News from Miras and SRVs with changing pulsation periods

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ABSTRACT Most Miras and SRVs have pulsation periods that are constant for centuries, but a few are known to exhibit a significantly changing period [2]. In a previous paper we investigated the evolutionary state of Miras with changing periods, showing that not all of them are likely to have recently undergone a thermal pulse (TP). Since then we have followed up on some of these stars and present new observations of their period and spectral type evolution as well as their mass-loss properties. These observations give insight into decisive, short-time evolutionary events of AGB stars.

LX Cygni: A carbon star is born (submitted to A&A)

LX Cyg is a Mira that increased its pulsation period from 460 to 580d within only 20 years from ~1975 to ~1995. It was previously classified as an S or SC star, but nowadays it is clearly a carbon star (Fig. 1). We obtained optical high- and low-resolution spectra as well as mid-resolution IR spectra to investigate its spectral features. In particular, the star was spectrally monitored over more than one pulsation cycle – the star always has a carbon-star spectrum.

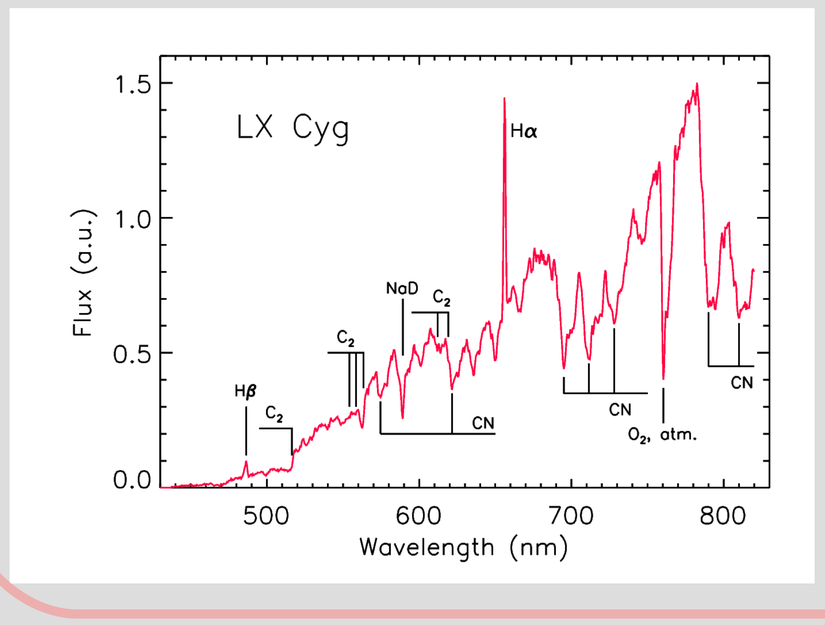

Figure 1: *Optical spectrum of LX Cyg obtained on 16 Nov 2012, close to visual maximum light. The main spectral features are labeled, in particular C_2. The star is clearly of C spectral type.*

Moreover, comparison with archival spectra reveals that LX Cyg is already a carbon star since at least 1994, see Fig 2. The C/O ratio of LX Cyg is estimated to be in the range 1.01 – 1.05.

A parallel change of period and spectral type was already observed in BH Cru, see below. We propose that the period and spectral type change are causally connected by a recent third dredge-up event. It raised the C/O ratio of the atmosphere, which caused its expansion, hence longer pulsation period.

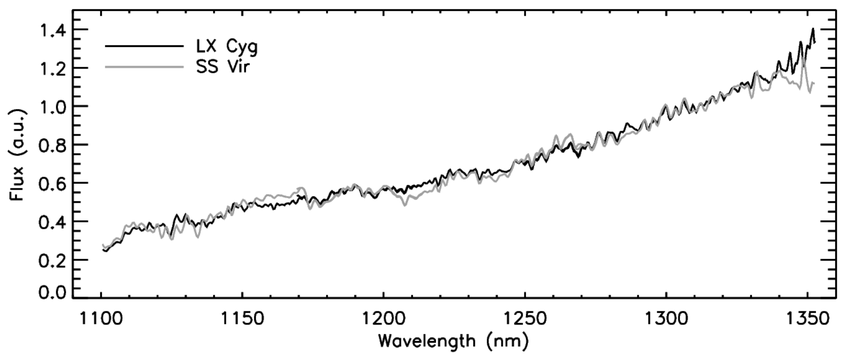

Fig. 2: *Low-resolution J-band spectrum of LX Cyg and the carbon star SS Vir from Joyce et al. (1998), obtained in 1994. The strong similarity between the spectra suggests that LX Cyg is already a carbon star since at least 1994.*

RU Vulpeculae: An SRV undergoing a thermal pulse? (submitted to Astronomical Notes)

RU Vul is an SRV that is known to have a pulsation period that is decreasing since the mid 1950ies. Since then, the period has declined from ~155 to ~108d. We obtained CCD photometry of the star to measure its period and amplitude, and compare the period evolution with model predictions from [3] for the period during a TP. The result is shown in Fig. 3. The period evolution is excellently described by a model chosen to well represent RU Vul. Also other observables agree with the TP hypothesis. We therefore suggest that RU Vul is currently undergoing a TP!

Spectral analysis shows that RU Vul is quite metal-poor, [M/H]=–1.6. It could be a member of the thick disc or the halo.

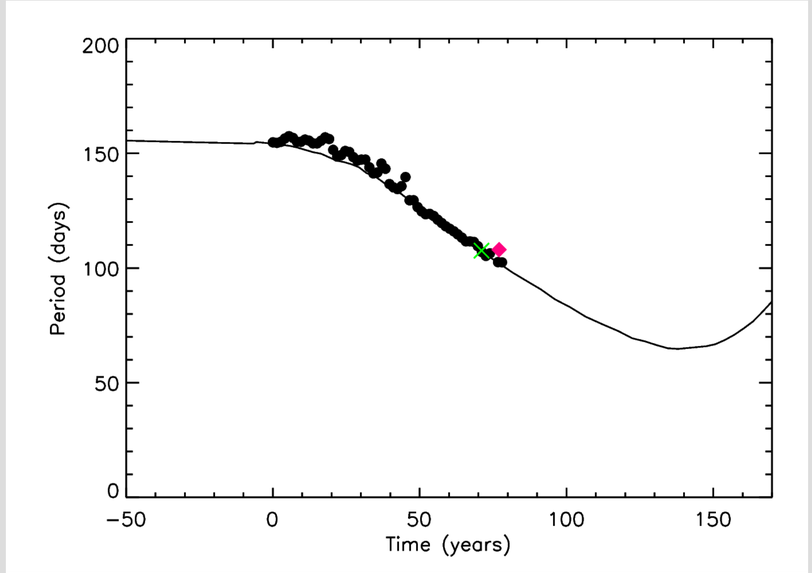

Fig. 3: *Period evolution of RU Vul between 1935 and 2013. Black dots: AAVSO observations. Green cross: data from ASAS. Red diamond: our own CCD photometry. Solid line: period evolution of the model from [3] with $M=1M_\odot$, $Z=Z_\odot/16$ ([M/H]=–1.2) during the 6th out of 11 TPs.*

BH Crucis: A dual-chemistry carbon star (in preparation)

BH Cru is a star similar to LX Cyg because it also experienced a marked period increase and a spectral type change from S/SC to C. Our aim is to study the mass-loss properties of this transition type object in more detail. We obtained VISIR mid-IR dust spectra and APEX observations of the ^{12}CO 2-1, 3-2, and 4-3 lines, as well as SiO 6-5 and HCN 3-2 lines. From the CO lines, an expansion velocity of ~4.7km/s is measured, which is unusually low for a Mira of such a long period. The gas mass-loss rate is determined from CO line modelling to be 2×10^{-7} $M_\odot$/yr. The abundances of SiO and HCN suggest that the envelope has a composition typical for S-type stars. The star seems to have a dual chemistry: carbon-rich atmosphere, but oxygen rich envelope.

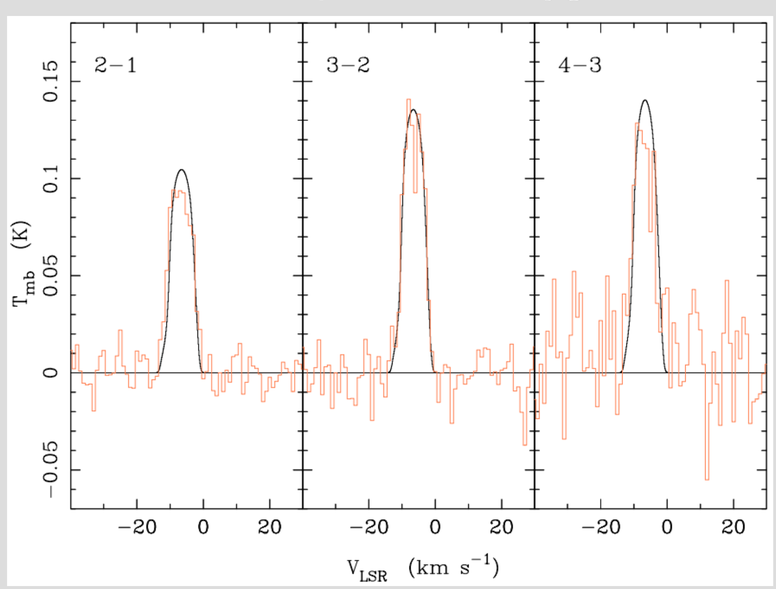

Fig. 4: Observed *CO lines of BH Cru with model fits.*

Discuss with me:

References:
[1] Joyce et al., 1998, AJ 116, 2520
[2] Uttenthaler et al., 2011, A&A 531, A88
[3] Vassiliadis & Wood, 1993, ApJ 413, 641