Revista Mexicana de Astronomía y Astrofísica, **26**, 41-46 (1993)

THE VIÑA DEL MAR NOVA SEARCH: 1982-1992

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RESUMEN

Los resultados de una década de patrulla rutina de la Via Láctea y la Nube Grande de Magallanes están resumidos y discutidos.

ABSTRACT

The results of a decade of routine patrol of the Milky Way and the Large Magellanic Cloud are summarized and discussed.

Key words: **NOVAE, CATACLYSMIC VARIABLES**

1. INTRODUCTION

The Instituto Isaac Newton, best known for the determination of deep, precise, multi-color (BVRI) color-magnitude diagrams of globular clusters, has recently been very well described (Alcaíno and Liller 1992). It is especially interesting to note at this conference that over a quarter century ago, our guest of honor, Allan R. Sandage, then at the Mount Wilson and Palomar Observatories, first suggested that the Instituto Isaac Newton undertake a systematic program of studying these important old stellar groups the majority of which lie well south of the celestial equator.

Although perhaps not so obvious at first, there is a rather close connection between globular clusters and novae. It is well known that both are old objects and in fact, there is good evidence that at least 2 novae have occurred in galactic globular clusters: in M80 in 1860, and in M14 in 1938 (Duerbeck 1987). From theoretical considerations, Spitzer and Mathieu (1980) concluded that many close binaries having nova characteristics are formed in the inner regions of globular clusters. Shortly afterwards, Hertz and Grindlay (1983) found numerous x-ray sources in galactic globulars and have shown that they are interacting short period binaries, some of which could become cataclysmic variables. This important contribution gave special significance to the M31 X-ray survey (van Speybroeck 1979). More recently, Ciardullo et al. (1987, here after CFNJS) have noted that the distributions of globular clusters and novae in M31 are remarkably similar, leading them to make the intriguing suggestion that most novae are created in globular clusters and then ejected into the field. If this is so, then we should expect more novae where there are more globulars – like in giant elliptical galaxies. In this connection, I note the nova survey done by van den Bergh and Pritchett (1989) on 3 S0/E galaxies in the Virgo cluster.

Like galactic globular clusters, galactic novae (as well as novae in the Magellanic Clouds) are found in greatest numbers south of the celestial equator, mainly in the constellation Sagittarius. Almost exactly 10 years ago (September 1992), a nova-search program was instigated at a small observatory just a few kilometers north of the site of this conference. Using nothing more than a Nikon camera with an 85 mm f/1.8 lens, sometimes with an H-alpha filter (for the Southern Milky Way patrol), and an 0.2-meter f/1.5 Schmidt (for the Magellanic Clouds), I have been fortunate to discover or co-discover a total of some 19 novae and nova-like objects, 3 in the LMC.

Not long after this patrol began, R.H. McNaught at Siding Spring Observatories joined me in the search for several years, and then beginning in April of last year, Paul Camilleri of Australia entered the fray and has been discovering galactic novae at an astonishing rate. In the last 18 months, this 21-year-old amateur has discovered or co-discovered 9 novae. Furthermore, he has extended the search to a greater area of the sky than previously covered.

The magnitudes to which the searches reach are difficult to determine exactly but on the whole, nearly all new images brighter than visual magnitude 10.0 have been discovered, and perhaps 15 per cent of those at 11th magnitude. Obviously, some novae will not get discovered because the Sun is in the region, extensive cloudiness curtails observations, or the observer(s) are away or indisposed for some reason.

This presentation will be a summary of what we can say about novae statistics based on the results of the last 10 years. During this time the Milky Way has been patrolled reasonably thoroughly from both hemispheres, thanks also to several active and very dedicated Japanese observers, plus the incredible octogenarian George Alcock in England, the diligent Peter Collins in the USA, and several others. (See Liller 1992.) And now – and this is most important to emphasize – really for the first time, we have something approaching an unbiased search for nova events in our Galaxy.

For reasons that will become clear, I will here concentrate primarily on classical novae, defining these to be cataclysmic variables in the general range of absolute magnitude at peak brightness of $-5 < M_V < -11$. These are now understood to be caused by thermonuclear runaways resulting from the deposition of fresh stellar material from a nearby companion star on the surface of (probably) a relatively massive degenerate white dwarf. At the present time we know of somewhere between 5 and 9 recurrent novae (2 discovered here in Viña) that underwent thermonuclear runaways and seem to be identical in most, if not all, respects to classical novae. However, as will be seen in a moment, there are some problems still to be answered. If we believe that all classical novae are recurrent, then according to the "hibernation" theory first suggested by Vogt (1982), the accretion rate varies, perhaps cyclically, and perhaps in a way analogous to the solar activity cycle.

2. THE SEARCH RESULTS

In the 10-year period since this program began (which is to say since the entire Milky Way was patrolled systematically), a grand total of 40 classical or recurrent galactic novae were discovered. See Table 1. Their location in the sky (Figure 1) reveals the well known high concentration to the galactic equator – and shows very clearly regions where novae are not discovered: near longitude 0° and north of the galactic equator; and everywhere more than 10 or 15° from the equator. The galactic bulge is not at all evident in this diagram. This distribution is to be compared with that found by CFNJS in the surveys in M31 which have shown that the novae appeared to be associated with the bulge population rather than with the disk. This comes as something of a surprise since we have always considered the novae in the Galaxy to be basically an old disc population. Can the problem be a discovery selection effect caused by sparse search coverage at high galactic latitudes? Or is it that we cannot see into the bulge around our Galaxy? Alternatively, as Shafter (1992) points out, there may be a strong selection effect in M31, namely, we are unable to see the novae in the disc because of heavy obscuration.

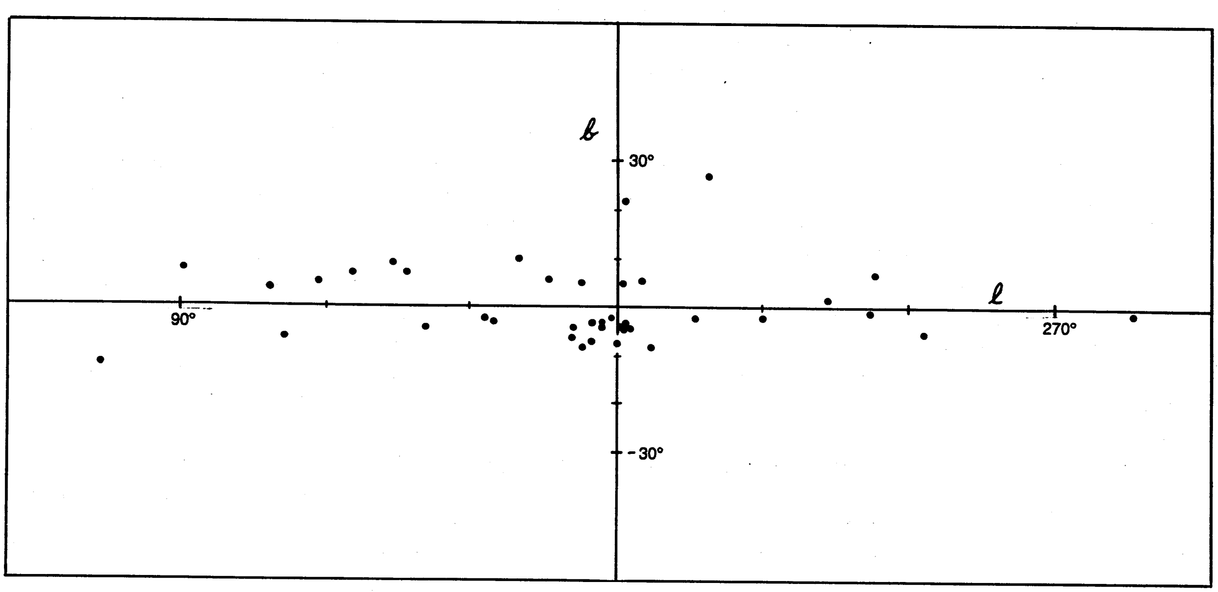

Fig.1. - The galactic coordinates of galactic novae discovered in the 10-year period ending 30 September 1992. Not shown is Nova And 1988 at l = 142°, b = −19°.

Table 1. Galactic novae discovered between September 1982 and September 1992

Designa–tion	t_3	Discoverer	Disc. Date	R.A. (1950)	Dec. (1950)	Peak Mag.	l	b	r cosb	IAUC No.
Sgr 1982	100	Honda	4 Oct	8 31	−26.5	8.0	7	−08	4.5	3733
Mus 1983	45	Liller	18 Jan	1 49	−66.9	7.2	297	−05	2.9	3764
Sgr 1983	>60	Wakuda	9 Feb	8 04	−28.8	9.5	3	−04	4.4	4119
		Ogura								4119
Ser 1983	5	Wakuda	21 Feb	17 53	−14.0	8	14	+06	0.3	3777
Lib 1983	15:	Gonzalez	10 Aug	15 17	−2 4.8	9.0	341	+27	21.1	3854
Nor 1983	14	Liller	9 Sep	16 09	−53.2	9.4	330	−02	4.9	3869
Vul 1984	97	Wakuda	27 Jul	19 24	+27.3	6.3	61	+05	0.9	3963
Sgr 1984	12	Liller	25 Sep	17 50	−29.0	9.7		−02	5.2	3995
Aql 1984	15	Honda	2 Dec	19 14	+03.6	10	39	−04	0.7	4020
Vul 1984	740	Collins	22 Dec	20 24	+27.3	5.1	68	−06	1.7	4023
rRS Oph	720:	Morrison	26 Jan	17 47	−06.7	5.2	20	+10	2.5	4030
Sco 1985	>30	Liller	24 Sep	17 53	−31.8	10.5	359	−04	8.1	4118
Cen 1986	121	Liller	3 Jan	3 17	−55.6	7.5	307	+07	3.0	4180
Cyg 1986	>100	Wakuda	26 Jun	9 52	+35.6	8.7	71	+04	3.1	4242
Sgr 1986	?	McNaught	25 Oct	8 00	−28.0	10.4	3	−03	6.1	4482
Cen 1986	50	McNaught	22 Nov	4 32	−57.4	4.6	317	+02	0.4	4274
And 1986	22	Suzuki	5 Dec	23 09	+47.2	7.5	106	−12	7.7	4281
Her 1987	65	Sugano	25 Jan	8 41	+15.3	7.5	46	+09	4.5	4307
		Honda								4307
rU Sco	7	Overbeek	6 May	6 19	−17.8	10.8	358	+22	34.8	4395
Sgr 1987	60	McNaught	8 May	17 56	−32.3	10	359	−04	6.5	4397
rV394 CrA	7	Liller	2 Aug	17 57	−39.0	7.2	353	−08	8.1	4428
Vul 1987	60	Beckmann	5 Nov	9 02	+21.7	7.0	54	+07	3.1	4488
		Collins								4488
And 1988	30:	McAdam	21 Mar	2 26	+39.8	10.0	142	−19	25.3	4570
Oph 1988	93	Wakuda	27 Mar	7 08	−29.6	8.5	355	+06	4.5	4581
rV745 Sco	2	Liller	30 Jul	7 52	−33.2	9.7	357	−04	10.1	4820
Sco 1989	8	Liller	7 Aug	7 48	−32.5	9.4	358	−03	6.2	4836
Scu 1989	80:	Schmeer	24 Sep	8 47	−06.3	9.5	27	−02	4.0	4862
Sgr 1990	3	Liller	23 Feb	7 56	−29.2	8.0	01	−03	3.9	4974
rV3890 Sgr	18	Jones	27 Apr	8 27	−24.1	8.5	09	−06	8.2	5002
		Liller								5010
Her 1991	6	Sugano	24 Mar	18 44	+12.2	5.4	43	+07	3.4	5222
		Alcock								5222
Cen 1991	9	Liller	2 Apr	3 36	−62.9	8.7	308	−01	4.5	5230
Oph 1991	40	Camilleri	11 Apr	7 17	−26.7	10.7	359	+05	13.8	5238
Sgr 1991	3	Camilleri	29 Jul	8 11	−32.2	7.0	00	−07	18.0	5313
Scu 1991	0	Camilleri	30 Aug	8 44	−8.4	10.5	25	−03	9.5	5331
Oph 1991	50:	Camilleri	11 Apr	7 40	−20.1	9.3	07	+05	6.7	5381
Pup 1991	26	Camilleri	27 Dec	8 09	−35.0	6.4	253	−01	3.9	5422
Sgr 1992	1	Liller	13 Feb	8 06	−2 5.9	7.0	05	−03	3.3	5451
		Camilleri								5451
Cyg 1992	48	Collins	19 Feb	20 30	+52.6	4.3	89	+08	2.3	5454
Sco 1992	120:	Camilleri	22 May	7 03	−43.2	8.2	344	−02	2.9	5526
		Liller								5535
Sgr 1992	70	Liller	9 Jul	8 20	−28.4	8.5	05	−07	5.8	5561

NOTES: r = recurrent nova & t_3 = time, in days, to fade 3 magnitudes. r cosb = distance, in kpc, to nova projected on galactic plane.

There are several ways to estimate the absolute magnitudes and distances to individual novae, the best being to compare the angular rate of expansion of the nebular shell with the observed Doppler motions. With the recent increased interest in novae brought about largely by people like R.E. Williams at CTIO, M. Della Valle at ESO, and their various colleagues, plus a number of investigators using orbiting observatories, especially the IUE, the spectroscopists are eager to obtain observations of new novae. I very much hope that when the time comes, CCD observers will begin looking systematically for the expanding envelopes around these forty novae.

The more usual way to obtain the peak absolute magnitudes for classical novae is to measure the rate of decline of the nova light which has been shown to correlate reasonably well with absolute magnitude. (See, for example, Shara 1989). However, Della Valle (1992) suggests that there may be a correlation between peak absolute magnitude and the z-distance from the galactic plane, and there may be astrophysical differences between novae of the disk population and novae of the bulge population. However, until we understand more fully the Della Valle effect, we will adopt Shara's diagram. For many of the forty novae, we now have well-determined fading rates, but I am still trying to track down additional observations, and time is still needed to measure the light curves of some of the recent novae.

3. INTERPRETATION

Figure 2 shows the novae as seen from the North Galactic Pole. Note that 30 of the 40 novae are included within a 60° sector. Note, too, the apparent distances of the recurrent novae. Are they really so luminous – and therefore so far away? (One, U Sco, lies entirely off the diagram.) It seems unlikely.

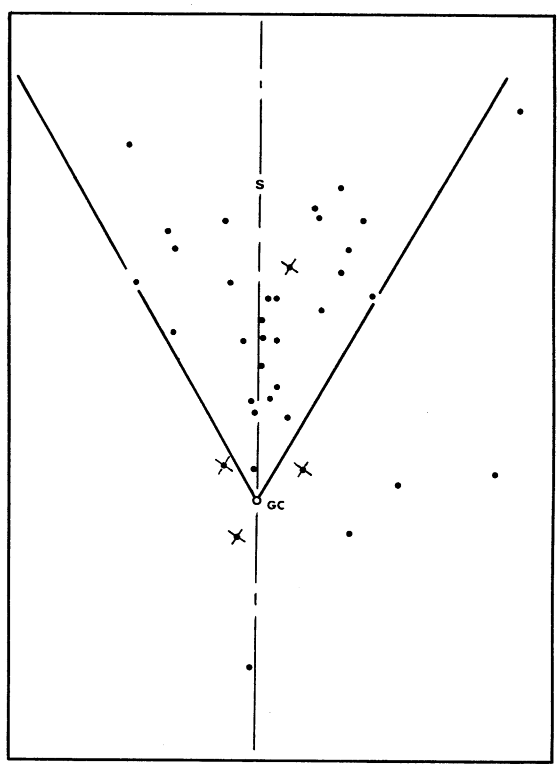

Fig.2. - The locations, projected onto the galactic plane, of galactic novae discovered in the 10-year period ending 1 November 1992. The location of the Sun and the Galactic Center are indicated by S and GC, taken to be 9 kpc apart. Recurrent novae are indicated by X's through the points. Off the diagram and within the indicated 60-degree sector is Nova And 1988. Two other novae are not shown, both on the other side of the galactic center region.

The idea that I and others have used before is that we have been able to see fairly clearly the novae in this 60° sector. If we have discovered them all, we should be able simply to multiply by 6 and get the average number that occur in all the Galaxy each year, or the number per square parsec projected on the plane. Thirty times 6 equals 180, or 18 per year, assuming we have seen them all.

Can we estimate how many have been missed? There are several correction factors needed. We must take into account the novae should have been discovered but were just plain missed for one of a variety of reasons: the sun passes right through the center of the richest hunting area – Sagittarius – once a year, and the Moon once a month; there are the problems of weather and of catching fast novae before they disappear; and searchers are not always available. In the past (Liller and Mayer 1987) I have tried to make a reasonable estimate of this correction factor, and I came up with 3.8, but now with more observers on the scene, I think that this can be cut almost in half. But since the new observers have not been there always, I will adopt 2.5 for this discussion.

So now we estimate 45 per year in the galaxy. But probably the most serious omission is caused by the obscuration in the Galaxy. Figure 1 clearly shows that there are regions, especially around $l = 0°$ and $b > 0°$, where suprisingly few novae are found. A rough estimate from symmetry considerations of how many obscured novae there were would be that the yearly rate should be (conservatively, I believe) increased by at least 30 per cent, raising the nova rate to a minimum of 60 y^{-1}. Additionally, the results of CFNJS, whose survey of M31 was done with a CCD and an H-alpha filter, show that the number of novae per square second of arc increases monotonic ally to the center of M31, leading them to conclude that the nova "hole" – the near dearth of novae in the central regions of M31 – noted by Hubble (1929), by Arp (1956) and by Rosino (1964, 1973) and colleagues is, in fact, an observational artifact. If the claim of CFNJS that the novae in M31 belong almost exclusively to the bulge population is correct, this has to be scaled to the Galaxy by the estimate that the bulge of the Galaxy is only $\sim$ 60% as luminous as that of M31 (de Vaucouleurs and Pence 1978). Another consideration arises from the suggestion of CFNJS that most novae originated as close binaries in globular clusters and were ejected, and that M31 has about 4 times as many globular clusters as the Galaxy (Crampton et al. 1985). Thus, from examination of Figure 2, one might estimate that in the central region, an additional 7 or 8 novae occurred, or 25% more, thereby raising the nova rate to at least 75 y^{-1}. Finally, CFNJS argue that 1 out of every 3 bulge novae should take place in a globular cluster. If most of our novae occur in the Galaxy's bulge, then the nova rate in the Galaxy should be not less than 100 y^{-1}.

Admittedly, many of the above corrections are based on handwaving arguments, and my rough estimate of the uncertainly is ±50. Firmer estimates of the nova rate must await additional H-alpha searches – in other spirals and in the Galaxy. For instance, one survey that could be done easily and with a small telescope is to monitor the integrated H-alpha light of galactic globular clusters which, as CFNJS point out, should increase by several tenths of a magnitude when a nova occurs. (Hogg (1973) calculated that only 1 in 10 globular cluster novae could be detected in integrated light; modern day cluster models lead me to suspect that even this low success rate is overly optimistic.)

In conclusion, I should like to thank Gonzalo Alcaíno for his support, both morally and financially, and my wife Matilde Pickhardt, for her frequent assistance in many ways. I also wish to record that I have benefitted greatly from conversations with Robert Williams, Masimo Della Valle, Hilmar Duerbeck, Nikolaus Vogt, Paul Camilleri, and Arturo Gomez.

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