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Absolute parameters of detached binaries in the southern sky - III: HO Tel

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HIGHLIGHTS

- First radial velocity analysis of HO Tel are presented.
- ASAS *V* and Walraven five-colour (*WULBV*) photometric light curves of HO Tel were solved.
- Absolute parameters of the components were derived.
- The evolution case of HO Tel was discussed.

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ABSTRACT

We present the first radial velocity analysis of the southern eclipsing binary star HO Tel, based on spectra obtained at the South African Astronomical Observatory in 2013. The orbital solution of this neglected binary gave the quite large spectroscopic mass ratio of 0.921(±0.005). The *V* light curve from the All Sky Automated Survey (ASAS) and Walraven five-colour (*WULBV*) photometric light curves (Spoelstra and Van Houten 1972) were solved simultaneously using the Wilson–Devinney code supplemented by the Monte Carlo search method. The final photometric model describes HO Tel as a detached binary star where both component stars fill about three-quarters of their Roche limiting lobes. The masses and radii were found to be 1.88(±0.04) $M_\odot$, 2.28(±0.15) $R_\odot$ and 1.73(±0.04) $M_\odot$, 2.08(±0.16) $R_\odot$ for the primary and secondary components of the system, respectively. The distance to HO Tel was calculated as 282(±30) pc, taking into account interstellar extinction. The evolution case of HO Tel was also examined. Both components of the system are evolved main-sequence stars with an age of approximately 1.1 Gy, when compared to Geneva theoretical evolution models.

1. Introduction

Christensen-Dalsgaard (2010) and Christensen-Dalsgaard and Houdek (2010) have succinctly described various important challenges facing current stellar models. The resolution of these challenges demands that physical parameters of stars are determined with greater accuracies than before. Spectroscopic and photometric observations of eclipsing binary (EB) systems provide one of the most reliable routes toward this goal. Algol EB systems allow the additional study of mass transfer and angular momentum transfer in binary systems, as well as the interaction of these systems with the interstellar medium. Since a high proportion of stars are born in multiple systems, the study of EB systems is also very important for understanding the evolution of a large population of stars in our Galaxy. Present techniques allow the determination of masses with accuracies approaching 1 per cent (Pavlovski and Southworth, 2012). Unfortunately, the actual number of systems analysed to this level of precision remains relatively small (Torres et al., 2010). The sample size of EBs with accurately-determined values of stellar and orbital parameters needs to be increased substantially in order to reach statistically-supported insights into stellar evolution

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based upon EB data, and also to improve our understanding of mass transfer and angular momentum transfer between stars and their environment. With this aim in mind, we have been conducting a long-term spectroscopic campaign to obtain radial velocities of Algol systems in the Southern sky, since 2012.

This paper is the third in a series of reports (Erdem et al., 2015; 2016) on the physical parameters of detached binary systems obtained by applying cross-correlation techniques to detailed radial velocity measurements of southern Algol systems (or Algol-like systems) which have not previously been studied for radial velocities, but appear to have spectroscopically separable components.

The variability of HO Tel (CPD −47 9372 = GSC 08390-00625 = HIP 97756, $V = 8.31$ mag) was discovered by Strohmeier et al. (1965) using Bamberg photographic plates. They classified HO Tel as an Algol-type binary star. They also determined the spectral type and orbital period of the system to be A2 and 0.89180 days, respectively. However, Spoelstra and van Houten (1972) corrected the orbital period of the system to 1.6131409 days using four epochs of the minimum obtained with five-colour photometry. Sistero and Candellero (1979) confirmed this orbital period of the system. Grygar and Horak (1980) analysed the five-colour (*WULBV*) photometric light curves of Spoelstra and van Houten (1972), using the limb-darkening scan technique (Horak, 1981). Giuricin and Mardirossian (1981) solved *LBV* light curves from Spoelstra and van Houten (1972) five-colour photometric data using Wood (1972)'s model. They suggested that HO Tel appears to be a normal main sequence (detached) system. Mallama (1981) obtained new *BV* times of minimum and an ephemeris of the system. Slee et al. (1987) did not detect microwave emission (5.0/8.4 GHz) from HO Tel in their microwave survey of southern active stars between 1981 and 1987. Renson et al. (1991) listed HO Tel in the general catalogue of Ap and Am stars.

2. Spectroscopic observations and data reduction

The first spectroscopic observations of HO Tel were made at the Sutherland Station of the South African Astronomical Observatory (SAAO) in 2013. A grating spectrograph with SITe CCD camera installed at the Cassegrain focus of the 1.9 m telescope was used. The SITe CCD is effectively 266 x 1798 pixels in size, and is usable over wavelengths ranging from 0.35 µm to 1 µm, with pixel size of 15 µm. We selected grating 4 of the spectrograph - which has a wavelength coverage of 410–510 nm with a blaze peak at 460 nm and a resolution of 0.1 nm (giving R = 4600 for the chosen wavelength range) - and a slit width of 1.5 arcs, for all of our observations.

We obtained a total of 45 spectra for HO Tel during the weeks of 24–31 July 2013 and 1–6 August 2013. We took comparison spectra with a Cu/Ar arc lamp before and after each stellar spectrum. A set of Quartz-Iodine lamp images was also taken for flat-field calibrations. The standard stars HD 693 (F8V, $V_r = 14.81$ km/s) and HR 3383 (A1V, $V_r = 2.80$ km/s) were observed to standardise our radial velocity measurements of the components of HO Tel. The exposure times ranged from 1000 to 1500 s, depending on weather conditions. Data reduction and calibrations were carried out using standard IRAF procedures.

3. Modelling of radial velocities

We derived radial velocities (RVs) of the components of HO Tel using the FXCOR task in the RV package of IRAF (Tonry and Davis, 1979; Popper and Jeong, 1994) and chose two different spectral regions (4400–4800 Å and 4900–5100 Å) for the cross-correlation technique (CCT). Especially, He I 4713, 4921, 5015, Mg I 4703 and Mg II 4481 lines were used for CCT. On the other hand, H Balmer lines, which are strong in B and A type stars, can lead to seriously underestimated RVs (e.g. Petrie and Andrews, 1966; Andersen, 1975). Therefore, we did not use the H Balmer lines and diffuse He I lines for CCT. However, in our previous study (see Sürgit et al., 2015), two different spectral regions (4600–4800 Å and 4700–4950 Å), including the Hβ line, were analysed simultaneously using a Fourier disentangling method (KOREL; Hadrava, 1995; 1997), and almost the same results were found.

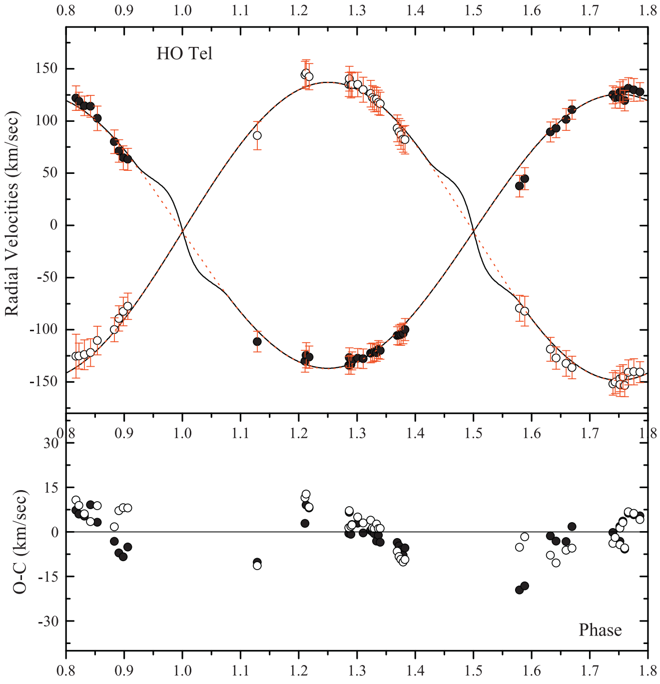

Fig. 1. Best theoretical fits to radial velocity curves for HO Tel. The solid black lines include proximity effects (see Section 4), while the dotted lines correspond to Keplerian orbits.

A Gaussian function was adopted as the best-fitting one, and the spectra of HD693 were used as a template for deriving RVs of the components. The RV measurements - with standard errors - of the components of HO Tel are given in Table 1. Phase values of the observed times of the RVs were calculated using the linear ephemeris in Table 2.

We calculated the orbital parameters from the RV data derived from the CCT by using the ELEMDR77 program, developed by T. Pribulla (private communication). After several iterations, the ELEMDR77 program gave a value close to zero for the eccentricity, e, within uncertainties. Consequently, we adopted a circular orbit for the system. During the iterations, the orbital period, P_{orb}, of HO Tel was fixed at the value 1.613097 days (from Pojmanski and Maciejewski, 2004). The adjusted parameters were the velocity amplitudes K_1 and K_2 of the components as well as the conjunction time T_0. The best-fitting orbital elements are included in Table 2, and the best theoretical fits to the radial velocity curves are shown in Fig. 1.

4. Modelling of light curves

In order to obtain absolute parameters of the system and its components, the 1965 Walraven five-colour (*WULBV*) photometric light curves (Spoelstra and van Houten, 1972) and the 2001–2009 ASAS *V* light curve (Pojmanski and Maciejewski, 2004) of HO Tel were solved simultaneously. The Wilson–Devinney (W-D) code (Wilson and Devinney, 1971) was used to solve these light curves. However, instead of the differential correction (DC) algorithm in the code, the Monte Carlo (MC) search method