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Letter to the Editor

HD 34700: A new T Tauri double-lined spectroscopic binary⋆,⋆⋆

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Abstract. We find the star HD 34700 to be a double-lined spectroscopic binary. We also identify it as a weak-line T Tauri object. The spectra of both components are very similar and both show the Li I feature at 6708 Å. Strong arguments in favour of the binary nature of the star as opposed to other possibilities are offered. It is very likely that the companion is also a T Tauri star of similar mass. A projected rotational velocity, $v \sin i$, of 25 and 23 km s^{-1} has been estimated for the blue and red components. We present a list of the lines identified and the radial velocities of the two components on three spectra obtained on consecutive nights.

Key words. spectroscopic binaries – T Tauri stars

1. Introduction

The star HD 34700 (SAO 112630) has been known for its strong infrared excess since it was identified in the IRAS Point Source Catalogue (Odenwald 1986; Oudmaijer et al. 1992). Due to its infrared excess and its spectral classification as G0V, it became apparent that it was a pre-main sequence (PMS), probably a weak-line T Tauri star (wTTS). It has been included in numerous optical and infrared works on Vega-like stars. Most of these studies were made to analyse the observed Spectral Energy Distribution (SED) and derive the properties of the circumstellar material surrounding them (Sylvester et al. 1996; Sylvester and Skinner 1996; Eiroa et al. 2001). The star shows a $J - H$ colour compatible with that of a G0V star but excess in the $H - K$ colour, which is probably due to non-photospheric flux contributing to the K magnitude (Eiroa et al. 2001; Sylvester et al. 1996). Radio observations made by Zuckerman et al. (1995) have led to the detection of CO for this object. These authors have reported the detection of ^{12}CO as well as ^{13}CO, $V_{\odot}$(CO) of 21 km s^{-1}, outer radius of molecular disk of 50 AU, and a dust mass of 1 Earth mass. The star also shows low level optical polarisation from which a non-spherical symmetry or disk-like geometry of the circumstellar dust is inferred (Bhatt & Manoj 2000; Oudmaijer et al. 2001). Large grains (size ∼ 1 mm) are not abundant in the circumstellar material of HD 34700 but it is mostly made of small grains (<10 μm) (Sylvester & Skinner 1996). The star did not show variability in JHK bands in the time scale of days or months (Eiroa et al. 2001).

The first spectroscopic analysis of this star was made by Mora et al. (2001). These authors have used seven low resolution (6700) spectra and two high resolution (49 000) spectra to classify the star as a G0IVe. Other than emission lines they did not report any peculiarity in the spectrum of the star.

Due to its position in the IRAS two-colour diagram (van der Veen & Habing 1988) the star was included in our program on post-AGB candidates. However the general appearance of the spectrum is very similar to those of some wTTS (moderate Hα emission and strong Li I 6708 Å). While examining the spectra we found a very distinct line doubling of virtually all lines, including that of Li I line at 6708 Å. In this paper, we report the duplicity of the star based on the analysis of the spectra taken on three consecutive nights.

Much to our surprise the star is continued to be listed as a post-AGB in the *SIMBAD* data base.

2. Observations

Three spectra of HD 34700 were obtained during October 7–9, 2000 with the 1.93-m telescope of the Haute-Provence Observatory (OHP), which is equipped with the high resolution (42 000) echelle spectrograph ELODIE. Details about the performance and characteristics of the instrument have been thoroughly described by Baranne et al. (1996). These spectra were reduced using spectroscopic data reduction tasks available in the IRAF package.

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⋆ Based on observations obtained at the Haute-Provence Observatory, France.

⋆⋆ Table 2 is only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/408/L29

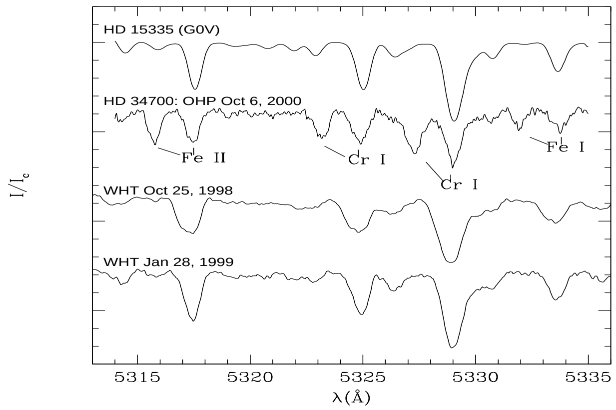

Fig. 1. Comparison of HD 34700 OHP spectrum (second from the top) with that of 13 Tri (HD 15335, G0V) taken from Montes & Martin (1998). The presence of line doubling is clearly seen. The two WHT EXPORT spectra at the bottom do not show the line doubling but lines are broadened by the blending of the two components.

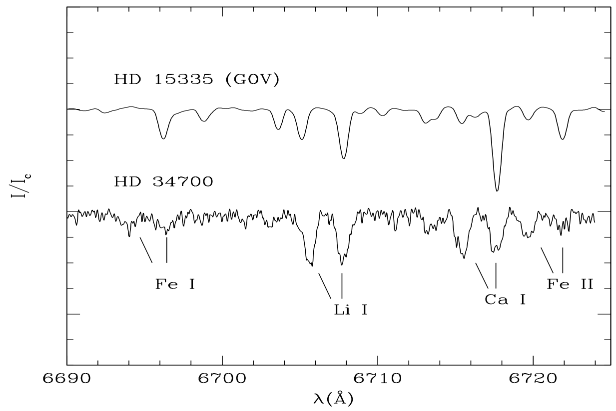

Fig. 2. The Li 6708 Å region in the OHP spectra compared with the standard star.

3. Spectral characteristics

We have found line doubling in virtually all lines in the spectrum of HD 34700 from 4000 to 6800 Å in the three spectra taken on consecutive nights. The two components show clear radial velocity variations from night to night. We used the spectrum of the highest S/N ratio (67 at 6000 Å) for line identification and line strength measurements. Two examples of the line doubling are shown in Figs. 1 and 2, where we have compared the spectrum of HD 34700 with that of a well-known G0V star (HD 15335) from the high resolution spectral catalogue of Montes & Martin (1998). We have degraded the resolution of HD 15335 such that it is comparable to the resolution of our spectrum. As the lines are double, they often blend with other stellar features, making the line identification difficult sometimes. The identified lines and radial velocities of both the blue and the red components are listed in Table 2, available at the CDS. We have included in Table 2 only those lines which have both the components clearly identified and unaffected by the neighbouring lines. The table also contains the lower excitation potentials and the ratios of line strengths of the two components, which are consistently of similar strengths. Since line duplicity is shown irrespectively of where the lines are formed

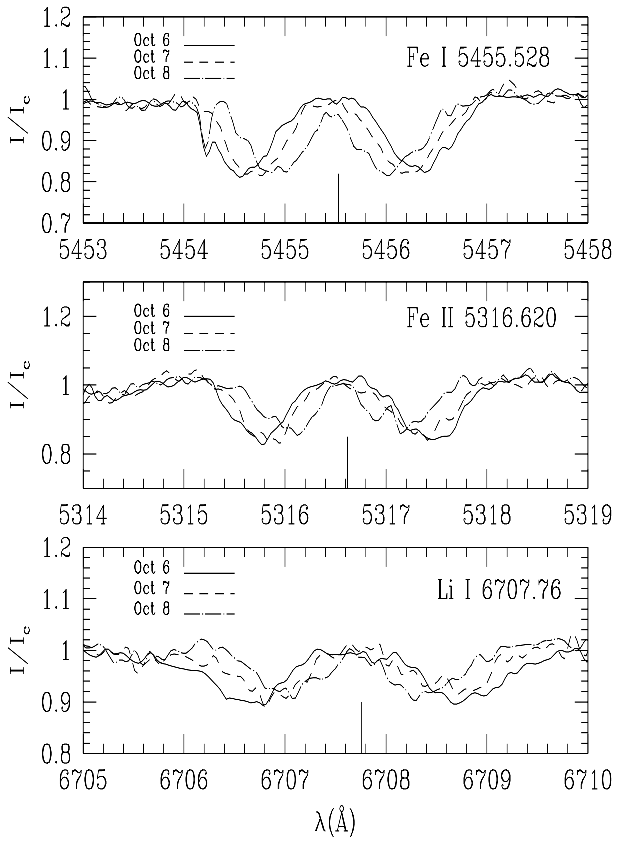

Fig. 3. Three examples of line radial velocity variations due to the binary's orbital motion. The long vertical mark indicates the rest position of the line. Note the line cores getting closer with increasing date.

Table 1. Heliocentric radial velocities in HD 34700 and its companion

Date	$V_{r,\odot}$ (blue) km s^{-1}	$V_{r,\odot}$ (red) km s^{-1}	N	HJD (2 451 000.+)
Oct. 6, 2000	−27.0 ± 4.3	+69.3 ± 3.9	106	823.70130
Oct. 7, 2000	−21.0 ± 5.8	+63.6 ± 5.8	98	824.72364
Oct. 8, 2000	−9.5 ± 4.6	+53.4 ± 5.8	80	825.66518

N = number of lines included in the calculation.

in the atmosphere, it is most likely that we have a composite spectrum of two different stars of similar spectral types.

The mean blue and red radial velocities of the identified lines in the three spectra are reported in Table 1.

In Fig. 3 we display examples of double lines in the three spectra. Obvious radial velocity variations are seen on both line components which may be interpreted as due to the orbital motion of a binary system as discussed in Sect. 4. The line depths are affected by the veiling phenomenon known to occur in T Tauri stars, consisting of additional flux coming from a featureless continuum that fills in photospheric absorption lines (Hessman & Guenther 1997; Mora et al. 2001). Thus an attempt to estimate the effective temperature and gravity of the star, by the standard procedure of excitation and ionisation equilibrium for a set of Fe I and Fe II lines with the same radial velocity, proved to be futile. It also prevented us from deriving the rotation velocities by comparing synthetic line profiles with observed ones.

Very distinct variations in Hα profiles are observed in the three spectra in our possession and are displayed in Fig. 4. While Hα variations could be caused by changes in the stellar chromospheric activity, it is also possible that veiling variations due to temperature changes do contribute to the observed changes in Hα. The weakening of the lines due to veiling has been illustrated by Mora et al. (2001) for five PMS stars.

All other lines also show depth variations from night to night, as it is illustrated for a few lines in Fig. 3. Therefore variations in the time scale of hours, like those described for the highly veiled T Tauri stars DR Tau, DG Tau and DI Cep (Hessman & Guenther 1997) may also be present in HD 34700.

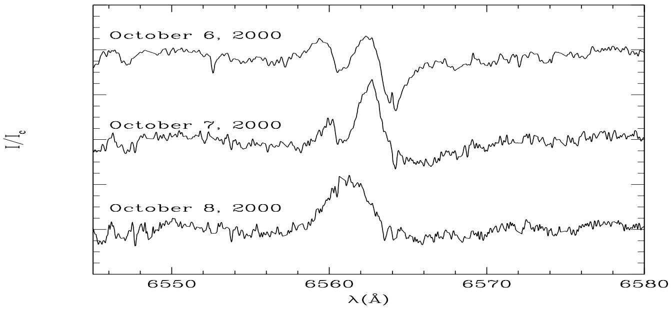

Fig. 4. Hα line variations in three consecutive nights. It can be seen how the line is being filled in. The equivalent width of Hα in the bottom spectrum is 0.6 Å.

4. Discussion

Apart from the variations in the line strengths as described in the last section, radial velocity variations are also evident. We have reasons to believe that the observed line doubling is caused by the presence of a companion around HD 34700.

4.1. The double-lined spectroscopic binary interpretation

Line doubling can be caused by the passage of a shock, like those observed in pulsating stars. However, in that case the line splitting is not as large as it is observed in Fig. 3 and it is generally accompanied by large luminosity variations (Tsesevich 1975).

We have also debated with the alternative explanation in terms of central emission in lines, giving the illusion of line doubling. But in that case, at the epoch of weaker emission, one would expect the two absorption components to appear stronger and closer. The observed line components do not follow this pattern but the line strengths of component pairs remained unchanged over the three epochs, although their separation changes. Secondly, if the two components are treated as part of a single wide absorption separated by central emission, then the *FWHM* of this single wide absorption turns out to be larger than 2 Å. If this broadening is ascribed to rotation, it would require $v \sin i$ larger than 100 km s^{-1} but for early G type PMS, the observed rotational velocities do not exceed about 40 km s^{-1} (Mora et al. 2001). Furthermore, as neither a P-Cygni profile is observed in Hα nor other emission lines are present, the line doubling is not likely to be caused by a central emission.

We are therefore more inclined to believe that the two components are arising from two different stars. Considering that the line strengths are very similar and that the Li I 6708 Å feature appears double and also follows the velocity pattern exhibited by other photospheric lines, it is likely that both members of the binary system are T Tauri stars of similar masses. This phenomenon of line doubling in HD 34700 has somehow escaped attention in previous works.

We have inspected the high resolution spectra, obtained on October 25, 1998 and January 28, 1999 using the 4.2-m William Herschell Telescope (WHT) at La Palma as part of the EXPORT project (e.g. Mora et al. 2001). As an example we have included in Fig. 1 a portion of the two WHT spectra. Line doubling cannot be observed but only a line broadening, which is different for the two epochs. Those spectra seem to have been obtained at orbital phases when the lines from the two components were almost merged, hence line duplicity was missed even at the high resolution of the WHT spectra. Unfortunately these two spectra do not cover the Hα and Li I 6708 Å regions.

A list of the known PMS spectroscopic binaries includes forty systems (Melo et al. 2001). The orbital periods are between 1.6 and 2500 days, but 80% have periods smaller than 100 days and about 50% are double-lined. They are mostly of K spectral type but F, G and K combinations also occur. HD 34700 should be added to the list. With spectral type of G0, the star is among the hottest known wTTS double-lined spectroscopic binaries.

4.2. Rotational velocity

Due to the reasons mentioned in Sect. 3, we did not use the method of comparing synthetic and observed line profiles to estimate the rotation velocities for the two components. Instead, we followed the *FWHM* vs. total broadening calibration described in Fekel (1997). We found the mean *FWHM* of 0.80 and 0.75 Å for the blue and red components. The *FWHM* of the instrumental profile (derived from weak telluric lines) was 0.15 Å corresponding to broadening of 8.5 km s^{-1}, and for spectral type GO IV, a macroturbulence velocity of 4.0 km s^{-1} was adopted. After subtracting the contribution from the above mentioned broadenings we have derived rotation velocities of 25 and 23 km s^{-1} for the blue and red components present in the spectrum. Following the discussion on the errors given in Fekel (1997), these estimates may have an uncertainty of ± 1 km s^{-1}. These values are considerably smaller than 46 km s^{-1} determined by Mora et al. (2001) but their result has clearly been affected by line blending. With this rotational velocities, and assuming a prominent chromospheric activity, light variations with periodicities of the order of a few days are expected. A photometric campaign on the star would be most valuable to test this scenario.

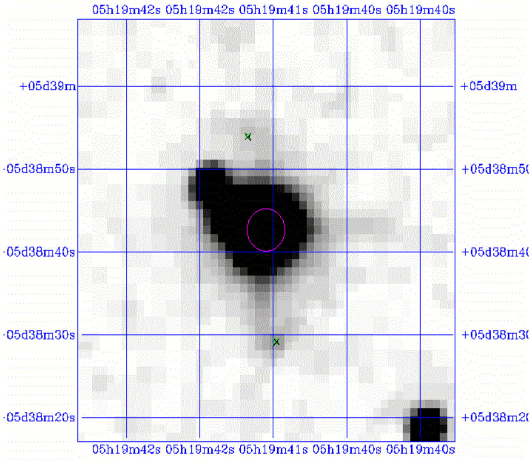

Fig. 5. *K* image of HD 34700 from the 2MASS catalogue. North is up and East is left. The asymmetry of the IR emitting region is likely due to the presence of a double star in the core of the region.

4.3. Asymmetric dust envelope

The *K* image of the star in the 2MASS catalogue is shown in Fig. 5. The asymmetry of the emission is evident, similar to that in *J* and *H* bands. The size of the IR emitting region in the NE-SW direction is about 20 s of arc. Adopting the distance to the star 180 pc as a lower limit (van den Ancker et al. 1998), the minimum physical size is about 30 000 AU and about half that size in the orthogonal direction. At these scale the non-symmetrical distribution of the circumstellar dust, is most probably due to the existence of more than one star near the core, although to be conclusive on this topic will have to wait until the orbit of this binary star is duly parametrized.

5. Conclusions

HD 34700 is a double-lined spectroscopic binary. Since it shows prominent Li I, moderate Hα emission and strong IR emission the star can safely be classified as a weak-line T Tauri star.

Because of the similarity of the primary and secondary spectra and the presence of Li I 6708 Å in both components, we believe that this double-lined spectroscopic binary is harbouring two T Tauri stars of similar masses. A spectrum very similar to that of HD 34700 is displayed by Covino et al. (2001) for the K2+K2 PMS system RX J0530.7-0434.

There are 26 known double-lined PMS spectroscopic binaries (Melo et al. 2001). HD 34700 should be added to the growing list of double-lined T Tauri spectroscopic binares.

With only few spectra to our disposal we cannot go further on orbital analysis, but the continuous spectral monitoring at high resolution is urgently required to confirm our finding and to derive the orbital parameters for this object.

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