THE FREQUENCY OF SUPERNOVAE IN EXTERNAL GALAXIES

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Abstract: A new determination of the SN-frequency in different morphological types of galaxies, obtained from the material of the Asiago SN-Search, is presented. From these values we derive a mean interval between SN events in our Galaxy consistent with values determined in different ways.

Introduction. Since 1959 the Asiago Astrophysical Observatory has been carrying out a systematic search for supernovae in about 70 fields by using 50/40 and 92/67 Schmidt telescopes. The more than 5000 plates devoted, up to now, to this aim constitute a unique batch of homogeneous material, accessible in the near future to the whole astronomical community. This plate archive is the base on which a new determination of the frequency of supernovae has been recently obtained (Cappellaro and Turatto, 1987), the main results of which are here briefly summarized.

The frequency of supernovae. The method of computation of the frequency is based on the knowledge of "control time" (Barbon, 1968; Zwicky, 1942).

The sample of objects used for this investigation consists of all the galaxies in RC2 with a morphological classification (de Vaucouleurs et al., 1976) which are included in the fields of the search and which have known radial velocities. The sample of supernovae is formed by all the objects present on the plates of the search in the sample galaxies. The total sample consists of 736 galaxies and 51 SNe. The unclassified supernovae have been assigned to Type I and II, following the ratio of occurrence in the corresponding galaxy type from Table 4 of Barbon et al. (1984).

In this way we overcome the main limitations of the previous investigations. No assumption has been made on the time-coverage of the galaxies, each object being treated individually as to distance, observation time distribution, luminosity, inclination and internal absorption. Longer coverage of the fields and larger samples allowed us to compute the frequency in a finer morphological subdivision and to determine the frequency for Types I and II supernovae independently.

Table I shows the main results. In the first four rows the numbers of galaxies and supernovae of different types are listed. Rows 5 and 6 report the total control times, Ct, for different galaxy types, separately for SNI and II. The control times for SNII are smaller than for SNI because of their lower luminosity. In rows 7, 8, and 9 the

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Table 1.

Galaxy type	E	S0	Sa	Sab	Sb	Sbc	Sc	Scd	Sd	Sm-Im
No.GAL	125	181	81	34	70	51	65	41	24	64
No.SNI	3	6	3	0	2	2	6	2	2	0
No.SNII	0	0	0	0	1	2	7	3	0	1
No.UNCLASS	0	1	0	1	2	4	2	1	0	0
C.t.SNI(yr)	990.9	1558.5	851.5	361.5	753.3	601.0	671.5	608.2	373.4	894.7
C.t.SNII(yr)	806.6	1293.4	744.6	296.5	658.2	533.0	593.9	552.6	338.3	827.4
ν SNI (*)	0.30	0.45	0.35	0.14	0.44	0.83	1.03	0.41	0.54	(<0.11)
ν SNII			(<0.13)	0.17	0.25	0.56	1.36	0.63	(<0.30)	0.12
ν All	0.30	0.45	0.35	0.31	0.70	1.39	2.39	1.04	0.54	0.12
	±0.19	±0.18	±0.21	±0.30	±0.31	±0.49	±0.61	±0.42	±0.39	±0.11
ν SNI (**)	0.09	0.25	0.27	0.07	0.19	0.39	0.71	0.50	0.79	(<0.58)
ν SNII			(<0.12)	0.11	0.16	0.31	1.17	0.81	(<0.48)	0.64
ν All	0.09	0.25	0.27	0.19	0.35	0.69	1.88	1.31	0.79	0.64
	±0.07	±0.12	±0.17	±0.17	±0.17	±0.24	±0.49	±0.52	±0.61	±0.60

(*) $yr^{-1} \times 100$.
(**) SNu (1 SNu = 1 SN per 100 yr per $10^{10} L_{\odot_B}$).

frequencies per average galaxy, ν, are shown. Errors (row 10) are quoted only for the total frequencies and are computed on the hypothesis that the occurrence of supernovae in galaxies is a random event. The last three rows report the frequencies of supernovae per luminosity unit. 25% of the galaxies (8% of Sne) have been rejected, since no data on the magnitude were found in the literature.

Our main conclusions are the following:

- The frequency of supernovae increases from early- to late-type galaxies and it is peaked at Sc's.

- S0 galaxies have a SNI rate 3 times higher than Ellipticals, in contrast with the results of Tammann (1982).

- The frequency of SNI in Sc and Scd galaxies is half that of SNII, being smaller than in Tammann (1982), Oemler and Tinsley (1979). This is partially due to their neglect of the different discovery chance for SNI and SNII.

- The SNI rate increases from E to Sd galaxies. This may be related to the different progenitor population of the SNI subclasses, SNI-a and SNI-b (Gaskell et al., 1986). No SNI-b belongs to our sample, but many SNI are without sub-type classification. On the hypothesis that SNI-b occur only in spiral galaxies, the relative ratio SNI-b/SNI-a $\approx$ 0.6, as observed in the last three years; i.e. since this subclass has been fully recognized, the numbers are consistent with the increasing rate of SNI in late spirals being due only to SNI-b.

The Galaxy. In order to compare the expected SN rate in the Galaxy with values deduced in different ways, it is crucial to establish the Galaxy's morphological type and luminosity.

Table 2.

	Predicted	SNR	Pulsar	Historical SNe	Others	Tammann (1982) (external evid.)
τ_{SNI} (yr)	88^{+94}_{-30}				100 (7)	45
τ_{SNII} (yr)	109^{+204}_{-43}		30÷120 (4)		120 (8)	55
τ_{All} (yr)	49^{+34}_{-14}	80±30 (1) 23±7 (2) 30 (3)		45^{+66}_{-16} (5) 17^{+12}_{-5} (6)		25

(1) Lerche,I.:1981,Astroph.and Space Sci. 74,273; (2) Smirnov,M.A., Sakhibov,F.Kh.:1984,Soviet Astron.28,137; (3) Mills,B.Y.:1983, "Supernova Remnants and their X-ray Emission",IAU Symp.No.101,pag.551, eds.I.J.Danziger and P.Gorenstein,P.,Reidel,Dordrecht; (4) Lyne,A.G., Manchester,R.N.,Taylor,J.H.:1985,M.N.R.A.S.213,613; (5) Van den Bergh, S.:1983,P.A.S.P.95,388; (6) Tammann,G.A.:1982,"Supernovae: a Survey of Current Research",eds.M.J.Rees and R.J.Stoneham,P.,Reidel,Dordrecht; (7) Woosley,S.E.,Weaver,T.A.:1986,Ann.Rev.Astron.Astrophys. 24,205; (8) Heiles,C.:1987,Ap.J. 315,555.

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If we consider the Galaxy a Sb-Sbc type with luminosity $L=3.9x10^{10}\ L_{\odot}$ (Tammann, 1982), we have a SN rate of 1.13 SNu for SNI, 0.92 SNu for SNII, 2.03 SNu for all SNe. In Table 2 the mean SN intervals in our Galaxy (with the derived internal errors) are compared with other recent determinations. It appears that the mean interval between two SN events, obtained from external galaxies, is twice the analogous value of Tammann (1982), and it is consistent, within the large errors, with independent estimations.

References

Barbon, R.: 1968, Astron. J. 73, 1016.
Barbon, R., Cappellaro, E., Ciatti, F., Turatto, M., Kowal,C.T.: 1984, Astron. Astrophys. Suppl. Ser. 58, 735.
Cappellaro, E., Turatto, M.: 1987, Astron. Astrophys. submitted.
de Vaucouleurs, G., de Vaucouleurs, A., Corwin, H.G.: 1976, Second Reference Catalogue of Bright Galaxies, Univ. Texas Press, Austin (RC2).
Gaskell, C.M., Cappellaro, E., Dinerstein, H.L., Garnett, D.R., Harkness, R.P., Wheeler, J.C.: 1986, Astrophys.J. 306, L77.
Oemler, A., Tinsley, B.M.: 1979, Astron. J. 84, 985.
Tammann, G.A.: 1982, Supernovae: A Survey of Current Research,Ed. Rees, M.J., Stoneham, R.J., D. Reidel, Dordrecht.
Zwicky, F.: 1942, Astrophys. J. 96, 8.