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V781 Tau: IMPROVED EVIDENCE FOR AN ORBITAL PERIOD CHANGE

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V781 Tau (= SAO 077615) is a G0 over-contact ($\sim$ 23%) binary. It was discovered by Harris (1979). Cereda et al. (1988) presented a photometric, and Lu (1993) a radial velocity analysis, while Zwitter et al. (2003) explored the spectroscopic and photometric solution based on Hipparcos photometry and GAIA-mode spectroscopic observations.

The orbital period is 0.34 days with the value changing with time. Liu & Yang (2000) established that the binary ephemeris published by Cereda et al. (1988):

$$\mathrm{Min.I} = \mathrm{HJD}\ 2443853.9096 + 0.3449094 \times \mathrm{E} \tag{1}$$

was not followed exactly. The residuals pointed to a quadratic solution with the binary period decreasing with time:

$$\mathrm{Min.I} = \mathrm{HJD}\ 2443853.9110 + 0.344909292 \times \mathrm{E} - 2.5 \times 10^{-11} \times \mathrm{E}^2 \tag{2}$$

This corresponds to a period decrease of $\mathrm{d}P/P = -5.0 \times 10^{-11}$.

Conclusions of Liu & Yang (2000) were based on 14 photographic observations of minima by Berthold (1983) and on 15 photoelectric minima determinations by Cereda et al. (1988), Pohl et al. (1987) and Keskin & Pohl (1989). Liu & Yang added two minima obtained in 1997 and 1998. These two points proved crucial for the determination of the parabolic term of the ephemeris (Eq. 2) and need robust confirmation by extending measurements of the times of minima well into the descending branch of the parabolic approximation. We report here on 10 additional minima secured between Nov-2001 and Jan-2003 to the aim of confirming the trend and strengthen the solution. This increases the total number of minima observed after the year 1990 to 12, therefore substantially decreasing the uncertainty of the orbital ephemeris.

Observations were obtained at the Remanzacco observatory ($13^\circ18'59''$ E, $46^\circ5'11''$ N) by members of A.F.A.M. (Associazione Friulana di Astronomia e Meteorologia). A 0.45-m F/24 Cassegrain telescope was used. The detector was an 1P21 photoelectric photometer. B and V filters conform to the Johnson system. Table 1 summarizes the observing log. Each data point listed in the № column of Table 1 is actually an average of twelve consecutive 5-sec integrations. The comparison star was TYC 1870-514-1 (V=$9\overset{\mathrm{m}}{.}68$, B=$10\overset{\mathrm{m}}{.}08$)

Table 1. Observations of V781 Tau used to determine times of photometric minima. Columns give the HJD, number of observations and type of filter used.

HJD	№	filter	HJD	№	filter	HJD	№	filter
2452229	56	B	2452230	51	B	2452231	89	B
2452252	82	B	2452260	41	B	2452587	21	V
2452652	41	V	2452658	60	V	2452659	49	V
2452665	86	B	2452666	61	B			

with colours very similar to V781 Tau. Typical errors of individual V and B band observations of V781 Tau are ~ 0.007 mag.

Times of minima were determined by the algorithm of Kwee & Van Woerden (1956). Table 2 reports times of 10 new minima together with their cycle number and residuals with respect to the ephemeris of Equation 1.

Table 2. Times of photometric minima with their standard deviations, type of minimum and filter used. The last two columns give the cycle number and ($O - C$ in days) according to the Equation 1.

HJD		type	filter	E	$(O-C)$
2452229.5042	± 0.0018	sec.	B	24283.5	− 0.0128
2452230.5361	± 0.0009	sec.	B	24286.5	− 0.0157
2452231.3946	± 0.0006	prim.	B	24289.0	− 0.0194
2452231.5723	± 0.0012	sec.	B	24289.5	− 0.0142
2452252.4369	± 0.0066	prim.	B	24350.0	− 0.0166
2452252.6076	± 0.0057	sec.	B	24350.5	− 0.0183
2452260.3694	± 0.0027	prim.	B	24373.0	− 0.0170
2452658.3967	± 0.0066	prim.	V	25527.0	− 0.0151
2452659.4252	± 0.0039	prim.	V	25530.0	− 0.0214
2452666.3276	± 0.0015	prim.	B	25550.0	− 0.0172

Figure 1 is an $O - C$ diagram of the period change for V781 Tau. The figure is identical to that in Liu & Yang (2000), but supplemented with our new observations from Table 2. We note that our minima show a certain degree of scatter. Average difference between the observed points and the parabolic solution is -0.0003 ± 0.0024 days. This is in general agreement with errors of minima determination (Table 2). But average $(O-C)$ residuals for the two observing seasons lie exactly on the parabolic ephemeris given by Equation 2. Our new data points clearly confirm the parabolic ephemeris of Liu & Yang. The observations from the literature have widely varying and sometimes subjective error estimates. We therefore refrain from re-estimation of errors of the Liu & Yang ephemeris.

We conclude that the period change in V781 Tau is now better constrained. Wang (1994) and Liu & Yang (2000) suggested that period decreases due to shrinking of the less massive star in a binary. The stars are in contact, so the missing volume is immediately filled by material from the other star. Change in the mass ratio of the stars finally decreases the orbital period. The shrinking star releases some gravitational energy to support its surface effective temperature higher than the other star. Zwitter et al. (2003) find that the component with the lower mass in V781 Tau is ~ 220 K hotter than the more massive one. Such a scenario may be common among the binaries of W UMa type.

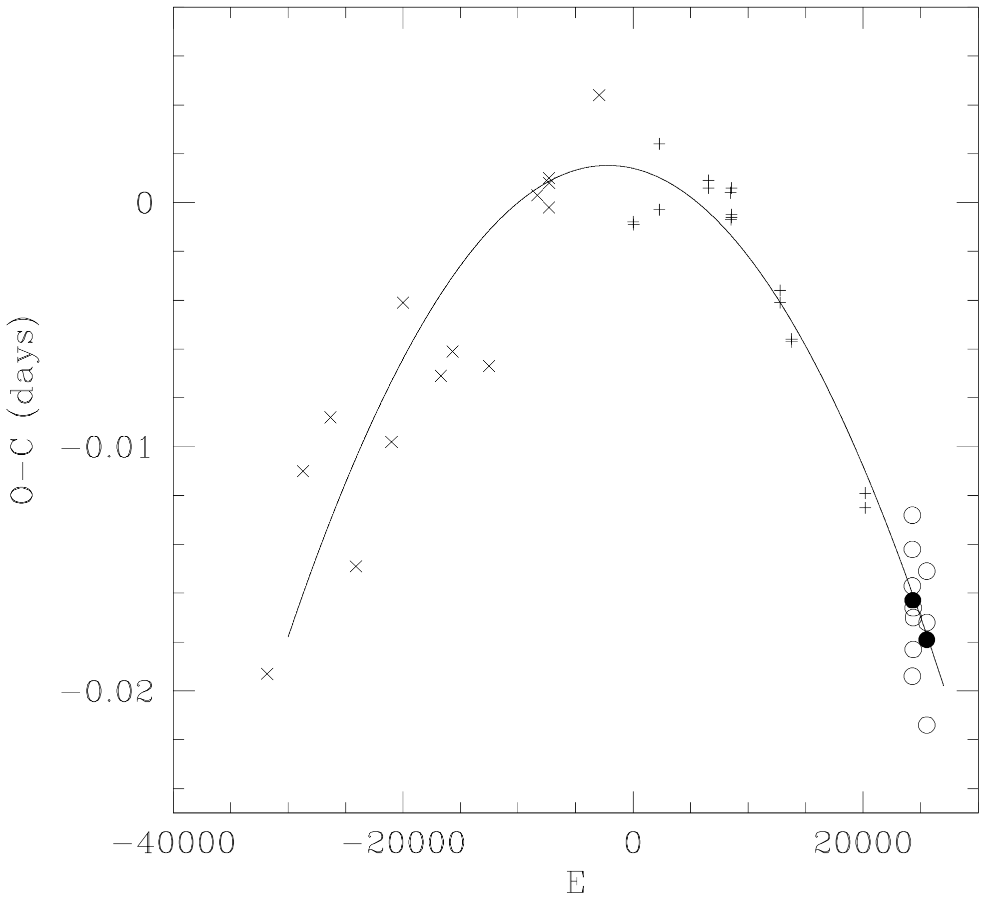

Figure 1. $O-C$ diagram of the period change for V781 Tau. Crosses indicate photographic observations and plus signs are photoelectric observations from the literature. Open circles mark photoelectric minima from this paper. Filled circles are their yearly averages for the 2001/2002 and 2002/2003 observing seasons. The curve denotes parabolic ephemeris from Equation 2.

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