High Resolution Spectroscopy of Recently Discovered Chromospherically Active Binary Stars

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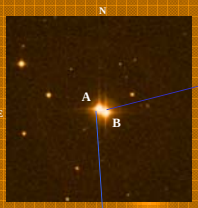
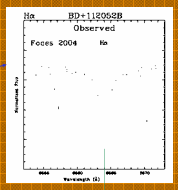
Abstract

During last years (1999-2004) we have carried out a spectroscopic survey of young single late-type active stars possible members of young stellar kinematic groups, in order to study the kinematic and spectroscopic properties of these groups of stars. One of the results of this survey is the detection of a set of active stars showing noticeable radial velocity variations.
Multiwavelength optical observations have allowed us to determine precise radial velocities by cross correlation with radial velocity standard and then to confirm or dismiss the binarity.
In addition, we have obtained information about orbital solution and about the activity of the chromosphere of these active binary systems using the information provided for several optical spectroscopic features (from the Ca II H & K to Ca II IRT lines) that are formed at different heights in the chromosphere.
The chromospheric contribution in these lines has been determined using the spectral subtraction technique.
Rotational velocities (vsin*i*) and lithium (LiI λ 6707.8) equivalent widths were determined too.

In these case we have made an exhaust study of two binary systems, BD+11 2052A and BD+39 2587 that are part of a binary system itself. We have obtained an orbital solution, with a high eccentricity for both systems and studied the chromosphere emission.

BD +11 2052 A





Element	Value	Uncertainty	Units
P_{orb}	4.8122	0.0001	days
T_{conj}	49650.424	0.0000	HJD
ω	191.1938	0.8477	degrees
e	0.1756	0.0180	
$K(*)$	28.5237	0.9630	km s^{-1}
γ	30.3529	0.3285	km s^{-1}
$a_1 \sin i$	1.9490	0.0092	10^6 km
$a_2 \sin i$	2.0545	0.0134	10^6 km
$a(*)sini$	1.8582	0.0630	10^6 km
"	0.01242		AU
"	2.6698		$R_\odot$
$f(M)$	0.0110399	0.0011234	$M_\odot$

This is the B component of BD+11 2052 (SAO 98614). We have measured a value of 27.07±0.04 km/s for radial velocity that is in agreement with the value given by Strassmeier et el. (2000), indicating that this component is a single star
We have found emission lines filling the absorption lines in Hα and Ca IRT indicate certain level of activity..

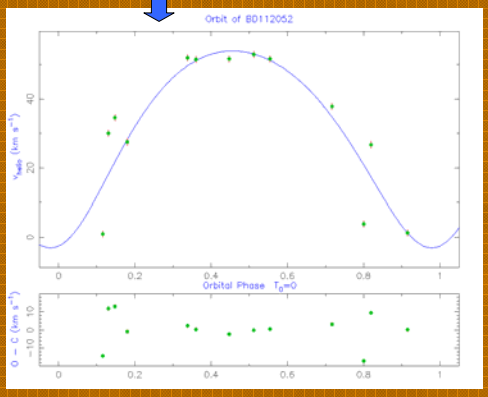


Fig. 9: Radial velocity data (9 of our data, 2 of Strassmeir et al. (2000) and 3 of Cutispoto et al. 1999) vs. orbital phase. Only primary star data is used. Blue line is the orbital solution

The orbital solution of the SB1 spectroscopic binary BD+11 2052A (HD 82159) has been obtained using 9 new data from our observations, two from Strassmeier et al. (2000) and three from Cutispoto et al. (1999). The results shows a eccentric orbit with a 4.812 days of period.

We have obtained a good fit between observed and synthetic spectra by using a G8V component but there is the possibility of certain secondary contribution to the spectra, showing a good fitting a 0.78 contribution of a G8V and 0.22 contribution of a K5V stars.

Chromospheric emission lines are observed in the subtracted spectra. The Hα line is completely filled by emission (Fig. 3), and a clear excess emission in the Ca II IRT lines is detected (Fig. 4).
It is a young star with a lithium (LiI λ 6707.8) equivalent width is about 131 mÅ.

Fig. 3: Hα

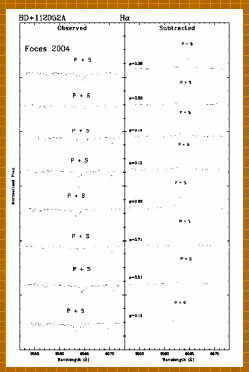
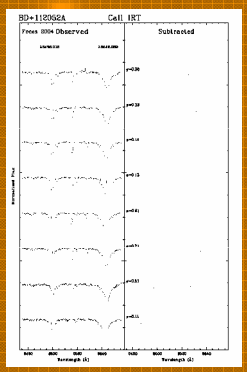


Fig. 4: Ca IRT



Observations

The spectroscopic observations of these binaries were obtained from 29 **March** to 7 **April 2004** using the 2.2m *Telescope* at the German Spanish Astronomical Observatory (CAHA) in Almería (Spain), with the Fibre Optics Cassegrain Echelle Spectrometer (Foces) (Pfeiffer et al. 1998). During this observing run, a 2048x2048 pixel 150μ Site#1d15 CCD detector was used. The spectrograph set up was chosen to cover the Ca H & K (3933 and 3962 Å), Hα (6563 Å) and Ca II IRT (8498, 8542, 8662 Å) lines. The wavelength range covers from 3720 to 10850 Å in 100 orders. The reciprocal dispersion ranges from 0.04 to 0.13 Å /pixel and the spectral resolution, determined as the FWHM of the arc comparison lines, ranges from 0.08 to 0.35 Å.

Radial Velocities

Heliocentric radial velocities of the principal components have been determined by using the cross-correlation technique. The spectra of the program stars were cross-correlated order by order, using the routine **FXCOR** in IRAF, against spectra of radial velocity standards of similar spectral types.
The radial velocity of the primary component of both spectroscopic binaries is derived from the position of the cross-correlation peak. In the of BD+39 2587 we observe the chromospheric emission lines of both componets and the secondary radial velocities have been measured with the variations in the wavelength between primary and secondary emission lines.

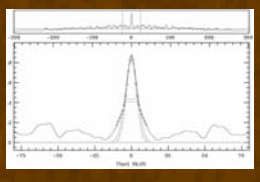
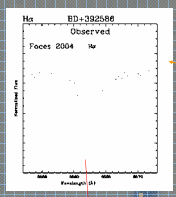


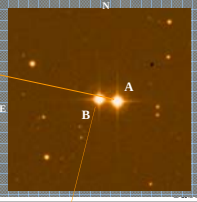
Fig. 1: Cross-correlation function (CCF) of a SB1 binary system fitted with a Gaussian.

Chromospheric activity indicators

The chromospheric contribution in the different optical chromospheric activity indicators has been determined using the spectral subtraction technique Montes et al. (1995; 1997; 1998). The synthesized spectrum was constructed using the program STARMOD developed at Penn State (Barden 1985).We have obtained the subtracted spectra for all the optical indicators (Ca II IRT, Hα, Hβ, Hδ, Hγ and H & K Ca lines). The profiles of the Hα, and Ca II IRT (λ8498, λ8542) lines are plotted in **Figs. 3, 4, 5, and 6**. For each observation we have plotted the observed spectrum (solid-line) and the synthesized spectrum (dashed-line) in the left panel and the subtracted spectrum (dotted line) in the right panel.

BD +39 2587





This is the A component of this system, BD+39 2586 (HD 112733).
We have measured a value of -4.62±0.06 km/s for radial velocity that is in agreement with Strassmeier et al. (2000), indicating that this component is a single star. No emission lines indicate that it is a inactive star.

Element	Value	Uncertainty	Units
P_{orb}	6.7231	0.0000	days
T_{conj}	51097.0156	0.0098	HJD
ω	64.2469	0.9664	degrees
e	0.3051	0.0025	
K_1	35.9049	0.2404	km s^{-1}
K_2	57.0066	0.5565	km s^{-1}
γ	-4.7654	0.0607	km s^{-1}
$q = M_1/M_2$	1.5877	0.0113	
$a_1 \sin i$	3.1611	0.0213	10^6 km
$a_2 \sin i$	5.0189	0.0492	10^6 km
a sen$i$	8.1801	0.0536	10^6 km
"	0.05468		AU
"	11.7530		$R_\odot$
$M_1 \sin^3 i$	0.2961	0.0060	$M_\odot$
$M_2 \sin^3 i$	0.1865	0.0039	$M_\odot$
$f(M)$	0.0278473	0.0005638	$M_\odot$

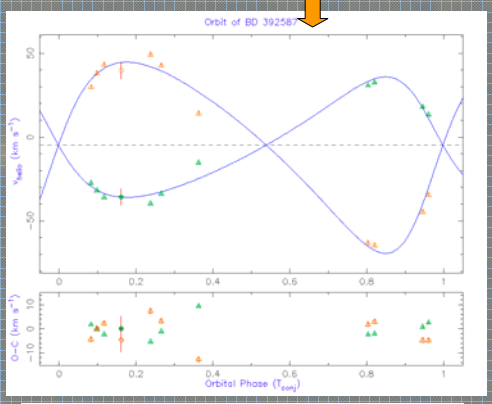


Fig. 8: Radial velocity data (**Δ** Our data, **O** Strassmeir et al. 2000) vs. orbital phase. Solid symbols for the primary and solid symbols for the secondary. Blue line is the orbital solution

The B component of the visual binary (BD+392587, SAO 63275) is a single lined spectroscopic binary (SB1). The orbital solution has been obtained using 10 new data from our run and one from the literature (Strassmeier et al. 2000). The results shows a very eccentric orbit (e = 0.3) with a 6.72 days of period.
We have obtained a good fit between observed and synthetic spectra by using a G8V Primary component with 89 % of contribution to the spectra and a M0V secondary component wit the 11% of contribution. This result is in agreement with the literature classification of the primary component and the relation of masses derived from the orbital solution.
Emission lines are observed in the subtracted spectra, show Hα almost completely filled by emission for primary component and always in emission above the continuum for the secondary (Fig. 6), and excess emission of similar intensity in the Ca II IRT lines (Fig. 5). The rest chromospheric indicators (Hβ, Hδ, Hγ and H & K Ca lines) presents excess emission from both components too.
Lithium (Li I λ 6707.8) equivalent width is about 104 mÅ

Fig 5: Ca IRT

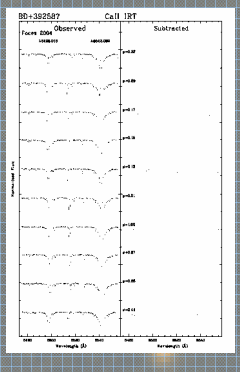


Fig 6: Hα