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The SN host galaxies in SDSS DR7

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ABSTRACT

The wide interest of the scientific community on SNe has triggered new, deep SN searches which, in a few years have enormously increased the number of SN discoveries. Unfortunately in a lot of cases, especially in deep SN searches, identification of host galaxies and their physical properties are incorrect or even absent. To solve this problem we cross-matched Asiago Supernovae Catalogue (ASC) with the SDSS DR7 in term to directly identify SN host galaxies and create a homogeneous database with the hosts integral properties. We provide accurate coordinates, morphological type, spectral and activity classes, SDSS magnitudes, apparent diameters, axial ratios, and position angles of galaxies. All SN type classifications taken from the ASC were checked through a complete search of the literature, IAU circulars and Sternberg Astronomical Institute SNe Catalogue. Our sample consists of 3072 SNe in 2918 hosts which are located in SDSS area. For 2808 SNe (in 2654 hosts) we directly identified host galaxies, which is about 91% of our sample. From this 91% 1600 host galaxies in ASC are marked as anonymous. Identifications of most of them have been done for first time. 1038 hosts (with 1107 SNe) have nuclear SDSS spectra. Photometrical information is available for the local position of 663 SNe. Spectra from direct positions of 83 SNe are also available. Detailed morphological classification has done for 1585 hosts. We found that approximately 10% of our sample galaxies have SDSS morphological classification which is dramatically different from the ASC (mainly from RC3) and HyperLeda database. In most cases, the morphological bias can be due to the over-exposure of the high surface brightness galaxies.

The creation of this homogeneous database will help to understand how the different type SNe events and their spatial distribution are correlated with the properties of the nuclei (activity class, chemistry, stellar population etc.) and global physical parameters (morphology, size, absolute magnitudes etc.) of the host galaxies and also how they interact with close and far environments properties of these galaxies, as well as minimize possible selection effects and errors which often arise when information for studied objects is selected from different sources and catalogues.

1. INTRODUCTION

A crucial importance in most current SN investigations is to find the links between the nature of SN progenitors and host galaxy stellar populations. The number of SN progenitors that have been identified directly from pre-SN imaging is small and is limited to the nearby core-collapse SNe events (e.g., Smartt 2009). This is the main reason to investigate the SNe progenitor stars indirectly through alternative methods. Nearly all constraints on the progenitor nature have used their distribution within host galaxies (e.g., Hakobyan et al. 2009) or stellar population studies with the absolute magnitudes as proxies for galaxy global metallicity (e.g., Prantzos & Boissier 2003) or metallicity gradients (e.g., Boissier & Prantzos 2009) or direct metallicity measurements with relatively small numbers of events (e.g., Modjaz et al. 2008, Anderson et al. 2010).

The first and critical point in SN progenitors study is the creation of a large and well defined sample of SNe and their host galaxies. Many studies are based on the heterogeneous nature of selected data sets (e.g., Anderson & James 2009; Hakobyan et al. 2009). Generally their samples were a random selection of nearby SNe and their host galaxies from the ASC (Barbon et al. 2009) or the Sternberg Astronomical Institute (SAI) SNe catalogue (Tsvetkov et al. 2004). For the galaxy data these catalogues made large use of the Third

Reference Catalogue of Bright Galaxies by de Vaucouleurs et al. (1991, [RC3]) and of the HyperLeda database and NED. Hence, the data are given with various degrees of accuracy depending on the accuracy of the original Catalogue. All this information is in wide use when constraining the nature of progenitors through analysis of the sample host galaxies global physical properties, as well as stellar populations found in the immediate location of SNe. Many selection effects and errors which often arise when information for studied objects is selected from different sources and catalogues can significantly affect obtained results and leads to wrong conclusions. In this respect the creation of well defined and as homogeneous as possible database is in crucial importance.

We report the creation of our database which collects several thousand cases when SNe were in host galaxies which can be identified in the Sloan Digital Sky Survey (SDSS) DR7. In addition, we discuss the selection effects and biases which can significantly affect obtained results.

2. DATA AND BASIC STATISTICS

We have used the ASC (version updated on February 2010) to obtain and investigate the main properties of SNe and their hosts information when available. The ASC is a compilation of information about SN discoveries obtained mainly from reports in the International Astronomical Union Circulars, as well as basic information about the host galaxies mainly from of the RC3, HyperLeda, and NED. The version of the SN catalog we have used contains 5206 entries. We have cross-matched this version of ASC with the SDSS DR7 using the coordinates of the host galaxies in the cases they are known and identified in the ASC, as well as the SNe coordinates.

The number of SNe which are located on SDSS area is 3072 (2918 host galaxies). After cross-matching we visually inspected the SDSS DR7 images around the SNe positions to directly identify the hosts, and exclude the galaxies that were wrongly selected as hosts. We have identified about 91% of our host galaxy sample (2654 hosts with 2808 SNe), from which 1600 hosts in ASC are marked as anonymous. Identification of most of them have been done for the first time. Using the SDSS images, photometric, and spectral data we have determined host galaxies SDSS names, accurate coordinates at the 2000.0 epoch, morphological type, spectral and activity classes, apparent diameters, axial ratios, and position angles.

We have done detailed morphological classification for 1585 host galaxies (54% of our sample). The number of hosts from S0 to Sm classifications is 1491; among them 420 galaxies have a barred structure. In Table 1 we present the distribution of the final matched sample of SNe of different types according to the morphological type of hosts.

Table 1. Distribution of SNe according to the morphological types of the host galaxies.

	E	E/S0	S0	S0/a	Sa	Sab	Sb	Sbc	Sc	Scd	Sd	Sdm	Sm	S	Irr	Not class.	Total
I	4	2	3	5	3	3	4	5	7	1	1		3	4	2	12	59
Ia	41	25	41	56	23	42	94	77	94	22	18	7	2	142		908	1592
Ib			1			2	5	7	11	5	4	2	2	2		8	49
Ib/c				1		1	1	6	6	1	1	3		2		7	29
Ic					2	3	11	20	16	6	7			3		15	83
Iac																3	3
II			2	4	8	11	78	89	144	35	33	11	7	38	8	97	565
IIb							4	5	9	5	3	3	1	2	1	1	34
IIn				1			11	7	25	8	3	3	3	5		22	88
Not class.	6	6	16	13	15	18	57	46	52	9	12	7	6	41	4	262	570
N_{SN}	51	33	63	80	51	80	265	262	364	92	82	36	24	239	15	1335	3072
N_{gal}	46	33	63	76	48	77	244	231	306	80	75	34	23	234	15	1333	2918

The cross-matching of the ASC with the SDSS DR7 has given large information on host galaxies photometry and spectroscopy. Among identified objects 1038 hosts (with 1107 SNe) have nuclei spectra. Photometrical information is available for the local position of 663 SNe. Spectra from direct positions of 83 SNe are also available. In our article which is currently in preparation, all this data is in large use for SN progenitor study.

3. DISCUSSION

As mentioned above, the morphology of SNe host galaxies plays an important role and is one of the crucial constituents in SN progenitors study. It is well known that for some very bright galaxies and high surface brightness objects, the central parts of their images may be over-exposed, which can significantly affect classification of the hosts. In respect to analyze this trend we have carried out detailed comparative study in order to find differences between morphological classifications for the host galaxies in our sample and in the ASC. It is important to note that visual classification avoids the introduction of biases associated with proxies for morphology such as color, structural parameters etc. In Fig. 1 we present some from extreme cases when difference between morphological type codes is ≥ 3. Images in color and in gray scale are taken from composition of the SDSS different bands and Palomar Observatory Sky Survey (POSS), respectively. Here the POSS images have been taken as examples to illustrate the quality of materials which was used before to classify the objects.

We found that approximately 10% (103 hosts) from 959 galaxies which are both classified in our sample and in the ASC have SDSS morphological classification which is dramatically different from the ASC. In nearly all cases, due to the over-exposure, late-type galaxies of high surface brightness were misclassified as being of early-type. We believe that the remaining few cases of misclassification are mainly due to the heterogeneous nature of morphological data sets in ASC.

It is generally believed now that the gas inflow caused by the large-scale gravitational asymmetry of the host galaxies, such as a bar structure, triggers both AGN activity and formation of the bulge. This mechanism is very important when constraining the nature of the SNe progenitors by comparing their radial distribution within their host galaxies with the distributions of stars and ionized gas in the disks. In this case well definition of barred structure of the host galaxies is an important point for sample creation. We have carried out a similar comparative study in order to find differences between detection of barred structure for the host galaxies in our sample and in the ASC. In Fig. 2 we present some examples of misdetections of bars.

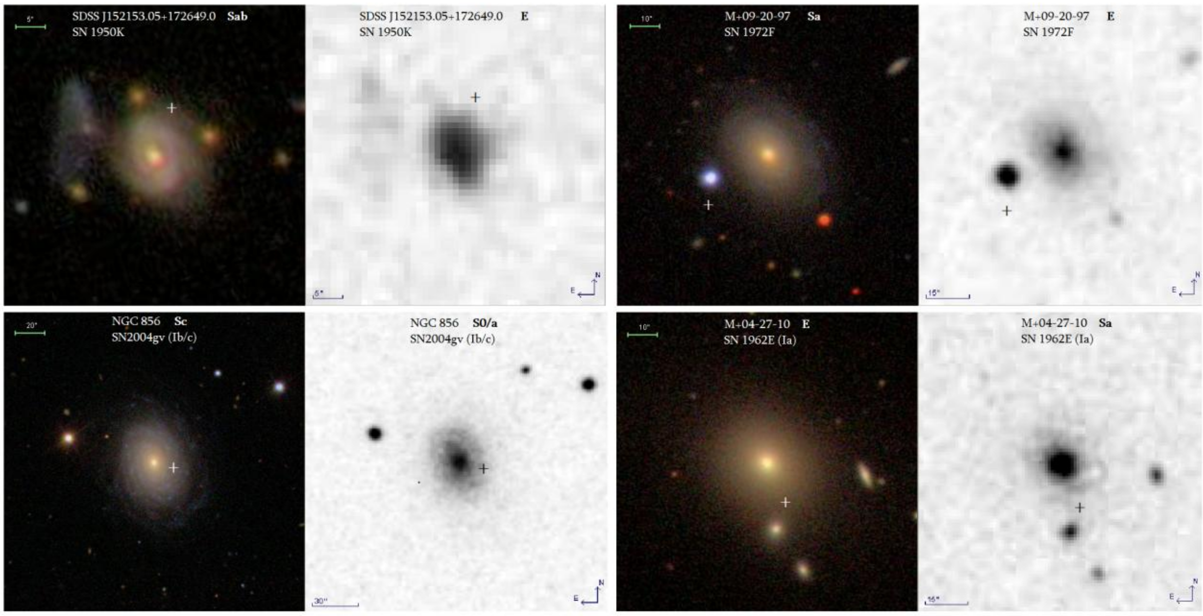

Fig. 1. Some from extreme cases when difference between morphological type codes is ≥ 3.

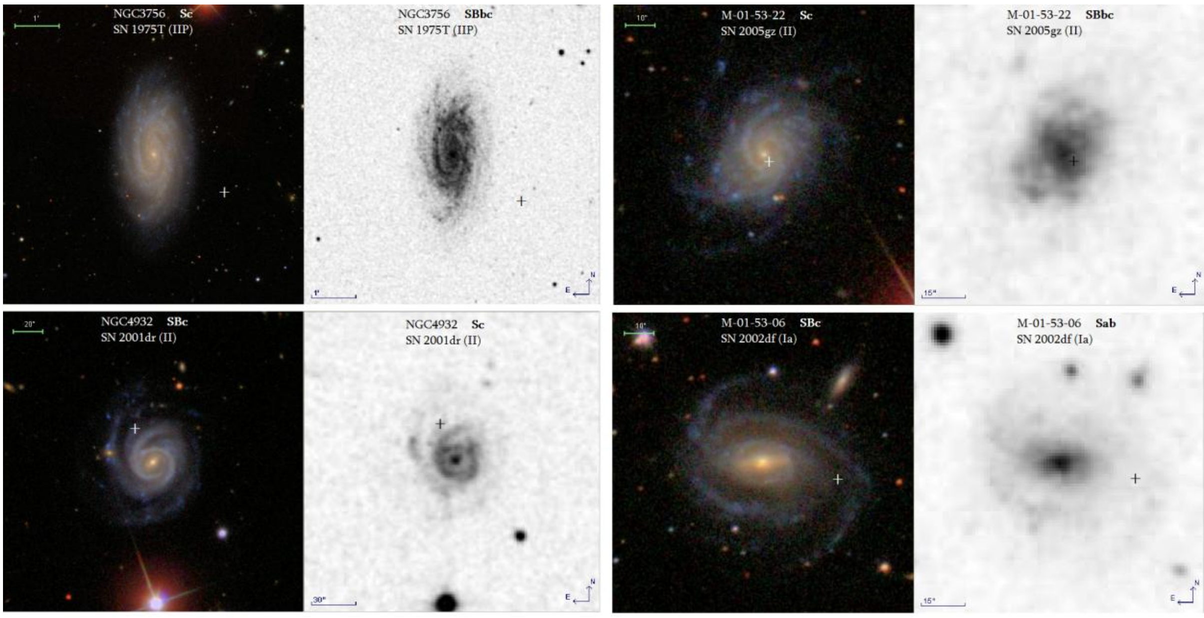

Fig. 2. Examples of misdetections of bars.

We found that 239 hosts from S0 to Sm morphological range in the ASC suffer from misdetection of barred structure. This is mainly due to galaxies high surface brightness of the central parts of their images and high inclination of the disks. The remaining cases of misdetection are again due to the heterogeneous nature of the data sets in ASC.

It is interesting to note that many core-collapse (CC) SNe studies often use the assumption that the CC SNe have young progenitors that are located in the geometrically ideal disks of the spiral galaxies. The SN radial distances as well as metallicity gradients in the disks are usually estimated from the deprojected separations from the host galaxy nuclei, using the inclinations correction of the host galaxies. But, we found that in many cases (clearly seen in 117 hosts) disk structures of the host S0/a to Sdm galaxies are disturbed and far from ideal spiral disk. In Fig. 3 we present examples of disturbed spiral host galaxies. We explain this trend by presence mergers, close interacting systems, and galaxies with different classes of activity in our host galaxies sample. For instants Reichard et al. (2009) recently found that more active AGN with younger circumnuclear stellar populations are on average associated with more lopsided host galaxies. In addition we have found unique counterexample when CC SN (SN IIP 2009by in UGC6260) exploded very far from disk structure in spiral host galaxy. Fig. 4 shows this counterexample.

In future studies we should isolate and investigate separately this kind of host galaxies when constraining SN radial distribution and metallicity gradients in the spiral disks.

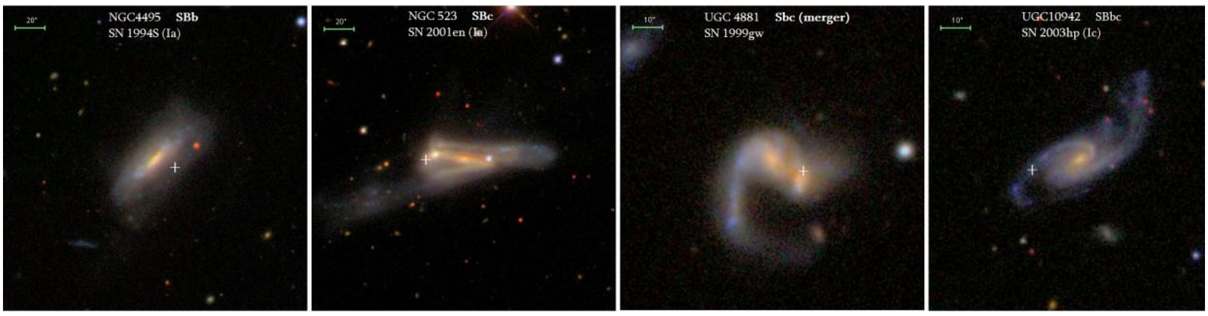

Fig. 3. Examples of disturbed spiral host galaxies.

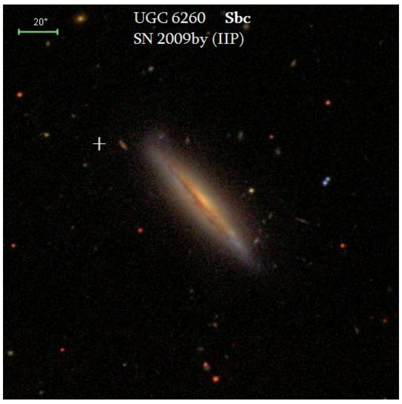

Fig. 4. CCSN exploded very far from disk structure in spiral host galaxy.

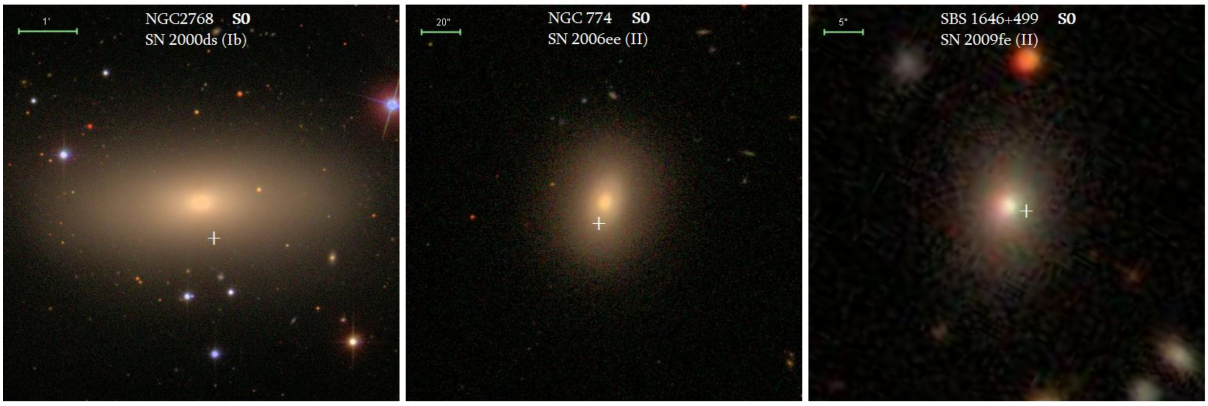

Fig. 5. CCSNe in early-type hosts.

It is generally believed that the hosts of core collapse SNe are objects with young stellar population (generally spiral or irregular galaxies) while the old stellar population of early-type galaxies can produce only SNe Ia. Nevertheless in our sample among the morphologically-classified host galaxies of CC SNe, we have noted 3 cases (SN Ib 2000ds in NGC2768, SN II 2006ee in NGC774, SN II 2009fe in SBS1646+499) in which the host has been classified as S0, in apparent contradiction to this conventional view. Fig. 5 presents these 3 cases of CC SNe in early-type hosts.

Hakobyan et al. (2008) already reported and investigated in detail two cases from these CC SNe. The presence of CC SNe in early-type galaxies can be interpreted as an additional indication that residual star formation episodes take place also in S0 galaxies due to merging/accretion or interaction with close neighbors.

4. CONCLUSION

We report about the creation of our large and well defined database of 3072 SNe and their 2918 host galaxies which are located on SDSS area. Identification of our host galaxy sample (2654 hosts with 2808 SNe) is about 91%, from which identification of about 1600 hosts have been done for the first time.

Approximately 10% of our sample galaxies have SDSS morphological classification which is dramatically different from the ASC. We share the view with van den Bergh et al. (2003) and explain this that high surface brightness in galaxies plays a crucial role in misclassification and misdetection of barred structure, particularly for largely inclined galaxies.

In addition we present counterexamples which are in apparent contradiction to the conventional view that the hosts of CC SNe are objects with young stellar population. In our sample one CC SNe exploded very far from disk structure in the halo of the spiral host galaxy and 3 cases in which CC SN host has been classified as S0. We explain the presence of such examples as an additional indication that residual star formation episodes take place also in S0 hosts and in halos of spiral galaxies due to merging/accretion or interaction with close neighbors.

In future analysis we will largely use all photometrical and spectral data which we collect in term to constrain the progenitor nature using their distribution within host galaxies of different activity levels, stellar population studies, metallicity gradients, and direct metallicity measurements in the intermediate location of SNe.

The creation of this large database will help to better understand *i*) how the different type SNe events and their spatial distribution are correlated with the properties of the nuclei and global physical parameters of the host galaxies, *ii*) also how they interact with close and far environments properties of these galaxies *iii*) as well as minimize possible selection effects and errors which often arise when information for studied objects is selected from different sources and catalogues.

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