GraF/Adonis high resolution spectroscopy of Herbig Ae/Be Binaries: preliminary results

L. Trouboul[1], J. Bouvier[1], A. Chalabaev[1], P. Corporon[1] & E. Le Coarer[1]

[1] Laboratoire d'Astrophysique, Observatoire de Grenoble,
Université Joseph Fourier, BP 53, F-38041, Grenoble Cedex 9

Abstract – Observation of Ae/Be Herbig binaries have been performed with GraF/ADONIS at the 3.6 m telescope at La Silla in order to determine the spectral class of each component by measuring EW of metallic and molecular lines in the infrared. We present preliminary results on three of this binaries HR 5999, MWC 166 and HEN 3-225. For HR 5999 & companion we propose a luminosity classification and an effective temperature based on measurement of metallic lines.

1 Introduction

Like their lower mass counterpart, the T Tauri stars, Herbig stars are pre-main-sequence stars. They are believed to be the progenitors of stars earlier than A0. The definition given by Herbig (1960), presence of emission line spectra, association with region of heavy obscuration and illumination of a reflection nebula, aimed to select recently formed stars. In the past years, studies were essentially concentrated on T Tauri binaries, so it is an important task to complete our understanding of the binaries phenomena in higher mass stars. Photometric work, with adaptive optics, has already been done by Corporon (1997). A refined knowledge of the physical parameters requires now a spectroscopic investigation with high angular and spectral resolution. This paper presents the first results obtain with GraF instrument well adapted for that purpose.

2 Observations

Observation were carried out at the 3.6 m telescope at La Silla observatory with the ADONIS adaptive optics system and the newly developed spectro-imager GraF. This instrument has the ability to make classical long slit spectroscopy (see Chalabaev et al., this proc.) and spectro-imaging by adding its own Fabry-Perot interferometer (with a resolution as high as 25000). For this study, the instrument was in the long slit mode with a grating of 300 $lines/mm$ which enables a resolution of about 4000 in H and K band. So far, only one star, HR 5999, could be observed in all 10 spectral lines needed for unambiguous classification. We could also obtain a limited spectroscopy for MWC 166 and HEN 3-225.

3 Data reduction

The extraction of spectra was done as follows. First, we construct a PSF in the spatial direction from the image itself. This is done by taking the spatial profile of the spectra averaged over several lines, and making a mirror image with respect of the maximum intensity point, to avoid the contamination by the fainter companion. This two step process is described in Fig. 1.

Then, line by line, this PSF is fitted in intensity and position on each star profile by a least square algorithm. Another important process is the removal of the telluric lines (OH, H_2O, CH_4).

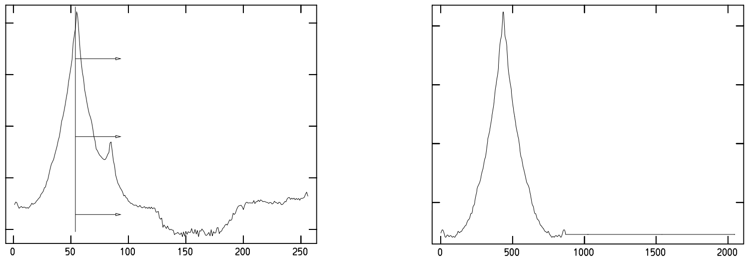

Figure 1: Extraction of the PSF

4 Preliminary results

4.1 HR 5999

HR 5999 is an irregularly variable star extensively studied in the past fifteen years. It is believe to be an A7 III-IV star with spectroscopic and photometric irregular variability. HR 5999 is forming a binary with Rossiter 3930 (Jeffers et al. 1963) their angular separation is equal to 1.46” and their Δm in JHK is $\sim$3. We present below the line profiles of MgI, SiI and HI.

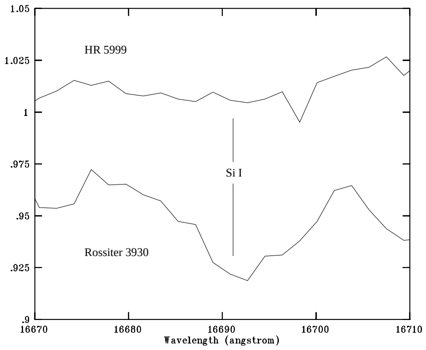

Figure 2: SiI (1.668μm) lines in HR 5999 & Rossiter 3930

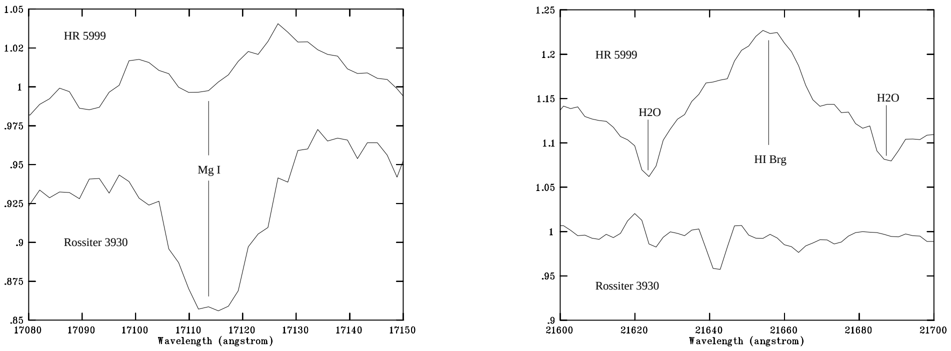

Figure 3: MgI(1.711μm) and HI Br$_\gamma$ (2.16μm) lines in HR 5999 & Rossiter 3930

	HR 5999	Rossiter 3930
SiI (1.596 μm)	0.17±0.05	0.29±0.09
SiI (1.668 μm)	0.46±0.18	0.39±0.11
AlI (1.6767 μm)	0.31±0.21	
AlI (1.6755 μm)	0.19±0.11	0.65±0.13
AlI (1.6723 μm)		0.8±0.11
HI(1.681 μm)		1.02±0.17
OH(1.689 μm)		1.14±0.36
MgI (1.711 μm)	0.66±0.16	1.48±0.16
Brγ (2.1656μm)	-1.08±0.16	0

Table 1: Equivalent width (Å)

The measured EW were compared with calibration diagrams of Meyer (1996) to evaluate the luminosity class and effective temperature of each member of the binary. The best agreement between our measurement and the calibration data is found when we consider HR 5999 and Rossiter 3930 to be luminosity class V objects. The first temperature's estimation for Rossiter 3930 was taken from photometric work of Corporon (1997),who found it to be K2-K4 star. For a class V star this led to an effective temperature of 4300±300 K (effective temperature scale taken from Bessel et al. 1988). Taking the Si(5993 cm$^-1$) diagrams in Fig. 4, which appears to have the best compatibility, it is possible to derive a new effective temperature of 3920±120 K which correspond to a spectral type of K7-M0.

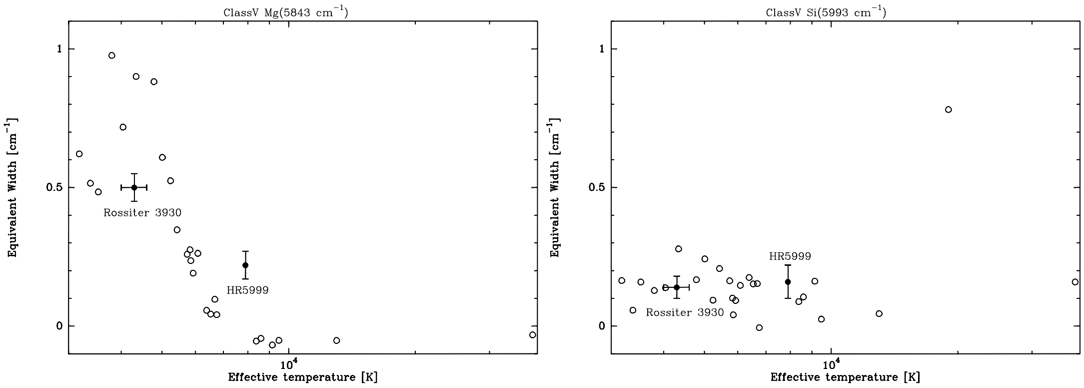

Figure 4: EW comparison for Class V

4.2 MWC 166 and HEN 3-225

- MWC 166 (HD 53367) is a B1 Ve visual binary star, with he angular separation of 0.6". It is the second brightest member of the CMa OB1 association. Thé et al. (1985) could not conclude whether the star is really an Herbig star (on the basis of the photometric variability and the UV extinction law) or not (absence of NIR excess). GraF spectra reveals significant Br$_\gamma$ emission in the primary, while it appears to be filled-in in the secondary.

	MWC 166	companion
Brγ (2.1656μm)	-8.58±0.22	0

Table 2: Equivalent width (Å)

- Also known as HD 76534, HEN 3-225 is a bright B2 Ve. Like MWC 166, the lack of infrared excess didn't permit Thé et al. (1985) to conclude that these star was an Herbig stars. It is a known visual binary(Innes

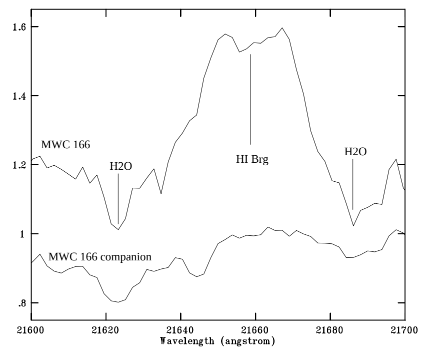

Figure 5: HI Br_γ line on MWC 166 and its companion

1972), with the angular separation of 2" and ΔH=1. The larger EW of the Mg I (1.711μm) line indicates the companion to be a much cooler star.

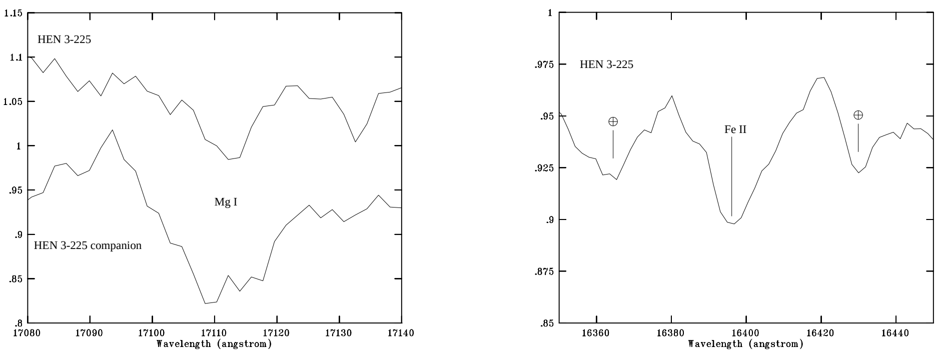

Figure 6: MgI and FeII lines on HEN 3-225 and its companion

	HEN 3-225	companion
FeII(1.64 μm)	2.0$\pm$0.2	
MgI (1.711 μm)	1.54$\pm$0.13	2.8$\pm$0.2

Table 3: Equivalent width (Å)

If we assume that HEN 3-225's companion is also a class V star, then the measurement of its Mg I line is compatible with the effective temperature of 4070$\pm$270 K. Its spectral type would then be K5-M0.

5 Conclusion

Of the three stars studied here, only HR 5999 had a sufficiently complete set of spectra to be conclusive. On the basis of the effective temperature/equivalent width diagram we propose a luminosity class of V for Rossiter 3930 and HEN 3-225's companion, and the effective temperature of, respectively, 3920$\pm$120 K and 4060$\pm$260. Though the results presented here are preliminary, they illustrate well the capabilities of both spectral and spatial resolution to investigate the properties of young massive binary systems.

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