A PERIOD STUDY OF V450 HERCULIS

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Abstract. A detailed period study of the eclipsing binary system V450 Her has been presented. A new period ($P = {}^{d}.712724$) has been given. The period changes in different portions of the O–C diagram, based on new period, have been estimated. The total period change ranges from 3.28×10^{-6} d to 7.06×10^{-5} d, which is appreciable.

1. Introduction

The eclipsing binary system V450 Herculis (= V450 Her = BD + 34°2831 = BV 104) was first observed by Geyer (1955). Filatov (1960) classified it as R CrB-type variable. Its spectral type was given by Götz and Wenzel (1962) as A0.

2. Epoch, Period, and New Period

Strohmeier *et al.* (1963) observed minima of the system of V450 Her photographically. Strohmeier and Bauernfeind (1968), Diethelm, Lelárko, Berthold, and Brestaff (cf. Banachiewicz, 1987) observed minima visually. No period study of the system was available in the literature. It is presented in this communication. Unfortunately, no photoelectric observations of V450 Her are available to us in the literature. Epochs and periods of the system, given by various authors, are presented in Table I. The minima are listed in Table II. Ninety-eight minima have been collected by us. On applying the method of least squares, a new period, equal to ${}^{d}.912724 \pm ({}^{d}.000005)$ has been derived.

3. O–C Diagrams and Period Variations

In all, 103 minima were available in the literature, which were observed in the time-interval 1902–1982. These are either photographic or visual minima. Out of these 103

TABLE I

Epochs and periods of V450 Her

Sl. No.	Author	Epoch and period
1	Strohmeier *et al.* (1963)	J.D. 2425687.565 + ${}^{d}.912729E$
2	Berthold (1986)	J.D. 2444635.591 + ${}^{d}.9127152E$
3	Lelárko (cf. Banachiewicz, 1987)	J.D. 2441471.387 + ${}^{d}.912680E$
4	Srivastava (present work)	J.D. 2415069.870 + ${}^{d}.912724E$

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TABLE II

Minima of V450 Her

J.D.$_{\odot}$	Min.	Based on $P = 0^d.912729$				Based on $P = 0^d.912724$				Reference
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2415069.870	I	0		$0^d.000$		0		$0^d.000$		1
2415541.718	I	517		−0.033		517		−0.030		1
2415791.872	I	791		+0.033		791		+0.037		1
2415844.840	I	849	802	+0.063	$+0^d.050$	849	802	+0.067	$+0^d.054$	1
2415887.738	I	896		+0.063		896		+0.067		1
2415941.648	I	955		+0.122		955		+0.127		1
2416284.661	I	1331		−0.052		1331		−0.045		1
2416575.686	I	1650		−0.187(?)		1650		−0.179(?)		1
2416693.603	I	1779		−0.012		1779		−0.003		1
2416868.901	I	1971		+0.042		1971		+0.052		1
2416909.890	I	2016		−0.042		2016		−0.032		1
2417081.544	I	2204		+0.019		2204		+0.120		1
2417287.891	I	2430	2364	+0.090	−0.015	2430	2364	+0.102	+0.007	1
2417301.881	II	2445.5		−0.067		2445.5		−0.055		1
2417619.910	I	2794		−0.125		2794		−0.111		1
2417641.879	I	2818		−0.061		2818		−0.047		1
2417642.876	I	2819		+0.023		2819		+0.037		1
2418200.561	I	3430		+0.031		3430		+0.048		1
2418221.502	I	3453		−0.021		3453		−0.004		1
			3555		+0.029		3555		+0.047	
2418398.696	I	3647		+0.103		3647		+0.122		1
2418438.754	I	3691		+0.001		3691		+0.020		1

Table II (continued)

J.D.$_\odot$	Min.	Based on $P = 0^d.912729$				Based on $P = 0^d.912724$				Reference
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2418771.824	I	4056		$-0^d.075$		4056		$-0^d.055$		1
2418919.494	I	4218		−0.267(?)		4218		−0.246(?)		1
2419504.837	I	4859		+0.017		4859		+0.041		1
2419557.787	I	4917		+0.029		4917		+0.053		1
2419902.757	I	5295		−0.013		5295		+0.013		1
2420246.822	I	5672	5593	−0.047	$+0^d.006$	5672	5593	−0.019	$+0^d.034$	1
2420268.788	I	5696		+0.014		5696		+0.042		1
2420570.913	I	6027		+0.025		6027		+0.055		1
2421171.480	I	6685		+0.017		6685		+0.050		1
2421721.749	I	7288		−0.090		7288		−0.054		1
2421796.616	I	7370	7329	−0.067	−0.079	7370	7329	−0.030	−0.042	1
2422335.970	I	7961		−0.136		7961		−0.096		1
2422840.730	I	8514		−0.115		8514		−0.072		1
2423132.876	I	8834	8614	−0.042	−0.066	8834	8614	+0.002	−0.023	1
2423175.763	I	8881		−0.053		8881		−0.009		1
2423176.743	I	8882		+0.014		8882		+0.058		1
2425038.698	I	10922		+0.002		10922		+0.056		1
2525687.560	I	11633		−0.086		11633		−0.028		2
2425687.565	I	11633		−0.081		11633		−0.023		2
2425728.766	I	11678		−0.047		11678		+0.105		1
2426050.875	I	12031		−0.038		12031		+0.023		1

Table II (continued)

J.D.$_{\odot}$	Min.	Based on $P = 0^{d}.912729$				Based on $P = 0^{d}.912724$				Reference
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2426190.458	I	12184		$-0^{d}.102$		12184		$-0^{d}.041$		2
2426231.522	I	12229		−0.111		12229		−0.050		1
2426448.831	I	12467		−0.031		12467		+0.031		1
2426458.802	I	12478		−0.100		12478		−0.038		1
2426459.759	I	12479		−0.056		12479		+0.006		1
2426534.682	I	12561		+0.023		12561		+0.086		1
2426617.500	I	12652		−0.217(?)		12652		−0.154(?)		1
2426770.906	I	12820		−0.150		12820		−0.086		1
2426780.868	I	12831		−0.228		12831		−0.164		1
2426827.551	I	12882		−0.094		12882		−0.030		2
2426827.572	I	12882		−0.073		12882		−0.009		2
2426856.764	I	12914		−0.088		12914		−0.024		2
2426879.648	I	12939		−0.023		12939		+0.042		1
			12895		$-0^{d}.092$		12895		$-0^{d}.038$	
2426921.569	I	12985		−0.087		12985		−0.022		1
2427136.909	I	13221		−0.151		13221		−0.085		1
2427147.903	I	13233		−0.110		13233		−0.044		1
2427182.603	I	13271		−0.094		13271		−0.027		2
2427183.548	I	13272		−0.161		13272		−0.095		2
2427513.892	I	13634		−0.125		13634		−0.057		1
2427535.817	I	13658		−0.106		13658		−0.037		1
2427556.750	I	13681		−0.165		13681		−0.097		1
2427630.637	I	13762		−0.209		13762		−0.141		1
2427664.563	I	13799		−0.054		13799		+0.015		1
2427664.622	I	13799		+0.005		13799		+0.074		1
2427945.774	I	14107		+0.036		14107		+0.107		1

Table II (continued)

J.D.$_{\odot}$	Min.	Based on $P = 0^{d}.912729$				Based on $P = 0^{d}.912724$				Reference
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2428235.918	I	14425		$-0^{d}.068$		14425		$+0^{d}.004$		1
2428250.533	I	14441		−0.056		14441		+0.016		1
2428267.861	I	14460		−0.050		14460		+0.022		1
2428278.841	I	14472		−0.043		14472		+0.029		1
2428310.729	I	14507		−0.101		14507		−0.028		1
2428310.775	I	14507		−0.055		14507		+0.018		1
2428364.589	I	14566		−0.092		14566		−0.024		1
2428364.594	I	14566		−0.087		14566		−0.014		1
2428430.311	I	14638		−0.086		14638		−0.013		1
2428668.518	I	14899		−0.101		14899		−0.027		2
2428690.449	I	14934	15033	−0.116	$-0^{d}.079$	14934	15033	−0.041	$-0^{d}.007$	2
2428753.401	I	14992		−0.102		14992		−0.027		2
2429014.473	I	15278		−0.071		15278		+0.006		2
2429024.474	I	15289		−0.110		15289		−0.033		2
2429045.499	I	15312		−0.077		15312		0.000		2
2429162.302	I	15440		−0.104		15440		−0.027		2
2429194.251	I	15475		−0.100		15475		−0.023		2
2429369.532	I	15667		−0.063		15667		+0.015		2
2429473.632	I	15781		−0.014		15781		+0.065		2
2429571.233	I	15888		−0.075		15888		+0.004		1
2429817.653	I	16158		−0.092		16158		−0.011		1
2430830.746	I	17268		−0.128		17268		−0.042		1
2431111.904	I	17576	17520	−0.090	−0.092	17576	17520	−0.003	−0.018	1
2431239.680	I	17716		−0.057		17716		−0.008		1

Table II (continued)

J.D.$_{\odot}$	Min.	Based on $P = 0^d.912729$				Based on $P = 0^d.912724$				Reference
		Cycle	Mean of cycles	O–C	Mean of O–C values	Cycle	Mean of cycles	O–C	Mean of O–C values	
2431561.817	I	18069		$-0^d.153$		18069		$-0^d.063$		1
2431917.787	I	18459	18502	−0.167	$-0^d.122$	18459	18502	−0.055	$-0^d.023$	1
2432391.596	I	18978		−0.045		18978		+0.050		1
2433070.620	I	19722		−0.091		19722		+0.007		1
			20336		−0.074		20336		+0.028	
2434191.486	I	20950		−0.056		20950		+0.049		2
2437820.458	I	24926		−0.095		24926		+0.030		2
2441434.429	II	28885.5		−0.074		28885.5		+0.070		3
2441471.387	I	28926		−0.082		28926		+0.023		4
2441471.394	I	28926	28939	−0.075	−0.082	28926	28939	+0.030	+0.043	3
2441555.342	I	29018		−0.098		29018		+0.047		5
2441755.579	I	29237		+0.251(?)		29237		+0.398(?)		6
2444635.591	II	32392.5		+0.147		32392.5		+0.309		7
			32521		+0.158		32521		+0.320	
2444869.270	II	32648.5		+0.168		32648.5		+0.331		8
2445077.411	I	32877		−0.250(?)		32877		−0.085(?)		9

? = Unusual O–C values differing from the smooth period trend, not included in the mean, not plotted in the figures.

References to Table II

	Ref. No.
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Diethelm, R. (cf. Banachiewicz, T.: 1987, *SAC*, No. 58).	6
Lelárko, I. (cf. Banachiewicz, T.: 1987, *SAC*, No. 58).	4
Strohmeier, W. and Bauernfeind, H.: 1968, *VBAM*, Bd. VII, 72.	1
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IBVS = Information Bulletin on Variable Stars.
JBAA = Journal of the British Astronomical Association.
SAC = Rocznik Astronomiczny (Krakow).
VBAM = Veröffentlichungen der Remeis-Sternwarte, Bamberg.

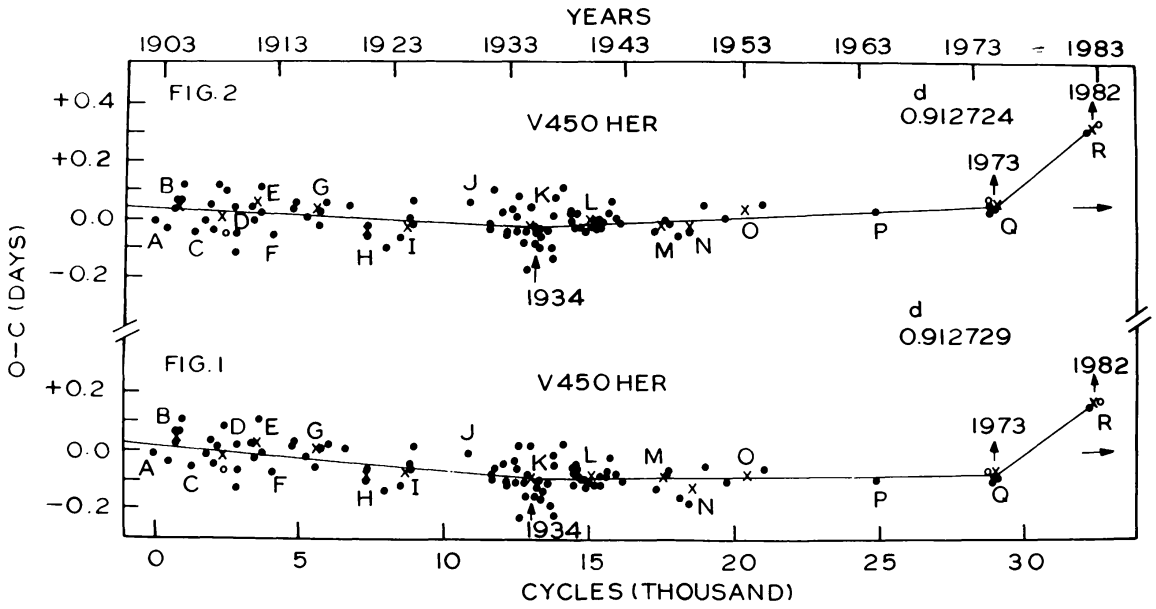

Fig. 1. The O–C diagrams of V450 Her based on $P = 0^d.912729$ and $P = 0^d.912724$, respectively. Filled and open circles represent primary and secondary minima values, while crosses indicate the mean O–C values. Vertical arrows indicate the increasing trends of the period. Solid lines represent the linear period trends.

Fig. 2. Same as Figure 1.

minima, 4 are secondary, while the remaining minima are primary. Out of these 5 primary minima (shown by bracketed question mark) have been left out from the present study as they have shown unusual O–C values not conforming to the regular period trend. Thus, 94 primary and 4 secondary minima have been considered for discussion of the period behaviour of V450 Her.

The O–C diagrams (Figures 1 and 2) have been drawn using the ephemeris

$$\text{Primary Minimum} = \text{J.D. } 2415069.870 + 0^d.912729E\,, \quad \text{(earlier)}$$

and

$$\text{Primary Minimum} = \text{J.D. } 2415069.870 + 0^d.912724E\,, \quad \text{(present)}$$

respectively.

In order to find the epochs of period changes from the O–C scatter, the O–C values have been grouped as shown in Table II, and mean O–C values have been plotted as crosses in Figures 1 and 2.

The O–C diagrams split up into 3 portions between points A and R. Figure 2, based on the O–C values using the new period, has been used to estimate the period changes. The period shows jumps around the years 1934 ($\pm$ 1) and 1973 ($\pm$ 1). Besides, these jumps, short-time period fluctuations are also evident; however, these are not consider-

TABLE III

Period variations of V450 Her

Portion	Interval of cycles	$\Delta P/P$	ΔP (days)	Period trend
BK	802–15033	4.29×10^{-6}	3.91×10^{-6}	*D*
KQ	15033–28939	3.60×10^{-6}	3.28×10^{-6}	*I*
QR[a]	28939–32521	7.73×10^{-5}	7.06×10^{-5}	*I*
	Mean	2.84×10^{-5}	2.59×10^{-5}	

[a] New period change.

able in the light of scatter. Period changes are given in Table III. It is evident from Table III that the period changes of the order of 3.3×10^{-6} d to 7.1×10^{-5} d are present in the system.

Around 1973 ($\pm$ 1) a new and sufficiently strong period change is apparent. The total change of $0^{d}.277$ in O–C values has occurred in 3582 cycles, which is far beyond any error either in the photographic or in the visual observations, as such this period change is real.

4. Summary

A detailed period study of V450 Her reveals that the average period change (ΔP) of the order of 10^{-5} d is present. Three linear trends of period changes are present. The last is a new, strong period change, and is a real one. The O–C values of primary and secondary minima change simultaneously and show large scatter. Very little is known about this system, thus, no further investigations are possible. Photoelectric observations are utterly needed for V450 Her.

References

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