PHOTOMETRY OF TT ARIETIS AND THE QUESTION OF SUDDEN DECREASE OF THE BRIGHTNESS

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ABSTRACT. Results of the observational campaign in 1988 of the intermediate polar TT Arietis are presented. The variable star was observed over 83 hours and 10 000 photoelectric observations were obtained. Two sudden decreases of the brightness were detected. The duration of events was shorter than 0.01 days and the decreases exceeded 0.5 magnitude.

1. INTRODUCTION

The cataclysmic variable TT Arietis (BD +14°341) was discovered by Strohmeier, Kippenhahn and Geyer (1957). It was initially considered to be a nova-like variable (Smak and Stepień, 1969) and it is recently believed to be possible an intermediate polar. The main argument for this classification is the difference of the photometric and spectroscopic periods of the system. Smak and Stepień (1969) found the light variation with a period of $0^d.1329$ but they assumed that the fundamental period is $0^d.2658$. Later on, the same authors (Smak and Stepień, 1975) revised their results and gave the half for the value of the period i.e. $0^d.1329$. This value was later confirmed by Sztajno (1979). Semeniuk et al. (1987) used both epochs of maxima and minima for the period determination. They obtained the values $0^d.1328$, $0^d.1334$ and $0^d.1340$. Volpi et al. (1988) derived the value $0^d.13298$. The most recent investigation confirmed slight variation of this period (Udalski, 1988). Semeniuk et al. (1987) discovered the decrease of the 20 minutes oscillations period. This was recently confirmed by Udalski (1988). Semeniuk et al. (1987) derived from Smak's 1966 observations $3^d.66$ beat period. This beat period arises from shorther photometric and longer spectroscopic period. Udalski (1988) gives the value of $3^d.8$ for the beat period which is in good agreement with data published by Semeniuk et al. (1987). The slight difference is caused by the variation of the $0^d.13$ photometric period. The spectroscopic (orbital) period of $0^d.1375$ was determined by Cowley et al. (1975) and confirmed by Thornstensen et al. (1985).

Recently series of photoelectric observations were obtained (Kraicheva, 1987; Roessiger, 1987) in which sudden dips on the light curve were detected. In order to elucidate this effect the observational minicampaign by one of coauthors (J.T.) in autumn 1988 was organized.

2. PREVIOUS OBSERVATIONS OF DIPS

The decrease of the X-ray flux accompanied by the decrease of the brightness in the photometric B region was detected by Jensen et al. (1983). The duration of the large X-ray minimum was 1000 seconds and the duration of the decrease of the brightness in the optical region was 500 seconds. They suggested that photoelectric absorption was probably responsible for the decrease of the X-ray. Later on, simultaneous X-ray and optical data were obtained during the coordinated program with EXOSAT satellite. For one X-ray drop simultaneous optical data were obtained (Wenzel et al., 1986, preprint). Similar optical dips have been detected by Kraicheva (1987) and Roessiger (1987). There is a serious suspicion concerning the reality of some observed dips. For the dip observed by Roessiger (1987) there are simultaneous optical observation at Skalnaté Pleso Observatory (Tremko, unpublished). No dip in this time at Skalnaté Pleso Observatory was observed. There are few other dips with the amplitude slightly lower than 0.5 magnitude observed at Skalnaté Pleso Observatory. Therefore there is a strong suspicion that some dips are caused by the absorption of the light in the atmosphere after jetliner flight. The occurence of dips was recently studied by Hudec et al. (1988).

3. NEW OBSERVATIONS AND RESULTS

The simultaneous optical observations were organized in two observational intervals in September and October 1988 in the nights without moonlight in order to minimize the effect of sky brightness. The important reason was to obtain the observations at different observatories at the same time or by means of two-channel photometer. The reason was in short duration of the dips, approximately 15 minutes and the suspicion that some dips can arise in the instrumentation and/or could be caused by some atmospheric effect. The distribution of observatories in a relatively narrow interval of geographic longitudes increased the probability of the superposition of observing intervals. The B photometric region for the observation was recommended. However, unfavourable weather during the campaign led the observers to obtain the observations outside the recommended time intervals, too. The list of the participating observatories and the log of observational intervals are presented in the Table 1. The symbol N in the last column denotes that these observations were not suitable for the search of sudden decreases of the brightness. The observational series in the Table 1 are arranged according to increasing Julian Date. As it is seen from the Table 1 ten observatories took part in the observational campaign. Total 33 series of observations in 26 nights were obtained. However, 10 series were not suitable for this sort of study as the intervals between two consecutive observations were long-lasting. Thus the star was continuosly observed during 3.484 days in 23 observational runs, except short intervals in which the comparison star was observed. Over 10 000 observations were obtained, one third of them at the Skalnaté Pleso Observatory. In three nights the observations were obtained at two observatories simultaneously: on JD 2447415, 2447444 and 2447454. All three series of observations lasted 0.4489 days. The ob-

Table 1

Date	Observatory	Number of observations	Photom. region	Note
J.D. 2440000+				
7412.4734 - .6314	Sonneberg	298	B	
7413.4530 - .6274	Sonneberg	407	B	
7414.5066 - .6227	Sonneberg	296	B	
7415.4463 - .6340	Sonneberg	410	B	
7415.3779 - .6179	Skalnaté Pleso	636	B	
7417.4368 - .5944	Rozhen	1250	B	
7418.4174 - .5743	Rozhen	1052	B	
7421.4564 - .5298	Abastumani	180	UBV	
7422.5160 - .5892	Abastumani	177	UBV	
7423.4719 - .5548	Abastumani	216	UBV	
7435.3987 - .5420	Crimea, GAIŠ	822	B	
7439.4934 - .5276	Crimea, GAIŠ	264	B	
7439.4026 - .5839	Ľvov	41	BV	N
7442.4470 - .5186	Majdanak	75	UBVR	N
7443.3880 - .4151	Majdanak	42	UBVR	N
7444.4213 - .4498	Majdanak	66	UBVR	N
7444.3846 - .6552	Skalnaté Pleso	684	B	
7444.4880 - .5921	Rozhen	60	UBV	
7445.3632 - .4646	Ľvov	32	BV	N
7447.3598 - .4145	Odessa	225	B	
7447.3652 - .5534	Ľvov	46	B	N
7448.3677 - .6127	Odessa	885	B	
7448.4331 - .5720	Ľvov	38	B	N
7450.3538 - .6325	Skalnaté Pleso	781	B	
7451.3853 - .5765	Ľvov	54	B	N
7452.3976 - .4232	Majdanak	30	UBVR	N
7452.4752 - .6625	Skalnaté Pleso	484	B	
7454.3980 - .5980	Piszkéstetö	435	ubvri	
7454.4248 - .6604	Skalnaté Pleso	680	B	
7455.3930 - .5843	Ľvov	52	B	N
7488.3306 - .4417	Shemakha	65	B	
7489.2493 - .3965	Shemakha	89	B	
7503.2438 - .2958	Shemakha	40	B	

servations at Abastumani Astrophysical Observatory were made with two-channel photoelectric photometer. We concentrated on the search of sudden decrease of the brightness with the duration shorter than 15 minutes and the depth greater than 0.5 magnitude. These constraints were accepted after checking the depth and the duration of dips observed in previous years and taking into account the amplitude of the flickering. All known sudden decreases of the brightness together with the dips observed during 1988 obervational campaign are collected in the Table 2.

Table 2

Date	Observatory	Duration (Minutes)	Depth (Magnitude)	Photometric phase	Spectroscopic phase	Note
2444440.983	Mount Wilson	8	0.5	0.225	0.374	1
6299.198	EXOSAT			0.885	0.906	2
6299.503	Sonneberg	10	0.2	0.182	0.123	3
6705.431	Piszkéstető	30	0.75	0.538	0.229	4
6705.592	Skalnaté Pleso	1.7	2.35	0.754	0.403	4
6737.406	Rozhen	10	2.3	0.365	0.688	
6737.410	Rozhen	10	0.8	0.395	0.717	
7040.413	Rozhen	10	0.8	0.542	0.650	
7137.417	Rozhen	10	0.6	0.154	0.778	
7417.551	Rozhen	15	0.55	0.057	0.358	
7488.361	Shemakha	7	0.54	0.382	0.149	

Notes

1 Confirmed in X-ray region (EINSTEIN satellite)

2 No observations in visual region

3 Confirmed in X-ray region (EXOSAT)

4 Not of stellar origin

References to 1 - 3: Hudec et al. (1987); Jensen et al. (1983).

The photometric phase was calculated with the period $P = 0^{d}.1327700$ (Wenzel et al., preprint 1986) and the spectroscopic phase with the value of the orbital period $P = 0^{d}.13755114$ (Thornstensen et al., 1985). We observed two sudden decreases of the brightness both with one channel photometers. There are not simultaneous optical observations at different observatories during these two events. The dips were observed at Rozhen Observatory on JD 2447417 and at Shemakha Observatory on JD 2447488. The dip observed at Rozhen Observatory is well defined by the observations. However, the dip observed at Shemakha Observatory is defined by low number of observations, only.

Table 1 contains three dips which were observed in the X-ray region. In addition two of them were confirmed by observations in the optical region. Another two dips observed on JD 2446705 are not of stellar origin. The rest of the dips except the dip on JD 2447488 were detected at Rozhen Observatory. The dips were not detected on several series of observations which were obtained before this campaign and are not mentioned in the Tables 1 and 2 but were checked by us.

Even there is a suspicion on the reality of some dips it is no doubt that at least the dips confirmed by two independent methods simultaneously are real events.

The modulation of X-ray emission was detected in 13 intermediate polars (Norton and Watson, 1989). Absorption dips were detected in both optical and X-ray regions in polars (Watson et al., 1989).

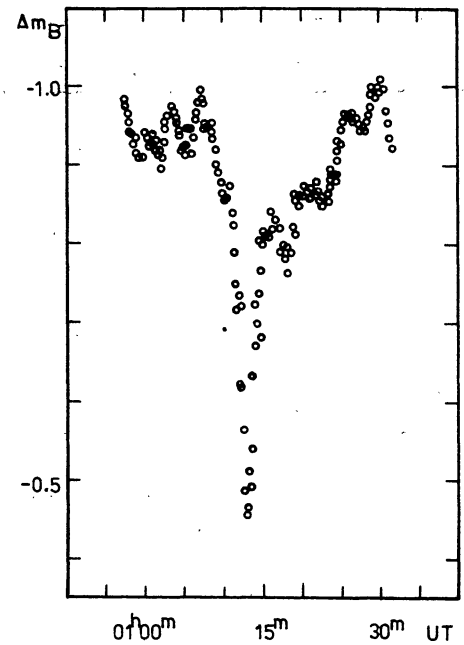

Fig. 1. The dip observed at Rozhen Observatory on Sept. 12/13, 1988.

The dips in TT Arietis can be characterized as follows:

1) The events are rare.
2) The duration of dips and their depth change.
3) The dips are neither photometric nor spectroscopic phase dependent.

The dips probably are the result of absorption of a radiating source near the surface of the white dwarf by the stream of infalling matter. Simple obscuration of the radiating source by infalling stream cannot explain observed dips. The picture is more complicated. Short-lived events of enhanced mass transfer, changes in the structure of the accretion stream, changes in its density and in the direction of the stream or the combination of these effects could explain the observational results.

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