Highlights of Spanish Astrophysics VII, Proceedings of the X Scientific Meeting of the Spanish Astronomical Society held on July 9 - 13, 2012, in Valencia, Spain. J. C. Guirado, L.M. Lara, V. Quilis, and J. Gorgas (eds.)

T Pyx: towards a new paradigm for nova explosions

Alessandro Ederoclite[1]

[1] Centro de Estudios de Física del Cosmos de Aragón

Abstract

T Pyxidis is a recurrent nova which underwent explosions at semi-regular intervals of about 22 years between 1890 and 1966. On the 14th Apr 2011, it started its sixth (long overdue) known outburst. In this talk, I present a multi-site campaign aimed at the follow-up of this object in the optical regime with intermediate resolution spectroscopy and I summarize some of our findings which challenge some of the common understandings of novae. Our observations may actually imply that the two populations of novae (Fe II and He/N) suggested by [9] are, in fact, a byproduct of the speed class and may have significant repercussions on the whole nova theory.

1 Introduction

Classical novae (CNe) are the result of the thermonuclear explosion on the surface of a white dwarf which is accreting mass from a less evolved companion (for a review, see [1]). Since the explosion does not disrupt the white dwarf, this phenomenon is recursive. The time between two eruptions is known as "recurrence time" (τ_R).

Recurrent novae (RNe) are a subclass of CNe which have more than a known eruption. This is due to the fact that the τ_R is (comparatively) very small and it is expected to be due to a high mass transfer rate and the large mass of the white dwarf (for a review, see [8]).

T Pyx is a long-known RN. Its first recorded explosion was in 1890 and it has been observed in eruption in 1902, 1920, 1944, and 1966. The long expected 1988 eruption never occurred, which gave rise to a series of speculation on the following eruption as well as on the nature of the object (e.g. [4] or [5]).

2 Observations

The evolution of the 2011 eruption of T Pyx was followed by many amateurs who shared their data on the website of the American Association of Variable Stars Observers (AAVSO). This

was the source of the B, V, and R data used in this paper and shown in Fig. 1.

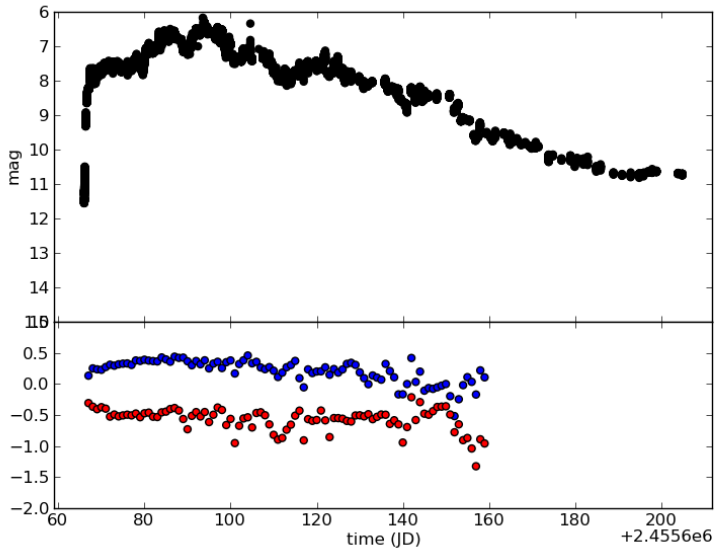

Figure 1: The light curve derived from the AAVSO website. The upper panel shows the evolution of V-band observations while the lower panel shows $B-V$ (in blue) and $V-R$ (in red) colors.

Spectroscopic observations were carried out with VLT/X-Shooter and PUCHEROS. X-Shooter is a multi-arm cross-dispersed echelle spectrograph, mounted on VLT, which reaches resolution of 20 000 covering, in a single observation, from U-band to K-band. PUCHEROS is the fibre-fed echelle spectrograph of Pontificia Universidad Catolica de Chile (PUC), installed on the 50 cm telescope at the PUC observatory. PUCHEROS provides also a resolution of 20 000 (see [6]).

3 Discussion

The discovery of the 2011 eruption of T Pyx occurred on the 14th Apr 2011 (MJD=55665.29; from now on, we will refer to this as t_0), as reported by [7]. Immediately after the discovery, the star went through a steep rise which stopped on $\sim t_0 + 2$ days. Followed by a "plateau" at $V \sim 7.9$ until $t_0 + 8$ days. Maximum light was reached on $\sim t_0 + 28.5$ days. It is interesting to note that throughout a period of ~ 70 days, the $B-V$ and $V-R$ colours remained almost constant with values 0.2 ± 0.2 and 0.5 ± 0.1, respectively.

The spectroscopic evolution of T Pyx is shown in Figure 2. Our first spectra show that the nova presents prominent Balmer lines as well as N and He lines. This suggests that the nova could be an He/N nova, according to the classification by [9]. Nevertheless, the p-Cyg profiles and the FWHM of the lines (~ 1400 km s^{-1}) are proper of Fe II novae.

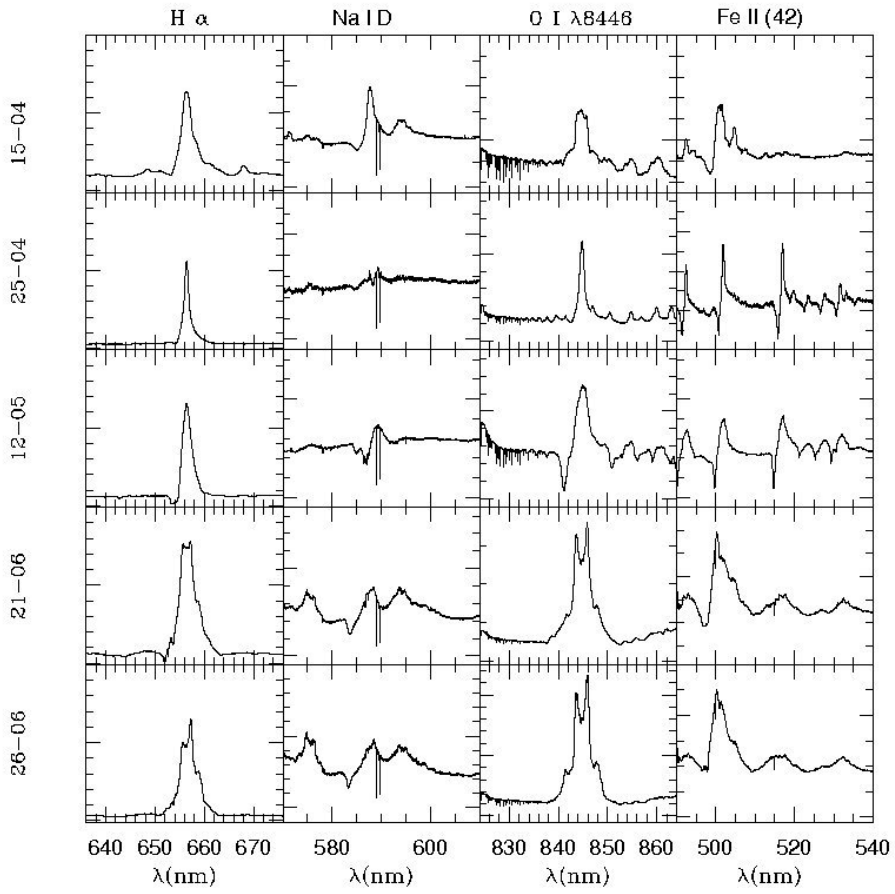

Figure 2: The evolution of selected lines from our VLT/X-Shooter spectra. Note that the labels only denote the spectral regions and not the identifications of the lines Note also how the width of the lines becomes smaller at first and then increases again.

The second spectrum obtained with VLT/X-Shooter clearly shows the absence of N and He lines and the presence of Fe II lines, thus making the spectrum a typical Fe II-type one. The transition betweeen the two X-Shooter spectra becomes clearer thanks to the PUCHEROS data. These data, taken every night between $t_0 + 1$ day and $t_0 + 6$ days, show that the FWHM and the equivalent width (EW) of all the lines decrease. The Fe II lines emerge, roughly, at the end of the "plateau" phase, on $t_0 + 8$ days. This is the same moment when the He and N lines disappear.

P-Cyg line profiles are characteristics of the presence of a wind. It is worth noting that, during the first 8 days of evolution, we observe a reduction of the FWHM and EW of all lines. This may be due to the photosphere receding in a wind which becomes less dense. Nevertheless, on day $t_0 + 8$, the lines (which, as mentioned, have changed from mostly N and He to mostly Fe II) start increasing their FWHM again. We speculate that we might be

witnessing two ejection of material due to the nova eruption.

On 21st June 2011, the Balmer lines do not show P-Cyg profiles anymore but they clearly indicate a bipolar expansion (see Fig. 2) as already mentioned in [2].

4 Summary

We have presented a preliminary analysis of the evolution of the 2011 eruption of the recurrent nova T Pyx. The nova showed a "He/N" spectrum at the time of discovery and turned into a "typical Fe II" nova one week later. This behaviour is also discussed in detail in [10]. We speculate that the slow evolution of T Pyx allowed for the detection of this transition and that it is likely that most (if not all) novae go through a similar phase during the early stages of their evolution. The lack of detection of this transition should be given to late discovery and/or to the velocity of the evolution. The evolution of the spectra, between $t_0 + 20$ days and $t_0 + 150$ days, follows quite closely the one of typical Fe II novae, like V5114 Sgr (see [3]).

Acknowledgments

CEFCA is funded by the Fondo de Inversiones de Teruel, supported by both the Government of Spain (50%) and the regional Government of Aragón (50%). This work has been partially funded by the Spanish Ministerio de Ciencia e Innovación through the PNAYA, under grants AYA2006–14056 and through the ICTS 2009–14, and the Fundación Agencia Aragonesa para la Investigación y Desarrollo (ARAID). This work is also partly supported by the Spanish Ministerio de Economa y Competitividad (MINECO) under the grant AYA2011–29517–C03–01.

References

[1] Bode, M. & Evans, N. 2008, "Classical Novae,Cambridge University Press

[2] Chesneau, O., et al. 2011, A&A, 534L, 11

[3] Ederoclite, A., et al. 2006, A&A, 459, 875

[4] Schaefer, B. E., Pagnotta, A., & Shara, M. M. 2010, ApJ, 708, 381

[5] Selvelli, P., et al. 2008, A&A, 492, 787

[6] Vanzi, L., et al. 2012, MNRAS, 424, 2770

[7] Waagan, E., Linnolt, M., & Pearce, A. 2011, IAUC, 9205, 1

[8] Webbink, R. F., et al. 1987, ApJ, 314, 653

[9] Williams, R. E. 1992, AJ, 104, 725

[10] Williams, R. E. 2012, AJ, 144, 98