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On the nova rate in the Galaxy

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Abstract. The nova rate in the Galaxy is determined, using the current estimates of nova rates in extragalactic systems as calibrators. A value of $\approx$ 20 novae/yr is obtained. This is smaller by a factor 3–4 than some of the previous estimates. The comparison of the derived value with the 'observed' nova rate in the Galaxy of $\approx$ 4 novae/yr, shows that nova surveys in our Galaxy are strongly affected by incompleteness. The frequency of occurrence of classical novae that are supersoft X-ray emitters, like GQ Mus, is also estimated.

Key words: Novae – Galaxy: stellar content – X-rays: stars

1. Introduction

The study of galactic novae at maximum light has a twofold importance. The photometric follow-up of novae at early stages enables us to determine the magnitude at maximum and the rate of decline. Both quantities are necessary for the derivation of the maximum magnitude vs. rate of decline relationship, which is the basic tool for the usage of classical novae as distance indicators. Secondly, the average number of nova outbursts per year (the galactic nova rate) is closely related to many properties of the galactic nova sub-system, such as: the recurrence time between outbursts (e.g., Truran 1990; Ritter et al. 1991), the true space density of novae (Duerbeck 1990), the relationship of novae to other CVs (Vogt 1989; Livio 1992), the possible dependence of the frequency of occurrence on the Hubble type of the parent galaxy (Della Valle et al. 1993, hereafter DRBL), and the contribution of the ejecta to the interstellar medium (e.g., Starrfield et al. 1978). It is therefore clear that the galactic nova rate should be regarded, in many respects, as a key-parameter for current nova theories, and therefore its accurate determination is very important.

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2. The galactic nova rate

In spite of the importance of an accurate determination of the galactic nova rate, the actual value is poorly known. This is illustrated quite well by the usage in current literature of old and contradictory estimates as 100 novae/yr (Allen 1954) and 260 novae/yr (Sharov 1972). More recently, Liller & Mayer (1987), corrected the 'observed' galactic nova rate of $\simeq$ 3.7 novae/yr for incompleteness and included several selection effects, to derive a 'true' frequency of occurrence of 73 ± 24 novae/yr. This result seems somewhat at variance with the nova rate of M31 of 29 ± 4 novae/yr (Capaccioli et al. 1989) unless to assume the existence of intrinsic differences in the nova production between Galaxy and M31. However, several authors have recently suggested considerably different values. Della Valle (1988) obtained a rate of 15 ± 5 novae/yr, by assuming that the nova rate per unit of B luminosity is constant for spiral galaxies. Van den Bergh (1991) found about 16 novae/yr after applying the globular cluster population ratio, Galaxy/M31 = 0.56, to the 29 ± 4 novae/yr found in M31. Ciardullo et al. (1990) set lower and upper limits to the galactic nova rate, of 11 and 46 novae/yr, respectively, by assuming a grid of constant values of the nova rate, per unit of K luminosity, across the entire range of galaxy Hubble types.

However, DRBL showed that the nova rate per unit of H luminosity is very probably *not constant* with the Hubble type of the parent galaxy, thus leaving open the question of the correct estimate of the nova rate for the Galaxy. The use of the H luminosity has been justified by the argument that since novae belong to an evolved stellar population, it seems reasonable to assume that the nova rate is proportional to the H luminosity of the parent galaxy (van den Berg & Pritchet 1986), rather than to B luminosity, which is a better tracer for young stellar populations.

In the present paper, we have estimated the galactic nova rate using the current values of the nova rates for LMC, M33, M31, NGC 5128 and 3 ellipticals in Virgo as calibrators, and taking into account the fact that the nova rate per unit of luminosity varies with the Hubble type. The data for our analysis are

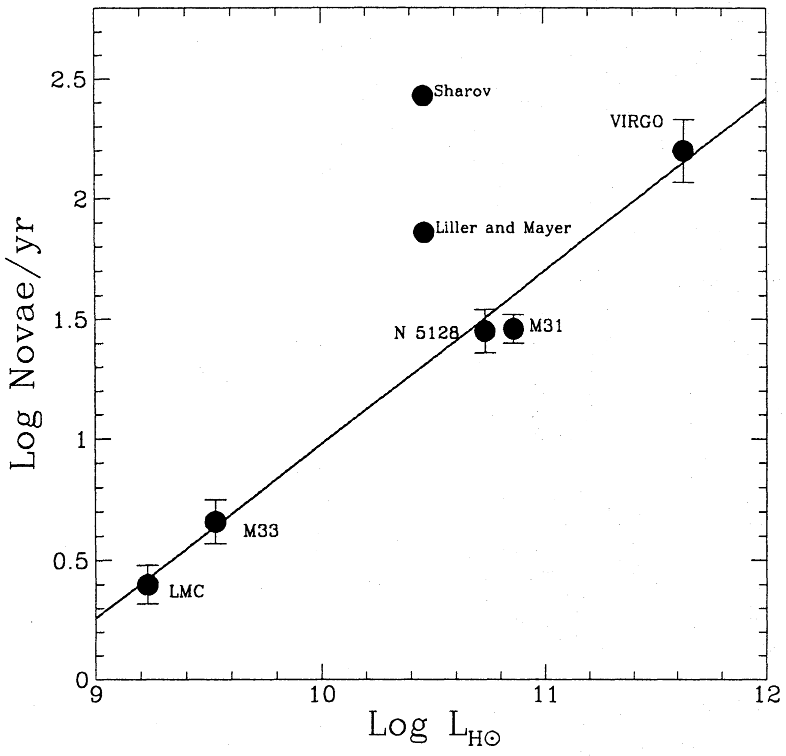

Fig. 1. The nova rate as a function of H-Luminosity of the parent galaxies

Table 1. The calibrators

Galaxy	Log($L_{H_\odot}$)	Log(novae/yr)	ν_H
M31	10.86	1.46 ± 0.06	4.0 ± 0.6
M33	9.53	0.66 ± 0.09	13.4 ± 2.8
Virgo	11.63	2.20 ± 0.13	3.7 ± 1.3
NGC 5128	10.73	1.45 ± 0.09	5.2 ± 1.3
LMC	9.23	0.40 ± 0.08	14.7 ± 3

shown in Table 1, where we report the name of the parent galaxy (col. 1), the H luminosity of the parent galaxy (col. 2), the nova rate with the associated error (col. 3), the nova rate per unit of H luminosity. The source of the data is DRBL (and references therein).

Figure 1 shows the relationship between the nova rate and the H luminosity of the parent galaxy. A simple least squares fit to the data gives:

$$\text{Log } N = 0.72 \times \text{Log } L_{H_\odot} - 6.22 \,, \quad (1)$$

where N is the nova rate per year. Assuming for the Galaxy $L_{B_\odot} = 2 \times 10^{10}$ (van den Bergh 1988) and (B-H) = 2.45 (corresponding to Sb Hubble type, van den Bergh 1990), $L_{H_\odot} = 3.7 \times 10^{10}$ and a nova rate of $\approx$ 24 novae per year are derived.

The data in Table 1 also allow us to set robust lower and upper limits on the nova rate in the Galaxy. If one assumes that the galactic nova production is M31-like, i.e., bulge dominated, we can set a lower limit of $\approx$ 15 novae/yr. If the galactic nova production is M33- or LMC-like, i.e. , mainly originating in the disk, then an upper limit of $\approx$ 50 novae/yr is inferred.

This result illustrates that the present data are definitely inconsistent with Allen's and Sharov's determinations. Figure 1 also shows that Liller and Mayer may have over-estimated some of the factors accounting for incompleteness of the galactic nova surveys.

3. Conclusions

Della Valle & Duerbeck (1993) compared the cumulative distributions of the rates of decline of the novae in the Galaxy, M31 and LMC and found that the galactic novae follow well the trend of the M31 nova population rather than the LMC novae. This is consistent with the finding of Tomaney et al. (1993) that the general spectral morphology and evolution of M31 bulge novae is similar to Galactic novae. Because of the fact that some of the fundamental parameters determining the speed class of a nova (in particular the mass of the white dwarf), depend on the evolutionary history of the binary system, the rate of decline distribution could serve as a valuable tracer of intrinsic differences between nova populations belonging to galaxies having different Hubble types. Therefore the similarity between the M31 and the Galaxy distributions suggests the following conclusions:

1) Since about 80% of the novae in M31 are produced in the bulge (Ciardullo et al. 1981; Capaccioli et al. 1989), the galactic nova production probably mainly originates from the bulge as well. This is consistent with observations in our Galaxy, which place about 2/3 of all the discovered novae towards the Sgr-Oph region.

2) A simple extrapolation of the nova rate vs. H luminosity of the parent galaxy relationship, yields a nova rate for the Galaxy of $\approx$ 24 novae per year. Since the galactic nova production is bulge dominated, values between 15 and 24 novae/yr are strongly favored.

3) According to Liller & Mayer (1987), the 'observed' nova rate is $\approx$ 3.7 novae/yr. A comparison with the 'true' nova rate (as suggested by (2) above) implies that nova surveys currently performed in our Galaxy are affected by severe incompletenesses, actually missing $\approx$ 80% of the objects.

4) The detection of supersoft X-ray emission from the nova GQ Mus (Ogelman et al. 1993) may have established an important link between the recently recognized class of supersoft X-ray sources (van den Heuvel et al. 1992 and references therein) and classical novae. In view of the important role that GQ Mus-like objects can play in the understanding of the late stages in the evolution of nova systems, it may be of interest to compute the 'true' annual rate of classical novae which behave like GQ Mus. From the analysis of the results of the ROSAT survey, Ogelman et al. (1993) were able to infer the fraction of GQ Mus-type events in Galaxy to be $\sim$ 0.04. In turn, this implies, for $\approx$ 20 novae/yr, a 'true' frequency of occurrence of $\sim$ 1 GQ Mus-like object per year in the Galaxy. The 'observed' frequency of outbursts of such systems is finally reduced by at least a factor $\approx$ 5 because of the above mentioned observational incompletenesses.

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References

Allen C.W., MNRAS 114, 387
Bothun G. D. 1992, AJ 103, 104
Capaccioli M., Della Valle M., D'Onofrio M., Rosino L., 1989, AJ 97, 1622
Ciardullo R., Ford H., Neill J.D., Jacoby G.H., Shatter A.W., 1987, ApJ 318, 520
Ciardullo R., Ford H.C., Williams R.E., Tamblyn P., Jacoby G.H., 1990, AJ 99, 1079
Della Valle M., 1988, in: van den Bergh S., Pritchet C.J. (eds) The Extragalactic Distance Scale, ASP Conference Ser. N. 4, p. 73.
Della Valle M., Duerbeck H. 1993, A&A 271, 175
Della Valle M., Bianchini A., Rosino L., Livio M., 1993, (=DRBL) A&A (in press)
Duerbeck H.W., 1990, in: Cassatella A., Viotti R. (eds) Physics of Classical Novae, p. 34.
Liller W., Mayer B., 1987, PASP 99, 606
Livio M., 1992 in: Vogt N. (ed) Vina Del Mar Workshop on Cataclysmic Variables, ASP Conf. Series Vol. 29, p. 269
Ogelman H., Orio M., Krautter J., Starrfield S., 1993, Nat 361, 331
Ritter H., Politano M., Livio M., Webbink R.F., 1991, ApJ 376, 177
Sharov A.S., 1972, SvA 16, 41
Starrfield S., Truran J.W., Sparks W.M., Arnould M., 1978, ApJ 222, 600
Tomaney A.B., Krotts A.P.S., Shatter, A.W., 1993, in preparation
Truran J., 1990, in: Cassatella A., Viotti R. (eds) Physics of classical Novae, Madrid 1989, p. 373
van den Bergh S., Pritchet C.J., 1986, PASP 98, 110
van den Bergh S., 1988, PASP 100, 8
van den Bergh S., 1990, PASP 102, 1318
van den Bergh S., 1991, PASP 103, 609
van den Heuvel E.P.J., Bhattacharya D., Nomoto K., Rappaport S.A., 1992, A&A 262, 97
Vogt N., 1989, in: Bode M.F., Evans, A. (eds) Classical Novae, p. 225
Warner B., 1989, in: Bode M.F., Evans A. (eds) Classical Novae, p. 1