# The recovery of accretion in a classical nova seen for the first time in X-rays with XMM-Newton


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**Nova Oph 1998 (V2487 Oph) was observed with XMM-Newton during 2001-2002, 2.7, 3.2, 3.7 and 4.3 years after outburst. The aim was to monitor the turn-off of the nova, i.e., the extinction of H nuclear burning on top of the white dwarf and thus the end of super soft X-ray emission from the whole hot photosphere. The nova was already extinguished when we observed it, but we detected thermal plasma emission with an Fe fluorescent Kα line at 6.4 keV, observed for the first time in a post nova. This is likely the signature of the reestablishment of accretion onto the white dwarf, but a longer exposure was needed to well define the properties of the cataclysmic binary and its magnetic character. In a new and longer XMM-Newton observation performed in 2007 (almost 9 years after the explosion), the postnova has been detected also with the RGS gratings.**


## X-rays from classical novae

Classical novae outbursts are caused by explosive H nuclear burning on top of accreting white dwarfs in cataclysmic variables. Ejection of mass at large velocities ensues. In the post-outburst stage, X-rays are emitted:

- **soft X-rays** → photospheric emission of the hot white dwarf, either related to residual H-burning (if the nova has not turned off yet) or to the impact of the accretion stream onto it -"hot spots" (**blackbody**-like emission)
- **hard X- rays** → nova ejecta emission and/or the recovery of accretion in the cataclysmic binary (**thermal plasma**, heated by shocks).

## Nova V2487 Oph 1998

- Discovered on 1998 June 15.561 UT (Nakano et al. 1998) with $m_v$ = 9.5.
- Very fast nova ($t_2$≈6.3 days)
- E(B-V)=0.38 ± 0.08, and thus $A_V$=1.16 ± 0.24 mag (Lynch et al. 2000).

→ extremely large distance derived (d=27 ± 3 kpc). As the real maximum was probably missed, a smaller distance is possible and the final range is 8 - 27 kpc (Hernanz & Sala 2002, Science). We adopt d = 10 kpc.

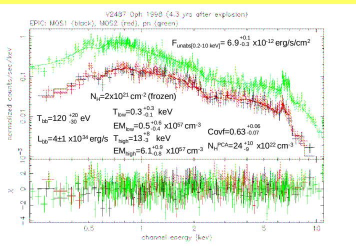
→ First nova seen in X-rays before (ROSAT in 1990) and after its explosion (Hernanz & Sala 2002, Science)

| Date of obs./day afer outburst | Camera | Exposure time (s) | Count rate (cts/s) |
|---|---|---|---|
| Feb. 25, 2001<br>986 d, 2.7 yr | MOS1<br>MOS2<br>PN | 7208<br>7235<br>- | 0.30 ± 0.01<br>0.29 ± 0.01<br>- |
| Sept. 5, 2001<br>1178 d, 3.2 yr | MOS1<br>MOS2<br>PN | 7494<br>7512<br>4346 | 0.31 ± 0.01<br>0.31 ± 0.01<br>1.05 ± 0.02 |
| Feb. 26, 2002<br>1352 d, 3.7 yr | MOS1<br>MOS2<br>PN | 5699<br>5875<br>4346 | 0.29 ± 0.01<br>0.30 ± 0.01<br>1.05 ± 0.02 |
| Sept. 24, 2002<br>1559 d, 4.3 yr | MOS1<br>MOS2<br>PN | 7549<br>7582<br>5678 | 0.32 ± 0.01<br>0.33 ± 0.01<br>1.09 ± 0.02 |
| March 24, 2007<br>3205 d, 8.8 yr | MOS1<br>MOS2<br>PN<br>RGS1<br>RGS2<br>OM (filter U)<br>OM (filter UVW1) | 34510<br>33646<br>28450<br>34661<br>34661<br>1880<br>3940 | 0.368 ± 0.003<br>0.374 ± 0.003<br>1.265 ± 0.007<br>0.029 ± 0.001<br>0.032 ± 0.001<br>0.64 ± 0.03<br>2.18 ± 0.08 |

# RESULTS

## 2001-2002

### 4th observation




**MODEL: blackbody + thermal plasma (simulated with MEKAL, Mewe et al. 1995) with two temperatures ($T_{low}$&$T_{high}$) + three Gaussian lines at 6.4, 6.7 & 6.97 keV. The photoelectric absorption $N_H$ is frozen to its interstellar value.**

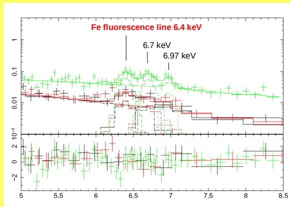
**→ good fit ($\chi_\nu^2$~1) but unrealistically large plasma T (≥ 80 keV).**

**→ with a Partial Covering Absorber (PCA) the two thermal lines are well reproduced, and just the fluorescent Fe($K_\alpha$) excess should be modeled as a Gaussian line (6.4 keV, eq. width=247 +102/-125 eV), obtaining a lower $T_{high}$ for the plasma (~13 keV).**

**→Small WD fractional emitting area f~$10^{-5}$ and very large unabsorbed luminosity, $L_{(0.2-10)keV}$ ~$9 \times 10^{34}$erg/s, point to a magnetic cataclysmic variable**

**→*Similar results for the 1st, 2nd & 3rd observations*.**

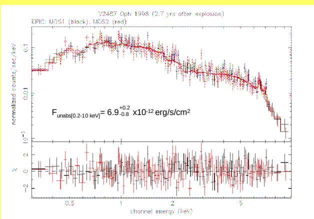
### 4th observation



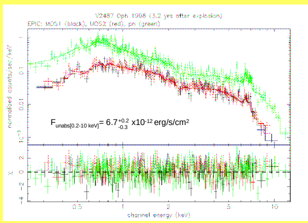

**Complex of Fe lines between 6-7 keV.**

- **The presence of the fluorescence line @ 6.4 keV indicates reflection on cold material (accretion is active).**
- **The other two lines correspond to highly ionized Fe: Fe XXV and XXVI (Ferri, Hernanz, Sala, 2007, ASP Conf. Ser. vol. 372).**

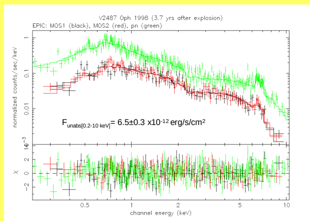
### 1st observation



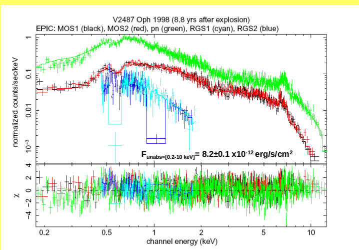

### 2nd observation



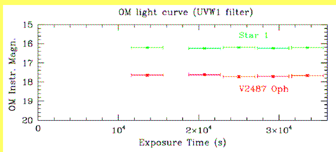

### 3rd observation




## 2007




**-Same model and results as for 2001-2002 data: blackbody + MEKAL with two temperature ($T_{low}$&$T_{high}$) + Gaussian line (6.4 keV) and PCA.**
**- Also fits RGS data.**
**- 19% growth in the flux [0.2-10 keV] after ~ 4.5 years.**
**- Some hints of time variability in the X-ray band (0.2-12) keV, and specially in the soft part (0.2-0.5) keV, with scales around 3hours (TBC), justifying the PCA model**
**- *Analysis in progress*.**




**OM light curve (UVW1 filter, 2450-3200 Å).**
**- average instrumental magnitude: 17.68 ± 0.05.**
**- average flux: $3.19 \times 10^{-16}$erg $cm^{-2}$ $s^{-1}$ $Å^{-1}$ (using Vega magnitude for flux conversion).**
**- no time variability found (but bins are too large)**

- **A detailed timing X-ray analysis is still in progress.**
- **Optical observations will be done next month in La Palma Observatory.**

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**Find out more about post-outburst novae included in our XMM-Newton observation program. Do not miss:**

**TALK by Margarita Hernanz on Friday at 15:35 in session C2, The turn-off and recovery of accretion in classical novae as seen by XMM-Newton**

**POSTER C4 by G. Sala, M. Hernanz, C. Ferri, J. Greiner, XMM-Newton observation of the Supersoft Classsical Nova V5116 Sgr 2005 No. 2**