THE FREQUENCY OF NOVAE IN THE GALAXY

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ABSTRACT. Recent statistics indicate that each year an average of 3.5 novae or nova-like objects are discovered in the Galaxy. With reasonable assumptions about the completeness of the surveys, we arrive at an overall galactic production rate of 76 ± 38 y^{-1}. When recurrent novae are omitted, this rate drops to 60 ± 30 y^{-1}. Hence, it seems that our Galaxy is more prolific than M31 in nova production. The total amount of material released into galactic space by novae each year is about one-tenth that ejected by supernovae.

In recent years the search for galactic novae has become sufficiently systematized so that reasonably accurate estimates of the nova rate in the Galaxy can be made. For several decades nova patrol work was dominated by the amazing Mr. Minoru Honda, but in recent years his disciples in Japan plus the PROBLICOM program in Chile (see Liller and Mayer, 1985) have played an increasingly important role. During the 5-year period 1978-82, 15 novae were found of which 6 were discovered by Honda; in the 3.4 years since then, 14 more have been added, 5 found by PROBLICOM, 3 by Wakuda in Japan, and one by Honda. All but 5 were brighter than the 11th magnitude.

These numbers correspond to an average discovery rate of 3.5 novae/year. They include 5 recurrent novae: WZ Sge, U Sco, RS Oph, VY Aqr, and a transient X-ray source Cen X-4 which has been identified with a nova-like object.

The first question to ask is *How many were missed?* We will group corrections to the observed rate as follows:

(1) Seasonal effects. Both the sun and the moon pass through the richest part of the Southern Milky Way. During 3 or 4 months around December, no observations can be made of the region where most novae occur. Also, surveys are severely hampered by moonlight once a month. A less

Paper presented at the IAU Colloquium No. 93 on 'Cataclysmic Variables. Recent Multi-Frequency Observations and Theoretical Developments', held at Dr. Remeis-Sternwarte Bamberg, F.R.G., 16–19 June, 1986.

Astrophysics and Space Science **131** (1987) 449–452.

rich region of the Northern Milky Way is similarly affected. These hiatuses indicate a correction factor close to 1.5.

(2) The Fade-out Effect. So-called fast novae can decrease in brightness by up to a magnitude a day, which means that a nova patrol that surveys the sky twice a week, such as my own, will miss perhaps half of these plus a smaller fraction of slower novae. Here I estimate a correction factor of 1.3.

(3) Weather, etc. Because there are few nova hunters, especially in the southern hemisphere, weather can play an important role. Note that the Chilean and Japanese observing stations are close to sea level and near the Pacific Coast. Temporary program holds for various reasons -- attending meetings, for example -- reduce the number of finds. The appropriate factor for these causes is estimated to be 1.3.

(4) Overlook. Sometimes novae are just simply missed. In my own experience I know of two which I should have found; fortunately, both were far enough north to be discovered by Mssrs. Honda and Wakuda. Moreover, nova patrols usually operate at $|b| < 15^{\circ}$ or 20°, and therefore many high-latitude objects are missed. Also, some of us tend to ignore the anti-center directions. Finally, it should be noted that there was only limited search activity in the SMW in the 1978-82 period. These lapses add up to an estimated correction factor of 1.4.

We thus arrive at an estimated true rate of appearance of novae of $3.5 \times 3.5 = 12.3\ y^{-1}$. If we consider only novae brighter than $V = 11$, the rate becomes $10.0\ y^{-1}$. These numbers are far smaller than the estimate once made to me by Prof. Payne Gaposchkin, namely $25\ y^{-1}$ brighter than $V = 9$.

The next, more difficult calculation to make is to extrapolate this rate to the entire Galaxy. With a good light curve it is possible to predict the absolute magnitude of a nova to ± 0.18 mag (Rosino 1964), but only a few of these recent novae have even rudimentary light curves. To calculate distances for the unfollowed majority of novae, we will assume that at maximum light $M_V = M_B = -7.7$. For extinction we will adopt 0.75 mag pc^{-1} within ± 500 pcs of the plane of the Galaxy, and zero everywhere else.

Three of the novae are noteworthy since they are calculated to lie > 59 kpc from the plane. Either they are not typical novae or they are extra-galaxtic -- and possibly supernovae. (To my knowledge spectra were obtained of only one of these. Incredible!)

When the remaining 26 novae are projected onto the plane of the Galaxy, 19, all brighter than $V = 11$ (except Cen X-4), fall within a sector of 60° centered on the sun. (Tammann (1977) found that a 50° sector included 5 of the

https://doi.org/10.1017/S0252921100105196 Published online by Cambridge University Press

6 most recent galactic supernovae.) Following Tammann, we write

$$n_G = n_{60} k_1 k_2 k_3$$

where the k's represent the correction factors arising from (1) the size of the slice of the Galaxy surveyed, (2) the effects of extinction within the sector, and (3) the completeness of the observations. In the earlier discussion we derived $k_1 = 6.0$ and $k_3 = 3.5$. To estimate k_2 we have to make a guess at the number of novae that occurred but were not seen behind the Sagittarius arm and near the nucleus of the Galaxy. Almost entirely arbitrarily, we will adopt 10 for this number, thereby giving us a value of $k_2 = 1.6$. See Figure 1.

Thus, we finally obtain

$$n_G = \frac{19}{8.4} \times 6.0 \times 1.6 \times 3.5 = 76 \pm 38 \ y^{-1}$$

The uncertainty -- 50 per cent -- is admittedly hardly more than a "guesstimate", but it should be reasonably close to reality. Omitting the 4 recurrent novae lying within the sector would give us $n_G = 60 \pm 30$.

Any discussion of this result must include comparison with M31 where Arp (1956) found 26 ± 4 novae y^{-1} during a one and a half year survey. The true rate may have been somewhat greater, but it seems clear that the rate of nova production in our Galaxy is significantly higher than in M31. This conclusion leads us to ask: Is the Galaxy significantly larger than M31? Is it somewhat more evolved? Are there more close binaries here than there?

Van den Bergh (1983) suggests a rate of $\sim 2 \times 10^{-2}$ SNy^{-1} for the Galaxy. Therefore, novae are nearly 4000 times more common. If we assume that each nova event releases 5×10^{-5} $M_\odot$ into space while each SN ejects 2 $M_\odot$, we find that novae are about one-tenth as productive in enriching the interstellar medium of the Galaxy as SN.

I wish to thank Gonzalo Alcaíno, Director of the IIN, for his continuing moral and financial support. The enthusiasm of PROBLICOM founder Ben Mayer made cold night observing more bearable. Thank you, Ben.

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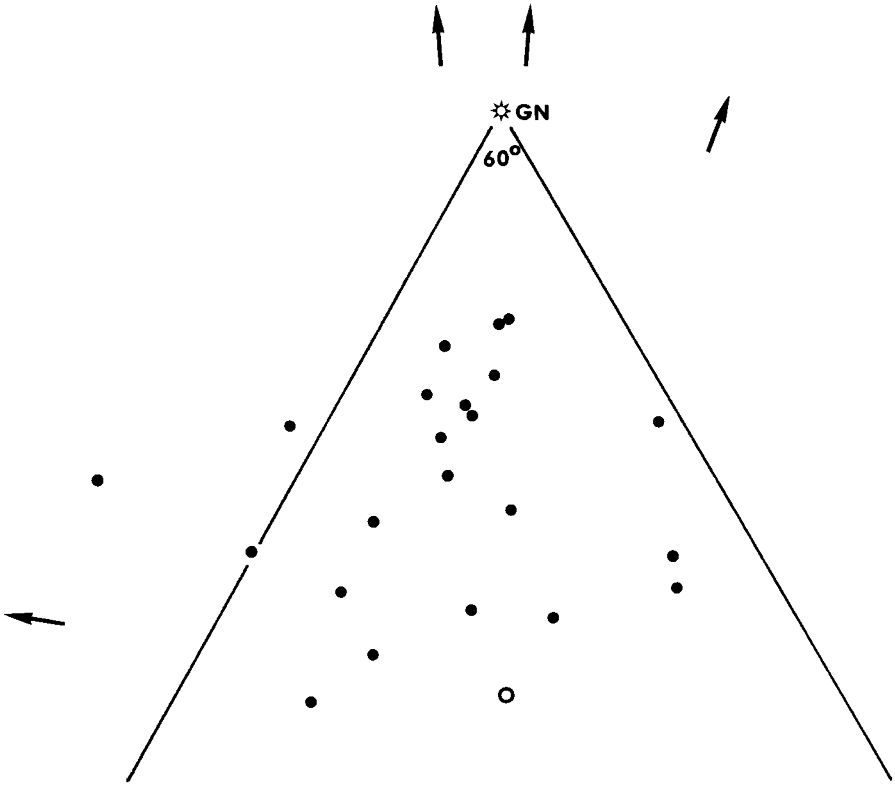

Fig. 1. Positions of 26 novae projected on the galactic plane. A 60^{0} sector of the Galaxy centered on the sun (open circle) includes 19 novae, at least 4 of which are recurrent. The distance sun-galactic nucleus is assumed to be 9 kpc.

https://doi.org/10.1017/S0252921100105196 Published online by Cambridge University Press