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GEOS CIRCULAR ON ECLIPSING BINARIES

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GEOS
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REVISED EPHEMERIS FOR THE ECLIPSING BINARY

RS Ser

ABSTRACT : RS Ser is an eclipsing binary which has not been subjected to publication for a long time. Between 1982 and 1990, visual observations made by GEOS led to the conclusion that the current ephemeris was not valid any more.
In this paper 23 minima observed by GEOS are analyzed, to which were added 4 other minima observed between 1915 and 1954.
On the basis of these data, a new ephemeris can be computed :

$$Min\ I\ JJ_{Hel}\ \underset{\pm 16}{2447355{,}4509} + \underset{\pm 2}{0{,}5981434} * E$$

RESUME : RS Ser est une étoile à éclipses qui n'a pas fait l'objet de publication depuis de très nombreuses années. Entre 1982 et 1990, des observations visuelles effectuées par le GEOS ont permis de conclure que l'éphéméride de l'étoile n'était plus valable.
Dans cet article, on analyse 23 minimums observés par le GEOS auxquels on a ajouté 4 minimums observés entre 1915 et 1954.
Ces observations permettent de calculer une nouvelle éphéméride pour l'étoile :

$$Min\ I\ JJ_{Hel}\ \underset{\pm 16}{2447355{,}4509} + \underset{\pm 2}{0{,}5981434} * E$$

RIASSUNTO : RS Ser è una binaria ad eclisse da molto tempo assente in letteratura. Fra il 1982 ed il 1990 le osservazioni visuali del GEOS hanno portato alla conclusione che l'attuale effemeride non fosse più valida.
In questo articolo vengono utilizzati 23 minimi osservati dal GEOS, cui sono stati aggiunti 4 minimi precedenti osservati fra il 1915 ed il 1954.
Queste osservazioni permettono di calcolare la seguente nuova effemeride per tale stella :

$$Min\ I\ JJ_{Hel}\ \underset{\pm 16}{2447355{,}4509} + \underset{\pm 2}{0{,}5981434} * E$$

RESUMEN : RS Ser es una estrella eclipsante que no ha sido objeto de publicacion desde hace muchos anos. Entre 1982 y 1990, observaciones visuales efectuadas por el GEOS han permitido concluir que la efeméride de la estrella ya no era valida.
En este articulo se analiza 23 minimos observados por el GEOS, a los cuales se ha anadido 4 minimos observados entre 1915 y 1954.
Las observaciones permiten calcular una nueva efeméride para la estrella:

$$Min\ I\ JJ_{Hel}\ \underset{\pm 16}{2447355{,}4509} + \underset{\pm 2}{0{,}5981434} * E$$

1. INTRODUCTION

The most recent edition of the GCVS (Kholopov *et al.*, 1985) gives the following elements :

EW/KW 10.8-11.5 V Min II : 11.4 V

Min I : JD_{Hel} 24434921.838 + 0.598140369 * E

According to the Rocznik Astronomiczny (Rudnicki, 1990), the star seems to have been unobserved since 1954. The scarce references led us to include RS Ser in the GEOS observing programme for under-studied eclipsing binaries in 1982. It was observed for the first time during the summer camp of Bédarieux (Hérault, France) with a 20-cm reflector (Ralincourt, 1983).

2. OBSERVATIONS

Visual estimates were carried out by GEOS members between 1982 and 1990 (Ralincourt, 1983, 1989; Wala; 1990). All observations were made using the Argelander method.

The magnitudes of the comparison stars were obtained by GEOS members during the 1990 August 13/30 run at Jungfraujoch Observatory (Switzerland) with the 76-cm Cassegrainian telescope fitted with a photometric photometer of the Geneva Observatory (Dumont, Ralincourt, Remis, 1990). The calibration to the Geneva standard photometric system was ensured by frequent observations of standard stars selected from the Geneva catalogue. The method of reduction is described in GEOS Circular RR 7 (Dumont, 1983).

Fig-1 shows the field of the variable and the comparison stars used. The magnitude of the comparison stars in the BV system and air-masses are reported in Table-1, where $(B-V)_G$ is the index in the Geneva photometry system and (B-V) the Johnson and Morgan index.

The air-mass is fairly high for the whole set of measurements, but in Europe, this fact is hardly avoidable.

Table-1

Star	*17/08/91 (U.T)*	*Air-Mass*	*V*	$(B-V)_G$	*(B-V)*
A	22h23	2,62	9,85	1,54	(2,10)
B	22h29	2,70	10,70	0,77	1,36
C	22h51	3,01	11,53	0,02	0,79
D	22h58	3,14	11,96	0,46	1,12

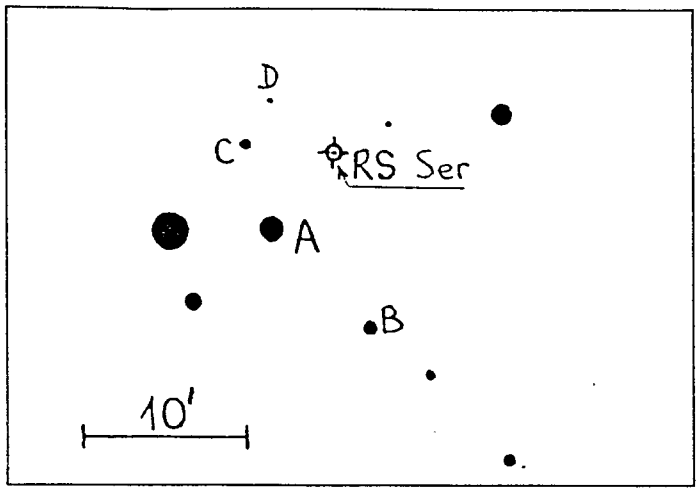

Fig-1 *Identification chart*

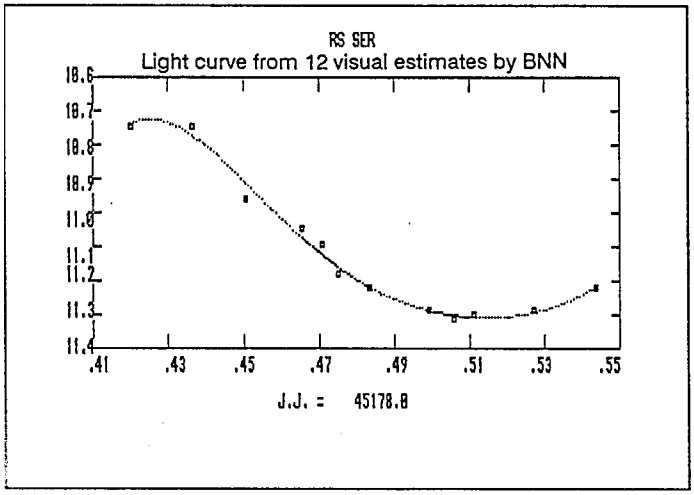

Fig-2

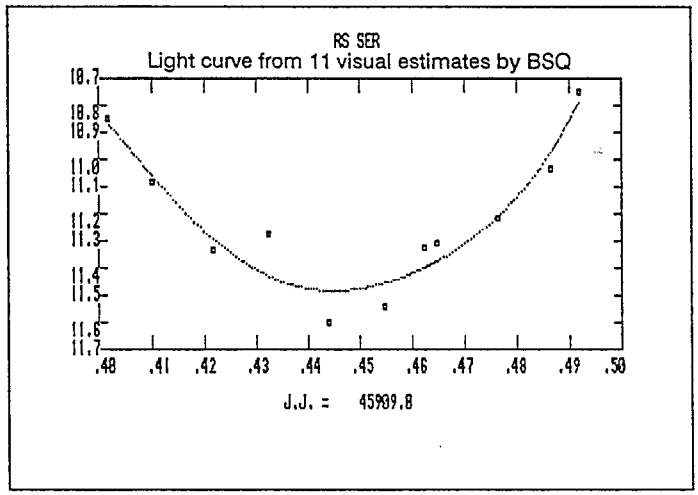

Fig-3

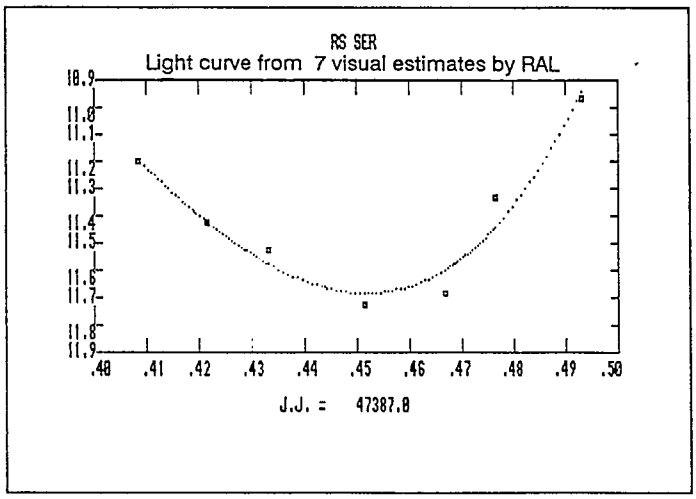

Fig-4

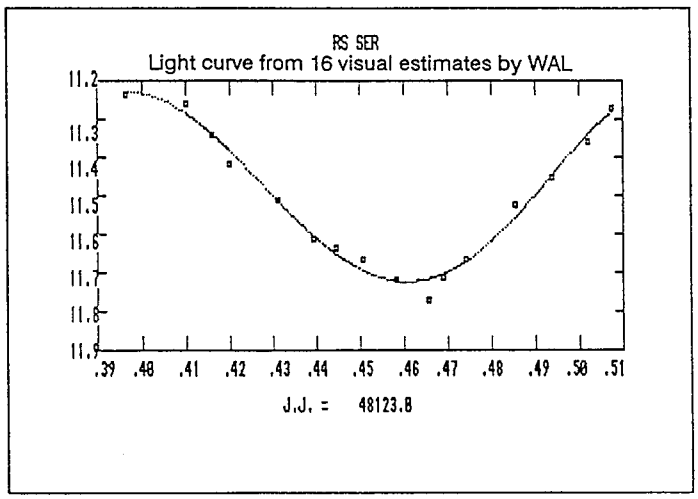

Fig-5

The light curves obtained by each visual observer during significant nights of monitoring were examined in order to find the times of minimum of the variable. The instants of minimum were determined using a computerized numerical method especially suited for visual estimations processing (Buzzoni, 1982; Gaspani, 1988, 1989).

Some light curves are shown in Fig 2-5.

A total of 23 minima from 7 observers were collected. Table-2 gives the observers ' names (identified by a three letter acronym), the observation sites and the number of collected minima.

Table-2

Observer	*Site*	*Abbr.*	*n. of minima*
G. Boistel	F-Sautron	BTL	6
R. Boninsegna	B-Dourbes	BNN	1
J. Busquets	E-Valencia	BSQ	1
M. Checcucci	I-Castellina	CHC	3
P. Ralincourt	F-Nantes	RAL	5
J-P. Verrot	F-Valence	VRR	1
O. Walas	F-Nantes	WAL	6

In addition to these, 4 more times of minimum have been found in the literature between 1915 and 1954.

The most recent one was obtained by Koch and Koch (1962) on 35 mm film strips taken at the Steward Observatory, University of Arizona .

A reexamination of 31 visual estimates collected by Piotrowski (1963) in 1938 at the Astronomical Observatory the Jagellonian University, Krakow, allowed the calculation of 2 more times of minimum. It is interesting to note that Kreiner's analysis of Piotrowski's observations was incomplete (Kreiner, 1976). He only extracted one time of minimum.

The latter is the epoch of the GCVS 1969 star ephemeris. No information concerning this observation was found in the literature.

The complete list of minima is reported in Table-3. The (O-C) [1] [2] column reports the (O-C)s in days with respect to ephemerides [1] [2] (see Table-3).

One can note a large positive (O-C) in both cases indicating the non-validity of these elements.

Table-3

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Minima of RS Serpentis

Ephemeris [1] : 2420656.1902 + 0.598139670 * E GCVS 1969

Ephemeris [2] : 2434921.8380 + 0.598140369 * E GCVS 1985

Ephemeris [3] : 2447355.4509 + 0.5981434 * E This paper

n	*Obs.*	*Min Hel.*	*E[1]*	*(O-C)[1]*	*(O-C)[2]*	*(O-C)[3]*
1	GCVS	20656.1902	00000.0	+0.0000	+0.0000	+0.0663
2	PIO	29129.4216	14166.0	-0.0152	-0.0251	-0.0018
3	PIO	29135.4093	14176.0	-0.0088	-0.0187	+0.0045
4	KOC	34921.8380	23850.0	+0.0166	+0.0000	-0.0061
5	BNN	45178.5112	40997.5	+0.0899	+0.0612	+0.0032
6	RAL	45178.5189	40997.5	+0.0975	+0.0689	+0.0109
7	BSQ	45909.4466	42219.5	+0.0986	+0.0691	+0.0074
8	VRR	47036.3424	44103.5	+0.0992	+0.0684	+0.0010
9	RAL	47354.5528	44635.5	+0.0993	+0.0681	-0.0009
10	RAL	47355.4528	44637.0	+0.1021	+0.0709	+0.0019
11	BTL	47355.4534	44637.0	+0.1028	+0.0716	+0.0025
12	BTL	47361.4359	44647.0	+0.1038	+0.0726	+0.0036
13	BTL	47387.4525	44690.5	+0.1014	+0.0702	+0.0009
14	RAL	47387.4525	44690.5	+0.1014	+0.0702	+0.0009
15	CHC	47734.3685	45270.5	+0.0964	+0.0648	-0.0062
16	CHC	47740.3575	45280.5	+0.1039	+0.0723	+0.0013
17	BTL	47768.4631	45327.5	+0.0970	+0.0653	-0.0058
18	RAL	47768.4665	45327.5	+0.1005	+0.0688	-0.0024
19	BTL	48091.4651	45867.5	+0.1036	+0.0715	-0.0013
20	BTL	48094.4525	45872.5	+0.1003	+0.0682	-0.0046
21	WAL	48094.4539	45872.5	+0.1016	+0.0696	-0.0032
22	WAL	48122.5675	45919.5	+0.1027	+0.0706	-0.0024
23	WAL	48123.4660	45921.0	+0.1040	+0.0719	-0.0010
24	WAL	48127.3546	45927.5	+0.1047	+0.0726	-0.0004
25	CHC	48127.3552	45927.5	+0.1053	+0.0732	+0.0002
26	WAL	48144.4017	45956.0	+0.1048	+0.0727	-0.0004
27	WAL	48162.3458	45986.0	+0.1047	+0.0726	-0.0005

3. DISCUSSION

The (O-C) diagram analysis according to the GCVS 1969 ephemeris (Fig-6) shows the erroneous modification of the GCVS 1985 and seems to establish the highly probable constancy of the period between Julian Days 2429000-2448000.

If the GCVS 1969 time of minimum is correct, data obtained in the interval 1915-1940 lead to the following conclusions :

- a period change occurred in the interval 2425000-2430000.

- the number of observations available does not allow this value to be specified.

It would be interesting to research the first times of minimum of the star to confirm the validity of the GCVS 1968 point and to improve the shape of the data cloud.

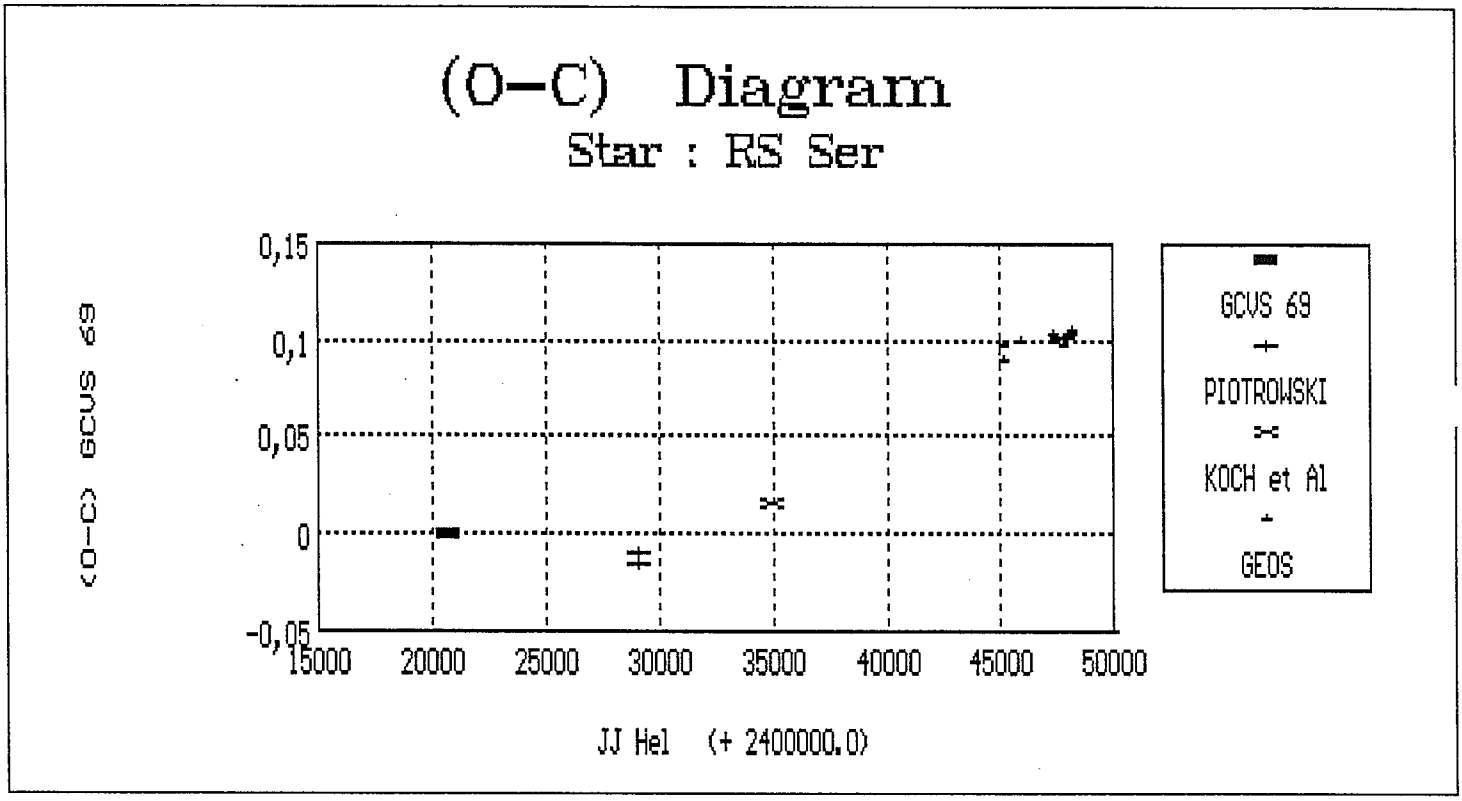


***Fig-6** (O-C) diagram*

A linear regression on the last 26 minima leads to the revised ephemeris :

$$\textit{Min I JJ}_{\textit{Hel}} \quad \underset{\pm 16}{2447355.4509} + \underset{\pm 2}{0.5981434} \quad [3]$$

(95% level of confidence for error intervals)

Table-3, column 3, shows the (O-C)s with respect to this new ephemeris. Low residuals indicate the good quality of the measurements and further confirm the reliability of visual estimates made with the Argelander method. (see Fig-7)

In order to check this new ephemeris [3] the folded light curves obtained by the three more productive observers are shown in Fig-8,9,10.

The shape of these curves is consistent with an EW type variable with deep minima. All the observers note a difference of about 1/10 of magnitude between the two minima in agreement with GCVS references.

It is difficult to conclude about the range of variations from visual estimates, but it seems that the star is fainter than expected during eclipses.

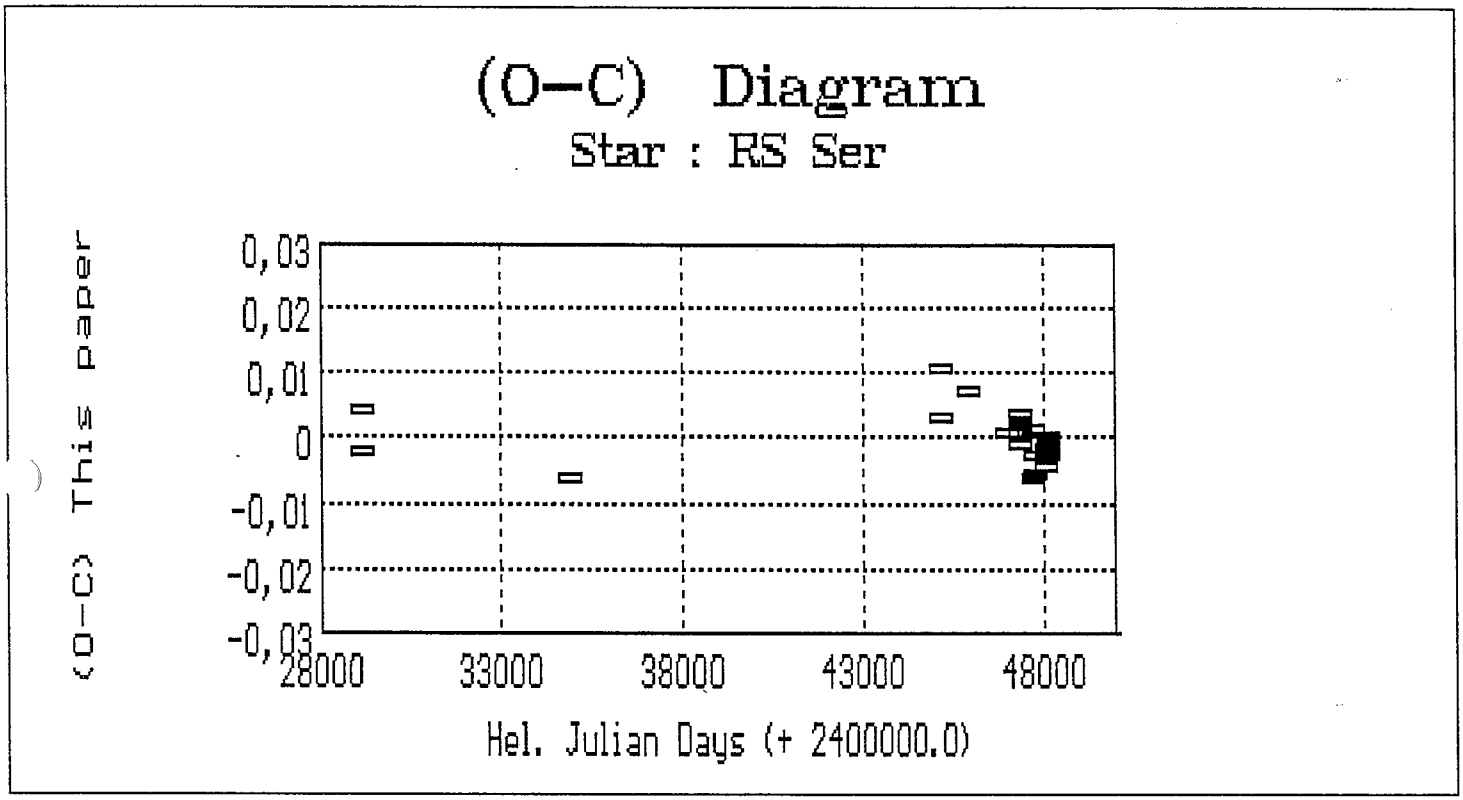


Fig-7 *(O-C)s according to the new ephemeris*

4. CONCLUSION

A revised ephemeris for the eclipsing binary star RS Ser has been calculated using GEOS visual observations obtained between 1982 and 1990. The GCVS hypothesis was found to be erroneous, and it seems that the period of the star has been constant for a long time. No further visual observations are planned by GEOS on the star, but photoelectric measurements would allow the collection of more accurate information concerning eclipse duration (Giuricin *et al.*,1983), the range of variation, and a check on the new ephemeris.

Olivier Walas

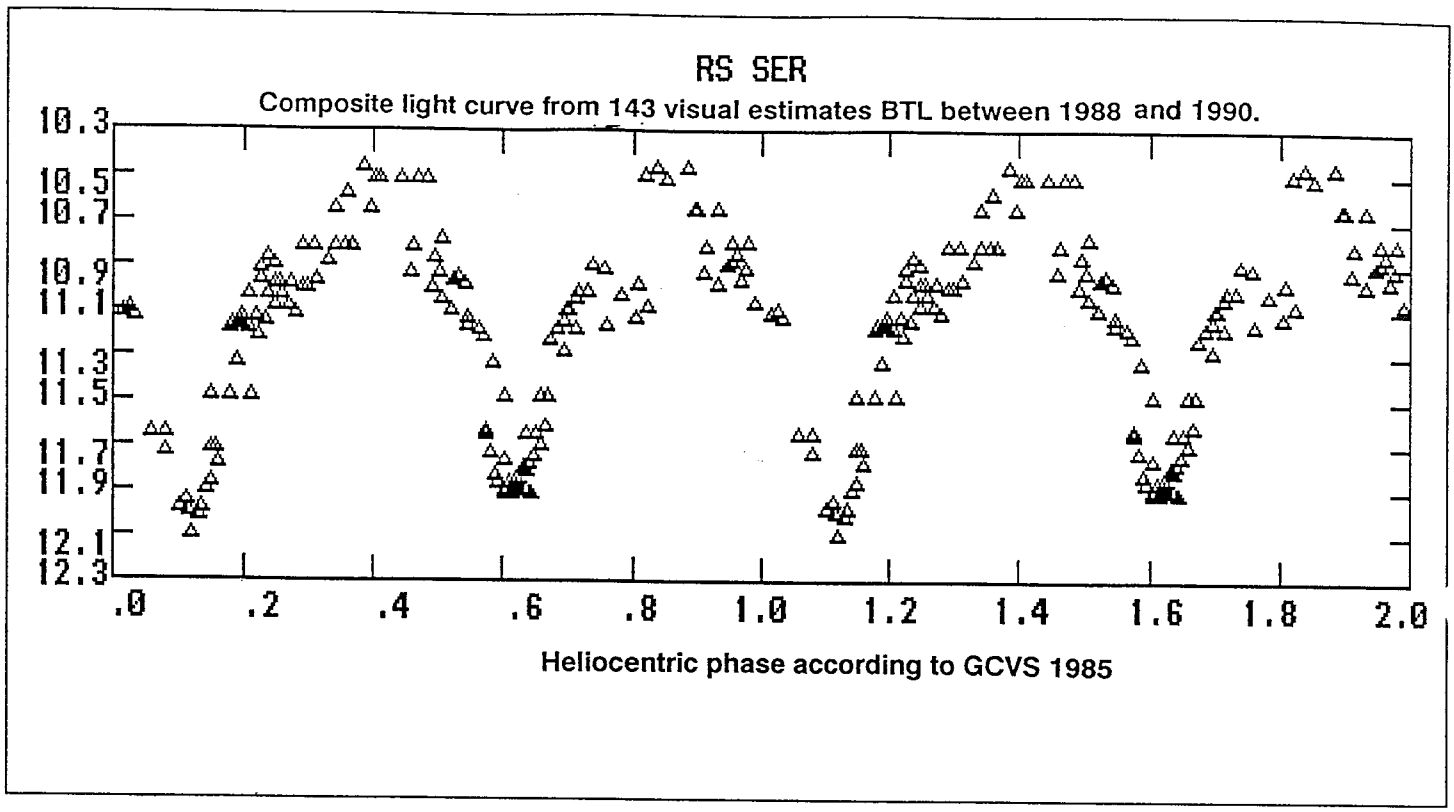
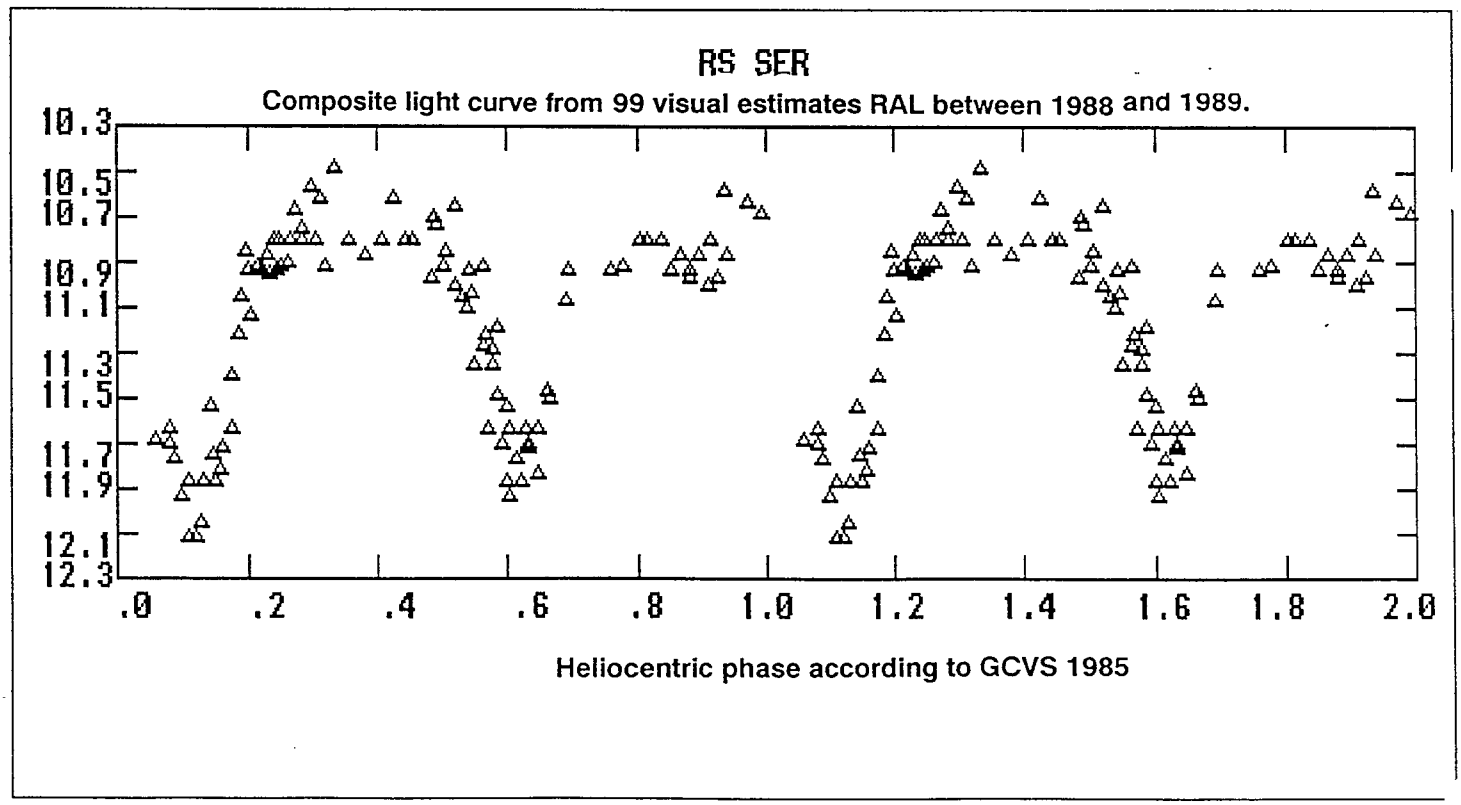

RS SER
Composite light curve from 143 visual estimates BTL between 1988 and 1990.
10.3
10.5
10.7
10.9
11.1
11.3
11.5
11.7
11.9
12.1
12.3
.0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Heliocentric phase according to GCVS 1985

Fig-8


RS SER
Composite light curve from 99 visual estimates RAL between 1988 and 1989.
10.3
10.5
10.7
10.9
11.1
11.3
11.5
11.7
11.9
12.1
12.3
.0
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1.0
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1.6
1.8
2.0
Heliocentric phase according to GCVS 1985

Fig-9

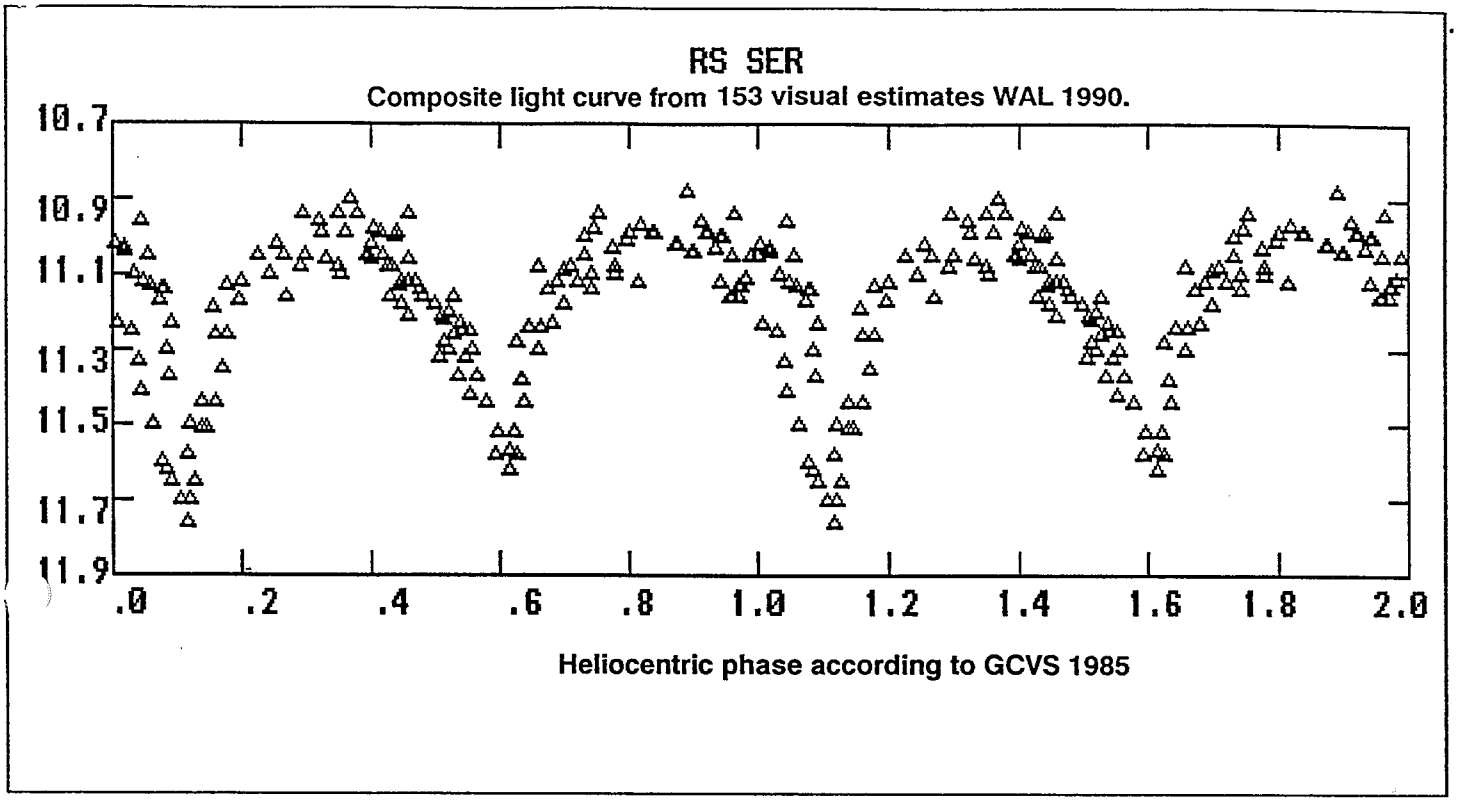

Fig-10

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