Trends in Apparent Time Intervals Between Multiple Supernovae Occurrences

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***Abstract*—This paper presents an analysis of recent and historic supernovae and the statistics found in multiple supernovae occurrences, as related to the apparent time intervals between successive events, and the application of trends found from those simple statistics to supernova surveying—a focused search: developing target lists from the International Astronomical Union (IAU), list of all known supernovae and their host galaxies, with the greatest immediate statistical potential for a timely successive supernova. This approach has yielded consistent results for target development since its inception, with a 96% success rate over 16 months, and one direct, and immediate, result for surveying (SN2002eg). These trends found in apparent time intervals have been seen to apply to known hosts with only one recorded supernova and not otherwise known to be "prolific" supernovae producers. This strong indication of applicable periodic behavior introduces a potential new role for extra-galactic supernovae, in modern cosmology, as possible observational evidence in support of the plasma cosmology theory of Hannes Alfven, based on fundamental principles.**

***Index Terms*—Extra-galactic supernovae, multiple supernovae statistics, supernova surveying.**

I. INTRODUCTION

THE RAPID succession of extra-galactic supernovae (SNe) in some host galaxies (and not in others) has been a subject of investigation and speculation since the very beginnings of systematic supernova (SN) searches and the subsequent determinations of "average" SN rates. In 1942, Zwicky made the first attempt to explain the few known multiple supernovae (M.SNe) events, at the time, in New General Catalog (NGC) 3184, 4321 and 6946; as either "wild fluctuation(s)" from his average SN rate, then, of $v = 359$ years [1], or "that the stellar content of these particular nebulae favors a more rapid succession of supernovae." A decade later, Reaves [2] found that an application of elementary Poissonian statistics indicated the high rate of SNe in the three systems mentioned were "probably not due solely to chance." Since then, the determination of an absolute "average" SN rate has followed two lines. Through statistical analysis of SN surveys, various selection effects, intrinsic to the host and to surveying, have been determined to affect the calculated "average" rate. And then, to speculation concerning physical properties, within certain host galaxies, that would explain the strongly non-Poissonian distribution of M.SNe occurrence, the underlying assumption being that "SNe are rare and probably independent (and) should follow a Poisson distribution" [3].

The non-Poissonian distribution of M.SNe was also found by Richter and Rosa (R&R) [4], in 1988, who believed the idea "of a single average SN rate for all normal galaxies" had no relevance, regardless of the corrections made for various selection effects, due to bursts of star formation in some galaxies, with "the mechanism that drives such…bursts at some times (and prevents the galaxies from doing so most of the time)" as yet unidentified. However, through more detailed statistical analysis, Guthrie [3] and Li and Li [5], determined that the "joint effects of star formation, Hubble types, luminosity, inclination and distance of the galaxies," as well as, "the nonuniformity of SN searches," accounted for most of the high deviation in M.SNe (approximately 4 to 6 times the "average" normal SN rate, as opposed to 70 times found by R&R, in 1988).

Over the years, SN search efforts have steadily improved technologically, and conceptually, with galaxy control times, charge-coupled device (CCD) imaging and automation, to provide the most complete coverage for statistical purposes. Of the most recent, and systematic, for "near" [6] surveying is the ongoing Lick Observatory Supernovae Search, with the Katzman Automatic Imaging Telescope, begun in 1997 [7]. The efforts of the many surveys have lead to the determinations of the physical attributes of host galaxies, and the limitations to surveying, known to influence the "average" SN rate, but the systematic automated coverage, and dramatic increase in SNe detections, in recent years [8], has especially, but not exclusively, revealed the trends in apparent time intervals (ATI) between M.SNe occurrences, now, being reported here.

A. Recent Coincidences

On August 24, 2001, Evans made the visual discovery, of SN2001du, in NGC1365. A few weeks later, on September 17, 2001, Monard discovered SN2001el, in NGC1448. Both of these galaxies had supernova in 1983, SN1983V, on November 25, and SN1983S, on October 6, respectively, about six weeks apart. Other obvious similarities between these two galaxies are both are in the same region of the sky (The Fornax Group), with recessional velocities of less than 2000 km s-1, and both are large, highly luminous intermediate to late type spirals (but at very different inclinations). From this coincidence, it seemed that the occurrence of some SNe might be quite timely. Rather than search randomly, with limited technology, it seemed worthwhile to follow-up on this coincidence, thinking simply, that if it happened once, it may have happened before; and if so, it might, quite possibly, happen again.

II. TRENDS IN ATI

There have been more discoveries of extra-galactic SNe since 1996, than in all the years prior (~1043 prior to 1996, and

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∼1634 since, as of August 31, 2003) due to the improved technical capabilities of SN surveyors, with most "near" [6] discoveries (discovery magnitudes of 19.5 and brighter), due largely to the systematic, automated coverage, of the Lick Observatory Supernovae Search, and similar surveys. Since 1996, the number of named host galaxies (those hosts on the IAU list with a catalogue designation, generally NGC, Uppsala General Catalog of Galaxies (UGC), Index Catalog (IC), Morphological Catalog of Galaxies (MCG), the European Southern Observatory (ESO), and not termed "Anon.") with more than one recorded SN has more than doubled, from 54 to 107 (as of August 31, 2003). The number of named hosts with more than two known SNe has more than tripled, from 7 to 24. Of those 24 galaxies, 16 have had three SNe, 6 have had four SNe, 1 has had six SNe, and 1 has had seven. (M.SNe histories were compiled from the NASA/IPAC Extragalactic Database (NED),[1] for named hosts on the International Astronomical Union (IAU) list, provided by Central Bureau for Astronomical Telegrams (CBAT) [9], back to 1977. Those prior to 1977 were compiled from the lists published by R&R [4], Guthrie [3], and Li and Li [5], and all were cross-checked with the online version of The Asiago Supernovae Catalogue [10].)

A. Percent of Named Host Galaxies With M.SNe Occurrences

All SNe, and information about them, are taken from the list provided by the IAU and CBAT [9]. Where discovery dates were incomplete a median date, of the fifteenth, was used for the month given. The sample is simply named hosts, as described earlier, separated by year, from 1977 through the present, and generally represents "near" [6] discoveries (hosts with radial velocities of less than 15 000 km s-1 and SNe discovery magnitudes of 19.5 and brighter). Table I lists the yearly totals of named, unique host galaxies and the total number and percent, each year, of M.SNe occurrences. Column 2 shows the steep increase in SNe discoveries, within the sample, in recent years. In 1999, Barbon *et al.* [8], also, reported this increase in their analysis of all SNe discoveries at the time (1447), "near" and "far," and this sample, of named hosts, follows that same trend.

In going back 25 years, it can be seen that M.SNe, in named host galaxies, are a consistent annual event, and that even though the total number, of discoveries, decreases dramatically in each previous year, the annual percent of recent hosts with prior history of SNe remains consistent and substantial. In 1988, R&R [4] reported of M.SNe events that 6% of all known hosts, at the time, had prior history of SNe. They went on to predict that 9% of galaxies that have produced one SN could be expected to produce another. From 1989 through 1995, an average of 9.1% per year of named hosts had prior history of SN. From 1996 through 2002, an average of 11.9% per year have had history of previous SN. R&R also expected an increase of about 1 M.SNe host per year when more galaxies had produced one SN. In referring to Column 3 of Table I, it can be seen that the number of galaxies per year with M.SNe, since 1988, has exceeded their expectations dramatically.

TABLE I
PERCENT OF M.SNE PER YEAR

Year	No. of named host galaxies	No. with M.SNe	Percent
2003	168	20	11.9
2002	119	13	10.9
2001	130	11	8.5
2000	81	9	11.1
1999	77	13	16.9
1998	57	6	10.5
1997	38	6	15.8
1996	32	3	9.4
1995	25	0	0.0
1994	23	2	8.7
1993	19	3	15.8
1992	28	5	17.9
1991	35	4	11.4
1990	22	0	0.0
1989	20	2	10.0
1988	17	0	0.0
1987	12	1	8.3
1986	13	2	15.4
1985	13	1	7.7
1984	19	1	5.3
1983	19	4	21.1
1982	14	1	7.1
1981	9	2	22.2
1980	8	1	12.5
1979	5	2	40.0
1978	5	1	20.0
1977	6	0	0.0

When this paper was begun (June 22, 2002), it seemed likely that the trends found for the majority of the last 25.5 years, would continue to hold true for the remainder of the year, and it was determined then that, potentially, between 5 and 12 new discoveries, in named hosts, would be from known hosts, in the remainder of 2002. There were, in fact, six discoveries in known named hosts in the second half of 2002, with three additional occurring within the first 11 days of 2003. In the last 26 years, only three years have had no recorded M.SNe occurrence. That is an 88% chance that a previously known, named host will have a successive SN in the upcoming year. You could, at this point, simply survey all previous, named hosts within your telescope's range of coverage, and with effective surveying be fairly assured of discovery; but in looking at the discovery dates of these hosts, there are some noticeable trends.

B. Percent of "Short Interval" M.SNe Occurrences

A large number of M.SNe have happened within four years of the previous SN, in the same host. Table II lists the yearly totals of M.SNe (from column 3 of Table I) and the number and percent of "short interval" occurrences (ATI less than or equal to four years), for the last 15 years. In 10 of the last 15 years and every year since 1997, 33%–54% of those hosts with prior history of SNe, had a successive SN within four years of the previous event. In addition, of the 107 named M.SNe hosts (as of August 31, 2003), 16 have had a successive SN within

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[1] This research has made use of the NASA/IPAC Extragalactic Database(NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contact with the National Aeronautics and Space Administration, http://nedwww.ipac.caltech.edu/.

TABLE II
PERCENT OF "SHORT INTERVAL" M.SNE

Year	No. with M.SNe	No. of 'short intervals'	Percent
2003	20	11	55
2002	13	7	54
2001	11	4	36
2000	9	3	33
1999	13	5	38
1998	6	3	50
1997	6	2	33
1996	3	0	0
1995	0	0	0
1994	2	1	50
1993	3	1	33
1992	5	2	40
1991	4	0	0
1990	0	0	0
1989	2	1	50
1988	0	0	0

one year of ATI from the previous event. R&R [4] noted similar occurrences with "the unusually high rates (short intervals) for two galaxies (NGC1316 and UGC06322) (that) have not been confirmed by any further SNe since the last ones. Their apparently rapid production of SNe must be considered as a statistical fluctuation." NGC1316 has had two observed SNe, SN1980N, and SN1981D, which occurred less than one year apart $(\text{ATI} = 0.23\text{years})$. UGC06322 has had two observed SNe, SN1966K, and SN1971A, which occurred 4.12 years apart.

In named M.SNe hosts, prior to 1996, 19.7% of pairs had ATI less than, or equal to, four years. Since 1996, 36.5% of pairs have had ATI less than, or equal to, four years (as of August 31, 2003). With the improved coverage in SN surveying, and possibly by the nature of the phenomenon itself, the percent of detected M.SNe, with "short intervals" between successive events, has substantially increased since 1996. Of named hosts with extreme "short interval" M.SNe (ATI less than or equal to one year), 7.0% of pairs prior to 1996, had an instance of an extreme "short interval" M.SNe, and 14.9%, since 1996 (as of August 31, 2003), showing an increase in extreme "short intervals" detections, in recent years, as well. These "short intervals," that were once thought of as "statistical fluctuations" [1], [4] can now be seen to be an increasingly consistent, and significant, trend in M.SNe occurrences, and a potential successive SN time frame, for any named host on the IAU list [9], at this point of the analysis.

C. *"Parallel" M.SNe Occurrences*

The original coincidence, of SN2001du and SN2001el, and the "parallel" M.SNe between NGC1365 and NGC1448, led to the notice of trending by historic year, or a narrow range of years. In 2001, the historic years showing successive SNe are 1965, the early 1950s and mid 1980s, which were still playing out in 2002. In 2000, almost all hosts with historic SNe are from the early 1970s. From 1994 to 1999, there is a narrow oscillating band with histories from the early 1960s, to the middle 1970s, with another layer of repeats, beginning in 1998, and going through 1999, whose historic SNe are from the early 1990s.

Table III lists the occurrences of "parallel" M.SNe, and their inclination angles from the Lyon–Meudon Extragalactic Database (LEDA) [11]. Over half of named M.SNe hosts display a "parallel" M.SNe with between one and six other hosts. It is plain that the coincidence between NGC1365 and NGC1448 is not an isolated event. A few hosts are shifted a year or two, but showing the same period, others are compressed or expanded a year or two, much like an oscillating Sine wave. Some "parallel" M.SNe hosts show similar galaxy inclination angles, but many do not.

When M.SNe histories are plotted, as in Fig. 1, with the most recent discovery date on a standard time line on the X axis, and historic discovery year (or ATI) on the Y axis, the ranges of ATI show a tremendous similarity to a sinusoidal curve, actually several Sine curves, layered on top of one another. This hint of periodicity in apparent time intervals generated by M.SNe, collectively, represents a potential to project which year, or years, will begin repeats next, in addition to those years that have already yielded a recent SN. So, besides the strong potential for another SN within four years, M.SNe beyond these recent years are coming from the same historic years or a narrow range of years around them for a certain period of time, and may be following a periodic pattern of reoccurring historic years.

III. PHYSICAL ATTRIBUTES OF THE TRENDS IN ATI

Morphology of the host, i.e., Hubble type, inclination (incl), total corrected blue magnitude (btc), and velocity relative to the local group (vlg), is from LEDA [11], for the sample of named M.SNe, as described in Section II-A. SNe classifications are from the IAU [9] and NED , and crosschecked with the online supernovae catalogue of the Sternberg Astronomical Institute (SAI) [12].

A. *Does the Sample of M.SNe in Named Host Galaxies Follow Known Trends?*

In a review paper on SN rates, Tammann [13] stated his belief that "the best test of the hypothesis, that SN rates are proportional to galaxy luminosity," specifically blue luminosity [14], [15] "is provided by galaxies with M.SNe occurrences." When binned by one magnitude (mag) increments of btc luminosity, from less than or equal to 8.0 to greater than 16.0 mag, the majority of M.SNe hosts, with two known SNe, are in a btc luminosity range of 10.0–16.0 mag. Hosts with three known SNe are in a btc range of 8.0–14.0. Those with four known M.SNe are in bins from 9.0–12.0, and those with six or seven known SNe, are from less than or equal to 9.0 mag. The maximum btc luminosity for each group steadily increases, with the increasing number of M.SNe per system, in what appears to be a linear relationship, along this logarithmic scale. In 1990, Guthrie [3] reiterated the "dependence of the SNe frequency on Hubble type and galactic luminosity (as) indicated by Tammann's analysis of distance-limited samples [14] and recently confirmed by Cappellaro and Turatto [16]." Guthrie then noted, "the dependence appears to be linear."

TABLE III
List of Galaxies Displaying "Parallel" M.SNe, SNe Designations, and Host Inclination Angles [11]

NGC0772: 03hl, 03iq (59.0)
IC5145: 02dn, 03hy (63.3)
NGC0628: 02ap, 03gd (23.3)
NGC6962: 02ha, 03dt (43.2)
NGC3464: 02J, 02hy (50.9)
UGC11468: 02dv,02eg (61.8)
NGC 5468: 02cr, 02ed (21.2)
NGC3190: 02bo, 02cv (77.3)
UGC02836: 01I ,03ih (34.1)
NGC1448: 01el, 03hn (82.1)
IC4229: 01ae, 02I (39.5)
UGC00005: 00da, 03lq (64.2)
NGC1376: 99go, 03lo (20.2)
UGC01993: 99gp, 03hc (90)
NGC2207: 99ec, 03H (61.1)
NGC1097: 99eu, 03B (51.2)
NGC2532: 99gb, 02hn (35.7)
NGC5468: 99cp, 02cr (21.2)
UGC11149: 98dx,03hs (54.6)
UGC03513: 98fa, 03bq (68.1)
UGC03432: 96bv,03kb (72.8)
E576G40: 97br, 03am (82.5)
NGC7678: 97dc, 02dp (46.4)
NGC3367: 92C, 03aa (13.2)
NGC1097: 92bd, 03B (51.2)
NGC1448: 83S, 03hn (82.1)
NGC3169: 84E, 03cg (62.8)
NGC4727: 65B, 03eg (47.2)
NGC3074: 65N, 02cp (29.9)
NGC4162: 65G, 01hg (56.5)
NGC4157: 55A, 03J (90)
NGC2403: 54J, 02kg (60.3)
NGC4129: 54aa, 02E (90)
NGC1961: 98eb, 01is (47.3)
NGC3504: 98cf, 01ac (26.2)
NGC5172: 98cc, 01R (59.8)
UGC03430: 96bn,02em(70.4)
NGC0673: 96bo, 01fa (42.5)
NGC4051: 83I, 03id (28.8)
NGC3169: 84E, 03cg (62.8)
NGC1448: 83S, 01el (82.1)
NGC1365: 83V, 01du (54.9)
NGC3947: 72C, 01P (43.3)
NGC0735: 72L, 00dj (66.2)
NGC2841: 72R, 99by (65.7)
NGC6754: 98X, 00do (64.8)
NGC2415: 98Y, 00C (NA)
NGC3810: 97dq, 00ew(47.8)
M-05-09-22: 78C,00ex (58.6)
E153-G27: 79D, 00ek (81.8)
NGC0664: 96bw, 99eb(39.3)
NGC1084: 96an, 98dl (52.2)
NGC6389: 92ab, 00M (45.7)
NGC1097: 92bd, 99eu (51.2)
NGC3690: 92bu, 99D (50.0)
NGC3631: 64A, 96bu (34.8)
NGC1084: 63P, 96an (52.2)
NGC4526: 69E, 94D (90)
N2276: 68V,68W, 93X (31.1)
M+02-32-144: 60B, 93I(54.5)
NGC2565: 60M, 92I (67.0)
NGC1365: 57C, 83V (54.9)
NGC5236: 57D, 83N (24.2)
NGC3913: 63J, 79B (22.3)
NGC1313: 62M, 78K (40.3)
NGC7177: 60L, 76E (51.1)
NGC1058: 61V, 69L (45.4)
NGC2276: 62Q, 68W (31.1)
NGC3938: 61U, 64L (13.0)
NGC4303: 61I, 64F (19.3)
NGC4321: 14A, 59E (37.5)
NGC2841: 12A, 57A (65.7)

The same relationship appears to be true of radial velocity (vlg). When binned in 0.2 increments of log(vlg), the M.SNe hosts with the largest number of SNe per system, have a lowest radial velocity. In 1979, Shaw [17] found a reduced discovery rate in the central regions "of distant, poorly resolved galaxies" initially attributed to over-exposure of photographic plates, but "distance" was also found to affect the SN rates in visual and CCD surveys [15]. In 1990, in his paper on M.SNe events, Guthrie [3] recognized the "marked decline in the SN discovery rate with increasing distance." Analysis of this sample, of M.SNe hosts, supports that the number of M.SNe, within a host, decreases as the radial velocity increases.

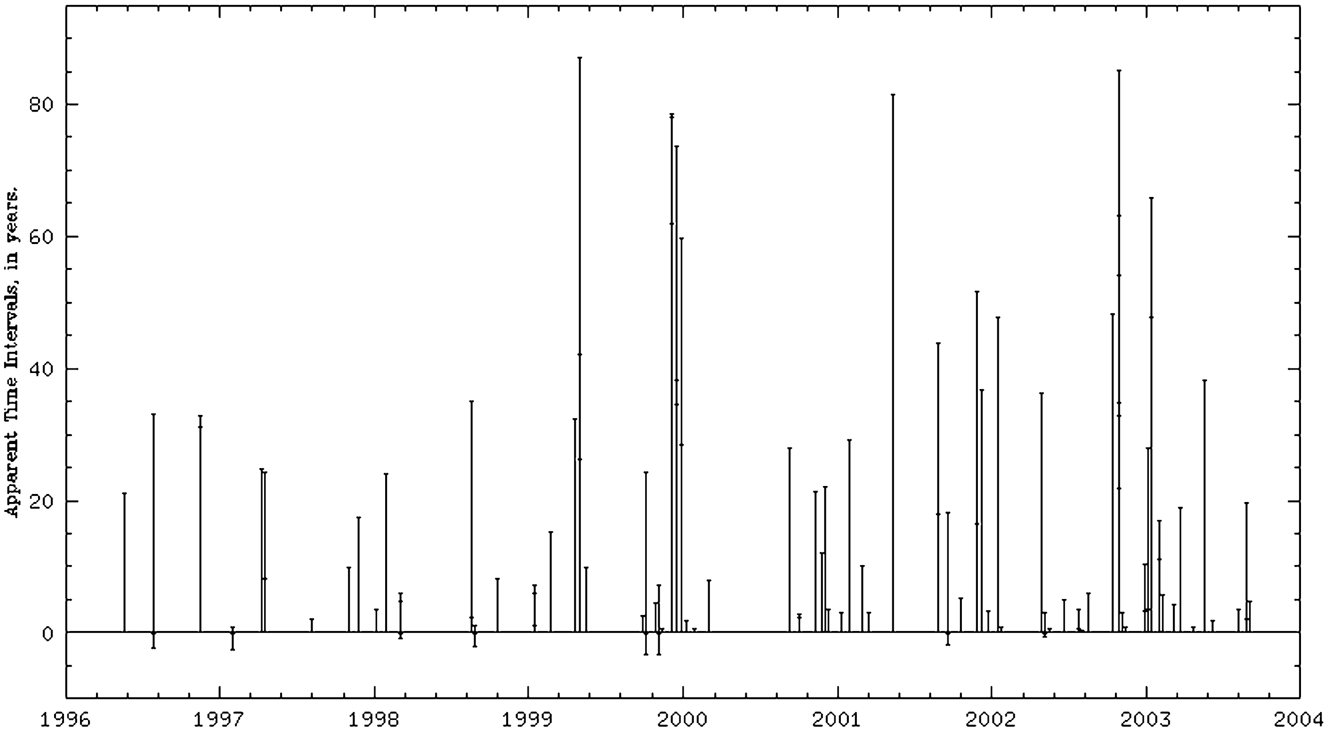
That the average SN rate depends on Hubble type was determined by the statistical work of Tammann [14]. When the sample was binned by Hubble types, it was found that 89% of named M.SNe hosts are of spiral type. This is comparable to recent statistics found by Barbon *et al.* [8], for all known SNe hosts, as of December 1999, that 78% of SNe hosts are of spiral type. M.SNe appear to be even more likely to occur in spiral galaxies, especially type Sb/SBb to Sc/SBc, and the host galaxies with the greatest number of M.SNe are type SBc, barred late-type spirals.

Inclination of the host galaxy to our line of sight, in late type spirals (Sc to Sd) only, was found to substantially affect the "average" observed rate for type II SNe, due to possible influences in galactic structure [18]; or alternately, the higher surface brightness of inclined spirals caused the overexposure of galactic disks on photographic plates, since this affect was not seen to influence visual or CCD surveys [15]. However, Bartunov *et al.* [19] found that galaxy inclination had no significant effect on the type II SN rate of their sample, from the Sternberg Supernova Survey's photographic plates, contradicting others who had "observed a rather strong dependence." M.SNe hosts, of Sc to Sd spiral type, were binned by 10° increments of galaxy inclination. The type II M.SNe amounts appear to display a "normal" distribution (as do all other SNe types) in Sc to Sd host galaxies, even if the unknown types are considered type II SNe [4], with most of the host galaxies inclined by 30° to 70°.

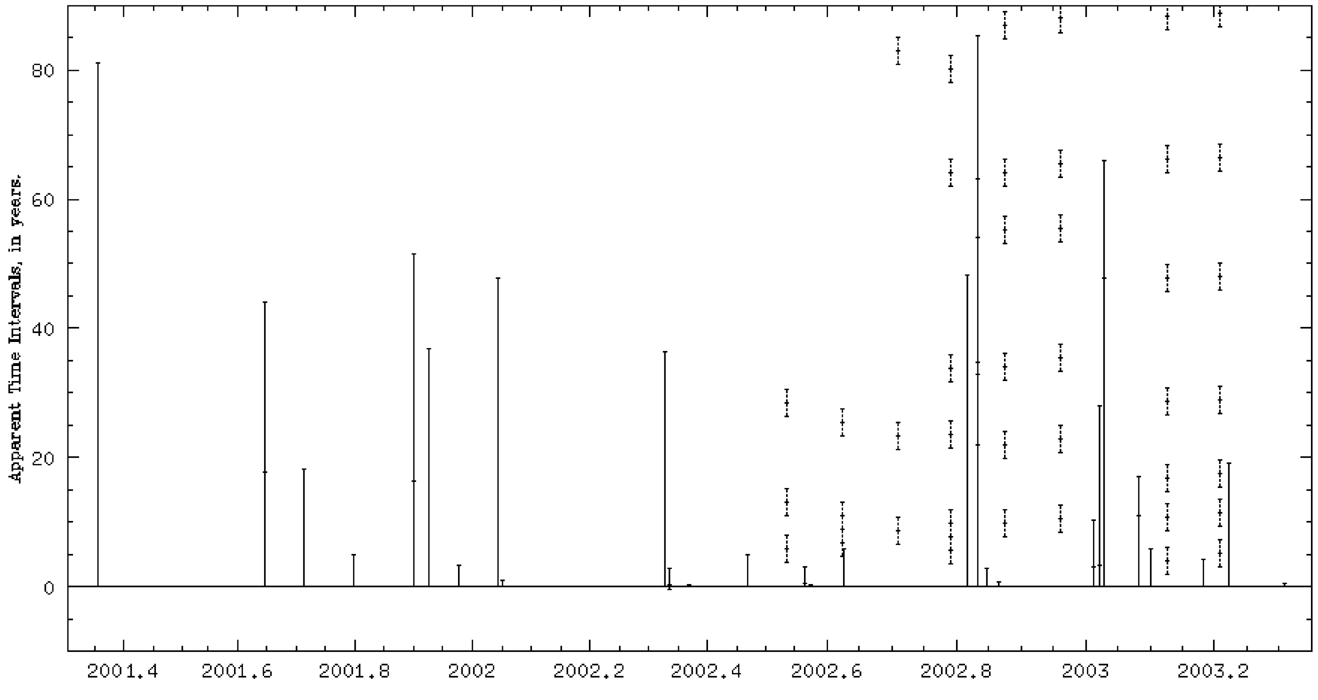
B. Are "Short Interval" M.SNe of A Specific Type?

It has been suggested, by staff members of the Herzberg Institute of Astrophysics (HIA), Victoria, BC, Canada, that those M.SNe, occurring within four years of a previous SN, may be primarily of Type Ib/c/II, i.e., from massive progenitors, in late type galaxies, with large star formation regions. SNe were binned by two general types: I/Ia and Ib/c/II, as coming from two distinct progenitors [13], [20] and unknown types. Type I SNe, in late type Sc-Sd galaxies, are not considered as type Ib SNe, as suggested by van den Bergh and McClure [18].

To determine if "distance" is a factor in the percent of M.SNe types, the sample was binned by 0.2 increments of log(vlg) and



(a)



(b)

Fig. 1. (a) Plot of multiple supernovae histories, since 1996, showing apparent time intervals in years between successive events and positioned along a standard timeline by discovery date of the successive supernova. Bars represent the total history of successive supernovae, for a galaxy. Points along those lines represent the discovery dates of previous supernovae within the same host galaxy. Points below the base line represent more recent successive supernovae, in those galaxies, and are also positioned later above the time-line. (b) Enlarged segment of Fig. 1(a) and depicts multiple supernovae histories during a two-year period from May 2001 through April 2002. Once again, the solid bars and the points along them represent multiple supernovae histories in individual host galaxies. The short dashed line segments beginning in mid-2002, represent projected years, and the ranges around each projected point, that best intuits the path of the perceived modulations. These projections were determined at the first of each month, but positioned on the plot at the mid-point of the 15th. Where the direction of the curve was uncertain, no change in slope was made from the previous discovery, but the range around the projected point was enough to capture the next discovery.

the two general SNe types, I/Ia, Ib/c/II, and unknown types. The lowest bin of log(vlg) (less than 2.2) and the very highest (greater than 4.0) displayed almost exclusively type I/Ia SNe, and the hosts from 2.2 to 2.6 log(vlg) were almost entirely of

TABLE IV
PERCENT OF SUCCESSIVE PARIS, BY SNE TYPE, FOR THE TWO SAMPLES

	Sample 1: Bin 1	Sample 1: Bin 2	Sample 2: Bin 1	Sample 2: Bin 2
I/Ia to I/Ia:	14.3	4.5	7.1	17.5
I/Ia to Ib/c/II:	28.6	31.8	35.7	15.0
Ib/c/II to Ib/c/II:	53.6	27.3	28.6	12.5
I/Ia to unk.:	0.0	11.4	7.2	17.5
Ib/c/II to unk.:	3.5	22.7	21.4	15.0
Unk. to unk.:	0.0	2.3	0.0	22.5
% Type I/Ia:	28.6	26.1	28.6	33.7
% Type Ib/c/II:	69.6	54.6	57.1	27.5
% Unknown:	1.8	19.3	14.3	38.8

type Ib/c/II. Eliminating these extremes, the group from 2.6 to 4.0 log(vlg) showed consistent amounts, and accounts for 88% of the sample, with type I/Ia M.SNe from 19.4% to 33.3%, type Ib/c/II from 44.4% to 56.7%, and unknown types from 11.1% to 29.0%.

Two samples were defined: M.SNe and their hosts, since 1996 (as of August 31, 2003), consisting of 54 named hosts with 128 SNe (including 13 SNe from known M.SNe hosts prior to 1996, but with the most recent SN occurring since then), designated Sample 1; and M.SNe and their hosts, prior to 1996, consisting of 54 named hosts with 125 SNe, designated Sample 2, to show the affects of improved survey coverage and the increase in SNe classifications in recent years [8], and then excluding those hosts, with log(vlg) less than 2.6 or greater than 4.0, for the following analysis.

M.SNe were separated by six possible scenarios of successive pairs: type I/Ia to another type I/Ia; type I/Ia to a type Ib/c/II; type Ib/c/II to another Ib/c/II; type I/Ia to an unknown type; type Ib/c/II to an unknown type; and two unknown types. These possible scenarios were binned into two general groups, of ATI: Bin 1, those pairs of M.SNe occurring within, less than or equal to, four years of apparent time; and Bin 2, those pairs occurring within more than four years of apparent time. The percent of successive pairs and the total percent for each SNe type and bin of ATI, are listed in Table IV. These totals are very similar to the proportion found by van den Bergh and Tammann [13] and also, those of R&R [4], with an observed ratio of the classified SNe II to SNe I of 2:1 and "a corrected ratio of …3:1."

By separating the hosts into the two samples, it clearly shows the increase in SNe classifications in recent years, with most of the increase in type Ib/c/II SNe. A similar result was found by R&R [4], that the observed fraction of SN II increases once the classification becomes more complete. Sample 1 shows a slightly higher total percent of type I/Ia SNe in Bin 1 than Bin 2, as well as, a greater percent of type Ib/c/II SNe, but Bin 2 had a much larger percent of unknown types, and no conclusion can be made.

Combining the two samples, and then separating Bin 1 into two parts: Bin A, extreme "short interval" M.SNe, with ATI of 0 to 1 year, and Bin B, regular "short interval" M.SNe, with ATI of 1–4 years, the percent of successive pairs of M.SNe, and SNe types, were tallied for each new bin and listed in Table V, along with the totals for Bin 2, from the combined samples. When separated by all of the apparent trends in ATI, mentioned in Section II, it appears that type I/Ia SNe are much more likely to occur in an extreme "short interval" M.SNe (0–1 year). It also appears that type Ib/c/II SNe are more likely to occur in a regular "short interval" M.SNe (1–4 years), given the decline in type I/Ia SNe within this bin, relative to the other totals, and the likelihood for unknown types to be of type II.

TABLE V
PERCENT OF SUCCESSIVE PARIS, BY SNE TYPE, FOR THE COMBINED SAMPLES

	Bin A (0-1yr.)	Bin B (1-4yrs.)	Bin 2 (>4yrs.)
I/Ia to I/Ia:	20.0	7.4	10.7
I/Ia to Ib/c/II:	40.0	25.9	23.8
Ib/c/II to Ib/c/II:	26.7	55.6	20.2
I/Ia to unk.:	0.0	3.7	14.3
Ib/c/II to unk.:	13.3	7.4	19.1
Unk. to unk.:	0.0	0.0	11.9
% Type I/Ia:	40.0	22.2	29.7
% Type Ib/c/II:	53.3	72.2	41.7
% Unknown:	6.7	5.6	28.6

The determination of a particular SN type, for a defined interval of ATI, represents an opportunity to prioritize a focused search, of the most recent known hosts, for a more probable extreme "short interval" M.SNe of type I/Ia. However, this particular apparent time interval may be subject to an observational bias, which will be described in Section IV-C and may account for this increase in type I/Ia M.SNe.

C. Are the Trends in ATI Related to the Morphology of the Host?

Within the two general bins of ATI, for the two samples, were listed four categories of influencing morphology [3], [5] on "average" SN rates: Hubble type, blue luminosity, inclination, and redial velocity. It was found that each bin contained a broad range of physical types, suggesting that the trends found in ATI, between M.SNe, may not be related by morphological attributes. R&R [4] did not find any significant physical differences between "normal" galaxies and their "fast producers," such as "mass-to-(blue) light ratios…in galaxies (of) similar types and luminosities." However, in looking at the morphological groups in Sample 1, more closely, similarities in patterns of ATI were found for those hosts with *more than two* known M.SNe (listed in Table VI) and can be described by the following classes of apparent time interval patterns and morphological ranges.

1) Class I: These hosts have all but one pair, of 33 pairs of M.SNe, with ATI greater than four years, hosts are of late and intermediate spiral type, display a range of btc luminosity from 7.55 to 11.89 mag (average 9.57), have a wide range of galaxy inclinations from 8.2° to 90.0°, and an average log(vlg) of 2.94.

TABLE VI
GALAXIES WITH MORE THAN TWO KNOWN M.SNE, LISTED BY CLASS OF ATI

log(vlg)	Galaxy	type,btc,incl	M.SNe/(ATI, in yrs.)
Class I, ATI greater than four years:			
2.43	NGC 5236	SBc,7.55,24.2	23A/45B/50B/57D/68L/83N (22.2,4.7,7.8,10.6,15.0)
2.53	NGC 6946	SBc,8.12,29.5	17A/39C/48B/68D/69P/80K/02hh (22.0,9.0,19.5,1.8,10.9,22.0)
2.56	NGC 5457	SBc,8.24,8.2	09A/51H/70G (42.6,18.9)
2.78	NGC 3627	SBb,8.98,66.3	73R/89B/97bs (16.1,8.2)
2.85	NGC 2841	Sb,9.52,65.7	12A/57A/72R/99by (45.0,14.8,26.4)
2.93	NGC 4157	SBb,10.99,90.0	37A/55A/03J (18.2,47.7)
2.95	NGC 5033	Sc,9.97,70.6	50C/85L/01gd (35.1,16.5)
3.06	NGC 4725	SBab,9.74,50.8	40B/69H/99gs (29.1,30.5)
3.17	NGC 4321	SBbc,9.79,37.5	01B/14A/59E/79C (14.0,45.0,20.2)
3.19	NGC 1365	SBb,9.90,54.9	57C/83V/01du (26.1,17.8)
3.36	NGC 4254	Sc,10.14,29.1	67H/72Q/86I (5.5,13.7)
3.46	NGC 3367	SBc, 11.89,13.2	86A/92C/03aa (5.9,11.0)
Class II, both bins of ATI:			
2.79	NGC 3184	SBc,10.30,17.3	21B/21C/37F/99gi (0.7,16.0,62.0)
3.02	NGC 1448	Sc,10.27,82.1	83S/01el/03hn (17.95,1.94)
3.09	NGC 1097	SBb,9.76,51.2	92bd/99eu/03B (7.1,3.2)
3.09	NGC 3631	Sc,10.86,34.8	64A/65L/96bu (1.6,31.1)
3.15	NGC 4303	SBbc,10.04,19.3	26A/61I/64F/99gn (35.1,3.0,15.5)
3.17	NGC 1084	Sc,11.15,52.2	63P/96an/98dl (32.9,2.01)
3.41	NGC 2207	SBbc,11.25,61.1	75A/99ec/03H (24.7,3.3)
3.42	NGC 2276	SBc,11.53,31.1	62Q/68V/68W/93X (5.9,0.2,25.4)
3.51	NGC 3690	SBm,11.33,53.2	92bu/93G/98T/99D (1.0,6.0,0.9)
Class III, ATI less than four years:			
3.43	NGC 5468	SBc,12.56,21.2	99cp/02cr/02ed (2.9,0.2)
3.50	NGC 6754	SBb,12.07,64.8	98X/98dq/00do (0.4,2.1)
3.75	NGC 0664	Sb,13.66,39.3	96bw/97W/99eb (0.2,2.7)

2) Class II: These hosts have successive pairs, of M.SNe, with ATI from both of the two general bins, less than or equal to four years and greater than four years. They are primarily of late spiral type, with a btc luminosity range of 9.75–11.53 (average 10.77), have a wide range of inclination from 17.3° to 82.1°, and an average log(vlg) of 3.20.
3) Class III: These hosts all have M.SNe with ATI less than four years, are of intermediate and late Hubble type, much less luminous than the other classes with btc range from 12.07 to 13.66 (average of 12.77). They have a broad range of inclinations, from 21.1° to 65.2° and much greater radial velocity than the other classes, with an average log(vlg) of 3.56.

The following generalities can be made from these Classes. The most luminous host galaxies with the lowest radial velocity have the largest number of M.SNe and the longest apparent time intervals between successive events. The least luminous host galaxies, with the greatest radial velocity, have the shortest apparent time intervals between occurrences. The intermediate group of host galaxies, those falling within the two luminosity and radial velocity extremes of this subset, has a mixture of both bins of ATI.

D. Similarities in Actual ATI Within the Classes

In looking at Table VI more closely, within each of the three classes described, of hosts with *more than two* known M.SNe, there are also distinct similarities in the actual apparent time intervals, besides that of the two general bins. Some of the more obvious similarities are within Class III, with all three of the hosts in this Class having two intervals each, with one of less than half a year, and the other, between two and three years. In Class II, NGC2276 and NGC3690 both have intervals of less than one year and six years. These two hosts are also closely associated in terms of log(vlg). NGC3631, NGC4303, and NGC1084 all have very similar intervals of 1.6, 3.0, and 2.0 years for the short interval, and 31.1, 35.1, and 32.9 years for the long interval. These three hosts are also closely associated in terms of log(vlg). In Class I, NGC5236 and NGC6946 both have intervals of approximately 10 and 22 years, with NGC6946 repeating an alternating 9–11-year interval twice and a 19.5–22-year interval three times. These two hosts are also closely associated in terms of log(vlg). NGC2841 and NGC4321 display almost identical intervals of 45 years and 14–14.8 years, with NGC 5457 having similar intervals within a narrow range. In Class I, the two hosts with the greatest radial velocity, NGC4254 and NGC3367, show very similar ATI.

E. Recap of Findings and Discussion

The sample, of named M.SNe hosts, appears to follow known trends in the ratio of type I to type II SNe, as well as the dependence of the SN rate on the blue luminosity, radial velocity and Hubble type of the host galaxy. However, within the sample, inclination of type Sc to Sd host galaxies, for type II M.SNe, shows a "normal" distribution and does not appear to be a factor affecting the frequency of M.SNe. The two general bins of ATI do not show an exclusive SNe, or morphological type. However, the extreme "short interval" bin (0 to 1 year) does show a much larger percent of type I/Ia SNe than the other bins of ATI, but this may be associated with an observational bias for this particular time interval that will be described in Section IV-C.

In host galaxies with *more than two* known M.SNe, it appears that the patterns of apparent time intervals between successive SNe, are linked to blue luminosity and radial velocity of the host, and can be described by three Classes of ATI patterns using the two general bins. The morphological ranges of each Class do overlap, but the general trend, in each subsequent Class, is toward shorter ATI with lower blue luminosity, and especially, greater radial velocity of the host galaxy. The larger numbers of detected M.SNe, in the "closest" most luminous host galaxies, may be the result of a longer history of survey coverage, at least where total discoveries are concerned. Just as the exclusive “short intervals,” for the M.SNe hosts with the greatest radial velocity, in Class III, could be due to recent improvements in SN surveying since all SNe, within that Class, are recorded since 1996. However, because of this assumed longer history of coverage of the “closest” most luminous galaxies, the patterns of actual ATI, within Class I, could be considered the most true. And the striking similarities, in actual ATI, within Class III cannot be easily discounted. Only time, and effective surveying of known hosts, with the greatest radial velocity, will confirm the trends found within that class.

IV. OBSERVING APPLICATIONS AND RESULTS

The original coincidence, of SN2001du and SN2001el, showed very similar morphological attributes, as well as actual histories of successive supernovae. Analysis of a small sample of southern SNe discoveries, in 2001, found ∼60% of all recent SNe could be grouped by a narrow range of galaxy types and positions, with historical repetition accounting for only ∼10% of discoveries. From October 2001 through April 2002, focused searches, with the 1-m telescope at Canopus Observatory, near Hobart, Tasmania, Australia, were developed by choosing targets that had similar positional and morphological attributes to recent discoveries, in the hopes of a repeat localized event. This method of determining targets lead to one paper result almost immediately (SN2001ig, in NGC7424), that was on a list of only 40 targets determined by their physical similarities and proximity to NGC1365 (SN2001du), NGC1448 (SN2001el), and NCG2280 (SN2001fz). For the next several months, a series of “near misses” occurred with recent discoveries falling just slightly beyond one morphological parameter, but well within others, of the various searches. An assessment and refinement of these parameters, at the end of February 2002, lead no closer to discovery, and by April 2002, the historic repetition aspect of the original coincidence was developed. Even though historic hosts represented a smaller percent of annual discoveries, these hosts were already known.

A. First Statistically Generated Target List

Using the NED to search for histories, for an initial sample of all named hosts, from 2000, 2001, and through March 2002, found that 33% of those hosts that did repeat did so within four years. Also, noted were the historic years found in recent M.SNe hosts from 2001, through March of 2002. These years were: 1950, 1954, 1957, 1965, 1972, 1983, 1985, 1991, and 1996. Using the IAU list [9], of all supernovae, a target list of all named host galaxies was compiled, from these years and from the last four years (1998–2002), within the pointing range (10° North to 70° South) of the 1-m telescope at Canopus Observatory. It amounted to approximately 220 targets, within these offsets, and 24 h of R.A., so approximately one third were not visible above the horizon at that time of year. This list was surveyed immediately upon completion, on April 13-14, 2002. On May 1, 2002, another surveyor discovered SN2002cr, in NGC5468. This galaxy had a previous SN in 1999 (cp) and was on the statistical target list generated two and a half weeks earlier. This host, prior to SN1999cp, had no previously recorded supernova, and yet followed the trend stated, that a large and consistent percent (33%–54%) of hosts, that have M.SNe, will do so within four years of their previous SN, as shown in Table II.

B. Prediction of Northern Discovery

The expanded analysis, in Section II, confirmed the original perception of the trend in “short interval” M.SNe and determined the other characteristics mentioned, i.e., “parallel” M.SNe, and the indication of periodicity overall, as well as showing that over 50% of M.SNe discoveries have been within (plus or minus) two months of the previous SN discovery date, with most of the remainder occurring within (plus or minus) four months. It seems likely that this is just a seasonal spread, what’s visible at what time of year, but it did represent another statistical means of culling a target list of known hosts, for surveying with limited means.

Using the same “parallel” years as before (1950, 1954,1957, 1965, 1983, 1985, 1996, 1998–2001), excluding 1972 and 1991, as what appeared to be an era that had played out; and then, taking targets from 1955, 1956, 1984, 1986, and 1997, as a first attempt to project new historic years that would soon show repeat activity, and then from those historic years, choosing only hosts with previous discovery dates within two and one half months prior to the June 1, and two and a half months past the June 30; this target list, of known hosts with the greatest statistical potential to produce a timely successive SN in June of 2002, was then sent to R. Robb (University of Victoria, Clemenhaga Observatory, BC, Canada). The northern target list, of approximately 260 hosts, yielded a result with the discovery of SN2002dp, in NGC7678, on 18 June 2002. This host had a prior SN in 1997(dc), but had no other known history of SN. Robb confirmed that this host galaxy was on the June 2002 target list.

C. Focused Search With the Plaskett Telescope

In late July 2002, a focused search of the northern statistically generated target list, for that month, was surveyed using the 1.8-m Plaskett Telescope, at Dominion Astrophysical Observatory (DAO), near Victoria, BC, Canada. It immediately yielded the discovery, on July 27, 2002, of SN2002eg [21], in UGC11486, a host galaxy with a previous SN from this year (SN2002dv) discovered on July 1, 2002, but with no other known history of SN. This discovery was achieved from a total of 31 galaxies surveyed on the first night of the observing run, in poor conditions with full moon and intermittent cloud, and only the most recent known host galaxies were covered. This discovery was also detected by the software of the Katzman Automated Imaging telescope, at Lick Observatory, two days later, but was discounted by the person on duty, possibly because it was mistaken for the previous SN, which occurred less than four weeks earlier. This discovery was later classified as a type IIb SN [22] and may represent a possible observational bias for extreme “short interval” M.SNe of type Ib/c/II, which may account for the increased percent of type I/Ia M.SNe within this interval, shown in Section III-B, simply because, even if unexpected, type I/Ia SNe are generally brighter and easier to see.

D. Further Results

A few days prior to the beginning of the next observing run at DAO (August 19–28, 2002), SN2002em was discovered, in UGC3430, which had a SN in 1996(bn). The hosts from 1996 were part of the basis used to compile the observing list for August 2002, which was partially determined from the projections shown on the plot of SNe histories, in Fig. 1(b). Three points were determined on the plot, at the middle of the month of August, which best intuited the path of the curves perceived; and then, a two and one half year range was added on either side of the points. Those years' hosts, with previous discovery dates, within a four-month range of August 2002, were added to the list. SN2002em, by falling within one of the three ranges depicted on the plot for August 2002, appears to be the first result, for this method of projecting which historic years will begin multiple supernovae events next.

At the end of October 2002, SN2002hh was discovered in NGC6946. This galaxy has a "prolific" history of supernovae, but its placement on October's target list was determined solely by projecting, on the plot of M.SNe histories from 1996 to the present, which historic year's hosts will yield a successive SN. Not one, but four of the six known supernovae in NGC6946 fell in projected ranges of historic years with the greatest potential for a timely successive supernova event in October 2002, as shown in Fig. 1(b). A fifth fell in a projected range for September 2002. This was the second, and most extraordinary, result for predicting by the perceived periodic behavior. In November 2002, regular "short interval" M.SNe occurred in previous hosts: NGC2532 and NGC3464.

In the first 11 days of January 2003, three M.SNe host galaxies produced a third SN: SN2003B, in NGC1097, and SN2003H, in NGC2207. Both had prior SNe in 1999 (eu and ec, respectively) and produced "parallel" SNe within four years of the previous events. Also, SN2003J, in NGC4157 had two prior SNe, SN1937A and SN1955A. NGC1097 other recorded SN was in 1992 (bd). The years 1937 and 1992 were predicted from the periodicity plot for mid-December 2002. NGC4157 also "parallels" NGC2403, whose M.SNe, SN2002kg on October 26, was not reported until much later. (SN2002kg is the first multiple *not* to be predicted by the trends in ATI.)

On the last day of January 2003, a fourth M.SNe host produced a third SN, with SN2003aa, in NGC 3367. This host had prior SNe in 1986(A) and 1992(C), and is another "parallel" M.SNe for January 2003, and also falls within the projections for mid-February 2003. There were four discoveries in January 2003 in hosts with prior history of SNe, the most so far for one month. All display "parallel" M.SNe occurrences and all were predicted by the perceived periodicity in M.SNe histories overall, as well as, by the general trends. Adjusted periodicity projections for February 2003 yielded two results with the discoveries of SN2003am, in ESO576-G40, which had a previous discovery in 1997(br).

In early March, SN2003bq occurred in UGC3513, which had a previous SN in 1998 (fa), and fell directly in the center of one of the ranges predicted for mid-February; and SN2003cg, in NGC3169, which had a previous SN in 1984(E), and fell within the ranges determined for March 2003. In April, SN2003dt occurred in NGC6962, which had a previous SN in 2002(ha), and was the first extreme "short interval" M.SNe for 2003.

In May 2003, without time to do proper projections for that month, only "parallel" years from the last 1.1 years were posted which yielded a result with the discovery of SN2003eg, in NGC4727, which had a previous SN in 1965(B). In June 2003, a regular "short interval" M.SNe occurred in NGC628. In August, three "parallel" M.SNe were detected, with SN2003hc, in UGC01993, which had a previous SN in 1999 (gp) and is a "short interval" and also "parallel" to NGC1097 and NGC2207; NGC1448 produced it's third detected SNe, with SN2003hn, which had previous SNe in 1983 (S) and 2001 (el), both within a one year range of the "parallel" years of 1984 and 2002; and then, SN2003hs, in UGC11149, which had a previous SN in 1998 (dx) and "parallels" UGC03513.

E. Recap of Focused Search Parameters and Conclusion

The following ways to prioritize a monthly target list from the IAU [9] list of all known supernovae and their host galaxies, with the greatest statistical potential for a timely successive supernova.

1) Include all known hosts within the last four years, which represents the statistic: that 33%–54% of all hosts that do have multiple supernovae will do so within four years, of the previous SN.
2) Include all hosts from historic years, which have generated a multiple occurrence recently (within the last year), in the hopes of another timely "parallel" supernova (as in Table III), and including a one-year range around those years. Also, include hosts from "secondary" years of recent M.SNe hosts (within the last month) with *more than two* known SNe.
3) Project from what appears to be sinusoidal curves, as shown in Fig. 1(a), by intuiting the position of the curves at a median point for the upcoming survey month, and allowing approximately a 2.5-year range, around that point, depending on the era.
4) To prioritize each list further, only include those historic hosts with previous discovery dates within two and one half months of the middle of the upcoming survey month. However, if possible, all visible hosts from these target years should be surveyed, as it seems likely that some SNe are missed when the host is not visible.

This analysis of M.SNe occurrences, as related to the apparent time intervals between successive events and applied to target development, has yielded consistent results with 23 of the last 24 M.SNe discoveries (as of August 31, 2003) following predictable patterns in apparent time, with five predicted extreme "short interval" M.SNe, five predicted regular "short interval" M.SNe, five predicted "parallel" M.SNe, and eight predictions by projected periodicity plot (which also includes two additional "parallel" M.SNe); with one of those 23 being captured directly, and immediately, by a focused search effort (SN2002eg), providing a narrow range of potential hosts (typically 140–250 galaxies), in which a discovery has fallen, within one month of generating the target list.

V. DISCUSSION

The determination of an "average" frequency of supernova for a "normal" galaxy has lead to a continually revised upward, and qualified rate, since Zwicky [23] determined his first average in 1938. With the exception of a few researchers, such as Kukarkin [24], and the determinations of "mean intervals' based on the known M.SNe at the time, the actual observed instances of successive SNe have been used as a check of the calculated averages, with observations that did not fit deemed "statistical fluctuations" [1], [4] rather than determinants of the actual physical relationship. With the increased and consistent M.SNe detections, in recent years, one must ask the question: When do "statistical fluctuations" become statistics? Or, how many coincidences does it take to make a trend?

The trends found, in apparent time intervals between M.SNe occurrences, are not considered possible, by some, given the disparity of the "true time" between the successive events and our perceived time here on Earth, due to inclination of the host galaxy to our line of sight. A point that should also affect any calculated "average" SN rate based in an increment of Earth time, e.g., SN unit (SNu) equals one SN per century per 10^{10} Solar (blue) luminosities [13]. And yet, these trends do exist and are consistent over time, and becoming increasingly obvious with the improved systematic coverage of automated SN surveying. This must mean some fundamental aspect of galaxy formation, or interaction, has yet to be understood, or accepted. Richter and Rosa [4] said as much in their discussion of "fast producers" of SNe, "it is clear that something in the chain IMF, SFR, mass consumption, galaxian evolution, SN progenitor mass must be different from current ideas."

In a paper on "chains of supernovae" as "launchers of stars," Zwicky [25] discussed the possibility of an induction affect generated by supernovae as a conceivable cause for the rapid succession of two SNe in NGC3184, that occurred in 1921 and 1937, and were separated, physically, by less than one second of arc. Zwicky speculated then that "chains of supernovae" could occur as a result of collisions between galaxies, or induction effects as a result of an initial SN in "crowded surroundings.". He also believed that this would be most likely to occur in the central regions of galaxies where the spatial density is highest, but analysis has shown that M.SNe are found throughout the galactic disk [4], and are more likely to be farther from the nucleus of the host galaxy [5]. Local interactions, within these galaxies, may explain the increased numbers of SNe in some hosts, but not their obvious regularity. That explanation may lie within the Plasma Cosmology Theory of Alfven [26], Swedish Nobel Prize winner 1970, whose most fundamental premise is "the same basic laws of plasma physics hold everywhere … from laboratory and magnetospheric plasmas out to interstellar and intergalactic plasmas," and in the subsequent plasma experiments of Peratt [27], whose laboratory simulations have revealed a "long-range interactive force" between galactic filaments. From a recent communication with Peratt (Los Alamos National Laboratory), he explains: "In a plasma universe as espoused by Hannes Alfven, periodicity of high-energy-density events in the universe is what one expects. The reason for this is that we view the universe as we view the solar system and laboratory plasmas, as being filled with current-conducting filaments. As such, energy built up in one part of space, say by the relative motion of plasma clouds, can be released hundreds of megaparsecs away by the filamentary 'transmission lines'. This release is usually found, either in solar plasmas, auroras, or pulsars, to be periodic … Supernovae in the plasma community have been viewed as the release of energy from a galactic-dimensional filament with a very plasma like behavior" [28]. This, now, appears to include periodicity: a predictable apparent timeliness between successive events.

With the trends found in ATI, potentially shared by any named host galaxy on the IAU list, the enormous number of "parallel" M.SNe found among M.SNe hosts, and a strong indication of periodicity displayed collectively, by all M.SNe histories, a large-scale interconnectedness is implied which cannot be explained by current conventional thinking. Throughout the very long history of observation and laboratory experiment of Plasma cosmology proponents is this very aspect and attribute: large-scale electromagnetic interconnectedness.

The initial question, why some galaxies produce SNe more rapidly than others, still remains, but within the plasma cosmology theory of Alfven [26], and his space "filled with a network of currents which transfer energy and momentum over large or very large distances," the following hypothesis seems appropriate: M.SNe, may not be exclusively the results of local "prolific" conditions, within certain host galaxies, but may represent "prolific" points in space, along this underlying network of electromagnetic filaments. According to Alfven, the understanding of phenomenon in cosmic plasma depends on the mapping of magnetic and electrical fields, and currents. Earlier experience, with this phenomenon, suggests it may be understood positionally, through mapping of SNe in space and time; and work, in this area, is currently under way.

VI. CONCLUSION

A sustained focused search of *all* known hosts would be ideal, to better define the periodicity perceived, as it is unknown if all potential hosts are surveyed consistently, with adequate control times, and therefore, as with "average" SN rates [13], M.SNe frequencies can be considered lower limits. However, without dedicated telescopes in both hemispheres, then the next steps would be: 1) a sustained focused search of the largest percent possible of most recent hosts to determine if an observational bias is the cause of the increase, in type I/Ia M.SNe, within the extreme "short interval" range of 0 to 1 year of ATI (this project is now under way with the automated 0.8-m telescope, at Lowell Observatory's Anderson Mesa site, near Flagstaff, AZ); and 2) a focused search of the previous discovery magnitude threshold, of 19.6–22.0 mag, in anonymous host galaxies, to see if the general trends in ATI hold up beyond the sample of named hosts. (In searching the IAU records further, an anonymous M.SNe host galaxy has been found, from 1997, with a recorded simultaneous detection of two type Ia SNe.) In addition, there is a need for target of opportunity spectroscopic, or multiband photometric, observations in order to classify all M.SNe discoveries.

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REFERENCES

[1] F. Zwicky, "On the frequency of supernovae. II," *Astrophys. J.*, vol. 96, pp. 28–36, 1942.

[2] G. Reaves, "Notes on extragalactic supernovae," *Pub. Astronom. Soc. Pacific*, vol. 65, pp. 242–245, 1953.

[3] B. N. G. Guthrie, "Multiple supernova events in spiral galaxies," *Astronom. Astrophys.*, vol. 234, pp. 84–88, 1990.

[4] O. G. Richter and M. Rosa, "Supernova rates and bursts of star formation," *Astronom. Astrophys.*, vol. 206, pp. 219–226, 1988.

[5] W. Li and Z. Li, "Studies of multiple supernovae in spiral galaxies," *Astronom. Astrophys.*, vol. 301, pp. 666–674, 1995.

[6] F. Zwicky, "New observations of importance to cosmology," *Int. Astronom. Union. Symp.*, vol. 15, pp. 347–358, 1962.

[7] V. Filippenko *et al.*, "The lick observatory supernovae search with the Katzman automatic imaging telescope," in *Astronom. Soc. Pacific Conf. Series*, vol. 246, 2001, p. 121.

[8] R. Barbon, V. Briondi, E. Cappellaro, and M. Turatto, "The asiago supernovae catalogue—Ten years after," *Astron. Astrophys. Suppl. Ser.*, vol. 139, pp. 531–536, 1999.

[9] IAU/CBAT [Online]. Available: http://cfa-www.harvard.edu/iau/lists/Supernovae.html

[10] The Asiago supernovae catalogue [Online]. Available: http://merlino.pd.astro.it/~supern/snean.txt

[11] HyperLeda [Online]. Available: http://www-obs.univ-lyon1.fr/hypercat/search.html

[12] Sternberg Astronomical Institute supernova catalogue [Online]. Available: http://www.sai.msu.su/sn/sncat/

[13] S. van den Bergh and G. A. Tammann, "Galactic and extragalactic supernovae rates," *Annu. Rev. Astron. Astrophys.*, vol. 29, pp. 363–407, 1991.

[14] G. A. Tamman, "On the frequency of supernovae as a function of the integral properties of intermediate and late type spiral galaxies," *Astronom. Astrophys*, vol. 8, pp. 458–475, 1970.

[15] E. Cappellaro *et al.*, "The rate of supernovae—Part Two—The selection effects and the frequencies per unit blue luminosity," *Astronom. Astrophys*, vol. 273, pp. 383–392, 1993.

[16] E. Cappellaro and M. Turatto, "A new determination of the frequency of supernovae," *Astronom. Astrophys*, vol. 190, pp. 10–16, 1988.

[17] R. L. Shaw, "Supernovae: A new selection effect," *Astronom. Astrophys*, vol. 76, pp. 188–191, 1979.

[18] S. van den Bergh and R. D. McClure, "SN rates and galaxy inclination," *Astrophys. J.*, vol. 359, pp. 277–279, 1990.

[19] O. S. Bartunov, I. N. Markarova, and D. Y. Tsvetkov, "The supernova rate," *Sov. Astron.*, vol. 17, pp. 71–74, 1991.

[20] S. D. van Dyk, "Association of supernovae with recent star formation regions in late type galaxies," *Astronom. J.*, vol. 103, pp. 1788–1803, 1992.

[21] E. Sanders, *Int. Astronom. Union. Circ.*, vol. 7944, 2002, p. 2S.

[22] A. V. Filippenko *et al.*, *Int. Astronom. Union. Circ.*, 2002, p. 7952.

[23] F. Zwicky, "On the frequency of supernovae," *Astrophys. J.*, vol. 88, pp. 529–541, 1938.

[24] B. V. Kukarkin, "Galaxies with frequent appearance of supernovae," *Inform. Bull. Variable Stars*, vol. 82, p. 1K, 1965.

[25] F. Zwicky, "Supernovae and chains of supernovae as launchers of stars and galaxies," *Pub. Astronom. Soc. Pacific*, vol. 74, pp. 70–73, 1962.

[26] H. Alfven, "Cosmology in the plasma universe: An introductory exposition," *IEEE Trans. Plasma Sci.*, vol. 18, pp. 5–10, Feb. 1990.

[27] A. L. Peratt, "3-Dimensional particle-in-cell simulations of spiral galaxies," in *Int. Astronom. Union. Symp.*, vol. 140, 1990, pp. 143–150.

[28] ——, private communication, 2002.

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