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ASTRONOMY AND ASTROPHYSICS

Theta Tucanae: a binary with a δ Scuti primary*

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Abstract. Using seven four-hour time series of high-resolution spectra, the binary nature and the oscillations of θ Tuc are investigated. The spectrum is double-lined, proving the binarity. θ Tuc is a binary with a circular orbit and with an anomalous mass ratio q=0.09. The for the first time determined orbital elements are P=7.1036 days, K_1=8.6 km/s and K_2=95.6 km/s.

The oscillations of the δ Scuti-type main component are spectroscopically investigated. Line-profile variations are discovered, and radial-velocity variations reveal a main oscillation frequency of f_1=20.27 c/d which corresponds to the main oscillation 20.2806 c/d in photometry. Another frequency, f_2=18.82 c/d found in the spectroscopic data and not present in the photometric dataset, needs to be investigated more profoundly.

Key words: stars: binaries: spectroscopic – stars: individual: θ Tuc – stars: oscillations – stars: variables: δ Sct

1. Introduction

θ Tuc (HR 139, HD 3112, V=6.11, $\alpha_{2000} = 0^h33^m23.4^s$, $\delta_{2000} = -71^\circ16'0.''0$) is classified in the Bright Star Catalogue (Hoffleit 1982) as an A7IV star. The variability of θ Tuc was first noticed by Cousins & Lagerwey (1971) using photometry, and these authors derived a period of the variations of the order of 70–80 minutes. Stobie & Shobbrook (1976) classified θ Tuc as a δ Scuti star and noted irregular changes in the frequencies. Therefore, θ Tuc was thought to be a δ Scuti star with variable frequencies. On the other hand, Kurtz (1980) determined a set of 8 stable frequencies for θ Tuc using a dataset spanning 7 years. Beating of these frequencies gives the impression that some frequencies appear and disappear, but this model could be ruled out thanks to the large time span over which the data were taken. Quite a few δ Scuti stars show a complex spectrum of frequencies, but studies which involve a large amount of observing time now suggest that most of them have a constant frequency behaviour.

A 6-week multisite campaign on θ Tuc was performed by Paparó et al. (1996). These authors identified 10 highly-stable frequencies. They also noted strict periodicity for the nightly mean variations, a fact that was already noted by Stobie & Shobbrook and by Kurtz. They suggested for the first time that θ Tuc might be the primary of a binary system with a late F-type companion. Sterken (1997) showed, using Strömgren $uvby$ data, that θ Tuc is an ellipsoidal binary with a period of $7^d.04$ with a low-mass companion. A mass ratio of the order of 0.1–0.15 was determined using these photometric data and making use of the method of analysing the variability of ellipsoidal variable stars described by Morris (1985).

Sterken et al. (1997) determined the physical parameters for θ Tuc assuming that the contribution of the secondary does not significantly affect the photometric indices. They found an effective temperature of 7575 K, no anomalous metallicity, a $\log g$ value of 3.8 and a mass of the primary not higher than 2.0±0.1 $M_\odot$. The $v \sin i$ values reported in the literature range from 52 km/s (Bright Star Catalogue, Hoffleit 1982) to 80 km/s (Uesugi & Fukuda 1982).

Until now, few radial velocity measurements of θ Tuc have been published and it has not been proven yet that the true nature of the nightly mean photometric variations is binarity. In Sect. 2 we describe our spectroscopic observations. We present the details of the computation of the elements of the orbit in Sect. 3 and of the physical parameters in Sect. 4. Sect. 5 is devoted to the analysis of the line-profile variations (LPV) of the primary of θ Tuc. Finally, we discuss our findings in Sect. 6.

2. Observations and data reduction

All the spectra are high S/N blue spectra taken with a CCD camera attached to the Coudé spectrograph of the 1.4m CAT telescope at ESO La Silla, Chile. From a first set of six high-resolution spectra taken in December 1995, it was not clear whether variations in the radial velocity could be ascribed to line-profile variations or to the binarity of θ Tuc or to both. An indication of the binary nature was, however, apparent in the photometric observations of θ Tuc. With the aim of determining the binary nature as well as studying the pulsational behaviour in a spectroscopic way, new high signal-to-noise spectra were obtained in September 1996, with an integration time of $\sim$ 15

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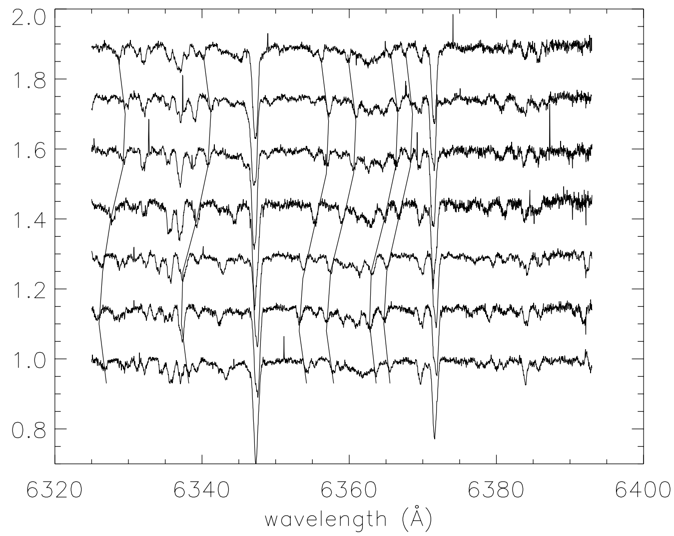

Fig. 1. 7 spectra taken at different phases in the binary orbit (from bottom to top: ϕ = 0.36, 0.5, 0.64, 0.78, 0.92, 0.06, 0.20). Some lines of the secondary star are marked.

Table 1. Journal of the observations of θ Tuc

Month-year	observer	N	S/N
December 1995	K. De Mey	6	> 200
September 1996	K. De Mey	148	~ 200
October 1996	G. Meeus	4	~ 200

minutes, which is a rather large fraction of the period of the main mode (71 minutes). These data consist of 7 time series observed from September 4 to September 10. A few spectra observed in October 1996 were taken with the specific aim of determining the orbital period with higher precision. A log of all the measurements is given in Table 1.

All the reductions (normalisation, flatfielding, wavelength calibration) were done using the MIDAS software package. The radial velocities for the lines of both components are derived by using Gaussian fits to the line profiles.

3. Orbital elements of θ Tuc

We used the 145 radial velocities determined from the spectra of 1995 and 1996 for the time-series analysis. Lines of the fainter, cooler component in θ Tuc were detected and identified on 7 series of spectra. The sharp lines of the primary are in clear contrast to the much shallower lines of the secondary (Fig. 1). The lines of both components seem to be strictly photospheric, and no emission at Hα is seen in the spectra of θ Tuc. Several lines are blended, which resulted in problems for the velocity determinations. The heliocentric radial velocities are derived using the Si II doublet (6347.091–6371.359 Å) for the primary and the mean of 11 lines for the secondary.

Using the observations made during several nights and within one night, we proved that θ Tuc is a binary star with a pulsating primary component. We then performed a period analysis

Table 2. Orbital elements of the binary θ Tuc determined with the Lehmann-Filhés method.

Element	θ Tuc
P (days)	7.1036 $\pm$ 0.0005
$v_{1\gamma}$ (km/s)	9.5 $\pm$ 0.1
$v_{2\gamma}$ (km/s)	7.31 $\pm$ 0.15
K_1 (km/s)	8.57 $\pm$ 0.15
K_2 (km/s)	95.6 $\pm$ 0.2
σ_1 (km/s)	1.27
σ_2 (km/s)	1.72
e	0.0
$a_1 \sin i$ (a.u.)	0.0056
$a_2 \sin i$ (a.u.)	0.062
q	0.0896

of all the radial velocity measurements of the primary and of the secondary component using the PDM-method (Stellingwerf 1978) and found an orbital period of 7.10 days, which is not in contradiction with what was found using photometry (P=7.04 days).

Preliminary solutions for the orbital elements of both components resulted in a small value of 0.02 for the eccentricity. Applying the Lucy-Sweeney test (1971) convinced us that the orbit is circular. Orbital elements were derived separately for each component using a code based on the Lehmann-Filhés method, where the period was also taken as a free parameter and with e fixed at zero. This code was first published by Bertiau & Grobben (1969) and is kindly put at our disposal by Dr. E. Bakker. Agreement between elements common to both orbits is good, except for a small difference in the γ velocity which is due to an uncertainty in the determination of the radial velocities of the secondary component. Our final orbital elements and their standard deviations are given in Table 2. In this table, P is the period of the orbit, v_γ the γ-velocity, K is the amplitude of the velocity curve, and q the mass ratio M_2/M_1. The radial-velocity curve folded with the 7.1036-day period is shown in Fig. 2. Asterisks correspond to the data for the primary component and triangles to those for the secondary.

4. Physical parameters of the binary components

From the orbital parameters, we obtained a spectroscopic mass ratio q=0.0896. The individual masses are then found to be $M_1 \sin^3 i$=0.7 $M_\odot$ and $M_2 \sin^3 i$=0.063 $M_\odot$ for the primary and secondary, respectively. The fact that lines of both components are observed in the high-resolution optical spectra means that these stars must have comparable brightness, and therefore cannot differ too much in radius. In order to obtain the properties of the components of θ Tuc, analysis of its light curve is required.

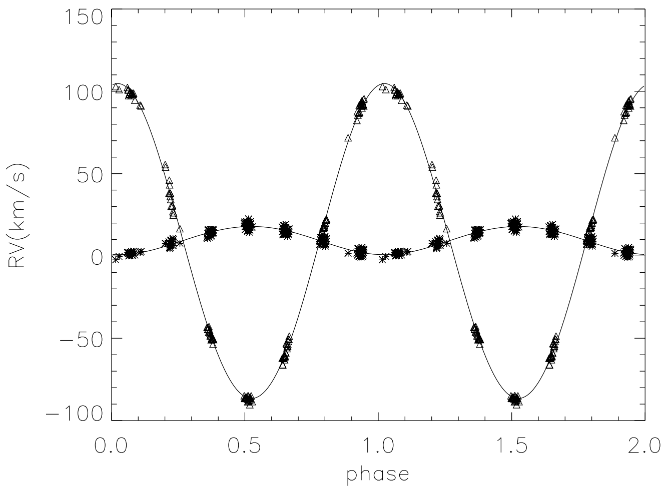

Fig. 2. Radial velocities of θ Tuc from observations obtained at La Silla during different campaigns in 1995 and 1996. Asterisks and triangles denote primary and secondary component data, respectively. The calculated orbit with $P = 7^d.1036$ is shown by the full line for the primary and secondary component. Phase zero corresponds to the time of periastron passage.

4.1. Analysis of the light curve

Combining the Strömgren data in the $uvby$ bands (Sterken 1997), prewhitened with the 10 high frequencies as found by Paparó et al. (1996), with the radial-velocity curves for both components, we can make an estimate of a few physical parameters. The data are not favourable for an accurate determination of basic system parameters, so we seek only an approximate solution that is reasonably consistent with all photometric and spectroscopic data. As already mentioned in Sterken (1997), the form of the light curve indicates that θ Tuc is a non-eclipsing binary with ellipsoidal variations. The light variability is probably due to tidal distortion of the components.

A physical model for θ Tuc can be proposed using a program analogous to the Wilson-Devinney code (Daems 1998) where the light curves corresponding to the different filters are decoupled. We assume that the gravity darkening exponents are $g_1 = g_2 =1$, as usual for radiative atmospheres. For the bolometric albedos we use the values $A_1 = A_2 = 1$; the limb darkening coefficients are taken from Wade & Rucinski (1985). Several discrete values of the inclination were assumed: 25°, 30°, 35°, 40°, 45°, 50°, 55°. This restriction on i is necessary because otherwise the masses would be unrealistic (Table 3). We carried out solutions with the effective temperature of the primary (T_1) fixed at a series of reasonable values, namely 7575 K, 8000 K and 8500 K, and explored all possible geometrical adjustments. The lower boundary for the temperature T_1 corresponds to the temperature found by Sterken et al. (1997) under the assumption that the secondary does not change the photometric indices. The upper boundary 8500 K corresponds to the temperature of an A4 type main-sequence star. As a function of this T_1 and the different values of i, three adjustable parameters remain in the construction of the synthetic light curve, i.e. the effective temperature of the secondary T_2 and the filling factors for both components s_1 and s_2. These preliminary fitted solutions to the observed light curves lead to a rough estimate for the inclination between $25°$ and $55°$, corresponding to $2.7R_\odot > R_1 > 1.7R_\odot$ and $2.2R_\odot > R_2 > 1.6R_\odot$ and temperatures T_2 for the secondary slightly cooler than the primary. All the models corresponding to different inclinations lead to a $\log g$ of about 4 for the primary and 3 for the secondary.

Table 3. The masses of both components of θ Tuc as a function of the inclination i.

i	$M_1(M_\odot)$	$M_2(M_\odot)$
10°	134	12
20°	17	1.6
30°	5.6	0.5
40°	2.6	0.2
50°	1.5	0.14
70°	0.8	0.07

The spectral energy distributions can be constructed after calculating the fluxes in the $uvby$ bands. We can fit these data in two ways. One way is by assuming that the contribution of the secondary is negligible, which results in a good fit with the Kurucz (1979) model having T=7500K and $\log g$=3.5 (found by Sterken et al. 1997). The second way is by assuming that the fluxes result from both components and by using the temperatures and $\log g$ values previously estimated. The fluxes can be well fitted with Kurucz models T_1=8000K and $\log g_1$=4, and T_2=7000K and $\log g_2$=3, assuming comparable luminosities, but in this case the secondary must be taken slightly more luminous (a ratio of L_1/L_2=0.7) to be able to fit the Balmer jump. The luminosity ratio of 0.7 is not in agreement with the observed ratio of the Hα lines of both components if we take into account the temperature dependence of this line. The spectra suggest that the primary must be more luminous than the secondary which is also confirmed by the ratio of the radii. The energy distributions are shown in Fig. 3.

4.2. Calculation of possible evolution scenarios

The large mass ratio of the binary is most unusual, certainly so for a double-lined spectroscopic binary. It can only be explained if the system is a post-mass-transfer binary, in which the present secondary once was the more massive component. Nevertheless, the presently less massive and cooler component seems to be smaller than its Roche lobe which means that the binary was probably once semi-detached, but is now detached. The secondary is possibly the remnant of an Algol-like loser. Repeated observations failed to find Hα emission from an accretion disk. This lack of Hα emission is also noted in another Algol system, S Cancri (Popper & Tomkin 1984). On the other hand, Templeton (private communications) found an IR excess for θ Tuc, which may arise from a shell ejected during the past episodes of mass transfer.

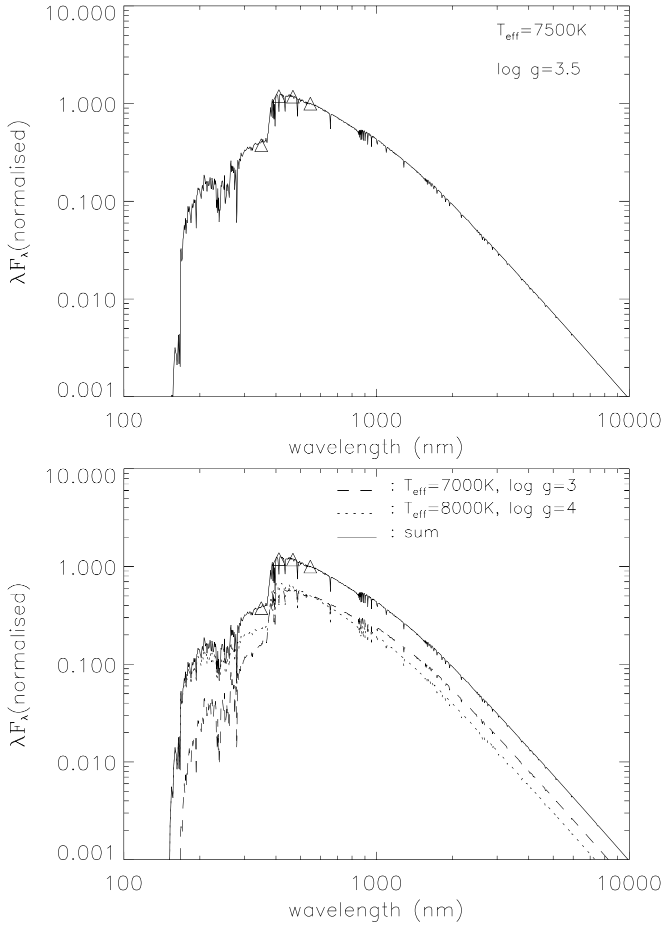

Fig. 3. The spectral energy distributions of θ Tuc. The fluxes in the $uvby$ bands are marked with triangles. Top: fit with one Kurucz model assuming no contribution of the secondary to the fluxes. Bottom: fit with two Kurucz models corresponding to both components of the star.

In an attempt to restrict the interval for the inclination i, we tried to calculate approximative binary evolutionary models by the code implemented by Daems (1998). We calculated back in time to determine the physical parameters of the system before the onset of mass transfer. We computed these tracks by first assuming that the evolution has occurred in a conservative way, meaning that no mass has left the system. Subsequently, a non-conservative approach has also been executed.

We assume that the small secondary mass is not significantly larger than the mass of the core, so that we can apply the relation between the mass of the core at the end of the main sequence and the total (initial) mass of the star. According to Iben & Tutukov (1985) this relation is $M_{He} \simeq 0.08 M_{total}^{1.4}$ for intermediate-mass stars. We can determine the masses of both components as a function of the inclination angle, and use this relation to calculate the initial mass of the secondary, which is considered as the former loser. Possible evolution scenarios can be calculated and give us parameters for the initial situation of the binary and its components before the onset of mass transfer in the case where ΔM=0 and in the non-conservative case where $\Delta M \neq 0$. The calculations make use of the tables of Maeder & Meynet (1988) in which the temperature and luminosity are given as a function of the age of the star.

The calculated evolution scenarios give us the possibility to restrict the inclination, because some solutions are unrealistic. Scenarios which result in an initial mass ratio q_i of the order of 1 can be excluded. If q_i is not significantly greater than 1, both stars would have started filling their Roche lobe at about the same time and this seems in our case an impossible scenario. Another assumption is that mass transfer must have started before a deeply convective envelope existed, otherwise the system would have gone through a common-envelope phase. Other scenarios which are immediately excluded are the models that lead to future losers with an initial radius that exceeds the Roche surface before the onset of mass loss.

More accurate values for the inclination of the system can be estimated, adopting these three assumptions. In the conservative case, only inclinations $40° < i$ lead to realistic scenarios. The lower value is fixed by the assumption that the initial R may not exceed the initial Roche lobe radius. For inclinations higher than $45°$, the initial mass of the loser becomes less than 1.7 $M_\odot$. This result does not fulfill the assumption of intermediate-mass stars, which means that the relation of Iben & Tutukov becomes invalid and therefore nothing can be said about the upper limit for i in the conservative case. An initial mass larger than $1.7 M_\odot$ is, however, a reasonable assumption considering the present spectral types and orbital parameters of both components.

Taking into account the possibility of mass escaping from the system even further reduces the inclination for realistic models. If the amount of mass lost from the system increases, the number of possible solutions decreases. For the non-conservative calculations, the upper limit for i is set by the non-convective envelope assumption. For higher ΔM values, the lower i value is fixed by the condition that $q_i \gg 1$. The latter condition implies that not more than 0.6 $M_\odot$ can be lost from the system, which leaves only one realistic scenario.

Thus, independently of whether the mass transfer has been conservative or non-conservative, the inclination for the binary θ Tuc is restricted to $33° < i$. The determination of the upper limit for i is uncertain due to the restrictions of the Iben & Tutukov relation which is only valid for intermediate-mass stars. Corresponding masses are $4.3 M_\odot > M_1$ and $0.4 M_\odot > M_2$, and the radii of the primary and secondary lie in that case between $2.6 R_\odot$ and $1.7 R_\odot$, and $2.2 R_\odot$ and $1.6 R_\odot$, respectively.

5. Line-profile variations

5.1. Global behaviour

We focus now on the description of the line-profile variations. We base our study on the observations obtained in September 1996 and concentrate on the behaviour of the Si II 6347 Å line. We subtracted the nightly averages from the individual profiles. The residuals have been combined into 2-dimensional greyscale pictures. A greyscale display (Fig. 4) of the behaviour of this line during three of the seven nights shows the variations within the

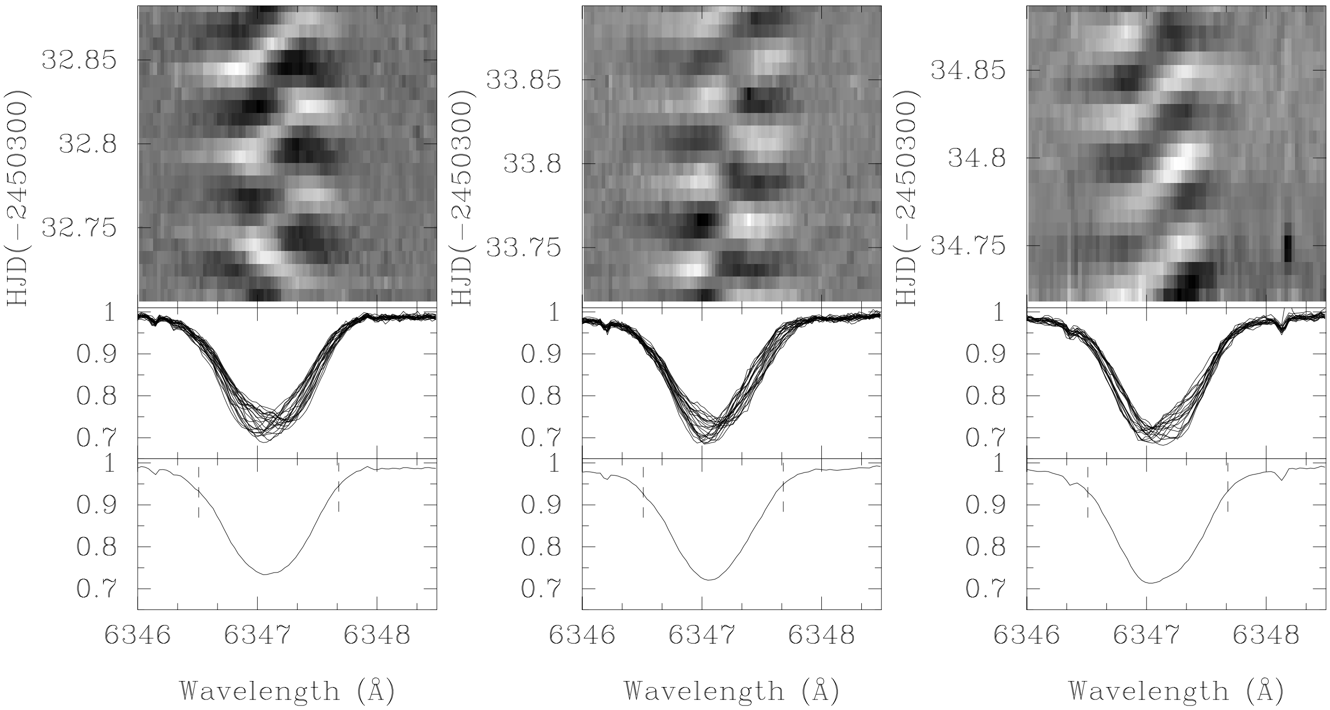

Fig. 4. An example of the variability of Si II 6347 Å in θ Tuc on three nights in September 1996 (HJD from bottom to top). The wavelength coverage is from 6346.0 to 6348.5 Å. Shown are: top: the residuals with respect to the mean profile. Black (white) denotes local flux deficiencies (excesses), middle: the normalised spectra, bottom: the mean profile of all the spectra of that night. The wavelength interval used for the determination of the moments is marked.

line profiles. Individual observations are represented by shades of grey that are proportional to the residual flux and stacked in order of time. The line asymmetry varies continuously on a time-scale of hours.

5.2. Period analysis

We prewhitened the data with the binary period to analyse the high-frequency variations observed in the primary component of θ Tuc. We used different diagnostics to study the periodic variations in the line profiles. We searched for periods on either the moments of the Si II absorption lines (Aerts et al. 1992) or on the intensity variations as a function of position in the line profile (Gies & Kullavanijaya 1988, Schrijvers et al. 1997).

The equivalent width, full width at half maximum, first, second, and third moment of the Si II 6347 Å line contain some uncertainty since lines of the secondary blend this Si II line at certain phases. The moments were therefore determined in an interval which gave the least scatter in the determination of the first moment. The wavelength interval used for the determination of the moments is also marked on Fig. 4.

A detailed frequency analysis carried out for the full data set on the first three moments using the phase dispersion minimisation method of Stellingwerf and the CLEAN-method (Roberts et al. 1987) revealed the most significant frequency f_1=20.27 c/d, which corresponds to the main photometric frequency 20.2806 c/d of this δ Scuti star. A second frequency f_2=18.82 c/d is found which is not present in the photometric data. A fit using both frequencies accounted for a fraction of the variance of 72% and 67%, respectively for the first and third moment without taking into account beat terms. A fit of the variations of the radial velocity with these two frequencies is shown in Fig. 5. Neither of the two frequencies are apparent in the second moment (Fig. 6). On the other hand, two other frequencies are dominant in the second moment: f_3=20.78 c/d and f_{4a}=18.14 c/d. A fit using f_3 and f_{4a} accounts for a variation fraction of 38% for the second moment. We also note a frequency f_{4b}=19.05 c/d in the first and third moment. However, due to the limited time base, the long integration time, and the small number of data points, the frequency determination is not very accurate and we cannot distinguish between the real frequency and the 1-day alias.

The CLEAN method was further applied to the second diagnostics, i.e. the intensity variations as a function of the position in the line profiles. We show the result in the periodogram in Fig. 7. We notice discrete patches of power in the periodogram, some of which extend across the whole line profile. We summed the detected power of the periodogram of the variation across the lines to a one dimensional periodogram (also shown in Fig. 7) and compared this with the periodogram determined from the first method. We can clearly distinguish the two frequencies f_1 and f_2 which are responsible for the variations in almost the whole line profile. We must note here, however, that after the first trials, a sizeable fraction of the power for the main frequency f_1 was found at its 1-day alias 19.275 c/d. We therefore obliged the CLEAN algorithm to put the power of this alias frequency at f_1 making use of the partial CLEANing technique, and thus

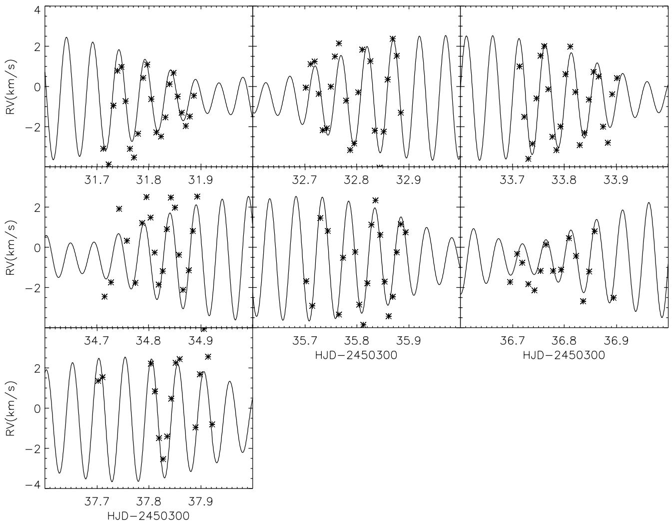

Fig. 5. Radial-velocity variations measured from Si II 6347 Å after removing the variations due to the orbital period. The full line represents the fit using the frequencies 20.2806 c/d and 18.82 c/d.

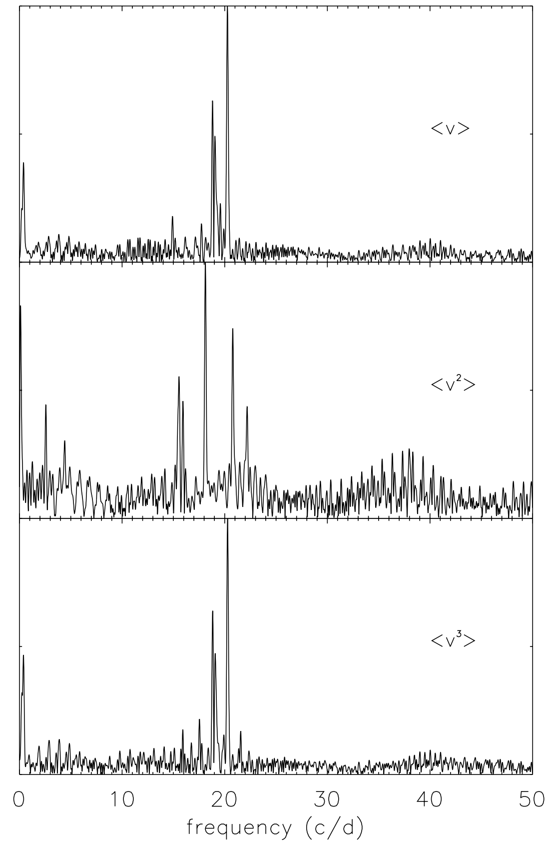

Fig. 6. The CLEANed periodogram of the velocity moments of the Si II 6347 Å line. One can see the dominant frequencies f_1 and f_2 in the first and third moment, and the frequencies f_3 and f_{4a} in the second moment.

ensuring that all power of the variations is CLEANed at the right frequency. Besides the two clear frequencies which we observed in the first and third moment, the frequencies f_3, f_{4a} and f_{4b} are also present in the intensity variations. The frequencies f_3 and f_4 are responsible for the variations in the center of the line. In this way, our different frequency-determination methods give a consistent picture since we notice the same frequency pattern as in the moments.

We found, besides variability at the previously noted frequencies and their one-day aliases, evidence for variational power at a complex pattern of other frequencies, which can be attributed to harmonics and/or other pulsation modes which are expected to be present in the case of θ Tuc.

5.3. Determination of the velocity parameters

The mode of the pulsation frequency can be determined using the method proposed by Telting & Schrijvers (1997). In a systematic study, including toroidal correction terms due to rotation, they analysed the phase diagrams for all possible spheroidal modes (ℓ,m) taking into account all the different parameters that play a role in the pulsation (i, k, pulsational amplitude, $\Omega/\omega, T$). It seemed that the maximum phase changes within the line profile (expressed in units of π radians) are related to the value of ℓ and $|m|$. For each of the detected frequencies, we read off the phase diagrams to obtain blue-to-red phase differences. These phase diagrams contain diagnostics on the pulsation mode.

The phase corresponding to the main frequency f_1 is constant over the whole line profile with a phase jump of the amplitude of π in the region where the amplitude of the variations due to f_1 is zero, as is shown in Fig. 8. Surprisingly, this phase behaviour corresponds to a radial mode (ℓ=0).

The phase difference corresponding to f_2 is difficult to determine, because the variational power in the wings is small, but also because the rotational velocity is not high enough to make use of Telting and Schrijver's method for $l \geq$1.

When attempting mode determination using the moment method (Aerts 1996), we do not recover the radial mode as the best solution. It is known from simulations that a radial mode is easily lost as best solution when noise is present (Aerts 1996). By means of higher signal-to-noise and more numerous spectra we could perhaps recover the radial mode as the best solution. For the mode with f_2, the moment method points to a non-axisymmetric pulsation mode with high ℓ ($\geq$ 3). This is consistent with the fact that this frequency is not observed in the photometric data. The mode responsible for the variations in the center of the line with frequency f_3 is probably a sectoral mode because there is no contribution of $2f_3$ in the variations of the second moment. A sectoral mode is also consistent with variations in the center of the line.

6. Discussion

High-spectral-resolution and high-S/N spectroscopy of θ Tuc allowed us to confirm the suspicion that the star is a binary system and to derive the orbital elements of this binary. Lines of both components were visible in the spectra which allowed us to determine the mass ratio q with much

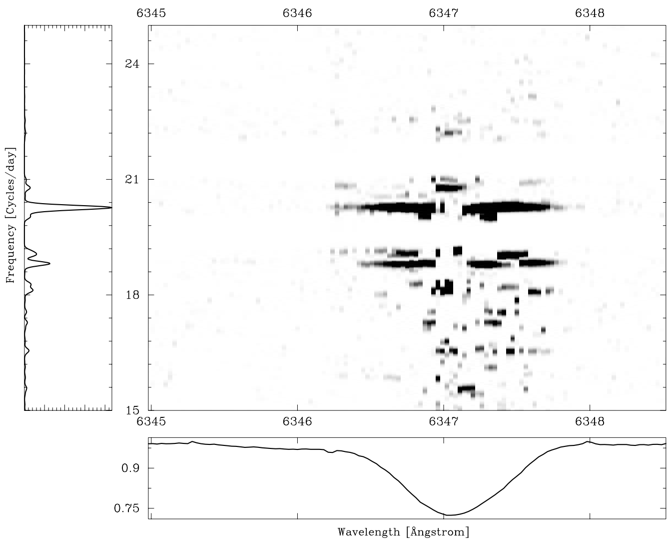

Fig. 7. CLEANed Fourier periodogram of the intensity variations in the Si II 6347 Å line. For each wavelength bin, the power as a function of frequency is plotted as a grey value. The bottom panel shows the mean spectrum of the data set. The left panel shows the sum of the detected power in a one dimensional periodogram. Clearly seen are the frequencies f_1=20.2806 c/d and f_2=18.82 c/d as found in the first and third moment and which extend throughout the whole profile. Also present are the frequencies f_3=20.78 c/d, which is only visible in the center of the line, and f_{4a}=18.14 c/d and its one day alias f_{4b}=19.09 c/d as seen in the second moment.

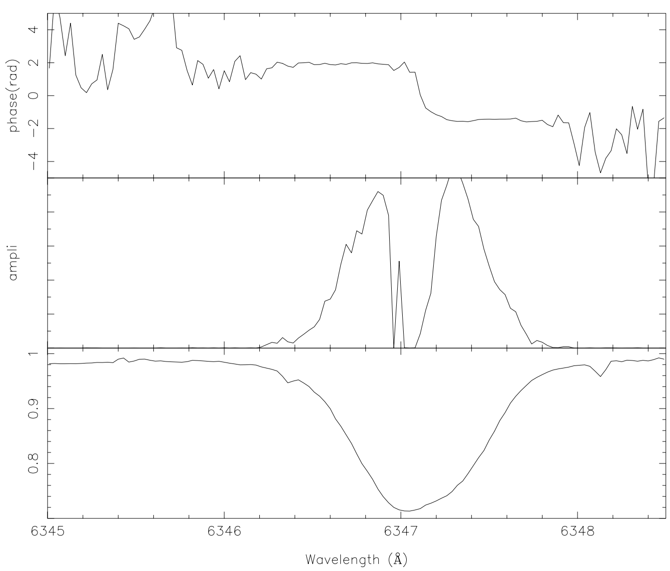

Fig. 8. Amplitude and phase diagram of f_1 of θ Tuc, as derived from the periodogram shown in Fig. 7. In the bottom panel we show the mean profile of the Si II 6347 Å line, in the middle the amplitude distribution is given, and in the top panel we show the phase diagram with the ordinate in radians.

more accuracy than photometrically determined. Thanks to the availability of the photometric light curve, we were able to determine an estimate of the physical parameters of both components. The cooler, less massive, secondary is probably the remnant of a former loser in an Algol system.

We detected rapid variations of the profiles of the lines of the main component and determined some of the frequencies responsible for these variations which in some part are consistent with the variations found in photometry.

We were able to determine not only the main pulsation frequency f_1 but we also showed that the pulsation mode solution is radial. This is rather surprising, because the light curve indicates that θ Tuc is a non-eclipsing binary with ellipsoidal variations. We must note here that the method used is only tested for single stars. No method for the determination of pulsation modes exists for stars in binary systems where one must include the effect of tidal interactions. We were not able to investigate all the modes present in the primary component of θ Tuc, due to the limited number of spectra and the long integration time compared to the variations, but we can conclude that some modes must be non-axisymmetric pulsation modes.

A further step in the investigation of this star is the detection of the new frequency f_2 as the one which is only visible in the spectra and, therefore, must be due to a high-degree pulsation mode. We need more high-signal to noise spectra to refine the value of this pulsation period and to identify the pulsation parameters.

Also in the case of the p-mode pulsations in this δ Scuti star, it remains a problem for future research to what extent the binary nature is related to the observed line-profile variations. By all means, θ Tuc is a δ Scuti star which deserves intensive further study. Full identification of the extremely rich pulsation-mode spectrum of this star should be confronted with theoretical computations of its pulsation frequencies. Such a study would put important constraints on structural models for this star, as it is now being performed in asteroseismological studies of δ Scuti stars such as FG Vir (Breger 1995) and CD-24.7599 (Handler et al. 1997). In the specific case of θ Tuc one is confronted with the exceptional opportunity to perform asteroseismology on a post-mass-transfer δ Scuti star, the history of which is severely constrained by the study of the orbit and the detectability of the companion. This object then offers a unique opportunity to put tight observational constraints on close-binary evolution, and on the structure of the mass gainer in particular.

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