ON A POSSIBLE LINKAGE BETWEEN W-TYPE WUMa SYSTEMS AND THE SHORT PERIOD RSCVn-LIKE BINARIES.

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ABSTRACT: We analize the general properties of a group of WUMa-type binaries, which show RSCVn-like activity. The position of these stars in the colour-density and mass-orbital momentum diagrams is studied, but no definite answer can be given on the linkage between short period RSCVn systems (SPG) and WUMa systems with RSCVn-like activity (WWG).

I. INTRODUCTION

In a review paper on RSCVn-like stars, Hall (1976) introduced the possibility that some systems, which shared with the RSCVn group some of the observed properties, like the H and K emission, the spectral type and the presence of a migration wave (more or less pronounced), could be subdivided into new groups, and introduced the definition of a 'Short Period Group' (hereafter SPG) and a 'WUMa Group' (WWG). The general properties of SPG have already been analyzed by one of us (Milano, 1981). In this paper we want study the general properties of the WWG in a similar way, and then to discuss a possible evolutionary linkage between SPG and WWG. We also introduce an empirical classification criterion based on the type of primary eclipse (transit/occultation).

II. DATA ON SPG AND WWG STARS

a) SPG stars

The lightcurve analysis of the stars belonging to SPG and some speculative considerations showed that these stars are detached systems (see fig. 1). Up to date, unfortunately, there is no homogeneous study of the lightcurves of these systems with modern lightcurve synthesis programs, so the data we present in Table 1 are collected from different sources and we think are affected by a certain degree of bias. As one can see from Table 1 the SPG has orbital periods that range from $0^{d}.5$ to $0^{d}.9$, the spectral classes range from F8V to G9V for the primaries

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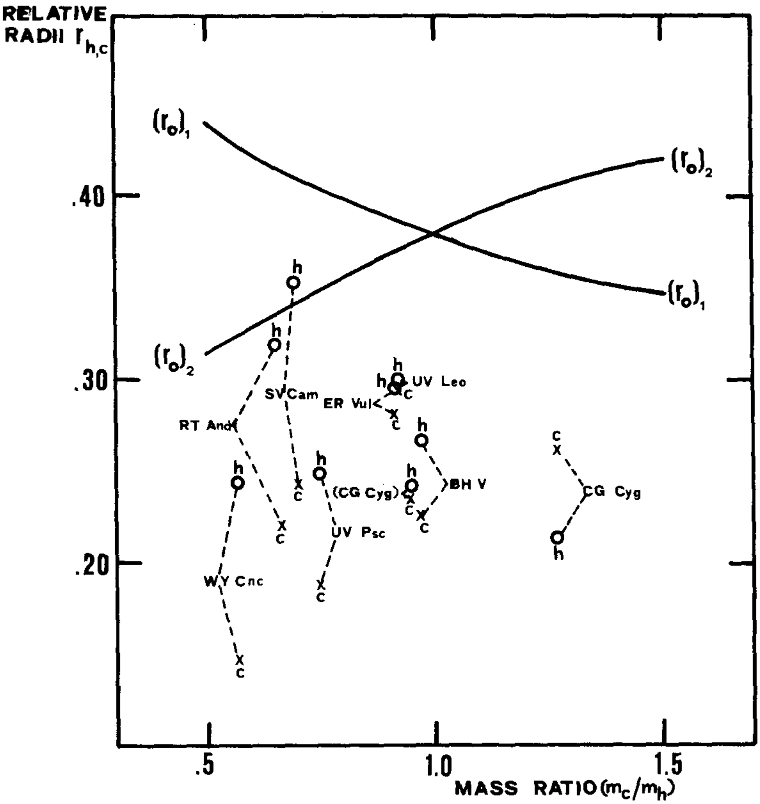

Figure 1: Relative radii for the SPG. The solid lines correspond to the contact configuration.

and practically from KOV to K5V, apart from a few exceptions for the secondaries. H and K emission lines of Ca II have been detected for almost all the components of the SPG.

There is no information on this subject for SV Cam.

From IUE observations by Budding et al. (1981) it has been ascertained h and k emission lines of Mg II on almost all the systems of the group (RT And, XY UMa, WY Cnc, ER Vul, SV Cam, UV Leo doubtful, CG Cyg,BH Vir). This is a clear index of active coronae and chromospheres. An interesting problem is the determination of the source of H and K emission, in other words which component is responsible for the emission. Practically we have information on this subject only for WY Cnc, UV Psc and for XY UMa. An interesting fact that came out from a previous analysis (Milano,1981) concerns the type of primary eclipse for these systems. It was ascertained that almost all the systems have a transit at the primary eclipse. This fact might be a clue to distinguish different type of RS CVn stars.

	Period(days)	m_c+m_h	Spectral type	$q=m_c/m_h$	B-V	T
RT And	0.629	0.98 + 1.50	F8V+G5-KOV	0.65	0.50	6210
SV Cam	0.593	0.7 + 1.0	GO-G5V+K4V	0.70	0.72	5750
WY Cnc	0.829	0.53 + 0.93	G5V+M2V	0.57	0.61	5520
CG Cyg	0.631	1.04 + 0.82 (0.78)+(0.82)	G1V+G9V (G9V+KOV)	0.79 (0.95)	0.78	5970
UV Leo	0.600	1.25 + 1.36	G9V+KO5	0.92	0.61	5980
UV Psc	0.861	0.9 + 1.2	G2V+KOIV	0.75	0.81	5740
XY UMa	0.479	0.7 + 0.95	G2-G5V+(K5V)	0.74	0.85	5660
BH Vir	0.817	0.86 + 0.87	F8V+G2V	0.97	0.57	6250
ER Vul	0.698	1.13 + 1.23	GOV+G5V	0.92	0.60	5980

Table 1: Fundamental data for the SPG. Masses are in solar units and temperatures in Kelvins.

In other words we think it is possible to classify from an observational point of view the RS CVn-like stars in two subcategories, that is, O Type (occultation) and T Type (transit), whatever the period may be. We think, in this way, the class of this stars can be enlarged and it will be possible to understand the behavior of many other eclipsing binaries of the solar type.

b) WWG stars

The data we present in Table 2 on WWG are collected mainly from Mochnacki's paper (1981) on W UMa's and as it is possible to see there are presented the nine candidates displayng RS CVn like activity. Apart from the periods that range between 0.23 to about 0.4 days and the mass ratios it is possible to see that the other parameters are quite similar to the ones of SPG. In fig. 2 is shown the period-colour diagram and the period-mass ratio diagram with the position of SPG and WWG components. As it is possible to see both SPG and WWG are in the same interval of colour D(B-V) = .27 and,obviously there is a shift in the periods of WWG and SPG with a gap practically between 0.4 and 0.5 - 0.6. If we consider the relations

$$C_1 = -.50 - 2.26 \log P$$

$$C_2 = -.50 - 2.26 (\log P - .18)$$

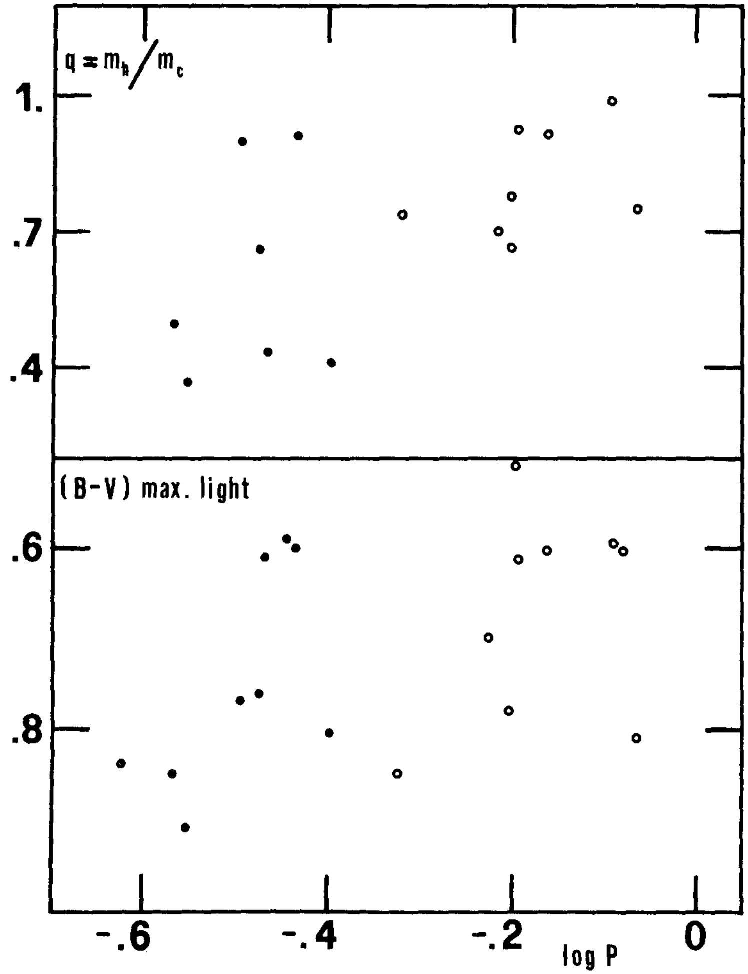

Figure 2: The period-colour and period mass ratio diagram for the SPG (open circles) and WWG (filled circles).

for WWG, it is also possible to consider a third relation for SPG

$$C_3 = -.50 - 2.26 (\log P - .54)$$

Apart this considerations we also know that WWG components are in a state of thin or marginal contact whilst SPG components are detached systems. To try to understand the evolutionary status of these systems without the knowledge of their absolute dimensions, a good way is the one suggested by Mochnacki (1981), that is the use of a colour-density diagram. The procedure we adopted here to derive this graph for SPG and WWG is derived from the paper already quoted above and the results are shown in fig. 3.

	Period(days)	m_c+m_h	Spectral type	$q=m_c/m_h$	B-V	T
RW Com	0.2373	—	G2e+G2e	—	0.841	—
44i Boo	0.2678	0.97+0.47	dG1+dG2	2.01	0.85	5150
VW Cep	0.2783	1.1 +0.4	G8:n+KOV	2.75	0.86	5100
SW Lac	0.3207	1.2 +1.1	G3p+G3p	1.11		5400
W UMa	0.3336	1.3 +0.9	dF8p+dF8p	1.52	0.76	5670
RZ Com	0.3385	0.9 +2.1	F7+GO	2.3	0.61	7250
AM Leo	0.3658	—	F8V	—	0.59	6350
U Peg	0.3748	1.3 +1.1	F3+F3	1.1	—	5830
AH Vir	0.4075	1.4 +0.6	KOV+(K1)	2.38	0.81	5380

Table 2: Fundamental data for the WWG. Masses are in the solar units and temperatures in Kelvins.

In the figure the full lines are the ZAMS and TAMS for Z = 0.002 while the broken line represents the ZAMS for Z = 0.003, to show the effect of the variation of metal abundances. This graph contains the same information as the period-colour diagram, but with the effects of different mass ratios and fill-outs removed.

It is to be noted the peculiar position of the primary of CG Cyg, either for occultation or transit solution (point 1 and 2) and the anomalous position of AH Vir. This diagram will be considered again during the final discussion on the evolutionary status of SPG and WWG after having considered the angular momenta of these systems.

In Tab. 3 we give H_{orb} and H_{rot} and the ratio H_{orb}/H_{rot} for the components of SPG and WWG. Using the relations between orbital angular momenta and total mass estabilished by Chaubey (1979) and modified by us we got the graph of fig. 4. In this figure are shown the WWG, SPG, CG and LG. It is easy to see that, if there is an evolutionary linkage between the groups, it must be in the sense SPG → WWG. This might be considered a working hypothesis to be verified. An interesting fact, which can be seen, is the position of SPG on the empirical straight lines deduced for semidetached systems and, taking into account that

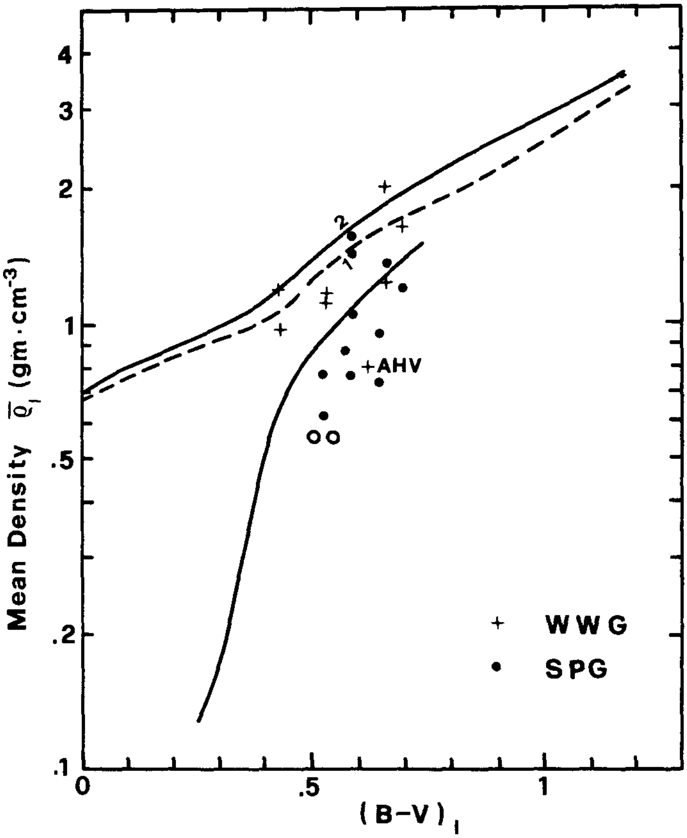

Figure 3: Mean primary density versus corrected primary color $(B-V)_I$. The ZAMS and TAMS are shown, together with a dashed line tc show the effect of varying the metal abundance.

SPG are detached systems, this might be strong indication of orbital angular momentum loss. In other words these systems would be detached systems of low masses that are losing orbital angular momentum.
This fact might be an observational evidence of a linkage betweer SPG and WWG.
Following Vilhu (1981), taking into account the mechanism of orbital angular momentum loss by magnetic braking, we could again hypothize an evolution from SPG to WWG.
We tried to verify the time of braking of some systems applying the relation by Mochnacki

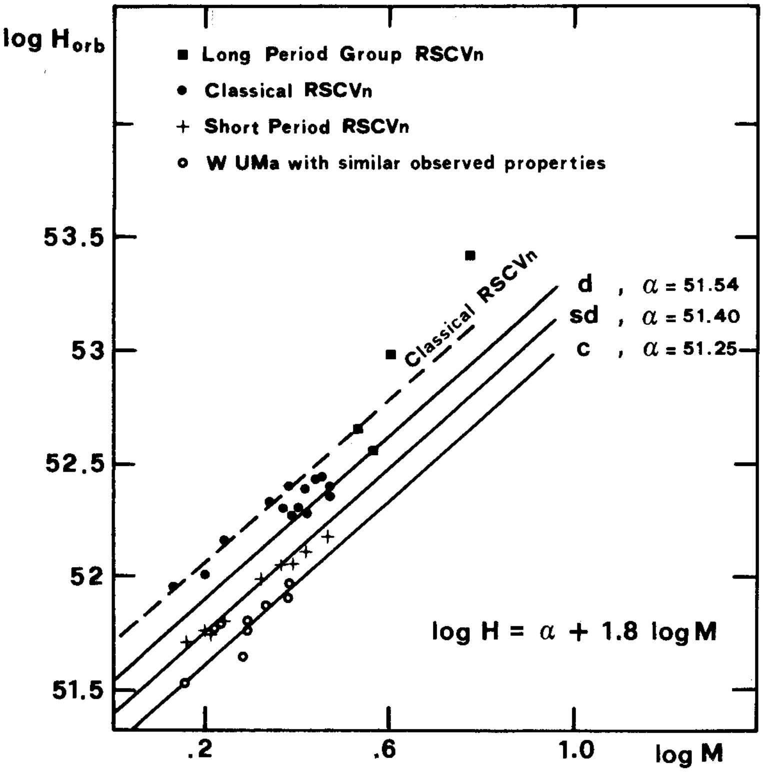

Figure 4: The angular momentum as a function of the total mass of the system. The lines are taken by Chaubey (1979).

$$\tau_B = \left(\frac{A}{R_1}\right)^3 \left(\frac{R_1\ M^2}{G\ \dot{M}\ \alpha_p^4}\right)^{1/3} f(F,q\ )$$

The time scale of SPG come out of the order of $\sim 6. \times 10^9 \div 2 \times 10^{10}$ years, with $\dot{M}$ typically $\sim 10^{-12} \div 10^{-13}$.
Considering now the density-colour diagram for the primaries, we note an inconsistency in the scenario we exposed above because we have that the densities of SPG are smaller than those of WWG. This fact might be an indication of a more advanced evolutionary state of SPG than WWG.

CONCLUSIONS

Two conclusions are possible: a) there is not evolutionary connection with WWG and SPG.

	H_{rot} (x10^{50})	H_{orb}(x10^{52})	ratio	ϱ_1(gr cm^{-3})	ϱ_2(gr cm^{-3})
RT And	4.12	1.15	28	0.87	1.38
SV Cam	2.46	0.61	25	0.72	1.52
WY Cnc	1.02	0.51	50	1.17	3.07
CG Cyg	3.59(1.34)	1.51(0.58)	42(43)	1.47(1.69)	2.13(1.65)
UV Leo	4.59	1.29	28	1.02	0.96
UV Psc	2.08	0.99	48	0.93	1.59
XY UMa	1.86	0.55	30	1.44	2.53
BH Vir	1.76	0.72	41	0.75	1.25
ER Vul	3.86	1.15	30	0.77	0.83
RW Com	——	——	—	——	——
44i Boo	2.45	0.33	13	2.00	2.60
VW Cep	8.50	0.99	12	1.78	2.51
SW Lac	8.86	1.27	14	1.26	1.30
W UMa	5.17	0.70	14	1.10	1.18
RZ Com	6.55	0.79	12	1.22	1.69
AM Leo	4.45	0.49	11	0.94	1.25
U Peg	5.87	0.95	16	1.18	1.10
AH Vir	5.14	0.59	11	0.79	1.07

Table 3: Data for angular and rotational momentum, and for the densities of the SPG and WWG.

b) there is somewhat of wrong either in Mochnacki's density-colour diagram or in our computations.
However, our work is still in progress and this very preliminary report on the hypothesis of a possible evolutionary linkage between SPG and WWG cannot permit us to derive definitive conclusions. In other words the problem is open and we are studying the way to overcome the difficulty we exposed above.

Acknowledgements

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