Relationships Between Star Size, Radio Wave Emissions, and Dust

Stellar Astronomy and Radio Emissions

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Abstract

Radio astronomy is a branch of astronomy that deals with radio emissions from celestial objects. Hydrogen is an abundant element that makes up much of the universe. Neutral Hydrogen, found in many parts of the sky, emits radio emissions at a frequency of 1420MHz as its protons fall into lower energy levels. Through the use of a radio telescope, one can determine the amount of neutral hydrogen in various parts of the sky.

This experiment deals with finding a relationship between the levels of neutral hydrogen as well as molecules and a stars mass. An infrared scan at 100microns provides sufficient information about the amount of dust, or molecules, around a star. The virtual observatory, SkyView, allows infrared scans and the 4.6m radio telescope, Smiley, detects levels of neutral hydrogen by scanning parts of the sky at 1420MHz.

Results from the experiment show a correlation between a star's size and its emission of radio waves at 1420MHz. In contrast, no correlation was found between a stars size and the amount of dust (molecules). Several theories were formulated in order to explain these results, the most prevalent being that a hotter star simply increases the average speed of atoms around it, thus increasing the likelihood of collisions and emissions of radio waves. The amount of molecules around a star can simply be explained by the star's location and properties.

Introduction

Hydrogen is the most abundant element in the universe, and neutral hydrogen is found in large quantities in parts of the sky around celestial objects. When ionized at a temperature of 10,000 degrees kelvin, neutral hydrogen emits radio waves at a frequency of 1420MHz. A spin change in the electron causes radio waves to be emitted from Neutral Hydrogen at 1420MHz. As an electron's spin changes, it emits waves. It is possible to receive this frequency on earth and determine amounts of neutral hydrogen through the use of radio telescopes. The task of finding the correlation between a star's size and its intensity of radio emissions at 1420MHz was selected because it has never been thoroughly explored before.

To bond and form molecules in space, a substantial amount of energy and pressure is required. For this reasons, finding molecules (or dust) around stars is rare. This experiment also explores the correlation between the size of a star and the amount of dust around it. At 100microns, an infrared scan will give a clear image of dust around a star. Through the use of a fits image and an analyzing software such as Iris, it is possible to calculate the intensity of the infrared scan and determine the amount of dust around a star.

The experiment began with the hypothesis that a larger star such as an O or B type star will emit radio waves at a higher intensity than a smaller star such as K or M type. It was also hypothesized that a larger star would have a greater amount of dust around it than a smaller star. After analyzing the data, the first hypothesis was supported. The latter was changed to explain that the amount of dust around a star depends on its location.

Observations: Method

Observations were primarily made with the 4.6m radio telescope Smiley and virtual observatory SkyView. Additional observations were made using Palomar plates, which resulted in several setbacks. The initial data gathered from Smiley did not account for other sources of radio wave emissions. Therefore, a five degree change in the viewing window was observed, and the difference between the star's emission and the offset was calculated.

Data was gathered from Smiley using an IF gain of 17. A star was found using its Right Ascension and Declination. These coordinates allowed Smiley to move to its target and gather radio emission data. Radio emission data after all the raw data was gathered from smiley it was analyzed and then averaged. The analyzed and averaged data showed a clear correlation between size and intensity of radio wave emissions. The data made it clear that a larger star such as an O or B type emitted a greater amount of radio waves than a K or M type star. The averaged and analyzed data is shown as a graph in figure 1-1.

The virtual observatory SkyView was used to gather data about the amount of molecules around a star. Right ascension and declination were entered into SkyView and an infrared scan at 100microns was selected. After the database loaded the one degree image, a fits image was downloaded. The program Iris was then used to calculate the intensity of the infrared scan at the center of the image. After scans were completed for all the stars, it was found that there was no correlation between a stars size and the amount of dust around it. A graph of the data can be found in the appendix.

Observations: Data

The analyzed and averaged data collected from the 4.6m radio telescope showed that the selected O stars, Lambda Orionis and Zeta Orionis, had an averaged peak intensity of 1.07. The B type stars, Rigel and Spica, had an averaged peak intensity of 0.95. A Type stars Sirius A and Vega showed an averaged a peak intensity of 0.73. F Type stars Mu Draconis and Procyon A averaged a peak intensity of 0.62. G type stars, our Sun and Tau Ceti, averaged a peak intensity of 0.58. The K Type stars Epsilon and Eridani and Groombridge 1618 had an averaged peak intensity of 0.41. Finally the M type stars, R Leonis and Betelgeuse, had an averaged peak intensity of 0.55.

SkyView results were not averaged. After analyzed using Iris, the peak intensity for each scan was found. Zeta Orionis had a peak intensity 26, Lambda Orionis 22, Rigel 15, Spica 1, Vega 6, Sirius A 19, Mu Draconis 0, Procyon A 3, Tau Ceti 0, Sun 16, Epsilon Eridani 3, Groombridge 1618 0, Betelgeuse 79, and R Leonis 22.

Results

The averaged data from Smiley showed a direct correlation between star size and radio emission. Despite that the M type stars had a higher averaged intensity than the K type stars, they can be seen as outliers because they are relatively brighter and larger than other M type stars. After the data was analyzed, a theory to explain it was created.

On the stellar classification scale, an O type star is the hottest, and largest. At the end of the scale the M type star, is the smallest and coolest. The main fuel source for a star is hydrogen, therefore a larger star has a larger amount of hydrogen. Neutral Hydrogen existing outside a star creates radio emissions. The hotter a star is, the more energy it puts into particles around it. The more the neutral atoms around the stars move, the more likely they are collide. This increased likelihood of collisions makes increases the possibility of electrons moving into higher energy levels. As these electrons move back down into their original lower energy levels, they emit radio waves at 1420MHz. Thus, the intensity of radio emissions all depends on the size and heat of the star.

The data collected from infrared scans using SkyView showed no correlation whatsoever. In addition to this, averaged data from SkyView also showed no correlation.

Data collected from SkyView contradicted the hypothesis about molecular dust and star size. The randomness of the data makes it clear that a the amount of molecules around a star is not dependent on the star's size but on its location and properties.

Discussion: Future Work and Continued Exploration

In order to further explore relationships between a star's size and its properties such as radio wave emissions it is necessary to obtain data for a much greater number of stars. In order to continue work on this topic, larger numbers of stars in each category of the stellar classification should be analyzed for radio emissions at 1420MHz and dust levels.

The gamut data from the radio telescopes and infrared scans should be averaged and a final graph that shows correlation should be created. Investigating this question on larger scale will give much more knowledge about this subject than this experiment. This experiment only focused on analyzing the data of 14 stars. A large scale experiment investigating the same question could possibly focus on analyzing 140 or 200 stars.

In this experiment stars were selected based on brightness and intensity to ensure their compatibility with the 4.6m Radio telescope. In a future experiment investigating the same question, more sensitive radio telescopes and equipment may be able to ensure that a much more broad range of stars in each level of the stellar classification can be analyzed.

Conclusion/Summary

The question of how a stars mass affects its emissions of neutral hydrogen and the amount of molecules around it was answered by picking stars, specifically two of each type, observing them, either through smiley of SkyView, and analyzing the gathered data to find any correlations.

The correlation between size and radio emission is linked to the fact that O and B stars are much larger and hotter thank K and M stars. This allows them to ionize neutral hydrogen around them more quickly, thus emitting more radio waves.

There was no correlation between dust levels and star size. This simply indicates that the amount of dust around a star is dependent on its location and properties, not on its size.

The only way to further analyze correlations between star size and radio wave emissions or dust levels is to analyze many more stars. Analyzing more stars will give more data, more data will give more answers, but more answers will ultimately lead to more questions.

Works Cited

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Appendix

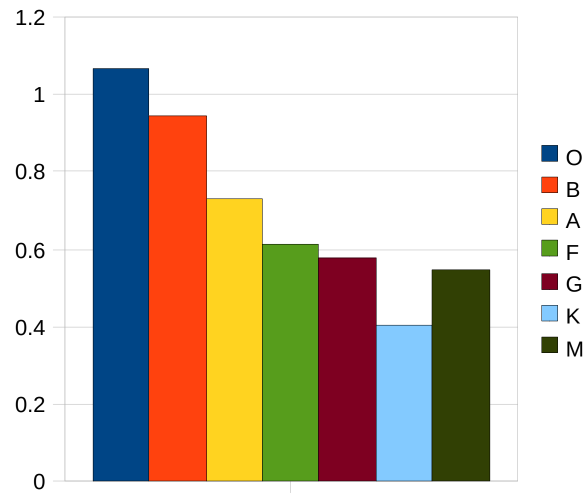

Figure 1-1: This graph shows the relationship between a star's size and its intensity of radio emissions. The stars are different bars on the X-Axis and intensity is listed on Y-Axis.

O	B	A	F	G	K	M
1.07	0.95	0.73	0.62	0.58	0.41	0.55

Figure 1-2: Figure 1-1
m of a table.

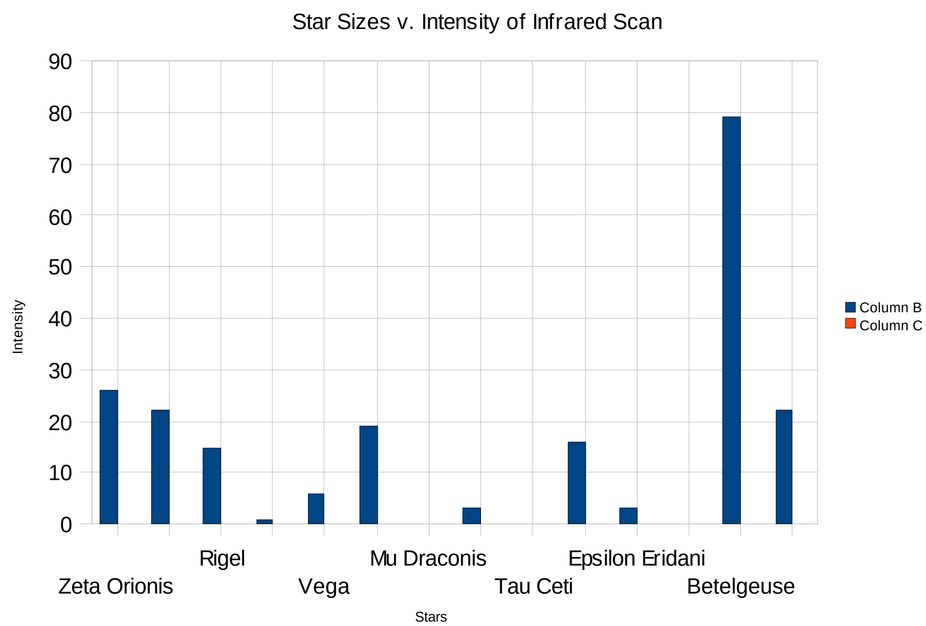

Figure 1-3: This graph shows that there is no correlation between a star's size and the amount of dust around it. The star's are listed on the X-Axis from in the order of the stellar classification scale. The Y-Axis shows the intensity of the Infrared Scan.

Zeta Orionis	26
Lambda Orioni	22
Rigel	15
Spica	1
Vega	6
Sirus A	19
Mu Draconis	0
Procyon A	3
Tau Ceti	0
Sun	16
Epsilon Eridan	3
Groombridge 1	0
Betelgeuse	79
R Leonis	22

Figure 1-4: This table gives exact values for the graph shown above (Figure 1-3).

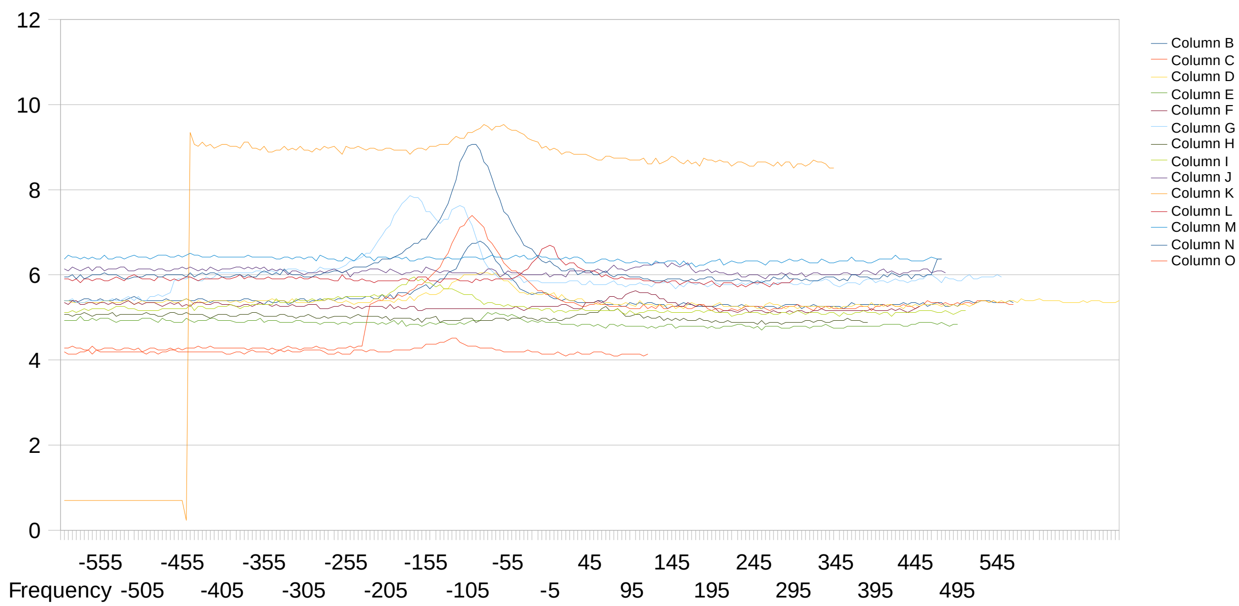

Figure 1-5: This graph shows the raw, unanalyzed, and non averaged data from the 4.6m Radio Telescope. The offset's for these data sets have not been calculated. Columns B through O represent the selected stars in order of size respectively (i.e. Zeta Orionis to R Leonis). Note that this is not the final data.