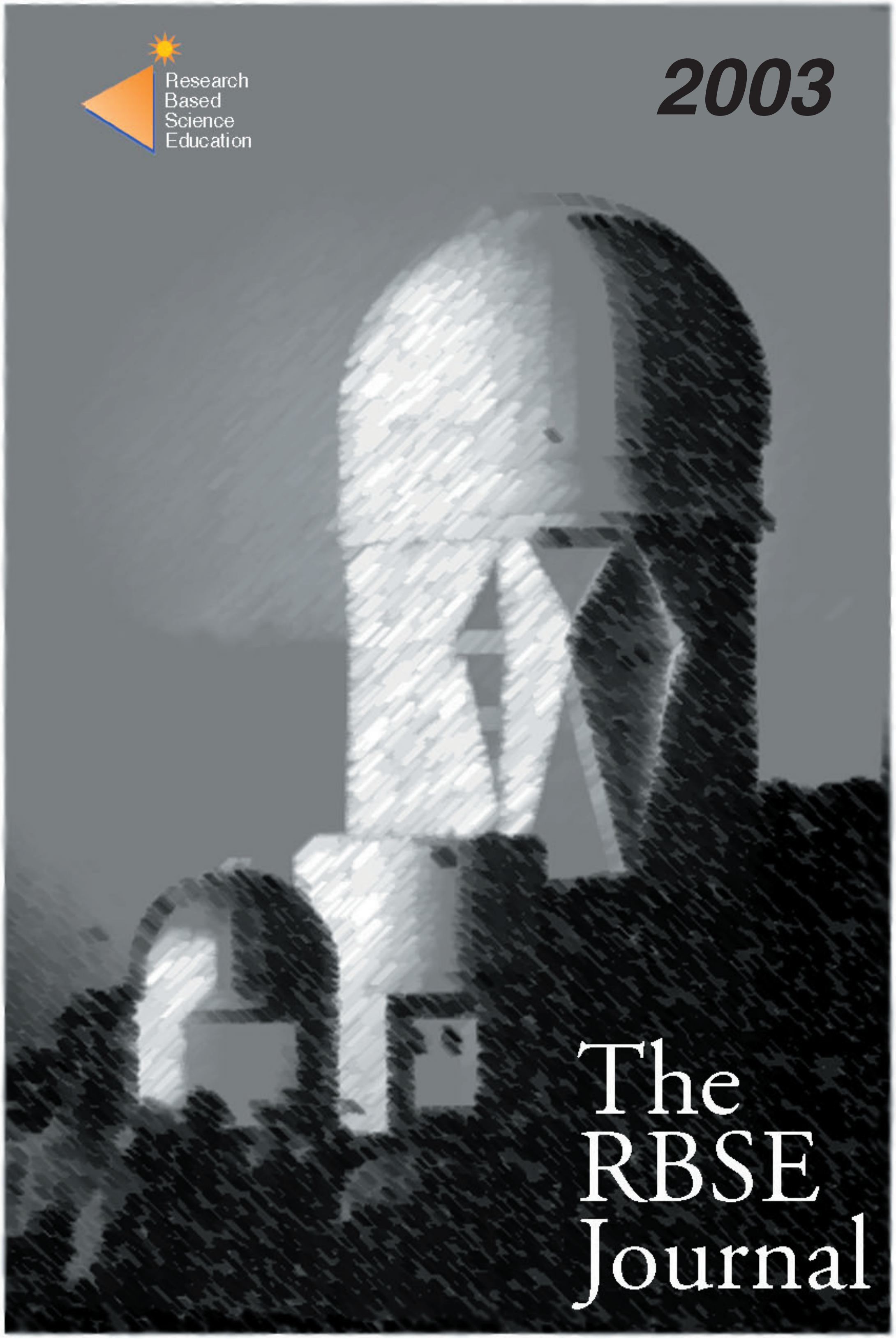
Research
Based
Science
Education

2003



The RBSE Journal

AURA

National
Optical
Astronomy
Observatory

NSF

The RBSE Journal

2003

"Teacher Leaders in Research Based Science Education" (TLRBSE) is a Teacher Enhancement Program funded by the National Science Foundation. It consists of a distance learning course and a summer workshop for middle and high school teachers interested in incorporating leadership and research within their classes and school. TLRBSE brings the research 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 TLRBSE program.

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Sunspot Area vs. X-Ray Intensity

Caroline Eibling, Nadira Lunat, Cory Hill, Gina DiSerio, Jannah Garing,
Matthew Elmore, Andreanna Barnes, Nolan Goodman, Jas Sidhu, Marty
Jellin, Joshua Clary, and Period 0, 1, and 2 Physical Earth Science Students
Lincoln High School, Stockton, CA
Teacher: Barbel Sepulveda, TLRBSE '02

Abstract

The area of sunspots and x-ray intensity were measured over time. After analyzing the available data our outcome was decisive. Our hypothesis that the area of sunspots correlates with the intensity of the x-rays is incorrect. The graphs show no correlation.

Introduction

Sunspots are huge dark spots on the sun's surface. They range in size from the very small to the size of the earth and they are known to rotate with the sun's movement. The duration of sunspots can vary from a few hours to a few months.

Formed on the photosphere, sunspots appear as dark blotches when viewed in visible light. They appear darker because they are cooler than the surrounding photosphere. They are associated with strong magnetic fields which are believed to play a role in their formation.

X-rays are emitted higher in the solar atmosphere where they show up as bright patches. Because x-rays and sunspots occur in different regions of the sun we wanted to see if there was a connection between the two kinds of light.

Purpose

The purpose of this research project is to determine if there is a correlation between sunspot area and X-ray intensity in the sun.

Method

Solar images were analyzed using the NIH image software. The intensity images were collected by the Kitt Peak Vacuum Telescope from August 1, 2000 through September 18, 2000. X-Ray images were obtained from the Yohkoh Satellite.

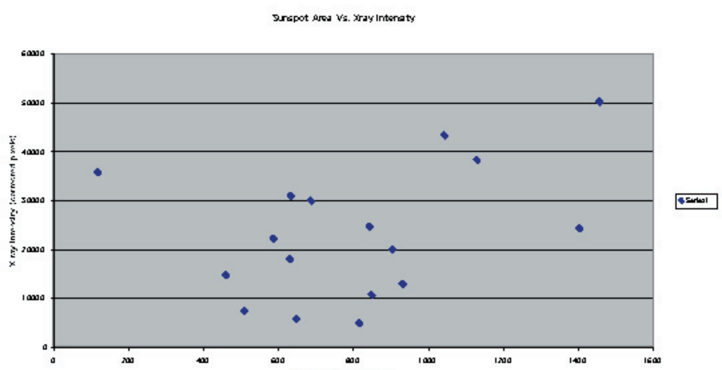
To make measurements NIH had to be running. Special commands, called MACROS, had to be loaded, then an image could be imported. The import scale minimum and maximum values had to be set to open the image. To measure the area the density slice option had to be used. The LUT (Look Up Table) turned partially red when activated. The bar was dragged to make it completely red and then slowly pulled down from the top. The image was completely red at first and then slowly only the sunspots were red. This allowed only the sunspots or x-rays to be highlighted red so that only those pixels were measured. Next a region on the image was selected to measure. The MACRO command "read sunspot area" under options was used. The sunspot area was displayed in the info box. The corrected pixels were recorded.

Measurements of the area of the sunspots and the x-rays were made daily for each distinct region. Daily totals were calculated. To graphically display the data a graph of Sunspot area vs. x-ray intensity was completed using computer graphic software.

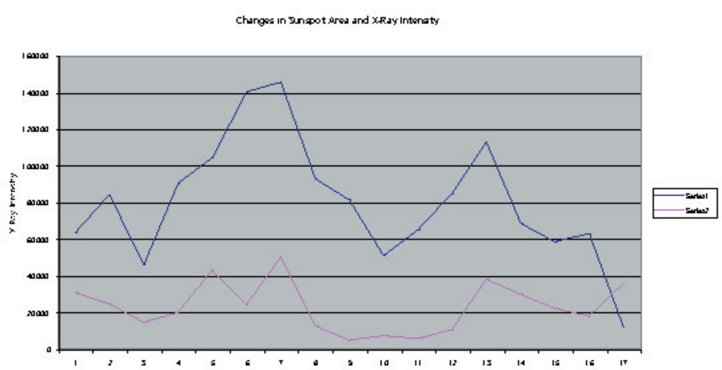
Data

Date	Sunspot Area (corrected pixels)	X-ray Intensity (corrected pixels)
31-Jul	634	30,922
1-Aug	843	24,589
2-Aug	460	14,695
3-Aug	904	19,914
4-Aug	1044	43,250
8-Aug	1404	24,233
11-Aug	1457	50,179
20-Aug	932	12,841
22-Aug	815	4,839
23-Aug	509	7,409
24-Aug	648	5,719
25-Aug	850	10,638
30-Aug	1130	38,287
1-Sep	687	29,883
2-Sep	586	22,254
3-Sep	631	17,967
11-Sep	118	35,715

Results



As shown in Chart 1 the data supports our hypothesis. Based on our interpretations of the graphs, we believe there is some correlation between Sunspot area and the amount of x-rays emitted by the sun; however, the relationship does not appear to be clear cut.



There are changes in x-ray intensity that are not reflected by changes in sunspot size, and vice versa as illustrated in Chart 2. We feel more research is required to determine the degree of correlation.

There are several sources of error in this study. The amount of data available was limited. Although the images were collected over a two month period we only used seventeen days. This was because on some days only intensity images were available while on others only X-ray images were available. In addition, four days were thrown out because the intensity images were distorted.

Another source of error involved how the measurements were made. There were inconsistencies among participants as to deciding which pixels to select. This problem was more pronounced when working with the x-ray images. Students found it difficult to decide how much of an active region to select.

The computers themselves were difficult to work on and had memory and display problems that made the task difficult. The contrast was not good and may have contributed to the confusion about which pixels to measure.

Finally, we feel there is some degree of error in interpreting the graph. It looks like it could be a line, but it is not clear. The spreadsheet will superimpose a trendline, but it doesn't go through the origin. We feel that if sunspot area and x-ray intensity are directly related then the line should go through the origin on the graph.

References

Robert J. Sayer, William L. Ramsey, Clifford R. Phillips, Frank M. Watenpaugh. Modern Earth Science. Orlando, FL: Harcourt Brace & Company, 1998

Shwartz, Mark. "Giant loops in the solar atmosphere may trigger reversals of the Sun's magnetic poles, new study reveals." 5 June 2002: 3 pp. Online. Internet. 2 Dec. 2002 Available www:http://www.stanford.edu/dept/news/report/news/june12/solaragnet-612.html

"Sunspot" The Universal World Reference Encyclopedia. 1968 ed

"Sunspots Lesson Plan" 7 pp. Online. Internet. 10 Dec. 2002. Available www:http://cse.ssl.berkeley.edu/SegwayEd/lessons/sunspots/sspot_lesson_plan.html

Does the Number of Sunspots Affect How the Average Temperature in Indiana Changes?

Angilee Lewis
Franklin Central High School, Indianapolis, IN
Teacher: Jim Hoffman, RBSE '00

Abstract

The question that was researched was "Does the number of sunspots affect how the average temperature in Indiana changes?" The hypothesis for this research is, the more sunspots there are, the warmer the average temperature will be. The research was done by picking random days from January-September, 2001. With these days, the sunspot index was calculated for each day. This was done by taking the number of sunspot groups, multiplying that by 10, and then adding the number of individual sunspots to the existing number. Then, the average temperature for each day in Indianapolis, Indiana was taken from the Farmer's Almanac. The temperature, and the sunspot index were then compared to see if there were any patterns within the numbers. The graphs were then compared, and the result of the research is that the number of sunspots does not affect the temperature, actually, the highest sunspot index was in March, and the highest average temperature was in August. Therefore, the hypothesis is incorrect.

Background Information

Sunspots are relatively large, dark spots on the surface of the sun. The sunspots have a lower temperature than the rest of the sun, but they are highly magnetic. The magnetic fields of sunspots are thousands of times stronger than the magnetic field of the earth. Sunspots usually come in groups, but there can be single sunspots also. One set of sunspots will have a positive magnetic field, and the other will have a negative magnetic field. The fields are strongest in the center, this section is called the umbra, and the fields are weaker along the outside, which is called the penumbra. Over 11 years, the number of sunspots goes from zero to over 100, and then decreases to zero again. This is called the sunspot cycle. It is an eleven-year pattern that shows the number of sunspots on the sun.

The way that the sunspot index is calculated is by counting the number of sunspot groups. A group of sunspots is classified as sunspots relatively close The next step is to multiply the number of sunspot groups by 10, and then count the number of individual sunspots, and add it to the existing number.

Purpose

The purpose of this research was to find out if there was any connection between the number of sunspots found, and the average temperature of the day.

Procedure

The way the research was conducted was by first picking random dates in the months January-September 2001. On each of those days the sunspot index was calculated. The way this was done was by taking the number of sunspot groups, multiplying that number by 10, and then adding the number of individual sunspots to the previous calculation. The next step in the research was to get online to the Farmer's Almanac, and look up the average temperature for Indianapolis, Indiana for the specific dates. Then, the two numbers were compared to see if there were any patterns in the numbers. Figure 1 shows how the number of sunspots changes over time. Figure 2 shows the average temperature in Indianapolis over time.

Conclusion

The conclusion to the research is that the number of sunspots does not affect the average temperature in Indianapolis Indiana. The next step in the research in this particular field would be to determine if the number of sunspots affected the extreme temperatures in Indianapolis Indiana. The reason for this, is because, there were no connections in the previous research, so maybe there would be a connection between the extreme temperatures, and the number of sunspots.

Bibliography

www.almanac.com/weatherhistory/index.php

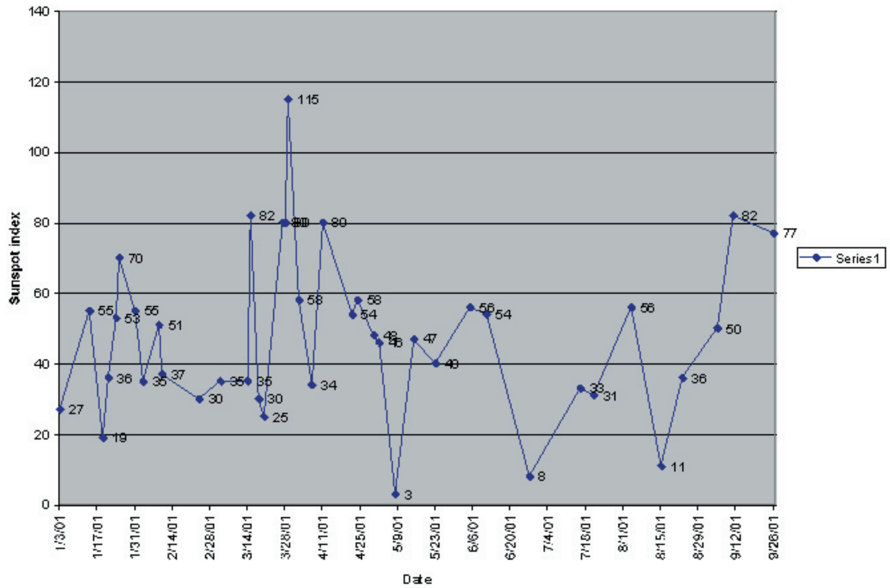


Figure 1.

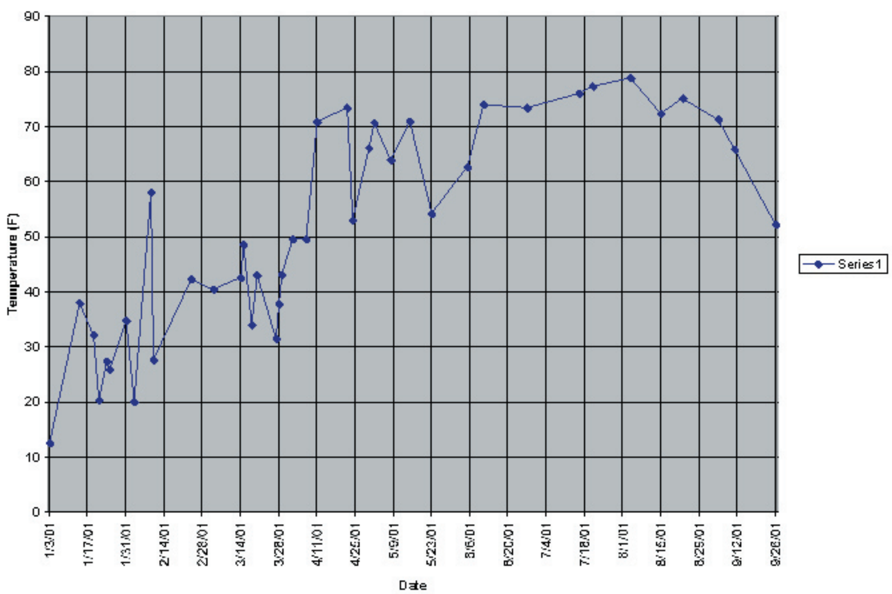


Figure 2.

Active Longitudes

Ryan Loftus and Marc Corrente
Cranston High School East, Cranston, RI
Teacher: Howard Chun, RBSE '99

Abstract

Active longitudes are regions on the sun where sunspots originate. There are many theories about active longitudes although they have never been definitively proven true. With the limited number of results it is hard to verify the existence of active longitudes. However, there were still certain longitudes on the sun that had repeat sunspot origination. More results could support the theory further. Although, it is possible that these results could have been in the same region by chance.

Purpose

The purpose of this study is to find any active longitudes.

Procedure

Using ScnImage and the appropriate Solar Macro, chart the journey of a sunspot across the Sun's surface. Record the sunspot's Julian data, Heliographic longitude and latitude, Area, Carrington rotation and longitude, and corrected longitude. After tracking the entire path of the sunspot across the Sun, calculate the new rotational period of the sunspot. Repeat this procedure for many other sunspots. Compare and contrast the new rotational periods and corrected longitudes of all the charted sunspots.

Conclusion

The hypothesis that the origin of sunspots could be determined by the active longitudes could not be conclusively proven. There were three sunspots originating from each of the following active longitudes: 28, 148, and 337 degrees. There were also two sunspots originating from the following active longitudes: 77, 127, and 177 degrees. Although there are indications that active longitude may exist, much more analysis is needed to conclusively substantiate the hypothesis.

References

Gesualdi, David and Joseph Venagro and Steven Sullivan. Active Magnetic Longitudes. The RBSE '02 Journal. 9.

Image Date	Julian Date	ROI	Latitude	Longitude	Area	Car. Rot.#	Car. Long.	Cor. Long.	Rot. Per.
10/23/89	2447823.3833	S	-19.8974	-34.1986	32.0563	1821.5525	126.9073	126.9073	
10/24/89	2447824.2437	S	-20.1063	-22.3649	32.9625	1821.584	127.3846	127.2566	
10/25/89	2447825.7076	S	-19.9529	-9.5086	25.6749	1821.6194	127.5187	127.2628	
10/26/89	2447826.2611	S	-20.5781	3.8528	27.9985	1821.658	126.9756	126.5917	27.0131
10/27/89	2447827.2160	S	-21.2517	16.4166	20.0509	1821.693	126.9364	126.4246	
10/28/89	2447828.2083	S	-21.4233	29.4959	15.0839	1821.7294	126.9178	126.278	
10/29/89	2447829.2160	S	-21.5699	42.8657	12.4159	1821.7663	126.988	126.2203	
10/30/89	2447830.2062	S	-21.2796	56.7511	7.4033	1821.8026	127.803	126.9073	
11/3/89	2447834.7139	N	17.767	-9.5733	31.645	1821.9496	8.5828	8.5828	
11/4/89	2447835.1097	N	24.0158	3.9237	50.5548	1821.9861	8.936	9.0198	27.4494
11/5/89	2447836.1965	N	23.9441	16.4274	46.1054	1821.0223	8.4151	8.5828	
3/18/85	2446143.1278	S	-10.8999	-43.8777	2.392	1759.9489	334.5102	334.5102	
3/20/85	2446145.1187	S	-10.7664	-18.8969	4.467	1760.0219	333.2127	333.3159	
3/21/85	2446146.0896	S	-11.0523	-5.7442	4.0314	1760.0575	333.5516	333.7064	27.382
3/22/85	2446147.0944	S	-10.9374	7.2894	4.2858	1760.0944	333.3223	333.5287	
3/23/85	2446148.1042	S	-10.9726	22.0914	3.1014	1760.1314	334.7972	335.0552	
3/24/85	2446149.1243	S	-12.3418	34.9594	1.4982	1760.1688	334.2006	334.5102	
3/25/85	2446150.1181	N	6.0112	-41.0844	13.1019	1760.2052	245.0406	245.0406	
3/26/85	2446151.2701	N	6.3082	-25.7057	15.2297	1760.2474	245.2132	245.0048	
3/27/85	2446152.1299	N	6.155	-14.5375	16.3562	1760.279	245.0341	244.6173	27.1895
3/30/85	2446155.1486	N	6.0876	25.9945	10.8989	1760.3896	245.7033	244.6614	
3/31/85	2446156.1903	N	5.7699	40.5883	6.9675	1760.4278	246.5675	245.3172	
4/1/85	2446157.0903	N	5.9944	53.0241	5.2771	1760.4608	247.1244	245.0406	
5/9/85	2445830.1201	N	11.5429	-40.9807	86.6691	1748.4731	148.7185	148.7712	
5/10/85	2445031.1979	N	6.5583	-27.1035	99.2484	1748.5107	149.0303	149.1357	
5/11/85	2445832.1083	N	6.6628	-14.1187	104.6015	1748.543	149.3388	149.797	27.3844
5/12/85	2445833.1993	N	7.0334	-0.8513	98.4601	1748.5859	148.2067	148.4176	
5/13/85	2445834.1976	N	7.0804	12.5681	104.7523	1748.6225	148.4549	148.7185	

Table 1.

Extrinsic Triggers for Nova Formation in the Andromeda Galaxy

Alex Hubbell, Julie Krugler and Margaret Walton
Grosse Pointe North and South High Schools, Grosse Pointe, MI
Teacher: Ardis Maciolek, RBSE '98

Introduction

For the past five years the students in our high school have been collaborating with astronomers from the National Optical Astronomy Observatory in Tucson, Arizona. Through the Research-Based Science Education program (RBSE), students are supplied with CCD images of the Andromeda Galaxy and specialized image-processing software to search for novae. It is then up to their discretion regarding what types of investigations to develop.

Upon studying the accumulated Nova Search data, it seemed that novae outbursts tended to form in close proximity to each other. This had many searching for a space and/or time relationship for the novae. If a student successfully discovered a relationship, the question arose: why would the novae be related? It has been believed that only the partner star of a white dwarf, most often a massive star in a close binary system, can cause novae formation by means of accretion. However, the mass accreted onto the white dwarf could possibly be the result of an extrinsic mechanism.

Purpose

The aim of this investigation is two-fold. It is to search for patterns in the distribution of novae, either in space or time. With these patterns, a question arises which needs to be addressed. Could nova outbursts be the result of an extrinsic mechanism?

Procedure

Space and Time Relationships

The first portion of the procedure involved determining if the novae discovered from the high school research had any relation to each other in space and time. The image analysis was done using a scientific image-processing program called Scion Image and specialized macros developed by NOAO to do photometry on FITS images. Using Adobe Photoshop 6.0, the location of all the novae was plotted onto an epoch mosaic. Then, all of the marked mosaics were exported into Scion Image, where they were blinked, or animated, in order to find any type of pattern in time. Finally a mosaic composite picture of all subrasters of data was created and the image was analyzed for any spatial novae patterns.

The next step in finding any type of pattern in space was to create an optical image of M31, then overlay the plots of novae onto this optical image. Using The Atlas of the Andromeda Galaxy[1], images were gathered of the area near the core being studied. These images were then cropped and fitted together in Adobe Photoshop to form one large image mosaic. This picture was then cropped further and enhanced to match the image size to the actual size of the Nova Search parameters. The plots of all novae were then imported into Adobe Photoshop and merged on top of the optical image. In all, 394 novae were plotted. Novae located in the core area, where features could not be ascertained, could not be examined. The novae located around the central area were then examined for further patterns. This reduced the original number by 249. The novae located around the central area were then examined to see if their locations correlated with dust clouds, stellar associations, or arm structure.

Extrinsic Mechanisms

For the second goal of this research, a list of possible triggering mechanisms for novae was developed. Ideas for possible mechanisms were supernova remnants, planetary nebulae, globular clusters, x-ray sources, and other novae.

Supernovae were an obvious choice, due to prior knowledge of their effect on the formation of stars. During a supernova, 80% of the star's mass is released into space. It has been documented that supernovae can cause star formation.[2] As witnessed by SN 1987a, shockwaves from the supernova trigger regions of formation in the surrounding interstellar gas. This raises the question, if a supernova causes star formation, then what other stellar events could it induce? More specifically, can a supernova induce nova formation?

Planetary nebulae are stars that in the late stages of evolution release shells of gas. As the gas from the outer part of the star is released, the core of the star heats up and eventually reveals itself as a white dwarf. When the shell is completely released, the white dwarf heats up the gases and causes them to glow. Much like a supernova, the mass is released into space and could possibly accrete onto the white dwarf.

Globular clusters provide an interesting aspect to the search for a novae trigger. They tend to be fairly massive objects in comparison with the nova progenitor. This abundance of mass could potentially aid the accretion of hydrogen from the red star onto the white dwarf, by creating a massive tidal effect and helping to induce the mass transfer between the partners.

An article written by Robin Ciardullo et al[3], suggests a different type of triggering mechanism by which globular clusters could form novae. Theoretically, the novae form within the globular clusters by cluster core collapse and are then ejected after they are formed. The ejection process has been hypothesized to be the result of three-body interaction or tidal disruptions. If the Ciardullo hypothesis is correct, the density of the novae should be directly correlated to the density of the globular clusters. Essentially, the higher the density of globular clusters, the higher the density of novae.

Another characteristic of globular clusters is their tendency to travel through the plane of the galaxy. Due to this unusual orbit, globular clusters like Palomar 5 undergo a process called tidal shredding. The tidal forces of the galaxy tear stars away from the globular cluster leaving behind a trail of stars that can be 6000 light years long. In the case of Palomar 5, the tails contain nearly 1.3 times the mass of the globular cluster itself.

X-Ray sources from the active nucleus of the galaxy could also participate in the formation of novae. The gases that escape from the active areas in the nucleus are in a hot cloud of wind. These massive clouds could possibly aid the accretion of the white dwarf.

Pulsars are rotating neutron stars that release "pulses" of waves at incredibly stable intervals. Their polar areas emit jets of materials in a manner similar to X-rays.

Once this list was narrowed and defined, a search was performed to find data. SIMBAD[4] and VizieR[5] provided the most of the information about the locations and types of objects in M31. The Atlas of the Andromeda Galaxy and Regulus![6] provided detailed optical images and maps of the Andromeda Galaxy. Data sets were acquired for the location of novae, supernova remnant (SNR) candidates, X-ray sources, planetary nebulae, and globular clusters. No pulsar data were available for M31.

Modeling Mechanisms for Extrinsic Triggers

Upon research, it was discovered that, in order for a classical nova to flare, it must accumulate .001 solar masses of material on its surface. This number was crucial to the determination of the plausibility of several of the triggering mechanisms. Simple physics constructs were created to determine the "sphere of influence" each mechanism might exert upon the nova. The constructs were based on the average values for the physical and dynamic characteristics of each object or phenomenon. The averages were then used in calculations to determine the possibility of influence on the novae.

Controls and Sources of Error

When using VizieR to find supernovae, data was only used if it had a high or medium confidence level. To find the limits of Scion Image the mouse was moved pixel by pixel to determine the change in right ascension and declination. It was determined to change ±.7 seconds with the movement of one pixel in all directions.

The Andromeda Galaxy is a roughly circular shape but is inclined 13 degrees to the line of sight. Because of this, the galaxy appears to be more elliptical to us. This was not compensated for in the plots, since there were no data for the radial distances to the objects, but it was assumed that the parallax effect it caused was small in comparison to the distance to M31 (2.15 million LY.). However, objects that appear to overlap may in reality be separated by a distance of thousands of light years.

Data

After determining which data fit the parameters of the Nova Search area of M31, the data were imported into Microsoft Excel to convert the celestial coordinates into a decimal form. Using PSI Plot, graphs were created to analyze the spatial relationship between novae and their possible triggers. Then other all the graphs were plotted against the optical pictures of the Andromeda galaxy.

Sources of data:

Planetary Nebulae – George Jacoby
High School Novae – from school research
Other Novae – Combined General Catalogue of Variable Stars (Kholopov+ 1998)
Globular Clusters – http://cfa-www.harvard.edu/~pbarmby/m31gc/m31gc.coo
Supernovae - New SNR Candidates in M31 (Magnier+ 1995)
X-Ray – Einstein IPC data 1998, ROSAT, Zim 2001, XMM Newton Observatory 2002, Chandra 2003

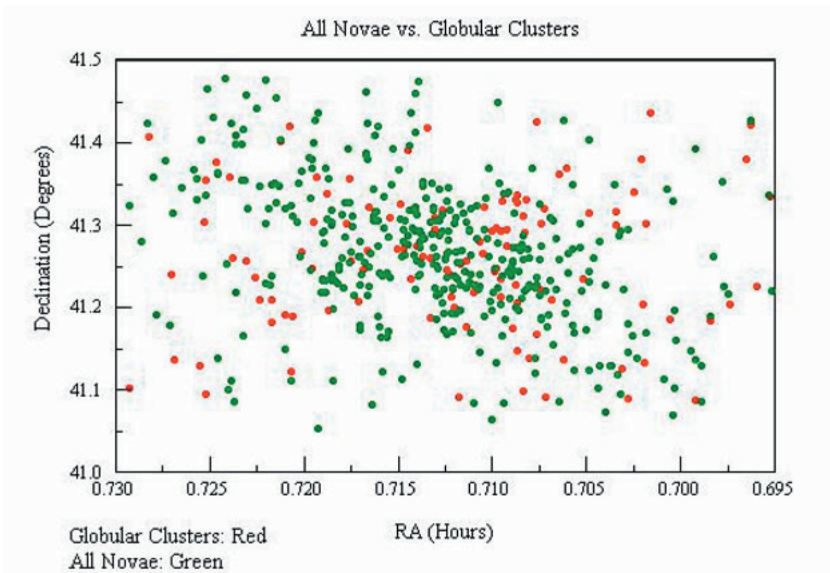


Figure 1: The graph of all novae vs. all globular clusters. Note the absence of nova in the so-called "finger area".

Analysis

A graphical analysis of the distribution of all novae shows that they are more numerous in the center. The most interesting is the cluster in the east center of the graph. Another interesting aspect is what has come to be known as "the finger" in the lower center of the graph. The region moves down from east to west and no novae are present in it. This is most likely because something in the galaxy has obstructed the view.

When the total mosaic of all novae discovered from the school Nova Search was examined, three interesting patterns emerged. The first was around the southwest galactic core. Several novae appear in a ring 8000 LY long that seems to wrap around and extend away from the core of the galaxy. While at first it may seem that the pattern is only due to its close proximity to the core, other novae exist even closer to the center of the galaxy. Therefore, the ring does not necessarily encompass the core itself.

The second pattern is located to the east of the core. A long string of novae stretches across 2 subraster images, creating a distinct chain roughly 5000 LY long and 1600 LY wide. The third pattern is located southwest of the core. Two diagonal lines of novae can be traced.

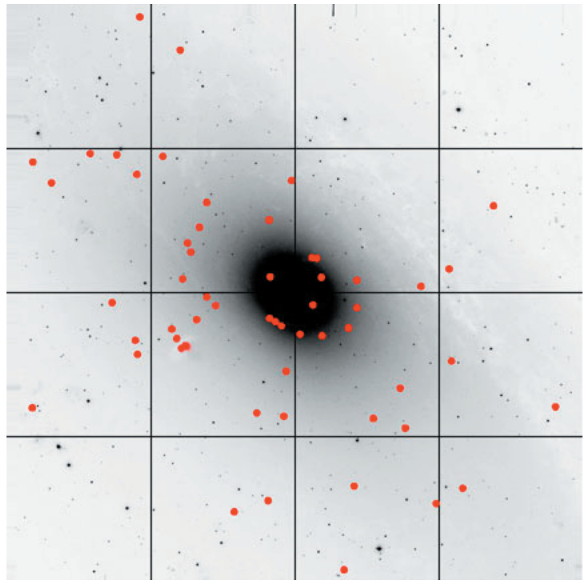


Figure 2: All GP novae plotted against the optical image. The three patterns can be seen.

There are two main ideas that may explain these occurrences. One explanation is that the novae comprising the ring and the east chain are spiral arm structures that are extending from the core. This would explain the wrapping pattern the ring has on the central area of the galaxy. The other explanation is far more intriguing. An article written by M. Irwin et al[7] suggests that the tidal force of M31 is actually pulling matter from its two satellite galaxies, M32 and NGC205. It is possible that these arcs mark material that is being transferred from the dwarf galaxies to M31, and that the greater occurrence of novae is due to a greater amount of matter accreting on the surface of a white dwarf star. Alternatively, the novae may mark a population of stars that is being transferred into M31 by merger.

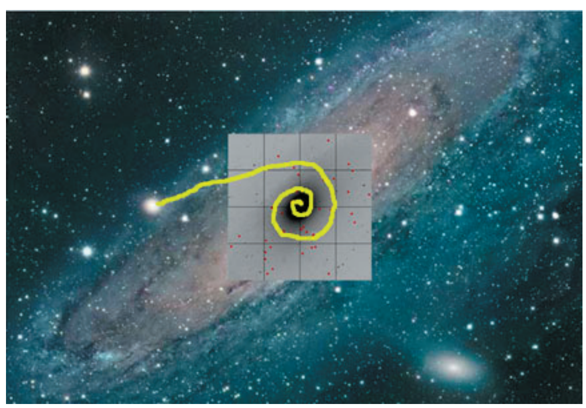


Figure 3: A proposed inflow path of the tidal merger of stars from NGC 205.

There is a small cluster of five novae that are clumped together in subraster 10 of the school Nova Search data. However, attempts to overlay the "glob" onto any other optical images failed, due to the fact that the cluster appeared in the overexposed area of galaxy. Therefore, no explanation for this clustering is readily apparent. Two of the "glob" novae occur at the same location, separated by an interval of two years. The second outburst lasted less than a week. This is intriguing because if it represents a recurrent nova, the period is much shorter than what has been previously documented by other observers. Typically, recurrent novae have a dormant period of decades. A possibility exists that the two novae are in fact separated in space by a radial distance of light years. The star may also represent a type of dwarf nova with a short outburst period, such as an SU Ursa Majoris variable.[8]

The images obtained from the Atlas of the Andromeda Galaxy showed the locations of various dust clouds and stellar associations. Of the total 145 novae left after the first reduction, 60 were found near or in the clouds and associations, a total of 41%. Out of the 60 of the novae found around these objects, 13.3% were found on the edge of stellar associations, 15% were found in stellar associations, 41.6% were found on the edge of dust clouds, and 30% were found in dust clouds. Overall, a greater percentage of novae occurred in dust clouds rather than stellar associations, but 59% of all novae were not associated with either feature.

Mathematical constructs were created in order to model whether or not any of the above extrinsic mechanisms could trigger a nova. However, when the calculations were finished, the distances and masses of material needed to induce a nova on the white dwarf progenitor were far too small to be a possible trigger. Therefore, these were ruled out as possible external mechanisms: supernovae, planetary nebulae, jets of X-ray sources or pulsars, other nearby novae, and the gravitational influence of globular clusters.

Graphical analysis of globular clusters shows that they are more random in their distribution than novae. The globular clusters do not outline the shape of the galactic plane. As the density of the globular clusters increases, so does the density of the novae. This supports the hypothesis that globulars may form some novae. The mechanism may be core collapse or perhaps accelerated accretion by tidal tails of shredded globular clusters such as Palomar 5.

Conclusion

No pattern in time exists for nova outbursts. However, several patterns in space existed, possibly related to the spiral arm structure of Andromeda or jets of material streaming from NGC 205 and M32 into M31. The data suggested no correlation between novae and their locations relative to dust clouds or stellar associations. Nova density did increase closer to the core of the galaxy, due to greater concentration of stars in general near the center of the galaxy.

The mathematical constructs indicated that globular clusters, planetary nebula, supernovae, and X-ray sources must be extremely close to a white dwarf star in order for it to accrete enough matter on its surface. The data showed only a small number of objects located close enough to trigger the novae, therefore this correlation is not plausible.

When the “finger” area was investigated, optical pictures showed that it correlated with a dust lane, therefore reducing the visibility of novae.

Extensions

There are several directions this research could turn in the future. Since it has been proposed that there is a possible correlation between novae and globular clusters, research needs to be done on whether this is caused by a tidal streamers due to globular shredding, or by core cluster collapse. The prospect of the dwarf galaxies NCG 205 and M32 causing novae formation by tidal streaming is also an interesting area that could be further investigated. Finally, the single recurring nova found does not seem to fit any of the other forms of recurring novae. This suggests that a new type of recurring novae may have been discovered.

Acknowledgements

We would like to thank George Jacoby for providing planetary nebulae data and insight into nova formation. We would also like to thank Connie Walker for aiding us in determining some of the mathematical models, Andrew F. for helping us create an Excel program to convert celestial coordinates, and Paul F. for providing suggestions in calculating the areas of our plots. Finally we would like to give our great appreciation to our teacher for guiding the course of our research and providing great insight and leadership throughout.

Bibliography

“Astronomy 311: Exploring the Universe” Peter Newbury. 28 February 2003.
<http://www.astro.ubc.ca/people/newbury/astro311/030303.html>
“Star Formation” James Schombert. 10 January 2003. 14 March 2003.
<http://zebu.uoregon.edu/~js/ast122/lectures/lec09.html>
“Imagine the Universe: Introduction to Cataclysmic Variables” High Energy Astrophysics Science Archive Research Center. 1997. 2002.
<http://imagine.gsfc.nasa.gov/docs/science/know_l2/cataclysmic_variables.html>
“Cataclysmic Variables” Jesse S. Allen. 10 March 2003.
<http://lheawww.gsfc.nasa.gov/users/allen/#novae>
“The Astronomy Stream: A Giant Trail of Tidal Stellar Debris in the Halo of M31” M. Irwin. October 2001. <http://

www.ing.iac.es/PR/newsletter/news5/science1.html>
"Students Help Astronomers Discover 73 Novae in Andromeda Galaxy" National Optical Astronomy Observatories. 13 January 2000.
<http://www.noao.edu/outreach/press/pr00/pr0001.html>
"Globular Clusters" Natko Bajic. 11 January 2003.
<http://www.geocities.com/natkobajic/natkobajic.html>
"X-Ray Astronomy Field Guide" Chandra. 19 March 2003.
<http://chandra.harvard.edu/xray_sources/quasars2.html>
"Atlas of the Andromeda Galaxy" University of Washington Press. 1981.
<http://nedwww.ipac.caltech.edu/level5/ANDROMEDA_Atlas/Hodge_contents.html>
"Hubble Space Telescope Finds a Double Nucleus in the Andromeda Galaxy" Hubblesite. 20 July 1993.
<http://hubblesite.org/newscenter/archive/1993/18/text>
"The Life Cycle of a Star" University of Bradford. <http://www.telescope.org/pparc/res8.html>
"Further Studies of the Double Nucleus of M31" Ivan R. King. 1994.
<http://www.aas.org/publications/baas/v26n2/aas184/abs/S3205.html>
"The M31 Atlas" John A. Blackwell. 2003
<www.regulusastro.com/regulus/papers/m31/index/html>
Zombeck, Martin V. "Handbook of Space Astronomy and Astrophysics." Astronomy and Astrophysics. New York: Cambridge University Press, 1990:23-140.
Ciardullo, Robin, et al. "The Nova Rate in the Elliptical Component of NGC5128." The Astronomical Journal. April 1990.
Durbeck H.W. "Light Curves of Variable Stars." New York: Cambridge University Press, 1996.
Gilmore, Gerard, et al. "The Milky Way as a Galaxy". Mill Valley: University Science Books, 1990.
Kepple, George Robert and Glen W. Sanner. "The Night Sky Observer's Guide" , Richmond: Willmann – Bell, Inc.1999: 12-24
Chandler, David L. "A Tidally Shredded Globular Cluster" Sky and Telescope. Cambridge: Sky Publishing Corp. September 2002, 17.
Chaisson, Eric. "Astronomy a Beginner's Guide to the Universe" Saddle River: Prentice Hall, 1998
American Association of Variable Star Observers. "Hands-On Astrophysics" Cambridge: The American Association of Variable Star Observers. 1997.

Footnotes

1 http://nedwww.ipac.caltech.edu/level5/ANDROMEDA_Atlas/Hodge_contents.html
2 http://www.telescope.org/pparc/res8.html
3 Ciardullo, Robin, et al. "The Nova Rate in the Elliptical Component of NGC5128." The Astronomical Journal. April 1990.
4 http://simbad.u-strasbg.fr/Simbad
5 http://vizier.u-strasbg.fr/viz-bin/vizier
6 http://www.regulusastro.com/regulus/papers/m31/index.html
7 "The Andromeda Stream: A Giant Trail of Tidal Stellar Debris in the Halo of M31". M. Irwin et al. 5 October 2001.
<http://www.ing.iac.es/PR/newsletter/news5/science1.html>
8 AAVSO-HOA

A Comparison Of M31 Nova Rates to Other Spiral Galaxies

Destinee Adkins, Melissa Begley, Farhan Ahmad, Jay Farris, Colleen Kennedy,
Jennifer Kennedy, Zac Landis, Morgan Osborne, Derek Whisman
A. Linwood Holton Governor's School, Abingdon, VA
Teacher: Dr. Steve Rapp, TLRBSE '02

Abstract

The astronomy class at A. Linwood Holton Governor's School wondered if it was possible to calculate the novae rate of the Andromeda Galaxy. We also wanted to compare that rate to other spiral galaxies. Scion Image software was used to examine images taken at Kitt Peak National Observatory between 1996 and 2002. About 90 nova candidates were either confirmed or discovered. The novae rate for M31 was calculated to be 15 novae/year, which is about half the value that most astronomers have calculated. We found, however, if other spiral galaxy novae rates were averaged, the value of 17.5 novae/year was obtained which, of course, is much closer to our value of 15 novae/year. Due to time constraints we were not able to determine the reason for this discrepancy but recommend that the astronomy class next year investigate this more fully.

Introduction

For thousands of years man has studied the sky. He has wondered and conceived theories about why the universe is the way it is. We as students of astronomy in the year of two thousand and three are no different from our predecessors. As our curiosity is appeased by certain documents and data, the questions that we have just answered raise others. One of these mysteries is the evolution of the star. A nova is a faint star that rapidly becomes much brighter, sometimes 10,000 times more intense, and then fades over an extended period of time. This increase in intensity is caused by hydrogen-rich material accreting from a companion star in the binary system and thus, causing intense thermonuclear reactions to occur. As the hydrogen is burned up the nova will fade again. The nova will ultimately reach the end of its life cycle as a star when it becomes a white dwarf (1).

The Andromeda Galaxy, M31, is an interesting celestial object to study because it is similar to our own Milky Way Galaxy. Andromeda is a spiral galaxy about 2.4 million light years away and is twice as large as our own Galaxy.

Studying the novae of the galaxy M31 has given us a chance to interact with our universe. By stacking and animating various images, novae are revealed and once the coordinates are known, one may find the magnitude of the dying star. Epochs 1 through 27 were examined closely. For this project, however, we are considering only epochs 2 though 39 since they are in consecutive years.

While this report might seem like a finished project, in fact it is far from it. Data in epochs 28-39 from the RBSE CD-ROM version 7.0 (2) were difficult to work with. It seems that a different size CCD was used than in previous observations making comparisons of data in other epochs problematic. Due to this technical difficulty and time constraints our class did not get to examine all of these closely. This data needs to be examined more closely in a future project. Our present research, however, has temporarily satisfied our thirst for knowledge of the heavens.

Methods

On the RBSE CD, provided by the National Optical Astronomy Observatories, many images specifically designed to be "blinked" together in order to look for novae are found. These images were collected over the course of more than six years. Using the program, Scion Image, these images, each with a total of 16 fields with 39 epochs, are blinked together in hopes that one will find a nova candidate.

In the search for nova there are 16 subrasters or fields that are all part of one original image of M31. This image was broken into 16 segments of 512 x 512 pixels each to make it easier to work with (see Figure 1). For each subraster, there are a total of 39 epochs, or times at which the images were recorded. These were divided up among the students working on the project. Each student then took his/her field, stacked the images, and began blinking them together, looking for possible novae.

Once a nova candidate was identified, its x and y coordinates were saved, as well as its right ascension (RA) and declination (DEC). Included with the CD, are the listings of magnitudes of several stars in each subraster. Using these finder stars, one can determine the apparent magnitude of each nova candidate. Several candidates are too close to the edge of the image to record their magnitude, but their coordinates can still be recorded. Once all this information is found, it was arranged in an orderly fashion on the table (see Figure 2). Although 117 novae are listed in our chart, we determined that the same nova was found in more than one epoch, decreasing our total to 90. Those students with an asterisk by their name confirmed nova found by students from Round Valley High School in Springerville, Arizona (3). The nova rate per year was found by computing the average number of novae per epoch. At last this rate was compared to the nova rate of other galaxies.

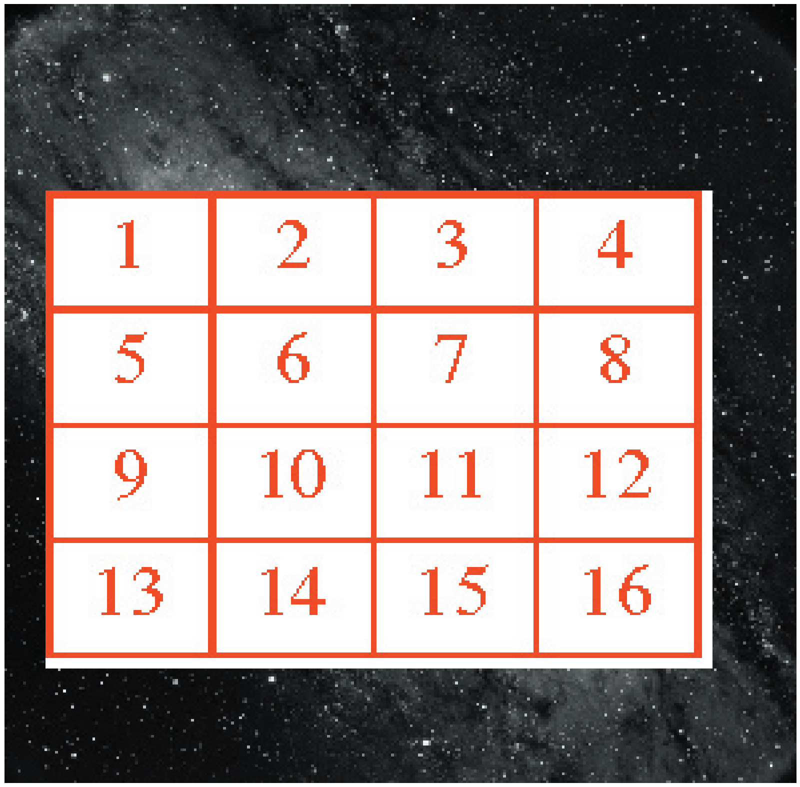


Figure 1: M31 divided into 16 subrasters (not to scale)

Conclusions

The point of this project has been two-fold. First, we searched images from the Kitt Peak National Optical Astronomy Observatory to discover novae. In examining epochs 2-39 we have found 90 novae, which translates into a rate of about 15 novae/year. This number may not entirely accurate, however, since there was difficulty in analyzing the data from epochs 30-39. Second, we did a literature search to see what others had found to be the nova rate for M31 as well as other spiral galaxies. We then compared our observed rate to the others.

Ciardullo (4) determined the nova rates of the following spiral galaxies during two epochs of data: M51: 9 novae and M101: 12 novae. After correcting for effective survey time, Ciardullo (4), found the novae rates/year of 18 +/- 7 and 12 +/- 4 for M51 and M101 respectively. Massimo Capaccioli reports a novae rate of 29 +/- 4 for M31 (5). A rate of 25 +/- 4 novae/year for the Andromeda Galaxy has been reported by Shafter and Irby (6). In his paper "Nova Populations," Della Valle (7) reports the following novae rates for these spiral galaxies: M33: 4.6 +/-.9 novae/year; M101: 12 +/-4 novae/year; M51: 18 +/- 7 novae/year; and M31: 29 +/-4 novae/year.

Most of the research seems to indicate a novae rate for M31 of about 30/year. This is twice the rate we calculated. However, if an average of the novae rates for all the spiral galaxies that we found is calculated, a novae rate of 17.5/year is obtained. We found that even among astronomers the calculation of novae rates is somewhat controversial.

It appears the calculation of the novae rate for M31 is much more complicated than we imagined. Correcting for effective survey time was beyond our capabilities. Still, we feel that our rate of 15 novae/year was at least in the parking lot if not the ballpark.

Field	Epoch	X-Coordinate	Y-Coordinate	Right Ascension	Declination	Magnitude	Student Name
2	1	84.9	192.9	43:09.9	+41:25:33.5	17.73	Melissa
2	3	78.8	247.7	43:10.3	+41:24:56.1	15.17	Melissa
2	4	74.8	242.8	00:43:10.54	+41:24:59.5	15.15	Melissa
2	5	102.8	244.7	43:08.9	+41:24:59.5	14.67	Melissa
2	6	74.8	250.4	43:10.6	+41:24:54.3	15.23	Melissa
2	8	107.1	249.8	43:08.6	+41:24:54.7	15.05	Melissa
2	9	130.6	251.2	43:07.2	+41:24:53.7	13.5	Melissa
2	11	114.2	224	43:08.2	+41:25:12.2	14.25	Melissa
2	12	163	208.9	43:05.2	+41:25:22.5	14.77	Melissa
2	16	124.3	228.6	43:07.6	+41:25:09.1	15.16	Melissa
2	3	78.00	246	00:43.10.42	+41:24:57.3	15.20	Colleen*
2	4	74.00	242	43:09.01	+41:24:59.5	15.15	Colleen*
2	5	103	244	43:08.9	+41:24:58.2	14.70	Colleen*
2	6	74.00	249	43:10.6	+41:25:15.6	?	Colleen*
2	11	102	323	43:09.0	+41:24:02.1	?	Colleen
2	11	113	223	43:08.2	+41:25:08.8	?	Colleen*
2	15	126	226	43:07.5	+41:25:06.0	?	Colleen
2	16	123	227	43:07.6	+41:25:06.2	?	Colleen*
2	3-7	412	505	00:42:19.28	+41:16:12.6	?	Colleen
2	10-11	118	466	00:42:37.04	+41:16:52.7	15.65	Colleen
5	2	377	28	43:23.2	+41:21:37.3	17.39	Derek*
5	3	377	28	43:23.2	+41:21:37.3	17.85	Derek*
5	4	377	28	43:23.2	+41:21:37.3	18.01	Derek*
5	5	377	28	43:23.2	+41:21:37.3	17.52	Derek*
5	6	377	28	43:23.2	+41:21:37.3	17.7	Derek*
5	9	290	23	43:28.4	+41:21:40.7	16.42	Derek*
5	10	290	23	43:28.4	+41:21:40.7	16.65	Derek*
5	11	290	23	43:28.4	+41:21:40.7	16.72	Derek*
5	12	290	23	43:28.4	+41:21:40.7	16.2	Derek*
5	13	290	23	43:28.4	+41:21:40.7	16.44	Derek*
5	14	290	23	43:28.4	+41:21:40.7	16.96	Derek*
6	1	111	462	43:08.3	+41:18:09.4	15.67	Colleen*
6	10	135.8	333.4	43:06.9	+41:18:09.4	15.82	Colleen*
6	11	135.8	333.4	43:06.9	+41:18:09.4	16.01	Colleen
6	12	135.8	333.4	43:06.9	+41:18:09.4	16	Colleen
6	1	115	474	00:43:08.09	41:16:33.8	15.81	Destinee
6	2-7	47	19	00:43:12.20	41:21:43.5	16.97	Destinee
6	10-17	139	342	00:43:06.67	41:18:03.5	15.74	Destinee
6	11	382	431	00:42:52.01	41:17:02.9	17.32	Destinee
6	11	407	341	00:42:50.50	41:18:04.1	18.13	Destinee
6	11	473	336	00:42:46.51	41:18:07.5	16.84	Destinee
6	11	141	360	00:43:06.56	41:17:51.2	17.85	Destinee
6	11	173	296	00:43:04.62	41:18:34.8	18.03	Destinee
6	11	288	331	00:42:57.68	41:18:10.9	18.37	Destinee

Figure 2: Novae confirmed or discovered by the Astronomy Students at Linwood Holton Governor's School

6	18, 19	181	216	00:43:04.15	41:19:29.2	17.35	Destinee
6	21-25	509	121	00:42:44.36	41:20:34.1	?	Destinee
6	24	337	410	00:42:54.74	41:17:17.4	13.89	Destinee
6	26	415	347	00:42:50.05	41:18:00.3	18.54	Destinee
6	28, 29, 30	79	361	00:43:10.33	41:17:50.7	16.65	Destinee
6	31	61	424	00:43:11.36	41:17:07.9	12.69	Destinee
6	31	451	279	00:42:47.84	+41:18:46.5	17.56	Zac
6	32	232	494	00:43:01.04	+41:16:20.2	16.28	Zac
6	1	111	464	00:43:08.34	41:16:40.6	15.89	Zac
6	10	134	332	00:43:06.98	41:18:10.2	15.92	Zac
7	22	108	381	42:37.6	+41:17:37.2	17.53	Zac
7	23	108	381	42:37.6	+41:17:37.2	17.57	Zac
7	1	65	396	00:42:40.22	+41:17:26.9	13.55	Jennifer
7	10	122	449	00:42:36.79	+41:16:50.7	?	Jennifer
7	10,13	233	483	00:42:30.15	+41:16:27.5	?	Jennifer
7	22	112	390	00:42:37.41	?	14.66	Jennifer
7	3	412.5	500.2	42:19.2	+41:16:15.9	15.79	Jay
7	10	119.4	441.8	42:37.0	+41:16:55.5	16.45	Jay
7	10	229.3	474.2	42:30.3	+41:16:33.5	15.73	Jay
7	14	113.5	94.4	42:37.3	+41:20:52.0	17.49	Jay
8	17	30.8	388.3	42:11.4	+41:17:31.19	18.13	Morgan*
8	24	144.3	388.2	42:04.5	+41:17:31.7	14.32	Morgan
8	2	386.9	21.9	41:49.9	+42:21:41.5	16.76	Morgan
8	1	194.8	203.1	42:01.5	+41:19:38.2	16.8	Morgan*
8	2	176.4	122.4	42:02.6	+41:20:33.1	18.78	Morgan*
9	24	396	327	43:22.0	41:11:16.7	16.7	Zac
10	1	471	441.2	42:46.6	+41:11:07.7	16.66	Jay
10	8	162.2	101.3	43:05.3	+41:14:58.8	15.23	Jay
10	9	109.7	196.4	43:08.4	+41:13:54.1	16.19	Jay
10	19	220.7	43.9	43:01.8	+41:15:37.9	14.75	Jay
10	19	422.1	92.2	42:49.6	+41:15:05.0	16.56	Jay
10	14	473.1	116.3	42:46.5	+41:14:48.6	16.34	Jay
10	28	155	337	43:05.7	+41:12:18.4	15.67	Jay
10	28	195	347	00:43:03.32	+41:12:11.6	15.66	Zac
11	1	253	227	00:42:28.87	41:13:33.5	16.66	Destinee
11	2	79	137	00:42:39.37	41:14:34.7	14.22	Destinee
11	3	205	130	00:42:31.77	41:14:39.5	15.79	Destinee*
11	5	290	448	00:42:26.65	41:11:02.9	16.82	Destinee*
11	8	376	343	00:42:21.47	41:12:14.5	17.09	Destinee*
11	8	18	168	00:42:43.08	41:14:13.6	17.43	Destinee
11	9	99	420	00:42:38.19	41:11:21.9	17.94	Destinee
11	11	98	194	00:42:38.25	41:13:55.8	17.34	Destinee
11	14	369	410	00:42:21.89	41:11:28.7	16.89	Destinee
11	16	369	410	00:42:21.89	41:11:28.7	17.55	Destinee
11	17	10	410	00:42:43.56	41:11:28.7	16.51	Destinee*
11	20	237	63	00:42:29.36	41:15:25.1	15.18	Destinee

Figure 2 (cont.)

11	25	325	36	00:42:24.57	41:15:43.4	18.45	Destinee
11	28-30	228	138	00:42:30.43	41:14:34.0	17.93	Destinee
11	3	200	126	00:42:32.07	41:14::42.2	15.79	Zac
11	18	92	160	00:42:38.61	41:14:18.8	15.72	Zac
11	20	233	59	00:42:30.11	41:15:27.8	15.18	Zac
11	31	71	244	00:42:39.86	41:13:21.6	15.86	Destinee
12	2	170.6	387.4	42:02.9	+41:11:44.3	16.83	Melissa*
12	20	234	60	42:30.4	+41:15:27.0	15.18	Zac
12	2	170.6	387.4	42:02.9	+41:11:44.3	16.81	Derek*
12	2	37	249.2	42:11.0	+41:13:18.4	18.02	Derek
12	3	78.5	130.6	42:08.5	+41:14:38.9	10.59	Derek
12	24	322.7	194.6	41:53.8	+41:13:55.0	14.52	Derek
12	24	390.5	251.7	41:49.7	+41:13:16.1	15.12	Derek*
12	24	247.1	93.6	41:58.3	+41:15:03.9	18.25	Derek*
12	23-27	431	42	00:41:47.22	+41:15:39.2	19.03	Jay
13	9	336.8	450.6	00:43:25.64	+41:05:12.6	17.83	Farhan
14	25	298	269	42:57.1	+41:07:16.2	17.04	Jay
14	25	298.8	269.3	42:57.1	+41:07:16.2	16.69	Morgan
15	12-18	356	11.6	00:42:22.67	+41:10:11.5	16.23?	Derek
15	13	172.1	473	00:42:33.77	41:05:57.4	15.16	Derek*
15	14	172.1	473	00:42:33.77	41:05:57.4	16.77	Derek*
15	15	172.1	473	00:42:33.77	41:05:57.4	17.33	Derek*
15	16	172.1	473	00:42:33.77	41:05:57.4	17.37	Derek*
15	17	172.1	473	00:42:33.77	41:05:57.4	18.85	Derek*
16	1	237	491	41:58.9	+41:04:45.4	14.7	Colleen
16	2	237	491	41:58.9	+41:04:45.4	14.74	Colleen
16	11	237	491	41:58.9	+41:04:45.4	14.75	Colleen

* confirmed novae

Figure 2 (cont.)

References

1. Chaisson, Eric and McMillan, Steve. Astronomy Today, 3rd ed. Prentice Hall Publishers, 1999.
2. Rector, Travis. “M31 Data.” Teacher Leaders in Research-Based Science Education RBSE Data CD-ROM, version 7, National Optical Astronomy Observatory, November 2002.
3. Calver, Tim, et al. “Do Nova Repeat? A Study of Novae Discovered in M31 Between the Years 1980-2000.” The RBSE Journal. p. 27-28; Round Valley High School. Springerville, AZ; 2001.
4. Ciardullo, Robin. Department of Astronomy and Astrophysics, Penn State University. http://www.astro.psu.edu/users/rbc/nova_abs.html .
5. Cappaccioli, Massimo, et al. “Properties of Nova Population in M31.” NASA/IPAC Extragalactic Database. 1989. http://ned.ipac.caltech.edu/cgi-bin/nph-ex_refcode?refcode=1989AJ.....97.1622C.
6. Shafter, Allen and Irby, Brian. “On the Spatial Distribution, Stellar Population, and Rate of Novae in M31.” NASA/IPAC Extragalactic Database. 2001. http://ned.ipac.caltech.edu/cgi-bin/nph-ex_refcode?refcode=2001ApJ...563..749S
7. Della Valle, Massimo. “Nova Populations.” http://arxiv:astro-ph/0210276 v1, 12 Oct 2002.

Patterns in the Occurrence of Novae

Josh Feidler and Brett Shaw
Fairfield Area High School, Fairfield PA
Teacher: Carl Katsu, RBSE '01

Abstract

The purpose of this project is to determine if there is any correlation of any kind in the occurrence of novae. There was no pattern that was recognizable. There seem to be more novae in the center and as many on the north and east. While there are more stars in the center of the galaxy, one might expect more novae because of that, we can't think of why there might be as many novae on one side of the galaxy than the other.

Procedures

There were two sets of data iImages folders to go through. As this is the first time the project has been attempted by those carrying it out, there is no past data to work around. As stated above, the program used was SCION Image. Several sudden appearances were noted on the screen and listed as 'Novae'. The novae are listed in Table 1.

Data

The data following after the text represents all data gathered for this assignment. The dash marks in each cell stands for the fact that nothing was observed in that Image. Two or more of the same Image number in a row means that more than one novae was observed on that Image. Figure 1 shows an image of the galaxy that is broken into sixteen segments. Each segment corresponds to a folder in the RBSE data. In each segment, the number of the slide that a nova was found on is marked in the location where it was found.

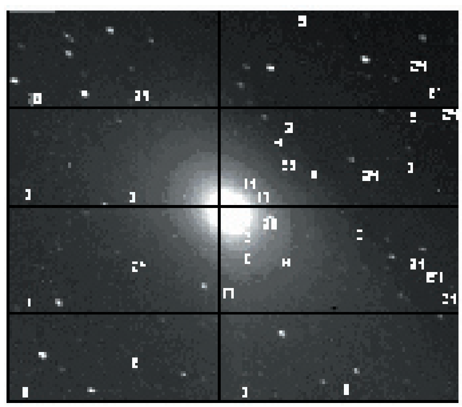


Figure 1.

Conclusion

There appears to be nothing relating the occurrence of novae to one another, other than the fact that there seemed to be a nova on the 24th slide (m31e24yy) there was no pattern that was recognizable. There seem to be more novae in the center (folders 7 and 11) and as many on the north and east sides (folders 4, 8, and 12). There are more stars in the center of the galaxy, so one might expect more novae there because of that fact, we can't think of why there might be as many novae on one side of the galaxy than the other.

	Appearance of Novae/ Image Numbers-RBSE 2002					
F01	-	-	-	-	-	-
F02	24	-	-	-	-	-
F03	5	-	-	-	-	-
F04	24	24	-	-	-	-
F05	-	-	-	-	-	-
F06	-	-	-	-	-	-
F07	3	9	10	14	14	23
F08	2	3	24	24	-	-
F09	-	-	-	-	-	-
F10	24	-	-	-	-	-
F11	3	8	17	18	20	-
F12	3	24	24	24	-	-
F13	-	-	-	-	-	-
F14	2	-	-	-	-	-
F15	-	-	-	-	-	-
F16	-	-	-	-	-	-

	Appearance of Novae/ Image Numbers- RBSE 2003			
F01	10	-	-	-
F02	-	-	-	-
F03	5	-	-	-
F04	25	25	-	-
F05	-	-	-	-
F06	1	11	24	31
F07	4	10	-	-
F08	3	5	23	-
F09	-	-	-	-
F10	-	-	-	-
F11	-	-	-	-
F12	25	-	-	-
F13	-	-	-	-
F14	2	3	24	25
F15	-	-	-	-
F16	24	-	-	-

Table 1.

Is the Magnitude of a Nova Greater Towards the Galactic Middle or the Outer Edge?

Brenna Green
Franklin Central High School, Indianapolis, IN
Teacher: Jim Hoffman, RBSE '00

Abstract

When I first started studying novas, I couldn't help but ask questions. One of the first ones I asked had to do with novas magnitude. It astounds me to know that not only are there many novas, but many diffrent magnitudes of novas. I couldnt help but think that maybe the nova magnitude changed by its location. I then asked the question ," Is there really a diffrence in the magnitudes of the nova in the galactic middle and the galactic outer edge, or does this seem to vary by looking from the naked eye?"

When starting research on novas magnitude and location I learned alot about their background. Novas have always been studied, they aren't new to researchers at all. They have been charted and studied by astronomers 100's of years ago, when interst in the sky first beame poplular.

I started my research on "RBSE". At first it took me a long time to get started but i picked up the pace when it became routine. The first step was to find the nova in each field , some fields though did not have novas in them, those were dropped. In the fields that did have nova, the magnitudes of the unknown nova was recorded and logged. This process was repeated in each of the 16 fields that contained novas. After all the data was logged from all 16 fields, they were divided up in to galactic center and galactic outer edge, these are as follows {(fields 6, 7, 10, 11, were the considered galactic cneter) and (fields 1, 2, 3, 4, 5, 8, 9, 12, 13, 14, 15, 16, were considered galactic outer edge)} After this was done the fields magnitudes in the galactic center were compared to the fields magnitudes on the galactic outer edge.

Background

One of the first cases regaurding the heavens as not fixed and changing was that of the novae, stars that suddenly flare into view. Nova, meaning "new star", comes from ancient civilazations that thought that these events were the making of new stars, which in reality isn't true. Instead they are stars near their death. Many of these nova are fairly visible to the naked eye, but some are fairly faint. Their magnitudes vary in number and seem to be diffrent in their location, which brings me to my question.

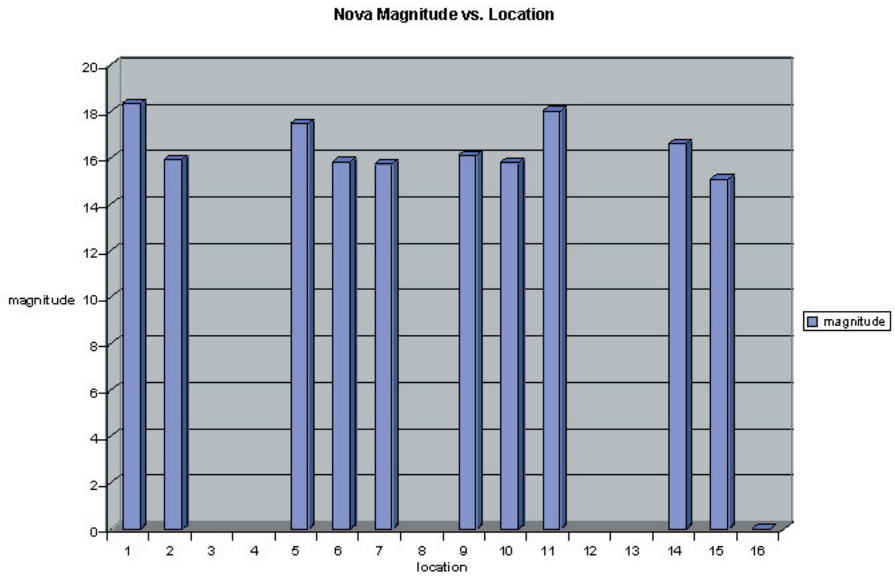
Question

Is there really a diffrence in the magnitudes of the nova in the galactic middle and the galactic outer edge, or does this seem to vary by looking from the naked eye?

Procedure

All of the research was done on RBSE. The first step was to find the nova in each field , some fields though did not have novas in them, those were dropped. In the fields that did have nova, the magnitudes of the unknown nova was recorded and logged. This process was repeated in each of the 16 fields that contained novas. After all the data was logged from all 16 fields, they wered divided up in to galactic center and galactic outer edge, these are as follows {(fields 6, 7, 10, 11, were the considered galactic cneter) and (fields 1, 2, 3, 4, 5, 8, 9, 12, 13, 14, 15, 16, were considered galactic outer edge)} After this was done the fields magnitudes in the galactic center were compared to the fields magnitudes on the galactic outer edge. When comparing the two the data found was logged and then used to make an offical log and a graph (shown in appendix).

Data



Conclusion

The conclusion after conducting research and viewing charts and graphs from information gathered is that no the nova in the galactic center are not of greater magnitude than those found on the gatlactic outer edge. The data gathered did show that the nova in all fields wether in the middle or outer edge did in fact vary. The magnitudes were all diffrent in number. The hypothesis given was proven incorrect, and false.

Bibliography

www.novasearch/research.com

The Lifespan of Novae in the Andromeda Galaxy

Nick Clark
Franklin Central High School, Indianapolis, IN
Teacher: Jim Hoffman, RBSE '00

Abstract

The data provided was analyzed in regard to the average lifespan of novae in each field of the Andromeda galaxy. These results were then compared to find a relationship in distance from the center of the galaxy and average lifespan. This was found not to be the case, however, but the data was skewed to the point of being inadequately conclusive. These tainted results came as a result of the incomplete data available and the fact that the epochs were not taken at regular intervals

Question

Does the average life of a nova increase with a decrease in relative proximity to the center of the galaxy?

Procedure

The procedures for completing this research project were as follows: First of all, each field was searched for novae, and each nova's length was recorded. After gathering all the raw data, the averages for the respective fields were taken, and put into a usable and organized format. To complete the research and draw a conclusion, the question: "In what fields, border or center, do the longest average lifespan occur?" was asked and answered.

Conclusions / Reasons for Error

Strictly speaking, the hypothesis was proven incorrect, in that there were more fields with long average lifespan on the outer edges of the galaxy. However, the data did not provide conclusive evidence to support nor disprove the hypothesis adequately, since the data did not show an apparent correlation between distance from the center and the average lifespan.

There were also major flaws in the data collection, which also severely tainted the results. The cause for these can be found in two major problems:

The first problem was because the epochs were not taken at regular intervals, and although much of the resulting error can be solved graphically, there remains inaccuracy and incomplete data.

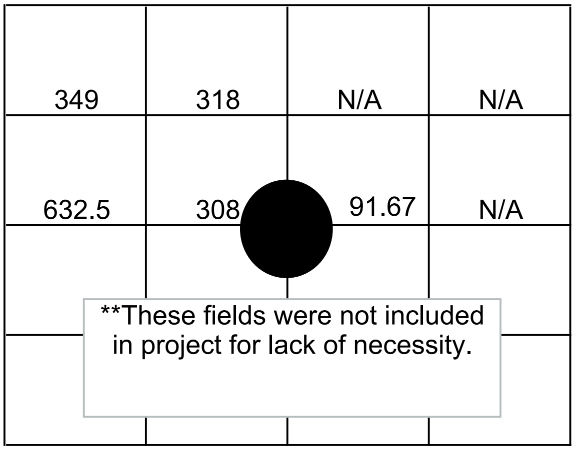
For the sake of argument, say a nova first appeared on epoch 7, August 1, 1997, and was still thriving on epoch 8, November 18, 1997, yet died out before the next epoch was taken more than 6 months later. This shows that the nova did last at least 107 days, but does not tell when it died out. This could be potentially important in that a nova with a more conclusive start-, or end-, point could be counted as being longer, when that could just as easily be untrue. This, compounded with the fact that novae are scarce in the outlying fields, provided only one or two novae to base an average from and thus a large measure of error.

Another point in case was in the nova designated "nova 3" of field 5. This fairly bright nova only appeared on one epoch because the epoch was taken after a long break (107 days) and was not followed up by another epoch for another 198 days. This means that there was a 107 day period in which the nova could have been "born" and a 198 day period in which the nova could have "died." For obvious reasons, this makes even an approximation of lifespan impossible, and therefore makes the data invalid and the average much less accurate.

The second problem came when a nova was spotted, yet epochs were not taken long enough to show the completed life cycle of the nova, or the novae began before the first epoch was taken. This means that any novae which were not "born" before September 3, 1995, or did not die out before November 11, 2002, were not accurately recorded. Again, this, compounded with the scarcity of novae in the outlying fields, skews the results severely.

These conditions were found in many of the fields, marring the data even to the point of making the results practically inconclusive.

Results



**since the distance from the center to the upper-outer fields is the same as the distance to the lower-outer fields, there was a lack of necessity to record novae data in the lower fields.

Data

	complete?	epochs	first/last spotted dates	aprx. lifespan
Field 1				
nova 1:	no	30 to 39	12/23/2001 - 11/11/2002	349 days
Field 2				
nova 1:	no	31 to 39	6/25/2002 - 11/11/02	318 days
nova 2:	no	1	9/3/95	N/A
Field 3				
			~ ~ ~ ~ ~ NO NOVAE FOUND ~ ~ ~ ~ ~	
Field 4				
nova 1:	no	1	9/3/95	N/A
Field 5				
nova 1:	yes	9 to 18	6/6/98 - 6/24/99	576 days
nova 2:	yes	2 to 7	6/18/97 - 8/1/97	689 days
nova 3:	yes	8	11/18/97	N/A
Field 6				
nova 1:	yes	18 to 19	6/24/99 - 7/20/99	173 days
nova 2:	yes	28 to 30	11/2/01 - 12/23/01	338 days
nova 3:	yes	9 to 17	6/6/98 - 1/27/99	429 days
nova 4:	yes	11	7/25/98	N/A
nova 5:	yes	21 to 25	7/17/00 - 11/10/00	292 days
Field 7				
nova 1:	yes	9	6/6/98	N/A
nova 2:	yes	14 to 17	10/14/98 - 1/27/99	142 days
nova 3:	yes	3 to 7	7/23/97 - 8/1/97	44 days
nova 4	yes	10 to 13	7/24/98 - 9/5/98	89 days
Field 8				
nova 1:	yes	2	6/18/97	N/A
nova 2:	no	1	9/3/95	N/A

The Average Maximum Magnitude of Novae in the Andromeda Galaxy

John McDowell
Franklin Central High School, Indianapolis, IN
Teacher: Jim Hoffman, RBSE '00

Abstract

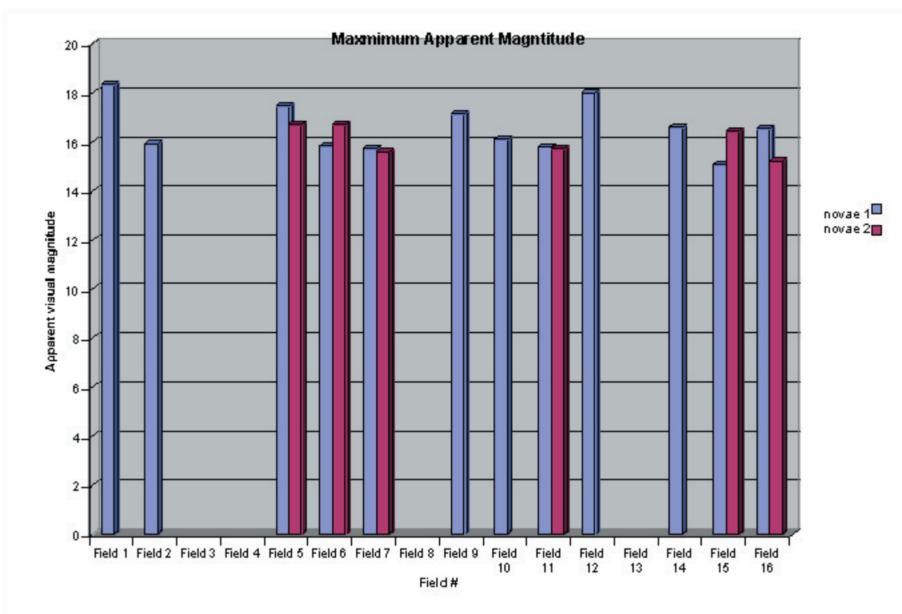
For this project the question, what is the average maximum magnitude of novae in the Andromeda galaxy was asked. The hypothesis concluded was that the average maximum magnitude for novae in the Andromeda galaxy should be somewhere between 15.5 to 16. To find the answer to this question, novae were looked for and found in the Andromeda galaxy. Once found, known magnitudes of other stars were plugged in. Using those known magnitudes the computer could calculate the magnitudes of the novae found. In total 18 novae were found in the different regions of the Andromeda galaxy. Some regions had multiple novae, while others had none. Although the hypothesis was wrong it was not to far off. The average maximum magnitude found was 16.48. See data on graph and chart.

Procedure

What is the average maximum magnitude of novae in the Andromeda galaxy? To find the answer to this question, novae were looked for and found in the Andromeda galaxy. Once found, known magnitudes of other stars were plugged in. Using those known magnitudes the computer could calculate the magnitudes of the novae found.

Discussion

In this research many novae have been found. To keep it accurate at lest one nova in each field was tried to find. The maximum magnitudes of the novae of ranged anywhere from 17.47 to 15.73. The research has come along slowly sometimes having trouble finding novae in each field, not to mention the computer trouble. Some fields seem to have more novae than others, yet that's good because it gives better results the more information is found. Although the average maximum magnitude turned out to be 16.48 there was a large chance of error with the data available to research this topic. For instance the amount of days from epic to epic varied. Two epics could be taken ten days apart or 110. So as you can see the maximum magnitude could have been in the period where no pictures were taken. Making the data collected incomplete at the least.



Conclusions

In total 18 novae were found in the different regions of the Andromeda galaxy. Some regions had multiple novae, while others had none. Although the hypothesis was wrong it was not to far off. The average maximum magnitude found was 16.48. After finding the maximum average magnitude for the available data, continuing once new data was compiled would allow you to see if the average was consistent. If so then maybe there's something more about

Can Novae in M31 be Used as Standard Bulbs?

Joe Chagnon, Juan Quinchia and Dave Coppola
Cranston High School East, Cranston, RI
Teacher: Howard Chun, RBSE '99

Abstract

In this project, novae will be observed in the Andromeda galaxy by comparing images taken weeks or months apart. A technique called blinking is used to search for "new stars" that appear in one image and not the other.

The collected data from the four nova candidates confirmed that the magnitude for a given nova experiences either a severe incline followed by a decline or a decline followed by an incline. Also, the magnitudes of each nova vary because all of the stars that turned into novae had different characteristics. This means that novae cannot be used as standard points to calculate other galactic distances.

Background

A nova is a star that suddenly increases its light output tremendously and then fades away to its former obscurity in a few months or years. Nova literally means "new star". The name comes from ancient civilizations that interpreted these events as the creation of a new star. In reality, however, stars near the end of their lives cause novae. Stars then expand into red giants, giving off massive amounts of helium and hydrogen. After fully expanded, the star will either become a nova or a white dwarf, depending on the size and type of star. The magnitude scale is a logarithmic scale in which each integral step corresponds to a change of approximately 2.5 times in brightness. This scale is used to measure the apparent brightness of an object. Each step in the magnitude is the fifth root of 100, or 2.512 times fainter than the last step. The lower the magnitude number an object has, the brighter the object is. The coordinates used to locate an object in space are composed of right ascension (RA) and declination (DEC). Right ascension is analogous to longitude on Earth; it describes an object's position in East-West direction, and is measured in (hh: mm: ss.ss). Declination is equivalent to latitude, and describes an object's position in North/South direction, and is measured in (dd: mm: ss.ss).

Procedure

Launch Scion Image. Blink images to find novae. Measure the celestial Coordinates. Calibrate the photometer. Measure the magnitudes of the nova candidates. Construct a light curve for each nova candidate (magnitude vs. time in days). The higher magnitude numbers signify a dimmer celestial body. The curve fits that were used for each light curve are as follows: Field 6: Quadratic, Field 10: Quadratic, Field 11: 3rd Degree Polynomial, and Field 14: Quadratic.

Data

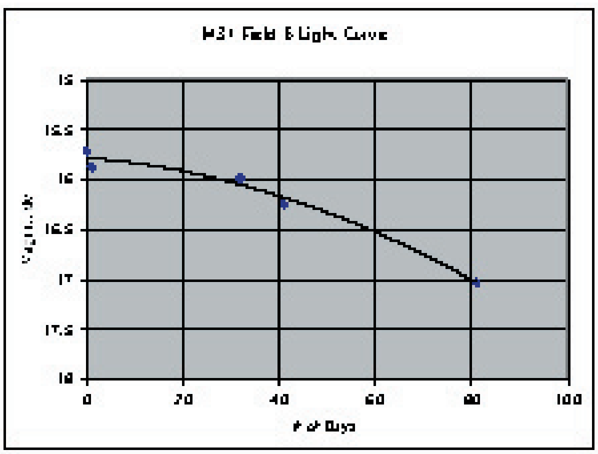
Data were collected from the RBSE files in Scion Image from fields six, ten, eleven, and fourteen. The magnitudes were determined and the life of the novae was calculated by data previously collected. See Table 1 and graphs.

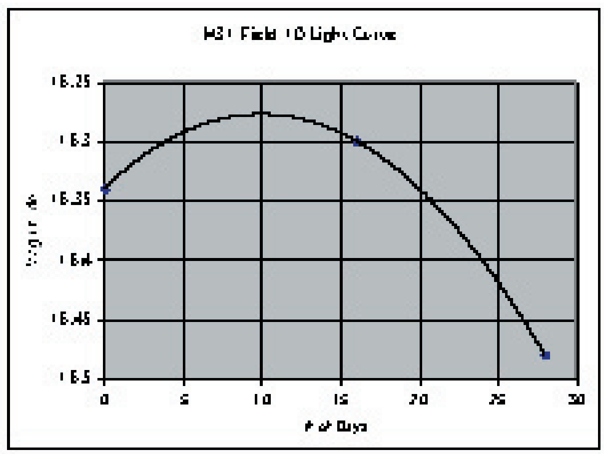
Analysis and Conclusion

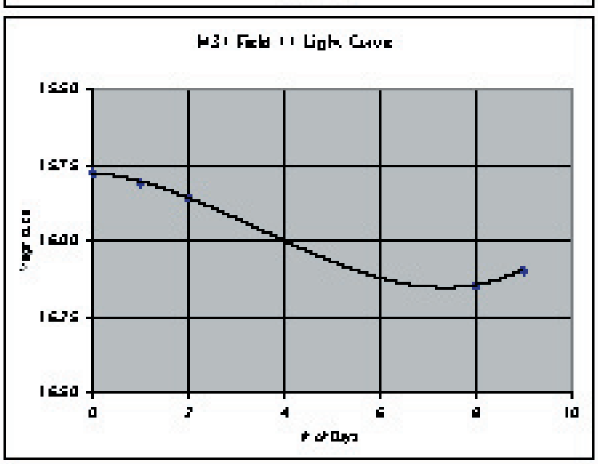
The first part of the hypothesis was not correct. The novae do not all act the same way because the time that it takes for the novae to reach their peak magnitudes that were recorded were all different. The second hypothesis was proved to be incorrect according to the data. There was too big of a difference between the lowest magnitudes. For each one magnitude the brightness increases by a factor of 2.512^(magnitude difference). Therefore, if the change was 2, the difference in magnitude would be 2.512^2. It is for this reason that the novae cannot be used as standard "bulbs" to determine the distances between other galaxies and the Milky Way.

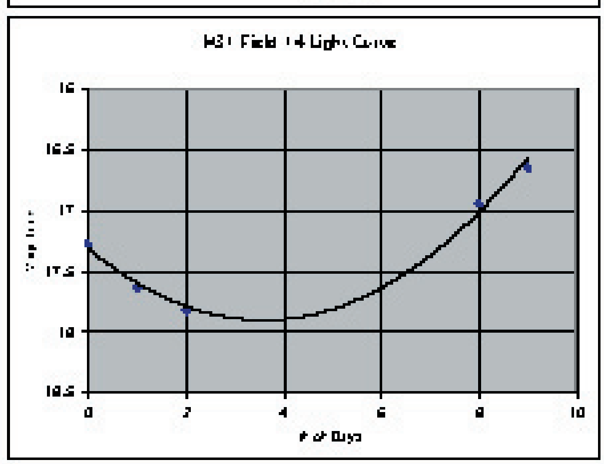
Table 1

Field #	RA (hh:mm:ss.ss)	DEC (dd:mm:ss.ss)	Epoch Date (y/m/d)	Magnitude
6	00:43:06.89	41:18:09.80	7/24/98	15.72
6	00:43:06.89	41:18:09.80	7/25/98	15.88
6	00:43:06.89	41:18:09.80	8/26/98	15.99
6	00:43:06.89	41:18:09.80	9/5/98	16.25
6	00:43:06.89	41:18:09.80	10/14/98	17.03
10	00:42:46.55	41:14:40.00	10/14/98	16.34
10	00:42:46.55	41:14:40.00	10/30/98	16.30
10	00:42:46.55	41:14:40.00	11/11/98	16.48
11	00:42:38.53	41:14:16.30	7/23/97	15.78
11	00:42:38.53	41:14:16.30	7/24/97	15.81
11	00:42:38.53	41:14:16.30	7/25/97	15.86
11	00:42:38.53	41:14:16.30	7/31/97	16.15
11	00:42:38.53	41:14:16.30	8/1/97	16.10
14	00:42:50.35	41:07:49.10	7/23/97	17.28
14	00:42:50.35	41:07:49.10	7/24/97	17.63
14	00:42:50.35	41:07:49.10	7/25/97	17.83
14	00:42:50.35	41:07:49.10	7/31/97	16.95
14	00:42:50.35	41:07:49.10	8/1/97	16.65









Does Distance Affect Types of AGN?

Michelle Miller & Randy Buhrman
Fairfield High School, Fairfield, PA
Teacher: Carl Katsu, RBSE '01

Abstract

In our project, we tried to figure out if there was pattern of what kind of Active Galactic Nuclei (AGN) is closer, and what kind is farther away. To do this, there were many steps. First we had to identify AGN from other galaxies. Then we measured some of the wavelengths so we could figure out what kind of elements it has in it. After that we measured some of the wavelengths so we could figure out what the red shift of the AGN were to tell how far away they are. After all that is done, we had to divide up the AGN according to types and their distances. We looked at a couple hundred spectra graphs. Out of those, we found 19 AGN. We found that the BL-Lac galaxies are the most distant, on the average, and quasars are more distant than radio galaxies.

Background

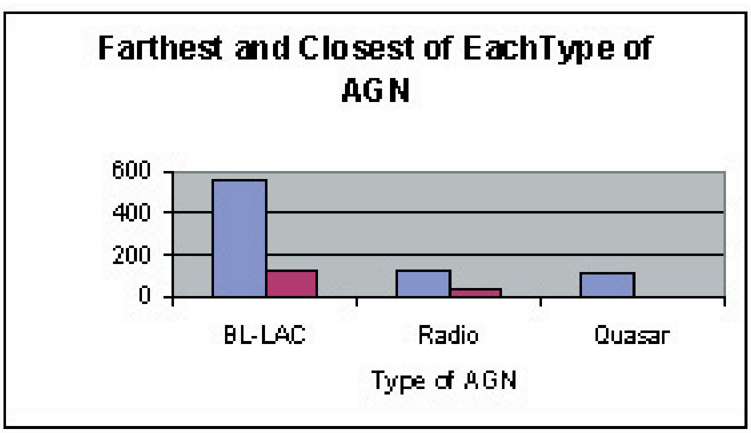
The universe is filled with many different kinds of galaxies. Many of them are called Active Galactic Nuclei (AGN). AGN are galaxies that produce enormous amounts of energy. Most of the energy is found in the nucleus of the galaxy. All galaxies emit radio energy, but the amazing thing about AGN is that most of it is based in the center. When looking at AGN, it almost looks like a normal galaxy, but once you focus in on the center, it is very obvious that it is not normal. AGN are just one kind of many different kinds of galaxies, but there are also different kinds of AGN. Some of the different kinds of AGN are Radio, Quasars, and BL-LAC.

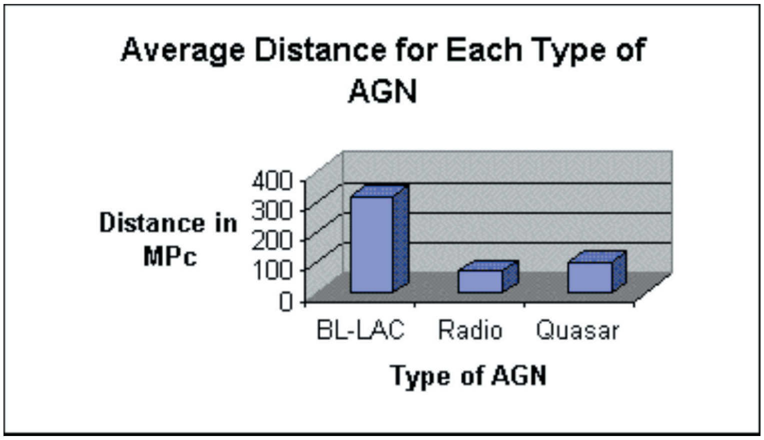
Hypothesis

My partner and I think that the distance will have no effect on where there are different kinds. We think this because we don't see a reason why distance would effect the types of AGN. The only possible connection might be that certain types of AGN evolved earlier in the history of the universe, and are thus farther away now, and other types of AGN took longer to evolve and thus are closer to us.

Conclusion

We have looked at many charts of all the different AGN and have identified what types they are and their distance from earth. So after doing our research and making our calculations we have come to the conclusion that the BL-Lac galaxies are the most distant, on the average, and quasars are more distant than radio galaxies. We are not sure how to explain this. Knowing more about the dynamics of each type of AGN might give us clues in their evolution. This could give us clues as to why the BL-Lac are not found near us in time or space, and why radio galaxies are.





Calculated Distances of
AGN in MPc

Quasar	Radio	BL-LAC
117.86	39.67	125.53
1.2	121.74	555.5
3.98	59.36	277.4
94.53	75.04	
75.04	67.2	
94.56		
15.91		
7.89		
56.58		
47.56		
39.67		

The Redshifts of Unknown AGN

Riley Trickett and Rachel Wolcott
Fairfield High School, Fairfield, PA
Teacher: Carl Katsu, RBSE '01

Abstract

In this experiment we have been trying to find the locations of active galactic nuclei, which have not been found already. To find this we are finding the red shifts of each AGN. So far we have found AGN, but we haven't yet found their red shifts. The results of this project may be useful to astronomers who do not have enough time to find the locations of AGN themselves.

The Problem

The goal of this project is to locate new active galactic nuclei using the program "Graphical Analysis". We will find the red shift of each active galactic nuclei to see how far from earth they are located, and if there is any pattern to their distribution.

We may find many active galactic nuclei located at certain distances, we may not find any pattern: they could be distributed randomly. No factors will really affect our project, for there are no factors that we are controlling.

Active Galactic Nuclei Background

AGN (Active Galactic Nuclei) are very interesting and incredible aspects of our universe and many others. AGN (as they will be referred to from here on) are generally only viewable through X-Ray astronomy because they are not only galaxies in their own right, but they are also surrounded by immense volumes of gaseous clouds that make most other astronomy forms useless to view and study them. This report will give you a general overview of what AGN are exactly and some history related to them.

AGN more technically are galaxies that emit very powerful energy rays (generally in the X-ray and beyond range). This energy has tended to emit from the center of this specific type of galaxy, or the nucleus. Hence the active galactic nuclei name and concept. There are actually some different types of AGN, notably Starburst galaxies, Radio galaxies, Quasars, and BL Hac objects. Thus far, from what I have looked into, many astronomers believe that AGN are caused b some sort of gravitational activity towards the center of the galaxy. This seems to generally be a result of a black hole near the galaxy that pulls matter from The galaxy into it and then reverbs that energy and feeds it back out into the galaxy and nucleus to emit large forces of energy. Quite the interesting concept. That is the basic informati8on on AGN, explanations of the afore mentioned types of AGN are not so much of a concern with our project there fore will not be explained. The main thing to understand here is what an AGN is and how it works in simple terms for the time being.

The Hypothesis

We expect to find AGN, and then find the red shifts of each AGN. Red shifts tell us how far each AGN is from us. We expect they will be located in certain areas of the universe, because there are none near by. The null hypothesis would be that we find no pattern to the distribution of AGN. Without any pattern the AGN could be any distance from earth.

Data and Observations

While testing we specifically observed the emission lines, Red Shift, and distance of the AGN specimen that we were given. All of those were key elements in the data we wanted to collect; therefore they were all very relevant. Each data value also influenced others; for instance the distance can be found with the Red Shift. However the emission lines are needed to find the Red Shift and so forth. So in turn, everything was relevant in some way to the success of the project. The main condition that was different each time we tested was the actual specimen. That would only make sense however since all AGN are not the same. Since they were all different the main important difference was the emission lines, which are consequently the most important part of the data gathering process. So really, all the conditions were different each time we performed a test of the specimens.

Discussion

The red shifts are different on each AGN because each AGN is a different distance from us. Therefore, there could be no pattern. There were no factors controlled by us in this project. There is a possibility that we may have made errors when we were determining whether each file was an AGN or not, finding the elements in each AGN or figuring the red shifts or distances. If we calculated correctly each time these particular AGN are measured the results will be the same, but we cannot say the same for any other AGN that might be tested.

Conclusion

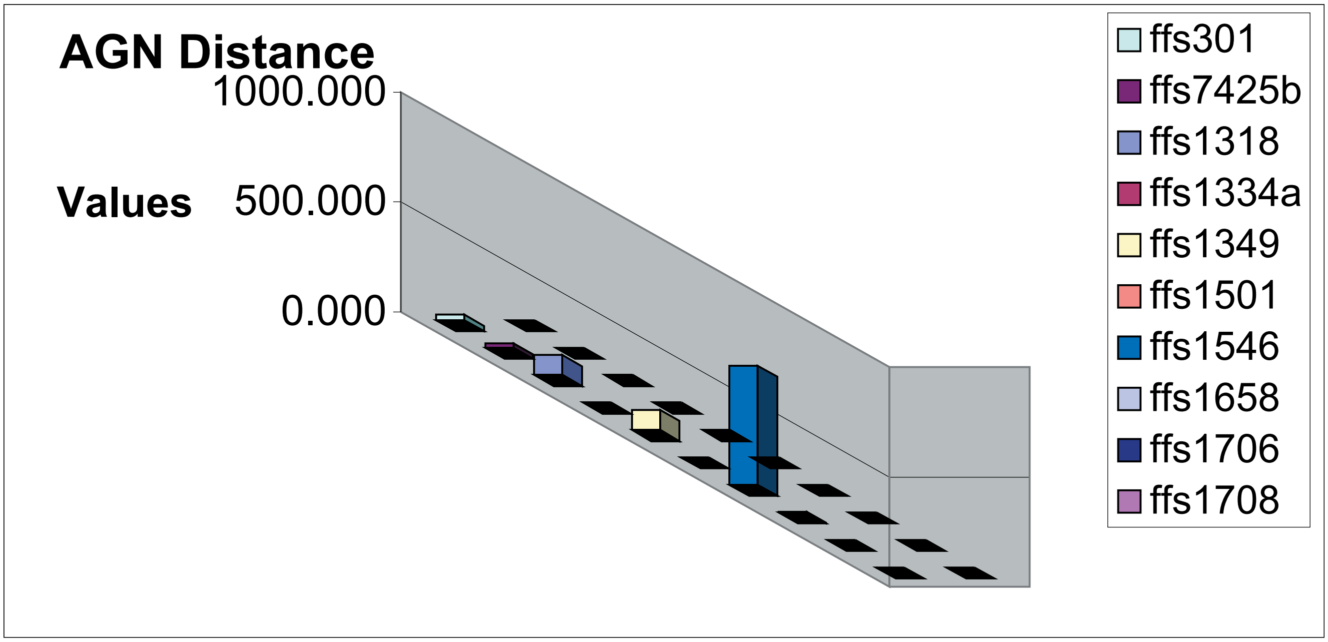
As a result of this project, we were able to find some real samples of AGN in the universe. We also looked at the Red Shift and the distances of the AGN specimen. The larger the shift, the further an object is away in the universe. Finally, our hypothesis was correct, as we were able to find specimens, Red Shifts, and distances of the former. Overall, this project was a success.

Active Galactic Nuclei Data Sheet

Object Identification	*Year*	*Right Ascension*	*Declination*	*Distance (in MPC)*	*Red Shift*
ffs301	2002	3h01m	1º18m	23.848	0.006
ffs7425b	2002	7h42m	54º44m	19.880	0.005
ffs1318	2002	13h18m	35º32m	90.662	0.023
ffs1334a	2002	13h34m	30º44m	0.796	0.002
ffs1349	2002	13h49m	35º24m	90.662	0.023
ffs1501	2003	15h01m	56º19m	0.796	0.002
ffs1546	2003	15h46m	26º21m	543.920	0.643
ffs1658	2003	16h58m	36º05m	2.780	0.007
ffs1706	2003	17h06m	50º49m	1.590	0.004
ffs1708	2003	17h08m	33º46m	1.590	0.004

Graphing Table Conversions

Object Identification	*Distance (in MPC)*	*Red Shift*
ffs301	23.848	0.006
ffs7425b	19.880	0.005
ffs1318	90.662	0.023
ffs1334a	0.796	0.002
ffs1349	90.662	0.023
ffs1501	0.796	0.002
ffs1546	543.920	0.643
ffs1658	2.780	0.007
ffs1706	1.590	0.004
ffs1708	1.590	0.004



The Search for Neutral Iron Emission Lines in Quasar Spectra

Amy Fearing and Laura Walker
Cranston High School East, Cranston, RI
Teacher: Howard Chun, RBSE '99

Abstract

Powerful Active Galactic Nuclei have been shown to have strong neutral iron emission lines (redshifted from 5576 angstroms). The objective of this research is to determine if very strong AGN such as quasars also have these neutral iron emission lines. The results show that quasars do not exhibit neutral iron lines. Perhaps quasars are so powerful that neutral iron no longer exists. They have already ionized iron long ago. However, less powerful AGNs such as radio and elliptical galaxies did display neutral iron emission lines.

Background

In "X-rays Show A Galaxy Can Have Two Hearts" from Science Magazine from November 29, 2002, Alexander Hellemans presents information about neutral iron emission lines in Active Galactic Nuclei. The unshifted wavelength of neutral iron is 5576 angstroms. The article discussed that weak AGN such as starburst galaxies do not have neutral iron emission lines because they are not energetic enough to excite them. It also stated that stronger AGN such as normal and elliptical galaxies and quasars would have these emission lines.

Another article from http://www-astronomy.mps.ohio-state.edu/~vester/IronEmission/Kentucky/mvest_ASPvol247p359.ps.gz stated that there were ionized iron lines in AGNs, but did not specifically mention quasars. It was also dealing with ionized iron and not neutral iron, which is what this investigation is looking for.

Yet another article from http://arxiv.org/PS_cache/astro-ph/pdf/0211/0211234.pdf states again that there are often strong FeK alpha lines that are present in AGNs. However, this one includes information about strongly ionized iron lines in quasar spectrum. These iron lines are present, which suggests that there may also be neutral iron lines present in the spectrum.

Purpose

The purpose of this study is to determine if quasars exhibit strong emission lines from neutral iron.

Procedure

Active Galactic Nuclei (AGN) were analyzed using the Graphical Analysis program. The spectrums of the AGNs were observed and classified as a radio galaxy, a starburst, a normal or elliptical galaxy, a BL Lac, or a quasar. If no calcium break was observed and the redshift was equal to or greater than 0.5, then the AGN was classified as a quasar. For all of the quasars observed, it was determined if the redshifted neutral iron emission line was present. The redshifted emission line for neutral iron was found by multiplying the redshifted value plus one and the unshifted wavelength of neutral iron (5578 angstroms).

Calculations

(Redshift + 1)*(Unshifted neutral iron wavelength) = Calculated Wavelength
(0.52+1)*(5576) = 8475 Angstroms
*This emission line is then observed on the spectrum to check if it actually exists.

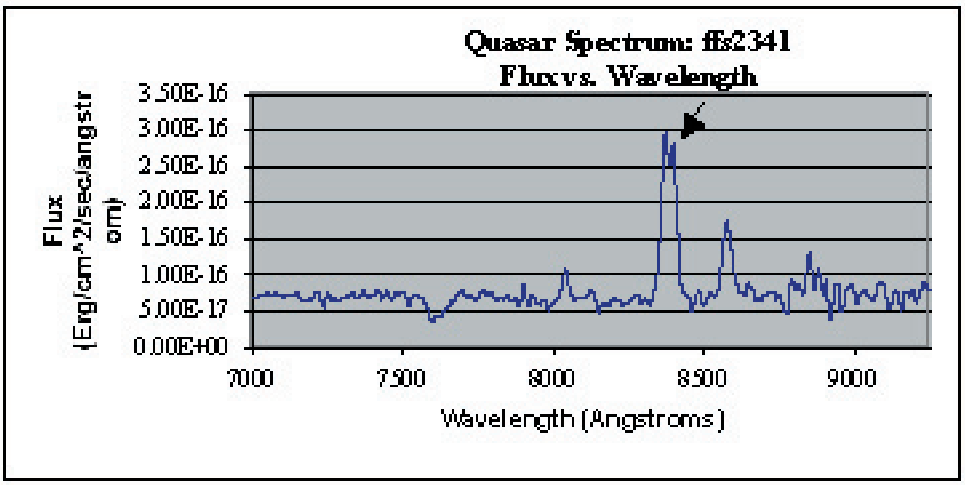
Conclusion

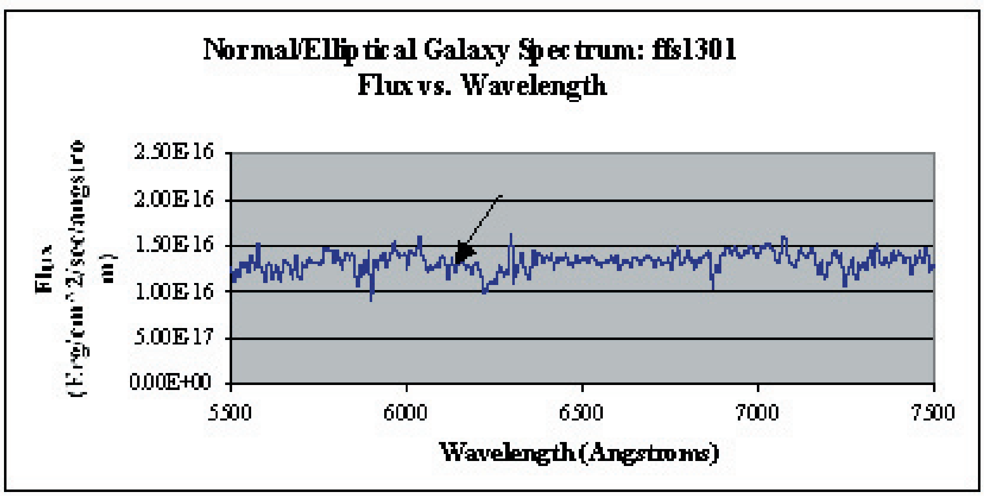
The hypothesis was incorrect. Most of the quasars did not exhibit neutral iron emission lines. There are few quasars with this emission line because the quasars are so hot that they may have ionized past neutral iron. The only quasar with a definite neutral iron emission line was ffs2341. The results of the data varied. Most of the quasars had very small neutral iron emission lines, some had no neutral iron emission lines, and only one quasar had an emission line that was in the spectrum region where neutral iron could be seen. The emission lines listed as actual wavelengths were not strong enough to be considered neutral iron emission lines. The lines were possible noise from when the spectrum was taken. Lines listed as "na" and "not definitive" were expected wavelengths that were past the end of the spectrum on the plot. There were several spectrums with no lines at all. The only emission line that was definitive was ffs2341, the last listing on the chart.

Upon further research of other AGN, it was found that there were no neutral iron lines in the BL Lacs or starburst galaxies. However, there were neutral iron lines in the radio galaxies and the normal or elliptical galaxies. These stronger AGN did have the neutral iron emission lines, even though quasars did not show strong emission lines.

References

1. Hellemans, Alexander. "X-rays Show a Galaxy Can Have Two Hearts." Science Magazine. 29 Nov 2002. Vol. 298. 1698.
2. http://www-astronomy.mps.ohio-state.edu/~vester/IronEmission/Kentucky/mvest_ASPvol247p359.ps.gz
3. http://arxiv.org/PS_cache/astro-ph/pdf/0211/0211234.pdf
4. www.sunspot.noao.edu/sunspots/pr/linezoo.com





Name	Redshift +1	Calculated λ (ang)	Observed λ (ang)	Classification
ffs0040	1.22	6802	6790	radio galaxy
ffs0254	1.13	6300	no line	Bl Lac
ffs0738a	1.216	6780	6770	normal/elliptical galaxy
ffs0728	1.285	7165	no line	Bl Lac
ffs0800	1.027	5726	5715	radio galaxy
ffs0817	1.12	6245	no line	starburst galaxy
ffs1049	1.5	8364	no line	starburst galaxy
ffs1301	1.1	6133	6133	normal/elliptical galaxy

Results of quasars

Name	Redshift +1	Calculated λ (Ang)	Observed λ (Ang)	Notes
ffs0020	1.46	8140	8127	not definitive
ffs0747	1.48	8252	8292	not definitive
ffs0955	1.48	8252	8301	not definitive
ffs1011	1.47	8196	8169	not definitive
ffs1036b	1.46	8140	8139	not definitive
ffs1119	1.52	8475	8406	not definitive
ffs1157	1.54	8587	8592	not definitive
ffs1238	1.46	8140	8250	not definitive
ffs1334a	1.5	8364	8431	not definitive
ffs1359	1.53	8531	8547	not definitive
ffs1410	1.54	8589	8587	not definitive
ffs1427	1.5	8364	na	off scale
ffs1439	1.5	8364	na	off scale
ffs1501	1.46	8140	8137	not definitive
ffs1534a	1.46	8140	8185	not definitive
ffs1557	1.46	8140	8195	not definitive
ffs1614b	1.46	8140	8163	not definitive
ffs0218	1.54	8589	na	off scale
ffs0722	1.51	8419	8392	not definitive
ffs0737	1.46	8140	8148	not definitive
ffs0742b	1.53	8531	na	off scale
ffs1006	1.53	8531	8537	not definitive
ffs1036a	1.48	8252	8254	not definitive
ffs1152	1.52	8475	8506	not definitive
ffs1257	1.49	8308	8286	not definitive
ffs1325	1.47	8196	8183	not definitive
ffs1424	1.52	8475	na	off scale
ffs1437	1.51	8419	na	off scale
ffs1534b	1.54	8589	8468	not definitive
ffs1546	1.54	8589	8469	not definitive
ffs1614a	1.51	8419	8419	not definitive
ffs1620	1.46	8140	8227	not definitive
ffs1641	1.53	8531	8583	not definitive
ffs0732	1.5	8364	8358	not definitive
ffs0740	1.5	8364	8320	not definitive
ffs0811b	1.5	8364	8359	not definitive
ffs0847	1.5	8364	8378	not definitive
ffs0928	1.5	8364	no line	
ffs1011	1.46	8140	8200	not definitive
ffs1036b	1.47	8196	no line	
ffs1119	1.47	8196	8235	not definitive
ffs1157	1.49	8308	8305	not definitive
ffs1238	1.49	8308	8260	not definitive
ffs1334a	1.46	8140	8134	not definitive
ffs1344	1.49	8308	8297	not definitive
ffs1359	1.49	8308	8307	not definitive
ffs1410	1.47	8196	8195	not definitive
ffs1427	1.47	8196	na	off scale
ffs1439	1.47	8196	na	off scale
ffs1501	1.52	8475	8482	not definitive
ffs1534c	1.47	8196	8206	not definitive
ffs1557	1.47	8196	8190	not definitive

Starbursts and their Redshifts

Amie MacMath, Amy Hierhager and Louis Alessi
Allentown High School, Allentown, NJ
Teacher: Linda Stefaniak, RBSE '00

Abstract

A starburst galaxy is a galaxy experiencing a period of intense star forming activity. Although this activity may last for ten million years or more, that is like a month in the life of a ten billion year old galaxy. During a starburst, stars can form at tens, even hundreds of times greater rates than the star formation rate in normal galaxies. Many of these newly formed stars are very massive and very bright, so starburst galaxies are among the most luminous galaxies. In order to better understand starburst galaxies, the increase of wavelength of electromagnetic radiation caused by the Doppler Effect was studied. It was predicted that all Starburst galaxies would have similar redshifts. By doing extensive research, using Graphical Analysis software, the redshifts were calculated and then compared. After evaluating the redshifts, a conclusion was made that all Starburst galaxies do not display the same redshifts.

Purpose

The purpose is to determine whether all of the starburst galaxies that were studied demonstrated equal redshift calculations. If the redshifts are the same then it can be concluded that the galaxies reside at the same distance from the earth.

Procedure

Using Graphical Analysis from Vernier software, it was determined that the galaxies FFS 2341, FFS 0148, FFS 0817, FFS 0859, and FFS 1641 belonged to the Starburst family. The galaxies were categorized as starburst galaxies based on a few very distinct characteristics. Starburst galaxies have strong and narrow emission lines, and their Hb and OIII lines are about the same strength. The same is true for their Ha and NII emission lines; however since these two lines are so close to each other they are usually "blended" together. Once five Starburst galaxies were identified, calculations of the wavelength ratio were performed using peaks on the spectrum graph. When a peak was matched, the numbers were inserted into an Excel spreadsheet to determine if the redshifts matched. The redshifts were calculated using the formula 1+z = lobs/lrest. After proving that the redshifts were quantitatively equal, the redshifts were recorded into a customized Excel graph that would display the wavelengths and redshifts (see attached). Once all of the redshifts were recorded, it could be concluded that the redshifts were not significantly similar throughout the galaxies studied.

Control and Error Analysis

Although it was said that the galaxies studied were determined to belong to the starburst family, the information was based solely on the visual comparison of a known starburst galaxy. Also, a limited amount of starburst galaxies were provided, therefore allowing only a certain number to be analyzed.

Data and Analysis

The Starburst galaxies that were chosen had to be visually analyzed based on a known starburst galaxy. The spectra of the study group appear below. By first finding the redshifts of each galaxy, the data found could be put into a Redshift Comparison Chart to help compare redshifts in a more organized way. Although the redshifts of the starburst galaxies were somewhat similar, they did not have equal redshifts. The data table below lists the wavelengths, tentative elements, and redshifts.

Conclusion

From this information, it can be concluded that the starburst galaxies studied were probably not formed at the same time. Since their redshifts were different, they are moving at different speeds and they reside at different distances from the earth. These results may help future studies of starburst galaxies and their redshifts.

References

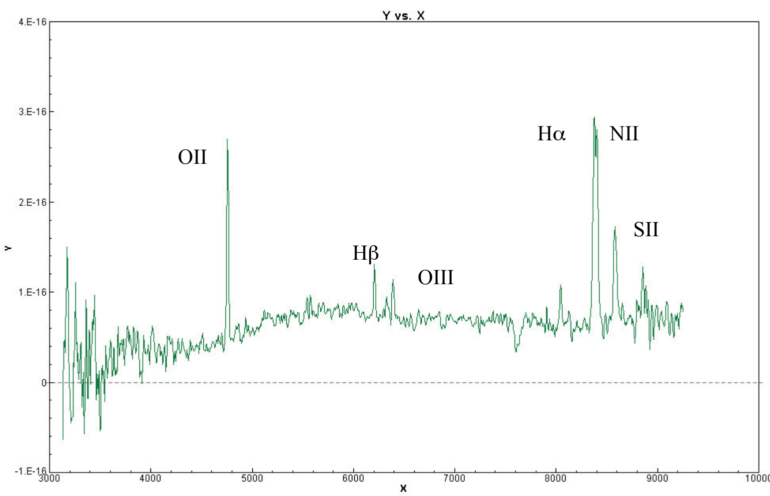
Chitre, A. "Starbursts and Galaxies Evolution." PRL's Astronomy and Astrophysics division. Sat Jan 30 1999. PRL, A & A division. January 13, 2003. <http://www.prl.ernet.in/astronomy/starbursts.shtml>

Ian Stevens, Trevor Ponman, Antonis Georgakakis, Lesley Summers, Jimena Bravo Guerrero and Jo Hartwell. Galaxies: Starburst Galaxies. November 24, 2000 <http://www.sr.bham.ac.uk/research/starburst.html>

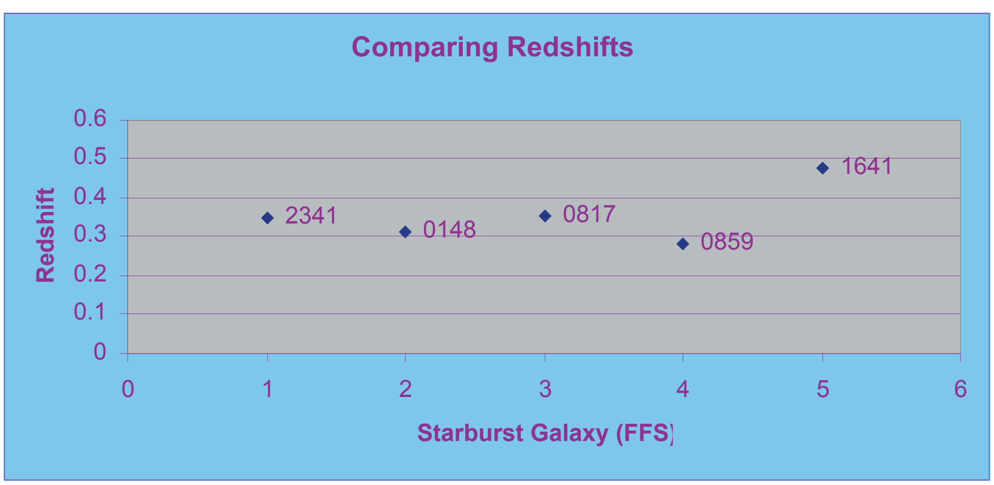
AGN Spectroscopy. "Studying natures most powerful 'monsters.' " RBSE Article. Rev. July 5, 2000

Redshift Comparison Chart

Starburst Galaxy	Wavelength 1	Wavelength 2	Wavelength 3	Tentative Elements	1+z	Redshift
FFS 2341	8378.1	6206.5	4599.4	Hα, Hβ	1.3499	0.3499
FFS 0148	7187.1	5465.1	4154.6	NII, OIII	1.3151	0.3151
FFS 0817	6211	4583	4120	OIII, Hβ	1.3552	0.3552
FFS 0859	6460	5039	3929.7	OII, Hβ	1.282	0.282
FFS 1641	8583	5811.9	3935.8	Hα, OII	1.1477	0.4768



FFS 2341



Hydrogen Alpha and Beta Wavelength Correlation in Radio Galaxies

Cheryl Garbowski and Andrea Cerankowski
Allentown High School, Allentown, NJ
Teacher: Linda Stefaniak, RBSE '00

Abstract

Specific Active Galactic Nuclei (AGN) were observed, in search of a particular relationship between two identifiable emission lines. The specific spectral lines being explored were Hydrogen alpha (Hα) and Hydrogen beta (Hβ). After classifying the AGN by physical characteristics in their spectral lines, the choice was made to focus on only the Radio Galaxies. Radio Galaxies are determined by showing strong, easily determined emission lines, containing a calcium break, and having the emission lines of Oxygen II, III, and Nitrogen II stronger than Hα and Hβ. Once the galaxies were determined, finding the location of Hα and H_ was necessary. Then by placing the polynomial best-fit line on the spectrum, the distance from the best-fit line to the highest point on the emission line of Hα or Hβ could be determined. When the distance of H_ was divided by the distance of Hβ, the percent correlation was found. After observing the data, it was determined that no real relationship could be ascertained between the distance of Hydrogen alpha and Hydrogen beta to the best-fit line (See example of Radio Galaxy).

Purpose

The purpose of these observations was to determine if there is a correlation between the relative strengths of Hα and Hβ lines in the spectra of Radio Galaxies.

Procedure

By using Graphical Analysis, the emission lines of Hα and Hβ were identified in each spectrum. The specific radio galaxies studied were FFS-0859, FFS-1052, FFS-0742, FFS-1036, FFS-1718, and FFS-0148. The line ratio of the wavelengths was 1.35, indicating that the lines mostly likely represented Hα and Hβ. A best-fit line graph was imposed over the spectrum and the heights of the Hβ and Hβ peaks were determined. Next, subtracting the number of the location of the best-fit line from the figure of the position of the Hα and Hβ was necessary. This then represents the difference, but in order to find a correlation, dividing the difference of Hα by the difference of Hβ was required. This answer would help to determine if there was a relationship between the distances of the Hydrogen alpha and beta lines and the best-fit line.

Data Analysis

The data attached shows that there is no determinable relationship found in the percentage ratio of the Hydrogen alpha and beta spectral lines and the best-fit line. The emission lines of the spectrum show how strong the Hydrogen gas is when it is present in the galaxy. It was believed it could be proven that if the gas was found at a certain intensity in one part of the spectrum as Hα that it would appear again in the spectrum as Hβ, in proportion to the amount first detected. This was proven wrong when the data showed there could be no rational proportion found to be equal in all of the radio galaxies observed (See attached data).

Conclusion

After extensive research and observation, it can be determined that no direct correlation can be found with the data, considering the irregularity of the answers received when finding the percentage ratio, using the differences between the wavelength and line of best fit. This is the only way the data can be interpreted. The data collected only shows that the answers received are too sporadic to find a relationship. The numbers found are of a wide range, whereas it was believed that there may be a correlation between the type of galaxy, the particular spectral lines observed, and the distance of the wavelengths.

References

Osterbrock, D.E. Optical Emission-Line Spectra.
(http://nedwww.ipac.caltech.edu/level5/Osterbrock2/Oster3.html)

Galaxy	H beta wavelength	H beta peak	H beta best fit line	Difference between H beta peak and H beta best fit line
FFS0859	6335.7	1.10 e-16	9.363 e-17	1.637 e-17
FFS1052	5545.5	1.37 e-16	1.24 e-16	1.3 e-17
FFS0742	5623	1.36 e-16	1.34 e-16	2 e-18
FFS1036	5478.8	1.67 e-16	1.505 e-16	1.65 e-17
FFS1718	5773	2.48 e-16	2.34 e-16	1.4 e-17
FFS0148	5307.3	2.29 e-16	1.855 e-16	4.35 e-17
Galaxy	H alpha wavelength	H alpha peak	H alpha best fit line	Difference between H alpha peak and H alpha best fit line
FFS0859	8550.3	2.14 e-16	9.070 e-17	1.233 e-16
FFS1052	7478.9	1.59 e-16	1.046 e-16	5.44 e-17
FFS0742	7679.8	2.15 e-16	9.532 e-17	1.197 e-16
FFS1036	7416.3	1.93 e-16	1.29 e-16	6.4 e-17
FFS1718	7793.36	3.36 e-16	2.196 e-16	1.164 e-16
FFS0148	7163.2	3.21 e-16	1.659 e-16	1.551 e-16

AGN Comparison

Dan Romans
Allentown High School, Allentown, NJ
Teacher: Linda Stefaniak, RBSE '00

Abstract

Active Galactic Nuclei (AGN) were observed and compared in order to determine similarities and differences of their characteristics. There are five categories that these galaxies fall into when studying their spectra: elliptical, starburst, radio, quasar, and BL Lac. Using graphical analysis, calcium breaks, emission lines, and the shape of spectra helped determine if a galaxy fell into the elliptical, starburst, or radio categories. Redshifts were calculated using data provided by observing emission lines to determine if a galaxy fell into the quasar or BL Lac categories. Within these categories the calcium II breaks were studied. There is no pattern of calcium II breaks in comparison to redshift. Data suggests that the bigger the calcium II break is, the closer the galaxy is to earth.

Purpose

The purpose of this research was to recognize the characteristics of different AGN by studying their redshifts, emission lines, calcium II breaks, and spectra shape.

Procedure

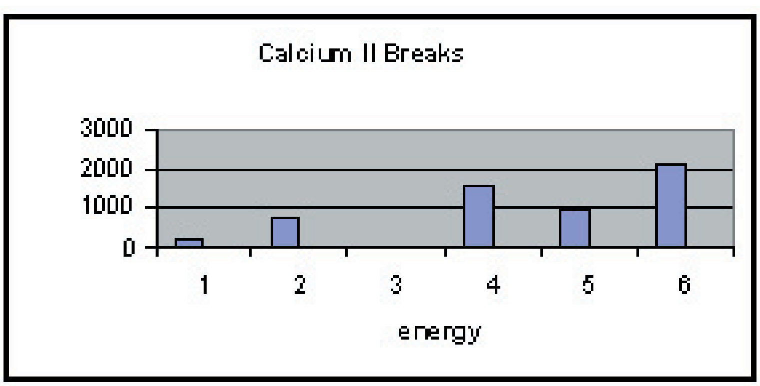
Using a computerized graphical analysis I studied emission wavelengths in the spectra and documented their emission lines. With the data from their emission lines I calculated their redshifts by dividing the number of resting wavelengths by the number of observed wavelengths and adding one. Then I categorized the spectra into galaxy types. Wavelengths with strong emission lines and no calcium break are quasar galaxies. Galaxies with strong emission lines and calcium breaks were broken down into starburst galaxies and radio galaxies. Wavelengths with weak emission lines were divided into elliptical and BL Lac galaxies. All the galaxies with the exception of quasars have calcium breaks in their spectra. The calcium II breaks were recorded and compared to the distance of the galaxies from the earth and compared to their redshift. There was no pattern of calcium II breaks to redshift but the shorter the distance from the earth showed a larger calcium II break in the spectrum.

Control and Error Analysis

The wavelengths were categorized by classified visual inspection. This proved to be trivial because of the vague detail that is hard to extract from the many galaxies' wavelengths. Size values of calcium II breaks were scaled by flux, measurement based on energy. Redshifts were found with reverse calculations of peaks in wavelengths, which compared the logistics of wavelength peaks to emission line ratios.

Data and Analysis

The size of the calcium II break increased in the galaxies that were found closer to the earth. Incidentally, the farther from the earth a galaxy is, the smaller the calcium break is. Quasar galaxies, which have no calcium break, are found farther from the earth than most other galaxies.



Conclusion

From data recorded from numerous AGN star wavelengths which can be seen in the graph above I have concluded that the presence of a large Calcium II break in a wavelength means that the galaxy is closer to the earth. All of the different galaxies are found closer to the earth than quasar galaxies, which do not have Calcium II breaks in them.

References

"Observing AGN's" by Andrew Marcaccio, Narath Serei, and Brian Callaci – Cranston High School East – Instructor -Howard Chun

RBSE Glossary, AGN Spectroscopy

RBSE-AGN wavelength, firstdat.database

Determining If FFS0859 is a Starburst Galaxy

Heather Lui
Allentown High School, Allentown, NJ
Teacher: Linda Stefaniak, RBSE '00

Abstract

The galaxies that are currently forming stars at furious rates are starburst galaxies, the object of this study. In determining the identity of the spectrum of these active galactic nuclei, several calculations can be made, such as redshifts, flux numbers, and luminosity. My data shows that the line FFS0859 may be qualified as a starburst galaxy.

Purpose

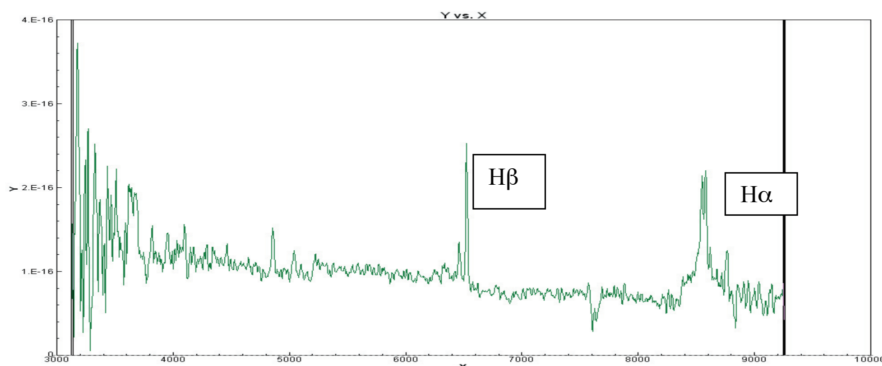
The purpose of this research is to practice the identification of starburst galaxies through the study of their spectra.

Procedure

After searching many different lines for the perfect one, on Graphical Analysis, the right one just stood out. The perfect line had good peaks and identical (or almost) redshifts calculated by the wavelengths. This line also shows characteristics that starburst galaxies are suppose to have which are strong, narrow emission lines that are very visible. These emission lines are created from newly-formed huge stars that heat up in the interstellar medium. One good line, that was not found very quickly, is FFS0859 and it looks like a starburst galaxy. In order to make sure it is a starburst galaxy, many calculations are needed to confirm it. First it is needed to calculate the redshifts of two wavelengths by using the formula $\lambda\_obs = (1+z)\ \lambda\_rest$. Then do the same for two more wavelengths and if the two redshifts equal then the peaks are good. The next calculation needed is the wavelengths divided by the closest emission line ratios. The formula needed to do this is $\lambda\_A\ obs/\ \lambda\_B\ obs = \lambda\_A\ rest/\ \lambda\_B\ rest$. After these two calculations are formed the luminosity also needs to be found. To do this on the graph, highlight the space in between the two peaks and use the button that shows the integral of the peaks. After all of these calculations, compare the data that is made and then determine the type of galaxy the line is which is hopefully a starburst line.

Data and Analysis

First off, the two sets of wavelengths picked to perform this data both were plugged into the formula told above and both had a redshift of .3439 and .3427 or a peak ratio of 1:1 making the combination redshift about .34. Two peaks on this line were also identified as Hα and Hβ and are also useful in determining the galaxy because the starburst also has those emission lines in their line. These peaks were also identified by using the other calculation above. The luminosity of the two different wavelengths also came fairly close with one calculation coming to 1.08117E+44 and the other coming to 1.06978E+44, making the possibility of the line being a starburst more believable because the peaks are almost the same. The chart on the next page helped to find this data.



Conclusions

This research concluded that line FFS0859 can be classified as a starburst galaxy. From the beginning, the possibility of the line being a starburst was extremely high and the information and calculations help to prove this point. Therefore many starburst galaxies may look like this one or similar to this line.

Predicting Element Location of Radio and Starburst Galaxies

Janine Largen and Bonnie Kizis
Allentown High School, Allentown, NJ
Teacher: Linda Stefaniak, RBSE '00

Abstract

The study of Active Galactic Nuclei (AGN), can become quite complicated if one knows no background information. It is useful to know about black holes, BL Lacs, Quasars, Starbursts, Radio, and other different galaxies. Starburst and Radio galaxies happen to be the fewest in abundance in the universe. These galaxies are expected to show various similar element emission lines. Through much detailed AGN calculation and research, it becomes clear as to which elements represent specific peaks in the stars. The resulting data shows that there is a continuing pattern within the four Starburst galaxies and Radio galaxies researched in this paper. The study of AGN helps prove the theory of patterns in Starburst and Radio galaxy element emission lines and how we should be able to predict, for each peak, what elements should be abundant.

Purpose

The purpose of this research in AGN is to compare the oxygen, and other elements found in radio and starburst galaxies. We are hoping to find a pattern within the group of starburst galaxies and the group of radio galaxies.

Procedure

The first step is to find different spectra that were classified as radio or starburst galaxies. Using Graphical Analysis for Windows by Vernier software, it was simple to determine which lines were classified into what galaxy. We compared what we found to what each galaxy was supposed to look like using the spectra of known AGN. Searching the available data, we had discovered 3 radio galaxies and 3 starburst galaxies to work with. Next, we had to make sure these lines had 2 well-defined peaks. If they did, we planned to divide the larger peak's number by the smaller peak's number. This will be done with all 6 spectra. We also expect to see a pattern form between all the radio galaxies and the starburst galaxies. The elements we expect to find mostly are oxygen and hydrogen, which seem to be the most abundant among the peaks in the spectra that were given to us previously. We received a packet of students' AGN reports over the past years and it has helped us greatly because we saw all the examples.

Control and Error Analysis

It is quite easy to make a mistake while trying to classify each line into what galaxy it belongs to. For example, when we first started this project, we thought we were going to compare different starburst lines and find a pattern. However, with the star ffs0148.dat, we were sure that was a starburst, turned out to be, in fact a radio galaxy. It is very frustrating and time consuming to find two good emission lines in a star. Therefore, we changed our entire purpose to our project into comparing radio and starburst galaxies. We must have went through about 10 different emission lines in about 76 lines between the two of us. Our result consists of 8 galaxies total. Emission lines are also deceptive. Sometimes, the lines are very tiny even when zooming in and they overlap over other lines. It is also frustrating to find in a star that there are many peaks of the same height and none of which stand out enough to be calculated accurately.

Data and Analysis/ Conclusion

The three Starburst galaxies show an obvious pattern in their element structure.

Galaxy	**Peak 1**	**Peak 2**	**Peak 3**	**Peak 4**
ffs 0742a	O II	H β	O III	H α
ffs 0817	O II	H β	O III	H α
ffs 2341	O II	H β	O III	H α

In all these stars, Hβ is present and in three of them, there is O III. Also, in three of these stars, there is a Hα pattern arising. This is an obvious pattern in which these elements stand out within these starburst galaxies.

Three radio galaxies:

Galaxy	Peak 1	Peak 2	Peak 3	Peak 4
ffs 0148	O II	H β	O III	H α
ffs 0936	O III	H α	S II	
ffs 1718	O II	H β	O III	H α

According to our sources, the pattern of elements among the peaks of starburst and radio galaxies is already set in a specific pattern. Our findings have verified this. We can make an assumption as to what order the peaks are in and be relatively certain about which element goes along with which peak. The pattern in our graph above is proof that the orders of elements are oxygen II, hydrogen beta, oxygen III, hydrogen alpha, and in some cases, sulfur II. Now, we are confident enough that we can predict which element is abundant in a particular peak according to our pattern findings and research.

References

Graphical Analysis for Windows, Copyright 1995, Vernier software. Written by Mark Topinka and Chris Chamberlin. 04/06/99 version.

"A study of Active Galactic Nuclei and Quasars", Ross Cunningham and Brian Costaldo. Staples High school, West Port, CT. The RBSE Journal 2000.

http://www.ufrsd.net/staffwww/stefanl/chemistry/agn.htm. Chem 1 honors-Active Galactic Nuclei Help Page.

The Origin of Elliptical Galaxies

Justin Rosser and John Gahler
Allentown High School, Allentown, NJ
Teacher: Linda Stefaniak, RBSE '00

Abstract

The purpose of this study is to support the assertion that elliptical galaxies were once quasars, through both acquired information and data gathered from two spectral lines identified as being from a quasar and an elliptical galaxy.

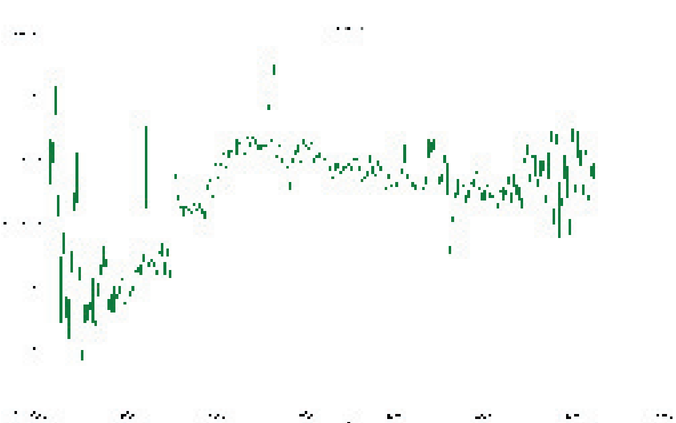
Introduction

Billions of years ago when the universe began, all of space was set into a tumult of confusion. It was at this time that the theorized black holes were created, super-dense and massive monsters in space, from which not even light can escape. These black holes serve as the nuclei for all galaxies to date, whether they are the Milky Way, or an active quasar. Within this diverse zoo of galaxies there are two distinct classifications: active and inactive galaxies. (Keel). The variety of active galaxies, which make up about 1% of all known galaxies today, are rumored to have been much more common when the universe began. (Pogge). As a result of this and many other factors, scientists theorize that at one time many of the oldest elliptical galaxies may have gone through a sort of adolescent period as young quasars. Another theory generated by the fact that almost all galaxies are riddled with striking similarities suggests that there may be a distinct genealogy associated with galaxies, and evidence from both active and inactive galaxies suggests that all galaxies may have common roots. (Keel).

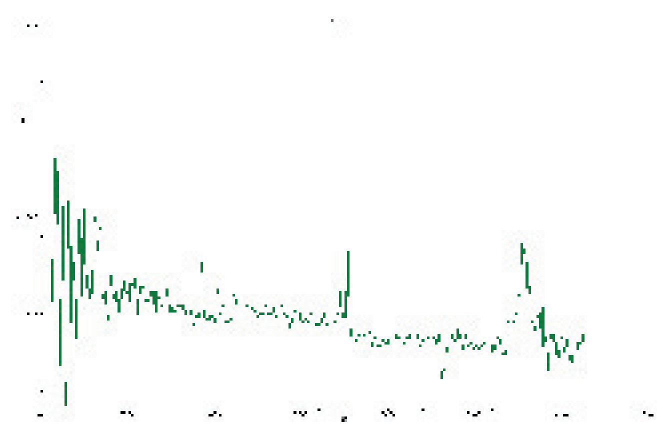
Procedures

Using Graphical Analysis, two spectral lines from the RBSE disk were identified: one as a quasar galaxy, and the other as an elliptical. Once wavelengths were determined, a Microsoft Excel spreadsheet equipped with redshift, velocity, distance, and luminosity generating formulas. Two wavelength ratios for each galaxy were calculated. Once two ratios that were the same for the same line were found, the wavelengths used to derive the ratios were entered into the spreadsheet. The spreadsheet calculated the redshift, velocity, and distance for each galaxy. Using Graphical Analysis, the flux was determined for each line. The fluxes were entered into the spreadsheet, and the luminosities were calculated. Through research, facts were obtained to support the hypothesis, and give a general background about all types of galaxies. Finally, the two lines were compared:

Data and Analysis



FFS -1036c (Elliptical)



FFS-0859+3802 (Quasar)

Analysis of the spectrum of the quasar FFS-0859+3802 (on the right) reveals a luminosity of about 5.16E+43 (erg/sec). The strong emission lines of this sample reveal samples of Hb within this galaxy, as well as H-a. The calculated redshift for this quasar was found to be about .34. The velocity is about 85921.79 km/s; the distance is about 1194.63 Mpc. The flux is 1.68E-13 erg/cm2/sec.

It should be noted that by nature, elliptical galaxies are old and very little star formation takes place in them. The lack of star formation is due to lack of materials present in the galaxy to form new stars. These materials are normally hot gases, which are often hydrogen or helium. These elements, and others, show up on spectrographs as emission lines. So, normally, elliptical galaxies show very few, if any, emission lines. In the case of this galaxy, strong emission lines correlating to H-a and Hb are present. This means star formation is occurring in this elliptical galaxy. Due to this irregularity, the data is different from what is commonly seen, due to the star formation. The luminosity of FFS -1036c is about 5.47E+43 (erg/sec). This is higher than the luminosity of the quasar, which has not been known to happen.

The emission lines of this sample reveal samples of Hb and H-a within this galaxy just as in the quasar, showing a similarity in composition. The calculated redshift for this quasar was found to be about .32. The velocity is about 81119.9 km/s; the distance is about 1121.31 Mpc. The flux is 2.09E-13 erg/cm2/sec.

AGN Data

	quasar	*elliptical*
wavelengths used to determine ratios:	4857.7, 6522.2, 8765	4536.3, 5985.9, 7913.8
wavelength ratio:	1.34	1.32
redshift:	0.34	0.32
velocity (km/s):	85921.79	81119.9
distance (Mpc):	1194.63	1121.31
flux (erg/cm^2/sec):	1.68E-13	2.09E-13
luminosity (erg/sec):	5.16E+43	5.47E+43

Quasars, the acronym for quasi-stellar radio sources, are both the most luminous and the most distant of the AGN scientists have speculated about. Quasars appear as stars do in the night sky, with the lighted nucleus shining many times more brightly than the galaxy that lies around it, and the quasar has been found to be in fact a thousand times brighter than galaxies with billions of stars. The particular compositions of quasars have been identified as having a flattened, orbiting, gas accretion disk surrounding a super-massive black hole, billions of solar masses made up of the same universal matter found in our galaxy, and jets of matter streaming forth from the quasar at near the speed of light. (Keel). The host galaxy in question, from what scientists have been able to decipher through the blinding quasar, appears to contain a kind of disturbed elliptical shape. At any rate, quasars epitomize their distinction as active, as they are the most active galaxies that have been identified, and it is easy to see that these giants share an affinity with not only elliptical galaxies but with other AGN as well.

True to their names, elliptical galaxies are normally ellipsoidal in shape. Elliptical galaxies are the oldest known galaxies. Very little star formation occurs in these galaxies due to the lack of dusts and gases needed to form new stars. The stars present in these galaxies are considered old population II stars, and give the galaxy an appearance of being red-yellow in color. The size of elliptical galaxies ranges greatly, from ten thousand light-years in diameter to one million light-years in diameter.

Evidence found in research indicates that within the elliptical galaxies lie dormant black holes large enough to have once powered quasars. Also, quasars are rumored to have an elliptical shape within their host galaxy. In addition, quasars are in fact very similar to their radio galaxy (Other form of AGN) cousins, in that they both have similar structure and they are both powerful radio sources. (Pogge). In fact, all AGN share many characteristics, such as dust cloudiness, luminosity, etc. Because of their similarity to radio galaxies, the emerging evidence shown in the linking radio galaxy Centaurus A (NGC 5128) suggests that there are striking similarities between elliptical galaxies and radio galaxies, as this galaxy was once classified as elliptical, and it contains young stars. (Chamberlin). Another fact that helps to prove this evolution of quasars to elliptical galaxies is that there were once probably many more quasars than there are today, but now there are many more elliptical galaxies than there were theorized to be billions of years ago. Since elliptical galaxies are much older than quasars, this also helps to show the evolution that probably occurs from quasars to elliptical galaxies.

Control and Error Analysis

Human error could have been made during the calculations, and of course the majority of the information given is based on scientific stipulations and theory. Also, within the very samples themselves one can see telluric and absorption lines which could account for more error.

Conclusion

In the end, we have no real way of knowing for absolute sure if quasars actually do form elliptical galaxies at some point, although we have found good evidence to support it. The evident data obtained from both research and spectral lines shows definite support for this theory, but it just is not enough to make a solid conclusion. Therefore this study was in fact inconclusive, although it indefinitely supports the hypothesis for further work.

References

Special thanks to: William Keel and Linda Stefaniak.

Chamberlin, Chris, Ttopinka, Mark. Graphical Analysis. 1st ed. CD-ROM. Vernier Software, 1999.

Frommert, Hartmut, Kronberg, Christine. "NGC 5128." SEDs. 2002. University of Arizona. 10 Jan. 2003 < http://www.seds.org/messier/xtra/ngc/n5128.html>

Janke, Elesa. "Quasars Unravel History of Giant Elliptical Galaxies." Astronomy April

Keel, Bill. "Quasars Explained." Astronomy Feb.2003: 34-41,2002.

Pogge, Richard. "Lecture 31: Active Galaxies and Quasars." Astronomy 162. 2002. The Ohio State University. 10 January 2003 <http://www.astronomy.ohio-state.edu/~pogge/Ast162/>

Exploring Quasars

Lipica Shah
Allentown High School, Allentown, NJ
Teacher: Linda Stefaniak, RBSE '00

Abstract

Quasars are the most distant Active Galactic Nuclei (AGN) known; yet they do not resemble normal galaxies at all. These luminous AGN have several strong emission lines, contrary to most galaxies, which show dozens of absorption lines. They also contain a Calcium II break. Several examples of Quasars were studied and produced the same answer when two of their wavelengths were divided to acquire an emission line ratio of 1.47, which indicates the presence of Carbon III (CIII) and Magnesium II (MgII) in the spectra. This leads to the identification of Oxygen II (OII).

Procedure

The purpose is to explore and study different emission lines in Quasar spectra, and to become familiar with their positions in relation to the rest of the spectra. Using Graphical Analysis for Windows, ten Quasar spectra were found. Two strong peaks were randomly selected on each, and their wavelengths were divided. In each case, the quotient was 1.47, which is the equivalent of the MgII emission line (2796) divided by the CIII line (1909). MgII and CIII were then located on the spectra and their placement was noted. Using the paper AGN Spectroscopy, the site of OII was determined. After observing the placement of all three emission lines on each of the ten spectra, it became simple to determine their locations on any Quasar spectra because of their obvious positions and definite character.

Data Analysis

Shown below are the ten Quasar spectra investigated. It displays the two wavelengths that were divided and their quotient. As previously stated, the answers are continuously 1.47. In addition the emission line ratios are also shown. Again, the results are the same: MgII and CIII. As a final comparison, the redshifts for each spectrum are given. Note that the redshifts are all within the range of .4500 to .4800, or from 1540 to 1600 Mpc: a close but not exact distance.

Quasar Comparisons						
FFS Number	Wavelength 1 (Å)	Wavelength 2 (Å)	Quotient	Emission Line Ratio	Red Shift	Distance (Mpc)
301	6235	4244	1.47	MgII, CIII	0.4691	1578.2698
1006	7351	5001	1.47	MgII, CIII	0.4699	1581.3657
1349	8085	5500	1.47	MgII, CIII	0.47	1581.7422
1501	7793	5290	1.47	MgII, CIII	0.4732	1594.4016
1708	7746	5281	1.47	MgII, CIII	0.4668	1568.8083
722	7355	5020	1.47	MgII, CIII	0.4651	1562.3040
747	7584	5177	1.47	MgII, CIII	0.4649	1561.5121
1144	6848	4651	1.47	MgII, CIII	0.4724	1591.2497
1210	7804	5325	1.47	MgII, CIII	0.4655	1563.9031
1306	7248	4965	1.47	MgII, CIII	0.4598	1541.0994

Conclusion

The likeness between the spectra studied is uncanny. From the data given, it can be concluded that all Quasar galaxies contain a Magnesium II and Carbon III emission line. It can also be ascertained that once those two lines are found, the location of Oxygen II is undoubtedly certain. Therefore, the purpose of this study has been complete.

Acknowledgements

Graphic Analysis for Windows. CD-ROM

AGN Spectroscopy: Studying Nature's Most Powerful "Monsters". 2000

Active Galactic Nuclei Spectroscopy

Rohit Malgaonkar
Carver High School of Engineering and Science, Philadelphia, PA
Teacher: Robert Welsh, RBSE '99

Objective and Goals

The objective is to emphasize that the distance at which the active galaxy is from the earth and the velocity at which it is traveling away from us or the earth (or the recessional velocity) can be determined by observing it's spectroscopy. The goal will be explore and observe spectrums of various active galactic nuclei and to determine their redshift. Then the redshift will be used to find distance and velocity of the galaxy and explore relationship between velocity and distance of galaxies.

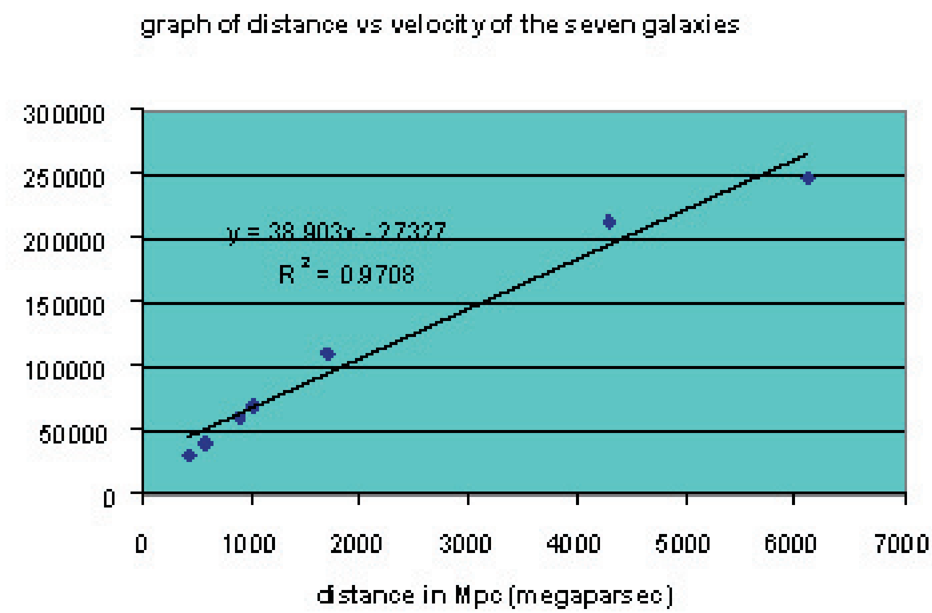
Procedure

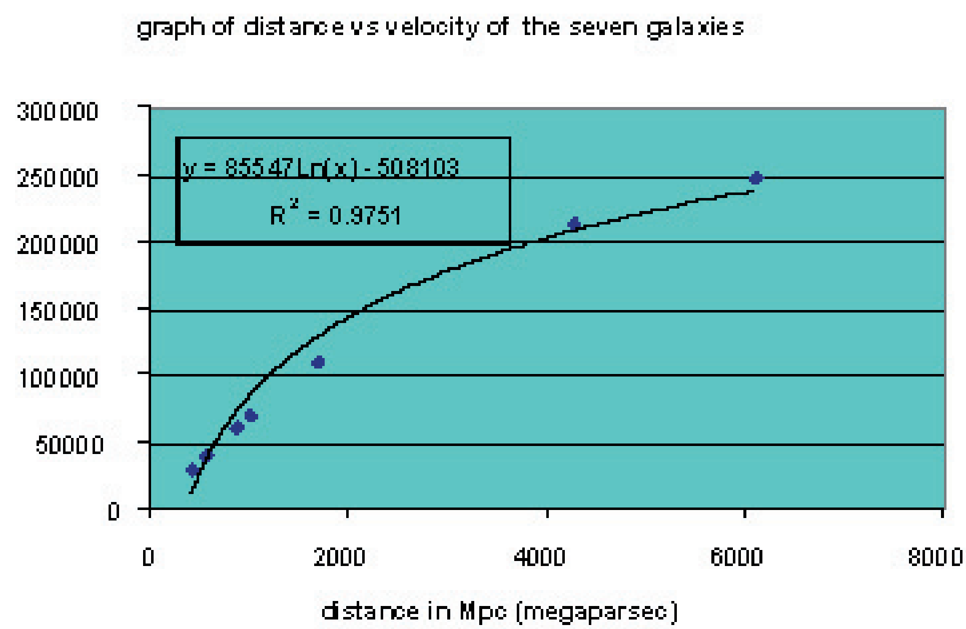
In this project, spectrums of active galactic nuclei from Vernier software will be observed. From the emission lines in the spectrum two close lines having strong wavelengths will be taken and their ratio will be determined. This ratio will be calculated by dividing the higher wavelength by the lower wavelength. Then this ratio will be tried to match with the ratios given in science booklet given by Tucson astronomical observatory. My wavelengths will be the observed wavelengths and the wavelengths in the corresponding close ratio given in the booklet will be the rest wavelengths. Then the redshift will be calculated by using the redshift equation in the AGN Spectroscopy documentation. Then the average of them will be taken as the tentative redshift for the whole active galaxy. Then the redshift will be tested by using the calculated redshift and a rest wavelength of any other elements to find its observed wavelength. Then the spectral graph of the galaxy would be observed to search for any emission lines near or at the calculated observed wavelength and the percent difference should be below 10%. this proves or assures that the redshift is correct for the given galaxy. By using the redshift, the velocity at which the active galaxy is traveling or the recessional velocity can be calculated. We assume H0 a Hubble's constant of 71 km/sec/Mpc. This procedure will be done for many active galaxies and help to determine which galaxies are farther away, which are traveling away with a faster velocity and explore the relationship between redshift, distance and velocity of the active galaxies.

Data and Analysis

The spectral graphs of the following 7 active galaxies were taken from Vernier software and analysed. FFS stands for FIRST Flat Spectrum.

Galaxy name	Redshift	Recessional velocity In Km/s	Distance In Mpc
FFS 0934	0.145	40,374.94	573.88
FFS 1656	0.475	111,060.82	1683.87
FFS 2148	0.107	30,391.49	430.26
FFS 1218b	2.22	247,222.12	6100.35
FFS 0040	0.267	69,699.25	1009.3
FFS 2341	0.227	60,529.61	870.43
FFS 1534a	1.435	213,410.23	4276.74





Conclusions

The galaxy having the fastest recessional velocity in my experiment was 1218b and as distance is directly proportional to velocity by Hubble's law, it is the farthest galaxy away from earth. It also demonstrates the greatest redshift. The two graphs of distance vs velocity show that velocity is directly proportional to distance by confidence of 97% (r2 values). The linear equation is y = 38.903x - 27327 (where x=distance and redshift = y). The equation of trend line of logarithmic regression is y = 85547Ln(x) – 508103. The values of y (velocity) do not differ much when calculated by each of the above two equations for a specific value for x (distance) and vice- versa. For eg distance of a galaxy = 8000 Mpc; then Velocity = 283,897 Mpc (by linear equation) and Velocity = 260,724.73 Mpc (by the natural log equation). Percent difference between the above velocities for a galaxy 8000 Mpc away is below 10% (8.16 % error).So both equations of distance and velocity are more or less the same. All galaxies were found to be moving away from earth, as their wavelengths were all found to be redshifted.

Sunspots in Relation to Tree Ring Width

Kurt Jankowski
Traverse City East Junior High, Traverse City, MI
Teacher: Lauren Chapple, RBSE '99

Abstract

The purpose of this paper is to reveal if there is a link between the annual number of sunspots, and tree growth of the corresponding year. Based on the information I have gathered on the characteristics of sunspots and tree rings, my hypothesis is: if there are more sunspots during any given year, then the tree growth corresponding to that year will be greater than years of lower sunspot numbers. I found my hypothesis to be true.

Introduction

Tree growth is affected by conditions known as sensitivities, and one of these sensitivities is temperature. When it is colder, trees do not grow as well. This minimized growth can be seen in the size of the growth rings. In good growing seasons, there are wide growth rings, in bad seasons, the growth rings a thinner.

In addition, there appears to be a correlation between the sunspot cycle and the average northern hemisphere temperature. A good example of this took place in the late 17th century. During that time, there were very few sunspots, and a worldwide cold occurred known as the Little Ice Age. Since it is believed that sunspots affect temperature, and tree ring growth is determined in part by the overall temperature of a growing season, the level of sunspot activity should be seen in the width of a tree's growth rings. My hypothesis is that if there are more sunspots during any given year, then the tree growth corresponding to that year will be greater than years of lower sunspot numbers.

Procedure

In gathering the data for this report, I first collected tree ring samples, all gathered at the same time. The samples can be slices of the trunk, or core samples from a borer. I used slices of trees, for samples. Trees are affected by sensitivities, or elements such as grade, sunlight, precipitation and others that can hinder growth. One of the easiest ways to keep these factors equal from tree to tree is to get your tree samples from the same area, preferably a swampy area. The swamp helps keep the grade equal and also insures that the nutrients and water the trees received will be unvarying. I was fortunate enough to have my tree samples meet the criteria. To measure the rings, I used dividers to find the width of each individual ring. To determine where the rings stop and start, I utilized two simple characteristics of tree growth. In each ring, there is earlywood and latewood; earlywood is usually lighter in color than latewood. Earlywood and latewood from the same growing season blend together (visually), but the end of latewood from one year, and the beginning of earlywood from another form a definite line. Measuring from one definite line to the next results in comparative measurements of the annual growth. After finding the width of a ring, I then transferred that measurement to very thin-lined graph paper. (Transferring to graph paper simply gives you a number to enter into a graph later in the process.) I repeat this process for every ring in the sample, making sure to measure the rings in a straight line from the center out, because there are different widths in the same ring in different areas of the tree.

Analysis

After measuring each tree ring, I counted how wide each ring was, making each line of the graph count as ten units. Once I had converted the tree rings to "numerical data", I entered them into Microsoft Excel, along with yearly sunspot numbers I found online at Kitt Peak National Observatory website. I then used Excel to create graphs of all the data. The resulting graphs made it very simple to compare the data and determine if sunspots effected tree growth.

Conclusion

My hypothesis, if there are more sunspots during any given year, then the tree growth corresponding to that year will be greater than years of lower sunspot numbers, was correct. Looking at the graph, you can see that there are certainly some similarities. These similarities are most evident in the years 1940 through 1943, 1950, and 1960. During the years 1970 to 2002, the pattern is still evident, just not as defined. The year 1976 is the only time the pattern is not followed. Within the scope of this study, I can say that my hypothesis is correct.

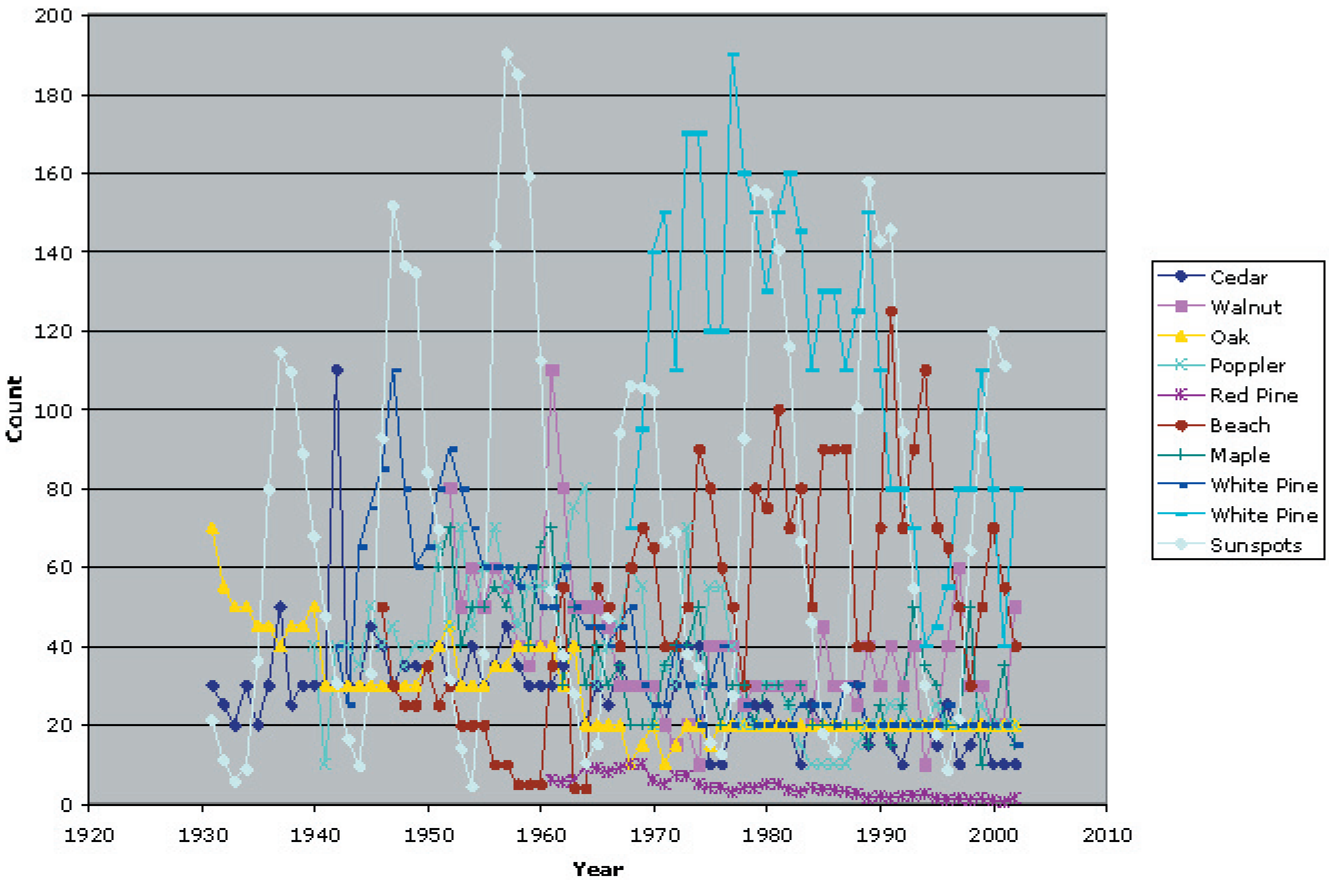
Bibliography

Berry, K., et.al; Holt Science of Technology Astronomy; Holt, Rinehart and Winston; New York, NY; 2002 pg. 47

Lori Martinez, Dendrochronology and the Solar Cycle, http://www.ufrsd.net/staffwww/stefanl/tlrbse2002/treerings/index.htm, 10-23-02

Lockwood, J., et.al; Blazing Sunspots; Researched Based Science Education; 2000

http://www1.physik.tu-muenchen.de/~gammel/matpack/html/Astronomy/Sunspots.html, accessed 11-23-02



The Excited Elements Found in the Supernova Remnant G292.0+1.8

Danielle Savage
Carver High School of Engineering and Science, Philadelphia, PA
Teacher: Robert Welsh, RBSE '99

Abstract

A program called DS9, which was created by Chandra X-Ray images, was used to make observations on the supernova remnant G292.0+1.8. The software has a function called an energy spectrum plot, and fifty energy spectrum graphs of G292.0+1.8 were plotted. The graphs were used to uncover the elements embedded in the supernova remnant. The examination of the graphs that were taken showed that oxygen and iron were the most prominent elements in G292.0+1.8. Other elements that were also present were carbon, chromium, argon, calcium, neon, magnesium, and silicon.

Introduction

DS9 is a program that allows students to download images of supernova remnants via Chandra,s X-Ray satellite. However, the images are not in real time, they are snapshots of the supernova remnant. DS9 was initially used to analyze Cassiopeia A and after discovering what elements that particular supernova produced, I was curious to know if the same exact elements were produced in other supernova remnants. After careful observations of the supernova remnant G292.0+1.8 it became evident that there were some elements in this supernova that were not present in Cassiopeia A. However, this difference in elements was not expected. It was assumed that the exact elements that were found in Cassiopeia A would be found in G292.0+1.8, but in different quantities. With some research it became clear that the elements found in a supernova are excited. These excited elements decay into more stable elements over time, and that seems to be the reason for the variety of elements found in different supernovae.

Methods

The tool that was used to collect and observe data is called DS9, which is used as a real-time data analysis program. Requests for analysis are made on local PCs, and immediately transmitted over the internet and analyzed using six parallel-processing computers at the <?xml:namespace prefix = st1 ns = "urn:schemas-microsoft-com:office:smart-tags" />Chandra X-ray Center, Harvard University. Then the results are immediately transmitted back to the local PC. DS9 has a function that is not unlike a spectroscope, and this function or operation is called the energy spectrum plot. A spectroscope is an instrument that breaks down the light from a source into its individual wavelengths. All elements emit light at a certain wavelength and these emissions are presented as line breaks in a continuous electro-magnetic spectrum, and the energy spectrum plot presents the emission lines on a graph.

Procedure

DS9 is opened and the image is downloaded from the Chandra X-Ray center at Harvard University. An annulus, which is a circular region of the supernova, is selected and the radius of the annulus is set to eight pixels. Then the energy spectrum plot in the menu section is selected. The energy spectrum plot is unable to be printed directly from DS9, so instead it is saved to an Excel spreadsheet. This is most advantageous because, using the cursor it is easy to select a few peaks in the graphs (which are the emission lines), and record the energy per bin number. However, the peaks are not useful if they are not in the right units, which happen to be angstroms. Converting the peak wave-lengths into angstroms is done by dividing 12398 by the energy per bin number. After the peaks are in angstroms, a website (<http://obsvis.harvard.edu/>http://obsvis.harvard.edu/WebGUIDE/ATOMDB) produces a list of elements that are in that specific region in exchange for the wavelength in angstroms, and a set width of .5. This process is then repeated fifty times, and the list of elements and their graphs, with the position on the image that it was taken, are saved on disks.

Results

The elements that were found in the supernova remnant G292.0+1.8 were Oxygen, iron, Argon, Calcium, Neon, Carbon, Chromium, Magnesium, Nickel, Nitrogen and Silicon. The graph below is one of the fifty energy spectrum plot graphs taken from G292.0+1.8. The element below the graph are from two of the peaks in the graph, 640 (19.37

angstrom), and 900(13.79 angstroms).

Conclusion

One of the most remarkable things about searching for elements in G292.0+1.8 was observing that there was an abundance of oxygen and iron in the supernova remnant. It is interesting to know that the element that humans breathe and the iron in our blood are created in a supernova explosion. Also, not all supernovae have the same elements embedded in them; some of the excited elements found in a supernova are present after years of decay. In conclusion, Iron was found mostly in the outer shell, and oxygen as well as other elements was found closer to the pulsar embedded in the supernova remnant G292.0+1.8.

Ratios of Different Elements in Cassiopeia-A

Phitha Philip
Carver High School of Engineering and Science, Philadelphia PA
Teacher: Robert Welsh, RBSE '99

Abstract

Cassiopeia-A (Cas-A) is a supernova remnant that emits electromagnetic waves. An X-ray spectrum is a tool to find elements. All of the elements, from lightest to heaviest ones, found on earth were formed in supernova explosions. It has been suggested that silicon is the dominant element in supernova remnants. Here in this project, it was found that silicon does have a higher intensity when compared to other elements. Chandra's Ds9 software offers a unique tool that analyzes x-ray spectra to determine the elements formed in a selected region. The software tool is called the Energy Spectrum Analysis. Calculating the wavelength and width and using the AtomDB (online database) yields a list of elements. A graph of relative intensity vs. wavelength provides a visual representation of the intensity of different elements in the Cas-A.

Introduction

Cassiopeia-A should have been visible around 1650 AD. It is about 350 arc- seconds in diameter. The density of the remnant steadily increases until about 100 arc-seconds in radius and then the remnant gets weaker. Cas-A resembles a hollow ball with a dense outer shell. Cas-A emits x-rays. The x-ray image of Cas-A looks like a diffusing smoke. The x-ray image is derived from the x-ray telescope focusing the incoming x-ray photons from Cas-A. Chandra's data analysis software offers many useful tools. However the most significant one is the energy spectrum analysis that detects the different elements based on the x-ray photons from Cas-A. Analyzing the different regions of Cas-A helps one to find out the activities inside supernova remnants.

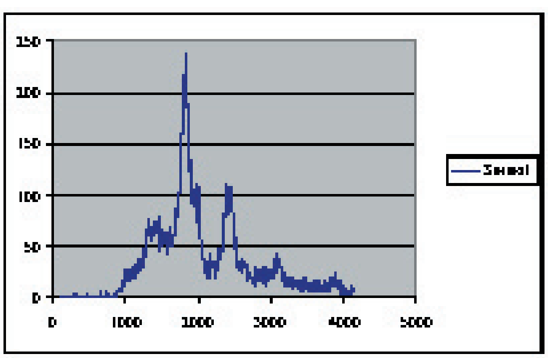
Objective

To identify different elements in the selected regions of the Supernova Remnant, Cassiopeia-A and compare the ratios.

Process

First, I selected the regions where I was going to perform the spectra analysis. I decided to start out from what is believed to be a pulsar, the center of the remnant and move along the x-axis and then along the y- axis. Second, I did the energy spectrum analysis on each of my selected regions. The graph showing the value vs. energy (in electron volts) has several peaks. I recorded the XY value of the highest peaks for further calculations. I calculated the wavelength and the width, using the equations:

Wavelength =12398/ energy (eV) =12398/1840 = 6.738A
Width =(2* wavelength)/ resolution = (2*6.738)/ 100 = .134A.



Wavelength =12398/1840 = 6.738A
Width = (2*6.738)/ 100 = .134A.

Then, using AtomDB, I compared the ratios of different elements within a range of wavelengths. For example, the range of elements that have wavelengths 6.74A falling within the width .134A

Lambda	Ion	Relative Intensity	(*18)
6.5800	Mg XII	.014	.252
6.6479	Si XIII	1.00	18.00
6.6528	Si XIII	.014	.252
6.6554	Si XIII	.025	.45
6.6850	Si XIII	.050	.9
6.6882	Si XIII	.137	2.5
6.7378	Mg XII	.031	.56
6.7388	Si XIII	.065	1.170
6.7403	Si XIII	.404	7.3
6.7432	Si XIII	.039	.7
6.8080	Fe XXIV	.018	.32

To make a reasonable graph: 1.00 = 18.00

The intensity of silicon at 6.7479A is set to 1.00 =18.00.

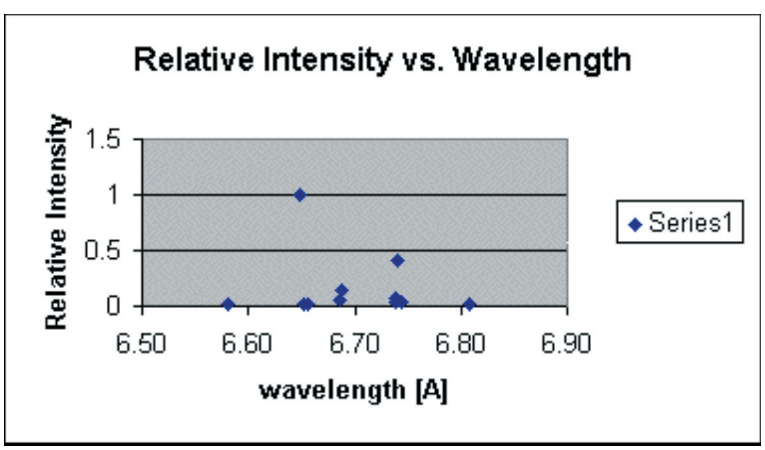
Now compared to silicon, the intensity of magnesium is .031. Therefore, relative intensity of magnesium at 6.7378 A = 18(.031) =. 56. Similarly, relative intensity of iron at 6.8080A = 18(.018) = .32.

Conclusion

The energy spectrum analysis was performed on 21 selected regions of Cassiopeia-A. The elements that were identified in the selected regions of Cas-A were silicon, iron, nickel, magnesium, neon and sulfur. Out of the 21, 14 of the selected regions had a relatively higher intensity of silicon. In conclusion, Silicon has a 66% higher intensity when compared with other elements that were identified in the Cas-A.

Bibliography

Abell, G, Morrison, D and Wolff, S, Exploration of the Universe, PA, 1993.
Chaisson, E and McMillan, S, Astronomy Today, Prentice Hall, NJ, 2002.
Seeds, M, Foundations of Astronomy, Brooks Cole, CA, 2001.
http://chandra-ed.harvard.edu/casa.html.
http://obsvis.harvard.edu/WebGUIDE/



Physical Right Ascension Declination	**Wavelength**	**Elements**	**Highest Intensity**
RA 23:23:27.892 Dec 58:48:42.75	6.8497	Si, Mg, Fe.	Silicon
RA 23:23:23.332 Dec 58:48:42.71	6.8121	Si, Mg, Fe	Silicon
RA 23:23:18.771 Dec 58:48:42.67	6.8497	Si, Mg, Fe	Silicon
RA 23:23:14.211 Dec 58:48:42.62	6.7380	Si, Mg, Fe	Silicon
RA 23:23:09.651 Dec 58:48:42.56	6.7380	Mg, Si, Fe	Silicon
RA 23:23:05.090 Dec 58:48:42.48	6.8497	Si, Mg, Fe	Silicon
RA 23:23:27.896 Dec 58:48:06.34	6.8121	Fe, Si, Mg	Silicon
RA 23:23:27.899 Dec 58:47:30.91	6.8877	Fe	Iron
RA 23:23:27.903 Dec 58:46:55.49	6.7016	Si, Ni, Fe	Silicon
RA 23:23:27.906 Dec 58:46:20.07	6.8877	Fe	Iron
RA 23:23:27.910 Dec 58:45:44.64	9.04	Fe, Ni, Mg	Magnesium
RA 23:23:27.889 Dec 58:49:17.19	9.464	Mg, Ne, Ni	Iron
RA 23:23:27.885 Dec 58:49:52.61	6.8121	Si, Mg, Fe	Silicon
RA 23:23:27.882 Dec 58:50:28.03	6.8121	Si, Mg, Fe	Silicon
RA 23:23:27.878 Dec 58:51:03.46	6.8121	Si, Mg, Fe	Silicon
RA 23:23:27.875 Dec 58:51:38.88	12.084	Ni, Fe, Ne	Iron
RA 23:23:32.453 Dec 58:48:42.77	6.7380	Si, Mg, Fe	Silicon
RA 23:23:37.013 Dec 58:48:42.78	6.8121	Si, Mg, Fe	Silicon
RA 23:23:41.573 Dec 58:48:42.78	6.7380	Si, Mg, Fe	Silicon
RA 23:23:46.134 Dec 58:48:42.77	11.9212	Fe, Ni, Ne	Iron
RA 23:23:50.567 Dec 58:48:42.76	11.6962	Ni, Ne, Fe	Iron