Classifications of the Host Galaxies of Supernovae, Set III

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ABSTRACT

A homogeneous sample comprising host galaxies of 604 recent supernovae, including 212 objects discovered primarily in 2003 and 2004, has been classified on the David Dunlap Observatory system. Most SN 1991bg-like SNe Ia occur in E and E/Sa galaxies, whereas the majority of SN 1991T-like SNe Ia occur in intermediate-type galaxies. This difference is significant at the 99.9% level. As expected, all types of SNe II are rare in early-type galaxies, whereas normal SNe Ia occur in all Hubble types. This difference is significant at the 99.99% level. A small number of SNe II in E galaxies might be due to galaxy classification errors, or to a small young-population component in these mainly old objects. No significant difference is found between the distributions over Hubble type of SNe Ibc and SNe II. This confirms that both of these types of objects have similar (massive) progenitors. The present data show that, in order to understand the dependence of supernova type on host-galaxy population, it is more important to obtain accurate morphological classifications than it is to increase the size of the data sample.

Subject headings: supernovae – statistics: galaxies – classification

1. The Lick Observatory Supernova Search

The present paper represents a continuation of the investigations by van den Bergh, Li, & Filippenko (2002, 2003; hereafter Papers I and II), in which we studied the morphologies of the host (parent) galaxies of supernovae (SNe) that were discovered (or independently rediscovered) during the course of the Lick Observatory Supernova Search (LOSS) with the 0.76 m Katzman Automatic Imaging Telescope (KAIT).[1] This is the first step in the LOSS-based calculation of rates of various types of SNe, currently being conducted by Leaman, Li, & Filippenko (2004).

LOSS, which started in March 1997 (Treffers et al. 1997), has been described by Li et al. (2000), Filippenko et al. (2001), and Filippenko (2003, 2005). During the interval late-October 2000 through mid-October 2003, it was expanded to the Lick Observatory and Tenagra Observatory Supernova Searches (LOTOSS; Schwartz et al. 2000), but thereafter it reverted back to simply LOSS (Filippenko et al. 2003), using KAIT alone, without the assistance of Tenagra Observatory.

KAIT is a fully robotic instrument whose control system checks the weather, opens the dome, points to the desired objects, acquires guide stars (in the case of long exposures), exposes, stores the data, and manipulates the data automatically, all without human intervention. We reach a limit of $\sim$19 mag (4σ) in 25-s unfiltered, unguided exposures (used in the supernova search), while 5-min guided exposures yield $R \approx 20$ mag. Besides conducting a supernova search, KAIT acquires well-sampled, long-term light curves of SNe and other variable or ephemeral objects — projects that are difficult to conduct at other observatories having a large number of users with different interests.

Special emphasis is placed on finding SNe well before maximum brightness. Although the original LOSS sample had only about 5000 galaxies, in the year 2000 we increased the sample to $\sim$14,000 galaxies (most with recession speed $cz \lesssim 10,000$ km s^{-1}), separated into three subsets (observing baselines of 2 days for about 100 galaxies, 3–6 days for $\sim$3000 galaxies, and 7–14 days for $\sim$11,000 galaxies). In early June 2004, we decreased the sample to 7500 galaxies, in order to have a shorter baseline and be better able to determine the explosion date accurately. Specifically, we adopted this last strategy to find SNe Ia for an extensive study of their ultraviolet properties with the *Hubble Space Telescope (HST)* — GO–10182 (P.I.: Filippenko).

We are able to observe $\sim$1000 galaxies per night in unfiltered mode. Our software automatically subtracts new images from old ones (after registering, scaling to account for

[1]Although most of the SNe were discovered by LOSS itself, some were first discovered and reported by other observers. Nevertheless, their host galaxies were being monitored with LOSS at the time of discovery, and LOSS independently recognized the new objects as SNe; thus, they are included in the complete sample.

clouds, convolving to match the point-spread-functions, etc.), and identifies SN candidates which are subsequently examined and reported to the Central Bureau for Astronomical Telegrams by numerous research assistants (mostly undergraduate students) in our group at the University of California, Berkeley. Interested astronomers elsewhere are also notified immediately. A Web page on LOSS is at http://astro.berkeley.edu/∼bait/kait.html.

LOSS found its first supernova in 1997 — SN 1997bs; ironically, it might not even be a genuine SN (Van Dyk et al. 2000). In 1998, mostly during the second half of the year, LOSS discovered 20 SNe, thereby breaking the previous single-year record of 15 held by the Beijing Astronomical Observatory Supernova Search. In 1999, LOSS doubled this with 40 SNe. In 2000, LOSS found 38 SNe, even though we spent a significant fraction of the observing time expanding the database of monitored galaxies rather than searching for SNe. With this expanded database, LOSS discovered 68 SNe in 2001, 82 in 2002, 95 in 2003, and 83 in 2004. We discovered SN 2000A and SN 2001A, and hence the first supernova of the new millennium, regardless of one's definition of the turn of the millennium! During the past few years, KAIT has discovered *well over half* of all nearby SNe reported world-wide, from all searches combined. Thus, KAIT/LOSS is currently the world's most productive search engine for nearby SNe.

At the Lick and Keck Observatories, we spectroscopically confirm and classify nearly all of the SNe that other observers haven't already classified. Thus, the sample suffers from fewer biases than most. Already, our observations and Monte-Carlo simulations have shown that the rate of spectroscopically peculiar SNe Ia is considerably larger than had previously been thought (Li et al. 2001a).

Follow-up observations for the discovered SNe are emphasized during the course of LOSS. Our goal is to build up a multicolor database for nearby SNe. Because of the early discoveries of most LOSS SNe, our light curves usually have good coverage from pre-maximum brightening to post-maximum decline. Moreover, LOSS SNe are automatically monitored in unfiltered mode as a byproduct of our search; these can sometimes be useful for other studies (e.g., Matheson et al. 2001). The positions of SNe in KAIT images were used to identify the same SNe at very late times in *HST* images (Li et al. 2002), allowing us to determine the late-time decline rates.

LOSS also discovers novae in nearby galaxies (e.g., M31), cataclysmic variable stars, and occasionally comets (Li 1998; Li et al. 1999). Although it records many asteroids, we do not conduct follow-up observations of them, so most are subsequently lost.

2. New Morphological Classifications

In Papers I and II, morphological classifications were given for the host galaxies of 177 and 231 SNe, respectively. In Table 1 of the present paper we list, for an additional 212

SNe, (1) the SN name, (2) the host-galaxy name, (3) the SN classification, (4) the type of the host galaxy on the Yerkes system (Morgan 1958, 1959), (5) the host-galaxy type on the David Dunlap Observatory (DDO) system (van den Bergh 1960a, 1960b, 1960c), and (6) the published radial velocity of the SN host galaxy. The database examined in the present investigation extends through the end of the year 2004.

However, recent careful inspection of the monitoring data of all the host galaxies classified in Papers I and II reveals that for 15 galaxies, the corresponding SNe (discovered and reported by other observers) were actually *not* successfully imaged by KAIT: either the SNe were too faint, or all the KAIT images for a particular galaxy were plagued by bad weather. Moreover, the host galaxy of SN 1998dl (NGC 1084) was included in both Papers I and II. We thus need to exclude classification for 16 galaxies in our sample, leaving the total number of host galaxies classified in Papers I through III to be 604. The 16 galaxies that need to be removed from the study are listed in Table 2.

The Yerkes classification system provides a one-dimensional classification along the sequence "a - af - f - fg - g - gk - k." Objects of type "a" have the lowest central concentration of light, and those of type "k" exhibit the strongest central concentration. In contrast, the DDO system of morphological classification is three-dimensional. The first DDO classification parameter is the Hubble type (Hubble 1936), and the second is bar strength measured along the four-stage sequence S – S(B?) – S(B) – SB. As a third parameter, the DDO system uses both spiral-arm morphology and surface brightness to assign galaxies to luminosity classes I (supergiant), II (bright giant), III (giant), IV (subgiant), and V (dwarf). In Table 1 uncertain values are followed by a colon (:), and very uncertain ones by a question mark (?).

The original Hubble classification system, and its subsequent evolution in the hands of Sandage (1961), was optimized for the classification of galaxy images on photographic plates obtained with large reflecting telescopes. On the other hand the DDO system was devised to classify the lower-resolution images of galaxies on the Palomar Observatory Sky Survey (POSS). The DDO system is therefore particularly well suited to the classification of lower-resolution paper prints of the galaxy images from the POSS-I blue and POSS-I red surveys. For some galaxies it was also possible to consult the higher-resolution POSS-II blue images. Furthermore, the KAIT images provide useful information on the structure of the cores of many images that were burned out on the POSS. The accuracy and long-term stability of the DDO system have been discussed in detail in our Paper II. A drawback of the lower-quality images that can be used for classifications on the DDO system is that they do not (except in the case of some edge-on galaxies) allow one to distinguish between elliptical (E) and lenticular (S0) galaxies.

3. SUPERNOVA CLASSIFICATIONS

The spectral classifications of SN type (see Filippenko 1997 for a review) that are given in Table 1 were drawn from the IAU Circulars. Supernovae of Type Ia were divided into "normal" and "peculiar" categories on the basis of careful inspection of the spectroscopic information in the IAU Circulars. Objects that showed the strong Si II λ5970 feature or Ti II absorption lines near 4200 Å (which are evidence for a subluminous SN 1991bg-like event; Filippenko et al. 1991b), or weak Si II λ6150 absorption or strong Fe III absorption (which indicates a possibly overluminous, SN 1991T-like event; Filippenko et al. 1991a) were classified as "peculiar" SNe Ia. Also in this category are true mavericks such as SN 2000cx (Li et al. 2001b) and SN 2002cx (Li et al. 2003; not in the LOSS sample), which cannot be put into the conventional SN Ia classification scheme.

Out of the 604 SNe that have their host galaxies classified in Papers I through III, only 15 SNe (2.5% of the total) were not spectroscopically classified.

4. DISCUSSION

4.1. Frequency Distribution over Hubble Types

In Table 3 the combined data from Table 1 of the present paper and those given in Papers I and II have been sorted by host-galaxy Hubble type and by supernova type. Galaxies that could not be confidently assigned to a Hubble type are excluded. Also, the 16 galaxies listed in Table 2 have been removed from the statistics. In doing the statistics that are discussed below, galaxies of intermediate morphology such as Sc/Ir were counted as 0.5 Sc and 0.5 Ir. By the same token, one supernova (SN 2002bt) that occurred in UGC 8584, a triple-galaxy system with DDO type "St + E + S," was counted as 0.33 E, 0.33 St, and 0.33 S. The new data show patterns that are broadly similar to those previously found in Papers I and II.

A Kolmogorov-Smirnov (K-S) test shows no significant difference between the distributions of the small numbers of SNe IIb and SNe IIn over Hubble type. Similarly, no significant difference is found between the distribution over Hubble types of normal SNe II and of the combined data for SNe IIb and SNe IIn. In the subsequent discussion the data on all 209 SNe II have therefore been combined.

A comparison between the distributions over Hubble types of normal SNe Ia and of SNe II is shown in Figure 1. Normal SNe Ia are common among early-type (E–E/Sa) galaxies, whereas all types of SNe II are rare in such early-type galaxies. A K-S test shows that there is only a 0.01% probability that the SNe Ia and SNe II in our sample were drawn from the same parent population of morphological types.

In Paper II we discussed five SNe Ibc and SN II that unexpectedly occurred in early-type galaxies. Two additional objects of this type occur in the new data contained in Table 1: SN 2004V, to whose host galaxy we assign type E:0, and SN 2004X, which occurred in a host that was assigned to type E3. The host galaxy of SN 2004V is small ($0'3 \times 0'2$), and our classification based on the low-resolution images is quite uncertain. Clearly it would be important to use images obtained with larger telescopes (or with *HST*) to search for a sub-population of massive young stars in these two host galaxies that appear to be of very early type. Another approach is to measure the integrated colors for all the early-type galaxies in our sample, and search for possible differences between the galaxies with recorded core-collapse SNe and all the others. This is beyond the scope of the current paper. However, here we give two examples for which we have some relevant information. From de Vaucouleurs et al. (1991), we find that NGC 3720, an "E1" galaxy that is the host of the Type II SN 2002at, has quite blue colors of $B - V = 0.69 \pm 0.01$ mag and $U - B = 0.01 \pm 0.03$ mag. This suggests that it does indeed contain a significant young-population component. On the other hand NGC 2768, an "E3/Sa" galaxy that is the host of the Type Ib/c SN 2000ds, has quite red integrated colors of $B - V = 0.99 \pm 0.01$ mag and $U - B = 0.53 \pm 0.01$ mag, implying that it is dominated by an old population.

Inspection of the numbers in Table 3 also shows that most peculiar SN 1991bg-like SNe Ia occur in early-type (E or E/Sa) galaxies. On the other hand the majority of peculiar SN 1991T-like SNe Ia were discovered in intermediate-type spirals. Figure 2 shows the Hubble-type distribution of the host galaxies of various subclasses of SNe Ia, and we clearly see the dichotomy between early-type hosts for the SN 1991bg-like objects and late-type hosts for the SN 1991T-like ones. A K-S test shows that there is only a 0.1% probability that the SN 1991T-like and the SN 1991bg-like objects were drawn from the same parent population. The observed difference is in the sense that would be expected if the more luminous SN 1991T-like objects have younger progenitors than do the fainter SN 1991bg-like objects. A K-S test shows that the distribution over Hubble type of the 12 SN 1991T-like SNe Ia does not differ significantly from that of "normal" SNe Ia. On the other hand there is only a 0.01% probability that the normal SNe Ia and the SN 1991bg-like ones were drawn from the same parent population. The observed difference is in the sense that would be expected if the subluminous SN 1991bg-like SNe Ia (which mostly occur in E and E/Sa galaxies) typically have old progenitors. Similar results have previously been obtained by Hamuy et al. (1996, 2000) and by Howell (2001).

A comparison between the distributions over Hubble types of normal SNe Ia and SNe Ibc shows that there is only a 0.04% probability that these two samples were drawn from the same parent population. On the other hand a K-S test shows no significant difference between the distributions over Hubble types of SNe Ibc and the sum of all three subtypes of SNe II. It is therefore concluded that SNe Ibc and SNe II occur among similar stellar populations.

It should be noted that the frequency distributions discussed above may be affected by several selection effects and observational biases. For example, the distribution reflects the SNe discovered in the sample of galaxies monitored by LOSS. As discussed by Li et al. (2001a), the LOSS sample galaxies were selected from several large galaxy catalogs, and the very late-type spiral (Scd, Sd, and Sdm) and irregular (Ir) galaxies are underrepresented. More generally, galaxies having low optical luminosity or low surface brightness are underrepresented. Observational biases, such as the Malmquist bias caused by the differences in the intrinsic luminosities of SNe, may also affect the apparent frequency distribution of the host-galaxy types. A more detailed discussion of the various observational biases that affect the discovery rate of SNe Ia can be found in Li, Filippenko, & Riess (2001). The intrinsic frequency distributions of various types of SNe in galaxies of different Hubble types (i.e., the SN rates) will need to consider all of the selection and observational biases. The SN rate calculation for LOSS is currently being investigated, and the initial results are reported by Leaman, Li, & Filippenko (2004). Finally, inspection of the data in Table 3 suggests that one of us (S.vdB.) had a strong classification bias in favor of Hubble types Sa, Sb, and Sc, and against the intermediate types Sab and Sbc.

4.2. Frequency Distribution over Broader Morphological Classes

The images of many of the distant host galaxies are so small that it is not possible to assign them with confidence to a Hubble type. Nevertheless, many of these objects can be placed in the broader "spiral" category. Furthermore, it is often difficult (or impossible) to distinguish between E and S0 galaxies on the Schmidt images of the Palomar Sky Survey. Consequently, only highly flattened $[(1 - b/a) \approx 0.7]$ objects are classified as being of type S0 on the DDO system. In order to take maximum advantage of the present observational material we have therefore sorted the supernova host galaxies into morphological classes E, S0, S, Ir, other, and "?" (Table 4). Again, galaxies of intermediate morphology were counted in all possible morphologies according to their probabilities. SN 1999gf, for example, with a host galaxy having a DDO type of "cD or E/Sa," was counted as 0.25 E and 0.25 S in Table 4.

These data allow one to compare the distribution of 200 normal SNe Ia with that of 251 SNe of types II, IIb, and IIn. A K-S test shows that there is only a 0.3% probability that these two samples were drawn from the same parent population. This result is less significant than the 0.01% probability that was previously found from the data in Table 2, showing that the confidence in our results is more dependent on accurate morphological classifications than on sample size. A similar conclusion may be drawn from a comparison of the 200 normal SNe Ia and the 88 SNe Ibc in Table 4. A K-S test shows that the probability that these samples were drawn from the same parent population is 1%, compared to a 0.04% probability found from the smaller number of normal SNe Ia and the SNe Ibc in Table 3. Clearly, fine morphological subdivision is important when the properties of supernovae are a sensitive function of the Hubble types of their host galaxies.

4.3. Frequency Distribution over Yerkes Morphological Classes

In the Yerkes classification system (Morgan 1958, 1959) galaxies are classified according to their central concentration of light. Such a classification system has the advantage that it is more easily adapted to automatic digital classification than is Hubble's tuning-fork system. Yerkes classifications of the host galaxies of newly discovered supernovae are listed in Table 1. As expected, these data show that the host galaxies of normal SNe Ia are, on average, more centrally concentrated than are those of SNe II (including SNe IIb and IIn). However, mainly due to the smaller database of Yerkes types, this result is of lower statistical significance than the comparable result from the Hubble types of host galaxies that was reported in § 4.1. The Yerkes classifications also confirm (albeit at a lower level of statistical confidence than from the larger sample of host galaxies having Hubble classifications) that the distribution of concentration classes of SNe II and of SNe Ibc are indistinguishable. Finally, almost all SN 1991bg-like SNe Ia are found to have occurred in compact host galaxies of Yerkes class "k."

5. Conclusions

A uniform sample of 604 host galaxies of recent supernovae has been classified on the DDO system. These data lead to the following conclusions.

1. The distributions of the morphological types of the host galaxies of SNe Ia and SNe II differ at a very high level of statistical significance, with SNe Ia favoring earlier-type galaxies.

2. The distribution of the morphological types of host galaxies of SNe Ibc is indistinguishable from that of SNe II.

3. The distribution over morphological types of small numbers of SNe IIn and SNe IIb do not appear to differ from that of normal SNe II.

4. SN 1991T-like SNe Ia occur mainly in host galaxies of intermediate morphological types, whereas SN 1991bg-like SNe Ia are mostly seen in E and E/Sa galaxies. This observed difference is significant at the 99.9% level.

5. A few SNe II were detected in E galaxies. Higher-resolution images will be required to establish if some of these galaxies were misclassified, or if they might be old galaxies in which a small young-population component is embedded. Comparison of the integrated colors may also help to reveal possible differences between the early-type galaxies with recorded core-collapse SNe and those without.

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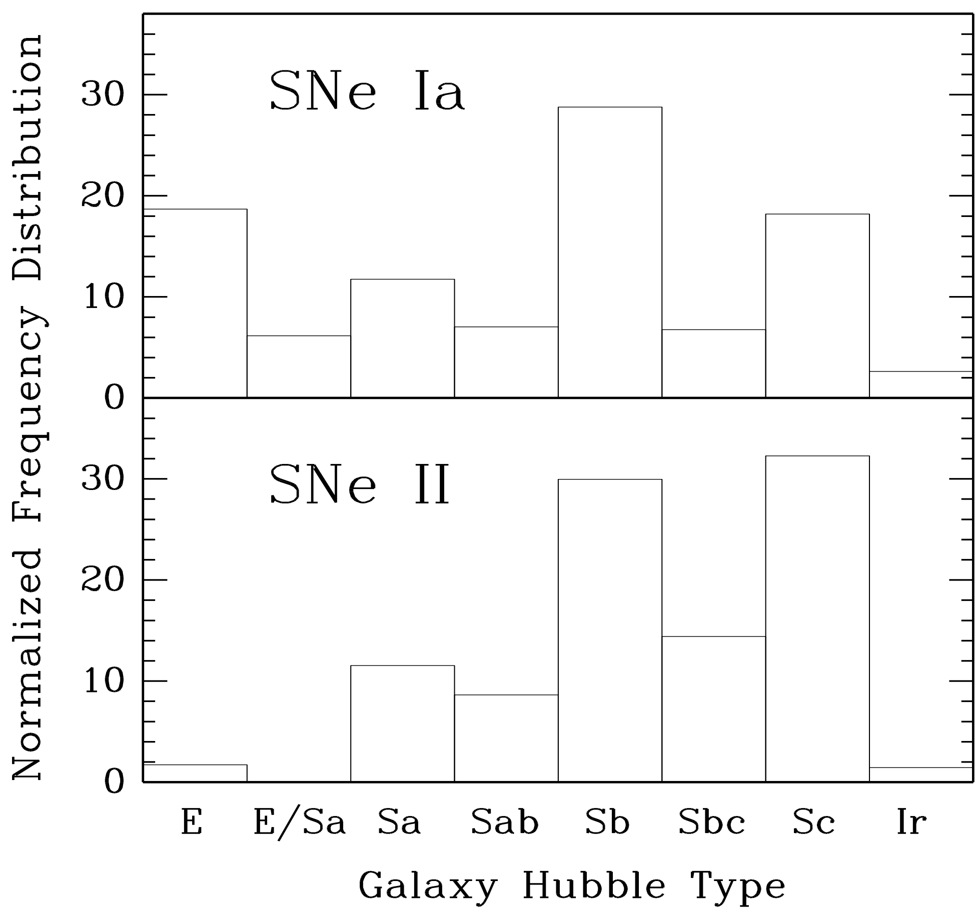

Fig. 1.— Normalized (total = 100) frequency distribution of SNe Ia and SNe II versus host-galaxy Hubble types.

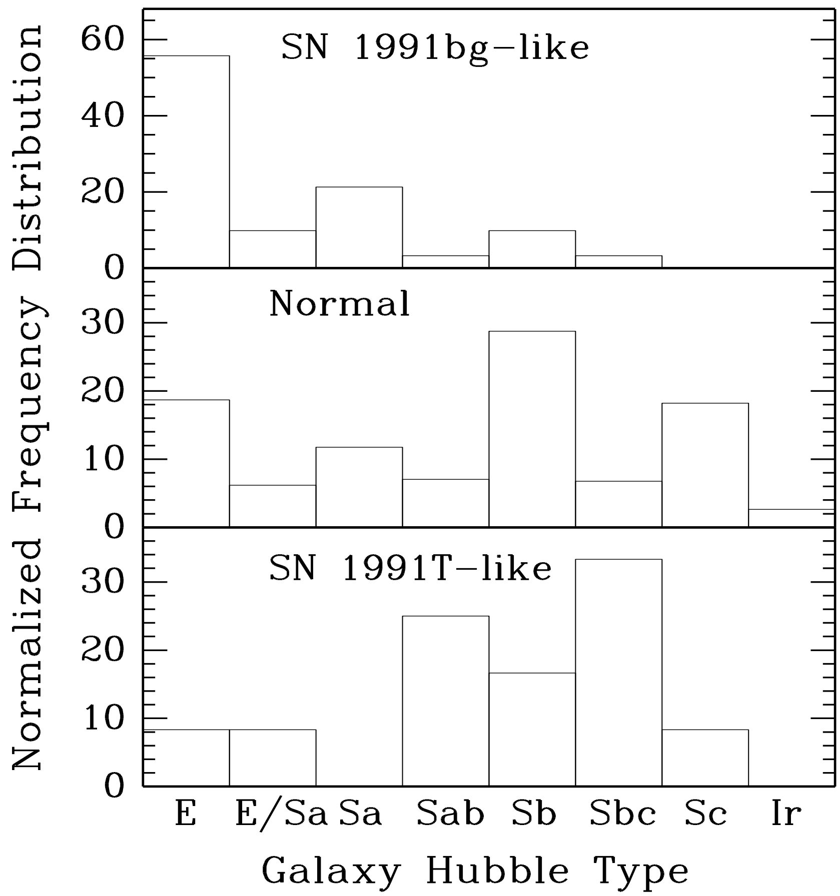

Fig. 2.— Normalized (total = 100) frequency distribution of SN 1991T-like, normal, and SN 1991bg-like SNe Ia versus host-galaxy Hubble types.

Table 1. Classifications of SN Host Galaxies

SN	Galaxy	SN Type	Yerkes Type	DDO Type	Redshift (km/s)	Remarks
1998C	U3825	II	fg	Sbc II	8281	
1998S	N3877	IIn	f	Sbc	895	(2)
1998aq	N3982	Ia	fg	Sc: II:	1109	
2000dx	U1775	Ia	fg	Sc pec	9108	(3)
2000ej	I1371	Ia-pec (91bg)	k	E2	9102	
2000fe	U4870	II	gk	Sb	4218	
2000fm	N1612	II	fg	Sbc	···	
2000fo	P70148	Ia	g	Sab	7152	
2001U	N5442	Ia	g	Sb: t	8517	
2001ah	U6211	Ia-pec (91T)	f	Sbc I	16788	
2001ak	U11188	II	af:	Sc:	5285	(2)
2001bb	I4319	Ic	g	Sab:	4653	
2001gb	I582	Ia	g	S	7714	
2001gc	U3375	Ia	fg	Sc II:	5783	
2001hf	M-03-23-17	II	?	S	4486	(12)
2001hh	M-02-57-22	II	gk	Sa	7445	
2002ct	Anonymous	unknown	gk	S0:	···	(2)
2002fk	N1309	Ia	fg	Sc	2136	
2002kg	N2403	IIn	fg	Sc III	131	
2003bt	M-01-28-06	Ia	fg	S(B?)c	7972	
2003cb	N4885	II	gk	Sa?	3366	
2003db	M+05-23-21	II	g	Sab:	8067	
2003eg	N4727	II	g	S(B)b II:	7495	
2003eh	M+01-29-03	Ia	fg	Sb pec	7651	
2003ei	U10402	IIn	?	St + Pec	···	(5)
2003ej	U7820	IIb	f	Sc II	5090	
2003ek	anonymous	Ia-pec (91bg)	f:	S	10804	(2)
2003el	N5000	Ic	fg	SBbc I	5608	
2003em	ESO 478-G6	Ia	fg	Sc I	5332	
2003ep	N7053	Ia	k	E2/Sa	4708	
2003ev	anonymous	Ic	g	Sab	7200	
2003ez	PGC 42782	Ia	g	Sb pec	14343	
2003fa	M+07-36-33	Ia-pec (91T)	g	Sb: t	1800	
2003fb	U11522	II	g	Sc:	5259	
2003fc	M-03-51-05	Ic	fg	S	10400	
2003fd	U8670	Ia	fg	Sc: II:	17911	
2003gd	N628	II	fg	Sc I	657	
2003gf	M-04-52-26	Ic	?	Pec	2600	
2003gg	I1321	II	g	S(B?)b II	6660	
2003gi	I1561	Ia	f	Sbc	3899	
2003gj	N7017	Ia-pec (91bg)	k:	E1 + E0	10119	(1)
2003gk	N7460	Ib	g	Sc II:	3192	
2003gl	N7782	Ia	g	Sb II	5379	

Table 1. (continued)

SN	Galaxy	SN Type	Yerkes Type	DDO Type	Redshift (km/s)	Remarks
2003gm	N5334	IIn	f	S(B?) III-IV	1382	
2003gn	CGCG 452-024	Ia	gk	Sab	10328	
2003go	ESO 595-G001	IIn	g	Sa:	10765	
2003gp	U10160	II	gk	SBab	9967	
2003gq	N7407	Ia-pec (91T)	f	Sbc II	6430	
2003gr	M-04-55-14	Ia	g:	SBb	7691	
2003gs	N936	Ia-pec (91bg)	k	SBa	1430	
2003gt	N6930	Ia	g	Sb t	4694	
2003gu	U12331	IIb	g	Sab:	5794	
2003gv	M+05-03-66	II	fg	Sbc:	10423	
2003gw	U3252	II	f	Sc I-II	6115	
2003hc	U1993	II	?	S	8018	(2)
2003hd	M-04-05-10	II	g	Sbc:	11842	
2003he	M-01-01-10	Ia	fg	Sb:	7649	
2003hf	U10586	II	g	Sab	9384	
2003hg	N7771	II	f	S pec	4277	(3)?
2003hh	U12890	Ia-pec (91bg)	k	E4	11602	
2003hk	N1085	II	g	Sb II	6789	
2003hl	N772	II	f	Sbc t?	2472	
2003hm	U2295	Ia	g	Sb	4172	
2003hp	U10942	Ic-pec	fg	Sb t?	6378	
2003hs	U11149	Ia-pec (91bg)	k	E3/Sa	14990	
2003ht	U2457	II	g	Sab:	10218	
2003hv	N1201	Ia	k	E4	1671	
2003hw	anonymous	Ia	g	Sb	· · ·	(6)
2003hx	N2076	Ia	gk	Sa	2142	(4)
2003hy	I5145	IIn	g	Sb II	7355	
2003hz	PGC 17866	Ia	fg	Sb:	6047	
2003ib	M-04-48-15	II	g	Sb	· · ·	
2003ic	M-02-02-86	Ia	g	E2/Sa	16690	
2003id	N895	Ic	fg	Sbc I-II	2288	
2003ie	N4051	II	f	Sc II	700	
2003if	N1302	Ia	k	Sa	1703	
2003ig	U2971	Ic	fg	Sb:	5881	
2003ih	U2836	Ibc	k	E:1	4963	
2003ik	U4185	Ia	?	Sc	7115	(2)
2003im	anonymous	Ia	k	Sa	5804	
2003in	I1956	Ia	fg:	Sb	6401	
2003ip	U327	II	g	Sa	5398	
2003iq	N772	II	fg	Sbc t?	2472	
2003ir	U3726	II	g	Sb	7657	
2003is	U11430	Ic	f	Sc	5482	
2003it	U40	Ia	g	SBb	7531	

Table 1. (continued)

SN	Galaxy	SN Type	Yerkes Type	DDO Type	Redshift (km/s)	Remarks
2003iv	M+02-08-14	Ia	k	E1	10285	
2003iw	N7102	II	f	Sc:	4866	
2003ix	U3746	Ia	g	Sa	7668	
2003iz	U638	Ia-pec (91bg)	k	E0	14453	
2003ja	N846	II	fg	SBb II	5118	
2003jc	M-01-58-18	II	f	Sc:	6029	
2003jd	M-01-59-21	Ic-pec	f	Sb:	5654	
2003je	N2668	II	gk	S(B)bc	7529	
2003jh	M-02-11-30	IIn	fg	Sbc II	8898	
2003jz	U5225	Ia	k	E0	4906	
2003ka	M+06-50-20	II	f	Sc III-IV	5761	
2003kb	U3432	Ic	?	S0/Sb	4998	(2)
2003kc	M+05-23-37	Ia	fg	Sc I?	10003	
2003kd	U2468	Ia	k	E0/Sa	···	
2003ke	M+06-22-09	IIn	fg	Sb:	6176	
2003kf	M-02-16-02	Ia	af	S IV	2215	
2003kw	M+05-27-49	II	g	Sa (pec?)	8012	
2003ld	U148	II	?	Sc?	4213	(2)
2003lo	N1376	II	fg	Sc I	4155	
2003lp	U6711	II	gk	Sa	2702	
2003lq	U5	Ia	fg	Sb II	7271	
2003ls	PGC 11402	Ia	fg	?	13000	
2004A	N6207	II	f	Sc/Ir	852	
2004C	N3683	Ic	f	S	1716	(2)
2004D	U6916	II	fg	Sb	6182	
2004E	PGC 46239	Ia	gk	Sa pec	8936	
2004F	N1285	IIn	g	Sc	5239	
2004G	N5668	II	f	Sc III-IV	1583	
2004H	I708	Ia-pec (91bg)	k	E2	9497	(7)
2004I	N1072	II	g	Sb	8018	
2004J	ESO 554-G33	Ia	fg	S	···	
2004K	ESO 579-G22	Ia	gk:	S(B)b:	10832	
2004L	M+03-27-38	Ia	g	S(B)b	9686	
2004P	U8561	Ia	fg	Sc	7120	
2004Q	ESO 507-G11	II	?	Sc pec?	7483	
2004T	U6038	II	gk	Sa	6437	
2004U	anonymous	II	gk:	SBb	···	
2004V	anonymous	II	k:	E:0	12500	
2004W	N4649	Ia-pec (91bg)	?	E1	1117	(8)
2004X	anonymous	II	k	E3	3917	
2004Y	anonymous	Ia	k	E2	20760	
2004ab	N5054	Ia	fg	Sc I	1741	
2004ak	U4436	II	f?	S	7214	(2)

Table 1. (continued)

SN	Galaxy	SN Type	Yerkes Type	DDO Type	Redshift (km/s)	Remarks
2004al	ESO 565-G25	II	g	Sa	···	
2004am	N3034	II	?	Pec	203	
2004an	I4483	II	fg	Sa	8979	
2004ao	U10862	Ib	f	SBb	1691	
2004ap	PGC 29306	Ia	k	E2	7177	
2004aq	N4012	II	g:	Sa	4182	
2004as	anonymous	Ia	af	S/Ir	9300	(9)
2004at	M+10-16-37	Ia	?	Ir ?	6935	
2004au	M+04-42-2	II	g	Sa	7800	
2004av	ESO 571-G15	Ia	?	S	7057	(2)
2004aw	N3997	Ic	?	St + St	4771	(1)
2004ax	N5939	Ibc	g	Sbc	6687	
2004ay	U11255	IIn	?	Sc/Ir	9723	(2)
2004az	U6853	Ia	k	E:4	8639	
2004bd	N3786	Ia	g	Sb pec	2678	(3)
2004be	ESO 499-G34	II	af	S IV:	2282	
2004bf	U8739	Ic	?	S	5032	(2)
2004bh	U5161	II	g	S/Ir	10079	
2004bi	U5894	IIb	g	Sb	6537	
2004bj	M+01-34-13	Ia	k	E0	15033	
2004bk	N5246	Ia	gk	SBb	6906	
2004bl	M+00-31-42	Ia	?	S/Ir	5192	(2)
2004bm	N3437	Ic	g:	Sbc ?	1283	
2004bn	N3441	II	g	Sa:	6533	
2004bo	ESO 576-G54	Ia	k	E3	7024	
2004bq	ESO 597-G32	Ia	gk	Sa:	···	
2004br	N4493	Ia-pec (91T/00cx)	k	E1 t?	6943	
2004bs	N3323	Ib	fg	S(B?)b	5164	
2004bt	U9178	unknown	f	S(B?)c:	8704	
2004bv	N6907	Ia-pec (91T)	?	S pec	3161	(3)
2004bw	M+00-38-19	Ia	fg	Sc	6355	
2004by	N7116	II-pec	?	Sb	3532	(3)?
2004bz	M+02-56-25	Ia	g	Sab:	10232	
2004ca	U11799	Ia	?	S	5338	(10)
2004cc	N4568	Ic	f:	S pec	2255	(3)
2004ci	N5980	II	g	Sb	4092	
2004cm	N5486	II	g	Sbc:	1390	
2004cq	U9882	Ia	?	S	6595	(2)
2004cs	U11001	Ibc	f	Sc pec	4215	
2004cu	N5550	II	fg:	Sbc:	7427	
2004db	N7377	Ia	k	E:2	3351	
2004dc	I1504	Ic	fg	Sb:	6271	
2004dd	N124	II	fg	Sc	4060	

Table 1. (continued)

SN	Galaxy	SN Type	Yerkes Type	DDO Type	Redshift (km/s)	Remarks
2004dh	M+04-01-48	II	f	S	5794	
2004dj	N2403	II	?	Sc III	131	(11)
2004dk	N6118	Ic	f	Sbc II	1573	
2004dn	U2069	Ic	?	Sc III-IV	3779	
2004dr	ESO 479-G42	II	af	S pec	6917	
2004ds	N808	II	f	Sb II	4964	
2004dt	N799	Ia	g:	Sbc	5915	
2004du	U11683	IIn	?	S	5025	(2)
2004dv	M-01-06-12	II	f	Sc pec?	4754	
2004dy	I5090	II	g:	Sb:	9340	(3)?
2004dz	anonymous	Ia	f	S/Ir	···	
2004ea	M-03-11-19	Ia	af	S pec	1953	
2004eb	N6387	II	?	St ?	8499	(1)
2004ef	U12158	Ia	g:	Sc I	9290	
2004eg	U3053	II	?	Sc ?	2407	
2004ep	I2152	II	gk	Sb II:	1875	
2004er	M-01-07-24	II	fg	Sbc:	4411	
2004es	U3825	II	fg	Sc:	8281	
2004et	N6946	II	f	Sc I	48	
2004ex	N182	II	gk	Sb	5261	
2004ez	N3430	II	g	Sc II	1586	
2004fc	N701	II	g	S pec	1829	
2004fe	N132	Ic	g:	Sc	5361	
2004ff	ESO 552-G40	Ic	gk	Sb	6790	
2004fg	M+05-56-07	Ia	fg	Sc	9034	
2004fx	M-02-14-03	II	?	S	2673	(2)
2004gd	N2341	IIn	gk	Sab:	5227	
2004ge	U3555	Ic	g	Sc t?	4835	
2004gg	U5234	II	f	Sc:	6017	
2004gh	M-04-25-06	II	g	S(B?)b	3662	
2004gi	M-05-25-32	Ia	f	Sc	3244	
2004gj	I701	IIb	f	Sc	6143	
2004gk	I3311	Ic	?	S	-122	(2)
2004gm	M-02-33-80	Ia	f	Sab	4975	
2004gn	N4527	Ic	fg	Sbc	1736	
2004go	I270	Ia	k	E1	8745	
2004gq	N1832	Ic	g	S(B?)bc II	1939	
2004gr	N3678	II	g	Sc:	7210	
2004gs	M+03-22-20	Ia-pec (91bg)	gk	Sa	7988	
2004gt	N4038	Ic	a:	Sc? pec t	1642	(3)

Note: (1) merger; (2) edge-on; (3) tides; (4) dusty; (5) SN closest to peculiar galaxy; (6) SN in small distant galaxy, not in nearer large SBb; (7) might also be classified E2/Sa; (8) our images of M60 (= NGC 4649) are overexposed, so the adopted E1 classification is from van den Bergh (1960c); (9) has bright Sc II companion; (10) strong Galactic foreground absorption possible; (11) galaxy too large to classify with present images, so we have adopted the Sc III classification from van den Bergh (1960c); and (12) bright foreground star superimposed on the nucleus.

Table 2. SNe and Host Galaxies (Papers I, II) Now Excluded from the Sample

SN	Galaxy	SN Type	Yerkes Type	DDO Type	Redshift
1998dl	N1084	II	f	Sc II:	1406
1998ey	N7080	Ic-pec	fg	S(B)bc I	4839
2000ce	U4195	Ia	fg	SBb II	4888
2000cr	N5395	Ic	fg:	Sbt I?	3491
2001bg	N2608	Ia	fg	Sc II:	2135
2001dp	N3953	Ia	g	S(B)bc I	1052
2001dr	N4932	II	fg	S(B?)c II	7088
2001eg	U3885	Ia	g:	Sbc III:	3809
2002bp	U6332	unknown	gk	Sa:	6227
2002cv	N3190	Ia	g	Sab t	1271
2002ed	N5468	II	f	Sc I-II	2845
2002jo	N5708	Ia	fg:	S pec	2751
2002cy	N1762	unknown	g	Sab:	4753
2003C	U439	II	g	Sa pec	5302
2003U	N6365	Ia	g	Sbn:	8496
2003X	U11151	Ia	fg	S0:	7017

Table 3. Host-Galaxy Classification and SN Type[a,b]

Galaxy type[c]	Ia	Ia(T)[d]	Ia(bg)[e]	Ibc[f]	II	IIb	IIn
E	31.83[g]	1	17	1	3	0	1
E/Sa	10.5	1	3	1	0	0	0
Sa	20	0	6.5	4	20	0	3
Sab	12	3	1	7	15	1	1
Sb	49	2	3	15	52	2	6
Sbc	11.5	4	1	19	25	3	4
Sc	31	1	0	21.5	56	3	9
Sc/Ir	0	0	0	0	1	0	1
Ir	4.5	0	0	0	2.5	0	0.5
Total	170.33	12	31.5	68.5	174.5	9	25.5

[a]All host galaxies of SNe discovered during LOSS/LOTOSS – i.e., the sum of the data from the present paper and those from Papers I and II.

[b]Half-integer values refer to intermediate morphologies (e.g., E/Sb is counted as 0.5 E and 0.5 Sb).

[c]Includes S(B) and SB.

[d]SN 1991T-like SN Ia.

[e]SN 1991bg-like SN Ia.

[f]Here, the "Ibc" designation includes SNe Ib, Ic, and Ib/c.

[g]The fractional number 0.83 comes from 0.50 + 0.33, due to SN 2002bt which occurred in a triple-galaxy system; see text for details.

Table 4. Frequency Distribution of Broad Morphological Types

Galaxy type	Ia	Ia(T)	Ia(bg)	Ibc	II	IIb	IIn
E	37.58[a]	1.5	18.5	1.5	3	0	1
S0	2.5	0	1.5	1	2	1	0
S	146.92[b]	12.5	15	82.5	193.5	11	27.5
Ir	4.5	0	0	0	3	0	1
Other	3.5	0	0	2	4	0	1.5
?	5	0	1	1	1.5	0	1
Total	200	14	36	88	207	12	32

[a]The fractional number 0.58 comes from 0.33 + 0.25, due to SN 2002bt (which occurred in a triple-galaxy system) and SN 1999gf (with a DDO type of "cD or E/Sa"); see text for details.

[a]The fractional number 0.92 comes from 0.67 + 0.25, which is due to SN 2002bt (occurred in a triple galaxy system) and SN 1999gf (with a DDO type of "cD or E/Sa."). See text for details.