BAAA, Vol. 57, 2015
A.C. Rovero, C. Beaugé, L.J. Pellizza & M. Lares, eds.

Asociación Argentina de Astronomía
Boletín de artículos científicos

A mini atlas of K-band spectra of southern symbiotic stars*

P.E. Marchiano[1], L.S. Cidale[1,2], M.L. Arias[1,2], M. Borges Fernandes[3] & M. Kraus[4]

[1] *Facultad de Ciencias Astronómicas y Geofísicas (UNLP)*
[2] *Instituto de Astrofísica La Plata (CONICET)*
[3] *Observatório Nacional, Rio de Janeiro, Brazil*
[4] *Astronomický ústav, Akademie věd České Republiky, Czech Republic*

Contact/ PEM: pmarchiano@fcaglp.unlp.edu.ar

Resumen / Observamos una muestra de estrellas simbióticas en las bandas infrarroja H y K con datos obtenidos con el espectrógrafo SOAR/OSIRIS que no presentaban datos previos. Nuestro objetivo principal es la búsqueda de bandas en emisión de CO y la clasificación espectral de la componente fría basada en mediciones de anchos equivalentes de líneas características.

Abstract / We observed a sample of symbiotic stars in the H- and K-band for which no IR information exists so far. The observations were obtained with SOAR/OSIRIS. We aim to search for molecular band emission from CO and to perform spectral classification of the cool companion based on measurements of equivalent widths of characteristic lines.

Keywords / binaries: symbiotic — infrared: stars

1. Introduction

Symbiotic stars are interacting binary stars composed of an evolved cool giant of spectral type G or later, and a hot companion, typically a white dwarf (Allen, 1984). This companion accretes material from the cool star's wind. Often, the accreted material accumulates in a disk around the hot companion. However, most of the wind from the red giant is not accreted onto the white dwarf but forms a large and dense circumbinary nebula, which is partly ionized by the white dwarf radiation. In addition, in many symbiotics jets or collimated bipolar outflows are observed. Their occurence seems to be connected with optical outbursts of the systems. As symbiotics can display a very complex and diverse structure of their surrounding material, their spectra typically display a composite of the individual contributors: the cool giant, the hot companion, and the mass flow in the system. Symbiotic stars are thought to be the progenitors of Type Ia supernovae.

Based on their characteristics in the near-infrared, symbiotic stars have been divided into two types (Webster & Allen, 1975). If they display an infrared (IR) excess emission that results from dust, they are called D-types (dust). In these systems, the cool giant is a very evolved Mira variable surrounded by warm dust. In the cases where the continuum emission from the cool companion dominates the IR spectrum, the symbiotics belong to the S-types (stellar), in which the cool star is a regular red giant, often filling its Roche-lobe. The orbital periods of S-type symbiotics are about 2–3 yr, while those of the D-types are at least an order of magnitude longer (Schmid & Schild, 2002). Moreover, recent observations at radio wavelengths have revealed simultaneous strong SiO and water maser emission from several systems (Cho & Jaeheon, 2010), indicating that molecules are also present in a noticeable amount.

IR techniques have shown to be very useful tools to perform spectral classification of the cool components of symbiotic systems. This is particularly important for such systems, in which the cool companion cannot be seen in the optical spectral range. The spectral region in the 1–4 μm range typically shows absorption bands of water vapour and carbon monoxide that allow to identify and classify the late-type stars in these systems. However, in systems with extremely dense environments, the CO bands might turn into emission. So far, only one such system is known (BI CRU, Whitelocke et al., 1983).

The study of the molecular composition in symbiotic systems enables us to derive the parameters of the cool star and the physical conditions of the disks from which molecular emission (if detected) originates. The later is crucial to improve our understanding of the disk formation mechanisms and history.

We analyse a sample of symbiotic objects in the near-infrared to search for molecular band emission from CO and to perform spectral classification of the cool companions.

*Based on observations obtained at the Southern Astrophysical Research (SOAR) telescope, which is a joint project of the Ministério da Ciência, Tecnologia, e Inovação (MCTI) da República Federativa do Brasil, the U.S. National Optical Astronomy Observatory (NOAO), the University of North Carolina at Chapel Hill (UNC), and Michigan State University (MSU).

Poster presentation – September 2014

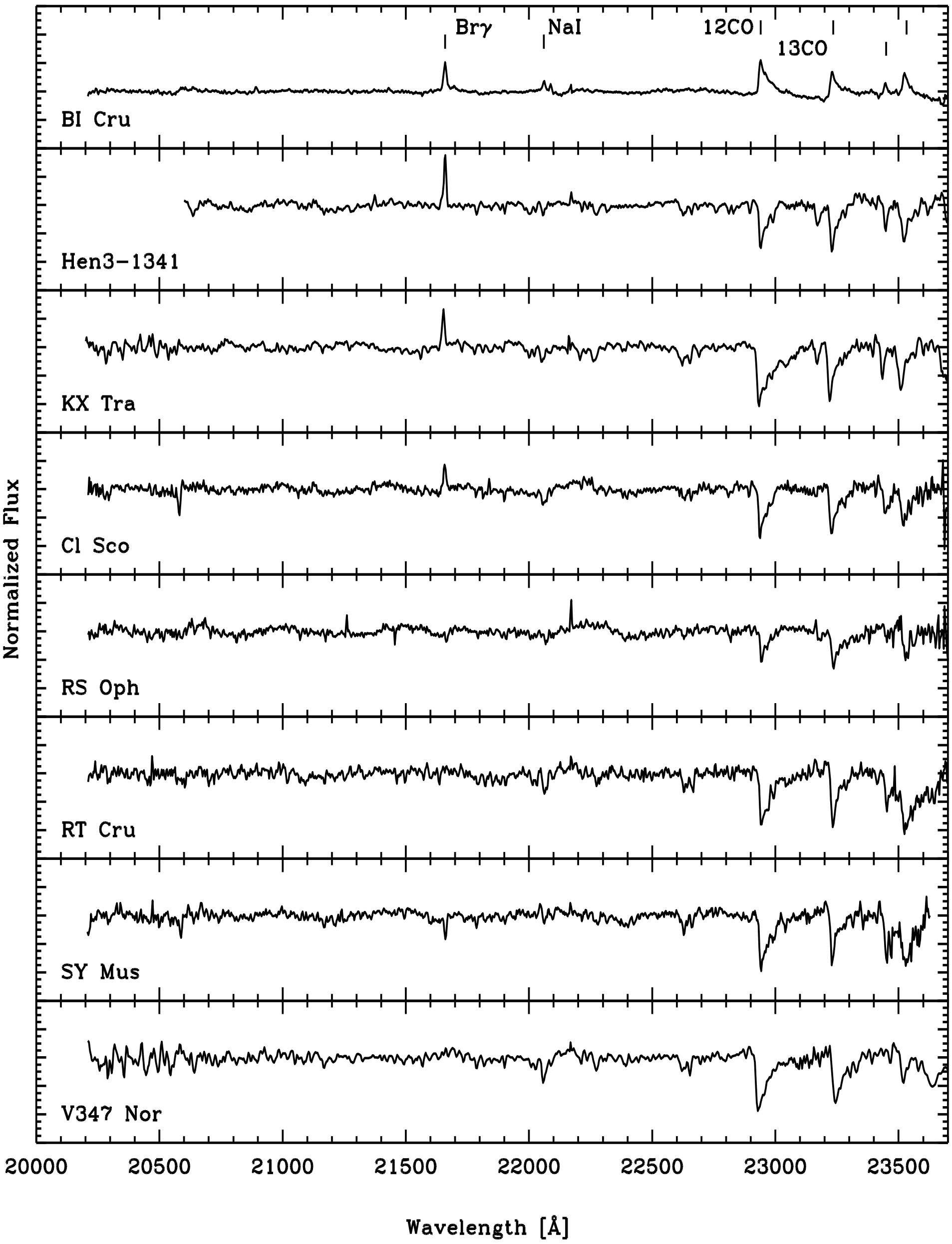

Fig. 1: K-band spectra of the symbiotic star sample.

2. Observations

The observational data were collected with SOAR/OSIRIS single-order long–slit spectrometer and the camera f/7 to obtain high-resolution (R=3000) spectra in the H- and K- band, during the observing run on 2014 June 8.

The observations were reduced using standard IRAF** tasks. Observations were taken with the offset

**IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy (AURA) under cooperative

Table 2: Equivalent width measurements and IR classification

Object	EW Na I [Å]	EW Brγ [Å]	EW CO [Å]	Sp.T. (Na I)	Sp.T. (CO)
BI Cru	-1.02	-3.49	–	–	–
RS Oph	1.59	0.94	8.0	K1-K2	K1-K2
RT Cru	3.07	1.01	26.0	M2.5	M3.5
KX TrA	2.64	-3.52	28.6	K5	M2
SY Mus	0.77:	1.85	19	F9	K4-K5
CL Sco	2.81	-2.27	12.7	M1	M0
Hen 3-1341	1.23	-4.13	8.9	K0-K1	K3
V347 Nor	3.55	0.55	21	M3	M2.5-M3.5

Table 1: Program star data

Object	α	δ	K [mag]	Type	Sp.T.
BI Cru	12:23:26	-62:38:16	5.064	D	–
RS Oph	17:50:13	-06:42:28	6.5	S	M0-M2
RT Cru	12:25:56	-61:30:28	5.185	–	M4-M5
KX TrA	16:44:35	-62:37:14	5.979	S	M6
SY Mus	11:32:10	-65:25:11	4.593	S	M5
CL Sco	16 54 51	-30 37 18	7.86	S	M5
Hen 3-1341	18:08:37	-17:26:39	7.479	S	M4/M0
V347 Nor	16:14:01	-56:59:28	4.943	D	M7-M8.5

pattern ABBA, and pairs were subtracted to remove sky background. Each spectrum was flat fielded, telluric-corrected and wavelength calibrated.

Information on the observed southern symbiotic stars is given in Table 1. There we list: star name, the stellar coordinates, magnitude in the K-band, the IR classification type (D or S) and the spectral type of the cool component determined from optical spectra (Belczynski et al., 2000) .

3. Preliminary results

We observed a sample of southern symbiotic stars in the H- and K-bands with the aim to search for H_2O and CO molecular band emission. The analysis of the H-band spectra is still in progress, so we focus here on the K-band only. The spectra are shown in Fig. 1. This is the first presentation of K-band spectra for the sample stars, except for BI Cru. BI Cru was reported to display CO band emission in the 1980's (Allen, 1984; McGregor et al., 1988). Our observations show that all lines in BI Cru are in emission and confirm the presence of both ^{12}CO and ^{13}CO. The remaining objects all show the CO bands in absorption, typically form in the atmosphere of cool giants (Rayner et al., 2009). ^{13}CO is observed in strong absorption in Hen3-1341, KX Tra, Cl Sco, RT Cru and SY Mus. The Brγ line is seen in emission in four stars of our sample: KX Tra, Hen3-1341, BI Cru and Cl Sco.

As the Na I 2.20 μm line is present in all the spectra, it can be used together with the CO absorption bands to classify the cool component. According to Rayner et al. (2009) "the Na I $\sim$ 2.2 μm feature increases monotonically with spectral type (temperature) between early F and mid M and, therefore, provides an approximate means of estimating a stellar spectral type, although the uncertainty in the classification can be fairly large ($\pm$ few spectral subtypes)". In Table 2 we give the line equivalent width measurements for Na I, Brγ and the first band of CO at 2.29 μm. We derive spectral types using the calibrations of Förster Schreiber (2000) for the line equivalent widths. Our classification based on Na I and CO lines are in fairly good agreement but differ from the ones obtained from the optical spectra. We suggest that the classification of the cool companion based on the IR spectra could be more precise than the one derived from the optical spectra since it dominates in this spectral region.

We plan to extend our sample of symbiotic stars with the aim to search for molecules formed in the envelopes, as the ones observed in the enigmatic object BI Cru.

agreement with the National Science Foundation.

Acknowledgements: LC thanks financial support from the Agencia de Promoción Científica y Tecnológica (Préstamo BID PICT 2011/0885), CONICET (PIP 0300), and the Universidad Nacional de La Plata (Programa de Incentivos G11/109), Argentina. Financial support for International Cooperation of the Czech Republic (MŠMT, 7AMB14AR017) and Argentina (Mincyt-Meys ARC/13/12 and CONICET 14/003) is acknowledged. M.K. acknowledges financial support from GA ČR (grant number 14-21373S). The Astronomical Institute Ondřejov is supported by the project RVO:67985815.

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