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Research Note

Orbital period–Hα correlation in Be star/X-ray binaries?

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Abstract. Reig, Fabregat & Coe (1997) plotted the equivalent width of Hα emission against the orbital period for several Be star/X-ray binary systems, and find a correlation. If instead of the equivalent width, which is a relative quantity, the luminosity of Hα emission, which is an absolute quantity, is used the correlation is not found.

Key words: stars: emission-line, Be – X-rays: stars

Reig, Fabregat & Coe (1997: hereafter RFC) have plotted the equivalent width of Hα emission from Be star/X-ray binaries at outburst against the orbital period of the x-ray emitting object and found a correlation between them. However equivalent width is a relative quantity and depends on the luminosity of the star at the Hα wavelength. The relevant quantity to correlate with the orbital period is the luminosity of Hα emission, which is an absolute quantity. The Hα luminosity is a product of the equivalent width and the luminosity of the Be star in the Hα region, which in turn depends on the spectral type and the luminosity class of the Be star. We have calculated the Hα luminosity for the seven stars given in Table 1 of RFC, for which the spectral type and luminosity class are given. In order to do this we have used the luminosity of the stars at the Hα wavelength as given by Kurucz(1979) for various temperatures and surface gravity (log g). The temperature, the radius of the star and the surface gravity (log g) for the different spectral types and luminosity classes are given by Straizys & Kuriliene (1981). In the case of A 0538-66,we have used the magnitude of the optical outburst. The Hα luminosity is plotted against the orbital period in Fig. 1. The errors in the calculated quantities due to the error in estimating the surface gravity is small(an error in log g of 0.5 leads to only $\sim$5% error in the calculated luminosity); the error in the temperature can lead to higher errors (a temperature change by $\sim$5000°K can lead to an error of $\sim$40% in the relevant luminosity). Straizys & Kuriliene(1981) give values of log T to the third decimal place so that the error on the temperature obtained must be of the order of a few percent. The total error on the calculated Hα luminosity should be less than 20%. In the figure the points for the systems for which the orbital period of the x-ray object is known, are represented by squares. The system A 1118-616 is represented as a circle with a question mark. The orbital period for the system A 1118-616 was derived by RFC using the spin period-orbital period relation of Corbet (1986). However, this relation may not hold for all Be star/X-ray systems (Apparao, 1994), as is seen for the case of A 1907+09 and 2S 1223-624; the reason for these anomalies is possibly the systems have not reached the equilibrium period or that the primary star is a supergiant instead of a Be star (Apparao,1994). Therefore the orbital period for A 1118-616 derived by RFC is doubtful.

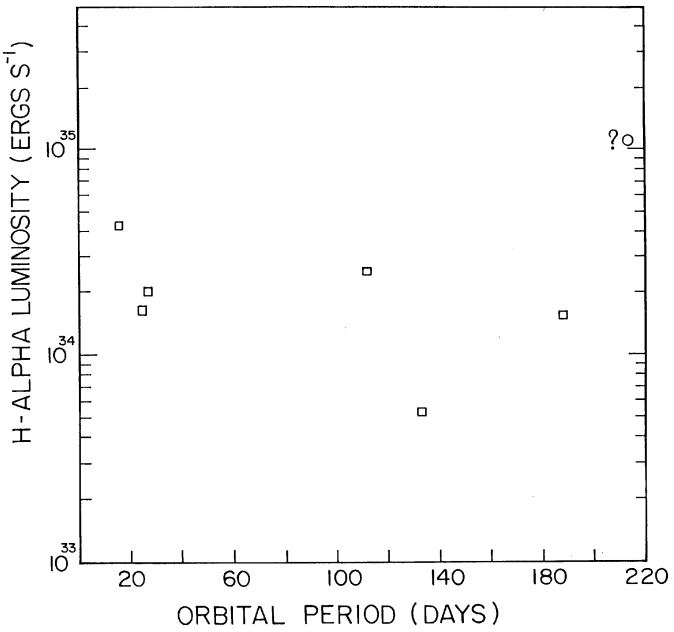

Fig. 1. A plot of Hα luminosity of Be star-X-ray systems at outburst versus the orbital period of the x-ray system. The Hα luminosity of the systems with known orbital period is represented by squares. The circle with a question mark represents the Hα luminosity of the x-ray system A 1118-616, whose orbital period has been indirectly obtained (see text) and is doubtful.

It is seen from Fig. 1, that there does not exist the trend derived by RFC, namely an increase of Hα emission with increase in the orbital period. If at all the trend seems to be a decrease in the Hα emission with increase in the orbital period (distance from the Be star). This is as expected, if the gas density of the

disk becomes smaller as the disk expands away from the Be star and becomes gradually density bounded.

There are several complications in a study of the correlation of the luminosity of the observed Hα emission with other quantities of the Be star/X-ray systems. In some cases the Hα from the HII region formed by the Lyman continuum of the Be star dominates while in some cases the Hα emission from the HII region due to the ionisation by the x-rays from the compact star dominates. Another complication is the self-absorption of the Hα emission by the emitting gas itself (Kastner & Mazzali 1989; Apparao & Tarafdar 1997), the correction for which is not simple.

RFC suggest that the compact object disrupts the disk due to the Be star and thus limits its size to the dimension of the orbit, and that the larger the period, the larger the dimension of the disk. They suggest that the larger the size of the disk, the larger the equivalent width and hence the correlation between the orbital period and equivalent width. However the strength of the Hα and hence the equivalent width depends on the strength of the Lyman continuum of the Be star. Since, for the usual densities derived for Be star disks,the disk is ionization bounded, the equivalent width at the maximum Hα luminosity, does not depend on the dimension of the disk.

In view of the complications given in the above paragraph and the doubtful nature of the orbital period of A1118-616, the correlation found by RFC is intriguing; we have no explanation for this finding. A study of a larger number is needed.

In conclusion the correlation suggested by Reig, Fabregat & Coe (1997) does not hold if the luminosity of the Hα emission is plotted against the orbital period of the x-ray system.

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References

Apparao K.M.V., 1994, A&A 291, 775
Apparao K.M.V., Tarafdar, S.P., 1997, Bull. Astr. Soc.Ind. 25, 345
Corbet R.H.D., 1986, MNRAS 220, 1047
Kastner J.H., Mazzali, P.A., 1989, A&A 210, 295
Kurucz, R.L., 1979, ApJS 40, 1
Reig P., Fabregat, J., Coe, M.J., 1997, A&A 322, 193 (RFC)
Straizys, V., Kuriliene, G., 1981, Ap&SS 80, 353