On the Coronal Activity of RS CVn Systems

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An analysis of the X-ray emission of a large sample of single MS stars shows that X-ray luminosity is strongly correlated with the photospheric radius (Fleming *et al.*, 1989) which implies the dependence of activity on bolometric luminosity $L_{\rm bol}$, effective temperature $T_{\rm eff}$, and thus stellar mass M (Micela *et al.*, 1985; Bookbinder *et al.*, 1986). The role of the emission area on the coronal activity of RS CVn systems has been noted independently by Majer *et al.* (1986), and Demircan (1986).

By using new data on some well known RS CVn systems, we produce new evidence that above idea is indeed valid. A plot of X-ray luminosity $L_{\rm x}$ versus $(B-V)$ for the sample of well known RS CVn systems in Fig. 1 shows that cooler, long period, more evolved systems with larger surface area have stronger X-ray emission.

Surprisingly, no clear correlation between the activity luminosity and rotation period was found in RS CVn binaries (Majer *et al.*, 1986; Demircan, 1986, 1987a, b, 1988; Basri, 1987; Morris and Mutel, 1988), unless the activity flux or the normalized activity luminosity $(L_{\rm x}/L_{\rm bol})$ is used as the activity indicator.

In order to understand the cause(s) of the scatter in $L_{\rm x}-P$ diagram we divide the systems in X-ray emission into two groups. The higher level X-ray emission group is formed by the systems RZ Cnc, RT Lac, SZ Psc, RZ Eri, GK Hya, RS CVn, AR Mon, AR Lac, CF Tuc, UV Psc, V711 Tau and CQ Aur. It is interesting to see that the component stars of a system in this group differ more in physical characteristics than is the case of the other group. The larger, more evolved components in the higher level X-ray emission group have filled more than 60% of their Roche lobes, while in other group, the more evolved components never exceed 60% of their Roche lobes. The short period RS CVn systems (such as ER Vul, SV Cam and UV Psc) with MS components do not obey this rule. The Roche lobe filling percentage $RL\%$ contains information on the radius R, mass ratio q, separation a between the components and orbital period P, which is equal to the rotation period of the components in synchronized binaries. It is known that a larger $RL\%$ requires in general a smaller distance between the components and thus a shorter

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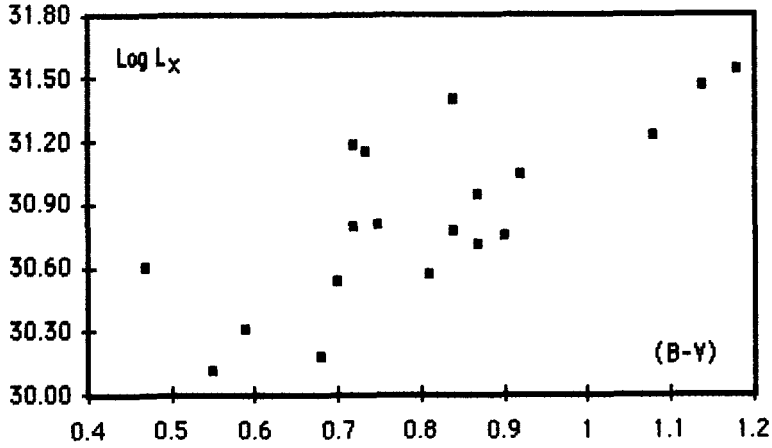

Fig. 1. A plot of X-ray luminosity versus colour index $(B-V)$ for the well known RS CVn systems. The cooler, long period, more evolved systems with larger surface area have more X-ray emission.

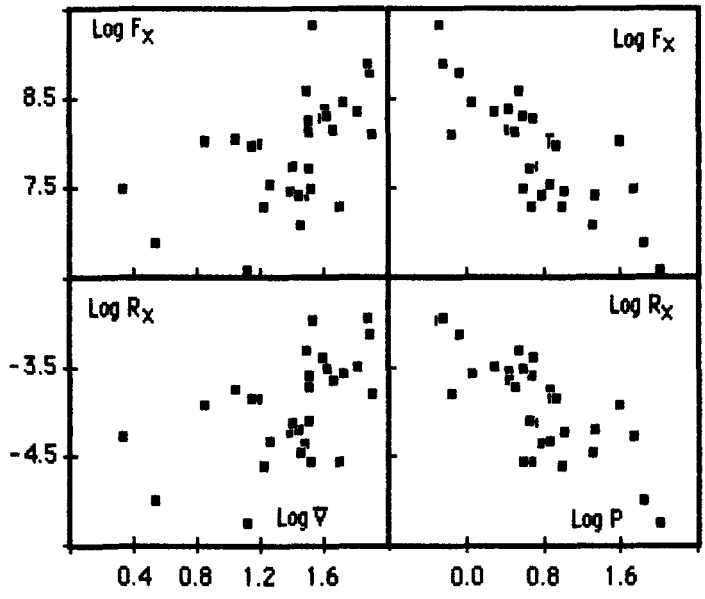

Fig. 2. The mean relative activity flux F_x, and the normalized flux R_x versus orbital period P, and mean equatorial rotation velocity $\bar{v}$ for the well known RS CVn systems. F_x and R_x tend to increase with increasing $v \propto 1/P$, as indicated by dynamo models.

period by Kepler's law. The higher level X-ray emission group have indeed smaller a, shorter P and larger equatorial rotation velocity v, on average.

We can safely conclude that the higher X-ray emission level of RS CVn type binaries is not only due to enhanced rotation by tidal interaction but is in general related to the larger $RL\%$ of one of the component stars. It should be kept in

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mind that the high X-ray emission level does not mean a high degree of activity. Remember also that the best measure of activity is not activity luminosity but the surface activity flux (e.g. Zwaan, 1986).

We have calculated the mean relative activity flux $F_x = L_x/(R_h^2 + R_c^2)$ and the normalized activity flux $R_x = L_x/[(L_{bol})_h + (L_{bol})_c]$ for each system of our sample. A plot of these two activity parameters, against orbital period P and mean equatorial rotation velocity $\bar{v}$, in Fig. 2 shows that an activity-rotation correlation exists for RS CVn type binaries. However a similar correlation exists between F_x (or R_x) and any system parameter such as total mass, distance a between the component stars, orbital angular momentum J, and mean density ρ of the component stars. Such correlations are clearly induced by the interrelations between mentioned parameters above. It is not clear from the present data whether one or more parameters are responsible in producing stellar activity. It seems that the activity in late-type binaries is directly related to their tidal interaction (Demircan, 1986). This conclusion is further strengthened by the findings of Glebocki and Stawikowski (1988), and Young *et al.* (1989). Evidence has been found (Demircan, 1990) that the X-ray surface flux F_x first increases with increasing $RL\%$ until a value of about 60%, and then decreases as $RL\%$ increases further.

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