HD 61273: a new semi-detached binary with an accretion disk

F. Royer (1), P. North (2), D. Briot (1), G. Burki (3) and F. Carrier (4)

(1) GEPI – Observatoire de Paris, Meudon, France †. (2) Laboratoire d'Astrophysique de l'EPFL, Sauverny, Switzerland. (3) Observatoire de Genève, Sauverny, Switzerland. (4) Instituut voor Sterrenkunde, Leuven, Belgium.
email: frederic.royer@obspm.fr

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Abstract

A detailed spectroscopic analysis shows for the first time that HD 61273 is a close binary system, composed of a dwarf early-type star and a K0 giant. The system underwent and perhaps still undergoes a mass transfer. The most evolved star fills its Roche lobe and transfers mass to the hotter companion which is now the most massive component of the system. The Hα line displays a variable emission: signature of an accretion disk. This new semi-detached system is not eclipsing, but only shows photometric ellipsoidal variability due to the elongated shape of the giant component filling its Roche lobe, with a $12\overset{\mathrm{d}}{.}919$ period.

HD 61273 (HIP 37232, BR CMi)	
α : 7h 38min $50\overset{\mathrm{s}}{.}98$	δ : $+7°57'59\overset{''}{.}6$
$V = 7.3$ mag	$B = 7.3$ mag (Simbad)
Spectral type:	B9 (Simbad)
	A6V (Paunzen et al. 2001)
Parallax:	$\pi = 6.70 \pm 0.88$ mas (ESA 1997)

Introduction

Although it is a relatively bright star, HD 61273 remains very little studied in the literature. HD 61273 is detected as a high-velocity early-type star by Stetson (1981), on the basis of a reduced proper motion diagram. In further studies of his sample of high-velocity early-type stars, Stetson (1991) classifies HD 61273 as a "field blue-straggler" using a diagram β versus $[m]$ from Strömgren photometry.

HD 61273 belongs to the set of stars observed by HIPPARCOS (ESA 1997). It is found to be an ACV (α^2 CVn) variable star from its photometry. The light curve in Hp band measured by the satellite shows a period $P_{\mathrm{Hip}} = 6\overset{\mathrm{d}}{.}458 \pm 0\overset{\mathrm{d}}{.}0016$ and an amplitude of about 0.06 mag.

Finally, Paunzen et al. (2001) observed it in the context of the classification of λ Bootis candidate stars. They derive a new spectral type for HD 61273: A6V, using the standard techniques of MK classification.

Data collection

HIPPARCOS observations

The astrometric data for HD 61273 (HIP 37232) in the HIPPARCOS Catalog (ESA 1997) give a parallax $\pi = 6.70 \pm 0.88$ mas, corresponding to a distance $d = 149 \pm 19$ pc. There is no suspicion of binarity from the astrometric data.

The observations in the Hp band show a periodic photometric variation of about 0.06 mag from $Hp = 7.163$ to 7.224 mag. The typical error associated to individual Hp measurements is 0.01 mag. HIPPARCOS observed HD 61273 on 93 occasions over three years (from March 15, 1990 to March 7, 1993), and the distribution in time is displayed in Fig. for HIPPARCOS as well as more recent data.

The period of variations of the Hp magnitude is $P_{\mathrm{Hip}} = 6\overset{\mathrm{d}}{.}458 \pm 0\overset{\mathrm{d}}{.}0016$. There is no photometric variation detected in B_T and V_T data.

Spectra with ÉLODIE

The spectra were obtained with the ÉLODIE spectrometer, mounted at the Coudé focus of the 1.93 m telescope at the Observatoire de Haute-Provence (OHP). The spectral range spans from 3900 to 6800 Å, with a resolving power of 42 000. Thirty two spectra have been collected during a nine year period. The mean signal-to-noise ratio (SNR) lies between 40 and 220.

GENEVA photometry

In order to obtain a better photometric phase coverage, HD 61273 was measured in the GENEVA 7-color system, using the two-channel aperture photometer P7 (Burnet & Rufener 1979) mounted on the 120 cm Belgian Mercator telescope at the Observatorio Roque de los Muchachos at La Palma (Canary Islands, Spain). This instrument is the refurbished photometer which has been active on the 40 cm and 70 cm Swiss Telescopes at La Silla (ESO, Chile).

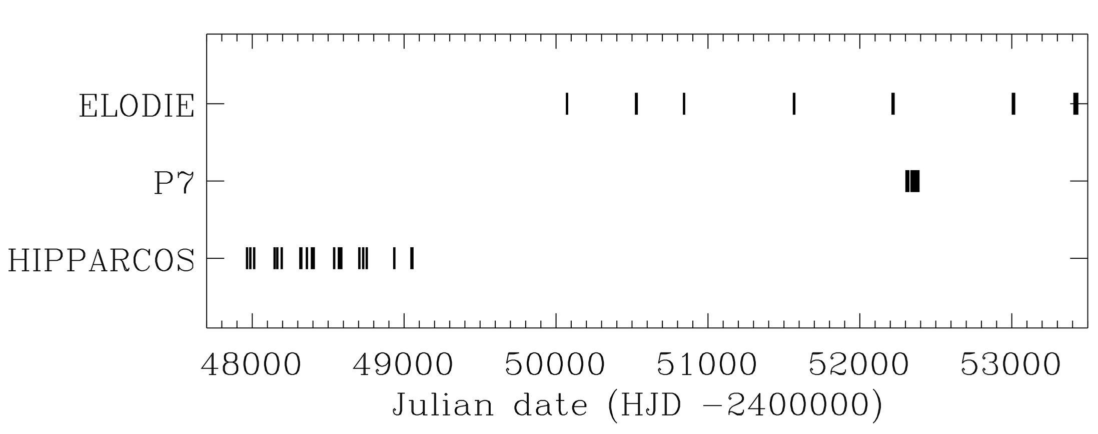

Figure 1: Monitoring of HD 61273: distribution in time (Julian dates) of the 32 observations made with ÉLODIE (OHP), the 24 measurements in the GENEVA photometric system with P7 (La Palma) and the 93 observations with HIPPARCOS.

Spectroscopic analysis

The cross-correlation of observed spectra with synthetic templates gives a variable radial velocity. Moreover the best correlation is obtained with the template corresponding to:

$$T_{\mathrm{eff\,B}} = 4600\,\mathrm{K},$$

$$v \sin i_{\mathrm{B}} = 22\,\mathrm{km\,s^{-1}},$$

suggesting the presence of a cool component (B).

The large wings observed in the Balmer lines (from Hϵ to Hα) suggest the presence of a hot component (A), $T_{\mathrm{eff\,A}} \approx 10000\,\mathrm{K}$, but the radial velocities of this component are difficult to measure.

Radial velocity curve

The analysis of the radial velocity curve of the cool component gives the following results:

- orbital period: $P = 12\overset{\mathrm{d}}{.}91900 \pm 0\overset{\mathrm{d}}{.}00003$
- orbit eccentricity: $e = 0.0141 \pm 0.0015$
- velocity of the center of mass: $\mathscr{V} = -13.28 \pm 0.09\,\mathrm{km\,s^{-1}}$
- velocity amplitude of component B: $K_{\mathrm{B}} = 88.91 \pm 0.13\,\mathrm{km\,s^{-1}}$
- projected semi-major axis: $a_{\mathrm{B}} \sin i = 15.79 \pm 0.02$ Gm

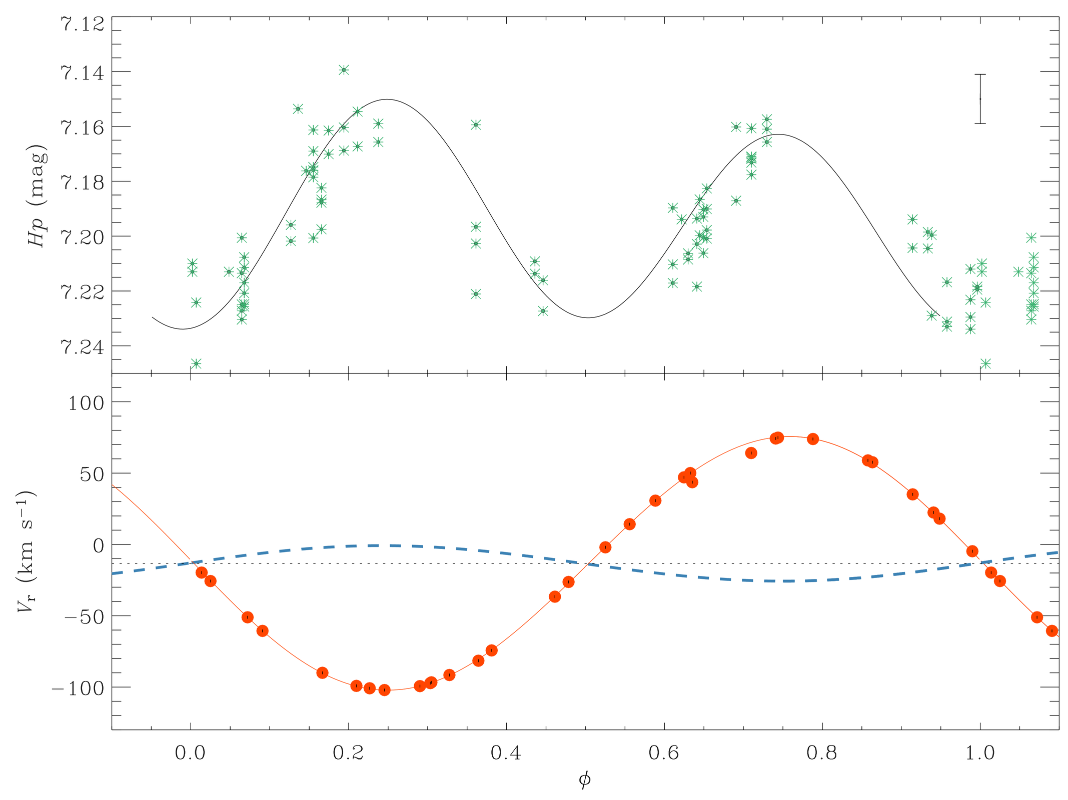

Figure 2: Variability curves of HD 61273, folded on the measured orbital period. **Top panel:** photometric variation in Hp band as measured by HIPPARCOS. **Bottom panel:** radial velocity variation. The red curve (cool component) is measured by cross correlation, whereas the blue curve (hot component) is deduced from the mass ration $q = 0.14$.

Flux ratio

The flux contribution f of the component B can be estimated using a synthetic spectrum with the above determined atmospheric parameters ($T_{\mathrm{eff}} = 4600$ K, $v \sin i = 22\,\mathrm{km\,s^{-1}}$).

In the spectral interval 5840–5870 Å, the contribution of a hot star mainly consists in continuum with no significant absorption line. A linear regression is computed between the observed flux and the synthetic spectrum (corrected for the velocity shift) to derive the flux contribution f (Fig. 3). The resulting f increases with $\log g$, from 0.29 at $\log g = 2$ dex to 0.34 at $\log g = 4$ dex.

Assuming a hot primary component with $T_{\mathrm{eff\,A}} = 10000\,\mathrm{K}$, $\log g_{\mathrm{A}} = 4$ dex, the ratio of continuum spectra per surface unit can be computed using theoretical flux distributions. From then, the ratio of the radii can be estimated. Varying as a function of $\log g_{\mathrm{B}}$ from 3 to 3.4, the radii ratio suggests that the secondary component is more evolved than the primary, and undoubtedly in the giant phase.

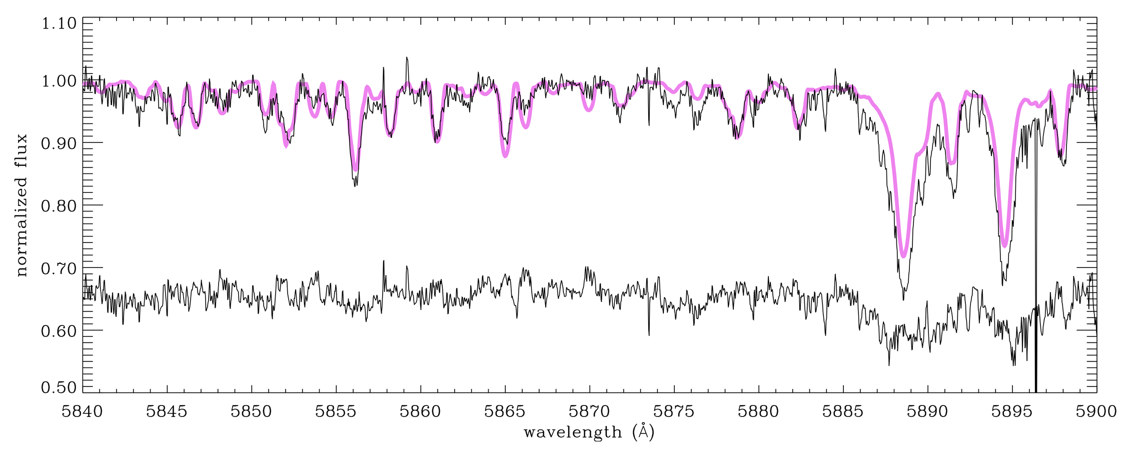

Figure 3: Adjustment of the flux contribution f of the component B in the observed composite spectrum. The thick magenta line is the synthetic spectrum with $T_{\mathrm{eff}} = 4600$ K, $v \sin i = 22\,\mathrm{km\,s^{-1}}$. The bottom spectrum is the residual spectrum, due to the primary component.

Mass ratio

One can derive the mass ratio q of the system on the assumption of spin-orbit synchronization of the Roche-lobe filling component using only the RV curve of this star (Harmanec 1990):

$$q = 0.14$$

Hα profile

The mass ratio $q = 0.14$ determined for HD 61273 corresponds to the Algol paradox, that means it is a binary with Roche lobe overflow and mass ratio inversion.

The Hα line of HD 61273 shows always double peaked emission superimposed to absorption components, whatever the phase of the orbital period (Fig. 4), signature of circumstellar material. This is in agreement with Peters (1980, 1989) who finds that permanent Hα emitting disks are observed in long period Algol systems ($P > 6$ d).

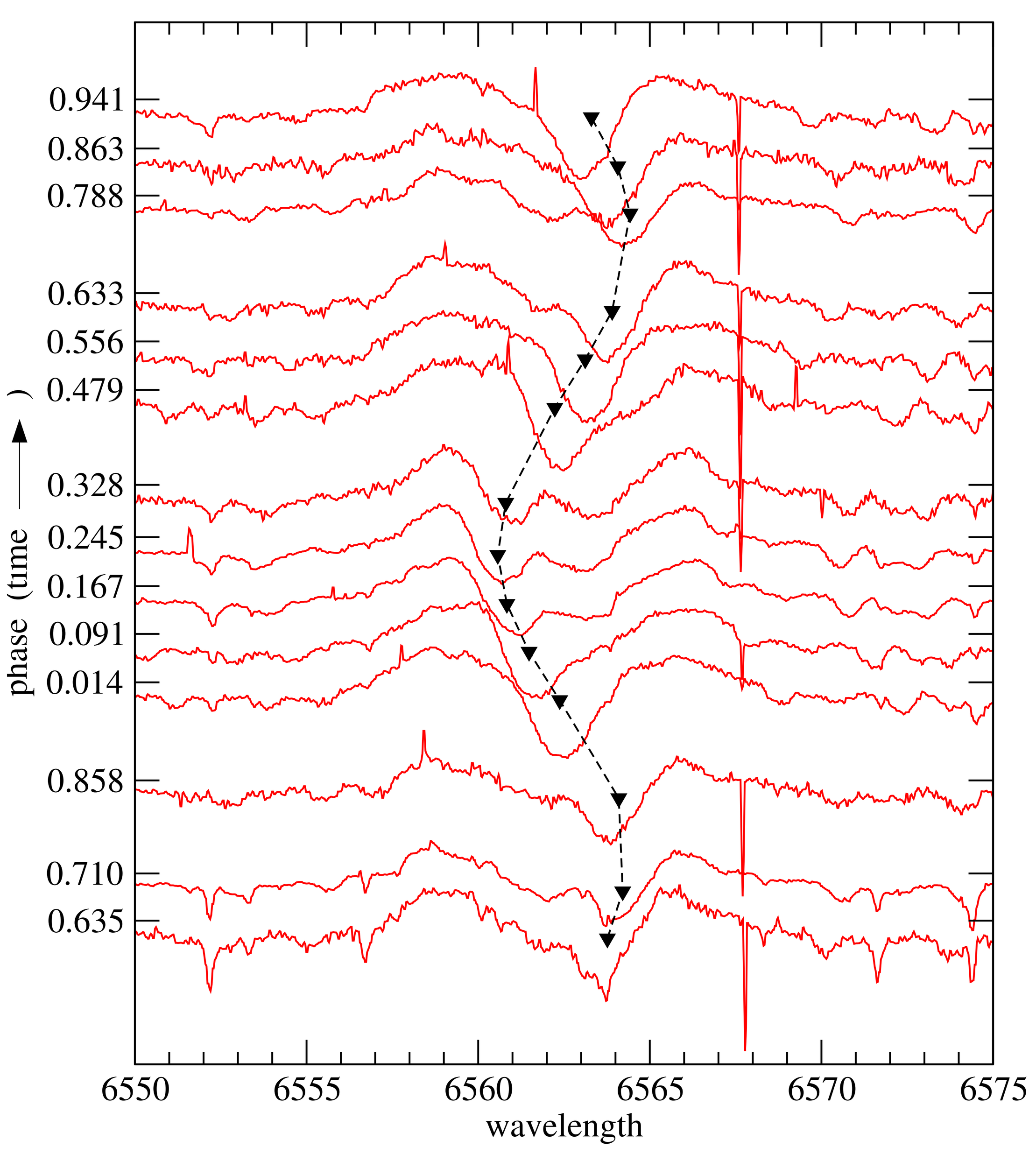

Figure 4: Variation of the Hα profile along one cycle. The black triangle show the positions of the Hα line from the component B.

The width of the Hα line is computed as the difference between the red and the blue edges of the emission feature, taken at the flux level 1.08 (in normalized unit). Its variation along the orbital phase is shown in Fig. 5. It is a signature of the global velocity dispersion of the circumstellar material

The width of emission is larger during phases around 0 and 0.5 and smaller during phases around 0.25 and 0.75. So the width of emission component is larger when we see the system along its axis.

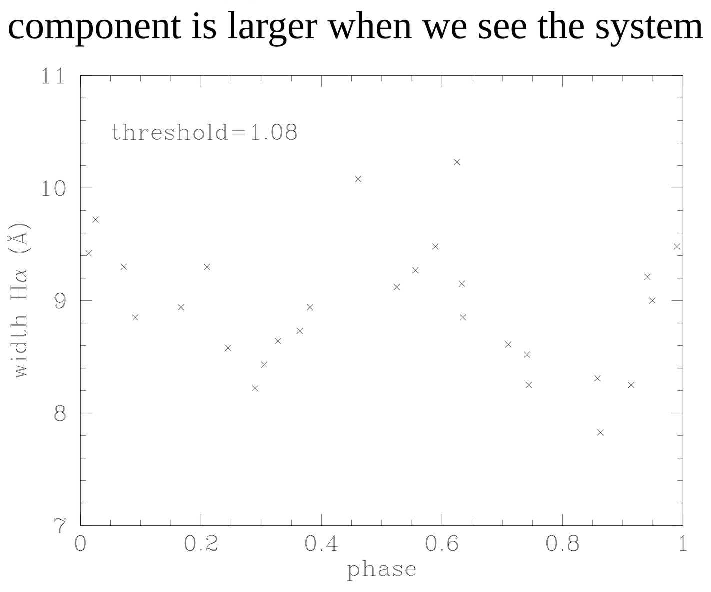

Figure 5: Variation of the width of the Hα emission feature along the orbital phase.

Photometric analysis

The determination of the photometric solution for HD 61273 is in progress, using the Wilson-Devinney computer program (Wilson & Devinney 1971) with the PHOEBE interface developed by Prša & Zwitter (2005), and the light curves in eight different photometric bands: Hp, U, B, V, $B1$, $B2$, $V1$ and G.

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† Address for correspondence: GEPI – Observatoire de Paris, 5 place Jules Janssen, F-92195 Meudon cedex