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PERIOD VARIATIONS IN SZ ARIETIS

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Abstract. A new period (P = 1^{d}.7175405) of the eclipsing binary system SZ Arietis has been presented. Period changes in different portions of the O–C diagram, with new period, have been estimated. The total change in period (ΔP) ranges from 3.64×10^{-5} d to 4.24×10^{-4} d, which is appreciably large. However, leaving the unusual value, the average period change comes out to be of the order of 6×10^{-5} d. The period changes around the years 1903, 1943, and 1977 are apparent in the O–C diagrams. A sinusoidal variation is also visible in the O–C diagrams, which indicates that SZ Ari may be a three-body system, having a period of nearly 66 years.

1. Introduction

Earliest references (cf. Wood *et al.*, 1980) suggest that the eclipsing binary system SZ Arietis (= SZ Ari = BD + 19°0531 = BV 126) was first observed by Strohmeier (1958) and it was later persued by Rossiger (1959). Strohmeier (1958) gave photographic light curve of SZ Ari, and Rossiger (1959) presented photographic light curve showing large scatter of nearly 0^{m}.3. Further details of their work are not available to us. Hilditch and Hill (1975) gave Strömgren indices of the system.

2. Epoch, Period, and New Period

Minima of SZ Ari have been compiled by Strohmeier and Bauernfeind (1968). Diethelm (1976, 1980) gave epochs of the system. Epochs and period of SZ Ari, given by various authors, are given in Table I. The minima of the system are given in Table II. It is evident that except last three visual minima, the remaining minima are photographic, and no photoelectric minima is available in the literature. By use of the minima given in Table II, a new period has been determined, applying the method of least squares, which comes out to be P = 1^{d}.7175405 (+ 0^{d}.0000005).

3. O–C Diagram and Period Variations

In all, 48 minima were available in the literature, which were observed in the time interval 1902 to 1982. Out of these, 4 minima are found to be secondary, while 44 minima are primary. Six minima (5 primary and 1 secondary) have not been considered in the means as they do not follow the smooth, normal period trend. These are indicated by a bracketed question mark in Table II.

Two O–C diagrams (Figure 1) have been drawn by use of the following ephemeris:

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$$\text{Primary minimum} = \text{J.D. } 2415430.608 + 1^{d}.717543E\,,$$
(cf. Strohmeier and Bauernfeind, 1968)

and

$$\text{Primary minimum} = \text{J.D. } 2415430.608 + 1^{d}.7175405E\,,$$
(present)

respectively.

O–C diagrams are split-up in to 4 distinct portions (*AB*, *BC*, *CD*, and *DE*) between points *A* to *E*. Figure 1(b) has been used for period discussion. The observations have

TABLE I

Epochs and periods of SZ Ari

S. No.	Author	Epoch and period
1	Strohmeier and Bauernfeind (1968)	J.D. 2426414.301 + $1^{d}.717543E$
2	Diethelm (1976)	J.D. 2442782.379 + $1^{d}.717543E$
3	Srivastava (present work)	J.D. 2415430.608 + $1^{d}.7175405E$

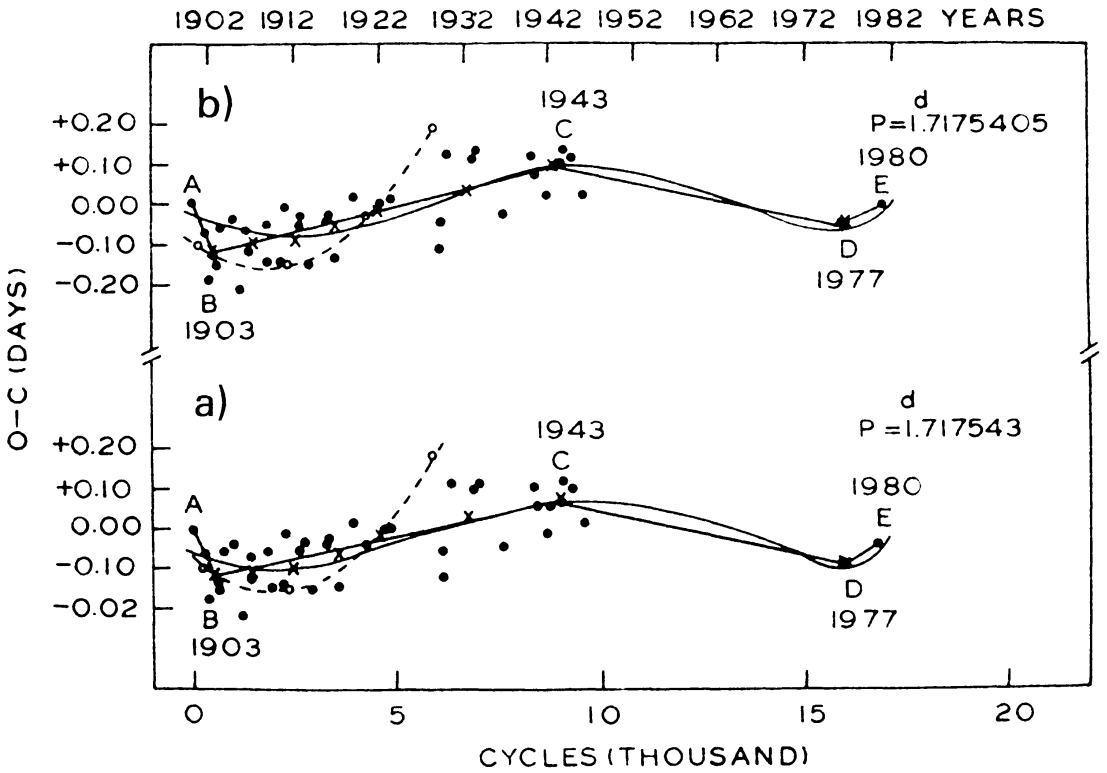

Fig. 1. O–C diagram based on $P = 1^{d}.717543$ and $P = 1^{d}.7175405$, respectively. Filled and open circles indicate primary and secondary minima, respectively, while the crosses indicate the mean O–C values. Solid lines represent the increasing and decreasing trends of the period. The thin-lined solid curve is a free-hand (smoothened) curve, which shows the sinusoidal variation. Dashed curve, based on O–C values of secondary minima, also show the sinusoidal trend.

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TABLE II

Minima of SZ Ari

J.D.$_\odot$	Min.	Based on $P = 1^d.717543$				Based on $P = 1^d.7175405$				Author and references
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2415430.608	I	0		$0^d.000$		0		$0^d.000$		1
2415819.526	II	226.5		−0.106		226.5		−0.105		1
2416031.676	I	350		−0.072		350		−0.070		1
2416165.535	I	428		−0.181		428		−0.179		1
			481		$-0^d.119$		481		$-0^d.116$	
2416400.890	I	565		−0.136		565		−0.126		1
2416407.730	I	569		−0.160		569		−0.157		1
2416711.834	I	746		−0.061		746		−0.057		1
2417230.547	I	1048		−0.046		1048		−0.041		1
2417532.760	I	1224		−0.221		1224		−0.215		1
2417534.695	I	1225		+0.097(?)		1225		+0.100(?)		1
2417848.838	I	1408		−0.071		1408		−0.067		1
2417855.870	I	1412	1475	+0.091(?)	−0.112	1412	1475	+0.095(?)	−0.101	1
2417922.636	I	1451		−0.127		1451		−0.123		1
2418288.725	I	1664		+0.125(?)		1664		+0.130		1
2418597.698	I	1844		−0.059		1844		−0.055		1
2418645.698	I	1872		−0.150		1872		−0.146		1
2419344.742	I	2279		−0.146		2279		−0.141		1
2419351.743	I	2283		−0.016		2283		−0.010		1
2419443.498	II	2336.5		−0.149		2336.5		−0.144		1
			2531		−0.093		2531		−0.088	
2420007.806	I	2665		−0.054		2665		−0.053		1
2420062.785	I	2697		−0.036		2697		−0.030		1
2420457.700	I	2927		−0.156		2927		−0.142		1

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Table II (continued)

J.D.$_\odot$	Min.	Based on P = 1^d.717543				Based on P = 1^d.7175405				Author and references
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2421144.827	I	3327		– 0^d.047		3327		– 0^d.038		1
2421163.735	I	3338		– 0.032		3338		– 0.023		1
			3550		– 0^d.056		3550		– 0^d.047	
2421570.670	I	3575		– 0.154		3575		– 0.136		1
2422233.804	I	3961		+ 0.008		3961		+ 0.028		1
2422739.571	II	4255.5		– 0.041		4255.5		– 0.031		1
2423315.836	I	4591	4559	– 0.012	– 0.019	4591	4559	0.000	– 0.007	1
2423724.620	I	4829		– 0.003		4829		+ 0.009		1
2425566.862	II	5901.5		+ 0.174 (?)*		5901.5		+ 0.189 (?)*		1
2425893.749	I	6092		– 0.130		6092		– 0.105		1
2425912.711	I	6103		– 0.061		6103		– 0.046		1
2426321.650	I	6341		+ 0.102		6341		+ 0.118		1
			6677		+ 0.022		6677		+ 0.034	
2427360.757	I	6946		+ 0.096		6946		+ 0.013		1
2427453.519	I	7000		+ 0.110		7000		+ 0.128		1
2428428.870	I	7568		– 0.103 (?)		7568		– 0.084 (?)		1
2428447.821	I	7579		– 0.045		7579		– 0.026		1
2429871.591	I	8408		– 0.118 (?)		8408		– 0.097 (?)		1
2429883.833	I	8415		+ 0.101		8415		+ 0.122		1
2429907.828	I	8429		+ 0.051		8429		+ 0.072		1
2430371.505	I	8699		– 0.009		8699		+ 0.013		1
			8917		+ 0.060		8917		+ 0.090	
2430730.551	I	8908		+ 0.070		8908		+ 0.088		1
2430730.556	I	9117		+ 0.109		9117		+ 0.132		1
2431429.610	I	9315		+ 0.089		9315		+ 0.113		1
2431812.541	I	9538		+ 0.008		9538		+ 0.032		1

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Table II (continued)

J.D.$_{\odot}$	Min.	Based on $P = 1^{d}.717543$				Based on $P = 1^{d}.7175405$				Author and references
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2442777.236	I	15922	15924	– 0.091	– 0.096	15922		– 0.051		2
2442782.379	I	15925		– 0.101		15925		– 0.061		3
2444266.391	I	16789		– 0.046		16789		– 0.004		4

? Unusual value, not conforming to the smooth period trend, not plotted in the figures.
?* Unusual value, not conforming to the smooth period trend, plotted in the figures.

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(1) Strohmeier, W. and Bauernfeind, H.: 1968, *VBAM*, Band VII, No. 72.
(2) Diethelm, R.: 1976, *BBS* **25**, 1.
(3) Diethelm, R.: 1976, *BBS* **26**, 2.
(4) Diethelm, R.: 1980, *BBS* **46**, 2.

BBS – Bedeckungs Veränderlichen Beobachter der Schweizerischen Gesellschaft Bulletin.
VBAM – Veröffentlichungen der Remeis Sternwarte, Bamberg.

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TABLE III

Period changes in SZ Ari

Portion	Interval of cycles	Total changes period ΔP (days)
AB	$E = 0$ to $E = 481$	4.24×10^{-4} (?)
BC	$E = 481$ to $E = 8917$	3.64×10^{-5}
CD	$E = 8917$ to $E = 15924$	3.83×10^{-5}
DE	$E = 15924$ to $E = 16789$	9.93×10^{-5}
	Mean	1.50×10^{-4}

? = unusually high value.
Mean of *BC*, *CD*, and *DE* = 5.80×10^{-5} d.

been grouped, as shown in Table II, and means have been derived and are plotted as crosses in both figures. The figure suggests that the period changes have occurred around the years 1903, 1943, and 1977. Portions *AB* and *BC* are well covered. The portion *CD* is scantilly covered. Seeing the short interval of time, the portion *DE* is also fairly covered. However, being a solitary point at *E*, its trend is undecided.

Period changes have been assessed in different portions of the O–C diagram (Figure 1(b)), and are given in Table III. The period change ranges from 3.64×10^{-5} d to 4.24×10^{-4} d, which is appreciable. The period change of 4.24×10^{-4} d is definitely high and, leaving this value, the average period change comes out to be 1.50×10^{-5} d, which is also appreciable.

4. Features

The light curve of Rossiger (1959) shows high scatter of the order of $0^m.3$. Also, the O–C diagrams show considerable scatter. In order to find the trend of period, mean O–C values against cycles have been plotted in the figures as crosses. These mean values smoothly lie in the portion *BC*. Thus, there is no doubt that there is a change in the period. Points *C* and *D* are well-defined, thus *CD* portion is also important for consideration, although it is rarely covered.

5. Third Body

Period patterns are shown by thick solid lines. The diagrams also indicate that a sinusoidal variation is present in the system. Although, there is large scatter in O–C values of primary minima, yet O–C values of secondary minima also show a continuous sinusoidal-type variation. Thus, it is possible that a third body is present in SZ Ari having a period of nearly 66 years. O–C values of secondary minima, however, show a steeper variation compared to primary minima, thus it is indicative of some other complication present in the system.

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Kholopov (1985) classifies the system as *EA/DM* indicating that it is a detached Main-Sequence eclipsing system in which both components do not fill their Roche lobes. This condition does not allow the system to possess such high order of period changes. Thus, it is evident that probably third boy may be the affecting factor. Accurate photoelectric minima are badly required to confirm this fact in future.

6. Summary

Detailed period study of SZ Ari, based on up-to-date collection of minima, has been presented for the first time. O–C values show large scatter, particularly to those of primary minima. Period jumps, and a sinusoidal variation, indicating the presence of a third body, are apparent in the O–C diagrams. However, the period changes of the order of 10^{-5} d are strange for a completely detached Main-Sequence system SZ Ari. The slow mass transfer alone cannot be responsible for such a large period change, thus the presence of a third body may be plausible source of period variations in SZ Ari.

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