PHOTOMETRY OF TT ARIETIS

I. SEMENIUK[1], A. SCHWARZENBERG-CZERNY[1], H. DUERBECK[2],
M. HOFFMANN[2], J. SMAK[3], K. STĘPIEŃ[1], and J. TREMKO[4]
[1] Warsaw University Observatory, Warsaw, Poland
[2] Astronomical Institute, University of Münster, Münster, F.R.G.
[3] N. Copernicus Astronomical Center, Polish Academy of Sciences, Warsaw, Poland
[4] Astronomical Institute, Slovak Academy of Sciences, Skalnate Plesno, Czechoslovakia

Abstract

An analysis of data spanning 24 years shows that a secondary 20^m periodicity is a persistent feature in photometric observations of TT Ari. This period decreases from 27^m in 1961 to 17^m in 1985. The 4^d beat period of $3\overset{h}{.}2$ photometric and $3\overset{h}{.}3$ spectroscopic periods is also apparent in observations of 1966.

1. Introductory Remarks and Observations

The interesting cataclysmic variable TT Ari, discovered in Bamberg thirty years ago by Strohmeier, Kippenhahn and Geyer (1957), and initially considered to be a nova-like object (Smak and Stępień 1969), is recently believed to be a possible intermediate polar (Warner 1983). The main argument for that is the difference of the photometric and spectroscopic periods of the system. The photometric period of TT Ari was determined by Smak and Stępień (1969) as

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equal to $0\overset{d}{.}1329$ ($3\overset{h}{.}2$). It is known now (Sztajno 1979) that this period is decreasing. Its value derived from our 1985 observations is $0\overset{d}{.}1323$. The spectroscopic period determined by Cowley et al. (1975) and recently confirmed by Thorstensten, Smak and Hessman (1985) is equal to $0\overset{d}{.}1376$ ($3\overset{h}{.}3$). TT Ari shares also some other properties with intermediate polars; like those systems it prefers to spend more time in high state than in low state and it has relatively high X-ray luminosity. TT Ari resembles particularly closely the intermediate polar TV Col whose basic photometric and spectroscopic periods are $5\overset{h}{.}2$ (Motch 1981) and $5\overset{h}{.}5$ (Hutchings et al. 1981) respectively. For TV Col two other photometric periods are also observed; the 4^d beat period of the two former periods and the 32^m rotation period of the compact object first discovered in the X-rays by Schrijver et al. (1984).

This discovery and the close resemblance of TT Ari to TV Col prompted us to search for secondary periods of TT Ari analogous to 4^d and 32^m periods of TV Col. When looking for the shorter period we were also encouraged by the fact that quasiperiodical variations with periods between 14 and 20 minutes were reported by earlier observers (Smak and Stępień 1969).

For our analysis we have collected 30 photometric runs of TT Ari obtained by various observers in various observatories including 15 already published (Smak and Stępień 1969, 1975). The observations were made during 7 observational seasons spanning the time interval from 1961 till 1985. The journal of observations is given in Table 1. The length of runs varied from 1 to more than 6 hours, most of them were at least 3 hours long. The main results concerning the longer and the shorter secondary periods of TT Ari which we will call here the 4^d and 20^m periods respectively are given in the next two sections.

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Table 1. Journal of Observations

Observer	Telescope	Filter	Season	Number of nights
Smak	36" Crossley Lick	U B Y	Dec 1961–Jan 62	8
Smak	60 cm Haute Provence	U	Aug–Sep 1966	5
Stępień	60 cm Lick	U B V	Oct 1967	2
Duerbeck	60 and 40 cm New Mexico	U B V	Dec 1977	4
Czerny	16" Kitt Peak	U B	Aug 1978	4
Hoffmann	1 m Hoher List	B	Aug 1981	2
Semeniuk	60 cm Ostrowik	B	Sep–Oct 1985	2
Tremko	60 cm Skalnate Pleso	B	Sep–Dec 1985	3

2. The 20^m period

We have performed the power spectrum analysis for all observational runs using two techniques, the Fourier analysis (Deeming 1975) and the maximum entropy method (MEM), which gave mutually consistent results. Beside the $3\overset{h}{.}2$ period which appeared in all sufficiently long runs our power spectra revealed

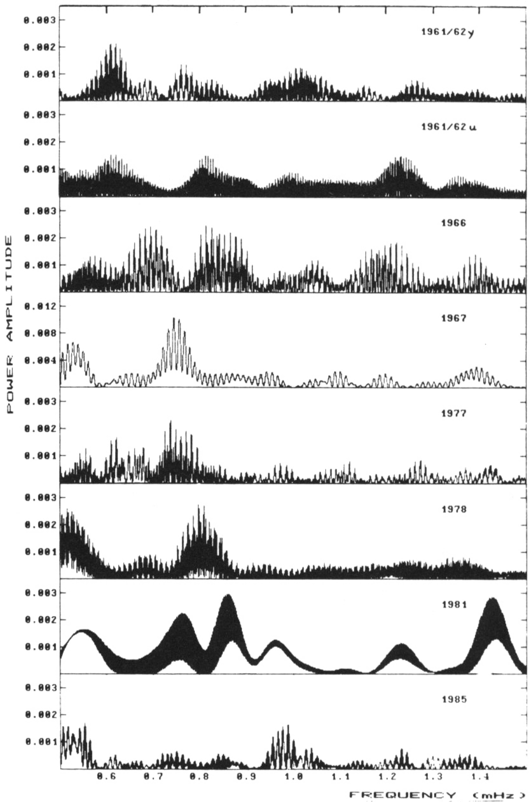

Fig. 1. Seasonal Fourier spectra of photometric observations of TT Ari.

another priviledged frequency corresponding to a secondary photometric period of about 20^m. A peak at the consistent position appeared on all except two nights albeit its amplitude varied from night to night. In 15 of 30 nights the corresponding peak was the strongest feature in the relevant frequency band.

Although on different nights of a season the peak appeared at the same frequency, its position varied smoothly from season to season. This is shown in Fig. 1 where the Fourier power spectra obtained for all observations of a given season are arranged chronologically. Three of the seasons need some comments.

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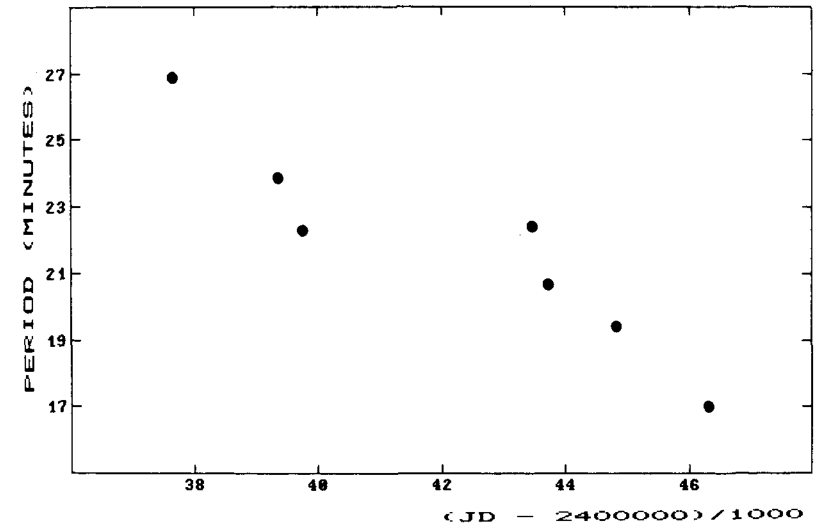

Fig. 2. The 20^m periodicity history in the time interval 1961 – 1985.

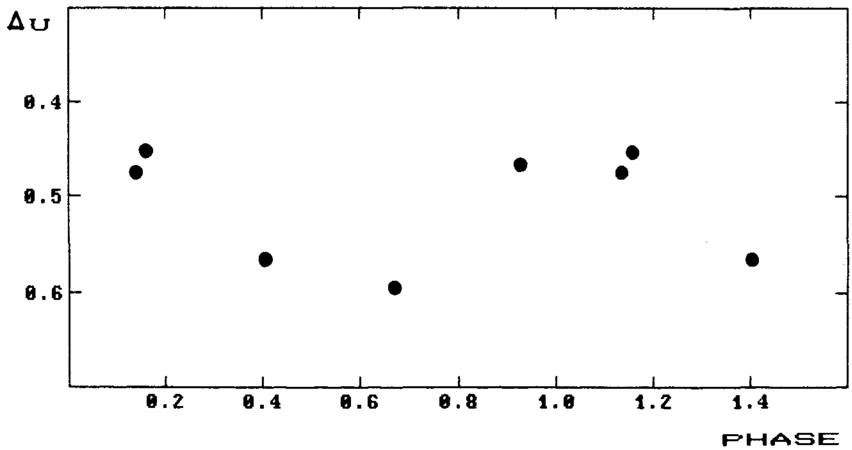

Fig. 3. Mean nightly differential U magnitudes (after eliminating the $3^h_.2$ periodicity) for the 1966 observations versus the phase of $3^d_.76$ beat period of $0^d_.1327$ photometric and $0^d_.13755$ spectroscopic periods.

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The power spectra of the Smak 1961/62 and 1966 observations are much noisier than these of later seasons. Therefore we have divided the 1961/62 data consisting of 8 runs into 2 parts; the first containing only earlier yellow observations and the second with later ultraviolet observations. Both spectra have one common night. Fig. 1 shows that two uppermost spectra indicate only one common priviledged frequency of about 0.62 mHz. What concerns the 1966 season our conviction that the priviledged frequency is at 0.7 mHz, albeit an equally high peak is visible at 0.8 mHz is based on the fact that the peak at 0.7 mHz is present in power spectra of all individual runs of the season while the peak at 0.8 mHz appears only on some nights. At last we would like to indicate that the power scale for the 1967 season is four time compressed in comparison with other seasons as in this season the peak corresponding to the 20^m period was about four time as powerful as in other seasons.

The seasonal mean value of the 20^m period versus time are plotted in Fig. 2 which shows that in the time interval of 24 years the period decreased from 27^m in 1961 to 17^m in 1985. This fast rate of decrease restrains us from identifying the 20^m period with the rotation period of the compact star as it was done for the 32^m period of TV Col. We cannot conclude from our observations whether this periodicity is coherent or only quasiperiodical. We have analysed additionally the X-ray observations of TT Ari by Jensen et al. (1983) obtained on two consecutive days. In the power spectra for each day there were peaks at frequencies around 1 mHz although inconsistent with one another and with our optical data.

3. The 4^d period

In available observations there is only one set distributed suitably to look for the beat period of the $3^h_.2$ photometric and spectroscopic periods and these are Smak's observations of 1966. To investigate the 4^d period we have eliminated previously the $3^h_.2$ periodicity. The Fourier analysis in the adequate frequency domain performed for so reduced observations showed a distinct peak corresponding to the period of $3^{d}_{.}66$ what – within the error limits – is identical with the value $3^{d}_{.}76$ of the aforementioned beat period for this epoch. Fig. 3 presents the mean nightly differential U magnitudes for five Smak's 1966 runs plotted against the phase of this beat period. The 4^{d} periodicity is clearly visible with the amplitude being about 0.15 mag in U. Of course this periodicity as revealed only in one set of observations needs further confirmation. The decrease of $3^{h}_{.}2$ period results in fast decrease of 4^{d} period. Its value expected for 1985 is $3^{d}_{.}47$.

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