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NSV 7457 HER : A NEW EW STAR WITH AN UNUSUAL B–V LIGHT CURVE

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SUMMARY

NSV 7457 Her was catalogued in the New Catalogue of Suspected Variable Stars (1982) as an RR: with a magnitude of 9.7 to 10.4 (p). Regular visual estimates and photoelectric measurements made by GEOS members allowed us to confirm the star's variability and to determine its ephemeris. It is probably an EW but the DSCT type cannot be dismissed with certainty. Its elements now agree with the following formula :

JD hel 47643.1786 (min) + 0.4190306 d x E

Its magnitude varies from 9.85 to 10.45 in V with a colour index B–V going from 0.618 to 0.684 in the Johnson system.

RESUME

NSV 7457 Her était cataloguée RR: avec une magnitude de 9.7 à 10.4 (p) dans le New Catalogue of Suspected Variable Stars (1982). Des estimations visuelles régulières et des mesures photoélectriques faites par des membres du GEOS ont permis de confirmer la variation de l'étoile et de déterminer son éphéméride. Il s'agit probablement d'une EW, mais le type DSCT ne peut être totalement écarté. Ses éléments correspondent actuellement à la formule suivante :

JJ hél 47643.1786 (min) + 0.4190306 j x E

Sa magnitude varie de 9.85 à 10.45 en V avec un indice de couleur B–V allant de 0.618 à 0.684 dans le système de Johnson.

RIASSUNTO

NSV 7457 Her è stata catalogata nel New Catalogue of Suspected Variable Stars (1982) come una RR: di magnitudine da 9.7 a 10.4 (p). Stime visuali e fotoelettriche fatte regolarmente da osservatori del GEOS hanno permesso di confermare la variabilità della stella e di determinare l'effemeride. Si tratta probabilmente di una EW, ma il tipo DSCT non può essere totalmente scartato. I suos elements correspondono attualmente alla seguente formula :

JJ hel 47643.1786 (min) + 0.4190306 j x E

La sua magnitudine varia da 9.85 a 10.45 in V con un indice de colore B–V de 0.618 a 0.684 nel sistema de Johnson.

RESUMEN

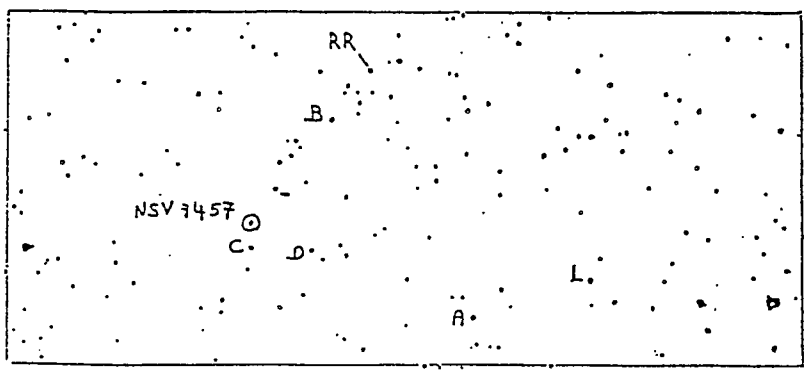
NSV 7457 Her está catalogada en el New Catalogue of Suspected Variable Stars (1982) como RR: con variaciones de magnitud de 9.7 a 10.4 (p). Las estimaciones visuales regulares y medidas fotoeléctricas realizadas por los miembros del GEOS han permitido confirmar la variabilidad de la estrella y determinar su efeméride. Se trata probablemente de una EW, aunque el tipo DSCT no ha podido ser totalmente descartado. Sus elementos corresponden actualmente a la fórmula siguiente :

DJ hel 47643.1786 (min) + 0.4190306 d x E

Su magnitud varía de 9.85 a 10.45 en V, y su índice de color B–V de 0.618 a 0.684 en el sistema de Johnson.

1. INTRODUCTION

NSV 7457 Her = CSV 007268 = BV 0103 = BD + 50 2255
α = 16h 06min 02s δ = +50° 11.2' (2000)



A = 9,71 (V); B = 10,16 (V); C = 10,56 (V) "Stellarum"

fig 1 : map with NSV 7457 Her and its comparison stars

The variability of NSV 7457 Her was discovered by E. Geyer et al (1955) when he examined photographic plates made between 1929 and 1939 in Bamberg ; the star was announced to have a photographic magnitude of 9.7 at maximum, an amplitude of 0.7 magnitude and rapid variations. G.S. Filatov (1960) mentions that the star has a short period and that it is probably of the RR type. After inspection of 134 photographic plates taken from 1939 to 1959 at the Tadjikistan Observatory he gives a list of 17 times of maximum brightness.

2. OBSERVATIONS (visual estimates and photoelectric measurements)

At GEOS, NSV 7457 Her was first chosen by Roland Boninsegna (BNN) who estimated it visually in 1984. Afterwards, it was incorporated in the observation programme of several GEOS members and principally in those of Claire Platteuw (FRD) who made 134 estimates of it in 1988 and 359 in 1989. Then the author also began to observe it and made 147 estimates of it in 1989 and 332 in 1990.

The first period searches made me suspect the star period. NSV 7457 Her was photoelectrically measured during the Easter 1991 GEOS mission at the Jungfraujoch station. The measurements were made with a cooled photometer equipped with filters of the Geneva photometric system, attached to the observatory's 76–cm telescope.

The star's variability so confirmed, new photoelectric measurements were made during subsequent GEOS missions and, in 1992, the star entered the priority programme of the group.

table 1 : principal visual estimates of NSV 7457 Her made by the GEOS members from 1984 to 1992

YEARS	BEN	BNN	BTL	CHC	DQZ	FRD	GBF	LIE	MRZ	VBR	VIA	ZMN
1984		22										
1985		1										
1986		6			6							
1987					5							
1988		4				134						17
1989						359				147		
1990						2				332		
1991										271		
1992	116		85	62			64	85	107	258	22	
TOTAL	116	33	85	62	11	495	64	85	107	1008	22	17

table 2 : photoelectric measurements of NSV 7457 Her

Dates	Number of measurements (in B and in V)
April 1991	6
August 1991	62
December 1991 – January 1992	51
September 1992	15
December 1992	70

3. RESEARCH OF THE STAR'S PERIOD

The first period searches were made in 1990 using 252 estimates by VBR, obtained between 89.05.23 and 90.05.06, with the PDM (Stellingwerf, 1978) and Fourier (Horne et al, 1986) methods programmed by Patrick Wils. Already at thistime 0.2095 and 0.4190 day were possible periods, but unfortunately the confidence level was small and the periods in competition with others.

The composited light curve was obtained with the Supervar programme of R. Dequinze.

In order to to check the reliability of the period, I have lumped my estimates into three small series, each of them spreading over two or three months only. I have casted aside my very first estimates, which seemed to me more imprecise than the others, and I have added the few obtained more recently. The only period that kept on appearing was 0.2095 day and this result strengthened my opinion. Nevertheless a value twice that period was equally plausible : in fact, the sinusoidal shape of the light curve allowed to suppose that NSV 7457 Her could be a pulsating star as well as an eclipsing star (of the EW type).

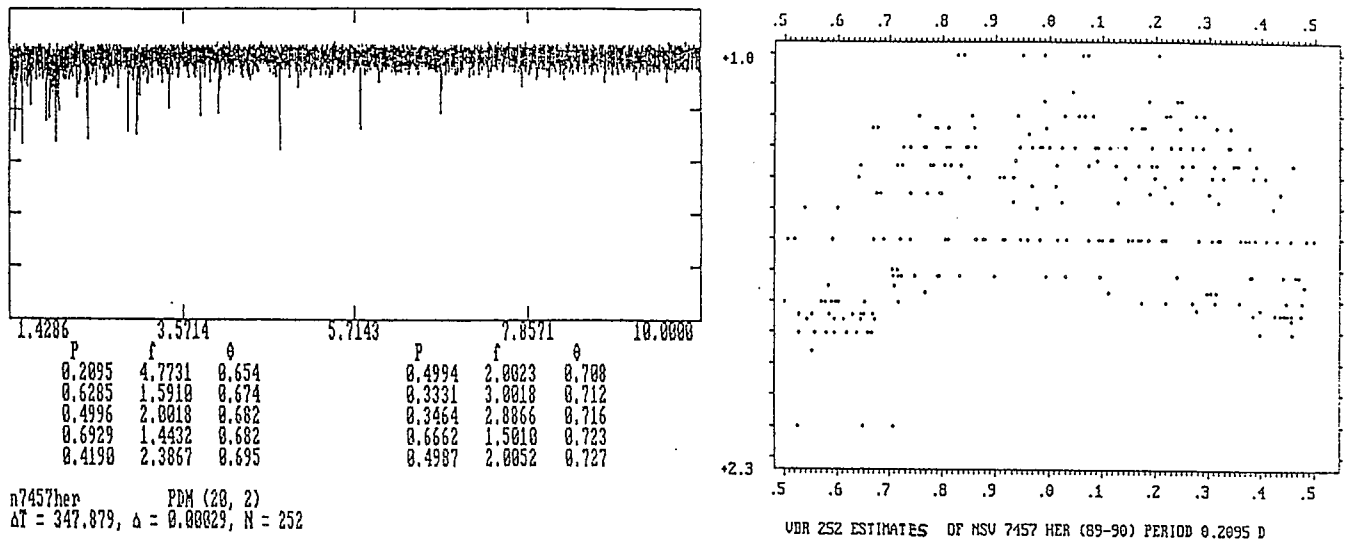


fig 2 : first period research (periodogram and composited light curve)

The first photoelectric measurements from April 1991 came to confirm the variability of the star and they were not in disagreement with the found period.

The following step in the search for an accurate period for NSV 7457 Her was the determination of the largest possible number of maxima from the visual estimates of C. Platteuw (FRD) and the author (VBR) (see table 3).

table 3 : first maxima of NSV 7457 Her

ABBREVIATIONS	DATES	JD HEL (2400000 +)	E	O − C (1)
FRD	26.04.89	47643.4806	1	− 0.0076
VBR	18.07.89	47726.4517	397	− 0.0053
VBR	02.04.90	47983.5298	1624	− 0.0046
VBR	04.04.90	47986.4826	1638	+ 0.0149
VBR	28.04.90	48009.5160	1748	+ 0.0014
VBR	27.05.90	48039.4741	1891	− 0.0014
VBR	25.06.90	48068.4039	2029	+ 0.0150
VBR	26.07.90	48099.3959	2177	− 0.0015
VBR	10.05.91	48387.4708	3552	− 0.0126
VBR	23.05.91	48400.4589	3614	− 0.0146
VBR	05.07.91	48443.4390	3819	+ 0.0145
VBR	10.07.91	48448.4701	3843	+ 0.0172
VBR	18.08.91	48487.4228	4029	− 0.0002
VBR	04.09.91	48504.4042	4110	+ 0.0103
VBR	13.09.91	48513.3908	4153	− 0.0124
VBR	17.09.91	48517.3810	4172	− 0.0030
VBR	30.09.91	48530.3717	4234	− 0.0023
VBR	08.10.91	48538.3278	4272	− 0.0079

So, using a linear regression, the following elements could be established for NSV 7457 Her :

(1) max JD hel 47643.2787 + 0.2095171 d x E
± 0.0053 ± 0.0000038 (confidence 95 %)

In 1992 NSV 7457 Her was introduced in the GEOS priority programme in order to obtain visual extrema from other observers. It was also measured again during the GEOS missions (August 91, December−January 91−92, September 92, December 92) at the Jungfraujoch observatory.

Here are the best results that have been obtained with the data now available. As the duration of the rising light curve corresponds to that of the descent (M−m = 0.50), it is permitted to use all the extrema (maxima and minima) for the determination of the ephemeris. Accuracy is the important point.

1° With the photoelectric measurements

The 204 photoelectric measurements in V were studied with the PDM method of period research (Stellingwerf, 1978) using Patrick Wils' programme. You can see here the periodogram at low resolution for a search between 0.15 and 1 day, and the graph of the most probable period obtained after a search at higher resolution.

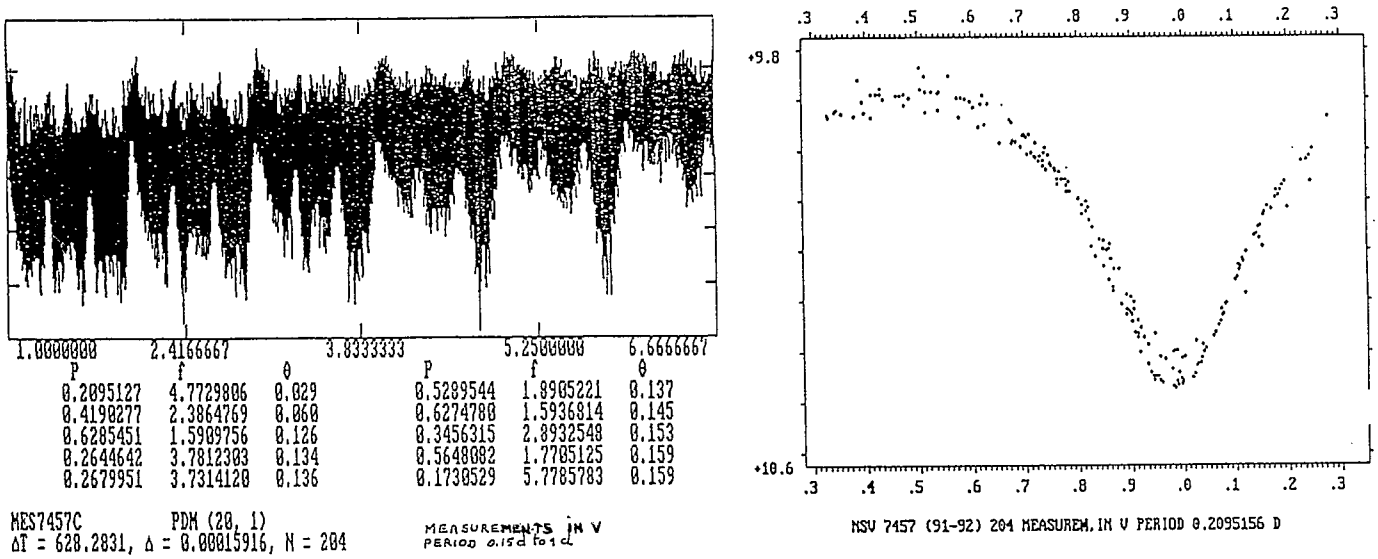


fig 3 : periodogram and composited light curve for period 0.2095156 day

The best period found is 0.2095156 day, the mean amplitude is 0.56 mag and M−m = 0.50. It is clear that the points don't perfectly superpose : the differences nearly reach 0.1 magnitude, which is more than the measurements' accuracy (± 0.03 mag). Thus, the shape of the light curve varies slightly from a cycle to the other.

2° With all the visual and photoelectric extrema

table 4 : the 50 visual and 3 photoelectric extrema used for the determination of the elements of NSV 7457 Her

OBSERVERS	EXTREMA	JD HEL (2400000 +)	E	O − C (2)
FRD	maximum	47643.4806	0.75	− 0.0123
FRD	minimum	47646.5258	8.00	− 0.0050
VBR	minimum	47724.4573	194.00	− 0.0132
VBR	maximum	47726.4517	198.75	− 0.0092
VBR	minimum	47758.4179	275.00	+ 0.0059
VBR	maximum	47983.5298	812.25	− 0.0064
VBR	maximum	47986.4826	819.25	+ 0.0132
VBR	maximum	48009.5160	874.25	− 0.0001
VBR	maximum	48039.4741	945.75	− 0.0027
VBR	maximum	48068.4039	1014.75	+ 0.0140
VBR	minimum	48072.4829	1024.50	+ 0.0075
VBR	minimum	48086.5102	1058.00	− 0.0027
VBR	maximum	48099.3959	1088.75	− 0.0023
VBR	minimum	48148.3332	1205.50	+ 0.0132
VBR	maximum	48387.4708	1776.25	− 0.0109
VBR	maximum	48400.4589	1807.25	− 0.0127
VBR	maximum	48443.4390	1909.75	+ 0.0167
VBR	maximum	48448.4701	1921.75	+ 0.0195
VBR	maximum	48487.4228	2014.75	+ 0.0023

OBSERVERS	EXTREMA	JD HEL (2400000 +)	E	O – C (2)
VBR	maximum	48504.4042	2055.25	+ 0.0130
VBR	minimum	48513.3116	2076.50	+ 0.0160
VBR	maximum	48513.3908	2076.75	– 0.0096
VBR	maximum	48517.3810	2086.25	– 0.0002
VBR	maximum	48530.3717	2117.25	+ 0.0006
VBR	maximum	48538.3278	2136.25	– 0.0049
PHO	maximum	48620.6606	2332.75	– 0.0116
PHO	minimum	48622.6629	2337.50	+ 0.0003
VBR	minimum	48661.6339	2430.50	+ 0.0015
VBR	minimum	48714.6430	2557.00	+ 0.0032
VBR	minimum	48732.4452	2599.50	– 0.0034
VBR	minimum	48733.4994	2602.00	+ 0.0032
VBR	minimum	48746.4931	2633.00	+ 0.0070
VBR	minimum	48747.5362	2635.50	+ 0.0025
BTL	minimum	48749.4341	2640.00	+ 0.0148
BTL	minimum	48755.5041	2654.50	+ 0.0088
VBR	minimum	48756.5507	2657.00	+ 0.0078
VBR	minimum	48759.4833	2664.00	+ 0.0072
VBR	minimum	48760.5381	2666.50	+ 0.0144
BTL	minimum	48763.4631	2673.50	+ 0.0062
BTL	minimum	48768.4776	2685.50	– 0.0077
VBR	minimum	48803.4718	2769.00	– 0.0025
VBR	minimum	48811.4271	2788.00	– 0.0088
BEN	maximum	48835.4123	2845.25	– 0.0131
MRZ	maximum	48861.3892	2907.25	– 0.0161
LIE	minimum	48862.3545	2909.50	+ 0.0064
LIE	maximum	48865.3912	2916.75	+ 0.0051
VBR	minimum	48877.4339	2945.50	+ 0.0007
VBR	maximum	48881.3178	2954.75	+ 0.0086
LIE	minimum	48888.3267	2971.50	– 0.0013
VBR	maximum	48908.3257	3019.25	– 0.0110
PHO	minimum	48983.6534	3199.00	– 0.0041
VBR	maximum	49061.4808	3384.75	– 0.0116
VBR	minimum	49061.5912	3385.00	– 0.0055

PHO = photoelectric extrema

The elements that now suit best to NSV 7457 Her were calculated by linear regression, giving a triple weight to the photoelectric moments.

These elements are the following :

(2) min JD hel 47643.1786 + 0.4190306 d x E
± 0.0023 ± 0.0000025 (confidence 95%)

The epoch was chosen considering the light curve obtained with the photoelectric measurements (see fig 4) for a star of the EW type (see chapter 4).

3° With the moments of the photographic plates

G.S. Filatov (1960) published 17 moments at which NSV 7457 Her was at maximum of light between 1943 and 1959. The period accuracy of ephemeris 2 theoretically just allows us to go back to these years. Unfortunately, the tests came to a failure. On the contrary, a slight modification of the period derived from the most recent observations yielded a period that suited the photographic timings well enough (see ephemeris 3).

table 5 : maximum's moments of NSV 7457 Her on the photographic plates

JD HEL (2400000+)	E	O – C (3)
30850.217	1	+ 0.0051
33358.376	11973	– 0.0158
33865.213	14392	+ 0.0314
33887.191	14497	+ 0.0115
34189.279	15939	– 0.0051
34190.312	15944	– 0.0196
34216.294	16068	– 0.0161
35602.383	22684	– 0.0045
35628.329	22808	– 0.0370
35957.334	24378	+ 0.0470
36065.192	24893	+ 0.0105
36449.225	26726	+ 0.0230
36701.408	27930	– 0.0366
36725.301	28044	– 0.0271
36734.372	28087	+ 0.0353
36745.242	28139	+ 0.0111
36815.192	28473	– 0.0132

(3) max JD hel 30850.002 + 0.2095038 x E
± 0.013 ± 0.0000017 (confidence 95%)

Times of maximum brightness were used here because they were the only available.

The period found is a little shorter than those suiting the current extrema and the photoelectric measurements. It is possible that a period change occured in the interval or that there exists a periodic variation of the star's period. To ascertain that, we need more years of observations.

4. RESEARCH OF THE STAR'S TYPE

The list of all the photoelectric measurements of NSV 7457 Her can be obtained from the author. The B–V corresponding to the Johnson and Morgan system were calculated from the transformation formulae described by Meylan and Hauck (1981) using the star's class III. These photoelectric measurements have been composed with ephemeris (2) for the V and B–V.

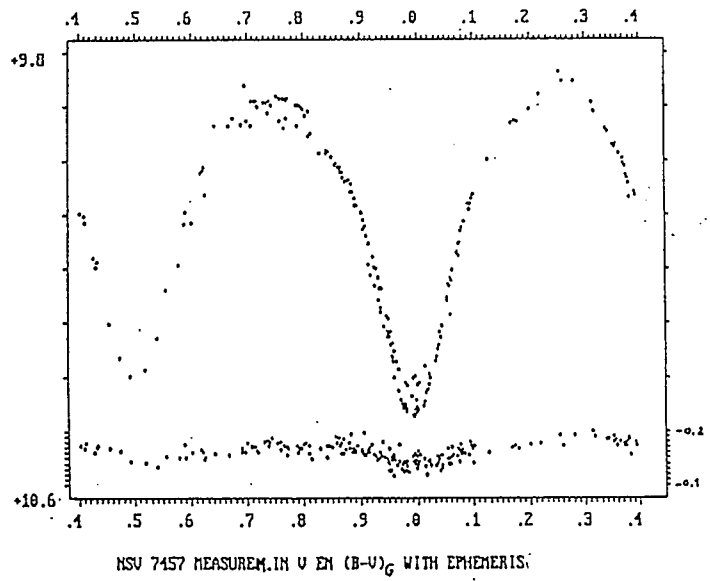


fig 4 : composited light curve of the photoelectric measurements of NSV 7457 Her with period 0.4190306 day

If we plot the light curve of NSV 7457 Her with the period 0.4190306 d, its characteristics can be summarized thus.

a) The magnitude of NSV 7457 Her varies from 9.85 to 10.45 in V with an accuracy of about ± 0.03 magnitude on the measurements.
b) Its primary minimum is generally a little deeper than its secondary.
c) Its maxima are clearly more rounded that its minima, but the ascending branches of the light curve are of the same length as the descending ones.
d) Its colour index B−V ranges from 0.62 to 0.68.
e) It is always redder when it is less bright (see fig 4).
f) The maxima and minima of the B−V light curve are a little shifted compared with the ones of the V curve.

The shape of the B−V colour index can suggest that NSV 7457 Her is a pulsating star. The mean amplitude of the B−V variations (0.04 mag) is low for a pulsating star, compared with those of the magnitude in V (0.56 mag). This characteristic is rare but not exceptional for such a star. In fact another case can be quoted : AR Ser (J. Lub, 1977).

Moreover DSCT type contains very different stars whose periods extend from 0.02 day to 0.21 day (A. Baglin et al, 1973). The GCVS 85 gives a larger sample of periods (0.01 d to 0.2 d) and a few stars were classified DSCT with still longer periods : RY Lep (0.2254 d) (Diethelm, 1985), VX Hya (0.2234 d) and TV Lyn (0.2410 d) (López de Coca et al, 1990).

The B−V colour index (0.618 to 0.684) is redder than the DSCT indices I can find in the literature. The star with the nearest NSV 7457 Her's colour index is V 356 Aur (B−V = 0.606) (Poretti et al, 1987). Moreover, it should be affected by insterstellar reddening. Moreover, the GO spectrum indicated in the New Catalogue of Suspected Variable Stars (1982) is not very far from the F8 spectrum attributed to four other DSCT stars : V 356 Aur, VX Hya, DE Lac and V 369 Sct (GCVS 85).

However the simplest explanation of characteristics a) to f) is to consider NSV 7457 Her as an EW variable. Indeed the period and the shape of the light curve are typical for a such class of variable stars.

Firstly, the shape of the light curve varies and the maxima and minima don't have always the same magnitudes. This is the particularity of double stars having dark or luminous spots on the surface of at least one of the component. VZ Piscium is such a star (C. Maceroni et al, 1990).

Secondly, the B−V index mimics the V behaviour : the star is bluer when it is brighter in V. This can be found in contact binaries : if the double star has a hot spot located near the contact point, the star is bluer at maximum light when the spot is visible than at minimum light when the spot is not. CK Aqr has such a B−V light curve (J.F. Le Borgne et al, 1989).

Thirdly, if we consider the period found using the timings derived from the Bamberg's photographic plates (ephemeris 3) we can suppose that the period increased since the years 1943−59. This is the case when material escapes from the system or when there is an exchange of material between the components. In fact there are about the same number of W−type systems with an increasing period as with a decreasing one, whereas a few systems are alternating their tendency (M.J. Sarna, 1991 according to Glownia).

To be absolutely certain of the EW type of NSV 7457 Her, we should have radial velocity measurements of the star.

5. CONCLUSION

NSV 7457 Her (16h 06 02 +50° 11.2) (2000) is probably an EW variable, but the DSCT type cannot be totally excluded. It is a contact system with a brightness ranging from 9.85 to 10.45 (V).

The current elements of the period are : (2) JD hel 47643.1786 (min) + 0.4190306 d x E
Min II is 10.40 (V) at 0.5 period and B−V = 0.618 to 0.684.

Radial velocity measurements would be decisive to confirm the EW type.

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