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UV turn–off times of classical novae*

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Abstract. We present IUE spectra of classical novae obtained at least one year after the outburst. The UV luminosities are compared with the ROSAT observations and significant parameters of the systems. The turn–off times derived from the IUE data are in agreement with the ROSAT results, showing that most novae decline in bolometric luminosity 1−5 years after the outburst. This is a signal of the exhaustion of the fuel in the hydrogen–burning layer on top of the white dwarf. There is not any clear dependence of the turn–off time on the speed class, the chemical composition or other parameters of the system. Data indicate that only a small fraction of the accreted layer is left on the white dwarf after the outburst.

Key words: stars: novae and cataclysmic variables — stars: white dwarfs — ultraviolet: stars — X-rays: stars

1. Introduction

The classical thermonuclear runaway model of the nova outburst predicts that not all the material accreted on the white dwarf is ejected by the outburst and subsequent radiation driven wind (e.g. Starrfield 1989). A substantial fraction of material returns to quasistatic equilibrium forming an envelope (10^{10}−10^{12} cm) around the white dwarf. This H–rich material burns steadily until the fuel is exhausted. During this time the nova radiates at Constant Bolometric Luminosity (hereafter CBL). This phase lasts as long as there is H–rich material burning on top of the white dwarf. The duration of this phase should be of the order of the nuclear time of the envelope (hundreds of years), but up to now observations have shown that the CBL phase is much shorter (e.g. Orio & Ögelman 1996; Orio et al. 1997). Therefore there must be some mechanism which removes efficiently material from the envelope. A line–driven wind ensuing months after the outburst (Starrfield, private communication), frictional drag energy during the common envelope phase (e.g. Mc Donald et al. 1985) and the magnetic field of the WD (Orio et al. 1992b) have been proposed to explain the decrease of mass of the envelope. Kato & Hachisu (1994) have shown that the introduction of the new OPAL opacities in the computations of optically thick winds in novae can reduce the predicted duration of the CBL phase to a few years or less, depending on the mass of the WD.

In summary, theoretical models predict that post–outburst novae will radiate at a very high bolometric luminosity (slightly below the Eddington limit) until hydrogen depletion finally causes the shell source to shut down. The time scale for this to occur, predicted to be in the range of 1 year to > 10 years, is correlated with the system parameters and, above all, in all models is inversely dependent on the white dwarf mass. As mass is lost and the envelope shrinks, the effective temperature increases until exceeding 10^5 K, and the peak emission moves to the UV and then to the EUV and soft X-ray ranges and therefore in these spectral regions the nova turn-off should be better observable. Most theoretical predictions imply that during the CBL phase soft X–ray luminosities are in the range 10^{36}−10^{38} erg s^{-1}, and the expected luminosities in the IUE band are $L_{\rm UV} \approx 10^{34}$−$10^{35}$ erg s$^{-1} \geq 10^{-3}$ $L_{\rm bol}$ (e.g. Prialnik 1986).

The determination of the length of the post–outburst nuclear burning phase for a significant number of objects will help to understand the factors that determine the active lifetime of classical novae.

Apart from GQ Mus and V1974 Cyg, the most recent novae are generally not bright in supersoft X–rays

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* Based on observations made with the International Ultraviolet Explorer collected at the Villafranca Satellite Tracking Station and de–archived from the ESA–VILSPA Database.

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Table 1. Basic characteristics of the sample

Object	Date of visual maximum	$E(B-V)$	distance (kpc)	t_3 (days)
V1668 Cyg 1978	14/09/78 [1]	0.40 [1]	3.6 [1]	30 [1]
PW Vul 1984	04/08/84 [2]	0.55 [2]	1.3 [2]	147 [2]
QU Vul 1984	24/12/84 [3]	0.61 [3]	3.5 [3]	31 [4]
V842 Cen 1986	24/11/86 [5]	0.55 [5]	.92 [5]	48 [5]
OS And 1986	07/12/86 [6]	0.25 [6]	5.1 [6]	20 [6]
QV Vul 1987	15/11/87 [7]	0.32 [7]	4.5 [7]	60 [7]
V433 Sct 1989	13/09/89 [8]	0.41 [9]	8.0 [9]	46 [9]
V838 Her 1991	23/03/91 [10]	0.53 [10]	3.4 [10]	3 [10]
V351 Pup 1991	27/12/91 [11]	0.30 [11]	4.7 [11]	40 [11]
V705 Cas 1993	07/12/93 [12]	0.50 [12]	3.2 [12]	100:[12]
LMC 1988 No. 1	23/03/88 [13]	0.05+0.10	50 [14]	33 [13]
LMC 1988 No. 2	14/12/88 [13]	0.05+0.10	50 [14]	10 [13]
LMC 1991	25/04/91 [15]	0.05+0.10	50 [14]	6 [15]

References:
(1) Stickland et al. 1981, (2) Andreae et al. 1991, (3) Saizar et al. 1992, (4) Rosino et al. 1992, (5) Sekiguchi et al. 1989, (6) Schwarz et al. 1997, (7) Gehrz et al. 1992, (8) Rosino et al. 1991, (9) Anuapama et al. 1992, (10) Lynch et al. 1992, (11) Orio et al. 1996, (12) Hauschildt et al. 1994, (13) Cappacioli et al. 1990, (14) Panagia et al. 1991, (15) Della Valle 1991.

at times ranging from a month until $\simeq$ 200 years after the outburst (Orio et al. 1997). So it is not unlikely that *all* the hydrogen is depleted soon after the outburst in *most* novae. Systematic long exposure X–ray observations of novae with the ROSAT PSPC during the first couple of years after the outburst have been performed for five objects: GQ Mus (Ögelman et al. 1993; Shanley et al. 1995), V1974 Cyg (Krautter et al. 1996; Balman et al. 1997); LMC 1992, V838 Her (Lloyd et al. 1992; Szkody & Hoard 1994) and V351 Pup (Orio et al. 1996). Only the first three were monitored in X–rays repeatedly allowing a measurement of the turn-off time. GQ Mus was detected by EXOSAT in X–rays in 1983−1984, without spectral resolution, (Ögelman et al. 1984, 1987) and later as a super-soft X–ray source by ROSAT in 1992 (Ögelman et al. 1993). In January 1993 it started to decline and the X–ray flux decreased below the ROSAT sensitivity threshold by September of that year. Shanley et al. (1995) derive a turn–off time of $\approx$ 9−10 years. Krautter et al. (1996) derive for V1974 Cyg a turn–off time of only 18 months from the ROSAT data, in agreement with the change in the ratio of the UV Nitrogen lines (Shore et al. 1996). Nova LMC 1992 instead never became a supersoft X–ray source, probably because all the hydrogen was depleted in the outburst (Orio et al. 1997). V838 Her and V351 Pup were detected as hard X–ray sources in the ROSAT range, but they did not show the super–soft X-ray, black–body like spectrum and the high luminosity expected for hydrogen burning after the outburst.

In principle soft X-rays or EUV observations are able to directly measure $L_{\rm bol}$, but the interstellar extinction levels of most novae are often too high to allow such data to be usefully obtained. It is also possible that intrinsic absorption of the ejected shell prevents the detection of extreme ultraviolet (EUV) or supersoft X-rays, and it might be negligible after a year or more only for masses of the order or below 1 $M_\odot$ (Yungelson et al. 1996).

Because of its spectral range, the ROSAT PSPC was the best instrument to monitor the late phase of classical novae. New information in the near future might be added only by the X–ray satellite Beppo–SAX, which however did not perform an all-sky-survey and allows less serendipitous detections. The database of X–ray observations of the hydrogen burning white dwarfs therefore consists primarily of observations which have already been made. A practical approach to observational constraints on post–outburst novae, which usually are at least moderately extincted, involves a combination of X–ray and UV spectrophotometry to constrain the luminosity directly radiated from the hot stellar remnant, as well as multi–wavelength measurements of the luminosity re–radiated by the nova ejecta. For this reason it is essential to reexamine the IUE data in a systematic way in order to better understand the evolution of classical novae after the outburst. Ultraviolet data provide one relatively direct window onto novae during their late outburst phases. The IUE spectra also provide information on the UV color temperature of the continuum, which is an additional point for comparison with the models, and show the physical conditions of the shell around the nova.

This paper presents an observational study of these issues through measurements of the the decay of the ultraviolet flux of a sample of post–outburst classical novae. Even if the bolometric luminosity cannot be precisely inferred from the UV tail of the spectrum, the UV observations constrain the duration of the late constant bolometric luminosity phase, often yielding upper limits on the flux that usefully describe the evolution. We analyze the IUE observations made at late stages after the outburst, performed by us or retrieved from the archive, and correlate the post–outburst UV spectral properties with the optical characteristics of the outburst. All the IUE spectra used in this work have been processed with the new IUE processing software (NewSips, see Nichols & Linsky 1996).

2. IUE observations of post–novae

Our sample consists of classical novae which have been observed with IUE *at least one year after the outburst.* From this work we exclude GQ Mus and V1974 Cyg, which have extensively studied by other authors, and whose turn-off times have been derived from ROSAT PSPC data. In the following context we refer to the UV flux or luminosity in the IUE "short" wavelength range, i.e. the integrated flux between 1230 and 1950 Å. The lower wavelength limit has been chosen to avoid the strong geocoronal Lyman α emission. Table 1 presents some of the most relevant characteristics of the objects included in our sample. In Table 2 we list the IUE images used in this work, the exposure time, the date of observation and the corresponding day after outburst. We also list in this table the UV luminosities (or the corresponding upper limits) measured in each spectrum, computed with the values of distance and reddening listed in Table 1. The spectra of all galactic novae have been dereddened with a standard UV extinction curve (Savage & Mathis 1979). For the LMC novae we have taken a distance to the LMC of 50 kpc (Panagia et al. 1991), and as interstellar reddening, we have assumed in all cases two components, one Galactic with $E(B-V) = 0.05$, and a LMC internal reddening of $E(B-V) = 0.10$ with a non–30 Doradus extinction law (Fitzpatrick 1986). We include both the total luminosity in the 1230−1950 Å range, and the continuum luminosity, obtained subtracting the luminosity in the emission lines from the total luminosity. Figures 1 and 2 show the spectra used in this work.

Since most of these novae were only observed sporadically in X–rays or in the UV range, we cannot systematically monitor their entire decline phases. We therefore have made an operational definition of the UV turn–off time as the time it takes for the remnant to drop below $L_{\rm UV} = 5\ 10^{34}$ erg s^{-1}, and for the X–rays turn–off the time when the blackbody temperature of the stellar remnant declines to less than 20 eV (Orio et al. 1997). These definitions are consistent with the lowest luminosity and black–body temperature predicted in the models for a hydrogen burning post–nova white dwarf, and with both the simulations (Starrfield, Prialnik, private communications) and the X–ray observations of nova turn–offs. In addition, the UV definition agrees with the luminosities of $L_{\rm UV} \leq 5\ 10^{34}$ erg s^{-1} in old novae where nuclear burning is known to be absent (e.g. Selvelli et al. 1989). Lower luminosities imply either that the nova has turned off or that the rapid cooling due to exhaustion of hydrogen is likely to be occurring.

2.1. The Galactic sample

2.1.1. V1668 Cyg (Nova Cyg 1978)

In January and May 1980 a weak continuum and emission lines of NIII], NIV], CIII] and CIV were unambiguously present in the IUE spectrum. The UV continuum luminosity at that time was 2.8 10^{34} erg s^{-1}. The nova was not detected in the last IUE observation, in December 1980. Some very weak emission lines could be present (NV 1240 and CIV 1550), but they could well be camera artifacts (Crenshaw et al. 1990). The turn–off time is therefore $<$ 1.3 years.

2.1.2. PW Vul (Nova Vul 1984 No. 1)

The IUE spectra obtained in March and June 1986 showed both UV lines and continuum clearly present. Two years later there was a faint continuum, with no emission lines, and the luminosity in the 1230−1950 Å band was 1.7 10^{34} erg s^{-1}. The possibility that this spectrum corresponds to a nearby star cannot be totally excluded, since there are a few faint stars close to the nova (see e.g. Ringwald & Naylor 1996). Assuming that the observed spectrum corresponds to the nova, we see the signature of the turn–off that started already in June 1986, so the turn–off time is less than 2 years. In agreement with this, the ROSAT upper limits for this nova in 1991 and 1992 imply $T_{\rm BB} \leq 20$ eV.

2.1.3. QU Vul (Nova Vul 1984 No. 2)

This nova was detected by ROSAT 6.5 years after the outburst, with a flux much lower than immediately after the outburst (Orio 1993). The X–ray flux did not seem to be due to the hot central source. The September 1989 IUE spectrum showed a very faint continuum with some emission lines, some of which could be just camera artifacts due to the very long exposure. The only lines which seem real are HeII 1640 Å and NeIV] 1602 Å. The UV continuum luminosity was still high, 6.6 10^{34} erg s^{-1}. Given the upper limit provided by the X–ray data, we conclude that the turn–off was about 5.5 (± 1) years after the outburst.

2.1.4. V842 Cen (Nova Cen 1986 No. 2)

At the time of the last IUE observations (May and July 1991) this nova still showed strong emission lines of CII, SiIV, NIV], CIV, HeII and CIII]. The UV continuum luminosity in July 1991 was 2.8 10^{34} erg s^{-1}, and between the May and July 1991 observations the UV energy distribution became flatter, consistently with cooling of the

Table 2. List of IUE Spectra and UV luminosities

Object	Image	Date of observation	Texp (min)	Day after outburst	$L_{\rm UV}$	$L_{\rm cont}$	Comments
					(10^{34}	erg s^{-1})	
V1668 Cyg	SWP07621	09/01/80	240	482	7.1	2.8	Weak continuum. Lines
	SWP09065	23/05/80	395	615	5.4	3.3	Weak continuum. Lines
	SWP10886	24/12/80	360	840	< 1.6		No continuum. Marginal lines
PW Vul	SWP28068	31/03/86	70	604	9.5	6.1	Continnum and lines
	SWP28461	09/06/86	70	628	5.6	3.0	Continuum and lines
	SWP33803	23/06/88	423	1428	1.7	1.7	Continuum. No lines. Wrong star?
QU Vul	SWP33794	21/06/88	303	1277	23	15	Weak continuum. Lines
	SWP36933	03/09/89	960	1727	9.5	6.6	Weak continuum. Lines
V842 Cen	SWP38684	27/04/90	95	1249	5.8	5.2	Continuum and lines
	SWP41667	20/05/91	230	1639	3.8	3.5	Continuum and lines
	SWP42122	24/07/91	790	1705	3.0	2.8	Continuum and lines
OS And	SWP32336	16/11/87	105	344	14	5.2	Continuum and lines
	SWP38031	15/01/90	290	1138	2.2	2.2	Weak continuum. No lines
	SWP42292	19/08/91	372	1719	2.6	2.6	Weak continuum. No lines
QV Vul	SWP41672	21/05/91	304	1284	< 1.1		No detection
V443 Sct	SWP39495	19/08/90	300	344	11	7.4	Weak continuum. Lines
	SWP44219	24/03/92	360	927	<4.6		No detection
V838 Her	SWP42119	24/07/91	395	123	11	9.2	Continuum and lines
	SWP48029	02/07/93	428	837	< 1.8		No detection
V351 Pup	SWP49921	31/01/94	470	765	14	12	Continnum and lines
	SWP52876	22/11/94	405	1062	4.8	4.2	Continuum and lines
V705 Cas	SWP55975	21/09/95	400	653	14	6.0	Continuum and lines
LMC 88 No. 1	SWP36218	07/05/89	865	413	53	46	Weak continuum. Lines
LMC 88 No. 2	SWP36615	05/07/89	410	266	390	385	Continuum and lines
	SWP40135	18/11/90	830	768	< 4.8		No detection. Other star in aperture
LMC 91	SWP44230	25/03/92	410	343	145	35	Weak continuum. Lines

central source. This nova was not detected during a very short exposure in the ROSAT survey (Orio et al. 1992a), implying an upper limit to the soft X–ray luminosity of approximately 10^{38} erg s^{-1}. This upper limit does not exclude continued nuclear burning, but since the UV luminosity was low in 1991, we conclude that the turn–off time was approximately 3.5 years.

2.1.5. OS And (Nova And 1986)

The last IUE observation of this object was taken in August 1991. A flat faint continuum was detected without any evidence of lines. Emissions were already absent in January 1990. The August 1991 UV continuum luminosity was 2.6 10^{34} erg s^{-1}. OS And was not detected in a ROSAT pointed observation about a year later (Orio et al. 1992a), indicating a black body temperature of the central source below 20 eV (Orio 1993; Ögelman & Orio 1995). This source appears to have shut down at the time of the last IUE observation, or even before, since the UV continuum luminosity in November 1987 was only 2.2 10^{34} erg s^{-1}. We find therefore an upper limit of 1 year for the turn–off time.

2.1.6. QV Vul (Nova Vul 1987)

This nova was poorly observed by IUE during the outburst. It was not detected 3.5 years later in a five hours exposure. The upper limit to the luminosity in the SWP band was 1.1 10^{34} erg s^{-1}. Since also ROSAT did not detect the nova after less than 4 years after the outburst (Orio 1993; Ögelman & Orio 1995), we find that the turn–off occurred in less than 3.5 years.

2.1.7. V443 Sct (Nova Sct 1989)

V443 Sct was sparsely observed by IUE during the first stages of the outburst. In August 1990 there was no continuum, but only marginal emission lines of NIV], CIV, HeII and CIII]. In March 1992 it was not detected in a six hours exposure, implying an upper limit to the UV luminosity of 4.6 10^{34} erg s^{-1}. The temperature of the ionizing source was estimated to be $T_{\rm BB}$ = 180000−200000 K (Rosino et al. 1991; Anupama et al. 1992) at day 250. If the source had maintained this blackbody temperature it should have been detected by IUE, while ROSAT did not detect it at approximately the same time of the last IUE observation (Orio et al. 1997). A turn–off time of less than 2.5 years is a realistic estimate.

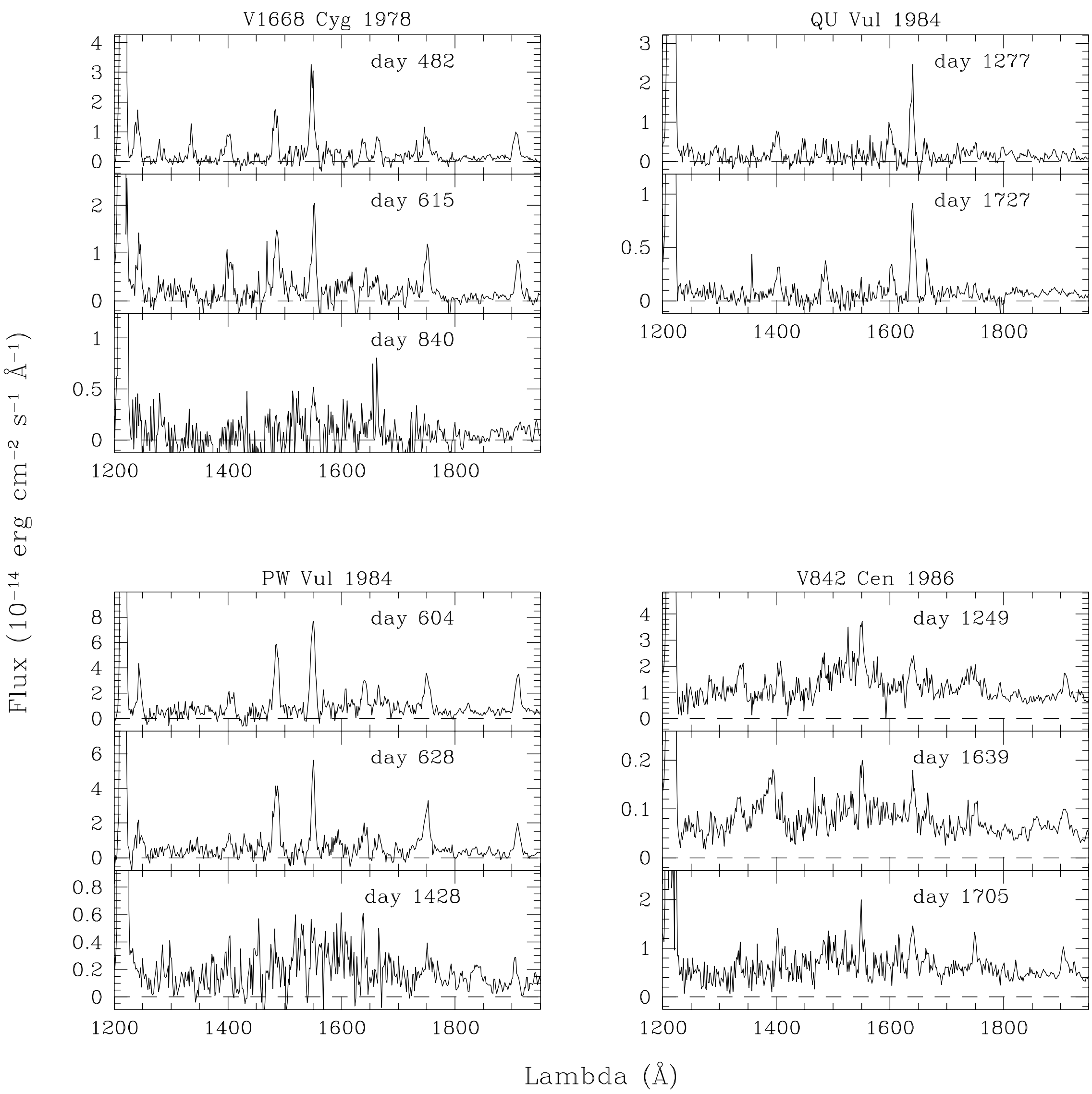

Fig. 1. Observed IUE spectra of the objects in the sample

2.1.8. V838 Her (Nova Her 1991)

This was a very fast nova with $t_3 = 3{-}5$ days (Lynch et al. 1992). It showed X–rays emission only a week after the outburst, possibly due to shocked material in the shell (Lloyd et al. 1992). Leibowitz et al. (1992) and Leibowitz (1993) claim that the disk was not disrupted during the outburst. It was not detected by ROSAT a year after the outburst (Ögelman & Orio 1995), but 7 months later weak hard X–ray emission was detected in long exposure (Szkody & Hoard 1994). This hard spectrum X–ray emission could be due to an accretion disk or to ongoing shocks in the ejected shell. This nova was poorly observed by IUE in the first stages of the outburst. It still showed a rather strong continuum with some broad emission lines in July 1991. It was not detected in July 1993, implying an upper limit to the UV luminosity of 1.8 10^{34} erg s^{-1}. Therefore, we estimate a turn–off time of less than two years.

2.1.9. V351 Pup (Nova Pup 1991)

X-ray emission from this nova was detected 16 months after the outburst. This emission was too hard to be associated with an X–ray source, and it was rather due either to shocks or to accretion (Orio et al. 1996). The comparison of optical spectra at different epochs led to an estimate of two years for the turn–off time. This is confirmed by our measurements of the UV continuum luminosity,

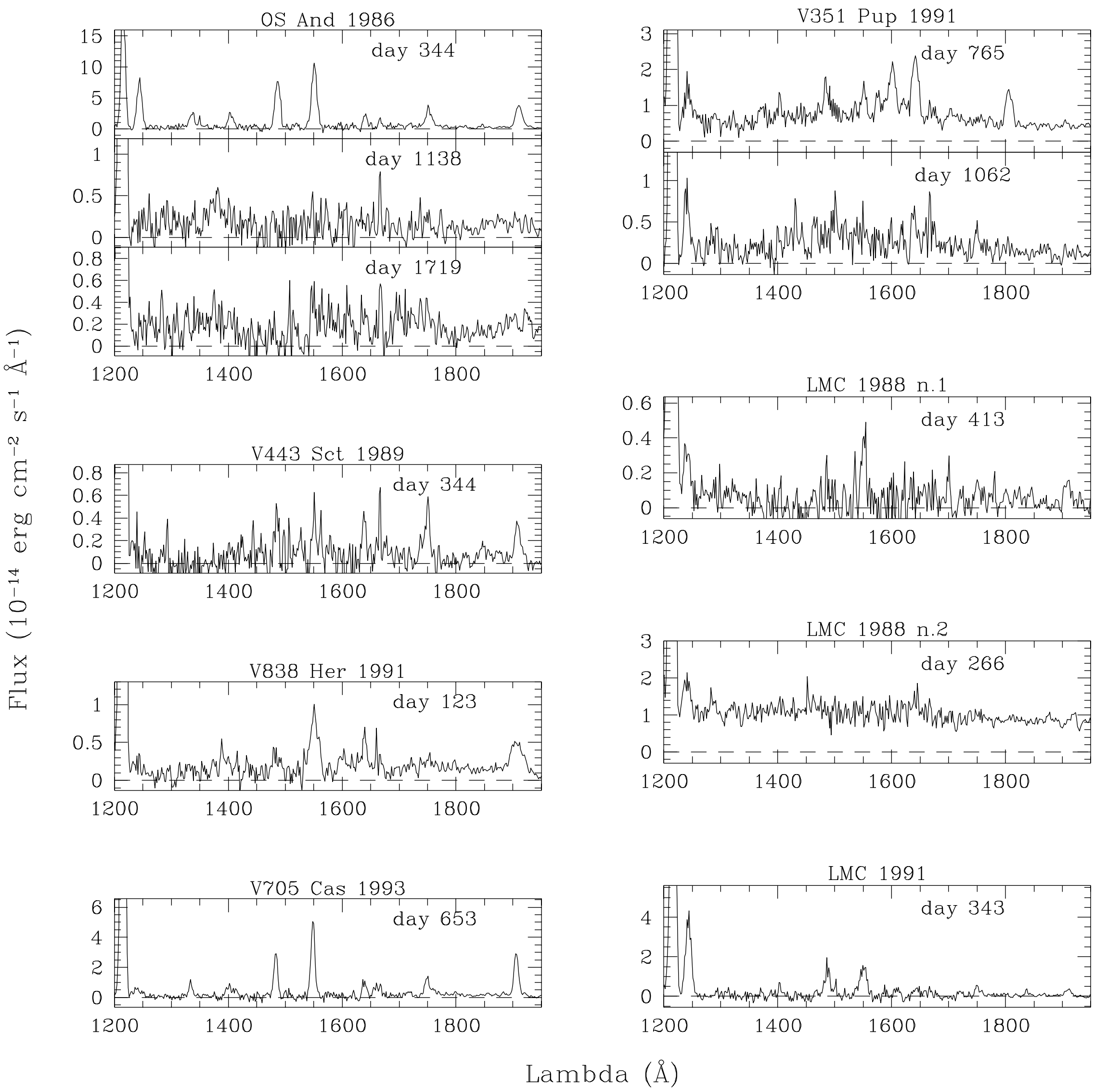

Fig. 2. Observed IUE spectra of the objects in the sample (continued)

which shows that the central source had already turned off at the time of the last IUE observations, 3 years after the outburst.

2.1.10. V705 Cas (Nova Cas 1993)

This nova has been observed by IUE during the two years following the outburst. The last spectrum still shows prominent emission lines and a weak continuum. The derived UV continuum luminosity shows that it was close to turn-off at the time of the last IUE observation, 1.8 years after the outburst.

2.2. The LMC sample

Novae in the LMC have been monitored by IUE only since 1988. This restricted sample is very meaningful because the different objects can be compared without uncertainties in distances and reddening. As stated above, we have used the same distance and reddening correction for all the objects. We include here only the novae which have been observed at least for approximately one year after the outburst i.e., LMC 1988 No. 1, LMC 1988 No. 2 and LMC 1991. Nova LMC 1990 No. 1 and Nova LMC 1992 were observed only for a few months, and Nova LMC 1990 No. 2 was a recurrent nova (Shore et al. 1991).

Table 3. Turn–off times of the objects in the sample

Nova	UV Turn–off time (years)	X–ray Turn–off time (years)	Turn–off time (years)
V1668 Cyg	< 1.3		< 1.3
PW Vul	$1.6-1.7$	< 7	≈ 1.7
QU Vul	> 4.7	< 6.5	$4.7-6.5$
V842 Cen	≤ 3.4	< 6	≤ 3.4
OS And	≤ 0.9	< 6	≤ 0.9
QV Vul	< 3.5	< 4	< 3.5
V443 Sct	$0.9-2.5$	< 3	$0.9-2.5$
V838 Her	$0.3-2.3$	≈ 0.5	≈ 0.5
V351 Pup	$2.1-2.9$	≈ 2	≈ 2
V705 Cas	> 1.8		> 1.8
LMC 88 No. 1	> 1.2	< 4	$1.2-4$
LMC 88 No. 2	$0.7-2.1$	< 3	$0.7-2.1$
LMC 91	> 0.9		> 0.9

2.2.1. Nova LMC 1988 No. 1

The spectrum taken in May 1989 showed only a weak continuum with evidence of emissions of NIV] 1486 Å, CIV 1550 Å and CIII] 1910 Å. Emissions near 1663 and 1750 Å are most likely camera artifacts. The UV continuum luminosity in May 1989 was 5.3 10^{35} erg s^{-1}, and by that time the nova had clearly not turned off. However, it was not detected in ROSAT observations in 1992 and 1994, implying a turnoff time of less than $\simeq$ 4 years (Ögelman & Orio 1995).

2.2.2. Nova LMC 1988 No. 2

The IUE spectrum taken in November 1990 showed a rather strong flat continuum without any emission line. The only spectral features are a few absorption lines of interstellar origin. A careful check of the spacecraft pointing has shown that this spectrum, which is clearly off–centered in the aperture does not correspond to the nova, but to a closeby star. The nova itself should have been well centered in the aperture, and it is not detected. The previous spectrum (July 1989) also shows two stars in the aperture, one of them with a very clear emission at 1240 Å (NV), so we conclude that it was the nova itself. For the values of distance and reddening quoted above, the continuum luminosity at the time of the July 1989 observation was 3.8 10^{36} erg s^{-1} and the turn off time is more than 1 year. The upper limit for the UV continuum luminosity derived from the November 1990 observation is 4.8 10^{34} erg s^{-1}, and therefore the nova had switched off by then. The ROSAT observations between 1991 and 1994 imply a turn–off time < 5 years and most likely even < 3 years (Ögelman & Orio 1995).

2.2.3. Nova LMC 1991

The IUE spectrum taken in March 1992 showed a weak continuum and very broad emission lines of NV, NIV], CIV, CIII] and possibly NIII]. The continuum luminosity in the IUE short wavelength range at the time of the last observation was 3.5 10^{35} erg s^{-1}, and therefore no turn off has been observed.

3. Discussion

The derived turn–off times (or limits) for the novae in our sample are listed in Table 3. The combination of X–ray and UV data presented here shows that most novae decline in bolometric luminosity in about $1-5$ years after the outburst to the level where hydrogen shell burning is likely to have ceased. GQ Mus remains the long–lived exception to this trend. Other novae seem to reach UV spectroscopic stages similar to that observed in GQ Mus after nearly a decade within only a few years after outburst, and thereafter turn off completely.

Furthermore, the turn–off times do not appear to correlate with the properties of the system. For instance V838 Her and QU Vul, both classified as Neon novae, had relatively short and long turn–off times, respectively. These are puzzling results when compared with the theoretical predictions. Classical novae with high mass white dwarfs are expected to shut down in a year or less, while low mass white dwarfs should sustain nuclear burning for a decade or more. Because this pattern depends on white dwarf mass, it also is expected to correlate with the peak luminosity and thus with the speed classes of classical novae (see Prialnik & Kovetz 1985). Neon novae are often theoretically attributed to outbursts on massive O–Ne–Mg white dwarfs and should therefore have short nuclear burning lifetimes. Thus far this trend has not been observed.

The lack of a pronounced correlation between turn–off times and neon abundances suggests either that only a subset of Neon novae are due to the presence of a high mass O–Ne–Mg white dwarf (Livio & Truran 1994) or possibly none at all (Shara & Prialnik 1994), or that factors other than the white dwarf mass control the turn–off times.

Since there is a spread in turn–off times, but not a clear dependence on the white dwarf mass, as expected from the basic theory, we suspect that the real turn–off times of novae are influenced by a variety of factors, including the white dwarf temperature at the onset of the outburst, the chemical composition, the white dwarf magnetic field, the number of prior outbursts or post–outburst irradiation induced mass transfer (e.g. Schwartzman et al. 1994; Kovetz & Prialnik 1994).

All the available data in the UV and X–rays ranges indicate that typical Galactic classical novae run out of nuclear fuel in the course of a few years after the outburst.

In the light of the theoretical predictions summarized in the Introduction, such a conclusion implies either that a highly efficient wind mechanism has to be active to remove material rapidly from the nova remnant, or that nova eruptions can occur with low mass accreted envelopes.

The mass of material converted to helium during a nova outburst is typically $M_{\rm burn} \approx 2\ 10^{-7}\ t_{\rm off}\ M_\odot$ (assuming a bolometric luminosity of $10^4\ L_\odot$), where $t_{\rm off}$ is the turn–off time in years. The ratio of mass burned to mass ejected in a typical classical nova outburst then is $M_{\rm burn}/M_{\rm eject} \approx 0.02\ t_{\rm off}\ (10^{-5} M_\odot/M_{\rm eject})$. Therefore, for the observed $t_{\rm off}$ of a few years, only a small fraction of the accreted envelope mass can remain on the white dwarf. The observed nuclear burning times agree with other data in suggesting that novae do not retain sufficient mass to evolve toward becoming Type I supernovae or neutron stars born by accretion–induced collapse.

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