X-shooter Science Verification Proposal

Title: Unveiling the nature of V1309 Sco, a candidate twin of V838 Mon.

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Abstract:

V1309 Sco was discovered in Sept 2008 as a slow nova. Our spectroscopic follow up at VLT+UVES has shown that the near maximum and early decline spectra do not resemble those of a classical nova. In addition, we have seen that the characteristics of 1) the red continuum, 2) the narrow but strong H emission lines and 3) the absorption features from s-elements, make it similar to the so called red-novae such as V838 Mon. Here we propose to monitor the V1309 Sco late spectral evolution with x-shooter to firmly establish whether the object is indeed the twin of V838 Mon, and to characterize its spectral evolution over a broad wavelength range. This will allow us to unveil its true nature and help understanding the yet unknown and largely debated phenomenon of red-novae.

Scientific Case:

V1309 Sco was discovered in early Sept 2008 at about 8 mag (IAUC 8972) and was described as a classical nova (CN) characterized by strong hydrogen emission lines, a smooth continuum and absorption features. Our group immediately requested a DDT follow up with UVES to monitor the evolution of the Transient Heavy Element Absorption (THEA) system that we discovered in the early decline spectra of CNe in outburst (Williams et al. 2008, ApJ, 685, 451). However, our Nova Sco high resolution spectra revealed that the object, beside being characterized by an enormous (and unexpected) number of s-elements absorption lines, had too narrow H emission lines and a too red continuum (possibly evolving toward cooler spectral energy distributions -SED- see Fig.1), to be a CN. The spectra of V1309 Sco are not at all those of a typical CN in outburst!

The combination of narrow H Balmer emission lines, s-element absorption lines, continuum evolution toward cooler temperatures and outburst amplitude comparable with CN outbursts, make of V1309 Sco an object very similar to the so called red-novae. Red novae are a small class of yet not understood but highly debated objects (only 3 are known up to now) with V838 Mon being the most famous and most observed one. Their observational characteristics cannot match altogether any of the currently known astrophysical phenomena (CNe, AGB or late AGB stars, Sakuray objects, symbiotic stars, Mira variables, etc.). Two competing scenarios have been proposed to explain their properties: stellar merging (Tylenda and Soker 2006, A&A, 451, 223), or CN outbursts on a small mass (<0.6 $M_{\odot}$) accreting white dwarf (Iben & Tutukov 1992, ApJ, 389, 369 and Shara 2009 at the Tucson CV meeting). In order to understand this class of objects it is necessary to perform long term, multi-wavelength observations of more red-novae, in addition to V838 Mon observations. For this reason we are applying for the monitoring of V1309 Sco with x-shooter. By observing V1309 Sco during the two SV periods and possibly at later epochs as well (we applied for x-shooter observations in P84), we will be able to ascertain the spectral evolution of V1309 Sco and compare it with the existing data on V838 Mon. By detecting further similarities or dissimilarities of V1309 Sco with V838 Mon and the other published data on red-novae we will be able to 1) definitely classify V1309 Sco as a member of the red-nova class, 2) better define the observational characteristics of the red-nova class (how many of the observational evidence of V838 Mon are intrinsic to itself?) and 3) help establishing the real nature of the red nova phenomenon and their progenitors.

The use of x-shooter is essential to optimize the spectral coverage and reduce our telescope time request. It is also essential to guarantee simultaneous optical and NIR observations which are critical to the determination of the continuum SED and to the computation of elemental abundances. More in detail, we need NIR observations, from J to K band, in order to monitor the possible development and evolution of cooler SEDs (from K to M spectra type or even L-giant type, as seen in the red novae case). We also need optical observations to monitor the evolution of the absorption and emission lines that we have identified in the UVES spectra. The analysis of the x-shooter spectra will enable us to; 1) establish whether the expanding envelope develops any forbidden emission line or stays free from forbidden emissions, as seen for V838 Mon; 2) compute the H mass of the expanding envelope (the Balmer series was optically thick at the time of our UVES observations), which will ultimately constrain the amount of energy involved in the outburst; 3) establish the possible binary nature of the object (in the case both a blue and a red continuum will be observed); 4) determine the expanding envelope elemental abundances and in particular whether it is O-enriched (as observed in V4332 Sgr, Tylenda et al. 2005, A&A, 439, 651 and V838 Mon, Kaminski et al. 2009, ApJS, 182, 33) or C-rich (as expected in the case of TNR ignition such as a He flash, see e.g. Tylenda and Soker 2006).

Calibration strategy:

A telluric and a spectrophotometric standard at each epoch V1309 Sco is observed will be sufficient. We will observe our science target nodding along the slit in order better remove the sky and telluric features. We will combine relatively short exposures (different exposure times will be set for each arm) in order to optimize the signal and avoid saturation of the emission lines.

Targets and number of visibility measurements

Target	**RA**	**DEC**	**V** mag	**Mode** (slit/IFU)	**Remarks**
V1309 Sco	17:57:32.9	-30:43:10.7	?	slit	SV slot# 1 (epoch 6)
V1309 Sco	17:57:32.9	-30:43:10.7	?	slit	SV slot# 2 (epoch 7)

Time Justification:

The object R mag is in the range 15-17 and driven by a strong Hα emission. Hence estimate that 30 min total exposure time on the object, per epoch should be sufficient to determine its SED from 300 to 2500 nm. Including the overheads and the observation of 1 telluric per epoch, we will need 1 hr telescope time per epoch and a total of 2 hr telescope time during the SV.

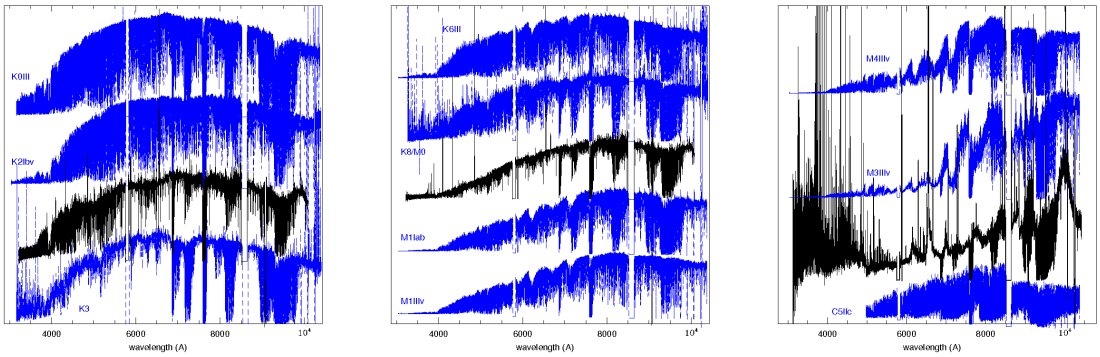

Figure 1: The comparison of V1309 Sco spectra (black color) with spectra from the UVES-POP database (blue color). The comparison shows that the nova in little more than one month evolved from an early K to a M dwarf. V1309 Sco spectra have been dereddened following the prescription by Munari and Zwitter (1997). From the observed EW of the KI λ7699.0 interstellar absorption line, we derived E(B-V)=0.55 mag. We then dereddened the spectrum assuming R=3.1. The UVES-POP spectra have been rescaled arbitrarily for an easier comparison. [The figure is from Mason et al. (in preparation).]