How Various
Open Star Clusters Metallicity, Size, Mass Relate To Age

Astronomy 1124 Honors Project

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Abstract

The purpose of our paper is to see how various open star clusters properties are related to age. We looked at several different open star clusters including: M37, Collinder 50, M44, M29, M35, NGC 188, M67, M7. Using these star clusters we analyzed their different characteristics such as: mass, size, age, and metallicity. Could the age of a star cluster be related to its mass, size or metallicity? Using these different properties we looked at them to determine if there is any type of correlation between: metallicity and age, size and age, mass and age. We found the data of these characteristics through published academic sources and came to a conclusion based on the data. For metallicity and age we found there is a correlation between them, however there was an outlier in our findings. For size and age, there was no correlation found. For mass and age, there is no correlation seen. After looking at the list of the star clusters above we could find there is a correlation between age and metallicity but for age and mass, age and size there is no correlation seen between them. Our conclusion showed how metallicity is a viable determinant for age.

Introduction

It was well accepted that there was strong correlation between metallicity and age, but there were no published academic papers that found correlation between size and age, mass and age. In our research for how various open star clusters characteristics relate to age we found that there is already a strong correlation found between age and metallicity and there is no correlation seen among age and size, age and mass.

We hope to find that our research aligns with what is already established or similar to what is already known about correlations amongst various properties of open star clusters. We accomplished our research purpose by acquiring information from numerous academic sources on the properties of various open star clusters.

We will use our acquired data and analyze it through graphs to see if correlations are apparent. Finding a correlation between age and metallicity would further reinforce the findings of previous published academic papers. we found a weak correlation between age and size and age and mass and it would positively impact the already published sources on this subject. This is a meaningful topic to research because through the discovery of a correlation of different properties, we will find out whether or not these properties will be useful to look for when attempting to determine the age of newly discovered open star clusters.

Data acquisition

We collected data from 10 different star clusters including: M37, Collinder 50, M44, M29, M35, NGC 188, M67, M7, NGC 4349 and NGC 433. We found the age in millions of years, metallicity in [Fe/H], size in radius and light years, and mass in solar masses for all of the star clusters. We obtained this data by reading various papers published on several academic sources including arxiv.org, nasa.org, iopscience.org, and other scientific databases. We searched for different academic papers on various properties. Using the data collected from the various sources we condensed the information into 5 different categories including: name, mass, size, age, and metallicity.

Star Cluster Names	Mass (Solar Masses)	Size (Radius in Light Years)	Age (years in millions)	Metallicity ([Fe/H])
M37	1500[1]	12.5[1]	425[21]	0.06[9]
Hyades (Collinder 50)	400[2]	10[23]	625[26]	0.14[12]
Beehive (M44)	550[3]	7.5[16]	650[25]	0.16[13]
M29	750[4]	11[17]	13.2[23]	0.55[11]
M35	1600[5]	11[18]	175[5]	0.15[8]
M7	650[6]	25[19]	220[22]	0.04[11]
NGC 4349	4400[1]	60[1]	250[24]	0.13[11]
NGC 433	479[7]	33[7]	65[7]	0.68[11]
NGC 188	2923[14]	11.8[14]	7700[10]	0.12[10]
M67	800[15]	28[20]	5200[10]	0.04[10]

Figure 1. data that we acquired for mass, size, metallicity, and age

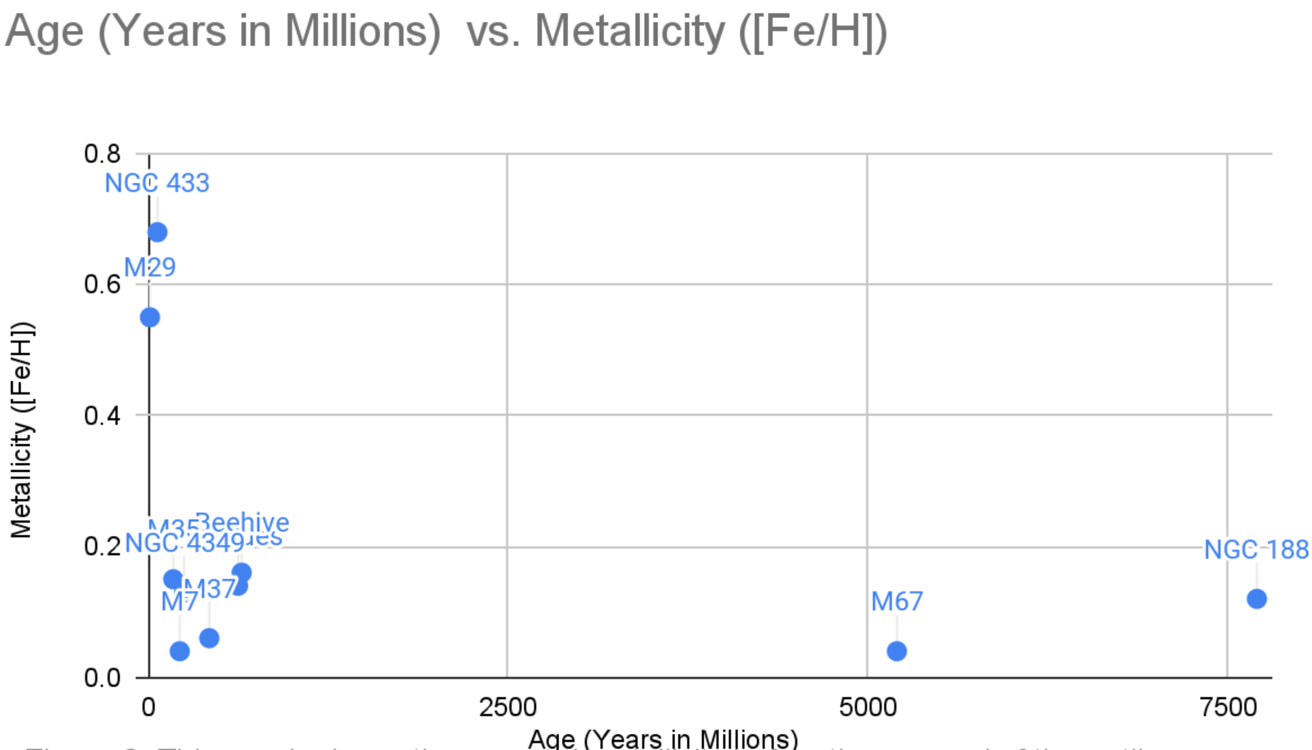

Figure 2. This graph shows the age and metallicity before the removal of the outliers.

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[1] Figure 2. [21] [26][25][23][5][33][34][7][9][12][13][11][8][10]

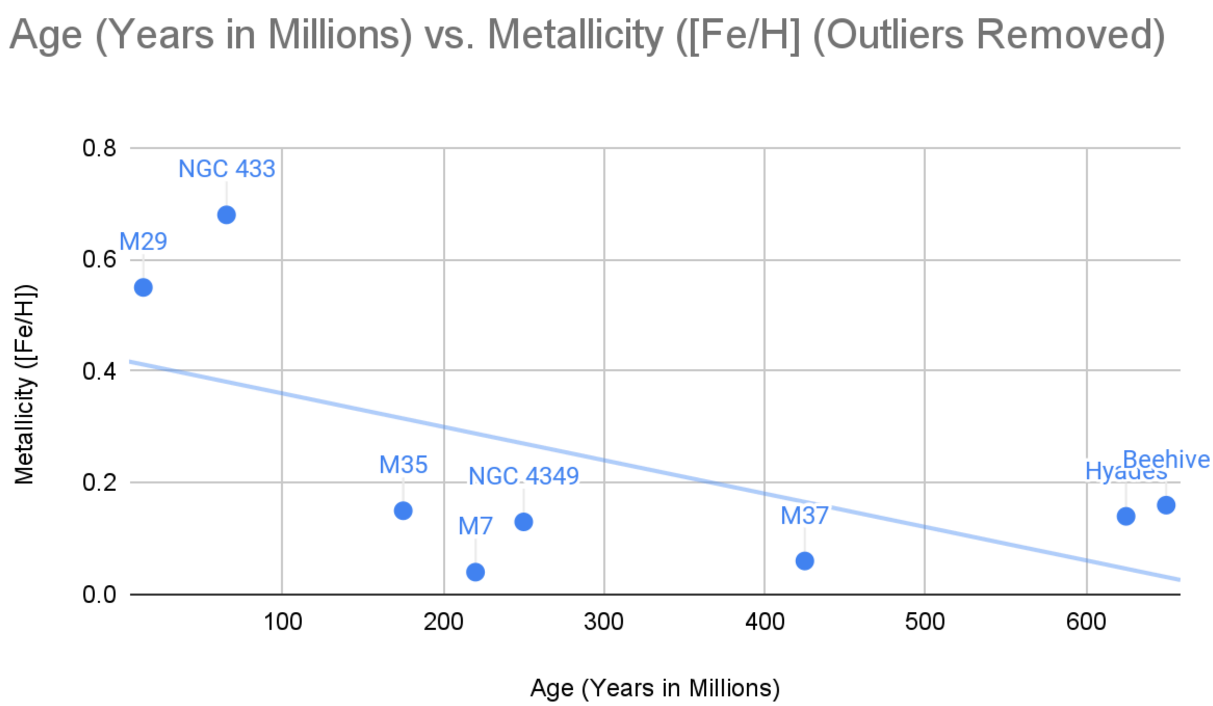

Figure 3 shows a new graph of age and metallicity with the removal of the two outliers M67

[2]

[2] Figure 3. [21][26][25][23][5][33][34][7][9][12][13][11][8]

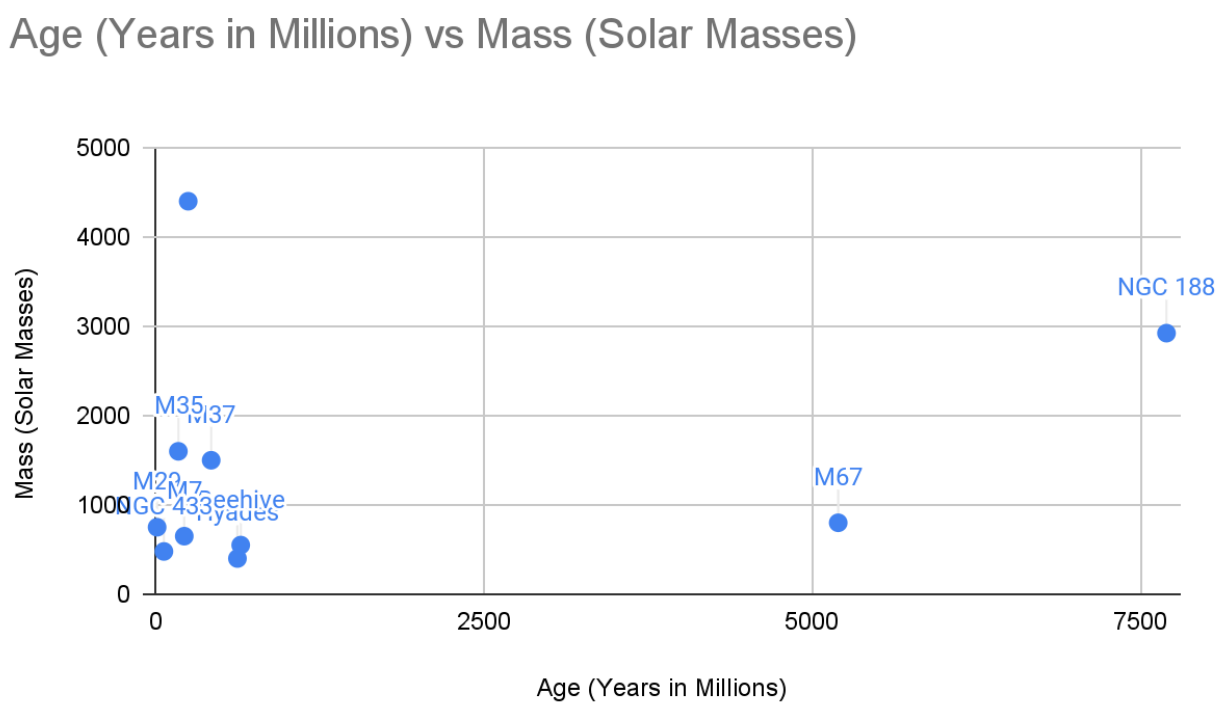

Figure 4. shows the data plotted over age and mass.

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[3] Figure 4 [21][26][25][23][5][33][34][7][10][1][2][3][4][5][6][14][15]

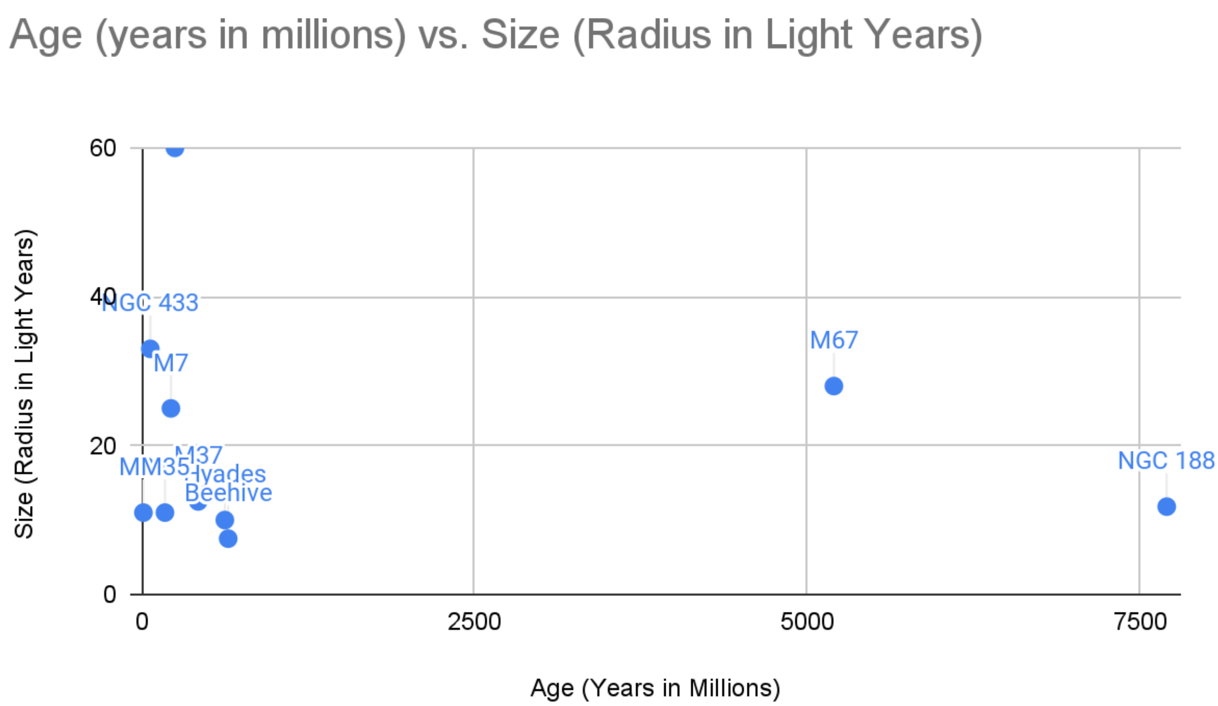

Figure 5. a graph that shows points plotted based on age and size.

[4]

Data Analysis

In our research, we defined a correlation as two properties either being directly or inversely proportional with each other. After, with the collected data we analyzed the various categories against age to see if a correlation is apparent amongst them. We conducted our analysis through graphing two properties against each other such as age vs. mass, age vs. size and age vs. metallicity and inserted a trend line to visualize if we saw a correlation. We used trendlines and various calculations along with academic sources based on our subject matter to make a complete and distinct analysis on all the data we collected. While we were creating the graphs

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[4] Figure 5. [21][26][25][23][5][33][34][7][10][1][16][17][18][19][7][14][20]

we found two outliers that came from really old star clusters. The removal of the two outliers helped make the graph: Age vs Metallicity clearer and gave us more of a distinct analysis of what we were looking at and showed a more direct correlation between the two properties.

Results

Our results indicate there is only a correlation between age and metallicity. We found this to be true by the use of trendlines and graphs it became quite clear that age and metallicity had a correlation. age and metallicity showed a correlation with the removal of some outliers; it showed the younger a star cluster, the higher the metallicity.

Regarding age and mass there was no correlation seen based on our analyzed data through the graphs we created. We came to this conclusion through the use of a trend line which showed that the plot points had no consistent trend.

There was no correlation between age and size either by using the same data analysis technique we used before, finding a result similar to age and mass, which led us to the conclusion of no correlation between them.

The questions still left unanswered among our data is: with more data and research, could there possibly be more of a correlation among age and size or age and mass?

Discussion

While we were researching we found interesting things that weren't exactly a part of our research. How various star clusters can have nicknames like Hyades and the Beehive cluster, while also having actual scientific names and they are sometimes based on their appearance. There can be really old open star clusters when we thought there could only be young open star clusters, relatively speaking.

There were several possible sources of error that could have occurred during our research process. While we were looking for possible candidates for our star cluster list we found that a lot of star clusters didn't have all the possible criteria for our list that made us have a small sample size. we looked at which could have skewed our results. Date of publication of our sources may have been outdated, our data may be slightly inaccurate due to use of older technology. Another possible issue was the numbers given for all the properties found were not exact and usually had ranges of what they could be.

After looking at these various open star cluster characteristics and coming to the conclusion that age was the only property that related to metallicity, location may be possible factor when it comes to a star clusters metallicity, with where it being formed and whether or not it formed in area of intergalactic space with a higher amount of heavy elements that adds to the star clusters total metallicity. A reason why metallicity could be higher in younger star clusters is because the star cluster could be a 3rd or 4th generation star cluster with the build up of heavier metals from previous star clusters high mass star supernovae.

Conclusion

During our research we learned that not all properties of a star cluster must correlate with other characteristics, meaning the characteristics of star clusters we were looking for are independent of each other. We also learned that although we thought certain characteristics would imply other properties we were wrong. We also discovered that finding certain information was harder than finding others such as our first proposal being about composition and we changed it to metallicity. We also found that the information for some of the properties we were looking for like mass and size are not always given an exact number, but a given range that they could fall under.

The data does not support our original thesis because size and mass are not related to age. We now know that size and mass are not related to age because through plotting the data we found on a graph, we saw how there was no trend found and extremely old star clusters can have a very high amount of mass, and younger ones can have a relatively low amount of mass.

Our work does not closely follow the work of other previous works because we did not do our own observations or calculations to find certain properties, we used the data already found to make our conclusions. Our research will help astronomers look at different characteristics of star clusters to see if they correlate to each other rather than the ones we found that didn't correlate. Our work is meaningful to astronomers because it helps them understand more clearly what happens in stellar evolution. It would help by showing a star cluster with a higher metallicity may be a third or fourth generation cluster, which formed in an area that was already enriched in heavier elements by previously formed stars that went through the stellar cycle. Other work that can be done is further finding more data of star clusters to reinforce the correlations found and not found between different properties.

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