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An Analysis of the Orbital Periods of Some Eclipsing Binaries Suspected to be in the Pre-Main Sequence Contraction Phase of Evolution

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Abstract. An analysis of the available photoelectric times of minima of KO Aql, TV Cas and Z Her, which are suspected to be in pre-main sequence phase of evolution, reveals that KO Aql shows a secular increase in its orbital period at the rate of 4.34×10^{-8} day per cycle while the period of TV Cas has been decreasing at the rate of $4{\cdot}08 \times 10^{-9}$ day per cycle. Z Her does not show any period change at all. The orbital period of any binary system which is in the pre-main sequence phase will be systematically affected because of ' shrinking' dimensions of the components. A simple formula for the characteristic period change, defined by (*P/P*), is derived from a consideration of the conservation of total energy and total angular momentum for a binary system whose components are still in the process of contraction or expansion. The derived formula is applied to the above systems to see whether theoretical characteristic period changes agree with the observed values. The systems are assumed to evolve independently in the pre-main sequence phase in accordance with the model calculations of Iben (1965). It is found that there is no agreement between theoretical and observed characteristic period changes. This suggests that KO Aql and TV Cas may not be in the pre-main sequence phase. We do not have sufficient data for Z Her to judge its evolutionary status by the present procedure; this is also true of TT Hya. We suspect that the period changes observed in KO Aql and TV Cas may be due to light-time effect.

Key words: eclipsing binaries—period changes—pre-main sequence evolution

1. Introduction

Kopal (1959) identified a group of close binary systems in which the subgiant secondary components appear to be smaller than their Roche lobes. Hall (1974) analysed a sample of 25 such binaries to see whether the secondaries are really undersize. Of these, he suspected only KO Aql, S Cnc and SX Cas, to be potential candidates for this class of binaries. Of course, for these 3 suspected systems he maintained that he did not have accurate data. When accurate elements for KO Aql became available (Blanco and Criztaldi 1974) it was learnt that this system also did not have an undersize subgiant (Hall 1975). Hall (1974) did not believe in the existence of such a class of systems, since it is an established notion that Algols are remnants of post-main sequence mass transfer, and hence the existence of such undersize components cannot be explained. Even for systems suspected by him to have undersize components he did not have reliable data. Recent accurate observations of some of these systems show the existence of undersize subgiants. For example, the discussion of KO Aql by Hayasaka (1979) reveals an undersize subgiant. Similarly, Kulkani's (1979) analysis of the photoelectric data of TT Hya shows the secondary to be undersized. One can, therefore, find the revival of the old idea of undersize subgiants in close binary systems.

If such systems are really in existence, then great importance should be attached to their evolutionary status. The only possible explanation for the existence of undersize subgiants, if at all they exist, is based on the assumption that the subgiant component is in the pre-main sequence contraction phase of evolution, while the primary has almost reached the main sequence. Roxburgh (1966 a, b), using Iben's (1965) evolutionary calculations and his fission theory, found that KO Aql is currently in the pre-main sequence phase of evolution. Field (1969) using a modified version of Roxburgh's method examined the undersize subgiant systems listed by Kopal (1959) to see whether they are in the pre-main sequence phase. Among the 18 systems listed by Kopal, he found only four systems, KO Aql, TV Cas, WW Cyg and Z Her in the pre-main sequence contraction phase. We present here a different approach, in order to confirm whether these undersize systems are in the pre-main sequence stage. We have taken for our analysis only those suspected systems for which photoelectric observations of minima exist for a few decades. These systems are KO Aql, TV Cas and Z Her. If these three systems are in the pre-main sequence phase of evolution, it may be inferred that their orbital period would be affected systematically. Therefore an accurate analysis of the behaviour of the orbital periods of these systems will definitely provide us with valuable information regarding their evolutionary status. The necessary details are presented in Sections 3, 4 and 5.

2. (*O—C*) Diagrams

The photoelectric times of minima available in the literature for the three systems KO Aql, TV Cas and Z Her are presented in Tables 1, 2 and 3 respectively. The light-elements for KO Aql used in the computations of time residuals have been taken from ' *Supplemento ad Annuario Cracoviense*, *No. 49* (*1978*)'. For TV Cas and Z Her the light-elements used are those given by Koch, Sobieski and Wood (1963). A plot of the observed minus computed (*O—C*) time residuals versus the number of cycles elapsed *E*, is shown for each of the systems in Figs 1, 2 and 3. It can be seen from these that the orbital periods of KO Aql and TV Cas change secularly while that of Z Her remains practically constant. The orbital period of KO Aql secularly increases and TV Cas shows a secular decrease of period. The points in the (*O—C*) diagrams of KO Aql and TV Cas were fitted with parabolas while that of Z Her with a straight line using the least squares method and assigning equal weights to all the points. The resulting ephemerides for the primary times of minima along with the standard errors are:

$$\text{KO Aql}: \text{JD}_{\odot}\ 2441887{\cdot}4731 + 2^{d}{\cdot}8640440\,E + 0{\cdot}217\times10^{-7}\,E^2$$
$$\pm13 \qquad \pm18 \qquad \pm32$$

$$\text{TV Cas}: \text{JD}_{\odot}\ 2436483{\cdot}8094 + 1^{d}{\cdot}8126107\,E - 0{\cdot}204\times10^{-8}\,E^2$$
$$\pm5 \qquad \pm3 \qquad \pm9$$

$$\text{Z Her}: \text{JD}_{\odot}\ 2413086{\cdot}352 + 3^{d}{\cdot}9928006\,E$$
$$\pm13 \qquad \pm19$$

It can be seen from the above quadratic ephemeris that the rate of increase of the orbital period is $4{\cdot}34\times10^{-8}$ day per cycle for KO Aql and the rate of decrease of the period is $4{\cdot}08\times10^{-9}$ day per cycle for TV Cas. Let us now define the characteristic period change by ($\dot{P}/P$) where P is the period used in the computation of the time

Table 1. Photoelectric times of primary minima of KO Aql.

JD$_{\odot}$		E	$(O-C)$ d	Reference
243	8937.5280	−1030	+0.00750	Pohl and Kizilirmak (1966)
	8980.4940	−1015	+0.01305	Blanco and Cristaldi (1974)
	9361.4030	− 882	+0.00606	Blanco and Cristaldi (1974)
	9696.4920	− 765	+0.00355	Blanco and Cristaldi (1974)
	9762.3640	− 742	+0.00286	Blanco and Cristaldi (1974)
244	0355.2140	− 535	−0.00135	Blanco and Cristaldi (1974)
	0435.4076	− 507	−0.00059	Pohl and Kizilirmak (1970)
	1148.5600	− 258	+0.00834	Pohl and Kizilirmak (1972)
	1827.3238	− 21	−0.00297	Hayasaka (1979)
	1887.4710	0	−0.00040	Kizilirmak and Pohl (1974)
	2245.4798	+ 125	+0.00465	Pohl and Kizilirmak (1975)
	2637.8558	+ 262	+0.00854	Margrave *et al.* (1978)
	2652.1712	+ 267	+0.00379	Hayasaka (1979)
	2947.1727	+ 370	+0.01020	Hayasaka (1979)
	3010.1771	+ 392	+0.00594	Hayasaka (1979)
	3305.1815	+ 495	+0.01525	Hayasaka (1979)
	3348.1400	+ 510	+0.01330	Hayasaka (1979)
	3351.0080	+ 511	+0.01727	Hayasaka (1979)
	3766.3019	+ 656	+0.02682	Cristescu, Oprescu and Suran (1979)
	4135.7568	+ 785	+0.02185	Margrave (1979b)

Table 2. Photoelectric times of primary minima of TV Cas

	JD⊙	E	$(O-C)$ d	Reference
243	2827.7665	−2017	−0·00218	Huffer and Kopal (1951)
	3181.2282	−1822	−0·00002	Tchudovichev (1958)
	3184·8515	−1820	−0·00194	Huffer and Kopal (1951)
	3213·8516	−1804	−0·00365	Huffer and Kopal (1951)
	6483·8091	0	0·0	Chou (1959)
	8472·2386	+1097	−0·00696	Lavrov (1966)
	8733·2560	+1241	−0·00583	Kristenson (1966)
	8791·2585	+1273	−0·00694	Lavrov (1966)
	8829.3230	+1294	−0·00732	Lavrov (1966)
	8840·1985	+1300	−0·00750	Lavrov (1966)
	9389.4182	+1603	−0.00953	Popovici (1968)
244	0056.4558	+1971	−0·01352	Pohl and Kizilirmak (1970)
	0105.3960	+1998	−0·01387	Pohl and Kizilirmak (1970)
	0105.3977	+1998	−0·01217	Pohl and Kizilirmak (1970)
	0154.3360	+2025	−0·01442	Bakos and Tremko (1973)
	0183.3372	+2041	−0·01503	Bakos and Tremko (1973)
	0194.2127	+2047	−0·01521	Bakos and Tremko (1973)
	0201.4632	+2051	−0.01516	Bakos and Tremko (1973)
	0203.2765	+2052	−0.01447	Popovici (1968)
	0203.2770	+2052	−0.01397	Pohl and Kizilirmak (1970)
	0442.5406	+2184	−0.01528	Walter (1979)
	0493.2930	+2212	−0.01605	Pohl and Kizilirmak (1970)
	0502·3569	+2217	−0·01522	Popovici (1970)
	0859.4399	+2414	−0·01698	Walter (1979)
	0899·3175	+2436	−0·01686	Pohl and Kizilirmak (1972)
	0948·2560	+2463	−0·01891	Grauer *et al.* (1977)
	0986·3210	+2484	−0·01879	Grauer *et al.* (1977)
	1207·4605	+2606	−0·01807	Walter (1979)
	1575·4190	+2809	−0·02001	Papousek (1974)
	1593·5455	+2819	−0·01964	Walter (1979)
	1595·3584	+2820	−0·01936	Papousek (1974)
	1604·4213	+2825	−0·01952	Papousek (1974)
	1671·3000*	+2862	−0·20750	Kizilirmak and Pohl (1974)
	1749·4291	+2905	−0·02076	Grauer *et al.* (1977)
	1919·8125	+2999	−0·02298	Scarfe and Barlow (1978)
	1981·4405	+3033	−0·02382	Walter (1979)
	1990·5030	+3038	−0·02439	Tremko and Bakos (1977)
	1992·3150	+3039	−0·02500	Tremko and Bakos (1977)
	2016·4240*	+3052	+0·52003	Pohl and Kizilirmak (1977)
	2019·5040	+3054	−0·02520	Tremko and Bakos (1977)
	2289·5820	+3203	−0·02653	Pohl and Kizilirmak (1975)
	2320.3969	+3220	−0·02606	Walter (1979)
	2590.4729	+3369	−0·02939	Pohl and Kizilirmak (1976)
	2659·3513	+3407	−0·03029	Pohl and Kizilirmak (1976)
	2775.3610	+3471	−0·02782	Tremko and Bakos (1977)
	3063.5585	+3630	−0.03579	Grauer *et al.* (1977)
	3090.7471	+3645	−0.03638	Grauer *et al.* (1977)
	3130.6234	+3667	−0.03757	Grauer *et al.* (1977)
	3442.3897	+3839	−0.04070	Ebersberger, Pohl and Kizilirmak (1978)
	3786.7774*	+4029	−0.04947	Margrave (1979a)
	3795.8442	+4034	−0.04574	Margrave (1979a)
	4094.9219	+4199	−0·04918	Margrave (1979b)
	4114.8601	+4210	−0.04973	Margrave (1979b)

*not included in the analysis

Table 3. Photoelectric times of primary minima of Z Her.

	JD⊙	E	$(O-C)$ d	Reference
243	3801·0030	+5188	+0·01754	Baglow (1952)
	3852·9058	+5201	+0·01401	Popper (1956)
244	0740·4884	+6926	+0·02523	Kizilirmak (1971)
	0752·5671	+6929	+0·02555	Kizilirmak (1971)
	0772·4314	+6934	+0·02587	Kizilirmak (1971)
	0816.3533	+6945	+0·02703	Kizilirmak (1971)
	0832.3241	+6949	+0.02665	Kizilirmak (1971)
	1111.8211	+7019	+0·02800	Scarfe *et al.* (1973)
	2217.8226	+7296	+0.02528	Scarfe and Barlow (1978)

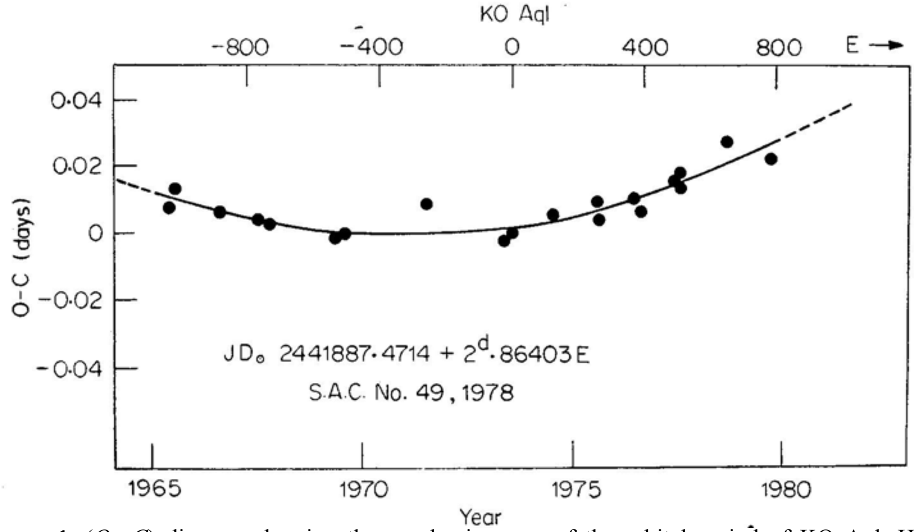

Figure 1. (*O—C*) diagram showing the secular increase of the orbital period of KO Aql. Here S.A.C. stands for *Supplemento ad Annuario Cracoviense*

residuals and $\dot{P}$ its time derivative. With this definition the observed values of the characteristic period change become

$$(\dot{P}/P) = +61\cdot 24 \times 10^{-15}\ \mathrm{s^{-1}}\ \text{for KO Aql},$$

$$(\dot{P}/P) = -14\cdot 37 \times 10^{-15}\ \mathrm{s^{-1}}\ \text{for TV Cas},$$

$$(\dot{P}/P) = 0 \qquad \text{For Z Her}$$

It is to be noted that the periods assumed by us are slightly different from those given in the fifth edition of the *Finding List for Observers of Interacting Binary Stars* (Wood *et al.* 1980). However, this does not alter the analysis because the least squares fit gives the best values of the initial epoch, period and $\dot{P}/P$ that satisfy all the data used.

3. An equation for $\dot{P}/P$

Almost all investigators in the field of eclipsing binaries have completely neglected the crucial role of rotational angular momentum and rotational energy in their

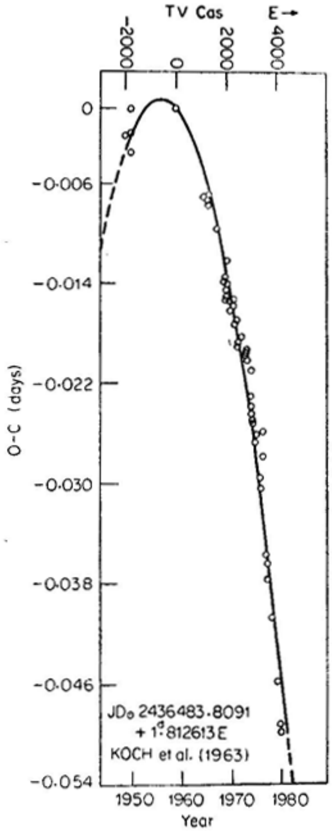

Figure 2. (*0— C*) diagram showing the secular decrease of the orbital period of TV Cas.

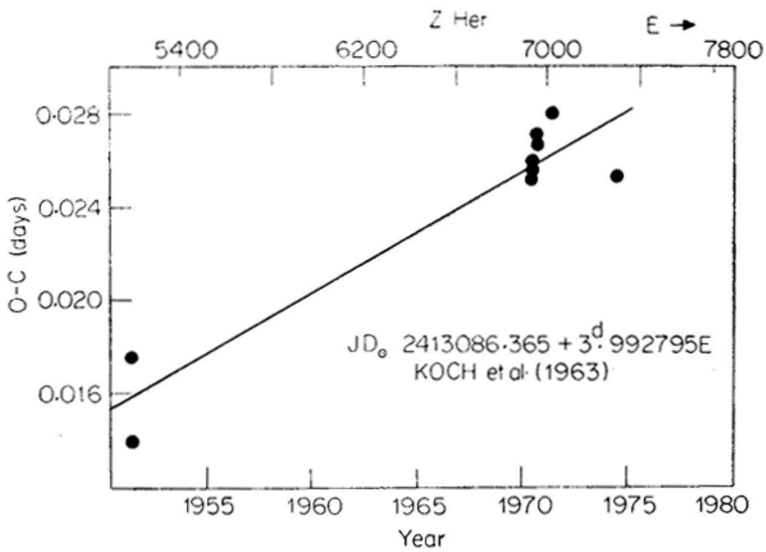

Figure 3. (*O—C*) diagram showing the constancy of the orbital period of Z Her.

studies. This practice becomes highly objectionable when the dimensions of the components are nearly comparable with the distance separating them. Therefore, any analysis of the behaviour of the orbital period of binaries should invariably include the contribution of angular momentum as well as energy arising out of the rotation of the components of the system.

We wish to consider here the effect of contraction (or expansion) of the components of a close binary system on the orbital period. It is easy to derive a simple formula for the characteristic period change of a binary system whose components undergo changes in their physical dimensions during their course of evolution. Let us make the following reasonable assumptions:

(1) Total mass of each component of the binary system remains constant;
(2) Orbit is circular.
(3) Orbital motion and rotation are synchronized.
(4) Total angular momentum, *i.e*. the sum of rotational and orbital angular momenta is conserved.
(5) Total energy of the system is conserved.
(6) Stars are spherical, *i.e*. distortions due to proximity effects and rotation are neglected.

Now the total angular momentum J of the system is given by

$$J=I_1W+I_2W+m_1r^2_1W+m_2r^2_2W, \tag{1}$$

where I_1, I_2 = the moments of inertia of the primary and secondary,
m_1, m_2 = the masses of the primary and secondary,
W = Keplerian angular velocity,
r_1, r_2 = the distances of the centres of the primary and secondary from the common centre of mass of the system.

The first two terms in equation (1) represent the rotational part of the total angular momentum. Using $m_1r_1=m_2r_2$ equation (1) becomes

$$J=I_1W+I_2W+\mu a^2\, W, \tag{2}$$

where $a=r_1+r_2$ and $\mu=m_1m_2/(m_1+m_2)$.

Differentiating equation (2) with respect to time and equating J to zero, we get

$$\dot{a} = -\frac{(I_1+I_2+\mu a^2)\,(\dot{W}/W)+(\dot{I}_1+\dot{I}_2)}{2\mu a}. \tag{3}$$

Let E represent the total energy of the system, then

$$E=\tfrac{1}{2}I_1W^2+\tfrac{1}{2}I_2W^2+\tfrac{1}{2}\mu a^2W^2-(Gm_1m_2/a), \tag{4}$$

where G is the gravitational constant. But $Gm_1m_2/a = \mu a^2W^2$ according to virial theorem for a stable and steady dynamical system. Hence

$$E=\tfrac{1}{2}I_1W^2+\tfrac{1}{2}I_2W^2-\tfrac{1}{2}\mu a^2W^2. \tag{5}$$

Differentiating equation (5) with respect to time and equating $\dot{E}$ to zero, we have

$$\dot{a}=+\frac{2(I_1+I_2-\mu a^2)(\dot{W}/W)+(\dot{I}_1+\dot{I}_2)}{2\mu a}. \tag{6}$$

Equating right hand sides of equation (3) and (6), we get

$$\frac{\dot{W}}{W}=-\frac{2(\dot{I}_1+\dot{I}_2)}{3I_1+3I_2-\mu a^2}$$

or

$$\frac{\dot{P}}{P}=\frac{2(\dot{I}_1+\dot{I}_2)}{3I_1+3I_2-\mu a^2}. \tag{7}$$

Let $I=kmR^2$, then

$$\dot{I}=2kmR\dot{R}+mR^2\dot{k}=2I(\dot{R}/R)+I(\dot{k}/k). \tag{8}$$

However for homologous contraction or expansion, which will be valid for a small period of time, k can be taken as constant. Hence equation(7)becomes

$$\frac{\dot{P}}{P}=\frac{4(I_1\dot{R}_1/R_1+I_2\dot{R}_2/R_2)}{3I_1+3I_2-\mu a^2}, \tag{9}$$

where R_1 and R_2 are radii of primary and secondary components respectively. We would like to point out here that the dominant term ($\mu\alpha^2$) in the denominator on the right hand side of equation (9) is negative which makes the sign of the period change opposite to that of the change in radius.

Equation (9) involves the moments of inertia of the components and their contractional rates. If we have a fair estimate of these quantities then the characteristic period change ($\dot{P}/P$) can be theoretically calculated. We can then apply equation (9) to systems whose components have been suspected to be in the pre-main sequence contraction phase of evolution, and see how far theoretical ($\dot{P}/P$) agrees with observed ($\dot{P}/P$).

4. Contractional rates of the components of the systems

Iben (1965) has discussed in detail the pre-main sequence evolution of single stars of various masses. Let us assume that each component of the system evolves similar to single stars in this phase of evolution. Therefore, we can confine our attention to those model calculations for stars whose masses correspond to the masses of the individual components of our systems. For example, Iben's (1965) calculations for $3M_\odot$ and $1{\cdot}5M_\odot$ model stars can be used for the components of TV Cas because these represent fairly well the masses of its components. From the graphs (Iben 1965) relating age with radius of model stars, both the age and contractional rate of the component in question can be estimated from the known value of its radius. For example, in the $3M_\odot$ track, the radius $3{\cdot}08R_\odot$ of the primary component of TV Cas gives its age to be about $1{\cdot}06\times10^6$ years. The slope at this point ($3{\cdot}08R_\odot$, $1{\cdot}06\times10^6$ years) gives the contractional rate of this component at the present time to be $-0{\cdot}087$ mm s^{-1} or $-2{\cdot}75$ km yr^{-1}. Thus using the appropriate evolutionary tracks the relative contractional rates have been estimated for different components of the systems. These values are given in Table 4. We also list the absolute dimensions used in our discussion taken from the literature. We have included in the table the system of TT Hya, the secondary of which is suspected to be in the pre-main sequence phase by Kulkarni (1979).

5. Moments of inertia of components

The moments of inertia of stars can be calculated easily assuming uniform distribution of density. But seldom does it represent the actual state of affairs in the stars. Based on the available information one can assume some specific polytropic distribution inside the stars, and hence calculate the moments of inertia. From Iben's (1965) graph relating age with the central density ρ_c for a particular mass of star, the ratio of central to mean density ρ_c/ρ_m can be obtained, finding ρ_c through the known age of the star. ρ_c / ρ_m values for the components of the four binaries have been given in Table 5.

Table 4. Dimensions and contraction rates.

Star	Component	Mass $M_\odot$	Radius $R_\odot$	Age 10^6 yr	Relative contractional rate $\dot{R}/R$ 10^{-15} s^{-1}	Distance between the components $R_\odot$	Reference
KO Aql	Primary	2.91	2.7	1.17	−44.79	13.06	Hayasaka (1979)
	Secondary	0.58	2.6	0.83	−16.99		
TV Cas	Primary	3.10	3.08	1.06	−40.67	10.50	Tremko and Bakos (1977)
	Secondary	1.39	3.36	0.70	−18.37		
Z Her	Primary	1.22	1.6	3.66	− 1.98	14·08	Popper (1956)
	Secondary	1.10	2.6	0.87	−10.78		
TT Hya	Primary	2.61	2.01	1.50	− 8.25	22.80	Kulkarni (1979)
	Secondary	0.70	5.53	0.10	− 9.84		

By comparing ρ_c/ρ_m values of the components with Eddington's (1926) table giving ρ_c/ρ_m values for different polytropic indices, we can fix the polytropic index η for each component of the systems. These are given in column (4) of Table 5. Eddington (1926) has reproduced Emden's tables, giving the masses interior to different points on the radii of stars of various polytropic indices. For a star of particular polytropic index these tabulated values were modified to its mass and radius. The moments of inertia were computed using the formula

$$I = \frac{2}{5}\sum_{i=1}^{N} m_i \frac{R_i^5 - R_{i-1}^5}{R_i^3 - R_{i-1}^3},$$

where R_i and R_{i-1} represent the outer and inner radii of the ith shell of mass m_t. N indicates the total number of shells. It should be mentioned here that for n1·5 and 3·0 we took N=12 and 17, respectively. The moments of inertia thus calculated are shown in last column of Table 5.

6. Discussion

Taking relevant data from Tables 4 and 5, the theoretical value of $(\dot{P}/P)$ can be calculated using equation (9). The observed and theoretical characteristic period changes have been given in Table 6. It is quite obvious from this table that there is

Table 5. Moments of inertia

Star	Component	Central condensation	Polytropic index n	Moment of inertia 10^{46} kg m^2
KO Aql	Primary	127·73	3	162·16
	Secondary	6·31	1·5	79·75
TV Cas	Primary	108·54	3	224·76
	Secondary	6·92	1·5	319·21
Z Her	Primary	7·36	1·5	63·53
	Secondary	6·31	1·5	151·26
TT Hya	Primary	64·69	3	80·61
	Secondary	—	1·5	435·00

Table 6. Comparison of theoretical and observed period changes.

System	$(\dot{P}/P)_{th}$ 10^{-15} s^{-1}	$(\dot{P}/P)_{obs}$ 10^{-15} s^{-1}
KO Aql	+4·77	+61·24
TV Cas	+7·00	−14·37
Z Her	+0·67	0
TT Hya	+0·76	—

no agreement at all between the theoretical and the observed values of $(\dot{P}/P)$. For KO Aql the observed value is about an order of magnitude higher than the theoretical value. This points to the fact that the period change occurring in these systems is not dimensional changes. However, it may be noted that the period variations occurring due to dimensional changes are not small enough to be neglected in the case of KO Aql and TV Cas. They are sufficiently large to be detectable photometrically over a time interval of a few decades. Any suspicion that these systems belong to the pre-main sequence can therefore be ruled out.

In the case of Z Her, $(\dot{P}/P)_{th}$ is very small. Therefore, the variation in its orbital period owing to changing dimensions cannot be detected at present due to insufficient data. In addition, Kulkarni's (1979) speculation that TT Hya is in the pre-main sequence phase can neither be confirmed nor rejected by analysing minima over a brief period of time, since $(\dot{P}/P)_{th}$ is very small for this system. We have not analysed the variation of period of this system for lack of accurately determined minima. The other two systems, KO Aql and TV Cas are probably not in the pre-main sequence phase of evolution, since there is no agreement between $(\dot{P}/P)_{obs}$ and $(\dot{P}/P)_{th}$. Therefore, the idea of subgiant secondaries being undersized is also doubtful. This supports Hall's (1974) conclusion that no system exists with undersize secondaries. Also, Field's (1969) belief that KO Aql and TV Cas are in pre-main sequence appears to be invalid. In this connection, we may note that in the recent discussion of TV Cas, Cester *et al*. (1979) have shown that the secondary is almost filling its Roche lobe.

We would like to point out that equation (9) for characteristic period change is derived on the assumption of continuous synchronisation between the orbital and angular motions. Our justification for this is based on the following reasons. (1) We have to make this simplifying assumption, in order to be able to evaluate the effect of the changing sizes of stars; (2) The assumption is not totally invalid in close binary systems where tidal forces are strong; and (3) All theoretical calculations of binary evolution invoke Roche model which presupposes circular orbit and complete synchronization of orbital and angular motions. But even if there were no instantaneous synchronization, contrary to our assumption, then the effect of changing size on period change will be less and we would get a lower estimate for $(\dot{P}/P)$ due to shrinking dimensions of the components of the binary. Thus the $(\dot{P}/P)$ values obtained by us represent the upper limit of the expected values and even this is inadequate to explain the observed period changes. It seems probable, therefore, that the observed period changes in KO Aql and TV Cas may be due to some other cause as discussed below.

It has been suspected that the period change found in TV Cas may be due to a third body (Frieboes Conde and Herczeg 1973, Grauer *et al.* 1977). Some authors (Tremko and Bakos 1977; Chaubey 1979; Wood *et al.* 1980) believe that the period change in TV Cas is due to mass transfer. But we support the former view although at present it is an indecisive conclusion. If there is mass transfer from the secondary component to the primary component then there should be a secular increase in the period contrary to what we observe. So mass transfer and mass loss do not seem to be appropriate to explain the observed period change in TV Cas.

Further, we suspect that the period change observed in KO Aql may also be attributed to light-time effect. However one can assume that there is mass transfer from

Secondary to primary, if the secondary is not undersize. Then the conservative mass transfer equation gives a mass flow rate of about 0.47×10^{-6} M yr $^{-1}$It may be noted that both KO Aql and TV Cas appear more or less similar in some respects. There fore the mechanism responsible for the period change in both cases should also be the same. If this is the case then mass transfer and mass loss cannot be the mechanism causing the period changes. But the third body hypothesis seems fairly reason able for these systems. The solution of third body orbit will lead to highly uncertain elements at present. To attain best representative values for the third body orbital elements, precise astrometric studies of these binaries are very essential. The import ance of such studies for all eclipsing binaries should be realised.

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