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uvby photometry of θ Tucanae

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Abstract

θ Tucanae (HR 139, $V = 6.11$, A7 IV) is a binary with a δ Scuti primary that was the subject of several photometric monitoring campaigns during the 1970s and again in the 1990s.

The data presented in this paper were collected during an observing campaign from mid-September to the end of October 1993 at ESO La Silla, Chile, using the simultaneous Strömgren *uvby* photometer at the SAT telescope during 25 partial nights.

We present a time series of 1432 four-colour extinction-corrected magnitudes in the SAT instrumental system. This collection of data forms a homogeneous and contiguous dataset, obtained in one single instrumental setup, at one single observing site using one single observing protocol, and with centralized data reduction.

Keywords: technique: photometric – stars: individual: θ Tuc, HR 169, HR 83 – variable stars: δ Scuti stars

1 Introduction

θ Tucanae (HR 139 = HD 3112, $V = 6.11$, A7 IV) is a binary with a δ Scuti primary that was the subject of several photometric monitoring campaigns during the 1970s and again in the 1990s. The binarity of θ Tuc was first suggested by Paparó et al. (1996), and aspects of the binary nature were discussed by De Mey et al. (1998).

Cousins & Lagerwey (1971) observed θ Tuc in V light during 10 partial nights in October–December 1970, and concluded that the star has a very short period between 70 and 80 minutes, with a variable range that is as large as $0\overset{\mathrm{m}}{.}06$.

Stobie & Shobbrook (1976) collected 556 V measurements during six nights in 1972. These authors could not detect coherent frequencies spanning the entire dataset, and they

concluded that the frequencies as well as the amplitudes present in θ Tuc change on a time scale as short as 24 hours.

Kurtz (1980) obtained 954 new V observations during 70 hours on 21 nights in 1979. He reanalyzed Stobie & Shobbrook's data along with his new data, and concluded that the frequency of highest amplitude ($f = 20.281\,\mathrm{d}^{-1}$) is present at a constant amplitude over the 7-year time span of the entire data set, and suggests that all of the frequencies in θ Tuc may be found to be stable when sufficient data are obtained – that is, when 20 to 30 six-hour runs in one observing season are collected. Kurtz concluded that "Many of these stars need extensive, *careful* observation.".

In September and October 1992, Bos (1994) collected half a dozen light curves in the Johnson B band, and also found $f = 20.281\,\mathrm{d}^{-1}$ for the dominant frequency.

In 1993, Paparó et al. (1996) undertook a major coordinated photometric observing campaign, and obtained more than 2300 new Strömgren y and Johnson V photometric observations during 246 hours spread over 42 nights at three observing sites located in Chile, South Africa and Australia. Ten frequencies were found in the range of 15.8–20.28 d^{-1}, and a 13-frequency solution was fitted.

Kurtz (1980) normalized the data in the mean to zero on a night-by-night basis to suppress low frequency power due to changes in the mean light level that occur in θ Tuc, and this approach was also followed by Paparó et al. (1996). Both research projects have profited from the fact that Cousins & Lagerwey (1971) and Stobie & Shobbrook (1976) had published their data *in extenso*, and Paparó et al. (1996) equally benefitted from the availibility of Kurtz's data. In order to facilitate future photometric campaigns on this star we have decided to release the data that were acquired in 1993. The present paper lists the *uvby* data obtained in Chile. The Strömgren b,y data collected in South Africa will be published by Paparó (2018).

2 Observations

The observing campaign extended from mid-September to the end of October, 1993 at ESO La Silla, Chile, using the simultaneous Strömgren *uvby* spectrophotometer at the SAT telescope[1] during 25 nights. Observers were C. Sterken and H. Spoon. Table 1 lists the journal of observations with the duration of those observations in hours and decimals, the number N of *uvby* measurements of θ Tuc and the name of the observer.

Two comparison stars C_1 = HR 83 (π Tuc, $V = 5.49$) and C_2 = HR 169 ($V = 6.86$) were observed. As a rule, sequences of measurements C_1, θ Tuc, sky, C_2, θ Tuc, sky .... were repeatedly carried out using the same sky-background measurement for the three stars. The observing sequence consisted of 4–7 times 10 s integrations depending on the brightness of the star and 10 s for the background. A complete differential measurement of θ Tuc amounted to about 4 minutes.

The standard method of differential extinction corrections was applied. Extinction coefficients were derived for all nights for which a sufficient amount of comparison star data

[1] Strömgren Automatic Telescope, a 50-cm Cassegrain $f/13.6$ Dall–Kirkham reflector.

Table 1: The journal of observations collected at ESO La Silla. The HJDs refer to the beginning of the observations.

Date 1993	HJD – 2440000	length (hours)	*N*	Obs	Date 1993	HJD – 2440000	length (hours)	*N*	Obs
18 Sep	9249.53	6.93	28	CS	10 Oct	9271.53	8.16	87	HS
21 Sep	9252.56	7.31	77	CS	11 Oct	9272.52	8.41	90	HS
22 Sep	9253.56	7.31	72	CS	12 Oct	9273.53	5.66	60	HS
23 Sep	9254.51	8.64	107	CS	13 Oct	9274.53	5.69	54	HS
24 Sep	9255.51	8.74	110	CS	17 Oct	9278.54	1.65	19	HS
25 Sep	9256.51	8.91	110	CS	18 Oct	9279.55	1.99	18	HS
26 Sep	9257.53	8.10	115	CS	19 Oct	9280.53	1.40	13	HS
4 Oct	9265.58	6.72	51	HS	20 Oct	9281.57	0.75	9	HS
5 Oct	9266.64	5.29	60	HS	21 Oct	9282.52	1.67	14	HS
6 Oct	9267.58	6.60	69	HS	28 Oct	9289.60	1.26	16	HS
7 Oct	9268.56	7.40	77	HS	29 Oct	9290.57	1.93	16	HS
8 Oct	9269.55	8.03	83	HS	30 Oct	9291.55	1.69	20	HS
9 Oct	9270.64	5.59	57	HS	Total		135.83	1432	

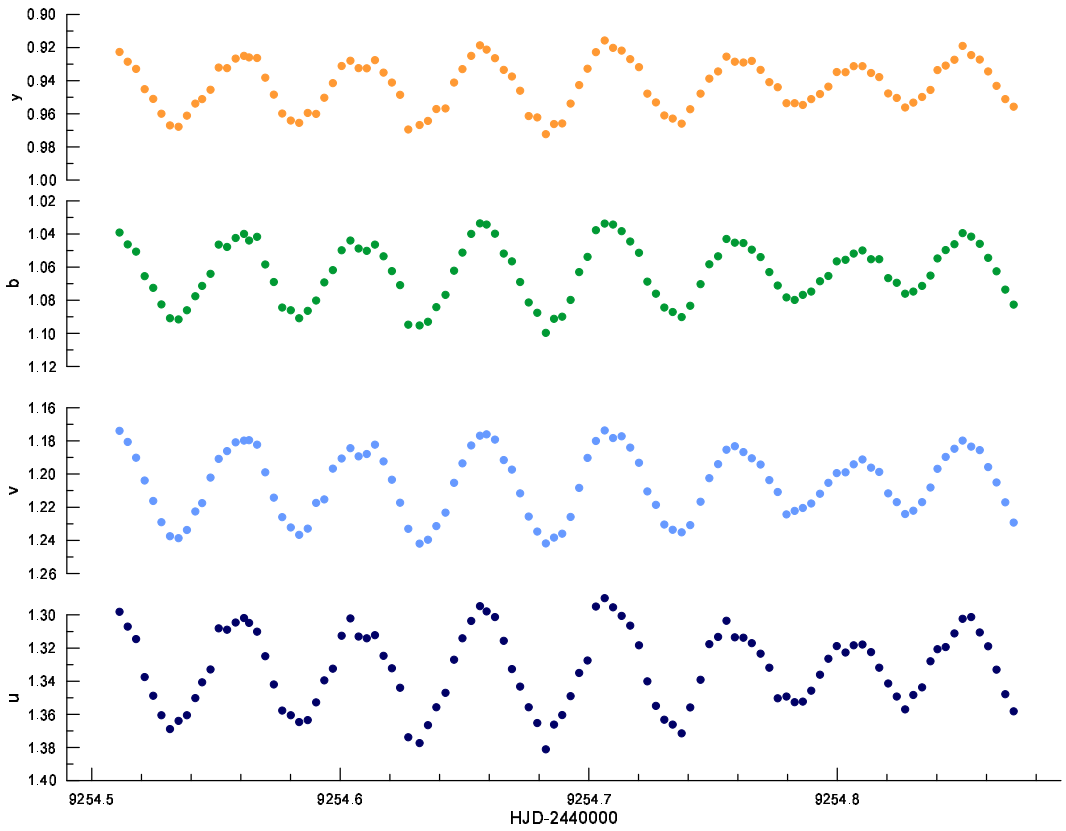

Figure 1: Sample *uvby* light curves observed during one night.

were obtained. For the nights during which few such measurements were available (viz. nights of mediocre atmospheric quality, but also for the last two weeks of the campaign when the star was followed during one cycle per night only) we used the average extinction value obtained from the other nights. All differential magnitudes (relative to the mean value of comparisons) were left in the instrumental system.

As Paparó et al. (1996) noted, there is no evidence for variability of any of the two comparison stars. Indeed, the standard deviation of our differences $C_1 - C_2$ amounts to $0\overset{m}{.}005$ in *u* and to $0\overset{m}{.}004$ in *v*, *b* and *y*.

The data presented in this paper form a homogeneous and contiguous dataset, obtained in one single instrumental setup, at one single observing site using one single observing protocol, and reduced by one single person (C.S.).

3 The data

All *uvby* differential magnitudes of θ Tuc are given in online Table **jad23_1.dat**. Figure 1 shows a typical well-covered night of observation. Figure 2 shows the *uvby* instrumental passbands (based on Table 1 of Helt et al. 1987), as well as the *V* band. It is generally known that linear equations can transform *y* to *V* for stars with emission-line free spectra. Grønbech et al. (1976), for example, obtained

$$\begin{array}{rcl} V & = & -0.003 + 0.015(b-y)_{\rm st} + y_{\rm instr} \\ & & \pm 1 \qquad \pm 4 \end{array}$$

where `st` refers to the standard $b-y$ value and `instr` refers to the instrumental *y* magnitude (corrected for extinction). Grønbech & Olsen (1976) give $b-y = 0.148 \pm 0.004$ for θ Tuc, and taking into account the $b-y$ colors that they list for the comparison stars, it follows that by not applying color corrections, the error on the differential *V* when combining *V* and *y* will amount to no more than $0\overset{m}{.}002$. Paparó et al. (1996), in Section 3.2, give the zeropoints that were used to combine the SAAO *y* and the Perth *V* differential magnitudes with the ESO *y* differential magnitudes listed in the present paper.

Acknowledgments

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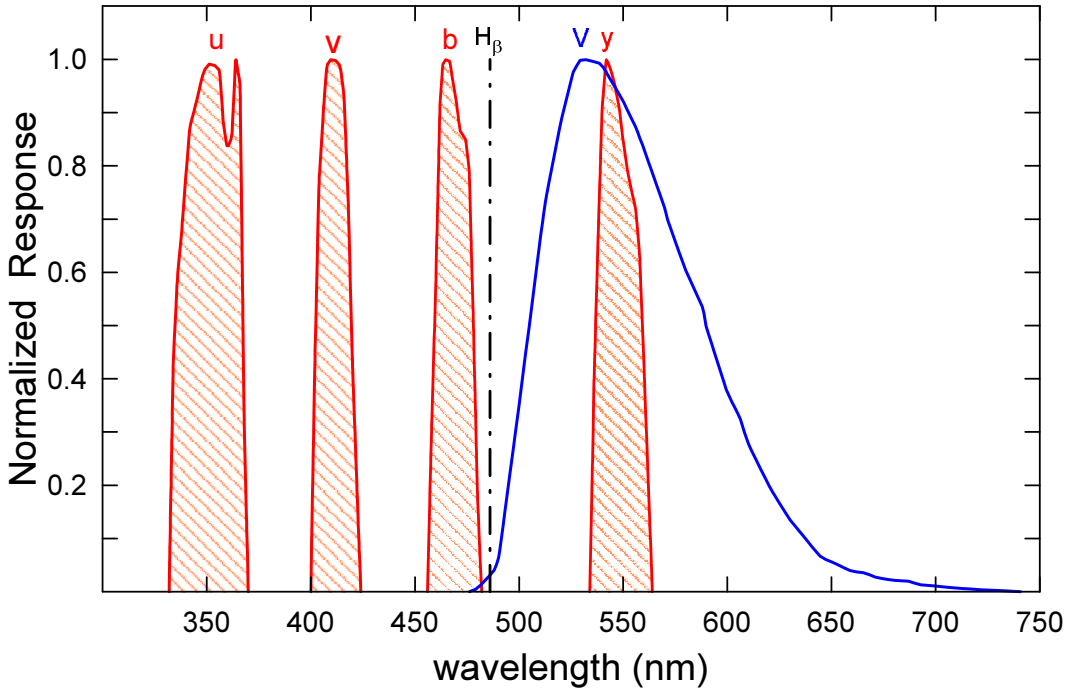

Figure 2: The sensitivity curves of the *uvby* system together with the normalized Johnson V-band response curve. The position of the H_β Balmer line is indicated.

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