Hostless Supernovae

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1 Abstract

In this paper, I discuss "hostless" supernovae. These are described as supernovae that do not have a host galaxy. The sample that we obtained for this project was acquired through SNANA which uses data collected by SDSS data release 7. What we found was that our sample of hostless supernovae were not in fact hostless. After visually checking the sample of over 600 potential hostless supernovae, we found that all of them were hosted by galaxies. After plotting the supernova redshift vs. galaxy redshift, we still found some points that laid outside of the trend where we would expect them. To account for these, I made the same plot but separated by supernova magnitudes less than 20.5 and supernova magnitudes greater than or equal to 20.5. The points that are dim (magnitudes greater than or equal to 20.5) represented the majority of the points that lie outside the trend. This leads to the conclusion that these objects were too dim for SDSS to accurately measure the redshift values, hence why they are lying outside the trend.

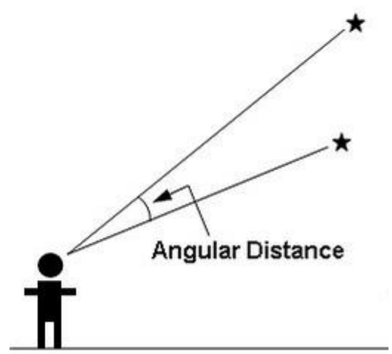
2 Introduction

The purpose of this research project was to investigate the claim made in the paper "Beacons In the Dark: Using Novae And Supernovae To Detect Dwarf Galaxies In The Local Universe". Conroy and Bullock propose that you can use supernovae as a method of detecting the smallest and faintest galaxies in the universe. As we know, all supernovae are hosted within galaxies however, these so-called "hostless" supernovae do not have an identifiable host galaxy. Conroy and Bullock propose that the hostless supernovae are actually members of dwarf galaxies that are just too small and dim to be easily detected.

3 Identifying the Hostless Sample

3.1 Using SNANA and SDSS

To begin investigating the claim made in the paper, we first had to start by identifying our hostless sample. Using both type IA and core collapse supernovae, we compared the isophotal distance to the angular distance by using the SuperNova ANAlysis (SNANA) software to find the host galaxy. Angular distance (Fig.1) is exactly what it sounds like, the angular distance between the supernova and its host galaxy. Sloan Digital Sky Survey (SDSS) defines isophotes as "lines drawn through areas of constant brightness. Isophote images are very similar to contour maps, which show lines through areas of



[2] **Figure 1** This graphic illustrates how the angular distance is measured between two stars. For our case, the angular distance is measured between the supernova and the host galaxy.

constant elevation."[1] Isophotal distance measures the candidate hostless supernova's distance from the center of the galaxy as a fraction of the galaxy's isophotal size. SNANA looks at data collected by SDSS data release 7 and gives us various properties of our hostless sample such as redshift, position and magnitude among others.

3.2 Comparing Angular and Isophotal Distances

The SNANA algorithm works by finding the galaxy that is closest in angular distance and the galaxy that is closest in isophotal distance. If the same galaxy is at both distances, then it is marked as a host. If it is not the same galaxy, then we find the redshifts of the respective galaxies. We then take these redshifts and compare them to the redshift of the supernova. The galaxy with the redshift that is closest to the supernova redshift is then marked as the host. To obtain our hostless sample, I then made a plot comparing the galaxy redshift with the supernova redshift. In Figure 2 you can see that the points that lie outside shaded trend region are our candidates for hostless supernovae.

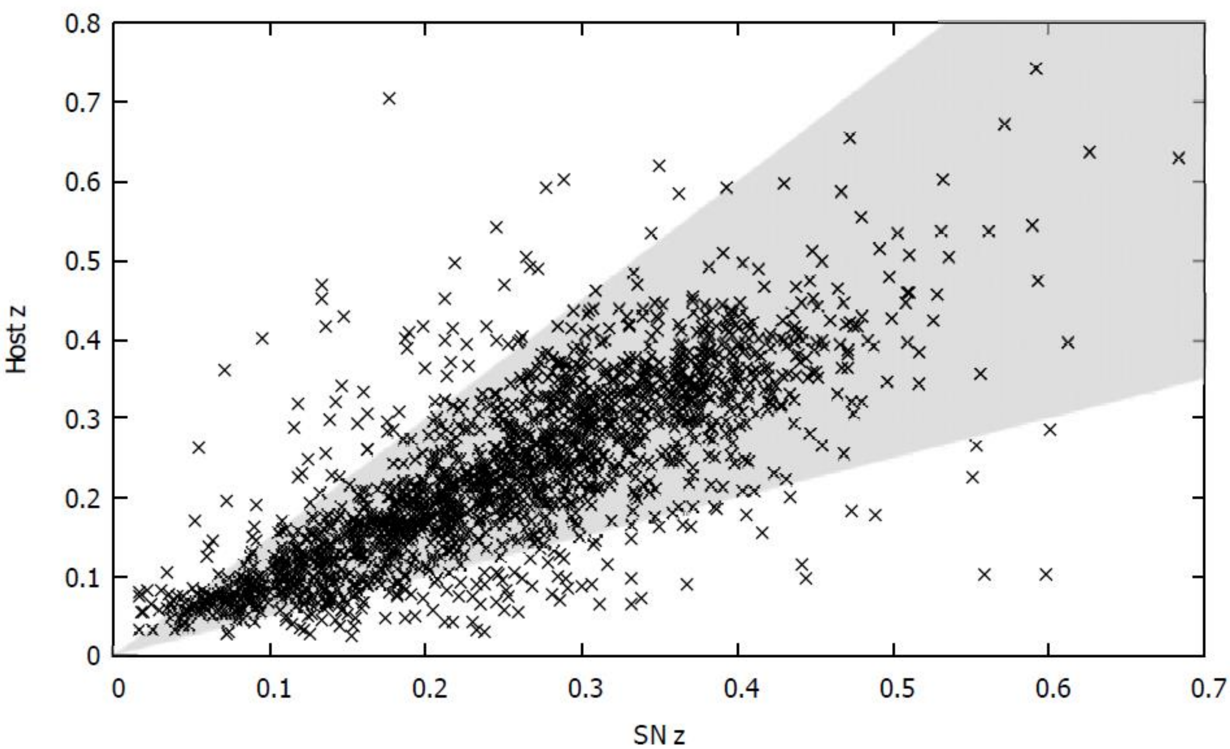
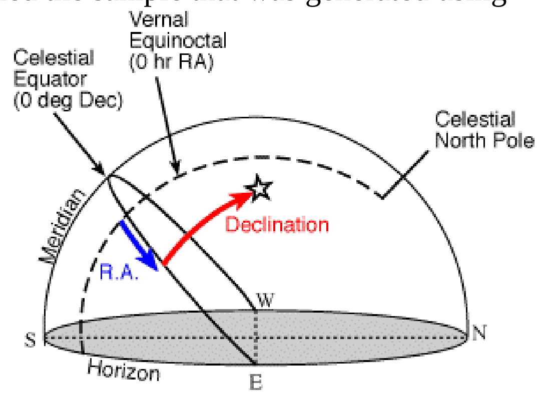


Figure 2 This plot compares the supernova redshift and host galaxy redshift. The shaded region represents the area where the two are the same. When these two redshifts are the same, it verifies that we have found the host galaxy since both the supernova and galaxy are at the same angular spot in the sky. Points that lie outside the shaded region are our candidates for hostless supernovae.

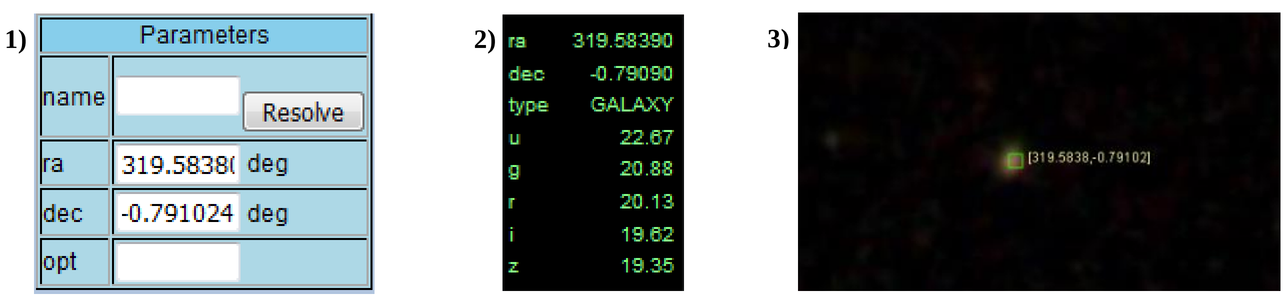
4 Verifying Hostless Sample with SDSS's Navigation Tool

It is important to note that sometimes the SNANA algorithm fails, so to make sure that we don't have any bad or incorrect data, I visually checked the sample that was generated using SDSS's Navigate Tool. As stated above, the data collected by SNANA was done with SDSS data release 7 but I used SDSS data release 12 to verify the coordinates. The Navigate Tool tells us what object is located at a particular location based on the right ascension and declination coordinates. (See Fig. 3)



[3]**Figure 3** Right ascension is measured around the celestial equator like longitude and runs from 0—360°. Declination is like latitude and measures how far above or below the object is from the celestial equator. It runs from -90°—90°.

For example, SNANA gave the coordinates of RA: 319.583801 DEC: -0.791024 as a potential candidate for a hostless supernova. To verify that there was not a host here, I plugged the coordinates into SDSS's Navigation Tool (Fig. 4.1). The output that we receive shows an image of what is at those coordinates, what type of object located there, and the different magnitudes depending on what filter you use (u,g,r,i, or z). As you can see, on the third line of output data (Fig. 4.2), SDSS tells us that there is a galaxy located at this position. We can verify it by also looking at the image (Fig. 4.3) to make sure we can visually see the object that is supposed to be there. This eliminates this supernova as being hostless.



[4]**Figure 4** **1)** Sloan Digital Sky Survey's Navigation Tool allows you to individually search different locations in the sky. I used this to search each coordinate to verify what object, if any, was at that position. **2)** The Navigation Tool output data shows us what object is located within the given parameters. **3)** The Navigation Tool also provides an image that you can zoom in or out from to see the object at the given coordinates.

5 Results

5.1 Verified Sample

Once I visually checked each individual supernova, the results were surprising. I found that there was a galaxy located at each coordinate. As shown above in Figure 2, there are several points that lie outside of the shaded trend area. Some of the points are pretty close to the area, but there are a few that seem to lie further away from the trend than the others. Because I already checked that there were galaxies located at the coordinates, they should've shown up within the trend or at least very close. To account for this, I individually checked the points that fell outside the trend using SDSS's Navigation Tool. For most of the points, SDSS also has values of redshift. I checked to make sure that SNANA had the proper values for redshift by comparing what was listed through the Navigation Tool and through the data collected from SNANA. When I corrected for the difference in redshift, several of the points shifted into the trend but some of them remained outside (See Fig. 5). Further work needs to be done in order to understand why these few points have different supernova and galaxy redshifts.

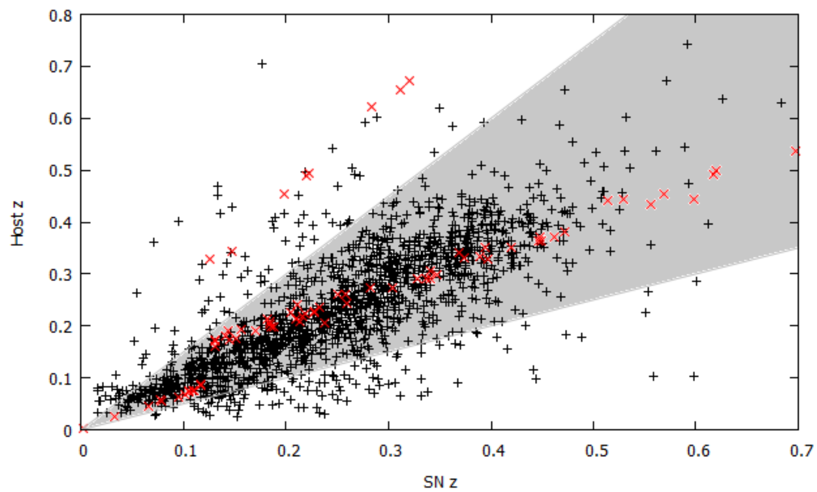


Figure 5 This is the same plot as Figure 2 after the corrected redshift values have been accounted for. The few red points are the corrected values of redshift while the black points are the original values.

5.2 Separation by Magnitude

My last idea to account for why the points were lying outside of the trend was to separate them out by supernova magnitude. When the magnitude is higher, it indicates a dimmer object and conversely when the magnitude is lower, the object is brighter. My thinking was that the objects that lie outside the trend are very dim or just too dim to have accurate values of redshift. In order to check this, I filtered the results from SNANA into two groups: supernovae with a magnitude less than 20.5 and supernovae with a magnitude greater than or equal to 20.5. Then I made another plot to separate out these two groups. As you can see in Figure 6, the objects that are dimmer, with a magnitude greater than 20.5, are not only evenly dispersed but they account for the majority of the points that lie outside the trend. What this says to me is that these points are too dim for the data to be accurate and SDSS does not have a good approximation for the redshift. The points with a supernova magnitude of less than 20.5 are representative of objects that are bright enough for SDSS to have a good approximation of the redshifts.

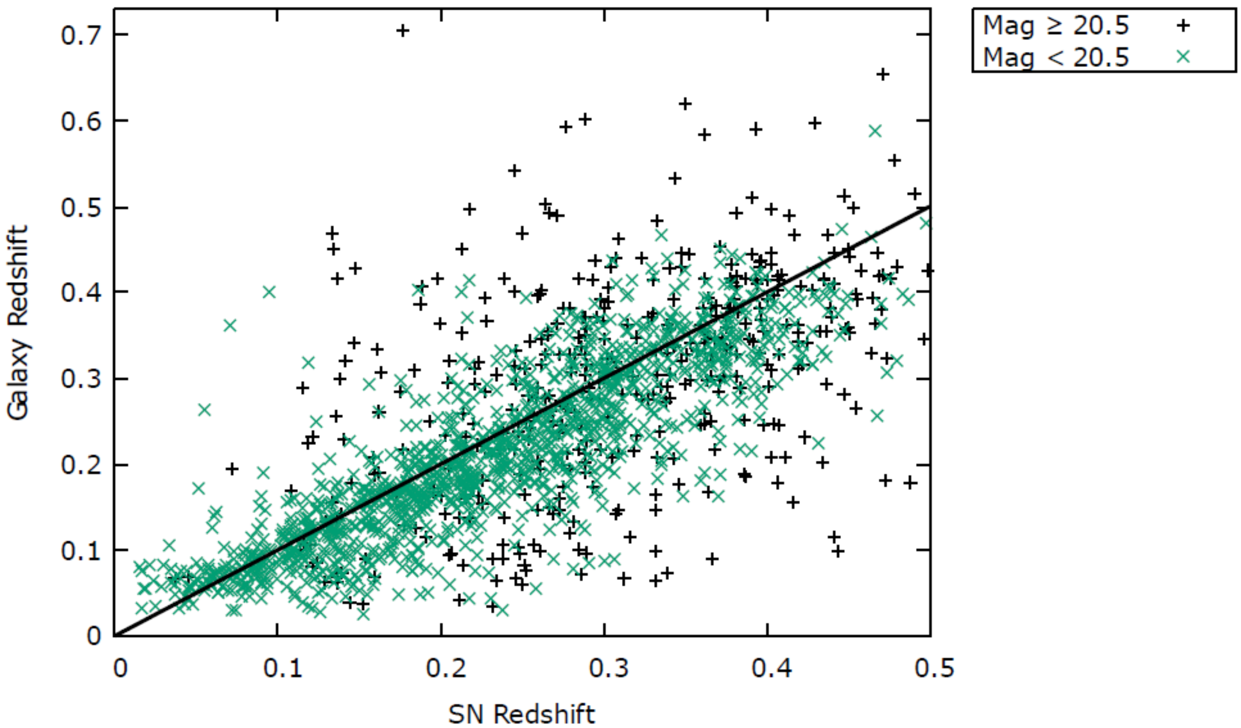


Figure 6 This is the plot comparing the two groups separated out by those with supernova magnitude less than 20.5 and those with supernova magnitude greater than or equal to 20.5. The black line is representative of where the redshifts of the supernova and galaxy are equal. The green points, where the magnitude is less than 20.5 stick very closely to the trend line. The black points are fairly evenly spaced

5 Conclusion

From the results previously discussed, it is safe to say that these so-called “hostless” supernovae do not exist within our obtained sample. Every single point was checked visually through SDSS, which is where SNANA obtains its data from.* To further check these points, the redshift values were also verified. In addition, to make sure that SDSS has accurate data, I separated the points out by magnitudes. Specifically, higher magnitudes where the collected data may have been inaccurate. What I found was that the majority of the points that lie outside of the trend area were ones where the magnitude was higher than 20.5, representing dim objects.

* SNANA uses data collected through SDSS data release 7 while I visually checked the sample using SDSS data release 12.

References

Conroy, C., Bullock, J., 2015, arXiv:1504.04015v1
[1]http://skyserver.sdss.org/dr12/en/proj/advanced/processing/alternateviews.aspx
[2]Fig.1 https://dept.astro.lsa.umich.edu
[3]Fig. 2 http://astronomy.uconn.edu
[4]Fig. 3 http://skyserver.sdss.org/dr12/en/tools/chart/navi.aspx