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Brightening of the T Tauri star RY Tauri in 1996*,**

Photometry, polarimetry and high–resolution spectroscopy

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Abstract. The T Tauri star RY Tau has increased its brightness from V= $10\overset{\mathrm{m}}{.}6$ to V= $9\overset{\mathrm{m}}{.}6$ in October–November 1996. By February–March 1997, the star has faded again to V= $10\overset{\mathrm{m}}{.}8$. High–resolution échelle spectra of RY Tau were obtained with the SOFIN spectrograph at the Nordic Optical Telescope (La Palma, Spain) at low and high brightness levels of the star. No significant changes in the photospheric lines, which are sensitive to temperature and gravity, were noticed. The spectral type of RY Tau is defined as G1–2 IV, which in combination with photometric data implies $A_{\mathrm{V}} = 1\overset{\mathrm{m}}{.}0 - 1\overset{\mathrm{m}}{.}3$. Polarimetric patrol of RY Tau during the fading of the star showed an increase of its intrinsic polarization from 0.5–1.0% at high brightness to about 2% at low brightness in the V, R and I bands. The flux radiated in Hα and the IR Ca II emission lines remained about the same, in spite of the one magnitude difference in the continuum flux. These results indicate that variable obscuration of the star by circumstellar dust clouds was responsible for the brightness change of RY Tau, and that the emission line source is mostly outside of the obscured region.

Key words: stars: circumstellar matter – stars: individual: RY Tau – stars: pre-main sequence

1. Introduction

RY Tau belongs to the classical T Tauri Stars (TTS), with irregular light variability and a moderate emission spectrum. The star has long been a target for photometric and spectroscopic observations, particularly after its brightening in 1983/84 from 11th to 9th magnitude in V (Herbst & Stine 1984, Zajtseva et al. 1985). The characteristic pattern of the photometric variability of RY Tau is the near constancy of its colours at different brightnesses. Therefore, the dependence of the colours on the brightness is not well expressed but somewhat similar to that of the UX Ori–type stars: the star becomes slightly redder when fading from V= $9\overset{\mathrm{m}}{.}5$ to $10\overset{\mathrm{m}}{.}0$, but then turns to be bluer when even fainter, with a large intrinsic dispersion in the colours (Zajtseva 1986, Gahm et al. 1993, Eaton & Herbst 1995, Kardopolov & Rspaev 1995).

The spectral classification is K1e IV,V(Li) (Herbig 1977, Cohen & Kuhi 1979) though the earlier spectral type G2 was estimated by Cabrit et al. (1990). The star has a low level of veiling, ≤ 0.1 in the visible region of the spectrum (Basri et al. 1991, Hartigan et al. 1995). No veiling was found in the blue (Valenti et al. 1993). The IUE spectrum shows weak Fe II emission and moderate far–UV excess (Herbig & Goodrich 1986). The equivalent width of the Hα emission is about 20 Å (which is not far from the conventional threshold of 10 Å between weak–line TTS and classical TTS), Hβ is sometimes in emission, sometimes in absorption, while higher Balmer line are always in absorption.

Contrary to other classical TTS, RY Tau is a rapid rotator; its $v\ \sin\ i$ was determined to about 50 km s^{-1} (see e.g. Bouvier 1990). It is an X–ray emitter with $\log L_{\mathrm{X}} = 29.71$ (erg s^{-1}) (Damiani et al. 1995), which is an average value for TTS in the Tau–Aur region.

RY Tau has a rather large level of intrinsic linear polarization of a few percent. The variability of the linear polarization was first discovered by Vardanyan (1964) and confirmed by Serkowski (1969). The wavelength dependence of the linear polarization indicates that most of the polarization arises in an external, circumstellar dust envelope which lies outside of the high–temperature, gas–emitting region (Bastien & Landstreet 1979). The dependence of the linear polarization on the brightness of the star is not unambiguous, however in the deep minima of the brightness the polarization was higher (Efimov 1980).

RY Tau has a remarkably flat distribution of energy in the far–infrared region (Bertout et al. 1988); it is also a strong source of millimeter continuum emission (Beckwith et al. 1990), but

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* based on observations collected at the Nordic Optical Telescope (NOT), European Northern Observatory, La Palma, Spain; at the 2.6m and the 1.25m telescopes of the Crimean Astrophysical Observatory; at the 60cm telescope of the Crimean Laboratory of the Sternberg Astronomical Institution.

** Tables 2 and 3 are 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/Abstract.html

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was not detected at radio wavelengths in a search for molecular outflows (Edwards & Snell 1982, Calvet et al. 1983).

There were many attempts to find a periodicity in the light variations of RY Tau on both short and long timescales. Some periods were reported on timescales from 5 to 66 days, but none was confirmed later on (Herbst et al. 1987, Herbst & Koret 1988, Bouvier et al. 1993, Bouvier et al. 1993, Bouvier et al. 1995). It is fair to say that if there is any periodicity in the light curve of RY Tau, it is hidden in a larger amplitude irregular variation and/or not persistent on a long timescale.

The relative constancy of colours during large amplitude variations of brightness indicates that the photospheric parameters of the star remain unchanged. Indeed, RY Tau does not show variations of the TiO bands with brightness even in rather deep minima, which could be expected if a cool spot were the cause of the brightness variability (Herbst & Lavreault 1990).

The Hα line profile is variable on a timescale of days, showing transient blue– and red–shifted absorption components (Zajtseva et al. 1985, Petrov & Vilhu 1991, Johns & Basri 1995). The same transient absorption was observed in the line profiles of the sodium doublet, which was interpreted as trace of stellar prominences (Petrov 1990). The most detailed review on the high–resolution line profiles was given by Hamann & Persson (1992).

The dependence of the Hα flux on the brightness of the star is somewhat controversial. Holtzman et al. (1986) found from UBVRI and Hα photometry that the Hα flux generally decreases as the star fades, but can change independently of brightness by a factor of 3 or more. On the other hand, Vrba et al. (1993) reported that the Hα flux increases with decreasing brightness, although with poor correlation.

During the patrol photometric observations of TTS at the Crimean Laboratory of the Sternberg Astronomical Institution, we have discovered a new event of brightness increase of RY Tau at the end of 1996. The star went from V= $10\overset{\mathrm{m}}{.}6$ to V= $9\overset{\mathrm{m}}{.}6$ within about one month (Zajtseva et al. 1996). This offered a new opportunity to study the phenomena connected with the brightening in great detail. In this paper we present photometric, polarimetric and spectroscopic data obtained at different brightness levels of the star, and discuss possible causes of its variability.

2. Observations

UBV *photometry:* The 60 cm telescope and the pulse–counting photometer at the Crimean Laboratory of the Sternberg Astronomical Institution (Ukraine) has been used for the photometric monitoring of TTS, including RY Tau, since 1965. Comparison stars and their magnitudes are given in Zajtseva et al. (1974). The diaphragm used was 27″; the typical error of the measurements is about $0\overset{\mathrm{m}}{.}01$.

UBVRI *photometry and polarimetry:* The 1.25 m telescope equipped with a five–channel photometer–polarimeter at the Crimean Astrophysical Observatory (Ukraine) was used for observations of RY Tau from December 1996 to March 1997. The diaphragm was 10″. UBVRI magnitudes of RY Tau were determined with respect to the comparison star SAO 76567 = BD +27°657, for which we determined V= $9\overset{\mathrm{m}}{.}13$, B–V= $0\overset{\mathrm{m}}{.}90$, U–B= $0\overset{\mathrm{m}}{.}34$, V–R= $0\overset{\mathrm{m}}{.}71$, V–I= $1\overset{\mathrm{m}}{.}23$, using the photometric standard BD +24°659 (K3 V, V= $9\overset{\mathrm{m}}{.}42$) from the list of Neckel & Chini (1980).

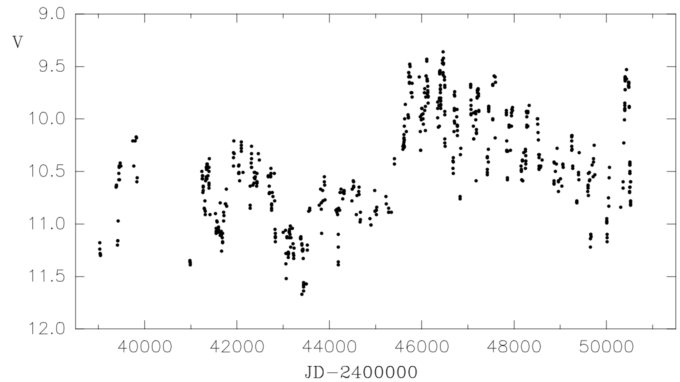

Fig. 1. The V light curve of RY Tau from 1965 to 1997

Spectroscopy: The high–resolution échelle spectrograph SOFIN at the 2.56 m Nordic Optical Telescope (La Palma, Spain) was used. The spectral range covered was 4500–9000 Å, the resolving power 25 000. For a typical spectrum, the S/N ratio was 100–200 longward of 5000 Å. One spectrum of RY Tau was taken at low brightness of the star on 4/5 Dec 1995, and several spectra were taken at high brightness during 20 Nov–01 Dec 1996. At low brightness in Dec 95, the star varied smoothly from V= $10\overset{\mathrm{m}}{.}8$ to $10\overset{\mathrm{m}}{.}5$; the nearest photometric measurement was obtained 4 days after the spectrum; we interpolate the brightness to V= $10\overset{\mathrm{m}}{.}65 \pm 0\overset{\mathrm{m}}{.}1$ at Dec 04, 1995. At high brightness, the first échelle spectrum was taken on Nov 20/21, 1996, at V= $9\overset{\mathrm{m}}{.}72$, simultaneously with photometry (see Fig. 2). The spectra of 84 Her (G1 III), 27 Ari (G5 III–IV), 70 Peg (G7 III) and δ Eri (K0 IV) were taken for comparison purposes.

Several spectra of RY Tau in the regions of Hα and Na D were also taken at the coudé spectrograph of the 2.6 m Shajn reflector at the Crimean Astrophysical Observatory, with a resolving power of 40 000.

The journal of our spectroscopic observations is presented in Table 1.

3. Results

3.1. Photometry

The photometric data are given in Table 2, and the light curve in the V–band for the period 1965–1997 is displayed in Fig. 1. A major part of these data (before JD 2 448 000) were included in the catalogue by Herbst et al. (1994). The last brightening started in October 1996 (JD 2 450 360). Within about 40 days, the star raised up to V= $9\overset{\mathrm{m}}{.}6$ and stayed at this level during three months, with small fluctuations of $0\overset{\mathrm{m}}{.}1 - 0\overset{\mathrm{m}}{.}2$ (Fig. 2). The subsequent fading of brightness down to V= $10\overset{\mathrm{m}}{.}8$ lasted for about one month, to the end of the observational season in March 1997. At the maximum brightness the average B–V colour was redder by about $0\overset{\mathrm{m}}{.}15$ as compared to that at the

Table 1. Spectroscopic observations of RY Tau 1989–1996.

Obs: CrAO – Crimean Astrophysical Observatory, Ukraine
NOT – Nordic Optical Telescope, La Palma, Spain
λ =spectral region: 1 – Hα
2 – Hα, Na D
3 – Hα, Na D, 6400 Å
4 – 4500–9000 Å
EW – equivalent width of the Hα emission in Å
F – flux in the Hα emission in 10^{-12} erg cm^{-2} s^{-1} Å^{-1}
When only one digit after the decimal point is given for the V magnitude, V has been interpolated from the closest points in the measured light curve.

date	JD 24...	Obs	λ	V	EW	F
30/31 Oct 89	47830.4	CrAO	2	$9^{m}.9$	14.6	15.6
07/08 Nov 89	47838.5	CrAO	2	$10^{m}.3$	18.7	15.2
10/11 Nov 89	47841.4	CrAO	2	$10^{m}.25$	22.0	14.9
18/19 Nov 89	47849.5	CrAO	1	$10^{m}.45$	24.9	20.2
30/31 Jan 90	47922.4	CrAO	1	$10^{m}.30$	17.4	12.9
08/09 Mar 90	47959.3	CrAO	1	$9^{m}.9$	12.0	12.9
17/18 Mar 90	47968.2	CrAO	2	$9^{m}.9$	12.3	13.2
19/20 Mar 90	47970.3	CrAO	1	$9^{m}.9$	11.4	12.0
22/23 Mar 90	47973.2	CrAO	2	$9^{m}.9$	7.6	8.1
04/05 Dec 95	50056.5	NOT	4	$10^{m}.65$	17.6	9.4
15/16 Nov 96	50403.5	CrAO	3	$9^{m}.62$	8.6	11.9
20/21 Nov 96	50408.5	NOT	4	$9^{m}.72$	6.0	7.6
20/21 Nov 96	50408.6	CrAO	3	$9^{m}.72$	6.0	7.6
25/26 Nov 96	50413.5	NOT	4	$9^{m}.7$	6.4	8.2
28/29 Nov 96	50415.7	NOT	4	$9^{m}.7$	8.5	10.9
29/30 Nov 96	50417.6	NOT	4	$9^{m}.7$	5.9	7.6
30/01 Dec 96	50418.6	NOT	4	$9^{m}.7$	10.3	13.3
01/02 Dec 96	50419.6	NOT	4	$9^{m}.7$	7.3	9.4
12/13 Dec 96	50430.5	CrAO	3	$9^{m}.6$	10.8	15.2

minimum brightness. The same change can be noticed in the U–B colour, but with larger scatter. The V *versus* B–V diagram is shown in Fig. 3: like was observed for previous photometric changes, the star becomes slightly redder when fading from V= $9^{m}.5$ to $10^{m}.0$, but then turns to become bluer when even fainter, with some intrinsic dispersion in the colours (Fig. 3).

3.2. Polarimetry

RY Tau is located in a region of large and non–uniform interstellar extinction. The value of $A_{\rm V}$ toward RY Tau was estimated as $1^{m}.24$ to $1^{m}.88$ by different observers (Cohen & Kuhi 1979, Kuhi 1974, Cernicharo et al. 1985).

Therefore, one may expect a large degree of interstellar polarization, comparable to the intrinsic polarization of RY Tau. Efimov (1980) found an interstellar polarization of $P_{\rm max} = 2.69$% with a position angle of PA= 27° for the wavelength of maximum polarization 0.55 μm, using observations of different stars in the vicinity of RY Tau and applying the normal law of interstellar extinction with $A_{\rm V} = 1^{m}.88$. After that publication, a large set of polarimetric UBVRI observations of RY Tau was carried out at the Crimean Astrophysical Observatory in

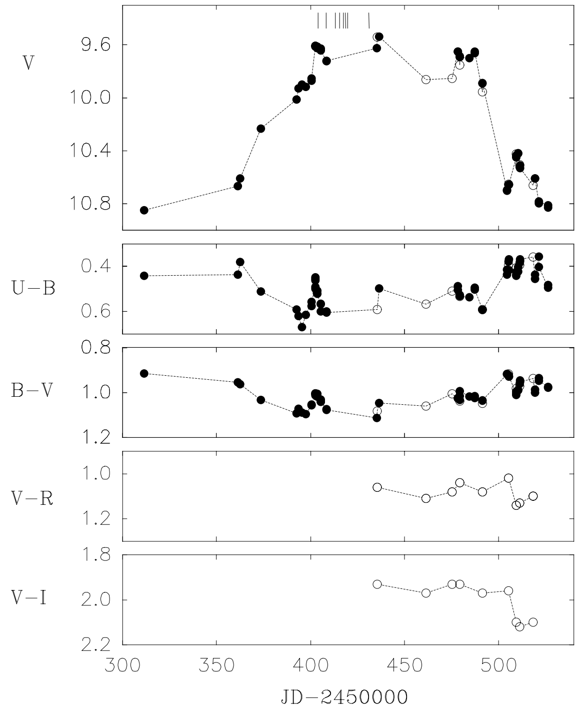

Fig. 2. The event of brightening in 1996/97. *Filled circles:* UBV photometry, *open circles* UBVRI photometry. The bars above the lightcurve indicate the dates of spectroscopic observations.

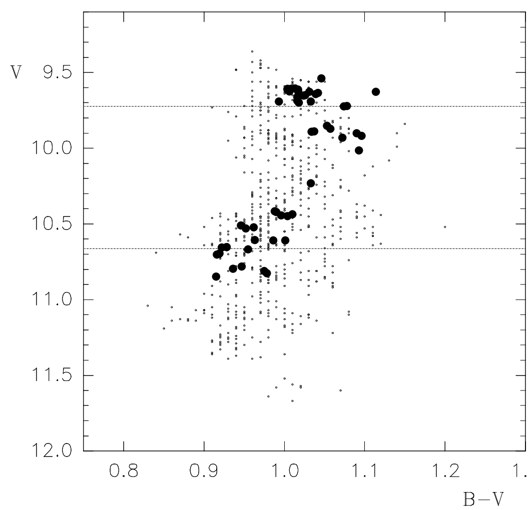

Fig. 3. Variability of brightness and colour of RY Tau. *Dots:* data of 1965–1997. *Filled circles:* the last event of brightening in 1996/97. The two dashed lines indicate the two levels of brightness, when spectroscopic observations were obtained.

the period of 1981–1987. Using the new method for determination of interstellar polarization proposed by Shakhovskaya et al. (1987), we made a new estimation of the interstellar polarization toward RY Tau, based on more than 140 observations of the star: $P_{\rm max} = 2.84 \pm 0.14$%, PA= $26° \pm 1.°4$. The Serkowski law of polarization was adopted with the maximum polarization wavelength of 0.55 μm (Whittet 1977).

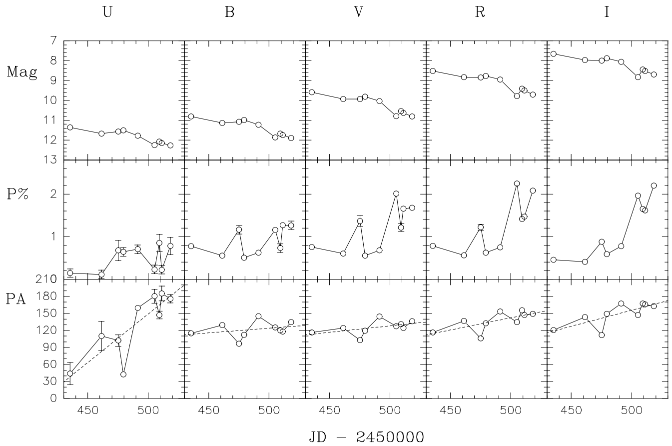

Fig. 4. Polarimetric observations in Dec 96–Mar 97; *upper panel:* the light curve in different bands; *central panel:* intrinsic polarizations P (%); *lower panel:* position angles PA (degrees).

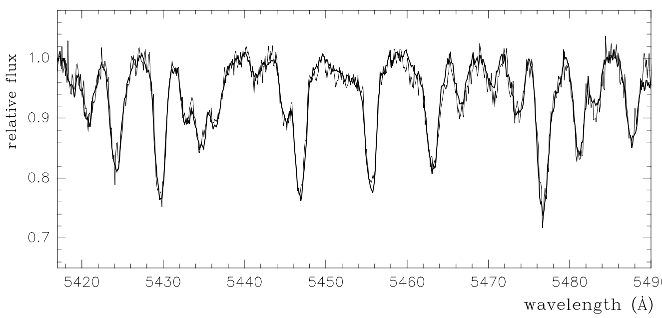

Fig. 5. Two overplotted spectra of RY Tau: one was taken at low brightness of the star, the other is the average spectrum at high brightness. The spectral lines belong to V I and Fe I of low excitation potentials, which are sensitive to the photospheric temperature. No difference in the line profiles exceeding 0.7 % of the continuum level was detected.

During the latest event of brightening of RY Tau in 1996, we started polarimetric observations in December 1996, when the star was already at high brightness, and followed the decline of brightness to the end of the observational season. The results of the observations are given in Table 3 and shown in Fig. 4. After correction for the interstellar polarization, the intrinsic polarization of RY Tau and its position angle were found to be variable with the brightness of the star. In the V, R and I bands the intrinsic polarization was increasing from 0.5–1.0% at high brightness to about 2% at low brightness. In the U and B bands this tendency is not well expressed. The position angle was progressively rotating as the star fades.

3.3. Spectroscopy

3.3.1. Photospheric spectrum

The depths of the photospheric lines in the 6 échelle spectra taken at high brightness in 1996 are the same; thus here we use the average photospheric spectrum.

The spectra of RY Tau at high and low brightness levels (Fig. 5) show remarkable constancy of the photospheric absorp-

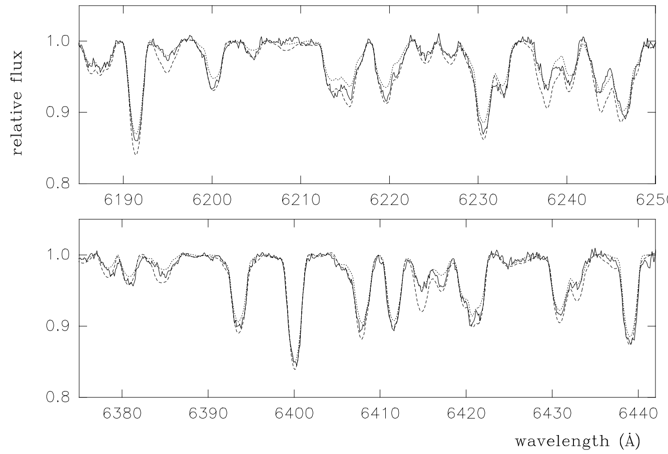

Fig. 6. Two fragments of the photospheric spectrum of RY Tau (*solid line*) compared to the reference spectra of G2 V (Sun, *dotted line*) and G1 III (84 Her, dashed line). All wavelengths are in the stellar restframe.

tion lines within the accuracy of our measurements, which indicates the constancy of the photospheric temperature within about 40 K, in spite of the one magnitude difference in stellar brightness. From the region of 5000–7000 Å we determined the radial velocity RV= $18 \pm 1\,\mathrm{km\,s^{-1}}$ and the projected rotational velocity $v \sin i = 52 \pm 2\,\mathrm{km\,s^{-1}}$. Both values are consistent with previous estimates (see e.g. Hartmann & Stauffer 1989 and Bouvier 1990).

The photospheric line spectrum of RY Tau is very similar to the solar spectrum, taken with the same spectrograph (day sky spectrum) and spun up to $v \sin i = 52\,\mathrm{km\,s^{-1}}$. Another suitable standard star is 84 Her: G1 III, $T_{\rm eff} = 5760$ K, $\log g = 3.2$ (Berdyugina 1994). The photospheric line depths and ratios in the spectrum of RY Tau are in the range given by spectra of the Sun and 84 Her (Fig. 6), in the spectral interval of 4500–8800 Å. An upper limit for the veiling factor can be set to ≤ 0.1. Therefore, we estimate the spectral type of RY Tau as G1–G2 IV with the intrinsic B–V colour $0^{\rm m}\!.65 - 0^{\rm m}\!.68$. At the bright state, RY Tau had V= $9^{\rm m}\!.5 - 9^{\rm m}\!.7$ and B–V= $0^{\rm m}\!.99 - 1^{\rm m}\!.05$, that is $E({\rm B-V}) = 0^{\rm m}\!.3 - 0^{\rm m}\!.4$ and $A_{\rm V} = 3.2 \cdot E({\rm B-V}) = 1^{\rm m}\!.0 - 1^{\rm m}\!.3$. With the distance to RY Tau of 140 pc (Elias 1978), we get $M_{\rm V} = 2^{\rm m}\!.5 - 3^{\rm m}\!.0$, which is in accordance with the spectral classification of G1–G2 IV.

3.3.2. Emission line spectrum

The most prominent emission lines in our spectra of RY Tau are those of Hα and the IR–triplet of Ca II. Weaker emission components are also present in Hβ, He I 5876 Å and Na I D. Of the forbidden emission lines only [O I] 6300 Å is clearly seen.

Fig. 7 shows several fragments of the average spectrum of RY Tau at high brightness. The range of variability in the emission line profiles is shown in Fig. 8.

It is interesting that the relative intensities of the emission components of Hα and the IR Ca II lines drop by a factor of 2–3 between Dec 95 and Nov 96, when the star has brightened by

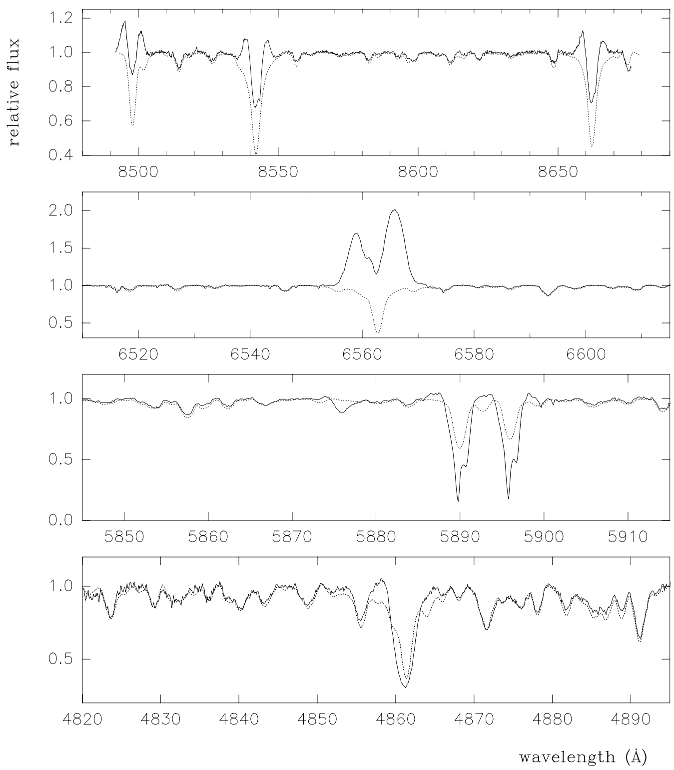

Fig. 7. Fragments of the average spectrum of RY Tau at high brightness in 1996 (*solid line*). The spectrum of 84 Her spun up to $v \sin i = 52\,\mathrm{km\,s^{-1}}$ is shown for comparison (*dotted line*). The wavelengths are in the stellar restframe.

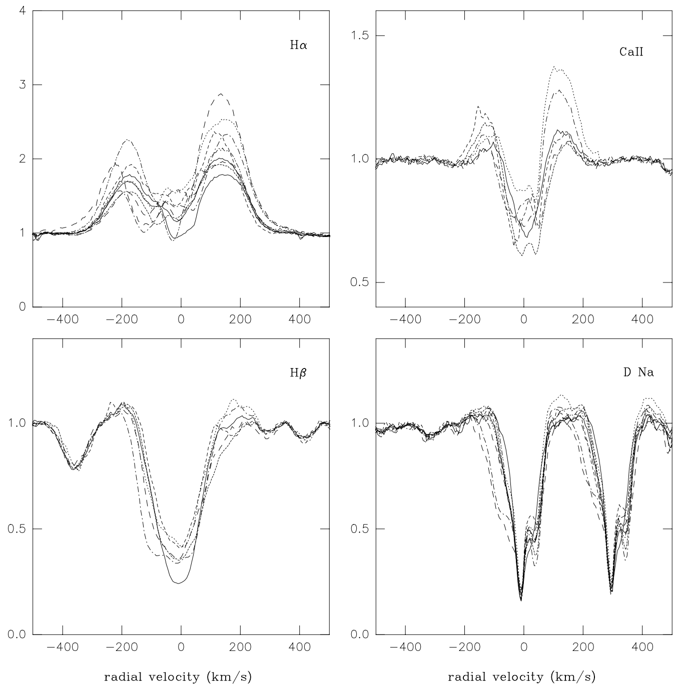

Fig. 8. Variability of line profiles in the spectrum of RY Tau at high brightness in 1996.

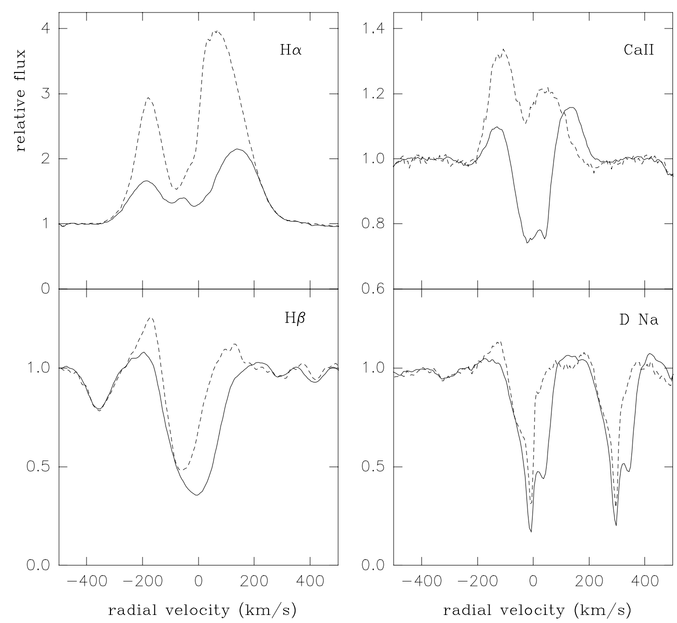

Fig. 9. The different line profiles in the spectrum of RY Tau at different brightness levels of the star; *solid line:* average spectrum at high brightness in 1996 (V= $9^{\mathrm{m}}_{.}7$); *dashed line:* spectrum at low brightness in 1995 (V= $10^{\mathrm{m}}_{.}7$).

one magnitude (see Fig. 9). This means that the *flux* radiated in these emission lines has remained about the same.

In the region around 5180 Å, the depths of the absorption lines of Mg I and Fe II at high brightness are consistent with the spectral type of the star (G1–2), but at low brightness these lines were shallower, as if the star were of late F–type. Since the photospheric temperature was the same at the two brightness levels, we conclude that at low brightness the Mg I and Fe II lines were partially filled in with emission. These emissions are shown in the differential spectrum: normalized spectrum at low brightness minus normalized spectrum at high brightness (Fig. 10).

In the high brightness state, the emission components of the sodium doublet are not prominent, while there are variable absorptions in the blue and red wings of the lines. The average equivalent width of the sodium lines is noticeably larger than in the comparison G stars (Fig. 7). The He I 5876 Å line is only slightly variable, with an average profile of inverse P Cyg–type, with the deepest absorption at +15 $\mathrm{km\,s^{-1}}$ and the red absorption wing extending to +100 $\mathrm{km\,s^{-1}}$ (the radial velocities are referred to the stellar restframe).

Since the Hα region was most frequently observed and the photometric history of RY Tau is well documented, we can check if the flux radiated in Hα relates to the stellar brightness. The equivalent widths of the Hα emissions and the fluxes radiated in Hα are given in Table 1. In addition to the spectra listed in Table 1, we also used several older spectra in the Hα region obtained at Crimea in 1988–89 (Petrov & Vilhu 1991).

Fig. 11 shows that the flux in Hα is variable by a factor of three but does not reveal any dependence on the stellar brightness. On average, when the star is fainter, the Hα emission appears stronger, because the range of the continuum variability is

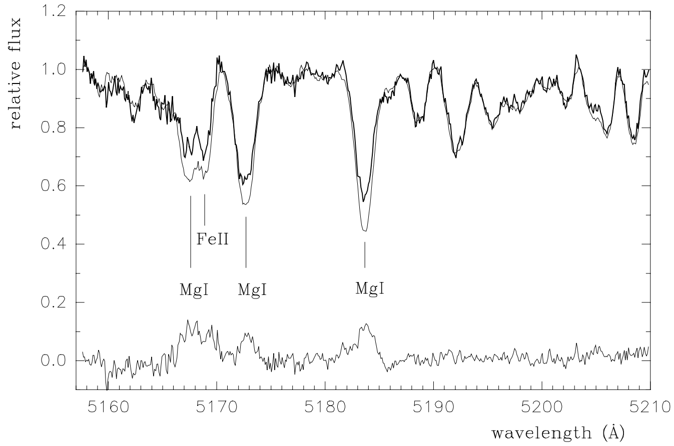

Fig. 10. The spectrum of RY Tau in the region of Mg I(2) 5167, 5172 and 5183 Å and Fe II(42) 5169 Å. The spectrum with the shallower lines is at low brightness (V= $10^{\mathrm{m}}.7$), the other one is the average spectrum at high brightness (V= $9^{\mathrm{m}}.6$). The curve at the bottom is the difference of the two spectra.

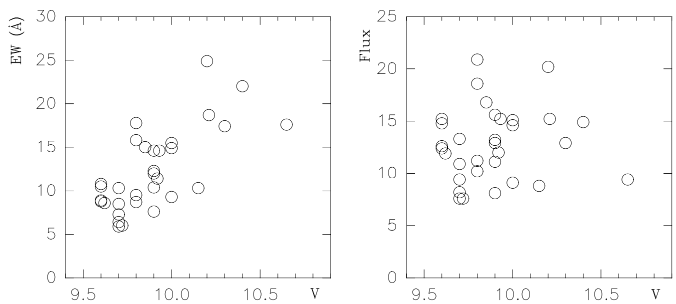

Fig. 11. Equivalent width and flux (in units of 10^{-12} erg cm^{-2} s^{-1} Å^{-1}) in the Hα emission as a function of stellar brightness.

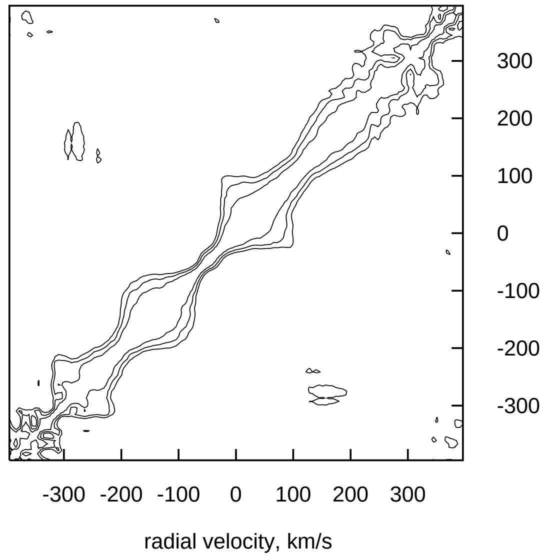

Fig. 12. Contour map of the correlation matrix for variations in the Hα *absolute flux* profile. The lowest contour represents a positive correlation at the 99.9% confidence level.

comparable to the range of intrinsic variability of the emission line flux.

The Hα line profile consists of a broad emission with symmetric wings extending to $\pm$ 400 km s^{-1}, and absorption components which appear and disappear on a time scale of days. There are two preferential velocities of these absorptions: one is around zero velocity and the other is at –100$\pm$50 km s^{-1}; both are clearly visible in the average Hα profile in Fig. 9. This kind of Hα profile variability was observed also in SU Aur (Giampapa et al. 1993, Johns & Basri 1995, Petrov et al. 1996).

The method of the correlation matrix is now commonly used to reveal a correlation in variability between different parts of a line profile or between two different lines. The correlation matrix Hα *versus* Hα plotted in Fig. 12 includes the 19 spectra listed in Table 1. The *absolute flux* profiles of Hα were used to compute the matrix, i.e. the variations of the continuum brightness do not affect the correlation matrix.

The two absorption components of Hα (at 0 and –100 km s^{-1}) vary independently from each other and independently from the rest of the emission profile. There is also no correlation between the blue (< -200 km s^{-1}) and red ($> +200$ km s^{-1}) wings of the line. The appearance of the correlation matrix is not very different from that published by Johns & Basri (1995).

4. Discussion and conclusions

There are at least three physical mechanisms which could account for the light variability of the TTS (see e.g. Herbst et al. 1994).

The first mechanism is an intrinsic one – the magnetic activity manifested in starspots resulting in (periodical) rotational modulation of the stellar brightness (the typical example is V410 Tau).

The second is related to interaction of the star with its circumstellar environment – irregular accretion of matter onto the star. This mechanism is probably dominant in the classical TTS, where accretion components are occasionally observed in the line profiles.

The third is an extrinsic one – obscuration of the star by circumstellar dust clouds. This phenomenon is most clearly observed in the UX Ori–type stars (Grinin et al. 1994), which are earlier spectral type counterparts of the TTS. It was also observed in the TTS RY Lup (Gahm et al. 1989). In a classical TTS, all three mechanisms may be in operation, which makes the observed variability very complicated.

The event of brightening of RY Tau, discussed in this paper, constitutes probably the rare case (for a classical TTS), when only one mechanism is dominant, while the others were not as efficient. Although the inflow of gas is evident through the red–shifted components of the sodium doublet lines and the He I line, the absence of measurable veiling indicates that accretion processes do not affect the brightness of the star. Neither is the presence of dark spots evident: no significant periodicity was found in the light variations. The case of a large polar spot of variable effective area can also be excluded: such a spot would be visible in the photospheric line profiles.

The constancy of the photospheric parameters indicates that the source of the light variability is extrinsic – the dusty circumstellar environment has changed its opacity along the line of sight, which was observed as an apparent brightening of the star. The increase of the linear polarization accompanying the decrease in brightness supports this conclusion. The circumstellar dust is most probably confined to a disk, i.e. we observe RY Tau almost equator–on. The large value of $v\,\sin i$ also supports this assumption.

The fact, that the flux radiated in the Hα emission does not correlate with the stellar brightness, may indicate that the emission line source is located mostly *outside* of the star. When the star is obscured by dust, the contribution from the emission line source becomes larger and the emission spectrum appears more prominent, while the flux radiated in emission lines remains about the same or varies independently.

The strengthening of emission lines at minimum brightness was reported earlier by other observers. From simultaneous photometric and spectroscopic observations, Holtzman et al. (1986) found that Hβ changes from absorption, when the star is bright (V$=9\overset{\mathrm{m}}{.}4$), to emission, when the star is faint (V$=11\overset{\mathrm{m}}{.}0$), and the forbidden line [O I] 6300 Å became visible when the star was faint. Analysis of IUE spectra showed that the line Mg II 2800 Å changes from absorption to emission when RY Tau is fading from V$=9\overset{\mathrm{m}}{.}9$ to V$=10\overset{\mathrm{m}}{.}8$ (Eaton & Herbst 1995). It was noticed also already by Herbig (1961) that the forbidden line of [S II] was more prominent in emission when the star was faint.

From all this, we may conclude that the emitting region is not screened by the circumstellar dusty disk, although we look at the star almost equator–on. The result is quite expected for the forbidden lines, which form in a region extending far out of the star. It could also be expected for Hα, which comes from a large volume of stellar wind, but was not expected for the Ca II emission, which is often treated as an indicator of chromospheric activity. The appearance of emissions in the Mg I and Fe II lines at lower brightness is also surprising. We may conclude that at least Hα and the Ca II emission lines in RY Tau are formed neither in a chromosphere nor in an atmosphere of a boundary layer, otherwise they would be subject to obscuration by dust as well as the central star.

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