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The oEA star TW Dra - a spectroscopic analysis

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Abstract

We investigate a spectroscopic time series of the oscillating Algol-type star TW Dra to derive basic system and stellar parameters and to prepare for mode identification. From the orbital solution we derive precise masses and get disentangled spectra of the components by using KOREL. For the primary we derive about solar abundance. Computed LSD profiles show a puzzling picture of blue-to-red traveling bumps indicating a rich spectrum of nonradial pulsations. Three pulsation frequencies could be found by using FAMIAS. A first attempt of mode identification indicates that TW Dra shows high-degree modes in the range of l=7-12.

Individual Objects: TW Dra

Observations

TW Dra is a member of the recently established class of the oEA stars (Mkrtichian et al. 2002, 2004), i.e. Algol-type systems with mass transfer where the primary shows δ Sct-like oscillations. Its spectral type is A5 V+K0 III. TW Dra is also part of a close visual binary. The investigation is based on spectroscopic time series taken in 13 consecutive nights in 2007 with the 2-m telescope at TLS. Spectra have a resolution of 33 000 and cover 4 700–7 400 Å.

Analysis

We used KOREL (Hadrava 2004) to derive the orbital solution and to disentangle the spectra of the three components. KOREL also derived the timely varying line strengths (eclipses of TW Dra, third component from the visual binary that contributes to the spectra in dependence on seeing conditions and slit orientation of the spectrograph). From the obtained RV semi-amplitudes and the inclination of the orbit of 86.4° known from photometry, we derived the masses of the primary and secondary to 2.13 and 0.89 $M_\odot$, respectively. The separation of the circular orbit is 12.11 $R_\odot$. Model atmospheres for the hot primary were calculated with the LL-method (Shulyak et al. 2004) and synthetic spectra with the SynthV-method (Tsymbal 1996). The values $T_{\rm eff}$=8150 K and $\log g$=3.88 were taken from the photometric solution and fixed. From an iterative fit of the disentangled spectrum of the primary using the 4895 to 5670 Å range, we derived the micro-turbulence to 2.9 km s^{-1}, $v \sin i$=47 km s^{-1}, and about solar abundance.

We obtained mean line profiles of high S/N by using the least squares deconvolution technique (Donati et al. 1997). Fig. 1 shows the obtained profiles from some of the runs of our time series. The puzzling picture of blue-to-red traveling bumps indicates a rich spectrum of nonradial pulsations. For a first analysis, we only used profiles from out-of-eclipse phases

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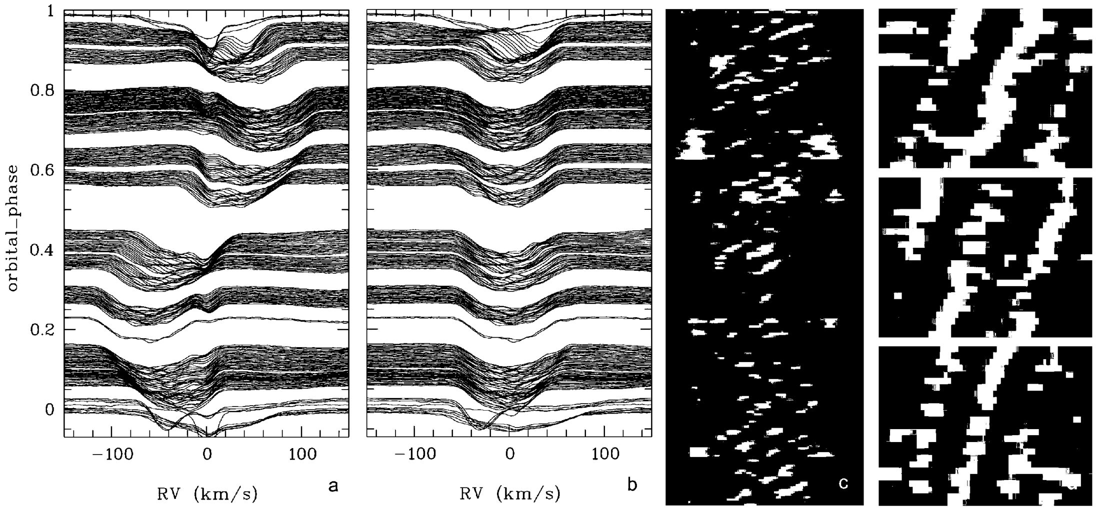

Figure 1: Time series of LSD profiles. a) Original profiles. b) Shifted and corrected for the third component. c) Differential profiles after subtracting the mean profile (in a running order). d) Central parts of profiles ($\pm 50\,\mathrm{km\,s^{-1}}$) averaged into 25 pulsation phase bins. From top to bottom for f_1 to f_3.

which were shifted to the rest frame of the primary and cleaned for the contributions from the second and third component by adjusting rotationally broadened Gaussian profiles (Fig.1c).

We used FAMIAS[1] (Zima 2008) and applied the pixel-by-pixel method and successive prewhitening to determine the oscillation frequencies. We found three modes of f_1=22.90 c d^{-1}, f_2=14.06 c d^{-1}, and f_3=24.72 c d^{-1} but could not detect the 17.99 or 18.95 c d^{-1} found by Kusakin et al. (2001) and Kim et al. (2003) in the photometry. The search in the line profile moments gave no findings. Fig. 1d shows the traveling bumps after averaging the LSD profiles into 25 pulsation phase bins folded with the corresponding period. In this way, the contributions from all other modes are smeared out.

A first attempt to identify the modes with FAMIAS using the FPF method showed that all three modes are high degree modes with l and m in the range of 7 to 12. No unique identification neither in l nor in m could be derived so far. In a next step, we want to improve the mode identification by improving the steps of data reduction to further reduce the influence of the second and third components, using the much more time-consuming multiple frequency analysis in FAMIAS in combination with a light curve analysis, and by modeling the spectra during the eclipses (spatial filtration technique, Gamarova et al. 2003).

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