### Introduction

Symbiotic stars are long period binary systems, composed of two evolved and strongly interacting stars: a red giant and a hot and luminous white dwarf, and a common envelope nebula. Mass loss from the giant undergoes accretion to the compact object via wind and/or Roche lobe overflow (e.g., [7, 11]) resulting in the formation of a binary system and the emission of lines of ionized calcium, which is indicative of the chemical evolution of the Galaxy and the formation of stellar populations. Knowledge of the chemical composition of symbiotic giants is essential to understand mass transfer and accretion, as well as to determine stellar abundance patterns.

### Observations and data reduction

The observational data are high-resolution (R=λ/∆λ ~ 30000, S/N ≥ 100), near-IR spectra collected with the Phoebe cryogenic echelle spectrometer on the 6m Gemini South telescope during the years 2003-2009. The 1.6m Chabot telescope (λ/∆λ ~ 15000) was used in the H and K photometric bands at mean wavelengths 1.563μm, 2.226μm (relative to the laboratory), respectively. The H-band spectra contain molecular CO and OH lines, while the K-band spectra CN lines, with both ranges useful for abundances of CO and OH.

### Methods

#### The standard LTE analysis

The abundance analyses were performed by fitting synthetic spectra to observed ones with a method similar to that used for CW Cyg by Schmidt et al. [16]. Standard LTE analysis and MARCS model atmospheres developed by Gustafsson et al. [14] were used for the spectral synthesis. The code WINDOOP developed by M.R. Schmidt was used to calculate synthetic spectra over the observed spectral regions. To perform a χ2 minimization, a special overlay was developed on the WINDOOP code with the use of the simplex algorithm. Use of this procedure, in our case, enables an improvement of about ten times in the computation efficiency. The atomic data were taken from the VALD database [38] in the case of K- and H-band regions and from the list given by Mildren & Barbuy [33] for the H-band region. For the molecular lines we used the line list published by Grevesse et al. [100] and from CD-ROMs of Kurucz [101] (CN and OH).

### Input stellar parameters

The input effective temperatures T eff were estimated from the known spectral type [7, 11] adopting the calibration by Feild et al. and van Belle et al. (see table below). From the infrared colors and colors excesses we obtained intrinsic colors. Using the Kurucz et al. [116] T eff-log g color relation for late-type giants, we estimated surface gravities and effective temperatures that are in good agreement with those from the spectral types. We then used model atmospheres for the estimated values of surface gravities and the effective temperature set to T eff=3700 K for RW Hya and T eff=400 K for SY Mus, BX Mon and AE Ara.

### Chemical abundance analysis of symbiotic giants

The following procedure was adopted to carry out the abundance analysis:

- Estimation of the initial values of the abundance parameters: initially the solar composition was adopted.
- Minimization with the simplex technique [112] so-called simplex algorithm, which is a method for optimization which is at least as efficient as alternative methods, but has the advantage of being easy to understand and easy to code.
- Building of the best fitting synthetic spectra: the minimization with the simplex algorithm was performed with the so-called non-linear regression.
- Recomputation of the abundance parameters.

### Results

The final derived abundances for CNO elements and atomic lines (Si, Fe, Mg, Ni) in the spectra of four objects: R W Hya, SY Mus, BX Mon and AE Ara, are given in Table 1. The isotopic ratios 13C/12C, microturbulence ξ and projected rotational velocities V sin i are summarized in the table below together with formal uncertainties. Our analysis of the chemical abundances reveals a significantly sub-solar metallicity (Fe/H ∼ −0.75) for RW Hya, slightly sub-solar metallicity in BX Mon and AE Ara, and an approximately solar metallicity in SY Mus.

The 13C/12C isotopic ratios are low: ∼10, and ∼9, for RW Hya, SY Mus, and BX Mon respectively.

### Symbiotic stars in Galactic populations

On the left below is shown the relation [Ti/O] vs [Fe/H] from Cunha & Smith (2006, fig. 11–[6]) for stars of different populations: disc stars (open, blue circles), LMC (magenta squares), SMC (magenta circles), Galactic bulge (pentagons with errorbars). The position of AE Ara in this diagram appears to confirm membership in the bulge population. On the right the CN cycle is shown (fig. 4–[4]). All of our stars analyzed so far fall into the 0.2-0.5 dex range. This is further evidence in addition to the low [12C]/[13C] isotopic ratio, that the first-dredge up has occurred in these objects.

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We expect that an analysis like that presented above when applied to a wide sample of symbiotic stars will provide new insights into the chemical evolution of symbiotic systems in various stellar populations.