	5	9	467	83	0-200	43:17.71	41:20:59.4	11,12,16	0.05	0.01	0.05	18
01-025	5	10	467	83	0-200	43:17.71	41:20:59.4	11,12,16	0.05	0.07	0.07	19
01-025	5	11	467	83	0-200	43:17.71	41:20:59.4	11,12,16	0.05	0	0.05	1
01-025	5	12	467	83	0-200	43:17.71	41:20:59.4	11,12,16	0.05	0.08	0.08	19
01-025	5	16	467	83	0-200	43:17.71	41:20:59.4	11,12,16	0.05	0.09	0.08	19
01-025	5	17	467	83	0-200	43:17.71	41:20:59.4	11,12,16	0.05	0.03	0.05	20
01-028	6	11	469	326	0-500	42:46.66	41:18:13.6	20,21,24	0.06	0.01	0.06	17
01-030	6	9	135	332	0-500	43:06.86	41:18:09.4	18,19,21,22	0.05	0.05	0.06	18
01-030	6	10	135	332	0-500	43:06.86	41:18:09.4	18,19,21,22	0.05	0.02	0.05	15
01-030	6	11	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.1	0.09	1
01-030	6	12	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.04	0.06	16
01-030	6	13	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.02	0.05	16
01-030	6	14	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.12	0.10	17
01-030	6	15	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.03	0.05	17
01-030	6	16	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.02	0.05	17
01-030	6	17	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.07	0.07	17
01-030	6	18	135	332	0-500	43:06.86	41:18:09.4	18,19,20,21	0.05	0.04	0.06	1

Nova	SR	Epoch	X	Y	Scale	RA (00h:m:s)	Dec (d:m:s)	SS Used	SS Err	Im Err	Comb. Err	Mag
01-037	8	2	175	121	0-500	42:02.60	41:20:33.1	81,89,92	0.08	0.03	0.08	17.88
01-041	9	11	453	224	0-400	43:18.56	41:13:34.7	31,34,35	0.05	0.08	0.08	17.36
01-046	10	1	470	440	0-1000	42:46.61	41:11:07.7	66,71,72	0.06	0.03	0.06	16.62
01-052	10	5	135	189	0-1000	43:06.84	41:13:58.7	66,71,72	0.06	0.01	0.06	17.65
01-053	10	1	154	215	0-1000	43:05.67	41:13:41.1	66,71,72	0.06	0.03	0.06	17.57
01-054	10	3	111	191	0-800	43:08.30	41:13:56.7	66,71,72	0.06	0.02	0.06	18.04
01-055	10	4	107	187	0-800	43:08.53	41:14:00.0	66,71,72	0.06	0.02	0.06	18.21
01-056	10	6	107	194	0-800	43:06.63	41:13:54.9	66,71,72	0.06	0.04	0.07	18.61
01-057	10	8	118	194	0-800	43:07.86	41:13:55.0	66,67,71,72	0.06	0.12	0.10	18.46
01-058	10	12	139	153	0-800	43:06.63	41:14:23.0	66,71,72	0.06	0.01	0.06	18.31
01-072	11	5	287	445	0-800	42:26.76	41:11:04.3	97,103,104	0.07	0.02	0.07	16.71
01-091	16	2	79	182	0-450	42:08.39	41:08:14.9	107,110	0.1	0	0.10	16.48
01-091	16	3	79	182	0-450	42:08.39	41:08:14.9	107,110	0.1	0	0.10	16.82
01-091	16	4	79	182	0-450	42:08.39	41:08:14.9	107,110	0.1	0	0.10	18.38
01-091	16	5	79	182	0-450	42:08.39	41:08:14.9	107,110	0.1	0	0.10	18.11
01-091	16	6	79	182	0-450	42:08.39	41:08:14.9	107,110	0.1	0	0.10	17.57
01-091	16	7	79	182	0-450	42:08.39	41:08:14.9	107,110	0.1	0	0.10	17.04
01-091	16	8	79	182	45-225	42:08.39	41:08:14.9	107,110	0.1	0	0.10	19.06
01-097	11	2	67	31	0-1500	42:40.05	41:15:46.0	97,103,104	0.07	0.04	0.08	15.74
01-097	11	3	67	31	0-1500	42:40.05	41:15:46.0	97,103,104	0.07	0.05	0.08	16.7
01-097	11	4	67	31	0-1500	42:40.05	41:15:46.0	97,103,104	0.07	0.05	0.08	16.58
01-097	11	5	67	31	0-1500	42:40.05	41:15:46.0	97,103,104	0.07	0.02	0.07	16.33
01-097	11	6	67	31	0-1500	42:40.05	41:15:46.0	97,103,104	0.07	0.08	0.09	16.87
01-097	11	7	67	31	0-1500	42:40.05	41:15:46.0	97,103,104	0.07	0.02	0.07	16.66
01-100	2	1	84	192	0-450	43:09.91	41:25:33.5	26,27,28	0.07	0	0.07	17.45
01-116	10	18	111	191	0-800	43:08.29	41:13:57.2	66,72,74	0.06	0.02	0.06	18.39
01-117	7	1	62	387	0-800	42:40.33	41:17:32.2	85,93,94	0.07	0.01	0.07	17.67
99-001	6	1	112	464	0-1000	43:08.24	41:16:40.0	18,19,22	0.05	0.03	0.05	15.63
99-002	6	11	169	286	0-1000	43:04.79	41:18:40.8	18,19,22	0.05	0.01	0.05	16.85
99-003	6	11	137	350	0-1000	43:06.72	41:17:57.6	18,19,22	0.05	0.01	0.05	16.76
99-004	6	14	416	452	0-3000	42:49.82	41:16:47.6	20,22	0.04	0	0.04	16.14
99-004	6	15	416	452	0-3000	42:49.82	41:16:47.6	20,22	0.04	0	0.04	16.38
99-004	6	16	416	452	0-3000	42:49.82	41:16:47.6	20,22	0.04	0	0.04	16.29
99-005	7	3	411	499	0-1000	42:19.25	41:16:15.9	85,93,94	0.07	0	0.07	15.8
99-005	7	4	411	499	0-1000	42:19.25	41:16:15.9	85,93,94	0.07	0.01	0.07	15.88
99-005	7	5	411	499	0-1000	42:19.25	41:16:15.9	85,93,94	0.07	0.05	0.08	15.79
99-005	7	6	411	499	0-1000	42:19.25	41:16:15.9	85,93,94	0.07	0	0.07	15.97
99-005	7	7	411	499	0-1000	42:19.25	41:16:15.9	85,93,94	0.07	0.03	0.07	15.95
99-006	7	10	228	473	0-1000	42:30.32	41:16:33.5	85,93,94	0.07	0.03	0.07	15.76
99-006	7	11	228	473	0-1000	42:30.32	41:16:33.5	85,93,94	0.07	0.02	0.07	15.58
99-006	7	12	228	473	0-1000	42:30.32	41:16:33.5	85,93,94	0.07	0.06	0.08	16.37
99-006	7	13	228	473	0-1000	42:30.32	41:16:33.5	85,93,94	0.07	0.04	0.08	16.43
99-006	7	14	228	473	0-1000	42:30.32	41:16:33.5	85,93,94	0.07	0.04	0.08	17.87
99-006	7	15	228	473	0-1000	42:30.32	41:16:33.5	85,93,94	0.07	0.02	0.07	18.03
99-006	7	16	228	473	0-1000	42:30.32	41:16:33.5	85,93,94	0.07	0.04	0.08	18.68
99-007	7	10	118	441	0-1000	42:36.95	41:16:55.5	85,93,94	0.07	0.03	0.07	16.4
99-007	7	11	118	441	0-1000	42:36.95	41:16:55.5	85,93,94	0.07	0.02	0.07	15.67

Nova	SR	Epoch	X	Y	Scale	RA (00h:m:s)	Dec (d:m:s)	SS Used	SS Err	Im Err	Comb. Err	Mag
99-007	7	12	118	441	0-1000	42:36.95	41:16:55.5	85,93,94	0.07	0.05	0.08	18.09
99-008	8	1	194	202	0-1000	42:01.49	41:19:38.2	89,90,92	0.08	0	0.08	16.79
99-009	10	10	71	124	0-1000	43:10.71	41:14:42.4	66,68,71,72	0.07	0.04	0.08	16.97
99-011	10	8	161	100	0-1000	43:05.27	41:14:58.8	72,73,74	0.06	0.04	0.07	15.25
99-012	10	9	109	195	0-1000	43:08.44	41:13:54.1	68,71,72	0.07	0.02	0.07	16.26
99-014	10	11	496	53	0-3000	42:45.09	41:15:31.0	67,73,74	0.05	0.06	0.07	16.02
99-015	10	14	471	115	0-2000	42:46.54	41:14:48.6	67,73,74	0.05	0.11	0.09	16.32
99-015	10	15	471	115	0-2000	42:46.54	41:14:48.6	67,73,74	0.05	0.11	0.09	16.34
99-015	10	16	471	115	0-2000	42:46.54	41:14:48.6	67,73,74	0.05	0.09	0.08	16.5
99-016	11	1	249	223	0-1000	42:29.04	41:13:35.4	97,103,104	0.07	0.02	0.07	16.57
99-017	11	3	200	126	0-1000	42:31.98	41:14:41.3	97,103,104	0.07	0.05	0.08	15.77
99-017	11	4	200	126	0-1000	42:31.98	41:14:41.3	97,103,104	0.07	0.05	0.08	15.97
99-017	11	5	200	126	0-1000	42:31.98	41:14:41.3	97,103,104	0.07	0.02	0.07	15.95
99-017	11	6	200	126	0-1000	42:31.98	41:14:41.3	97,103,104	0.07	0.08	0.09	16.17
99-017	11	7	200	126	0-1000	42:31.98	41:14:41.3	97,103,104	0.07	0.02	0.07	16.13
99-017	11	8	200	126	0-1000	42:31.98	41:14:41.3	97,103,104	0.07	0.06	0.08	18.12
99-018	11	8	34	84	0-2000	42:42.05	41:15:10.0	97,103,104	0.07	0.06	0.08	15.95
99-019	11	8	371	339	0-500	42:21.68	41:12:15.8	97,103,104	0.07	0.06	0.08	17.05
99-020	11	14	365	405	0-400	42:22.10	41:11:30.8	97,103,104	0.07	0.04	0.08	16.65
99-020	11	15	365	405	0-400	42:22.10	41:11:30.8	97,103,104	0.07	0.08	0.09	17.22
99-020	11	16	365	405	0-400	42:22.10	41:11:30.8	97,103,104	0.07	0.01	0.07	18.32
99-020	11	17	365	405	0-400	42:22.10	41:11:30.8	97,103,104	0.07	0.08	0.09	19.75





Single epoch only.

Type NB.

Type NA.

The Average Appearances of Novae

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Abstract

Sixteen data fields were inspected for novae that lasted for more than one day. After thurough examination, 22 novae were discovered in all fields. Magnitude and locations were recorded, as well as "imposters" that are hard to determine. In conclusion, novae last up to 2 weeks.

Purpose

The purpose of this research project was to see how long novae last in the Andromeda Galaxy.

Procedure

The National Optical Astronomy Observations supplied digital images on a RBSE CD-ROM. The CD contained images taken of M31 on 19 nights.

The images were analyzed using software provided on the CD-ROM: Scion Image Beta 3 for the Windows 9x-based system. Special Macros written for this program allowed the importing of "*.FITS" files, the extension under which the images were saved.

The M31 galaxy was divided into 16 fields with 19 epochs. After collecting all epochs for the appropriate fields, "stacks" were created to record what novae stayed the longest. After that, using a magnitude chart and the "record known magnitude" command, magnitudes were recorded on 2 novae. Then, using the "measure magnitude" command, magnitudes were recorded on the nova in the previous procedure. The novas' magnitude and location were recorded.

Control and Error Analysis

Glitches in the different fields were identified as "imposter novae." When closely identified, square or rectangular shapes can be made out, and they are also either pure white or pure black. Some "imposters" are hard to tell from others at first glance, so by magnifying the field 3 or 4 times, they can be noticed pretty well. It seemed best to record locations of some glitches, as well as glitches that may have been novae.

Magnitudes of some novae could not be recorded, either. In some cases, novae appeared on the edge of the data field. When using the "measure magnitude" option, a message appears saying magnitudes cannot be recorded on the edge of the data field.

Analysis and Conclusions

Novae last at least for 2 weeks. After taking an average of all novae that lasted for more than one day, the end result was 14.42.

References

A Search for Novae in the Andromeda Galaxy, Garavaglia, Jeff, 1999 RBSE Journal
The Search for Novae in the M31 Galaxy, Nascenzi, Ben, 2000 RBSE Journal

A Search for White Dwarf Masses in Cataclysmic Binary Pairs in the Andromeda Galaxy

Thomas Lynch and Janice Manion
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Teacher: Robert Groover, RBSE '00

Purpose

Working in conjunction with astronomers in Arizona and data from the National Optical Astronomy Observatories (NOAO), the goal of this project was to identify possible novae in the Andromeda Galaxy (M31) for the purpose of estimating the masses of white dwarf stars. Once the novae candidates were selected, it was a matter of verification and measurement. Novae with a three-magnitude change in brightness were qualifying factors for this investigation. To achieve this goal, the Scion Image program was used to view the entire Andromeda Galaxy in small sections over a period of approximately four years.

Procedure

Using the Scion Image program and digital images of the Andromeda Galaxy provided by the NOAO on the Research Based Science Education (RBSE) CD-ROM, the search for novae began.

A CCD camera took the original pictures of the Andromeda Galaxy. The pictures were too large (2048 x 2048 pixels) to be closely examined, so the images were broken down into sixteen subrasters of 512 x 512 pixels each. There were a total of 18 photos taken over a course of about four years. Each date a photo was taken corresponds to an epoch number. The exact dates for each epoch are listed as:

Epoch Number	Date
01	September 03, 1995
02	June 18, 1997
03	July 23, 1997
04	July 24,1997
05	July 24,1997
06	July 31, 1997
07	August 01, 1997
08	November 18, 1997
09	June 06, 1998
10	July 24, 1998
11	July 25, 1998
12	August 26, 1998
13	September 05, 1998
14	October 14, 1998
15	October 30, 1998
16	November 11, 1998
17	January 27, 1999
18	July 20, 1999

In order to view the images, it was necessary to import them into the Scion Image program. The Nova Search macros allowed the images of a particular epoch to be stacked in a slideshow fashion.

Once the images were stacked, it was then possible to "blink" them and watch for novae to appear. This component of the project required a significant amount of judicious observation. Not all stars that demonstrate the qualities of novae are true novae. In many instances, what appeared to be potential novae candidates were merely artifacts. The artifacts have a variety of sources including imperfections in the camera, glitches in the software, or the product of any other inaccuracy.

After the novae have been observed, it was necessary to record respective locations of the candidates. This later proved to be a difficult task for one member of this research team. Working with the object log, each nova found was automatically recorded. The object log listed each of the selected novae's location of the (X,Y) axis as well as Right Ascension and Declination.

When comparing results with a partner performing the research, it was discovered that the coordinates did not re-align with the *.FITS image files. After recovering from this setback, the magnitudes of the nova candidates were to be measured. To meet this end, the NIH Image macro was employed to gauge the magnitudes by using known values of standard stars from the RBSE Nova Search Program manual.

Data & Analysis

The data collected by one researcher of this team was not exactly usable. The conventional blinking method was used to peruse the M31images, however, instead of recording the data by hand; the data was recorded in the Object Log. While this seemed a beneficial action to take, it later proved counter-productive. When comparing data, the novae candidates did not align, and what was worse is that they could not be located again.

To resolve this situation, the aid of Dr. Rector was enlisted. The team e-mailed him and in his response, "the X coordinate value is the same for both [Object Log and Information Box], and the Y value in the object log equals 511 minus the Y value given in the info box" (Re: Nova Search). Upon first application of this fix, the "fix" did not appear to ameliorate the situation immediately. Data amassed using Dr. Rector's fix (may include artifacts and non-novae phenomena) are shown below to the left. The data on the right expresses nova candidates that have been researched and found to be true novae using the hand-written method (X and Y coordinates written from Information Box). After the data was collected the magnitudes were measured and the light curves were constructed (see Appendix A).

Field	Epoch	X-Coordinate	Y-Coordinate
2	1	45	329
5	9	199	262
6	5	114	461
6	10	155	206
6	11	25	262
6	11	78	242
6	12	134	464
7	4	345	81
7	10	229	52
7	14	209	315
8	1	167	293
9	11	398	304
9	11	399	441
10	1	389	83
10	10	326	232
10	11	97	429
11	1	227	296
11	3	127	393
11	5	228	80
11	8	340	173
11	8	348	185
11	15	373	107
11	17	-20	95
12	2	107	117

Field	Epoch	X-coordinate	Y-coordinate
5	2	373	424
5	8	468	82
5	9	286	17
6	1	112.6	464.9
6	4	44.2	10.3
6	12	135.8	333.4
7	5	412	500
7	10	228	473
8	2	386	200
8	9	23	421
9	11	372.1	34.3
10	1	470	440
10	8	162.2	101.3
10	9	109.7	196.5
15	13	172.1	473
16	2	80.4	183.2

Conclusions

In order to estimate mass of dwarf star in a nova pair, it required a 3-magnitude change, which appears not to be very common in the light curves plotted or observed in those plotted by other observers. Using a white dwarf vs. decay time chart (see Appendix B) places the solar masses of the one qualifying dwarf stars between 0.4 and 0.6. In this research team's data, graph B was the only one of the six curves plotted that qualified.

Field 6 (43,10)

Epoch Number	Magnitude
2	15.57
3	15.75
4	15.80
5	16.28
6	16.39
7*	15.85
8*	16.04

Field 15 (172.1,473)

Epoch Number	Magnitude
13	15.95
14	16.58
15	17.18
16	17.34
17	19.21

Field 6 (135,332)

Epoch Number	Magnitude
10	15.34
11	15.35
12	15.35
13	15.48
14	15.56
15	15.78
16*	15.75
17	15.78

Field 5 (468,82)

Epoch Number	Magnitude
9	16.32
10	16.61
11	16.75
12	16.84
13*	16.36
14	17.03
15*	16.89
16	17.15
17	18.15
18	19.01

Field 5 (286,17)

Epoch Number	Magnitude
6	15.79
7	16.36
8	16.39
9	16.38
10	16.16
11	16.22

For the purpose of the light curve, objects marked with an asterisk were omitted due to unreliable data. In instances with unreliable data, the magnitude calculated by the software was not concurrent with the apparent trend.

Aside from the human error encountered by this research team, there were other factors that contributed to inconsistencies. The time periods between the images taken by the CCD camera could have added to some of the unusual and unexpected magnitudes of certain novae. Despite some setbacks, this project enhanced this research team's knowledge of galactic phenomenon

In a future study, this research team's intent is to locate more qualifying novae candidates for mass determinations, as well as recurrences from images taken prior to the start of this program. In addition, a correlation between location and type of novae will be sought.

Acknowledgments

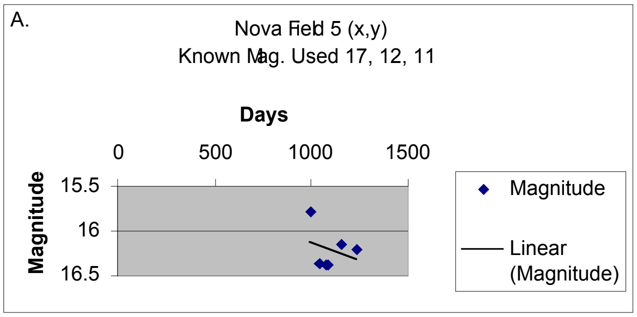
This team would like to start by thanking Mr. Robert Groover for initiating this program in Bordentown Regional High School and for the support and many hours of insight he provided. Additionally, guest speakers such as Dr. Strauss of Princeton University provided background information on stellar phenomena. Finally, Dr. Travis Rector for his research and assistance in our own research.

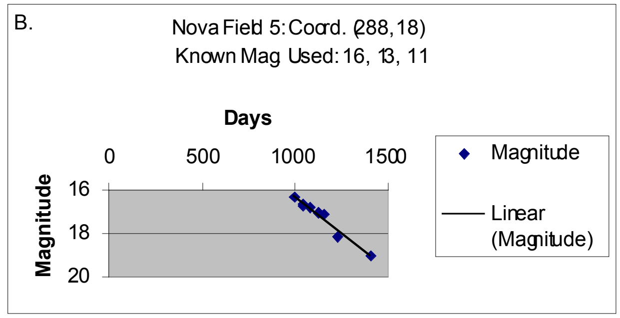
References

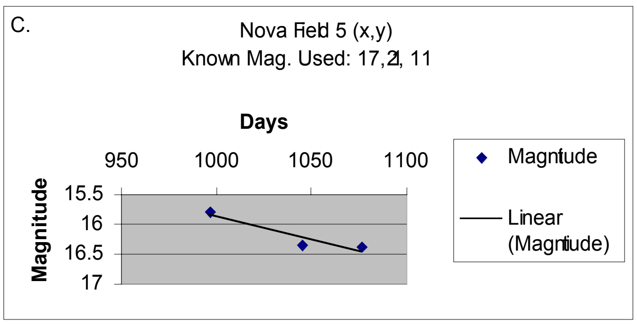
Rector, Dr. Travis. "Re: Nova Search." E-mail to Robert Groover. 17 March 2001

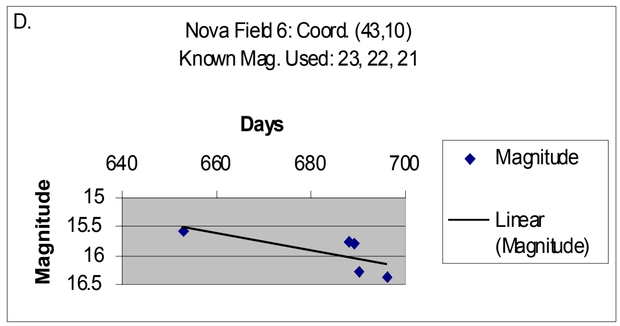
Phelps, Ken, Provenzano, Chatherine, and Maciolek, Ardis, (2000). A search for novae in the Andromeda galaxy-Year two results. RBSE Journal.

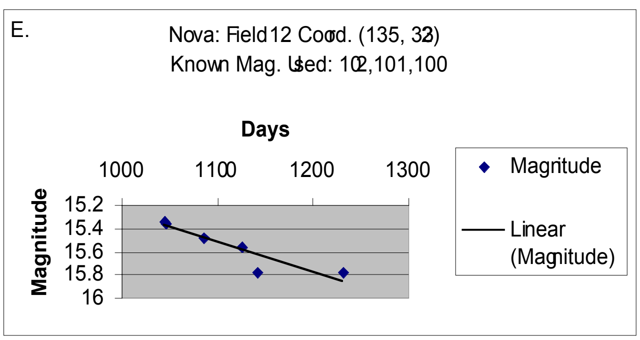
Appendix A

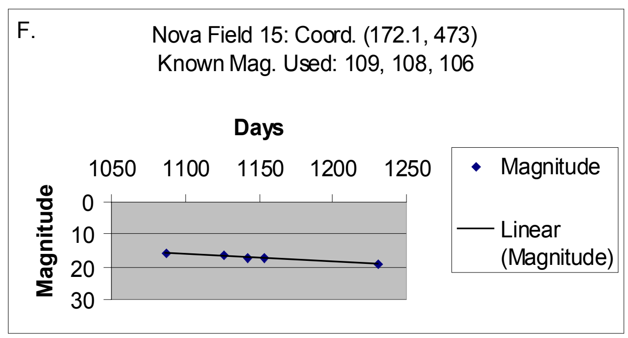




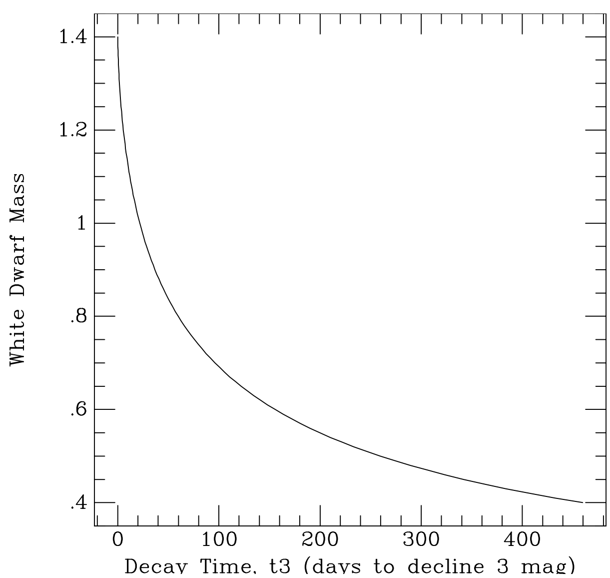








Appendix B



Do More Novae Appear Toward the Center of M31?

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Abstract

For this project I believe there would be many different outcomes for the numbers of novae in M31. To do this project I first chose a field in M31. Then, I counted the number of novae in each. Finally, I noted their location to the galactic center of the galaxy. After completing this research I found there to be no relation to the appearance of novae and their location in the galaxy.

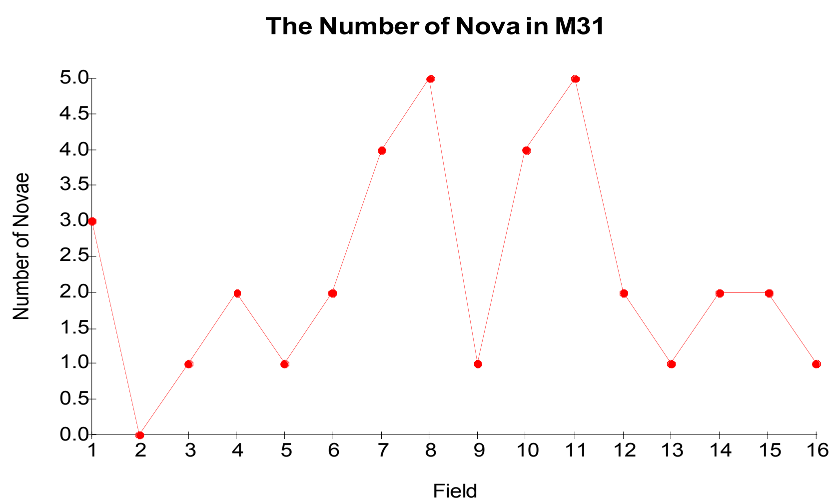
Introduction

The idea of doing this project on new novae compared to their location in M31 came from me "blinking" all the fields and noticing that in different fields there seemed to be more activity. Therefore the idea of doing this project came to mind.

Hypothesis

I think there will be more novae toward the center of the galaxy. I think this because there are a larger number of stars in this area, therefore the possibility of there being a nova is greater. Also the outer edges of M31 seam to no be as active with nova.

Procedure



First I "blinked" all fields in M31. then I recorded all of the novae in each field. Then, I compared the numbers to the fields location in the galaxy. Finally, I gathered my conclusion and composed the graphs.

Conclusions

After completing all of the research I found there to be no relation between the novae in M31 and their location in M31 compared to the center of the galaxy. I came to this because the numbers throughout the galaxy vary and their location did not determine the numbers of new nova. As one can see in the data the numbers and locations vary. This is why I feel there is no relation between their location in the galaxy and the numbers of novae produced.

Do Novae Reoccur?

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Teacher: Howard Chun, RBSE '99

Abstract

Over the past six years, forty-four confirmed novae were discovered in the M31 galaxy using ScionImage software. By comparing these findings with eighty-two novae found between 1953 and 1986, it was determined whether or not novae reoccur over a period of time. The findings showed that they do not, although there is evidence that an 1885 supernova may have re-ignited, since one, smaller nova was found in the region of the galaxy near where it once occurred.

Purpose

The purpose was to investigate if novae reoccur over a period of years.

Background

In 1885, there was a tremendous super nova in the M31 galaxy at RA 00:42:07 DEC 41:16:00. Today, there is a nova at RA 00:42:19.31 and DEC 41:16:16.5, close to the site of the supernova. Old research provided the coordinates of novae found over the past half-century. In a paper written by Halton C. Arp, there were thirty novae found between June 1953 and January 1955. Another paper written by L. Rosino and et al (1989) had fifty-two novae from the years 1971-1986. The reference coordinate systems for these novae were in Standard Coordinate form, with x and y axis through an ellipse (see Figure 1). Once the coordinates were converted to delta RA and delta DEC (see Figure 2) they were compared to the findings published by RBSE at NOAO.

Procedure

Scion Image was used to locate recent novae in M31. To do so, stacks were made for blinking in each field, and then animated. Novae were identified as faint stars that appeared and remained for one or more epochs. Then, using the Internet, papers were recovered with lists of novae found between 1953 and 1986. To compare the lists the coordinates were converted from standard coordinates to delta RA and delta DEC.

The center coordinates used were the 2000 coordinates, according to findings from Scion Image, which are RA: 00: 42: 44 and DEC: 41: 16: 9.3. The delta x and y were determined from the standard coordinates by using the equations:

Delta RA = delta x cos (A) + delta y sin (A)
Delta DEC = -delta x sin (A)+delta y cos (A)

For the Rosino et al paper, the rotation angle used was 38 degrees and in the Arp paper, it was 37.7 degrees. The Delta RA and Delta DEC were then added to the center according to the 2000 values.

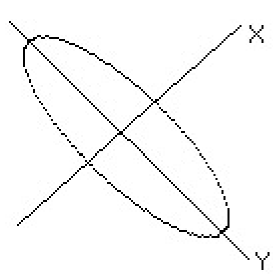

Figure 1

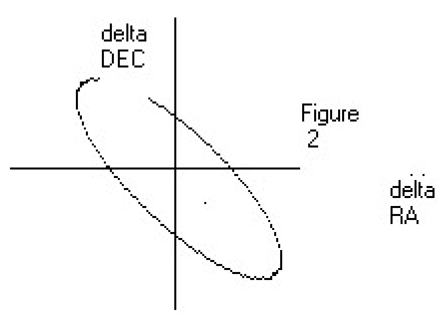

Figure 2

Novae Discovered By Arp, 1956						
		RA			DEC	
Number	Hours	Minutes	Seconds	Degrees	Minutes	Seconds
Center	0	42	44.0	41	16	9.3
1	0	45	65.3	41	15	51.8
2	0	12	87.9	41	38	61.4
3	0	38	60.6	41	15	16.4
4	0	31	69.6	41	8	53.4
5	0	37	54.5	41	16	29.4
6	0	43	96.2	41	13	37.3
7	0	45	59.9	41	7	30.2
8	0	42	69.9	41	18	20.9
9	0	44	72.0	41	17	62.4
10	0	42	77.5	41	22	55.7
11	0	44	57.9	41	12	47.3
12	0	78	81.1	41	13	18.4
13	0	51	97.8	41	9	17.9
14	0	29	88.0	41	30	26.1
15	0	37	58.0	41	16	62.4
16	0	69	57.2	40	52	66.7
17	0	39	66.1	41	19	38.7
18	0	37	75.6	41	16	60.9
19	0	43	80.9	41	18	34.3
20	0	27	47.9	41	35	15.3
21	0	36	69.3	41	31	13.8
22	0	45	84.7	41	17	28.9
23	0	31	80.0	41	35	29.1
24	0	45	64.2	41	15	43.4
25	0	39	79.5	41	17	62.8
26	0	42	77.2	41	19	21.8
27	0	60	51.8	41	13	40.7
28	0	47	51.2	41	8	24.6
29	0	33	84.7	41	20	28.5
30	0	46	51.2	41	5	10.6

Results

By comparing the coordinates, it was found that no novae were within ten arcseconds of a previous nova, thus showing that novae have not reoccur. The nova closest to SN1885 is no closer that 12 arcseconds in RA and 16.5 arcseconds in DEC. One possible reason for the null results is that the region of study was smaller than the ones used by Arp and Rosino. The outer boundaries of the center region was RA: 00:43:45.93 to 00:41:42.56, and DEC: 41:27:45.5 to 41:04:40.6. Novae found by Arp and Rosino were located as far as RA 00:37:52 and DEC 41:16:60.8. The coordinate transformations from standard coordinates to delta RA and delta DEC also did not take into consideration the planar tilt in the calculations. Perhaps novae reoccur in periods of one hundred years, instead of fifty.

Bibliography

1. "Novae in the Andromeda Nebula," Halton C. Arp. The Astronomical Journal, February 1956, Volume 61, No. 1235.
2. "Fifty-two Novae in M31 and Observed at Asiago From 1971 to 1986," L. Rosino, M. Capaccioli, M. D'Onofrio, and M. Della Valle. The Astronomical Journal, January, 1989, Volume 97, No. 1.
3. "A Search for Novae in the Bulge of M31," T. A. Rector, G. H. Jacoby, D. L. Corbett, M. Denham, RBSE Search Team, National Optical Astronomy Observatories, wysiwyg://14/http://www.noao.edu/outreach/rbse/confirmednova.html

Novae Found Between 1971 and 1986					
Number	Year	Month	Day	RA	DEC
91	1971	August	18	42'22.995"	41'02'57.32"
92	1972	January	11	43'20.01"	41'02'34.82"
93		August	11	31'59.704"	41'04'6.74"
94		September	16	34'5.7"	41'00'24.8"
95		October	17	43'8.1"	40'56'29.6"
96		October	18	38'42.36"	41'05'26.66"
97		November	1	25'42.06"	41'09'31.28"
98		November	29	46'38.7"	41'04'29.9"
99	1973	February	6	43'42.06"	40'58'50.54"
100		August	6	38'25.14"	40'59'43.88"
101		October	4	38'12.72"	41'02'2.96"
102		October	4	36'23.94"	41'10'14.42"
103	1974	July	23	43'8.76"	40'57'33.8"
104		July	23	41'45.72"	40'57'27.86"
105		August	12	31'1.92"	41'01'59.06"
106		August	21	33'25.02"	41'07'5.24"
107		September	9	29'41.82"	40'59'55.1"
108		October	21	41'51.48"	41'01'53.54"
109		December	12	45'40.92"	40'57'13.16"
110	1975	October	26	42'55.92"	41'03'14.18"
111		December	4	44'41.94"	40'59'32.12"
112		December	29	39'14.16"	41'02'31.88"
113	1976	September	17	40'26.16"	41'02'44.18"
114		September	17	42'8.52"	40'59'17.96"
115		December	23	52'55.08"	40'46'49.52"
116		December	23	39'8.28"	41'02'27.32"
117	1977	August	13	41'57.66"	40'56'46.58"
118		November	12	37'57.66"	41'00'33.5"
119		December	29	32'21.96"	41'06'25.4"
120	1978	October	23	44'31.62"	40'51'23.12"
121	1979	August	21	44'36.24"	40'58'27.32"
122		September	30	41'22.5"	41'00'25.82"
123	1980	October	10	49'25.08"	40'57'53.6"
124		October	10	55'33.06"	41'11'5.72"
125	1981	November	26	37'19.74"	40'51'3.26"
126		November	29	1h6'14.88"	40'55'58.76"
127		December	26	39'18.54"	40'58'3.56"
128	1982	September	18	42'9.84"	40'57'9.02'
129		September	17	44'34.38"	40'59'27.32"
130		September	17	39'55.8"	40'57'39.68"
131		September	17	44'38.16"	40'52'17.36"
132		October	14	40'42.18"	41'06'24.62"
133	1983	September	8	47'35.58"	40'56'51.38"
134		September	8	38'34.38"	41'04'9.2"
135		October	31	41'41.1"	40'55'8.36"
136		December	5	38'59.22"	40'55'17.48"
137	1984	July	31	40'40.26"	40'59'40.4"
138		November	2	40'38.94"	40'58'45.08"
139	1985	August	19	49'26.82"	40'58'17.36"
140		November	6	45'46.38"	40'59'1.58"
141	1986	January	16	40'0.3"	41'07'20.84"
142		October	8	46'1.44"	40'58'39.92"

Coordinates from RBSE Search Team					
	Ra			Dec	
hour	min	sec	degree	min	sec
0	42	1.51	41	19	38.7
0	42	8.49	41	8	15.4
0	42	11.09	41	13	19
0	42	11.45	41	17	32.6
0	42	13.44	41	7	45
0	42	19.31	41	16	16.5
0	42	19.78	41	14	8.4
0	42	21.76	41	12	16.5
0	42	22.17	41	11	31.7
0	42	26.46	41	16	56.6
0	42	29.1	41	13	36
0	42	30.37	41	16	34.2
0	42	32.05	41	14	41.7
0	42	33.86	41	4	58.2
0	42	37.01	41	16	56.3
0	42	37.37	41	20	52.9
0	42	40.14	41	15	46.7
0	42	41.21	41	12	0.4
0	42	42.12	41	15	10.7
0	42	43.1	41	16	4.1
0	42	43.82	41	11	31.5
0	42	43.82	41	16	52.4
0	42	45.16	41	15	31.6
0	42	46.59	41	14	49.5
0	42	46.66	41	11	8.2
0	42	49.64	41	15	5.8
0	42	49.91	41	16	48.5
0	42	50.38	41	7	48.5
0	43	1.82	41	15	38.5
0	43	3.78	41	16	3.9
0	43	4.41	41	19	35.9
0	43	5.34	41	14	59.3
0	43	6.12	41	13	41.3
0	43	6.8	41	17	58.1
0	43	6.96	41	18	9.9
0	43	8.34	41	16	40.2
0	43	10.1	41	25	34.1
0	43	12.53	41	21	49.7
0	43	17.84	41	20	59.7
0	43	18.63	41	13	35.1
0	43	23.6	41	15	44.7
0	43	23.63	41	21	39.3
0	43	28.76	41	21	42.6
0	43	35.55	41	20	39.5

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A Study of Active Galactic Nuclei and Quasars

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Abstract

The study of AGN and, more specifically, quasars through spectroscopy is a complex one. There are very few proven facts regarding AGN, an acronym for Active Galactic Nuclei, and quasars, which makes their analysis, much like the rest of astronomy, mostly theoretical. However, the unknowns regarding this field means that work by amateurs is vital. The legwork performed by students and astronomy enthusiasts gives the professionals a head start in their quest for knowledge regarding the universe.

Introduction

Quasars are an enigma in the astronomical community. Even their existence is disputed, but what causes more controversy than any other issue is a common definition of a quasar. The following is a more popular definition of what is considered to be a quasar.

The quasar is a class of astronomical objects that appear on optical photographs as star like but have large red shifts quite unlike those of stars. The first quasars were observed in 1961 when it was found that a strong radio emission was emanating from many of these star-like bodies. Over 600 such objects are now known and their red shifts can be as high as 4. The red shifts are characteristic of the expansion of the universe. If the red shifts are cosmological, as favored by most astronomers, quasars are the most distant objects in the universe, some being up to 1010 light years away. The exact nature of quasars is unknown but it is believed that they are the nuclei of galaxies in which there is violent activity. The luminosity is so much greater than the rest of the galaxy that the source appears point like. It has been proposed that the power source in a quasar is a super massive black hole accreting material from the stars and gas in the surrounding galaxy.

Purpose

The purpose of this project is to discover whether the flux of a quasar has any bearing on the luminosity of the aforementioned object. AGN spectroscopy was used to gather data, which was then collated and processed into a spreadsheet holding the results we needed to come to our final conclusions.

Procedure

Most of the quasar spectra were gathered at the Kitt Peak National Observatory in Arizona, using a 2.1-meter telescope. These spectra were supplied on a CD created by The Use of Astronomy in Research Based Science Education program, also known as RBSE.

The spectra of the quasars were pulled up via Graphical Analysis. The wavelengths of the emission lines were found using the program and the data was then assembled in a spreadsheet on Microsoft Excel.

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Wavelength A	Wavelength B
5941	3777.9
4826	3777.9
5941	4826

The wavelengths were divided into each other wavelength within the spectrum, yielding a ratio. All the ratios that were equal to or less than one were removed, since they would not have led to accurate data.

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Wavelength A	Wavelength B	Ratio
5941	3777.9	1.277429
4826	3777.9	1.572567
5941	4826	1.23104

Using the following charts, the two elements that created the emission line could be found and their resting wavelengths are needed for the further calculations.

Emission Line Ratios

	Ly α	C IV	C III	Mg II	Hβ	O III	Hα
Ly α							
C IV	1.28						
C III	1.57	1.23					
Mg II	2.31	1.81	1.47				
Hβ	4.01	3.14	2.55	1.74			
O III	4.13	3.23	2.62	1.79	1.03		
Hα	5.41	4.24	3.44	2.35	1.35	1.31	

Lines at rest

Ly α	1213
C IV	1549
C III	1909
Mg II	2803
HB	4861
O III	5007
Hα	6563

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Wavelength A	Wavelength B	Ratio	Line A	Line B	A Rest	B Rest
5941	3777.9	1.277429	C IV	Ly α	1549	1213
4826	3777.9	1.572567	C III	Ly α	1909	1213
5941	4826	1.23104	C III	C IV	1909	1549

Using the equation 1+z=wavelength observed/ resting wavelength, the redshift of the quasar was determined. Z=red shift.

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Wavelength A	Wavelength B	Ratio	Line A	Line B	A Rest	B Rest	Redshift	Redshift
5941	3777.9	1.277429	C IV	Ly α	1549	1213	2.1155	2.1145
4826	3777.9	1.572567	C III	Ly α	1909	1213	2.1121	2.1145
5941	4826	1.23104	C III	C IV	1909	1549	2.1121	2.1155

The remaining equations for velocity and distance depend on the redshift of the quasar in question. Since the two redshifts are almost identical, it doesn't matter which redshift we use. We chose the first redshift, redshift A.

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Wavelength A	Wavelength B	Ratio	Line A	Line B	A Rest	B Rest	Redshift	Redshift	Velocity	Distance
5941	3777.9	1.28	C IV	Ly α	1549	1213	2.1155	2.1145	243960	2642.8
4826	3777.9	1.57	C III	Ly α	1909	1213	2.1121	2.1145	243847	2640.6
5941	4826	1.23	C III	C IV	1909	1549	2.1121	2.1155	243847	2639.7

Next using the Graphical Analysis program, the flux of the quasar's spectrum was calculated from the wavelength band of four thousand angstroms to five thousand angstroms. This was also recorded on to the Excel spreadsheet. The flux was needed to determine the luminosity of the object. Using the equation L=4Pi*f*d2(1+z)2

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Wave A	Wave B	Ratio	Line A	Line B	A Rest	B Rest	Redshift	Redshift	Velocity	Dist	Luminosity	Flux
5941	3777.9	1.28	C IV	Ly α	1549	1213	2.1156	2.1145	243960	2642	0.000305	3.59E-13
4826	3777.9	1.57	C III	Ly α	1909	1213	2.1121	2.1145	243847	2640	0.000305	3.59E-13
5941	4826	1.23	C III	C IV	1909	1549	2.1121	2.1155	243847	2639	0.000305	3.59E-13

Controls And Error Analysis

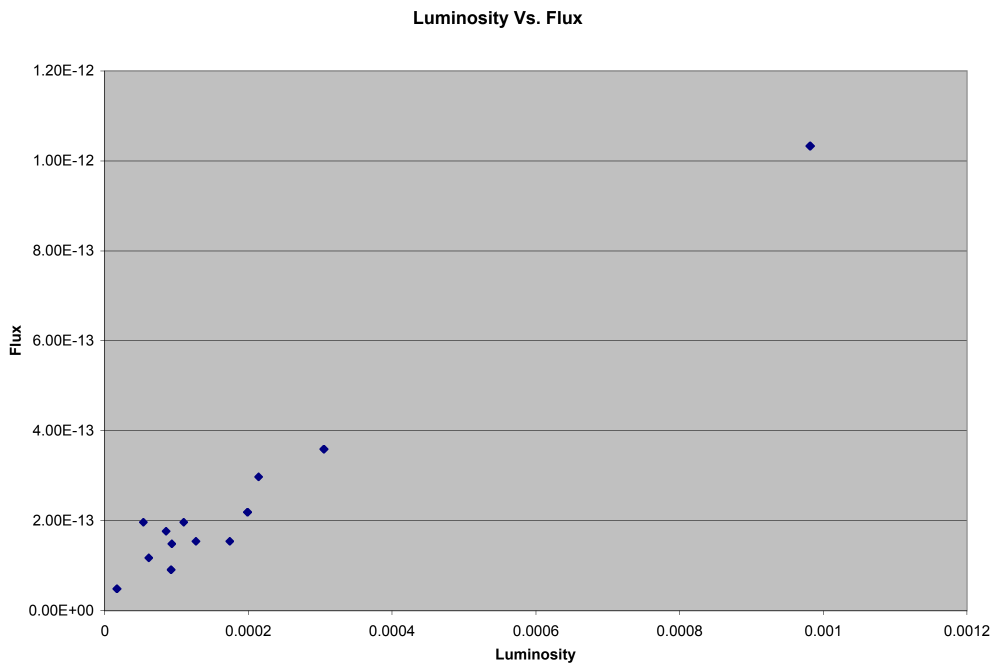
One possible source of error in the data could be within the calculations themselves. The use of Hubble's constant as 75 Km2 could pose a problem as some people assume it to be anywhere from 50 to 100 Km2. In some cases earth's atmosphere could have caused telluric lines, red herrings that appear on the spectra, lines that look like emission lines but are not. Thankfully astronomers have discovered many of the possible telluric lines and so any possible errors were avoided. During this project, several negative values were encountered when calculating the red shifts of quasars. However, once the luminosities of the quasars were determined it became clear that these were anomalous results and were discounted from the project.

Analysis

From the results, it is clear that there is a definite relationship between the luminosity and the flux of a quasar object. This direct, linear relationship between each of the 22 suspected quasar spectra was verified once an XY scatter graph was viewed. The graph showed that all our results followed the trend set by our line of best fit.

Another trend that appeared was the repetition of carbon-based elements. Most spectra contain either C III, C IV or a combination of both.

Most of the results were concentrated in the lower part of the XY scatter graph, which proves that there is not only a definite correlation between both luminosity and flux, but that the values of both often remain constant throughout the spectra.



As the data was formed, records were also made regarding the other factors from the spreadsheet including distance, red shift and velocity although no correlation was found.

Conclusions

Due to the complex and theoretical nature of this project no concrete conclusions regarding the relationship between luminosity and flux could be found. Amateur astronomers do not have enough background knowledge to base any conclusions on. The information from this project can be simply passed on to the professionals who have the knowledge to take this project to the next level. If time wasn't a factor, an extension of this project could be to delve into the relationship between luminosity and flux, and perhaps discover why there is so much carbon in or surrounding the studied quasars. Time could also become a factor and research could be carried out over several decades of archived material as opposed to the few months of data used in this project.

Acknowledgements

We would like to thank Dr. Travis A. Rector, Dr. David Goldberg and our teacher, Mrs. Kaye Sullivan, for their input.

Comparing Distance and Width of Emissions of Quasars

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Abstract

The purpose of this project was to determine what, if any, relationship there was between the width of an emission line of a quasar to that quasar's distance from earth. The data was compared based upon what element the emission line corresponded to so that the widths and distances of all emission lines of one element were compared. It was discovered that there is no correlation between the two.

Introduction

Originally, the thought was to put the widths and distances of all of the found elements into one graph to see if there was a relationship. It was then realized, however, that it would be better to compare each of the same elements so that one would take the width and distance of the same emission line from different spectrographs and compare them.

Problem

To determine what sort of relationship there is when comparing the width and distance of an emission line of a quasar.

Hypothesis

There will be a direct relationship between the distance and width of an emission line of the same element from different spectrographs. This was thought because the brighter an object appears, the wider the emission lines will be. The objects that are closer are more likely to have wider emission lines because if one takes two objects with the same absolute magnitude and places one closer and the other farther, the one that is closer will appear brighter.

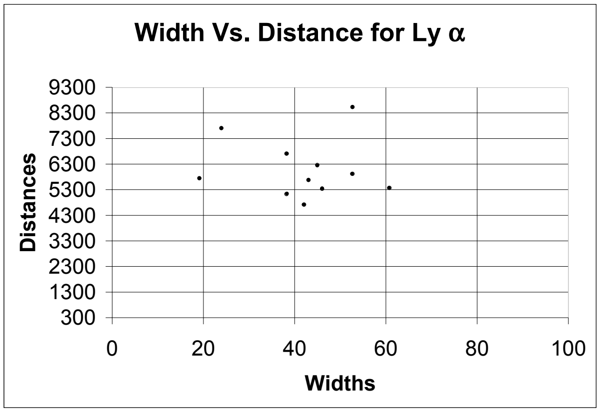
Methodology

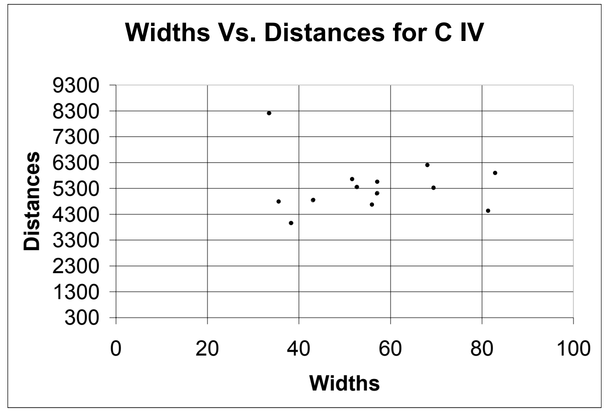
In order to find the widths of the emission lines, the vertical middle of the emission line was estimated. It was difficult to accurately determine this middle point, for it was difficult to determine the bottom of the emission line due to all of the noise. The difference between the right side of the emission line at this height and the left side of the emission line at this height was measured. This difference is the width of the emission line.

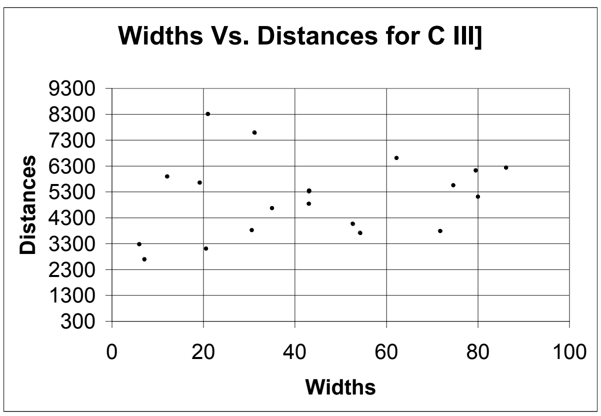
Finding the distance was a more difficult process. First, the red shift and element of every emission line was found by calculating the ratio for that emission line. The ratio was determined by comparing each wavelength of one spectrograph with all of the other wavelengths of that same spectrograph, taking the larger wavelength divided by smaller. This ratio was then used to determine the chemical element as well as the red shift. The red shift was then plugged into the distance formula, $d=(cz/Ho)((1+.5z)/(1+z))$, where z is the red shift, c is the speed of light, and Ho is Hubble's Law constant. Then all of the emission lines were put into different categories, one for each chemical element that was represented in the data. Each group of emission lines and distances was then graphed based upon its element.

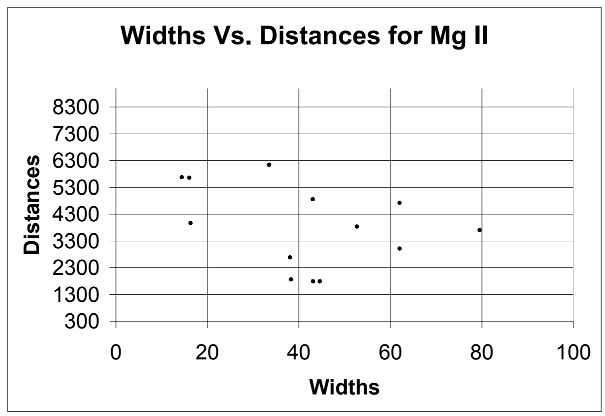
Data Analysis

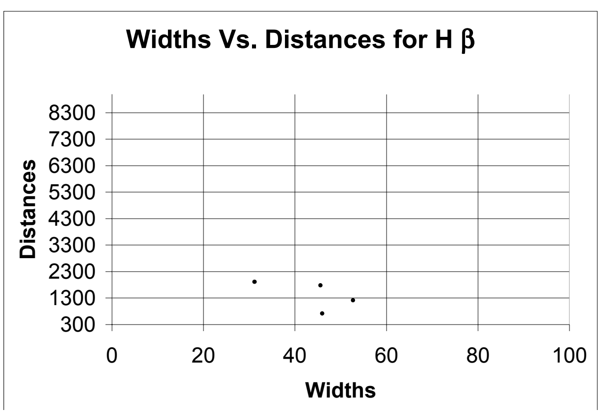
Most of the graphs showed no correlation, so if there is any relationship at all between the width of the emission lines and their distance from Earth, it is a weak one. The graph of Lyα shows no sign of having a trend in any direction. The only possible relationship is a clump rather than a line. C IV's graph is one of two out of all of the graphs that appears as if it could possibly contain a direct relationship. It is a very unclear relationship though. The other graph that possibly contains the hypothesized result is C III]. However, it is also not a definite relationship. Mg II has an interesting graph. At first it appears as if it might have some sort of a relationship, but it would be an indirect relationship rather than a direct one. This is also not easy to spot, and certainly not definite. The graph of Hβ simply doesn't have enough points to make any form of conclusion whatsoever. There are only four points plotted on this graph. O III] doesn't really seem to have a trend either. It is possible that if more points were added that we would be able to see something with a near horizontal slope, but other than that it's another clump. There is only point for Hα, so there is no way to form a conclusion for that either. Overall, the general trend is that there is no relationship between the width of an emission line and the distance of the quasar.

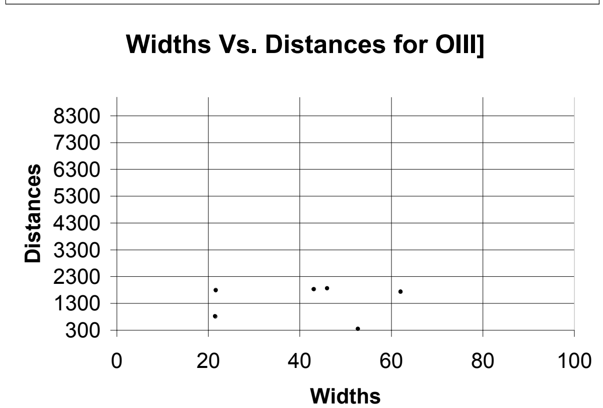












Conclusions

There is no relationship between the width of a quasar's emission line and its distance. Through our analysis of several graphs of width vs. distance for various elements there is no consistent correlation. The graphs of C IV and C III] both show a possible positive slope, but then Mg II shows a possible negative slope. This cancels out the possibility of having any sort of trend at all. The only possible correlation between the widths and the distances is that most appear to clump at some point, but the places on the graphs where they clump is inconsistent.

There was quite a bit of human error in this project however. Measuring the widths was quite difficult because finding the bottom of the emission line was more of a guess than a fact, which made trying to find the vertical center even more challenging. Then, on top of those possible errors, there were also not always data points that corresponded to where on the emission line we wanted to measure for the width. This data shows clearly that there is no relationship between the width of an emission line and the distance for a quasar.

The Correlation of Distance with Luminosity in Quasars

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Abstract

The spectra of Active Galactic Nuclei can reveal many extremely important characteristics of the object(i.e. distance, velocity, redshift, luminosity, flux, etc.). Using knowledge of these spectra, one can find information and relationships otherwise impossible to attain. This project used the spectra of AGN's (specifically quasars) to find a correlation between the distance of an object and its luminosity. My hypothesis is that there will be a direct relationship, so as distance increases, luminosity does as well.

Purpose

The purpose of this research project was to determine what relationship, if any, exists between the distance of a quasar from earth and that object's luminosity.

Procedure

First, it was determined which spectra were in fact quasars by using the program Graphical Analysis. After the spectra were identified, each one was studied individually in order to find the necessary information. The observed wavelengths of the most prominent emission lines from each spectrum were noted and ratios of the lines with each other were taken. These ratios were then compared with known ratios of emission lines. After the lines were identified as elements, the redshift was found by using the following formula:

$$z=(lobs/lrest)-1$$

After the redshift was determined, the distance of the object from earth was determined by using the equation:

$$d=cz/H0(1+0.5z)/(1+z),$$

where c is the speed of light, z is the redshift, and H0 is Hubble's constant of 75 km s-1 Mpc-1.

The unit of distance determined is Mpc. Once distance is determined, the next step is to find the total flux of the spectrum. Using Graphical Analysis, the entire graph was selected, and the integrate tool was used. This gave the flux of the object in erg cm-2 s-1. Finally, after flux was found, luminosity was determined. The following equation was used to determine luminosity:

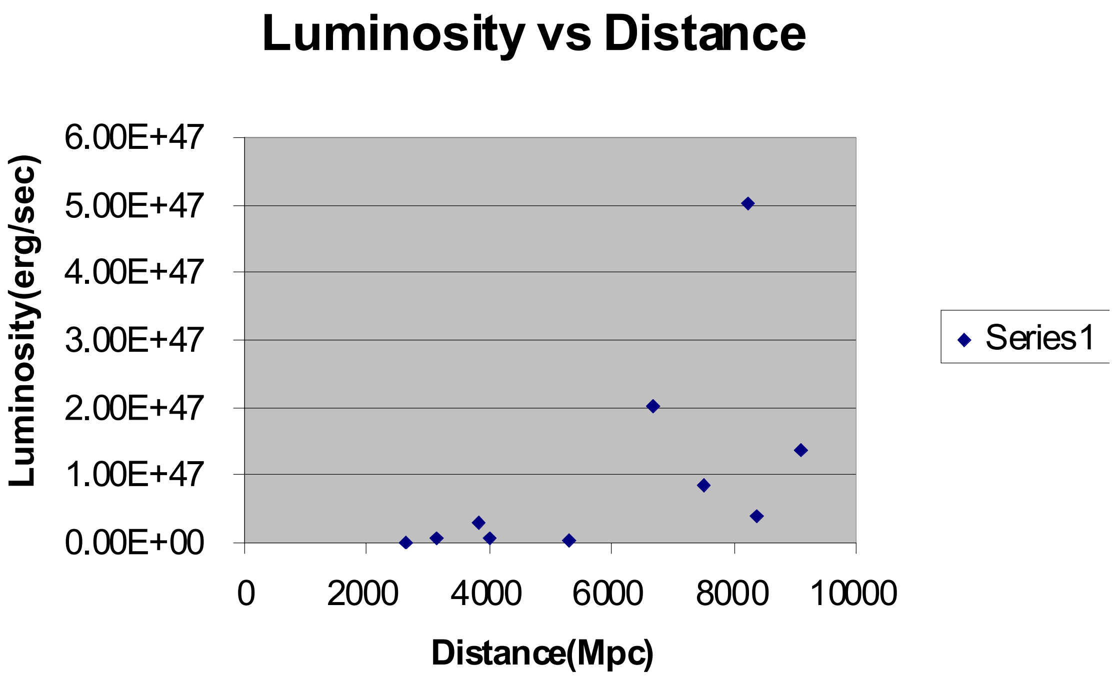
$$L = 4pfd2(1+z)2$$

Because the flux was calculated in erg cm-2 s-1, however, distance must be converted into centimeters by knowing that there are 3.26*10^6 light years in a megaparsec and that there are 9.5*10^17 centimeters in a light year. Once converted, the new distance value may be entered into the equation.

Once all of the preceding information had been calculated, the distance of each object and its luminosity were compared and correlated to what relationship was involved.

Error Analysis

Several errors may have affected the validity of the results. First, the Hubble constant used was 75 km s-1 Mpc-1, although the actual value is disputed and scientists use anywhere from 50-100 km s-1 Mpc-1. Also, the analysis of the lines may have been inaccurate, in that some may have been noise or the ratios between lines may have been incorrectly determined as a known ratio. Another source of error may be in the actual data. Clouds of gas between the object and earth may be moving at different velocities and directions than the object, causing a lower redshift in the absorption lines of the object.



Conclusions

After calculating the distance and luminosity of the quasars and correlating the data, it was found that there does in fact appear to be a direct relationship between the two. A possible reason for this may be that the farther away an object is from us, the older it is, and the farther back we are looking. Because we are looking at these very old objects when they were very young, it is possible that they had not yet used up as much of their energy as closer objects. The increase in energy creates an increase in luminosity.

The Determination of the Look Back Time of Distant Active Galaxies

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Abstract

The distance to objects informs astronomers of the possibilities of the evolution of the Universe. Spectroscopy, which is the essential tool in the study of astronomy, is used to determine these distances. Active Galactic Nuclei (AGN) are the main objects studied in our project. These objects include elliptical galaxies, starburst galaxies, radio galaxies, BL Lac objects, and quasars. They have been found to contain super massive black holes, which trigger a tremendous amount of energy radiating from their nuclei. By calculating the redshifts of the light from these objects, an indication of distance and look back time can be determined.

Purpose

To verify the age of the universe as determined by the inverse of the Hubble constant using the look back time of AGN's.

Hypothesis

We believe this data will conclude that there is an upper age limit of the Universe, and further research may indicate that the Universe was created simultaneously.

Procedures

As part of an educational outreach program sponsored by the National Optical Astronomy Observatories we obtained a list of eighty objects to study. The program was entitled the Use of Astronomy in Research-Based Science Education (RBSE). They were sent to us on a CD ROM. The data was in the form of spectrographs. From the spectrographs of the objects we had to decipher whether they were starburst galaxies, quasars, BL Lac objects, elliptical galaxies, or radio galaxies. Once we determined the proper category for each object we proceeded to calculate the redshifts of each AGN.

There are two distinct ways to measure the redshifts of the objects. One way is to measure the calcium break, which is a break in the line at the wavelength that calcium radiates energy. We determined the redshift using the formula, Z= (observed wavelength / rest wavelength)-1. (Where z is the redshift)

If there wasn't a calcium break within the AGN spectrum, we calculated the redshift by using the two strongest emission lines. We took the longest wavelength, and divided it by the shortest wavelength to come up with a ratio. This ratio determined the elements represented by the two emissions lines. The ratio was found in a table of emission line ratios on the RBSE CD ROM. We then consulted the table labeled Strong Emission Lines commonly seen in AGN (The RBSE Journal 22).

After all the redshifts were plotted into Microsoft Excel, we then determined the receding velocity using (v/c=(z+1)^2-1/(z+1)^2+1). Next we found distance in Mpc using the formula D=(cz(1+0.5z))/(Ho(1+z)). Distance in light years was calculated using (Distance in light years=distance in Mpc v*3,260,000). Finally look back time was determined using the following formula: Look Back time=(13,000,000,000 years*z)/(1+z). To make the line graph we took the redshifts versus the age in years, and entered the data into a xy scatter graph. This created the curved graph, which showed the objects getting closer to the speed of light. As objects recede from us approaching the speed of light, the distance to those objects gets closer to the edge of the universe. Because of the finite speed of light, the time it takes light to reach us from the most distant objects nears the age of the universe.

To determine the upper age limit we used the formula T=1/75 km/sec/Mpc. (where 75 km/sec/Mpc equals Hubble's Constant) When converting megaparsecs into kilometers, one megaparsec equals 3.08*10^19.

Expressed in seconds this is 1/2.435*10^-18. When inversed, it is equivalent to 4.1*10^17sec. From here we had to convert seconds into years.

Data Determined from the Spectra of Various Elements

Object	Emission line 1	Emission line 2	Redshift	Velocity in km/s	Distance in Mpc	Proper Distance in light years	Angular-size distance in light years	Look-back Time in Years
ffs1005	6709	6699	0.001	430	6	18,673,876	18647154	18,603,265
ffs0847	7010	6857	0.022	6628	88	288,166,249	281868521	284,108,417
ffs0733	4656	4536	0.026	7832	104	340,528,010	331751515	335,051,546
ffs0811	6231	5891	0.058	16825	225	732,467,372	692478702	709,728,151
ffs0816	5637	5302	0.063	18359	245	799,491,938	751975741	772,628,890
ffs1019	6560	6048	0.085	24320	325	1,060,619,402	977855519	1,014,435,976
ffs1006	7849	7188	0.092	26305	352	1,147,816,452	1051220572	1,094,030,707
ffs0955	6479	5934	0.092	26307	352	1,147,893,875	1051285261	1,094,101,124
ffs0754	4627	4206	0.100	28541	382	1,246,227,889	1132804667	1,183,171,955
ffs1106	7554	6817	0.108	30690	411	1,341,009,327	1210174819	1,268,334,657
ffs0957	6315	5692	0.109	31009	416	1,355,121,173	1221594149	1,280,956,529
ffs1039	7853	7054	0.113	32079	430	1,402,389,840	1259656187	1,323,125,310
ffs1047	7712	6693	0.152	42250	569	1,854,947,139	1609753530	1,718,386,929
ffs0722	4714	4073	0.157	43536	587	1,912,591,769	1652532517	1,767,638,199
ffs1011	6508	5575	0.167	46068	622	2,026,444,482	1735853763	1,864,190,892
ffs1030	6560	5594	0.173	47410	640	2,086,960,406	1779515507	1,915,121,951
ffs0737	7144	6082	0.175	47872	647	2,107,848,437	1794486121	1,932,639,006
ffs0732	6833	5680	0.203	54824	744	2,423,816,697	2014804059	2,193,715,515
ffs0742b	5889	4819	0.222	59358	807	2,632,109,690	2153905924	2,361,850,261
ffs0928	5550	4483	0.238	63097	861	2,805,380,309	2266027951	2,499,333,381
ffs1112	7568	5965	0.269	70098	961	3,133,651,600	2469814645	2,753,937,424
ffs0738b	7694	6063	0.269	70152	962	3,136,242,840	2471379413	2,755,916,871
ffs1036b	7967	5728	0.391	95567	1344	4,382,299,346	3150408493	3,654,378,632
ffs1119	7120	5052	0.409	99058	1399	4,561,551,837	3236907935	3,775,112,360
ffs1036a	7967	5627	0.416	100321	1419	4,627,020,803	3267854132	3,818,691,870
ffs0747	7584	5168	0.468	109764	1573	5,126,549,945	3493046003	4,142,269,455
ffs0800	7332	4990	0.469	110038	1577	5,141,301,506	3499411720	4,151,588,308
ffs0740	8292	5570	0.489	113426	1634	5,325,552,160	3577599584	4,266,859,624
ffs1001	8771	5737	0.529	120233	1750	5,704,259,167	3730868523	4,497,354,980

Controls and Errors

There are certain factors that must be considered when analyzing the data. One factor that may give a false distance is the Hubble's constant used. We used seventy-five km/sec/Mpc, while astronomers use anywhere from seventy to eighty km/sec/Mpc. It is possible that some of the emission lines and calcium breaks are slightly misinterpreted.

Conclusions

After determining the redshifts of Active Galactic Nuclei (AGN's), and distances to the objects, we discovered 5.5 to be the highest redshift known to astronomers today. We then applied Hubble's Law to determine distance to AGN's in light years. Astronomers discovered Hubble's constant to be between 70km/sec/Mpc and 80km/sec/Mpc. If an object is 11 billion light-years away then we are looking at it as it appeared 11 billion years ago. In look back time, this would be near the beginning of the universe.

Data Derived from Calcium Break

Object	Calcium Break Observed Wavelength	Calcium Break Rest Wavelength	Redshift	Velocity in km/s	Distance in Mpc	Proper Distance in Light years	Angular-size Distance in Light years	Look-back Time in Years
ffs1240	3984	3968	0.004	1,185	16	51,493,089	51,290,152	51,233,778
ffs1254	3988	3968	0.005	1,538	21	66,868,873	66,526,849	66,492,829
ffs1019	4053	3968	0.021	6,365	85	276,727,363	270,917,119	272,951,568
ffs1030	4053	3968	0.021	6,365	85	276,727,363	270,917,119	272,951,568
ffs1238	4106	3968	0.035	10,252	137	445,887,008	430,901,035	436,921,578
ffs1534a	4149	3968	0.046	13,344	178	580,585,599	555,311,106	565,925,855
ffs0715	4187	3968	0.055	16,073	215	699,628,163	663,097,634	678,784,694
ffs0934	4193	3968	0.057	16,494	220	718,019,064	679,570,578	696,124,031
ffs0701	4202	3968	0.059	17,199	230	748,823,509	707,055,893	725,109,461
ffs1725	4218	3968	0.063	18,279	244	795,986,392	748,879,458	769,347,496
ffs1049	4243	3968	0.069	20,044	268	873,211,150	816,693,028	841,417,998
ffs1614a	4243	3968	0.069	20,044	268	873,211,150	816,693,028	841,417,998
ffs0932	278	3968	0.07	20,267	271	882,942,056	825,179,492	850,467,290
ffs0254	4255	3968	0.072	20,916	280	911,357,044	849,885,958	876,850,764
ffs1406	4257	3968	0.073	21,021	281	915,964,447	853,881,575	881,122,988
ffs1655	4268	3968	0.076	21,805	292	950,318,777	883,582,470	912,927,338
ffs1210	4272	3968	0.077	22,127	296	964,404,363	895,713,436	925,941,530
ffs1317	4280	3968	0.079	22,678	303	988,562,089	916,455,859	948,226,718
ffs0936	4288	3968	0.081	23,193	310	1,011,153,485	935,781,563	969,026,961
ffs2346	4303	3968	0.084	24,248	324	1,057,444,885	975,165,312	1,011,527,378
ffs1411	4305	3968	0.085	24,421	327	1,065,044,188	981,602,987	1,018,488,839
ffs1325	4318	3968	0.088	25,243	338	1,101,112,941	1,012,052,336	1,051,470,588
ffs0148	4355	3968	0.098	27,866	373	1,216,489,229	1,108,286,096	1,156,311,705
ffs2327	4381	3968	0.104	29,608	397	1,293,264,010	1,171,347,088	1,225,519,288
ffs0758	436	3968	0.11	31,195	418	1,363,326,126	1,228,221,735	1,288,288,288
ffs1412	4459	3968	0.124	34,841	468	1,524,730,002	1,356,835,310	1,431,486,880
ffs0904	4474	3968	0.128	35,841	481	1,569,123,314	1,391,627,659	1,470,530,386

Using the time equation, which is an indication of the expansion rate of the Universe, we discovered when the objects were plotted on a graph they created a curve. Showing the relationship of redshift vs. age of the universe. Extending the x-axis of redshift to infinity, we verify the age of the universe as expressed by T=1/Hubble constant.

With technological advances we will be able to see further into space, and it is possible that astronomers will discover objects further away. Objects with redshifts greater than six, may not be discovered, which could indicate that the objects observed were formed sometime after the creation of the universe. Thereby, providing additional evidence to support the Big Bang Theory.

Acknowledgements

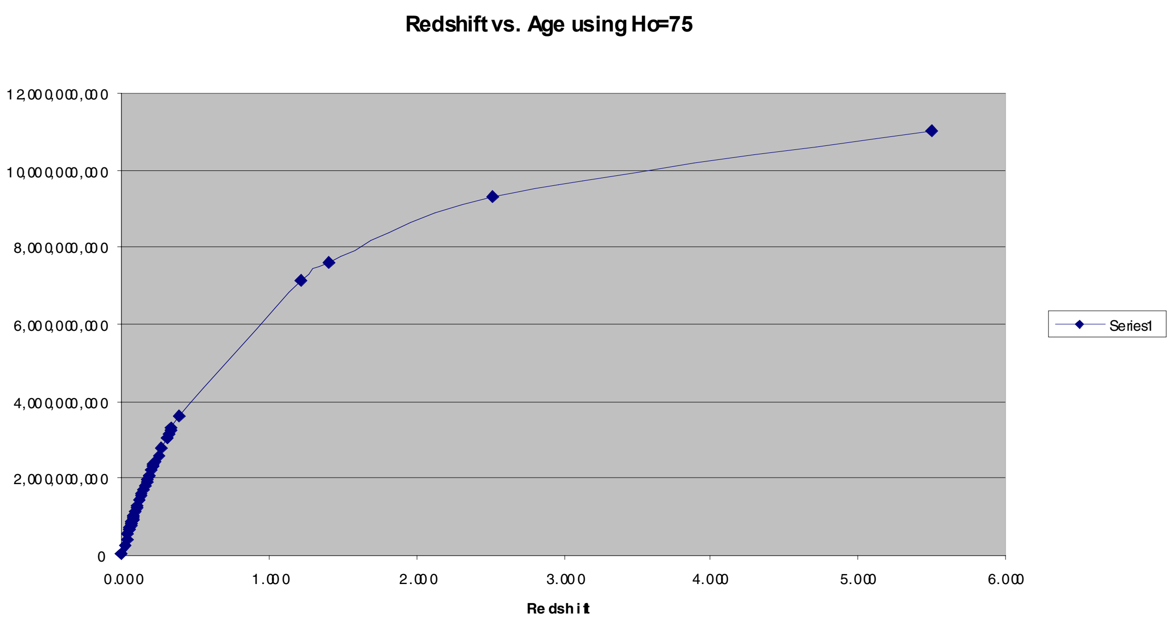
Thank you to our astronomy instructor, Tom Gehringer, and Dr. Travis A. Rector of the National Optical Astronomy Observatories, Tucson, AZ.

References

Baade, Walter. Evolution of Stars and Galaxies. Harvard University Press: Cambridge, Massachusetts, 1963.
Berry, Adrian. The Iron Sun: Crossing the Universe Through Black Holes. E.P. Dutton: New York, New York, 1977.
Bondi, Hermann. Cosmology Now. Taplinger Publishing Company: New York, New York, 1973.
Rector, Travis. AGN Spectroscopy: Studying Natures Most Powerful "Monsters." RBSE Journal: Tucson, Arizona, 1999.
Sullivan, Walter. Black Holes: The Edge of Space. The End of Time. Anchor Press/ Doubleday: Garden City, New York, 1979.

Data Derived from Calcium Break (cont.)

Object	Calcium Break Observed Wavelength	Calcium Break Rest Wavelength	Redshift	Velocity in km/s	Distance in Mpc	Proper Distance in Lightyears	Angular-size Distance in Lightyears	Look-back Time in Years
ffs1036c	4498	3968	0.134	37,422	503	1,639,411,677	1,446,207,407	1,532,046,864
ffs0728	4526	3968	0.141	39,273	528	1,721,873,015	1,509,453,897	1,603,746,907
ffs1052	595	3968	0.150	41,658	561	1,828,434,783	1,589,943,289	1,695,652,174
ffs1707	635	3968	0.16	44,202	596	1,942,510,345	1,674,577,883	1,793,103,448
ffs0742a	4657	3968	0.174	47,614	643	2,096,189,385	1,786,136,291	1,922,865,487
ffs0218a	4671	3968	0.177	48,498	655	2,136,128,394	1,814,673,290	1,956,303,924
ffs1450	4709	3968	0.187	50,862	688	2,243,265,368	1,890,309,197	2,045,424,621
ffs1718	4711	3968	0.187	50,998	690	2,249,445,953	1,894,632,154	2,050,540,214
ffs2148	4789	3968	0.207	55,750	757	2,466,221,113	2,043,510,979	2,228,199,131
ffs0202	4829	3968	0.217	58,167	791	2,577,249,537	2,117,731,655	2,317,871,195
ffs0020	4829	3968	0.217	58,191	791	2,578,350,535	2,118,460,870	2,318,755,953
ffs0738a	4847	3968	0.222	59,241	806	2,626,721,956	2,150,367,799	2,357,540,747
ffs0040	4892	3968	0.233	61,900	843	2,749,762,450	2,230,387,858	2,455,437,449
ffs0731	4963	3968	0.251	66,021	902	2,941,813,016	2,352,075,208	2,606,077,092
ffs1615	5051	3968	0.273	71,018	975	3,177,233,166	2,496,042,527	2,787,166,644
ffs2341	1210	3968	0.305	78,026	1,077	3,512,431,418	2,691,518,328	3,038,314,176
ffs0859	5197	3968	0.310	79,053	1,093	3,562,072,157	2,719,547,134	3,074,846,555
ffs0737	5235	3968	0.319	81,056	1,122	3,659,349,387	2,773,801,935	3,145,946,359
ffs1152	5295	3968	0.334	84,226	1,170	3,814,455,518	2,858,500,377	3,257,979,226
ffs1724	5314	3968	0.339	85,226	1,185	3,863,656,828	2,884,910,296	3,293,176,772
ffs1410	5501	3968	0.386	94,647	1,330	4,335,413,369	3,127,348,794	3,622,454,916
ffs0301	4861	3968	1.225	199,170	3,551	11,576,662,921	5,202,994,571	7,157,303,371
ffs1054	5563	3968	1.402	211,369	3,971	12,946,635,337	5,389,939,774	7,587,843,464
ffs1723	13987	3968	2.525	255,309	6,483	21,133,354,610	5,995,277,904	9,312,056,738
RDJ030117	7900	1213	5.500	286,127	12,692	41,376,923,077	6,365,680,473	11,000,000,000



Active Galactic Nuclei

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Abstract

The purpose of this project is to analyze and classify Active Galactic Nuclei spectra. Using the Graphical analysis software the spectra of 15 Active Galactic Nuclei were examined. They were checked for calcium break (CAII) emission wavelengths, absorption wavelengths, redshift, and the ratio of elements. Analysis of the data obtained was guided by a flowchart (see figure 3) that identified the characteristics of each AGN. Classification of each AGN spectrum was made according to the characteristics displayed. Results were as follows: 0 Radio AGNs, 5 Starburst galaxies, 3 BL Lacs objects, 1 Elliptical galaxy and 6 Quasar AGNs. This was not compatible with the hypothesis, which was that more BL Lacs would be identified.

Purpose

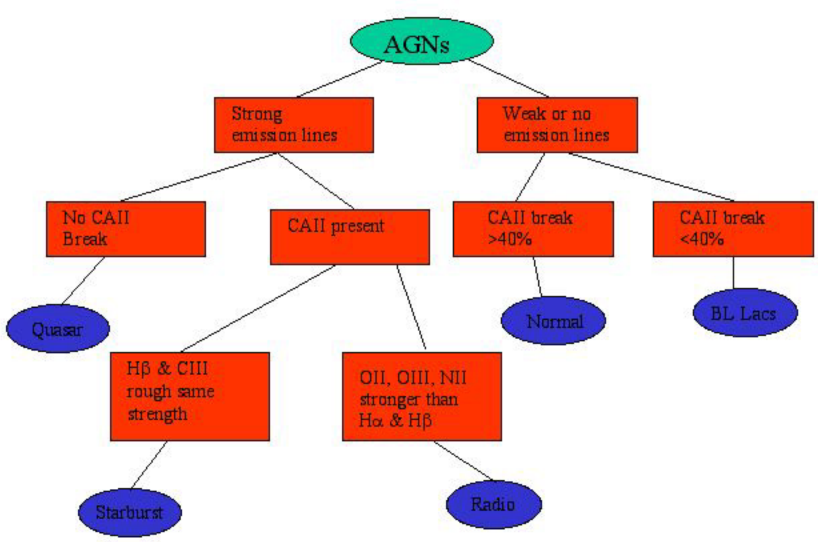
The purpose of this project is to analyze the spectra of Active Galactic Nuclei objects and classify them according to the characteristics displayed on the spectra.

Procedure

Using the Graphical analysis software the spectra of 15 Active Galactic Nuclei objects were classified. They were checked for calcium break (CAII) emission wavelengths, absorption wavelengths, redshift, and the ratio of elements. The ratio of elements is found when the two strongest emission lines are divided. The ratios are compared to the table of non-red shifted emission lines. If the ratio is compatible then the number, minus one, is the red shift.

The calcium break is a characteristic in some AGN spectra. That is, not all AGNs have a calcium break. Locating the calcium break is fairly simple--look at the spectrum and find the place where it drops off. However, to measure it is a little more perplexing. After locating the calcium break, measure the average wavelength between 200 (a) angstroms on both sides and the CAII (calcium break) and subtract the right wavelength from the left wavelength and divide by the right wavelength.

Analysis of the data obtained was guided by a flowchart that identified the characteristics of each AGN. Each AGN spectrum was then classified according to the characteristics displayed.

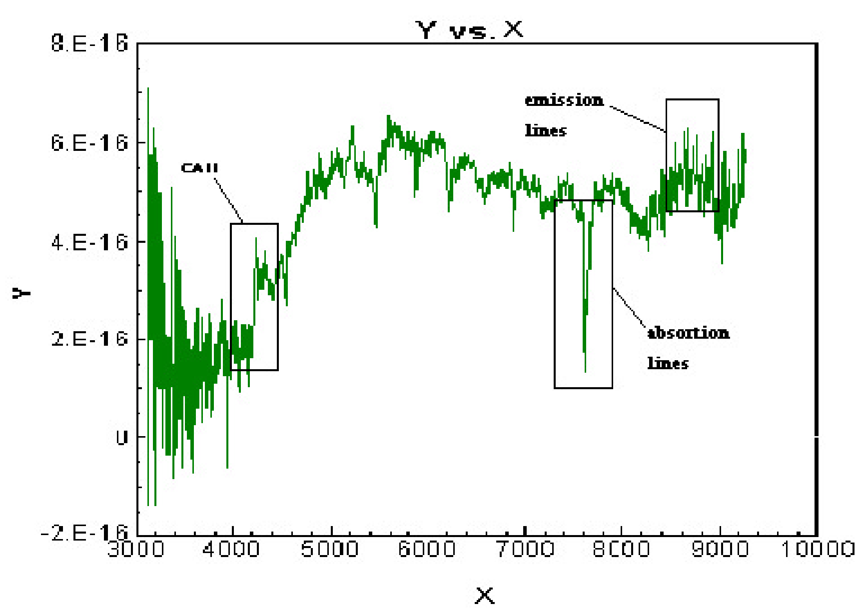


Data Number	Classified as	Redshift (aprox.)
Ffs.0020.data	Starburst	0.0087962
Ffs.0040.data	Quasar	0.0889721
Ffs.0202.data	Starburst	0.0325995
Ffs.0218a.data	Starburst	0.0093391
Ffs.0218b.data	Quasar	0.0257146
Ffs.0254.data	Starburst	0.015201
Ffs.0301.data	Quasar	0.0121742
Ffs.0701.data	Elliptical	0.0159275
Ffs.715.data	Starburst	0.0116434
Ffs.1036a.data	Quasar	0.0039349
Ffs.0722.data	Quasar	0.0399927
Ffs.0728.data	Quasar	0.0440229
Rgb.0112.data	Bl Lac	Not Available
Ffs.148.data	Starburst	0.0136575
Rgb.2243.data	Bl Lac	Not Available

Conclusions

After conducting this project my results were as follows: 0 Radio AGNs, 5 Starburst galaxies, 3 BL Lacs objects, 1 Elliptical galaxy and 6 Quasar AGNs. This was not compatible with the hypothesis, which was that more BL Lacs would be identified. However further study would be necessary to make an assumption about Bl Lacs being rare objects.

Figure 2



A Correlation Between Calcium Breaks and Velocities, Redshifts, and Distances in AGN

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Abstract

This research was done in order to compare the redshifts, calcium breaks, velocity and distance of three different types of galaxies. The first type analyzed was starburst galaxies, and measurements of emission lines and calcium breaks were taken of two spectrum. The second type was radio galaxies, and measurements were taken of emission lines, absorption lines and calcium breaks of eight galaxies. The third type was elliptical galaxies, and measurements were taken of absorption lines and calcium breaks of seven galaxies. From the collected data redshifts, velocities and distances were determined and compared.

Introduction

This project was originally designed in order to compare only the calcium breaks of these three galaxies. However, as not many graphs were available, it became important to collect data on more than just the calcium breaks in order to find some sort of correlation between these three galaxies.

Problem

To determine relationships between three galaxies; starbursts, radios, and ellipticals, through their calcium breaks, velocities, and distances.

Hypothesis

The calcium breaks of these three types of objects will have some association with either the redshifts, velocities, or distances of these three objects.

Methodology

Fist spectrum were collected that appeared to be those of starburst galaxies, radio galaxies or elliptical galaxies. The starbursts were recognized by their calcium breaks, strong emission lines, and weak of absorption lines. Radio galaxies were recognized by their calcium breaks, strong emission and absorption lines. Elliptical galaxies were recognized by their calcium breaks, their strong absorption lines and lack of emission lines. These spectra were sorted and labeled accordingly. Second, measurements were taken of these spectra. The wavelength of the calcium break was observed as well as its percentage determined.

The wavelengths of the emission and absorption lines were also noted as well as their height and width. Their heights were determined by taking their point farthest from the flux and subtracting the flux from it, giving the emission lines positive heights and the absorption lines negative. Their widths were determined by finding the midway point between the base and "top" of the emission or absorption line on either side and determining the wavelength difference of the two. Thirdly this data was the organized and the velocities and distances were computed. Fourth, the results from these computation were compared and contrasted.

Data Analysis

The data collected shows that the redshifts, velocities, distances, and calcium breaks of the radio galaxies appear to be smaller than those of the starburst or elliptical. At the same time the redshifts, velocities, distances and calcium breaks of the elliptical galaxies appear to be larger. Velocity is measured in km/sec and distance in Megaparces.

There are several anomalies in this data, including redshifts of zero where the redshift calculated was negative, and a graph where the measurements for the calcium break were missing. Negative redshifts, due to miscalculation

redshifts:	velocities:	distances:
0.00000	**0**	**0**
0.00000	**0**	**0**
0.04545	**21413**	**286**
0.07412	*98901*	*1397*
2.58072	**256590**	*1473*
0.40841	*103661*	*1489*
0.43385	*104670*	*1537*
0.43935	*107589*	*1702*
0.45545	*117484*	*1869*
0.51241	*126985*	2132
0.57096	141131	*3479*
0.66634	*196890*	*4403*
1.19523	*222059*	4486
1.58807	22391	**5135**
1.91111	**236672**	**5251**
1.96279	**238639**	**6055**
2.32795	**250312**	**6603**

wavelength	%
4184	**41.29%**
4207	**49.06%**
4224	*46.13%*
4241	**47.08%**
4277	*49.38%*
4288	*44.97%*
4293	*43.66%*
4298	**47.67%**
4346	23.43%
4360	40.40%
4455	**43.75%**
4498	*36.94%*
4672	*54.82%*
4745	*39.88%*
4824	**57.12%**
4963	**15.86%**

The data is coded for recognition of the different galaxies. White text for starburts, *italic for radio* and **bold for elliptical**. The redshifts, velocities and distances were sorted numerically while the calcium break percentages were sorted by their wavelength

of the elements, were ignored as no other element locations were made available to complete this research. However the overall observation is that the radio and elliptical galaxies occupy the extremes in both cases with the starbursts sandwiched in the middle.

Conclusions

This data leads in the direction of a correlation between an AGN's calcium break and its velocities, redshifts, and distances. From the above data collected it appears that while the elliptical galaxies have the fastest velocities and furthest distances, their calcium breaks also occur at the highest wavelengths. And, while radio galaxies have the slowest velocities and closest distances, their calcium breaks occur at the lowest wavelengths. This means that the distance of the object observed or the velocity of the object observed could have some affect upon the calcium break, or vice versa.

Projections

With a larger sample size of data the numerical relationship between these velocity or distance and the calcium break could be determined. Data on the resting wavelengths of the Calcium breaks may also provide more information on this topic as none was available to do this research. It may also be determined, through further research with more spectra that there is in fact no correlation.

Observing AGNs

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Abstract

Different Active Galactic Nuclei (AGN) were observed to find relationships within their characteristics. The spectra of different types of galaxies were studied and carefully classified into five categories: Elliptical, Spiral, Starburst, Radio, Quasars, and BL Lac galaxies. For all of the AGN categories except for quasars and BL Lacs, this was determined by observing the calcium breaks, emission lines, and shape of the spectra, while distance and ratio of elements were ascertained according to formulas. To determine the characteristics of the quasars, the emission lines were studied and the redshifts determined. Most of the AGNs observed were quasars. When comparing the percentage in the calcium break to the z value (which indicates the distance of the galaxy), it was determined that there is no apparent pattern. In the hypothesis it was stated that the stronger the calcium II break, the closer the galaxy is to Earth; and the stronger the redshift, the stronger the luminosity. Our data shows there is no relationship between the z value and calcium II break, but there was a direct relationship between redshift and luminosity. The quasars with higher redshifts had higher luminosities (see graph attached).

Purpose

The purpose is to study and learn more about Active Galactic Nuclei (AGN's) and to become experienced in determining different types of galaxies by looking at their emission lines, and Calcium II breaks.

Procedure

Using Graphical Analysis, emission lines were searched for in the spectrum. The emission lines helped to determine a redshift for the object. Then the wavelength and width of the emission lines at FWHM were determined. Following that, if there were no strong emission lines, absorption lines in the spectrum were searched for to find a redshift(s). Next the Ca II absorption line doublet was found to determine a minimum redshift. From there the Ca II break strength was found. Based on the Ca II break, the red shift, and emission lines the group determined if the galaxy was a quasar, elliptical, starburst, radio, or BL Lac AGN. If the galaxy did not have a Ca II break, then it was classified as a quasar. For all the quasars the red shifts, integrals or flux, velocity, distance, and luminosity were determined. For the BL Lacs, radio, normal, and starburst AGNs the Ca II break and z value, which is the distance, were ascertained. The Hydrogen alpha / nitrogen II ratio as well as the Hydrogen beta / Oxygen III ratio were also found. By determining those ratios, the objects were more accurately classified.

Control and Error Analysis

The values for the different characteristics were not easily determined. For example, the full width, half-max measurements were done by eye. No measuring instruments were used, and the FWHM was also visually ascertained. Emission lines were also deceptive. Some AGN's had emission lines larger than others did, and the smaller emission lines were hard to classify while looking for red and blue shifts. There also could of have been sensor noise in the pictures of the emission lines.

Data and Analysis

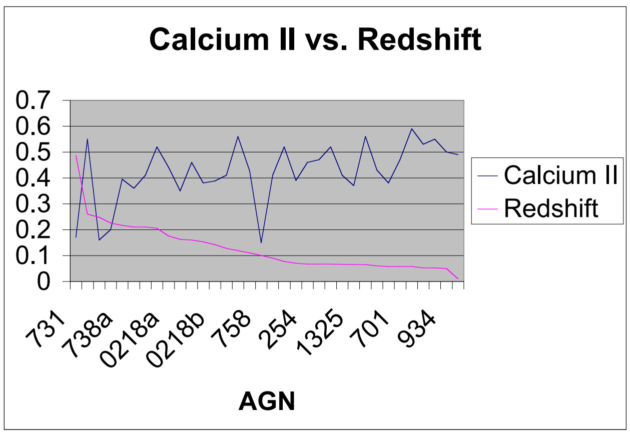
The class of galaxies that includes quasars generate enormous amounts of energy in a relatively tiny Active Galactic Nucleus, often no larger than Earth's own solar system. Quasars show redshifts of 15% to almost 95% of the speed of light (meaning they appear to be moving away from Earth at those speeds), and can be up to 100 times more luminous than normal galaxies. They are located, as are all AGN's, within galaxies, but they are so bright that the galaxy can be impossible to detect. Most scientists now believe that AGN's derive their energy from matter falling into and forming a hot "accretion disk" around an extremely massive black hole. Perpendicular to the disk are jets of hot and energetic matter shooting outwards, giving observers on Earth the impression of a lighthouse, where every few weeks the jet is noticeable and the rest of the time it is aimed in a different direction. Types

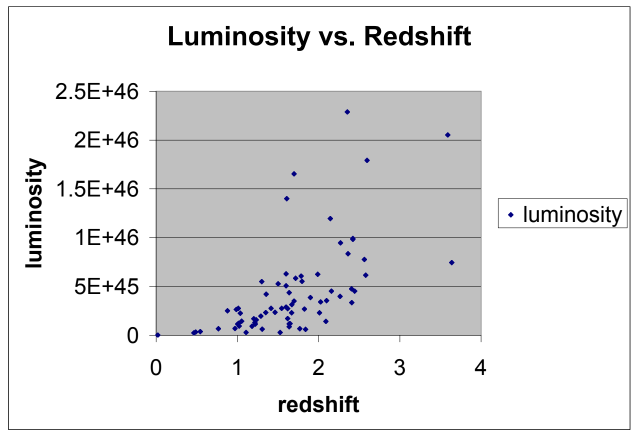
Quasar Data

AGN	1+z	1+z	red shift	red shift	integral	v (km /s)	d (Mpc)	d (ly)	cm	luminosity
1047	1.020722	1.005700	0.020722	0.005700	5.62E-13	1705.12658	82.654028	269452132	2.54923E+26	4.64196E+41
1537	1.465004	1.466768	0.465004	0.466768	4.04E-13	109608.977	1564.059	5098832423	4.8239E+27	2.54162E+44
1157	1.488700	1.488563	0.488700	0.488563	5.13E-13	113422.427	1634.0063	5326860507	5.03964E+27	3.62794E+44
1534b	1.545193	1.542870	0.545193	0.542870	4.84E-13	122508.724	1797.1118	5858584340	5.54269E+27	4.4479E+44
1533	1.766655	1.764010	0.766655	0.764010	4.22E-13	154076.067	2402.5277	7832240157	7.40993E+27	9.06049E+44
1606	1.880486	1.886530	0.880486	0.886530	1.16E-12	168392.06	2694.4172	8783800040	8.31018E+27	3.58274E+45
1448	1.971962	1.966550	0.971962	0.966550	2.62E-13	176728.859	2932.4189	9559685531	9.04423E+27	1.04151E+45
957	1.988206	2.042693	0.988206	1.042693	8.76E-13	184004.012	2943.964	9597322534	9.07983E+27	3.78683E+45
1106	2.005004	1.993714	1.005004	0.993714	4.13E-13	179394.451	3018.1794	9839264890	9.30873E+27	1.78758E+45
1223	2.012866	2.007596	1.012866	1.007596	9.77E-13	180726.141	3034.7669	9893340059	9.35989E+27	4.33509E+45
1036a	2.014296	2.037192	1.014296	1.037192	4.05E-13	183498.59	3024.3702	9859446723	9.32783E+27	1.83776E+45
1006	2.023946	2.020168	1.023946	1.020168	3.20E-13	181914.804	3061.6148	9980864339	9.4427E+27	1.46328E+45
1630	2.036145	1.995711	1.036145	0.995711	8.24E-13	179587.304	3110.6604	10140752926	9.59396E+27	3.79602E+45
1001	2.052716	2.011001	1.052716	1.011001	5.03E-13	181049.691	3152.3901	10276791844	9.72267E+27	2.41642E+45
1112	2.107756	2.103981	1.107756	1.103981	8.36E-14	189436.315	3268.5201	10655375460	1.00808E+28	4.72599E+44
1039	2.182273	2.180723	1.182273	1.180723	2.35E-13	195752.837	3448.8407	11243220769	1.0637E+28	1.58897E+45
1408	2.204610	3.154789	1.204610	2.154789	1.31E-13	245218.96	3172.89	10343621450	9.78589E+27	1.569E+45
1349	2.217156	2.227698	1.217156	1.227698	3.10E-13	199373.431	3527.0584	11498210271	1.08782E+28	2.28771E+45
1430	2.221687	2.217977	1.221687	1.217977	2.75E-13	198638.761	3544.996	11556686921	1.09336E+28	2.03226E+45
1546	2.234233	2.244478	1.234233	1.244478	3.65E-13	200624.12	3568.2598	11632527070	1.10053E+28	2.79858E+45
1534c	2.290623	2.299214	1.290623	1.299214	4.13E-13	204555.62	3703.9117	12074752157	1.14237E+28	3.58039E+45
1131	2.302001	2.217129	1.302001	1.217129	1.33E-12	198574.339	3778.4958	12317896374	1.16537E+28	1.11576E+46
1143	2.307898	2.248298	1.307898	1.248298	1.42E-13	200905.751	3779.2538	12320367292	1.16561E+28	1.22549E+45
1334a	2.356326	2.349136	1.356326	1.349136	8.25E-13	207953.414	3867.3966	12607712795	1.19279E+28	8.13969E+45
1054	2.415654	2.399948	1.415654	1.399948	5.03E-13	211239.302	4011.0455	13076008413	1.2371E+28	5.57169E+45
1501	2.463622	2.464117	1.463622	1.464117	3.90E-13	215156.863	4115.1914	13415524065	1.26922E+28	4.79367E+45
1257	2.502144	2.450936	1.502144	1.450936	8.97E-13	214372.415	4230.0608	13789998065	1.30464E+28	1.15252E+46
1119	2.528549	2.538412	1.528549	1.538412	3.99E-14	219393.136	4261.4328	13892271038	1.31432E+28	5.58096E+44
1614b	2.546482	2.545102	1.546482	1.545102	4.14E-13	219759.76	4308.2241	14044810669	1.32875E+28	5.94987E+45
1306	2.601624	2.596191	1.601624	1.596191	8.85E-13	222482.705	4437.0737	14464860131	1.36849E+28	1.40382E+46
1254	2.671818	2.642673	1.671818	1.642673	4.16E-13	224847.054	4608.8831	15024958777	1.42148E+28	7.37687E+45
1335	2.718528	2.711053	1.718528	1.711053	7.16E-13	228142.059	4704.85	15337811005	1.45108E+28	1.39245E+46
1545	2.769496	2.776218	1.769496	1.776218	7.42E-14	231092.982	4813.7462	15692812549	1.48467E+28	1.58408E+45
1210	2.785490	2.806327	1.785490	1.806327	6.70E-13	232397.941	4843.4542	15789660797	1.49383E+28	1.47966E+46
1152	2.797276	2.820207	1.797276	1.820207	6.00E-13	232987.588	4869.1226	15873339751	1.50174E+28	1.35243E+46
1359	2.828276	2.825170	1.828276	1.825170	2.90E-13	233196.661	4950.8295	16139704248	1.52695E+28	6.78178E+45
1036b	2.989671	3.027205	1.989671	2.027205	5.51E-13	240967.959	5293.868	17258009665	1.63275E+28	1.69154E+46
1005	3.012912	3.037098	2.012912	2.037098	2.00E-13	241314.352	5351.3724	17445473897	1.65048E+28	6.30244E+45
1620	3.144578	3.167548	2.144578	2.167548	9.29E-13	245619.476	5643.2502	18396995548	1.7405E+28	3.54831E+46
1351	3.159852	3.146449	2.159852	2.146449	3.57E-13	244954.852	5692.5851	18557827363	1.75572E+28	1.36908E+46
1318	3.265332	3.277824	2.265332	2.277824	2.81E-13	248910.636	5912.8824	19275996606	1.82366E+28	1.26176E+46
1616	3.269580	3.257715	2.269580	2.257715	6.80E-13	248332.45	5932.516	19340002109	1.82972E+28	3.03608E+46
1619	3.355153	2.714825	2.355153	1.714825	2.80E-12	228317.743	6445.3362	21011795856	1.98788E+28	1.02479E+47
1628	3.363561	3.297538	2.363561	2.297538	5.80E-13	249468.394	6160.6538	20083731427	1.90008E+28	2.86129E+46
1011	3.406068	3.420445	2.406068	2.420445	2.98E-13	252753.842	6219.0113	20273976817	1.91808E+28	1.61185E+46
1238	3.409296	3.416323	2.409296	2.416323	2.11E-13	252648.765	6229.0542	20306716826	1.92118E+28	1.14221E+46
1019	3.423176	3.437758	2.423176	2.437758	6.09E-13	253191.474	6256.0948	20394869137	1.92952E+28	3.36725E+46
1030	3.423822	3.467436	2.423822	2.467436	6.01E-13	253928.067	6245.6921	20360956183	1.92631E+28	3.3694E+46
1627	3.444158	3.407791	2.444158	2.407791	2.87E-13	252430.189	6322.7676	20612222494	1.95008E+28	1.59273E+46
1406	3.566282	3.557392	2.566282	2.557392	4.40E-13	256060.17	6575.3523	21435648628	2.02798E+28	2.87776E+46
1144	3.580671	3.629019	2.580671	2.629019	3.30E-13	257656.36	6583.5824	21462478684	2.03052E+28	2.25174E+46
1535	3.597073	3.552195	2.597073	2.552195	1.02E-12	255940.955	6656.3826	21699807182	2.05298E+28	6.81665E+46
1450	4.592498	4.497407	3.592498	3.497407	6.46E-13	271733.673	8782.5822	28631217928	2.70874E+28	1.20476E+47
1410	4.641426	4.623939	3.641426	3.623939	2.19E-13	273191.324	8857.8845	28876703368	2.73197E+28	4.39166E+46
811	3.350000	2.350000	1.350000	1.350000	4.56E-13	208010.732	3848.9362	12547531915	1.1871E+28	4.45457E+45
722	3.600000	2.600000	1.600000	1.600000	4.04E-13	222680.412	4430.7692	14444307692	1.36655E+28	6.41053E+45

of AGN's that are not as luminous as quasars but are more luminous than average normal galaxies are radio, BL Lac, elliptical, starburst and radio.

0742b	3.600000	2.600000	1.600000	1.600000	7.09E-13	222680.412	4430.7692	14444307692	1.36655E+28	1.12395E+46
800	3.610000	2.610000	1.610000	1.610000	1.94E-12	223196.068	4453.7165	14519115709	1.37362E+28	3.13349E+46
847	3.620000	2.620000	1.620000	1.620000	2.34E-13	223706.831	4476.6412	14593850382	1.38069E+28	3.84461E+45
859	3.620000	2.620000	1.620000	1.620000	3.74E-13	223706.831	4476.6412	14593850382	1.38069E+28	6.14512E+45
732	3.640000	2.640000	1.640000	1.640000	1.54E-13	224713.913	4522.4242	14743103030	1.39482E+28	2.62745E+45
740	3.640000	2.640000	1.640000	1.640000	1.15E-13	224713.913	4522.4242	14743103030	1.39482E+28	1.96463E+45
816	3.640000	2.640000	1.640000	1.640000	5.83E-13	224713.913	4522.4242	14743103030	1.39482E+28	9.93219E+45
733	3.650000	2.650000	1.650000	1.650000	1.56E-13	225210.346	4545.283	14817622642	1.40187E+28	2.70371E+45
738b	3.670000	2.670000	1.670000	1.670000	2.94E-13	226189.275	4590.9363	14966452434	1.41595E+28	5.28227E+45
747	3.700000	2.700000	1.700000	1.700000	4.35E-13	227623.643	4659.2593	15189185185	1.43702E+28	8.23286E+45
754	3.700000	2.700000	1.700000	1.700000	2.06E-12	227623.643	4659.2593	15189185185	1.43702E+28	3.89509E+46
301	3.840000	2.840000	1.840000	1.840000	6.22E-14	233815.743	4975.7746	16221025352	1.53464E+28	1.48497E+45
928	3.900000	2.900000	1.900000	1.900000	3.86E-13	236238.045	5110.3448	16659724138	1.57614E+28	1.01236E+46
737	4.026000	3.026000	2.026000	2.026000	3.01E-13	240925.555	5391.0615	17574860383	1.66272E+28	9.56896E+45
905	4.090000	3.090000	2.090000	2.090000	1.18E-13	243117.718	5532.7508	18036767638	1.70642E+28	4.10523E+45
955	4.100000	3.100000	2.100000	2.100000	2.92E-13	243449.576	5554.8387	18108774194	1.71323E+28	1.03644E+46





The calcium break is actually caused by a cloud of gas between the AGN and earth. The z values for the calcium breaks we observed are almost always the same as those for the AGNs themselves, meaning the dust clouds are very close to the AGNs. There is no apparent relationship between Calcium II break and z value. The Calcium II break, once again, is caused by an intervening gas and dust cloud between the AGN and the observer, and is not part of the AGN itself. The fact that the z value for the AGNs are the same as those for the objects themselves indicates that the gas clouds are very close to the Active Galactic Nuclei. The lack of a relationship between the two variables demonstrates that as objects are progressively farther away there is no substantial change in the level of absorption of Calcium II by stars from the same galaxy.

There appears to be a direct relationship between luminosity and distance with the quasars, and this relationship is likely due to the fact that more distant AGNs are older. Quasars are extremely distant, and are also the oldest objects that have been observed. As stellar and galactic objects age, they burn energy, and it would make sense, then, that younger AGNs are more luminous. The more distant quasars are likely younger, and therefore more energetic. The presence of a greater amount of energy to burn would likely increase luminosity. This is probably what accounts for the relationship between luminosity and z value. The further away the AGN, the brighter it must be for it to be detected.

References

"Investigating and Categorizing AGN Objects" Beaudry, McClain, McCusker, Robinson
RBSE Journal 2000, AGN Spectoscopy.

The Identifying, and Determing the Redshift of, the Objects in the FFS Sample

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Abstract

In my project I shall be examining some samples in the FIRST data on the RBSE disk. I chose ten of them to sample. The research I used gave me the Redshift, distance, and the velocity of each galaxy. At this point I made rough estimates as to what each of the objects were. The three classes found were Radio Galaxies, Bl Lac objects, and Quasars. The Farthest type of galaxy is the Quasars, then the Bl Lac objects, then the Radio Galaxies.

Hypothesis

It seems that the hardest data to collect is about the Bl Lac objects. Primary suggestion says that the farthest away would be the Bl Lac objects. For the reason that the further away, the more chance of atmospheric interruption. It is also commonly known that the greater the redshift, the greater the distance.

Conclusions

In the end, I found that Quasars had the largest amount of distance from earth on average. I had thought originally that the Bl Lac objects would have the largest amount of distance because it was so difficult to find the Redshift for them. In reality though, the Bl Lac objects were on average about halfway closer than the Quasar galaxies. The closest were the Radio galaxies, which were relatively close compared to the Bl Lac objects and the Quasars. In the end the results were as I expected other then the distance of the Bl lac objects and the Quasars.

Location and Distance of Active Galactic Nuclei

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Abstract

The goal of this project was to find out the location and distance of various AGN. We were trying to see if AGN appear in the same concentrated location and distance or if they were scattered randomly. To test this problem, we used Vernier Software's Graphic Analysis program to analyze various types of spectra. We determined these spectra to be, either AGN, Normal Galaxies, Stars, or something unknown. We looked at over a hundred spectra and came up with exactly 66 galaxies to be AGN in some form. There were six other spectra that we found to be AGN. These were found from another astronomer's research, so we included them in our chart. We found that AGN seemed to be located more towards the Northern Central Hemisphere of the Galactic Sphere, with very few AGN scattered at random around the outside of the "cluster". We believe that this is because of some gravitational pull in the AGN, pulling themselves closer to each other. That is one theory. Another is just that from where our planet is located, we see them as being in a cluster, when they could possibly be scattered about the universe at random. So, we tried to figure out if they were scattered about the universe by distance formulas involving red shift. We found that they are scattered about the universe, and we don't know why. To further investigate this problem, one could look at every Galaxy found in the universe, and continue to find new AGN that could be added to this chart. This would further prove, or disprove our problem. With the fact that our project hits at a fairly new field in astronomy, this could be useful to astronomers in trying to solve the mystery of AGN and maybe of the universe.

Problem

This project is on Active Galactic Nuclei (AGN). The goal of this project is to find the location in the sky of these AGN. In addition we will be calculating the approximate distance of the AGN after we locate them in the sky. We will also be observing other pictures and data found by astronomers. To test these, we will compare the data we find with other data by computer research.

One way this project could turn out is that we could absolutely nothing. Anther way is that we could find something really important to other astronomers. Lastly, we could find something really significant to the world. It will be hard to find data for the entire sky. This could mean that there might be AGN in some areas we will not observe. Therefore, we will not know for certain if all AGN are located in the areas we will tell of.

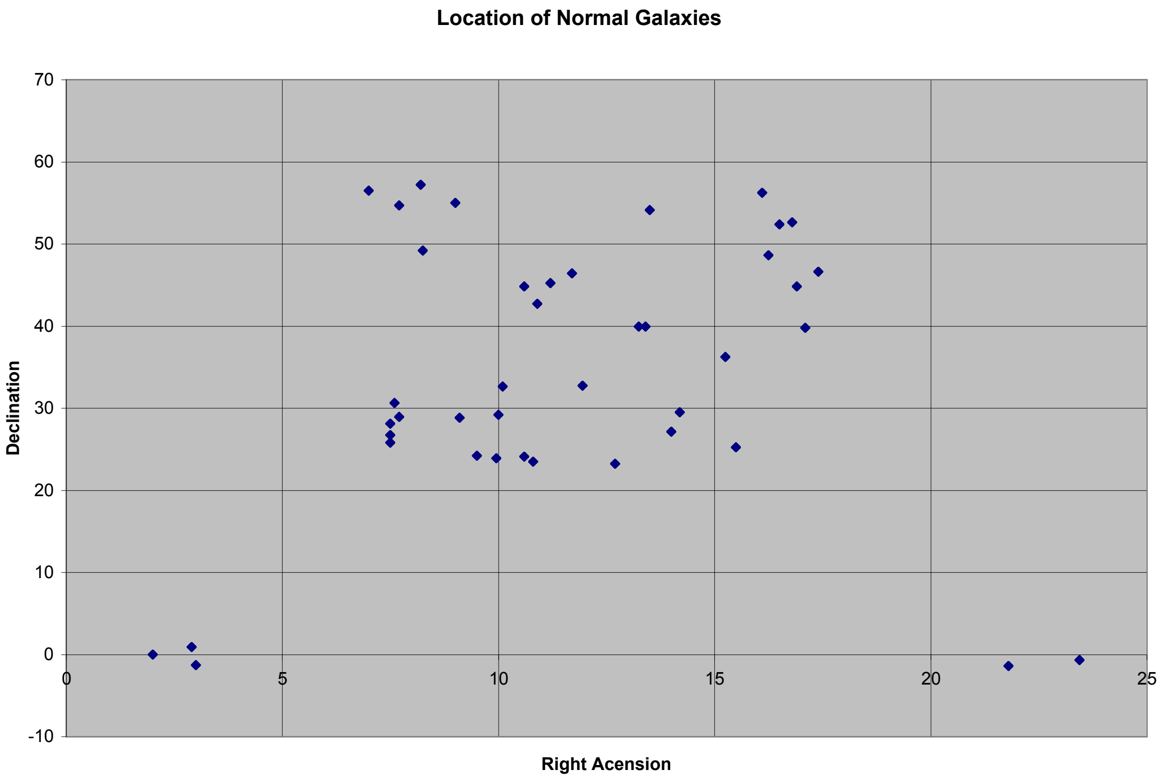
Procedure

We used Veneir Software's Graphic Analysis, to analyze spectra of several galaxies in space. We analyzed over one hundred of them to determine if they were AGN or not. We observed for signs in the spectra that prove them to be AGN, or AGN elements. The signs that were observed were tings such as, calcium breaks or the form the spectrum lines are, if they are emission or absorption. Venier Software only contains these spectra images and displays of them. We have to observe them for any kind of clue that it may be an. Possible AGN.

After we have determined if they were AGNs or not, we used their coordinates to determine where they are in the sky. Afterwards we used a formula to calculate the red shifts to find their distances. The formula is obs/rest -1. This means the observed point of the gas's line, divided by its normal resting point, minus one. With that, we could use the distance formula to calculate its distance from earth. This gives us a distance in megaparsecs of the AGN.

Data

We specifically observed the spectrum lines to determine if the spectrum was an Active Galactic Nuclei. This is relevant to how the results turned out because after we identified that it was an AGN, then we could plot the location of it. Each time we performed the tests, each spectrum reading was different. Therefore, we had to



determine if it was, in fact, and Active Galactic Nuclei.

Analysis

There seems to be no difference in location, other than specific coordinates of the AGN, but they all seem to be located together in a largely concentrated area in the night sky. This could be explained by, possibly, gravity. The gravity of the AGN could be trying to hold each other near each other. The other possibility is that the AGN are really scattered in the universe, and, in our night sky, they seem to be clustered. We could have made some mistakes I our project. For instance, we could have over looked some AGN and not had them included. If that is the case, then we could have found them all even more concentrated. Another possibility is that we could have misjudged a Normal Galaxy or Star to be an AGN. With that as a case, then we could have had too many AGN in our findings, and the AGN could really be spread out at random. We are sure, however, that any error was slight, and could not have affected the findings too much. We are sure and not sure that it will always turn out this way with further research. We are sure that the AGN will be clustered where we found them. They could be found all around the Northern Hemisphere of the Galactic Sphere.

Bibliography

AGN Spectroscopy. Travis A. Rector and Brenda A. Wolpa. 2000. National Optical Astronomy Observatories 950 N. Cherry Ave. Tucson, AZ 85719 USA

Astronomy. Michael A. Seeds. 1999. Wadsworth Publishing Co.

Graphic Analysis. Mark Topinka and Chris Chamberland. 1995. Vernier Software

http://astro.sci.mni.cz/lehky/agn.html

http://www.astronomy.ohio-state.edu/~agnwatch/

http://www.eso.org/projects/vlti/science/node10.html

Blue-Side Suppression of Ly α Continuum in Quasars

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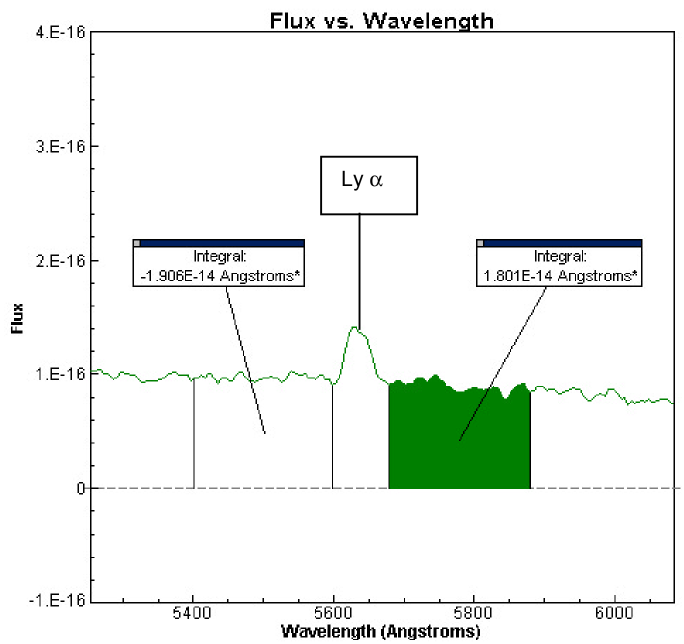
Abstract

It has been reported that UV emissions by quasars are absorbed by intervening intergalactic neutral atomic hydrogen resulting in the suppression of the continuum blue-side of the Ly a line. Examples of quasars in the redshift range of 2 to 5 have shown an increasing suppression of blue-side continuum. In this investigation, the flux ratio for quasars with a redshift of 2.4 to 3.8 within 200 angstroms of the Ly a was determined. The results showed blue side suppression in only 1 of the 7 quasars measured.

Procedure

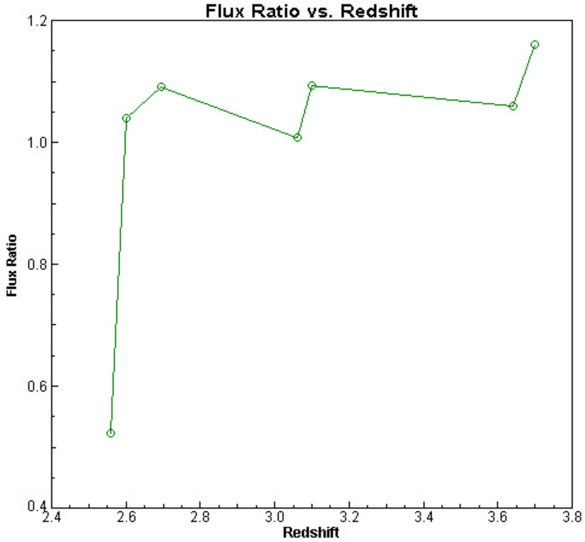
Quasars for this investigation were selected on the basis of all wavelengths being measured falling within the visible spectrum. Flux values within 200 angstroms of Ly a lines were then measured. The ratio of the blue-side to the red-side flux was calculated. From this data and calculations, two graphs were generated: Flux Ratio vs. Redshift and Blue-Side Flux vs. Red-Side Flux.

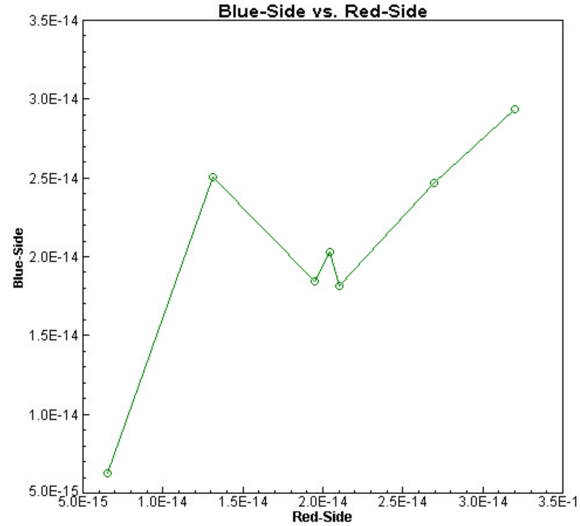


Observations

Shown below is an example of how the fluxes were determined on either side of the Ly α emission line. The integral was carried out by 200 angstroms on each side of the Ly α emission line. The position of the Ly α line was determined using the derived equation: $1213(1+z)=\lambda obs$.

FFS Number	Redshift	Blue-Side	Red-Side	Flux Ratio
1406	2.560	1.311E-14	2.506E-14	0.523
1143	2.600	6.501E-15	6.251E-15	1.040
811	2.695	3.206E-14	2.935E-14	1.092
738b	3.060	2.043E-14	2.029E-14	1.007
1534b	3.100	2.695E-14	2.466E-14	1.093
1036a	3.640	1.952E-14	1.842E-14	1.060
1001	3.700	2.100E-14	1.817E-14	1.160





Conclusions

From the graph on the leftthere appears to be no blue side suppression due to redshift (except for point 1). This may be partly due to little or no intervening H2 gas in the line of sight. Other possible explanations are that measured flux intervals of 200 angstroms were too small. And finally, the spectrographs may not have had the ability to measure appropriate emission spectra or the observer chose inappropriate blue-side values for this study. The graph on the right just reconfirms the researchers' previous observations that there is little blue-side suppression in the wavelengths chosen for this study.

References

Schneider, D, Schmidt, M, and Gunn, J. (2001). Surveys for High Red Shift Quasars.
(http://www.astro.psu.edu/users/dps/surveys.html).

e-mail from Dr. Rector, 3/5/01

e-mail from Dr. Strauss, Princeton University, 3/1/01, 5/14/01

Which Types of AGN Are More Common And How Far Away Are They?

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Abstract

My research project is based on data collected from the FIRST survey ("Faint Images of The Radio Sky at Twenty Centimeters"). It is a radio survey of a portion of the night sky with the Very Large Array (VLA) radio telescope in New Mexico. Assembled by Dr. Sally Laurent - Muehleisen at the Lawrence Livermore National Laboratory. I used the data from the FIRST survey on the RBSE CD - ROM to identify objects that are emitting radio waves. These objects are called AGN (active galactic nuclei), and some examples would be elliptical galaxies, starburst galaxies, quasars, BL Lac objects, radio galaxies, and other types of AGN objects. I use this data to find out which types of AGN is most common and how far away they are. My research is based on twelve different spectra picked at random from the FIRST data on the RBSE CD - ROM, this data was analyzed and calculated to find the distance of the AGN objects from local space, and what types of AGN were more common throughout the visible universe. As expected by my hypothesis quasars are the most common, and the farthest away.

Introduction

The goal of this research project is to find out what AGN is most common in the known universe, and how far away from us they are.

Problem

Identifying the AGN objects from the data provided on the RBSE CD through graphical analysis. Sort through many different emission lines to determine the wavelengths of as many as possible to find the redshift, so that I can tell the different AGN apart from one another to determine the most frequent one. To use the redshift to determine how far away these AGN are from us.

Hypothesis

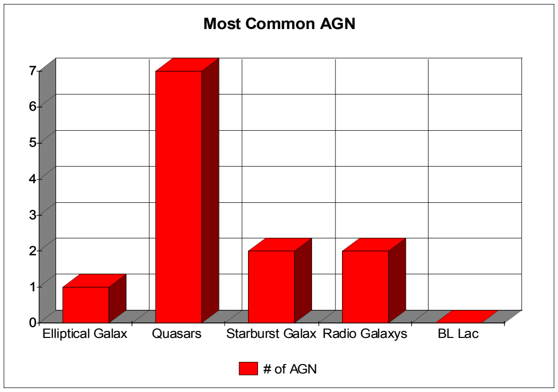
I believe that BL Lac objects will be the most rare in the data collected, because their emission lines are hard to detect in the spectra. I predict that quasars will be the most common because of their extreme luminosity.

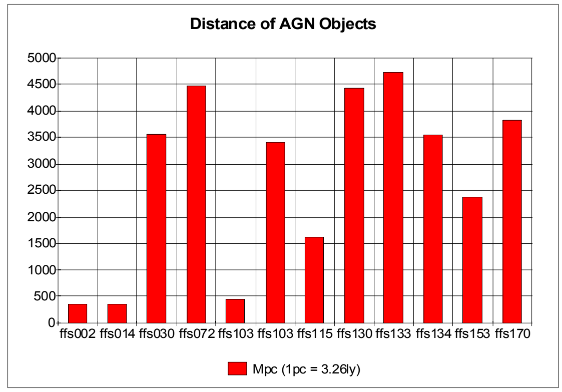
Procedure

Analyze data from the FIRST survey on the RBSE CD - ROM using graphical analysis, I will try to find AGN objects that are more common than others to determine the most common AGN found in the data. Using graphical analysis I will determine the wavelength of the emission lines, with this information I can find the redshift of the AGN object. I randomly picked the data from the FIRST survey on the RBSE CD- ROM, then carefully analyzed the spectra for the most predominant peaks available. After finding the highest peaks I calculated the redshift of the emission lines so that it could be used to determine the distance of the AGN from local space. The next step was to properly identify the spectra with the type of AGN that best fits its description, then make charts and graphs of the findings. Out of the twelve spectra analyzed I compared and listed the most common AGN objects in the universe, and how far away they are. The equation used to find the distance of the AGN object is d(distance) equals c(the speed of light) times z(redshift) over Ho(Hubble's constant) times one plus one half times z(redshift) divided by one plus z(redshift).

Results

My results from the FIRST survey data were as follows; quasars (being the most luminous type of AGN) were the most common found. Radio and starburst galaxies were the second most common type of AGN, and elliptical galaxies (having the lowest emission lines, and being very weak radio sources) were only found once, so as expected the elliptical galaxy found was fairly close to earth. BL Lac objects were not found in any of the spectra that I viewed, all the spectra that I found had much to high emission and absorption lines. My final results for distance of the





Data Table

Spectrum #	type of AGN	Distance	Redshift
ffs0020	Elliptical Galaxy	3.598E2 Mpc	0.094
ffs0148	Radio Galaxy	3.561E2 Mpc	0.093
ffs0301	Quasar	3.563E3 Mpc	1.23
ffs0722	Quasar	4.48E3 Mpc	1.62
ffs1036c	Radio	4.543E2 Mpc	0.12
ffs1039	Quasar	3.418E3 Mpc	1.17
ffs1157	Quasar	1.631E3 Mpc	0.488
ffs1306	Quasar	4.43E3 Mpc	1.6
ffs1335	Starburst Galaxy	4.727E3 Mpc	1.73
ffs1349	Quasar	3.539E3 Mpc	1.22
ffs1533	Starburst Galaxy	2.384E3 Mpc	0.76
ffs1708	Quasar	3.825E3 Mpc	1.34

AGN objects were as follows, quasars ranged from 1.631E3 Mpc to 4.48E3 Mpc, starburst galaxies (which were the farthest) ranged from 2.384E3 Mpc to 4.727E3 Mpc, Radio Galaxies (the closest to earth) ranged from 3.561E2Mpc to 4.543E2 Mpc, and elliptical galaxies which ranged from 3.598E2 Mpc.

Conclusions

Concluding the report I find that quasars are most likely the most common type of AGN, because they are easy to identify, and they are the easiest type of AGN to detect (because they are so luminous).

The Measurement of Astronomical Source Intensity In the Milky Way

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Abstract

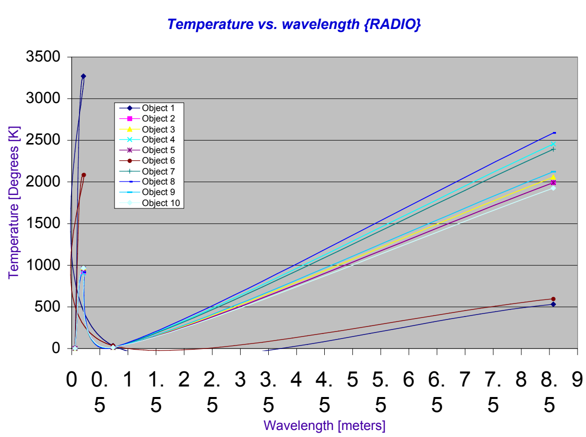
The measurement of astronomical sources in the universe enabled me to analyze their respective intensity as well as provide me with essential information concerning the galaxy in which we inhabit. Beginning with the observation of the Milky Way using a crude telescope, image analysis has evolved into an on going highly advanced technical field. Using this type of modern image analysis, more in-depth investigations, such as the analysis of an object's intensity and frequency, can be achieved.

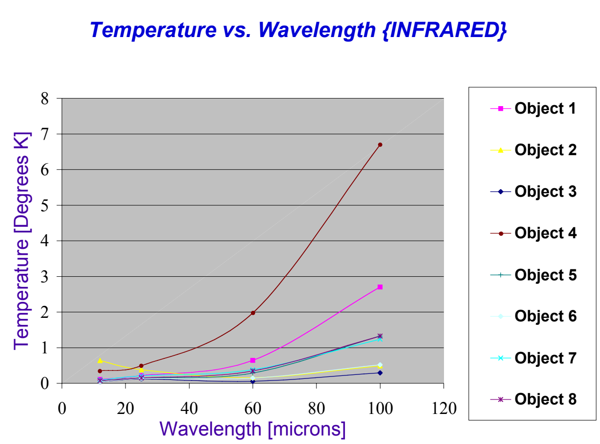
Introduction

This paper discusses developments in image analysis, and what the universe looks like at different wavelengths. The measurement of astronomical sources in the universe enables the analysis of its respective intensity as well as provides essential information concerning the galaxy in which we inhabit. In using this concept, I developed a project that would answer the question, "What does the universe look like at different wavelengths?". I used FITSview (Flexible Image Transport System) analysis software to investigate several images of arbitrary objects in NGC1999 within the Milky Way Galaxy at radio and infrared wavelengths.

Analysis and Conclusions

The FITS images I analyzed are available from the National Radio Astronomy Observatory (NRAO) web site in Charlottesville, Virginia and the NASA SkyView web site. Using this software, available to me through my advanced placement physics teacher, Mr. Robert Welsh, I recorded the frequency, right ascension, declination, and pixel value of each object within NGC1999 in both the radio and infrared wavelengths. To achieve this, I randomly selected an object at the 35 Megahertz frequency, recorded its pixel intensity, and proceeded to collect the intensities of the same object in several other radio frequencies; 408 Megahertz, 1420 Megahertz, and 4850 Megahertz. This procedure was repeated for eight completely different objects within NGC1999 at four infrared wavelengths; 100 microns, 60 microns, 25 microns, and 12 microns. With this data, I calculated the temperature of each object by converting the pixel value using conversion factors. Because the pixel scale varied for each image, I divided the pixel value into the respective degrees Kelvin per pixel. For the 35, 408, 1420, and 4850 MHz NGC1999 image, I divided by 0.1525o K, 0.3515 o K, 0.250 o K, 0.025 o K respectfully by each pixel value. The recorded pixel value for each infrared wavelength was divided into 0.025o K to calculate the temperature. I created spreadsheet, using my data, within Microsoft Excel and used the chart wizard to generate figures 1 and 2 below:





The graph illustrated in Figure 1 (left) shows more activity in the 35 and 1420 megahertz frequencies. Therefore, that is where the objects are the most intense, or bright. On the other hand, the 408 and 4850 megahertz frequencies are where the intensity of that object is the least. In the analysis of the graphs illustrated in Figure 2 (right), I deduce the objects in the infrared frequencies lose energy as the wavelength decreases; therefore, it is evident the objects emitted the greatest amount of energy at the longer infrared wavelengths. Currently, I am not aware of the reason for this phenomenon. The internal energy of an ideal gas is described using the equation: $U=3/2NkT$. In other words the internal energy is the product of the number of moles within the gas, a constant, and the temperature. Thus, the energy of an ideal gas is independently related to temperature and the number of moles of gas. As a result of the analysis, I conclude in both radio and infrared frequencies, a temperature increase in an object in the Milky Way galaxy causes the electromagnetic radiation emitted by the object to be the strongest.