X-ray emission from optical novae in M 31

W. Pietsch

Max-Planck-Institut für extraterrestrische Physik, Giessenbachstraße, D-85748 Garching, Germany

Received ??, accepted ??
Published online later

Key words X-rays: galaxies – galaxies: individual (M 31) – novae, cataclysmic variables – stars: individual (M31N 2007-12a)

The first supersoft source (SSS) identification with an optical nova in M 31 was based on ROSAT observations. Twenty additional X-ray counterparts (mostly identified as SSS by their hardness ratios) were detected using archival ROSAT, XMM-Newton and Chandra observations obtained before July 2002. Based on these results optical novae seem to constitute the major class of SSS in M 31. An analysis of archival Chandra HRC-I and ACIS-I observations obtained from July 2004 to February 2005 demonstrated that M 31 nova SSS states lasted from months to about 10 years. Several novae showed short X-ray outbursts starting within 50 d after the optical outburst and lasting only two to three months. The fraction of novae detected in soft X-rays within a year after the optical outburst was more than 30%. Ongoing optical nova monitoring programs, optical spectral follow-up and an up-to-date nova catalogue are essential for the X-ray work. Re-analysis of archival nova data to improve positions and find additional nova candidates are urgently needed for secure recurrent nova identifications. Dedicated XMM-Newton/Chandra monitoring programs for X-ray emission from optical novae covering the center area of M 31 continue to provide interesting new results (e.g. coherent 1105 s pulsations in the SSS counterpart of nova M31N 2007-12b). The SSS light curves of novae allow us – together with optical information – to estimate the mass of the white dwarf, of the ejecta and the burned mass in the outburst. Observations of the central area of M 31 allow us – in contrast to observations in the Galaxy – to monitor many novae simultaneously and proved to be prone to find many interesting SSS and nova types.

1 Introduction

The outbursts of classical novae (CNe) are caused by explosive hydrogen burning on the white dwarf (WD) surface of a cataclysmic variable, a close binary system with transfer of material from a main sequence star to the WD. After about $10^{-7} - 5 \times 10^{-4} M_\odot$ of H-rich material are transferred to the WD, ignition under degenerate conditions takes place in the accreted envelope and a thermonuclear runaway is initiated (see e.g. José & Hernanz 1998; Yaron et al. 2005). As a consequence, the envelope expands and causes the brightness of the star to increase to maximum luminosities of up to $\sim 10^9 L_\odot$. A fraction of the envelope is ejected, while a part of it remains in steady nuclear burning on the WD surface. This powers a supersoft X-ray source (SSS) which can be observed as soon as the expanding ejected envelope becomes optically thin to soft X-rays, with the spectrum of a hot ($T_{eff} : 10^9 - 10^6$ K) WD atmosphere (MacDonald & Vennes 1991). The duration of the SSS phase is inversely related to the WD mass while the time of appearance of the SSS is determined by the mass ejected in the outburst and the ejection velocity. Models of the post-outburst WD envelope show that steady H-burning can only occur for envelope masses smaller than $\sim 10^{-5} M_\odot$ (Sala & Hernanz 2005b; Tuchman & Truran 1998), and the observed evolution of the SSS in V1974 Cyg has been successfully modeled by an envelope of $\sim 2 \times 10^{-6} M_\odot$ (Sala & Hernanz 2005a). WD envelope models show that the duration of the SSS state also depends on the metallicity of the envelope, so the monitoring of the SSS states of CNe provides constraints also on the chemical composition of the post-outburst envelope. Hachisu & Kato (2006) have developed envelope and wind models that simulate the optical and X-ray light curves for several WD masses and chemical compositions.

Accreting WDs in recurrent novae (RNe) are good candidates for type Ia supernovae (SNe) as RNe are believed to contain massive WDs. However, one of the main drawbacks to make RNe convincing progenitors of SNe-Ia was their low fraction in optical surveys (Della Valle & Livio 1994). In the case of CNe the ejection of material in the outburst makes it difficult to follow the long-term evolution of the WD mass. For some CNe there is a disagreement between theory and observations regarding the ejected masses, with observational determinations of the mass in the ejected shell larger than predicted by models. The duration of the SSS phase provides the only direct indicator of the post-outburst envelope mass remaining on the WD in RNe and CNe. In the case of CNe with massive WDs, the SSS state is very short (<100 d) and could have been easily missed in previous surveys. CNe with short SSS state are additional...
good candidates for SNe-Ia progenitors which makes determining their frequency very important.

Nevertheless, the number and duration of SSS states observed in optical novae are small: in a systematic search of X-ray emission from CNe in the ROSAT archive (Orio et al. 2001), found only three novae with SSS emission in X-rays from a total of 39 CNe observed less than ten years after the outburst with SSS phases lasting between 400 d and 9 yr. The Chandra and XMM-Newton observatories have detected SSS emission for several more novae; but only a limited number of observations have been performed for each source, providing little constraints on the duration of the SSS state. Of specific interest was the monitoring of the recurrent nova RS Oph in spring 2006 with the Swift satellite which clearly determined the end of the SSS state less than 100 d after outburst (see e.g. Osborne et al. 2006) which suggests a WD mass of 1.35 M⊙ (Hachisu et al. 2006). The observations of the Galactic nova V458 Vul (detected as highly variable SSS ~400 d after outburst, see e.g. Drake et al. 2008) and nova V2491 Cyg (starting its SSS state 36 d after the optical outburst, see e.g. Ness et al. 2008) demonstrated that each Galactic nova seems to have its own peculiarities.

The small number of novae found to exhibit a SSS state, and the diversity of the duration of this state (from 10 years down to few weeks) present one of the big mysteries in the study of hydrogen burning objects over the last years. Despite an extensive target of opportunity program with Chandra and XMM-Newton (of order 3 dozen observations during the last 4 years), little progress has been made in constraining the duration of SSS states, or to even putting constraints on the long term evolution of accreting WDs in binary systems. This now may change with the monitoring campaign for Galactic novae with the Swift satellite (see Osborne et al. in this issue).

2 Why observe optical novae in M 31?

In contrast to the Galaxy, observing novae in the nearby galaxy M 31 offers the unique chance to learn more about the duration of the supersoft X-ray state in a global population of novae with minimal effort:

- M 31 is the only nearby galaxy with many (more than 100 nova detected over the last 5 years!) reported optical novae within the FoV of one XMM-Newton or Chandra observation (Fig. 1).
- All novae are effectively at the same, known distance, thus allowing easy comparison of light curves and maximum brightness/luminosity in the optical and X-ray regime.
- Low Galactic foreground as well as low intrinsic M 31 absorption allows accurate determination of color and temperature.
- With comparatively little observing time one can obtain a homogeneous nova sample and follow the X-ray evolution of all of them over time.

3 X-ray detection of optical novae in M 31

Already in the ROSAT proposal for a “Deep Survey of the Andromeda Nebula” with the PSPC in 1989, it was speculated that several tens of novae should be detectable in the survey (extrapolating from EXOSAT detections of optical novae as SSSs: Ögelman et al. 1987). ROSAT has observed the full disk of the M 31 galaxy twice (about 6.5 deg²). A ROSAT PSPC mosaic of 6 contiguous pointings with an exposure time of 25 ks each was performed in July 1991 (first M 31 survey; Supper et al. 1997, hereafter SHP97). A second survey was made in July/August 1992 and January and July 1993 (Supper et al. 2001, hereafter SHL2001). Several SSS candidates were identified. In a search for counterparts, only one recent nova (which erupted in 1990 in M 31) was found on optical images (Nedialkov et al. 2002). The population of SSS in M 31 has been studied by Greiner et al. (2004 1996), in particular their variability. One of the surprising results was that more fading than rising sources have been found. Coincidentally, one of these faders was the above-mentioned nova (RX J0044.0+4118; Nedialkov et al. 2002). This led to speculation that the difference in the num-

Fig. 1 DSS1 image of M 31: the SuperLOTIS and Skinakas field of view (FoV) are overlaid as big squares. Circles show the Chandra HRC I and XMM-Newton EPIC PN fields. Novae with outbursts after 2000 are indicated by green dots. Big circles indicate X-ray detected novae (extracted from our M 31 nova web page, see http://www.mpe.mpg.de/~m31novae/opt/m31/M31_table.html).

- With the derived time of appearance of the SSS and the durations of nova SSS phases one can constrain envelope and WD masses, and potentially correlate differences in metallicity with location in M 31 (bulge versus disk population).
- X-ray parameters can be correlated with nova type (Fe II, He/N) and speed class for many novae.
bers of faders and risers is due to a fraction of classical novae for which the X-ray rising phase could be much shorter than the fading phase. Based on the, until then, known durations of the supersoft X-ray phases, this explanation was considered unlikely. Also, the global (bulge+disk) nova rate of \( \sim 37 \) nova per year in M 31 (Shafter & Irby 2001), combined with the short duration of the ROSAT survey, did not suggest more than two novae among the two dozen ROSAT SSSs in M 31 when taking into account the wide spread locations of the SSSs over the M 31 disk. Similarly, recurrent novae were not expected to contribute to the observed SSS sample, since the outburst rate of recurrent novae in M 31 has been estimated to be only 10% of the rate of classical novae (Della Valle & Livio 1996).

However, the very incomplete M 31 optical nova catalogues at the time were the most likely reason for the low number of ROSAT SSS identifications. Another reason may be that the limited spatial resolution of the ROSAT PSPC led to a reduced sensitivity for SSS detections in the crowded central M 31 field where many of the optical novae are detected.

This situation changed with the advent of Chandra and XMM-Newton and the improved optical nova catalogues. In a search for X-ray emission from optical novae, Pietsch et al. (2005a, hereafter PFF2005) correlated M 31 X-ray source catalogues sensitive to the detection of SSS (ROSAT PSPC: SHP97, SHL2001; Chandra HRC-I: Kaaret (2002, hereafter K2002); Chandra ACIS-S; Di Stefano et al. (2004, hereafter DKG2004); XMM-Newton: Pietsch et al. (2005b, hereafter PFH2005)) with the nova list of the Wendelstein Calar Alto Pixellensing Project (WeCAPP, Riffeser et al. 2001) and novae from the literature. Within the ROSAT lists, PFF2005 identified five novae. Within the Chandra HRC-I catalogues, eight nova counterparts were detected with count rates of \( (3-30) \times 10^{-4} \) ct s\(^{-1}\). Five of these novae have also been detected in ACIS-S and were classified as SSS. The XMM-Newton observations of the M 31 center (four pointings with 6 month spacing from June 2000 to January 2002) revealed three additional novae. Four novae were detected as SSS within a year after outburst. While nova N2000-03 turned on as a SSS \( \sim 180 \) d after outburst and was still active more than a year later, nova N2001-06 was just detected once \( \sim 120 \) d after outburst and 65 days later had dropped in X-ray flux by at least a factor of 10. The sample at the time more than tripled the number of known optical novae with a SSS phase. The SSS phase of at least 15% of the novae started within a year.

Pietsch et al. (2007b, hereafter PHS2007) searched for optical nova counterparts in Chandra HRC-I and ACIS-I X-ray monitoring observations of the M 31 center that were performed from June 2004 to February 2005 to detect black hole X-ray transients and time variability similar to that from the Galactic center black hole (Sag A\(^*\)) also from the M 31 center black hole (M 31\(^*\)). PHS2007 serendipitously detected eleven out of 34 novae within a year after the optical outburst. While for eleven novae from PFH2005 they detected the end of the SSS phase, seven novae were still bright 1200 to 3380 days after the outburst. Several of the X-ray outbursts lasted less than 100 days. They found that the number of optical novae detected as SSSs is much higher than previously estimated (\( > 30\% \)). From the X-ray light curves estimates for the mass of the ejecta and of the mass burned were given.

Smirnova & Alksnis (2006) showed that one SSS candidate of PFH2005 correlated with the position of a nova which was detected on their optical images 84 days before the X-ray detection. The position of this nova differs from that of the nova close-by proposed as identification for the SSS by PFH2005 and is the more likely counterpart. Inspired by the success, Smirnova et al. (2006) identified another up to then undiscovered optical nova with a PFH2005 SSS.

In a search for M 31 X-ray transients with Swift, Voss et al. (2008) identified a SSS transient with the nova M31N 2006-11a. It is detected both in X-rays and the UV about half a year after the optical maximum and decayed below the Swift detection threshold within a month.

In the “Deep XMM-Newton Survey of M 31” catalogue 40 SSS were detected. Fourteen of them can be classified as optical nova counterparts by correlations with the M 31 nova catalogue (see below). While many of the sources are already in the list of PFH2005, four sources are reported for the first time. They were serendipitously detected 299 d – 1167 d after the optical outburst (see Stiele et al., this issue).

### 4 The M 31 nova catalogue

About 60% of the \( \sim 65 \) novae occurring in M 31 per year are located in the central regions, with a rate in the bulge of \( 38^{+15}_{-12} \) yr\(^{-1}\) (Darnley et al. 2006). The central field of M 31 was continuously monitored since 1997 initially with WeCAPP and later using telescopes at Skinakas (Greece), SuperLOTIS (Kitt Peak) and several other sites (Fig. 1). Novae are amongst the brightest variable sources in the data set and, due to the rather dense time coverage, time of outburst and speed class can be well determined. The optical monitoring is essential for later identification of SSS counterparts. In addition to M 31 optical nova searches at other sites, the optical monitoring of M 31 by our collaboration will be carried on during 2009/10 securing close coverage for nova detections also for the latest accepted X-ray observations. After the commissioning phase, the PanSTARRS1 project will monitor daily 7 deg\(^2\) of M 31 for variable objects starting in summer 2009 (PAAndromeda). GALEX will monitor daily the same field for several weeks in September/October 2009 in the near and far UV. These programs are supplemented by a H\(_\alpha\) nova search program that allows us, due to the longer detectability of novae in H\(_\alpha\), to identify novae missed during observation gaps, and by a program for M 31 nova spectroscopy at SAO RAS 6m, Skinakas (Greece) and Asiago (Italy) to determine their type (Fe II, He/N). Additional spectroscopy is assured by fast
publication of newly detected novae in “The Astronomer’s Telegram” and direct notification of interested observers.

We combined the WeCAPP nova list with novae from other surveys of M 31. Many of the new detections are listed in the nova pages “M 31 (Apparent) Novae Page” provided by the International Astronomical Union, Central Bureau for Astronomical Telegrams CBAT and the finding charts and information, collected by David Bishop. We also adopted the CBAT naming scheme for novae that were not registered by CBAT. We intend to update the internet pages regularly and encourage observers to provide input for historical and forthcoming optical novae in M 31. We will include photometric and spectroscopic data of optical novae and candidates in M 31 covering all wavelengths. The table is available on our M 31 nova web page. Similar catalogues have been compiled for novae in other Local Group galaxies and are available from our Local Group nova web pages.

5 Position improvement and search for novae on archival plates

During the catalogue work we noticed that the positional accuracy for many of the old novae is poor. This prevents the secure identification of recurrent novae specifically in the M 31 center where the nova density is high. We therefore initiated a re-analysis of the Tautenburg plates of M 31. The analysis of the digitized plates yielded 22 new nova candidates and improved positions for 84 novae (Henze et al. 2008). In collaboration with M. Orio we are working to improve positions of the novae of the “Rosino et al.” catalogues by analyzing digitized original plates. It would be important to also re-analyze other archival plates (e.g. from Hubble, Baade, Arp, Sharov & Alksnis).

6 Ongoing XMM-Newton/Chandra monitoring of the M 31 center

Following the serendipitous detection of SSS phases of optical novae in M 31 by PFF2005 (see Sect. 3) we proposed in 2005 – and got approved – a dedicated XMM-Newton/Chandra monitoring program of the M 31 center area consisting of four XMM-Newton and four Chandra observations separated by 1.5 months. In this way we hoped to characterize the SSS light curves of several novae. Henze et al. (this issue) give some results from these observations.

Working on the PHS2007 paper we noticed that by using monitoring observations with 1.5 months spacing, one still would not be able to follow – or one even could miss – the very interesting very short SSS phases of novae involving massive WDs. In 2006, we therefore proposed a monitoring strategy that would not cover the entire year but would allow us to specifically monitor these short duration SSS states. We were granted ten XMM-Newton/Chandra observations with 10 day spacing starting in November 2007. The optical window for efficient M 31 nova monitoring opened well before that (June to February) securing an optical nova catalogue for detecting fast SSS states as complete as possible.

We detected nine novae in X-rays, four within 4 months after the optical outburst (see Fig. 1). The SSS state of three novae lasted less than 3 months with M31N 2007-11a holding the record of just 60 days. Following Hachisu & Kato (2006) only novae with WDs with very high masses (> 1.3 M⊙) are expected to show such a short SSS phase (Henze et al. 2009b, and Henze et al., this issue). One SSS correlated with the first nova detected in a globular cluster (the He/N nova M31N 2007-06b in Bol 111, see Henze et al. 2009a; Pietsch et al. 2007a; Shafter & Quimby 2007, and Henze et al., this issue). We even detected a second SSS in a globular cluster (Haberl et al. 2007ab; Henze et al. 2009a, and Henze et al., this issue). SSS and novae in globular clusters are extremely rare objects, just one SSS and two novae were known in globular clusters before the M 31 detections. Henze et al. (2009a) discussed the properties of these SSSs, unsuccessfully searched for a nova counterpart of the second SSS in a M 31 globular cluster and estimated the nova rate in M 31 globular cluster systems. Our monitoring data for the interesting SSS counterpart of nova M31N 2007-12b are discussed below.

These first results showed that the new monitoring strategy allows us to effectively select peculiar cases of SSSs and novae and to obtain a better understanding of the SSS nova population. This monitoring is also essential to improve the poor statistics of SSS and novae in globular clusters. An extension of the program was granted for 2008/2009 and 2009/2010.

7 Periodicity in the SSS counterpart to nova M31N 2007-12b

The optical outburst of nova M31N 2007-12b was detected by several groups (see entries on the Central Bureau for Astronomical Telegrams CBAT M 31 (Apparent) Novae Page and Lee et al. 2007). The time of outburst can be constrained to less than one day by the report from Nishiyama and Kabashima (first detection with 16.1 mag and last nondetection with lower limit of 18.9 mag on 2007 December 9.528 and 8.574 UT, respectively). From optical spectroscopic data obtained on 2007 December 15, the nova is classified as He/N with a Full Width at Half Maximum of the Hα line of ~4500 km s⁻¹ (Shafter 2007). Kong & Stefano (2008) reported the discovery of a new X-ray source with Swift on 2008 January 13 at a position consistent with the position of the optical nova M31N 2007-12b. No source was present at the position in Swift observations on 2007.

---

1 http://www.cfa.harvard.edu/iau/CBAT_M31.html
2 http://www.rochesterastronomy.org/novae.html
3 http://www.mpe.mpg.de/~m31novae/opt/m31/index.php
4 http://www.mpe.mpg.de/~m31novae/opt/index.php
5 http://www.cfa.harvard.edu/iau/CBAT_M31.html#2007-12b
December 16 and December 30. The emission of the new source was supersoft and the source interpreted as a supersoft transient associated with M31N 2007-12b detected 34 d after the optical outburst.

In our monitoring program no counterpart of nova M31N 2007-12b was detected in Chandra HRC-I observations on 2007 December 7 and 17. In XMM-Newton observations on December 29 (21 d after the optical outburst) a very faint source is detected which increased in brightness by a factor of more than 200 (XMM-Newton observation on 2008 January 8, see Fig. 2). In three consecutive XMM-Newton observations (2008 January 18, 28, and February 7 until 60 d after the optical outburst) the source stayed bright and showed a supersoft spectrum. During these observations, 1105s pulsations are detected (see e.g. the light curve of January 18, Fig. 3). The pulsation period stayed constant (within the errors) during the four observations separated by 30 d which suggest this period as the WD rotation period. During three observations “dips” can be identified which may be explained by scattering material within the orbit. These results may indicate that the nova outburst occurred in a cataclysmic variable system with a magnetic WD. Pulsations in M 31 SSS have been reported for two other systems. Osborne et al. (2001) reported 865 s pulsations from a transient source which may also have been detected during the SSS state of an optical nova. The second source is the brightest persistent SSS in M 31 in which Trudolyubov & Priedhorsky (2008) detected 217 s pulsations.

A detailed analysis of the M31N 2007-12b X-ray counterpart is in progress (Pietsch et al., in preparation).

8 Optical nova statistics and outlook

Figure 4 shows the number of optical novae detected per year as collected in the optical nova catalogue of M 31 used for cross-correlation with the X-ray data. X-ray detected novae are indicated separating ROSAT and XMM-Newton, Chandra, or Swift detections. The time span of the M 31 observations of these satellites is also indicated. Only few optical novae were detected in the years before the ROSAT observations, which may explain the lack of nova identifications with ROSAT SSSs. With XMM-Newton and Chandra several novae were detected which had their optical outburst years before the detection of X-ray outburst. This may be caused by very long supersoft states of these novae. Many novae with short supersoft states (shorter than 6 months) may have been missed in the sparse and inhomogeneous sampling of the light curves and even during the denser monitoring for the center area starting in November 2007. The crowding of X-ray sources in the very center may also prevent the detection of novae in XMM-Newton observations.

In Table 1 we compare detection rates of optical novae and SSS counterparts in Local Group galaxies. M 31
by far leads the list for detected novae per year and for detected SSS counterparts. This demonstrates the importance of M 31 optical nova detections and spectroscopic classifications as well as X-ray monitoring to get a better understanding for the percentage of optical novae showing SSS states and statistics on the dependence on nova type. Only M 31 allows us to determine the duration of many optical nova SSS states to constrain ejected, burning, and WD masses. While deep observations of individual novae in the Galaxy allow detailed investigations using high time and spectral resolution, the large number of objects in M 31 allows for a higher probability to find rare objects. This has been proven by the diversity of nova counterparts detected from the monitoring of the center of M 31 during the last few years.

Acknowledgements. Based on photographic data of the National Geographic Society–Palomar Observatory Sky Survey (NGS-POSS) obtained using the Oschin Telescope on Palomar Mountain. The NGS-POSS was funded by a grant from the National Geographic Society to the California Institute of Technology. The NGS-POSS was funded by a grant from the National Geographic Society to Palomar Observatory Sky Survey (NGS-POSS). The plates were processed into the present compressed digital form with their permission. The Digitized Sky Survey was produced at the Space Telescope Science Institute under US Government grant NAG W-2166. I am grateful to all the members of the XMM-Newton M 31 large program team and the XMM-Newton/Chandra M 31 nova monitoring collaboration.

References

Darnley, M. J., Bode, M. F., Kerins, E., et al. 2006, MNRAS, 369, 257
Della Valle, M. & Livio, M. 1994, ApJ, 423, L31
Della Valle, M. & Livio, M. 1996, ApJ, 473, 240
Di Stefano, R., Kong, A. K. H., Greiner, J., et al. 2004, ApJ, 610, 247
Drake, J. J., Page, K. L., Osborne, J. P., et al. 2008, The Astronomer’s Telegram, 1721, 1
Greiner, J., Di Stefano, R., Kong, A., & Primini, F. 2004, ApJ, 610, 261
Greiner, J., Supper, R., & Magnier, E. A. 1996, in Supersoft X-Ray Sources, Lecture Notes in Physics, ed. J. Greiner, Springer (Berlin Heidelberg New York), 472, p.75
Haberl, F., Henze, M., & Pietsch, W. 2007a, The Astronomer’s Telegram, 1296, 1
Haberl, F., Pietsch, W., & Henze, M. 2007b, The Astronomer’s Telegram, 1306, 1
Hachisu, I. & Kato, M. 2006, ApJS, 167, 59
Hachisu, I., Kato, M., Kiyota, S., et al. 2006, ApJ, 651, L141
Henze, M., Meusinger, H., & Pietsch, W. 2008, A&A, 477, 67
Henze, M., Pietsch, W., Haberl, F., et al. 2009a, A&A, 500, 769
Henze, M., Pietsch, W., Sala, G., et al. 2009b, A&A, 498, L13
José, J. & Hernanz, M. 1998, ApJ, 494, 680
Kaaret, P. 2002, ApJ, 578, 114
Kong, A. K. H. & Stefano, R. D. 2008, The Astronomer’s Telegram, 1360, 1
Lee, C.-H., Ries, C., Riffeser, A., & Seitz, S. 2007, The Astronomer’s Telegram, 1324, 1
MacDonald, J. & Vennes, S. 1991, ApJ, 373, L51
Nedialkov, P., Orio, M., Birkle, K., et al. 2002, A&A, 389, 439
Ness, J.-U., Starrfield, S., Gonzalez, R., et al. 2008, The Astronomer’s Telegram, 1573, 1
Ögelman, H., Krautter, J., & Beuermann, K. 1987, A&A, 177, 110
Orio, M., Covington, J., & Ögelman, H. 2001, A&A, 373, 542
Osborne, J., Page, K., Beardmore, A., et al. 2006, The Astronomer’s Telegram, 838, 1
Osborne, J. P., Borozdin, K. N., Trudolyubov, S. P., et al. 2001, A&A, 378, 800
Pietsch, W., Burwitz, V., Greiner, J., et al. 2007a, The Astronomer’s Telegram, 1294, 1
Pietsch, W., Fliri, J., Freyberg, M. J., et al. 2005a, A&A, 442, 879
Pietsch, W., Freyberg, M., & Haberl, F. 2005b, A&A, 434, 483
Pietsch, W., Haberl, F., Sala, G., et al. 2007b, A&A, 465, 375
Riffeser, A., Fliri, J., Gössl, C. A., et al. 2001, A&A, 379, 362
Sala, G. & Hernanz, M. 2005a, A&A, 439, 1057
Sala, G. & Hernanz, M. 2005b, A&A, 439, 1061
Shafer, A. W. 2007, The Astronomer’s Telegram, 1332, 1
Shafer, A. W. & Irby, B. K. 2001, ApJ, 563, 749
Shafer, A. W. & Quimby, R. M. 2007, ApJ, 671, L121
Smirnova, O. & Alksnis, A. 2006, Informational Bulletin on Variable Stars, 5720, 1
Smirnova, O., Alksnis, A., & Zharova, A. V. 2006, Information Bulletin on Variable Stars, 5737, 1
Supper, R., Hasinger, G., Lewin, W. H. G., et al. 2001, A&A, 373, 63
Supper, R., Hasinger, G., Pietsch, W., et al. 1997, A&A, 317, 328
Trudolyubov, S. P. & Priedhorsky, W. C. 2008, ApJ, 676, 1218
Tuchman, Y. & Truran, J. W. 1998, ApJ, 503, 381
Voss, R., Pietsch, W., Haberl, F., et al. 2008, A&A, 489, 707
Yaron, O., Priyalnik, D., Shara, M. M., & Kovetz, A. 2005, ApJ, 623, 398

Table 1 Optical nova statistics in Local Group galaxies extracted from our Local Group nova web pages http://www.mpe.mpg.de/~m31novae/opt/index.php, for the Galaxy see http://www.cfa.harvard.edu/iau/nova_list.html.

| galaxy | opt. novae | nova/year | detected | as SSS |
|--------|------------|-----------|----------|--------|
| Galaxy | 391 | ~8 | ~10 | |
| LMC | 39 | 0.7 | 3 | |
| SMC | 17 | 0.3 | | |
| M 31 | 816 | 22 | 53 | |
| M 32 | 3 | 0.2 | | |
| NGC 205 | 4 | 0.1 | | |
| M 33 | 32 | 0.5 | 2 | |