COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 3763

Konkoly Observatory
Budapest
2 September 1992
HU ISSN 0324 - 0676

ON HOUR-SCALE PHOTOMETRIC VARIATIONS OF TT ARIETIS

The cataclysmic variable TT Ari was observed photometrically during an international campaign in 1988. Tremko *et al.* (1990) and Hudec *et al.* (1989) published the results of sudden decreases in the brightness. From the whole data set we chose 15 relatively long runs to test reality of a 4.68-hour secondary photometric period (Wenzel *et al.*, 1986; Andronov *et al.*, 1992). These runs were obtained mainly by the authors (4 in Sonneberg, 4 in Skalnate Pleso, 4 in Cracow and 1 in Piszkéstető), and 2 were published by Andronov *et al.* (1992).

The original observations were averaged over bins of duration tipically less than $0^d\!.06$. Their number n_{α_j} in j^{th} bin in α^{th} run was used as "weight" for the least squares solution

$$\begin{aligned} m_{\alpha_j} &= a_\alpha + s_1 \sin\left(2\pi f_1\, t_{\alpha_j}\right) + c_1 \cos\left(2\pi f_1\, t_{\alpha_j}\right) \\ &\quad + s_2 \sin\left(2\pi f_2\, t_{\alpha_j}\right) + c_2 \cos\left(2\pi f_2\, t_{\alpha_j}\right) = \\ &= a_\alpha - r_1 \cos\left[2\pi f_1 \left(t_{\alpha_j} - t_1\right)\right] - r_2 \cos\left[2\pi f_2 \left(t_{\alpha_j} - t_2\right)\right] \end{aligned} \qquad (1)$$

where m_{α_j} and t_{α_j} are averaged values of the magnitude and time in j^{th} bin, and a_α, s_1, c_1, s_2, c_2 are the parameters being determined for trial frequencies f_1 and f_2. The moments t_1 and t_2 correspond to a maximum brightness of waves with amplitudes r_1 and r_2. The function $S(f_1, f_2) = \sigma^2_{O-C}(f_1, f_2)/\sigma^2_0$ was used as a test function, where σ^2_{O-C} and σ^2_0 are weighted variances of residuals from the fit (1) and from nightly mean. A total number of averaged observations is n = 478, a r.m.s. deviation from nightly means is $\sigma_0 = 0^m\!.048$.

The shifts a_α for each night were computed as best fit parameters, thus taking into account their possible night-to-night changes. The first reason for this is that there may exist systematic differences among brightness values obtained at different telescopes in instrumental systems. Secondly, there may exist physical variations in the mean brightness from night to night.

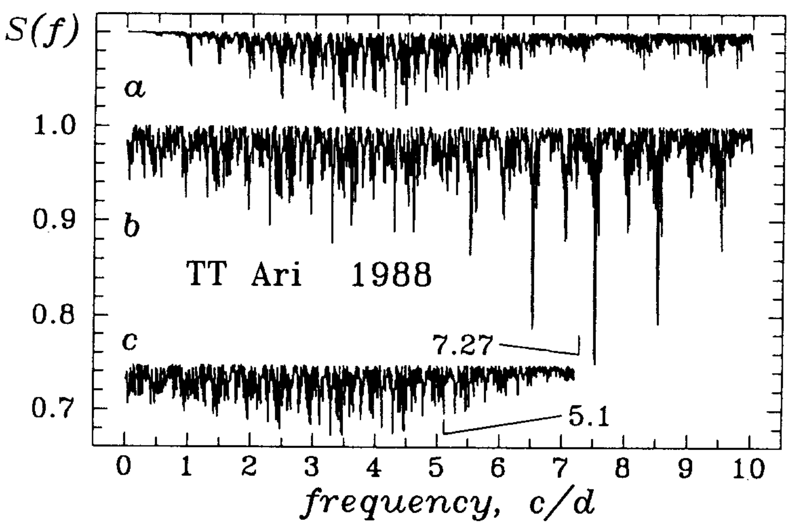

Fig. 1 Periodograms for 478 mean points of TT Ari obtained in 1988. Vertical bars correspond to the spectroscopic frequency (7.27 c/d) and previously detected secondary oscillation (5.1 c/d).

a) $S(f_2)$ +0.10 is a shifted periodogram for prewhitened observations;

b) $S(f_1, 0)$ is a periodogram without taking into account the variations with a secondary period;

c) $S(f_1, f_2)$ is a periodogram for a two-frequency model (1), where f_1 was slightly corrected to obtain a minimum value of the test-function.

Table 1

Parameter fits of TT Arietis

f_1	f_2	r_1	r_2	t_1	t_2	$S(f_1, f_2)$
7.5217	3.2914	0.032	0.016	39.8975	39.8432	0.673
7.5216	3.4635	0.036	0.020	39.9007	39.7631	0.672
7.5217	4.2918	0.033	0.020	39.8975	39.9993	0.674
7.5211	4.4614	0.037	0.019	39.9007	39.9284	0.678
7.5211	5.1074	0.037	0.016	39.8984	39.9576	0.695
7.5215	–	0.035	–	39.8979	–	0.747

By using non-linear least squares procedure in the vicinity of the previously found values $f_1 = 7.5346$ cycles/day and $f_2 = 5.123$ c/d (Wenzel *et al.* , 1986), we found that $f_1 = 7.5211$ c/d and $f_2 = 5.1074$ c/d. The corresponding best fit parameters are listed in Table 1.

For a wide-range period search, we also computed a periodogram $S(f_1, 0)$ corresponding to one-frequency model with 17 unknown parameters ($a_{\alpha j}, j = 1, \ldots, 15$; s_1, s_2). It is shown in Fig. 1b. The most prominent feature in this periodogram occurs at $f_1 = 7.5215$ c/d. Several features at daily bias frequencies $f_1 \pm 1$, $f_1 \pm 2$ are seen as well, corresponding to a spectral window of observations.

A linear ephemeris for the moments of maximum brightness obtained for our observations in a time interval J.D. 2447411-2447471 is as follows:

$$Max.\,HJD = 2444739.898 + 0.132953E \qquad (2)$$
$$\pm\ 2 \qquad \pm\ 13$$

This value of the photometric period differs significantly from $P_1 = 0^{d}\!.132771$ published by Wenzel *et al.* (1986) for observations obtained in 1986, as well as from $P_1 = 0^{d}\!.13277082$ (Roessiger, 1988). However, it is close to $P_1 = 0.132957$ published by Udalski (1988) for observations obtained in 1987-1988. Udalski (1988) also suggested that this photometric period may undergo real long-term changes. It may be noted that it differs by a few per cent from the period $P_{SP} = 0^{d}\!.13755114$ (Thorstensen *et al.*, 1985) of spectral variations.

Such discrepancy allows to classify TT Ari as an intermediate polar, despite the rotational period of the white dwarf is still unknown (Schwarzenberg-Czerny, 1990).

To search for a secondary period in a wide frequency range we used two methods. At first, a one-frequency model was applied to the prewhitened observations $m'_{\alpha_j} = m_{\alpha_j} - a_\alpha + r_1 \cos 2\pi f_1 (t_{\alpha_j} - t_1)$ with r.m.s. deviation $\sigma_1 = 0^{m}\!.041$. A corresponding test function $S(f_2) = \sigma^2_{O-C}/\sigma^2_1$ is shown in Fig. 1a. It shows a variety of dip features, the most prominent of which does not coincide in frequency with the previously obtained value of f_2 (Wenzel *et al.*, 1986). Secondly, we computed a test function $S(f_1, f_2)$ (Eq. (1), Fig. 1c), which exhibits similar behaviour.

The relatively large noise at low frequencies corresponds to larger value of estimated parameters (l=19) as compared with l=3 (Fig. 1a). The relative depths of dips in Fig. 1a differ from those in Fig. 1c, but their frequencies coincide within the error estimates. Best fit parameters for four most prominent dips are listed in Table 1. Their frequencies exhibit well pronounced biases. However, the durations of our individual observational runs are not sufficient to cover the corresponding periods $P_2 = 1/f_2$, thus new observations longer than 5-6 hours are needed to solve the problem of a secondary photometric period.

This research was partially supported by the Grant 2/61/92 of the Slovak Academy of Sciences.

J. TREMKO[1], I.L. ANDRONOV[2], R. LUTHARDT[3], G.PAJDOSZ[4], L. PATKÓS[5], S.ROESSIGER[3], S. ZOLA[4,6]

[1] Astronomical Institute, Slovak Academy of Sciences
[2] Odessa State University, Ukraine
[3] Sonneberg Observatory, Germany
[4] Mt. Suhora Observatory, Pedagogical University Cracow
[5] Konkoly Observatory, Hungarian Academy of Sciences
[6] Astronomical Observatory, Jagiellonian University Cracow

References

Andronov I.L., Kolosov D.E., Movchan A.I., Rudenko A.N.: 1992, *Commun. Spec. Astrophys. Obs. Russian Acad. Sci.* **69**, 79

Hudec R., Valnicek B., Tremko J., Wenzel W., Goetz W., Roessiger S., Kraicheva Z., Patkós L.: 1989, *Comm. Konkoly Obs.* **10**, 244

Roessiger S.: 1988, *Mitt. Veränderl. Sterne* **11**, 112

Schwarzenberg-Czerny A.: 1990, *Contrib. Astron. Inst. Skalnate Pleso* **20**, 9

Thorstensen J.R., Smak J., Hessman F.V.: 1985, *Publ. Astron. Soc. Pacif.* **97**, No 591, 437

Tremko J., Antov A., Genkov V., Kraicheva Z., Azimov A.A., Chernysev A.V., Zakirov M.M., Babaev M.B., Hudec R., Kolosov D.E., Kumsiashvili M.I., Luthardt R., Roessiger S., Movchan A.I., Rudenko A.N., Patkós L., Shpychka I.V.: 1990, *Contrib. Astron. Inst. Skalnate Pleso* **20**, 69

Udalski A.: 1988, *Acta Astron.* **38**, 315

Wenzel W., Bojack W., Cristescu C., Dumitrescu A., Fuhrmann B., Goetz W., Grzelczyk H., Hacke G., Hudec R., Huth H., Kozhevnikov V.P., Kumsiashvili M.I., Mrkos A., Oláh K., Oprescu G., Patkós L., Peresty R., Pfau W., Reimann H.-G., Richter G., Roessiger S., Shpychka I.V., Schult R., Stecklum B., Tóth I., Tremko J., Valnicek B., Verdenet M.: 1986, *Preprint Astron. Inst. Czechoslovak Acad. Sci.* No. **38**, 44