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AU Serpentis and FG Hydrae: two contact binaries with sudden variations in their orbital periods

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Abstract. Many available published times of light minima of the two contact binaries AU Ser and FG Hya are collected and the changes in their orbital periods are analyzed. It is indicated that the orbital period of AU Ser shows a sudden decrease in the time interval of 1987-1988 and several period jumps are found in FG Hya. The connections between the period jumps and the variable O'Connell effects (asymmetries in the light curves) of the two contact binaries are also discussed.

Key words: stars: binaries: close – stars: individual: AU Ser – stars: individual: FG Hya

1. Introduction

AU Ser is a W UMa-type eclipsing binary, which was discovered and confirmed as a variable by Hoffmeister (1935). Later, the system was observed visually and photographically by Soloviev (1951) and Huth (1964). Binnendijk (1972) published the first photoelectrical light curve and obtained a revised ephemeris:

$$Min.I = HJD2440748.8592 + 0.38650124 \times E$$

Recently, the system was observed photoelectrically by Kennedy (1985) and the variable O'Connell effect in the light curves were found by Zongyun Li et al. (1992). The first radial velocity curve of AU Ser was obtained by Hrivnak (1993) and the spectroscopic mass ratio $q = 0.71$ was obtained for the system. Although Kennedy (1985) suspected that a period change might be taken before HJD2436673, the study of the period of the binary still remains neglected.

FG Hya is another W UMa-type contact binary which was also discovered by Hoffmeister (1934), with the spectral type being G0. The system was observed visually by Tsesevich (1949) and photoelectrically by Binnendijk (1963), Smith (1963), Yang et al. (1991), Mahdy et al. (1985) and others. The light curves of FG Hya also show the variable O'Connell effect (Two maxima in the light curves are unequal). A photometric study by Yang et al. (1991) indicated that the system is an A-type contact binary, with an overcontact factor being about 0.9. Although Yang et al.(1991) pointed out that the orbital period of the star changes, the property of the period variation is not clear. In this present paper the changes in the periods of AU Ser and FG Hya are studied and the possible connections with the variable O'Connell effects are also discussed.

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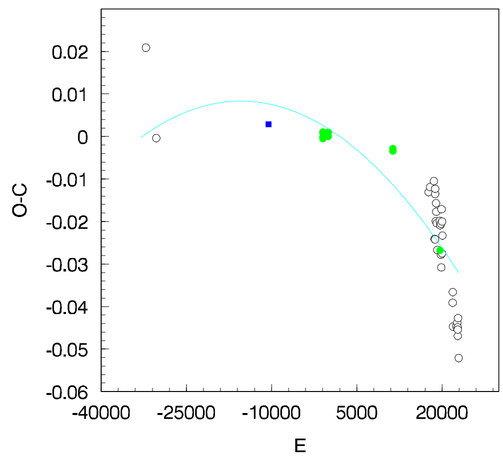

Fig. 1. The O-C curve of AU Ser and its description by a quadritic ephemeris. Boxes, circles and dots refer to photographic, visual and photoelectric observation

2. Change in the orbital period of AU Ser

In order to study the change in the period of AU Ser we have compiled as many minimum times as we can find in the literature. With Binnendijk's ephemeris (1972) the O-C values for these minima (the $(O-C)_1$ in Table 1) have been computed. Four visual minima 2447713.475, 2447723.516, 2447737.427, and 2447743.440 are discarded because their O-C values show large deviations from the general O-C trend formed by other points. Assuming that all minima have a parabolic O-C variation and using the weights 8, 4 and 1 for the photoelectric, photographic and visual observations respectively, we obtain the followimg quadratic light elements:

$$Min.I = HJD2440748.8610(127) + 0.38650039(11) \times E \\ -2.75(3) \times 10^{-11} \times E^2$$

and a period decrease rate: $dP/dE = -5.5 \times 10^{-11}$day. Unfortunately, as we can see in Fig. 1, the quadratic ephemeris does not fit the O-C observations very well.

Table 1. Times of minima for AU Ser

JD.Hel.	Min.	Method	W	E	$(O-C)_1$	$(O-C)_2$	Ref.
2400000+							
28334.267	II	vis	1	-32120.5	+0.0210	+0.0109	(1)
29039.224	II	vis	1	-30296.5	+0.0000	-0.0098	(2)
36673.593	I	pg	4	-10544	+0.0030	-0.0005	(3)
40385.7421	II	pe	8	-939.5	+0.0008	+0.0003	(4)
40386.7074	I	pe	8	-937	-0.0001	-0.0006	(4)
40386.9019	II	pe	8	-936.5	+0.0011	+0.0006	(4)
40387.8665	I	pe	8	-934	-0.0005	-0.0010	(4)
40748.8592	I	pe	8	0	+0.0000	-0.0002	(4)
40749.8264	II	pe	8	2.5	+0.0009	+0.0008	(4)
45142.9884	I	pe	8	11369	-0.0034	-0.0001	(5)
45143.0227	II	pe	8	11369.5	-0.0028	+0.0004	(5)
47381.407	II	vis	1	17160.5	-0.0067	+0.0028	(6)
47563.636	I	vis	1	17632	-0.0131	-0.0030	(6)
47668.379	I	vis	1	17903	-0.0119	+0.0001	(6)
47713.475	II	vis	0	18019.5	+0.0567	discard	(6)
47723.516	II	vis	0	18045.5	+0.0487	discard	(6)
47737.427	II	vis	0	18081.5	+0.0456	discard	(6)
47743.440	I	vis	0	18097	+0.0679	discard	(6)
47925.597	II	vis	1	18568.5	-0.0105	+0.0061	(7)
47968.485	II	vis	1	18679.5	-0.0241	-0.0067	(7)
48002.497	II	vis	1	18767.5	-0.0242	-0.0062	(7)
48010.431	I	vis	1	18788	-0.0135	+0.0046	(7)
48016.423	II	vis	1	18803.5	-0.0123	+0.0059	(7)
48058.544	II	vis	1	18912.5	-0.0199	-0.0009	(7)
48068.404	I	vis	1	18938	-0.0157	+0.0035	(7)
48085.408	I	vis	1	18982	-0.0177	+0.0018	(7)
48121.350	I	vis	1	19075	-0.0204	-0.0003	(7)
48163.279	II	vis	1	19183.5	-0.0267	-0.0058	(8)
48356.3364	I	pe	8	19683	-0.0267	-0.0024	(9)
48358.468	II	vis	1	19688.5	-0.0209	+0.0035	(8)
48404.462	II	vis	1	19807.5	-0.0205	+0.0047	(8)
48405.421	I	vis	1	19810	-0.0278	-0.0026	(8)
48429.381	I	vis	1	19872	-0.0308	-0.0052	(8)
48440.410	II	vis	1	19900.5	-0.0171	+0.0087	(8)
48475.378	I	vis	1	19991	-0.0275	-0.0010	(8)
48486.401	I	vis	1	20019.5	-0.0200	+0.0067	(8)
48504.563	I	vis	1	20066.5	-0.0233	+0.0037	(8)
49201.409	II	vis	1	21869.5	-0.0391	+0.0004	(10)
49206.436	II	vis	1	21882.5	-0.0366	+0.0030	(10)
49232.324	II	vis	1	21949.5	-0.0447	-0.0046	(10)
49441.614	I	vis	1	22491	-0.0446	-0.0007	(10)
49520.461	I	vis	1	22695	-0.0438	+0.0015	(10)
49544.421	I	vis	1	22757	-0.0469	-0.0012	(10)
49544.423	I	vis	1	22757	-0.0449	+0.0008	(10)
49549.447	I	vis	1	22770	-0.0454	+0.0004	(10)
49567.422	II	vis	1	22816.5	-0.0427	+0.0034	(10)
49609.348	I	vis	1	22925	-0.0521	-0.0052	(10)

References: (1) Soloviev (1936); (2) Soloviev (1951); (3) Huth (1964); (4) Binnendijk (1972); (5) Kennedy (1985); (6) SAC 62 (1991); (7) SAC 63 (1992); (8) SAC 64 (1993); (9) Zongyun et al.(1992); (10) SAC 67 (1996).

The O-C diagram may show a sudden period jump in 1987-1988. Using the solution of the weighted linear least squares, we derive the ephemeris:

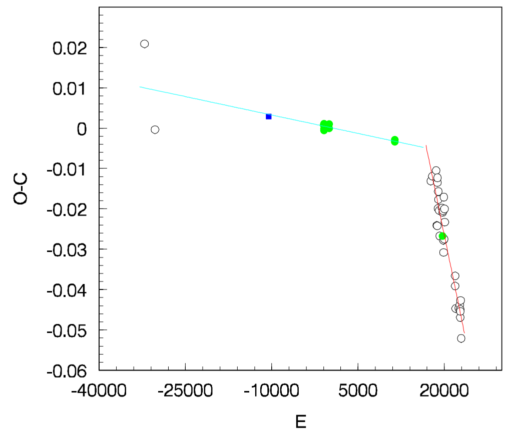

Fig. 2. A sudden change in the orbital period of AU Ser in the time interval 1987-1988. Symbols are as in Fig. 1

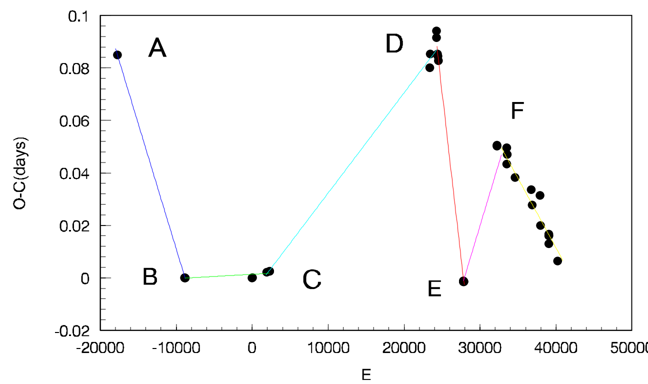

Fig. 3. O-C observation of FG Hya and their description by several linear ephemeris

$$Min.I = HJD2440748.8594(16) + 0.38650094(16) \times E$$

for the O-C values before 1987. As for the O-C values after 1988, with the same method we obtain the following ephemeris:

$$Min.I = HJD2440748.9717(93) + 0.38649429(46) \times E$$

and a sudden period decrease $\Delta P = -6.65 \times 10^{-6}$day. The respective ephemeris was used to compute the $(O-C)_2$ values in Table 1. It is shown from Fig. 2 that the two ephemerises fit the O-C values very well.

3. Change in the orbital period of FG Hya

37 times of light minima of FG Hya have been collected in total. Fortunately, except for one, the others are the photoelectric ones. Out of the 37 minima 20 are primary and 17 are secondary. The O-C values of the minima are computed with the folowing ephemeris proposed by Smith (1963):

$$Min.I = HJD2436968.7067 + 0.32783433 \times E$$

which are given in Table 2 and plotted in Fig. 3. The O-C diagram splits up into 6 portions (AB,BC,CD,DE,EF and FG) between points A and G, with which the orbital period is discussed.

Table 2. Times of minima for FG Hya

JD.Hel.	Min.	Method	E	$(O-C)$	Ref.
2400000+					
31150.388	I	vis	-17748	0.0850	(1)
34056.7184	II	pe	-8882.5	0.0001	(2)
34057.7018	II	pe	-8879.5	0.00003	(2)
34084.5842	II	pe	-8797.5	0.00002	(2)
36968.7067	I	pe	0	0	(3)
36992.6387	I	pe	73	0.0001	(3)
37614.8705	I	pe	1898	0.0022	(3)
37726.6622	I	pe	2312	0.0025	(3)
37727.6458	I	pe	2315	0.0026	(3)
44640.2739	II	pe	23400.5	0.0800	(4)
44641.0989	I	pe	23403	0.0854	(4)
44933.3719	II	pe	24294.5	0.0941	(4)
44934.3528	II	pe	24297.5	0.0915	(4)
44968.2776	I	pe	24401	0.0854	(4)
44997.2899	II	pe	24489.5	0.0844	(4)
44998.1079	I	pe	24492	0.0828	(4)
46089.3545	I	pe	27821	-0.0016	(5)
46090.3679	I	pe	27824	-0.0013	(5)
46090.5314	II	pe	27824.5	-0.0012	(5)
46109.3822	I	pe	27882	-0.0014	(5)
46110.3655	I	pe	27885	-0.0016	(5)
46111.3492	I	pe	27888	-0.0013	(5)
47530.5958	I	pe	32217	0.0505	(6)
47532.5624	I	pe	32223	0.0501	(6)
47952.3476	II	pe	33503.5	0.0434	(6)
47953.3374	II	pe	33506.5	0.0479	(6)
47968.2512	I	pe	33552	0.0471	(6)
48308.3705	II	pe	34589.5	0.0382	(6)
49007.4727	I	pe	36722	0.0337	(6)
49046.3152	II	pe	36840.5	0.0279	(6)
49387.4305	I	pe	37881	0.0315	(6)
49401.3518	II	pe	37923.5	0.0199	(6)
49772.2926	I	pe	39055	0.0161	(6)
49772.4570	II	pe	39055.5	0.0166	(6)
49772.4535	II	pe	39055.5	0.0130	(7)
49779.3410	II	pe	39076.5	0.0161	(6)
50156.3407	II	pe	40226.5	0.0063	(8)

References: (1) Tsesevich (1949); (2) Smith (1963); (3) Binnendijk (1963); (4) Yang et al. (1991); (5) Mahay (1985); (6) Muyesseroglu et al (1996); (7) Agerer and Hubscher(1996);(8) Agerer and Hubscher (1997)

Unfortunately, apart from the portions FG and BC, which are sufficiently covered, the other portions are scantily covered.

As we can see in Fig. 3, several orbital period jumps may have occurred in FG Hya. The ephemeris in each portion is derived from the linear least squares solution on the assumption that the period is constant in every portion. The epoch and orbital period in each portion are listed in Table 3. According to Table 3, we can estimate that several orbital period jumps may have occurred in the years 1952, 1962, 1982, 1985 and 1989.

Table 3. Epoch and orbital period in each portion for FG Hya

portion	year	epoch	orbital period
AB	1944-1952	2436968.6222(7)	0.32782478(6)
BC	1952-1962	2436968.7081(4)	0.32783450(7)
CD	1962-1982	2436968.7008(25)	0.32783815(13)
DE	1982-1985	2436969.4078(47)	0.32780911(17)
EF	1985-1989	2436968.4385(228)	0.32784396(76)
FG	1989-1997	2436968.9300(127)	0.32782903(35)

Table 4. Variable O'Connell effect for the contact binary FG Hya

year	author	$\Delta max(V)$	$\Delta max(B)$
1956	Smith	+0.012	+0.012
1962	Binnendijk	+0.014	+0.023
1982	Yang et al	-0.060	-0.050
1985	Mahdy	+0.008	+0.010

4. Conclusions and discussions

The orbital periods of the two contact binaries AU Ser and FG Hya are investigated. The orbital period of AU Ser shows a sudden decrease in 1987-1988 and several orbital period jumps may have occurred for FG Hya in the years of 1952, 1962, 1982, 1985 and 1989. Such a kind of sudden change in the orbital period is typical for many other contact binaries such as DF Hya (Srivastava, 1991), AG Vir (Michaels, 1988), TU Boo (Niarchos et al.,1996) and so on.

The two contact binaries show the variable O'Connell effect. When Bennendijk (1972) observed AU Ser, its light curves showed positive O'Connell effects (the maximun following the primary minimum (maxI) is greater than the other), $\Delta max = maxI - maxII = -0.042$ mag. in V and -0.025 mag. in B. After the sudden period decrease in 1987-1988 the light curves of AU Ser show negtive O'Connell effects (the maximum following the primary minimum is smaller than the other)(proposed by Zongyun Li et al. in 1992), $\Delta max = 0.05$mag. in B and V, respectively. The same case also occurred in FG Hya, as we can see in Table 4, when Smith (1963) and Binnendijk (1963) observed the star, all of the light curves showed negtive O'Connell effects and during that time the orbital period was constant (see the portion BC in Fig. 3). After the sudden period increase in about 1962, the positive O'Connell effect are seen in the light curves (Yang et al. observed in 1981-1982), and $\Delta max = -0.06$ mag. in V and -0.05 mag. in B, after the sudden period decrease in about 1982, the light curves showed negtive O'Connell effects once more ($\Delta max = 0.008$ mag. in V and 0.010mag. in B) (Mahdy et al., 1985). Possibly a connection between the asymmetries of light curves and the sudden changes in the orbital periods of the two contact binaries may exist. More observations of the two interesting systems AU Ser and FG Hya are needed.

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