THE DEPENDENCE OF He I 10830 ABSORPTION ON X-RAY LUMINOSITY IN RS CVn BINARIES AND VERY ACTIVE F AND G MAIN-SEQUENCE STARS

(Letter to the Editor)

M. V. MEKKADEN

*Sternwarte der Universität Bonn, F.R.G.**

(Received 19 December, 1984)

Abstract. A study of the relationship between soft X-ray luminosity and He I 10830 equivalent width in RS CVn binaries and very active late-type Main-Sequence stars is made. Long-period RS CVns and very active F and G Main-Sequence stars show strong dependence on their X-ray luminosities. This is attributed to the dominance of coronal excitation of the line in these stars. Short-period RS CVn binaries have lower He I 10830 absorption compared to their X-ray emission. This phenomenon is explained by the presence of He I emission region also in their chromospheres.

1. Introduction

There have been many investigations to study the light variations, extreme chromospheric and coronal activities of RS CVn binaries. The emissions in Ca II H and K and Mg II h and k are good diagnostics of chromospheric activity. From the Einstein IPC observations, Walter and Bowyer (1981) found a close relation between the fractional X-ray luminosity and the rotation period. The work of Pallavicini *et al.* (1981) showed the correlation between X-ray luminosity and $v \sin i$. This formulation is independent of the bolometric luminosity for the late-type stars and the centroid of RS CVn data falls on the continuation of the $\log L_x$ versus $\log v \sin i$. From the X-ray flux measurements of AR Lac during a total eclipse with the *Einstein* Observatory, Walter *et al.* (1983) found that the K0IV star exhibits a two-component coronal structure. Schrijver and Mewe (1984) have suggested the existence of two coronal loop structures; this distinction disappears for very active stars.

However, an extensive study of the coronal activity may not be possible unless we have a ground-based diagnostics. The He I 10830 absorption line is a good possible candidate, since the level populations of He I may be controlled by coronal soft X-ray emission (Zirin, 1975). But several mechanisms have been suggested to explain this line in the solar spectrum; the details are given by Myron Smith (1983). Zirin (1982) made a survey of the He I 10830 line in late-type stars including RS CVn binaries. He tried to find the dependence of equivalent width on luminosity, spectral type and the then available X-ray observations. From his analysis of the behavior of He I 10830 with respect to the fractional X-ray luminosity, Myron Smith (1983) concluded that in giants

* On leave from Indian Institute of Astrophysics, Bangalore, India.

Astrophysics and Space Science **110** (1985) 413–416. 0004–640X/85.15

the coronal excitation mechanism is dominant in the formation of the line and in dwarfs electronic collisions and coronal EUV photons contribute more or less equal amounts.

If coronal excitation is the main factor for the He I 10830 line, we should expect that stars with higher X-ray luminosity show a strong He I line. RS CVn binaries, being strong soft X-ray emitters, should have larger equivalent width. In this paper we have made a study of the behaviour of He I 10830 with respect to the soft X-ray luminosity in RS CVn binaries and highly active Main-Sequence stars.

2. Data and Discussion

It would be ideal to study the nature of the correlation between He I line and soft X-ray emission when they are observed simultaneously; but there are no such observations. The He I 10830 equivalent width measurements are taken from Zirin (1982). If several observations exist for a star then the largest value is taken corresponding to a highly active phase. The soft X-ray data are from Pallavicini *et al.* (1981), Walter and Bowyer (1981) and Marilli and Catalano (1984). We have selected Main-Sequence stars with $\log L_x \gtrsim 29.0$. Main-Sequence stars with lower X-ray luminosity ($\log L_x < 29.0$) behave quite differently in their He I line. Dwarfs of spectral type K have larger He I 10830 equivalent width compared to their X-ray emission. From the observations of He I 10830 in solar plages we know that active plages have stronger absorption and thus the stellar plages may contribute largely for the comparatively stronger line in late-type dwarfs with lower coronal emission. Table I gives the X-ray luminosity and He I 10830 equivalent width of RS CVn binaries. In Table II we present the data of very active Main-Sequence stars of type F and G.

TABLE I

X-ray luminosities and He I 10830 equivalent widths of RS CVn systems

System	Orbital period	Spectral type	log L_x (erg s^{-1})	He I 10830 EW (mÅ)
RS CVn	$4^d.798$	F4V – IV + K0IV	31.27	200
Z Her	3.993	F4V – IV + K0IV	30.30	200
HR 1099	2.838	G5IV + K1IV	31.41	200
HR 5110	2.613	F2IV + K1IV	31.11	200E
UX Ari	6.438	G5C + K0IV	31.32	470
SZ Psc	3.965	F8V + K1IV	31.40	600
α Aur	104.023	G5III + G0III	30.30	775
HR 8575	–	K2III	30.23	850
ζ And	17.769	K1III	30.14	900
λ And	20.521	G8IV – III	30.56	1000
AR Lac	1.983	G2IV + K0IV	31.18	1000
HR 7275	28.590	K1IV	30.56	1025
HR 8703	24.649	K1IV – III	30.64	1225
σ Gem	19.603	K1III	31.31	1570

E-denotes emission.

TABLE II

X-ray luminosities and He I 10830 equivalent widths of very active F and G Main-Sequence stars

Star	Spectral type	log L_x (erg s^{-1})	He I 10830 EW (mÅ)
ρ Psc	F2V	29.20	200
46 Tau	F3V	29.10	300
α Tri	F6IV	29.50	440
HD 8774	F7IV	29.20	200
111 Tau	F8V	29.30	300
δ Tri	G0V	29.10	200
π^1 UMa	G0V	29.10	200
χ^1 Ori	G0V	29.50	350

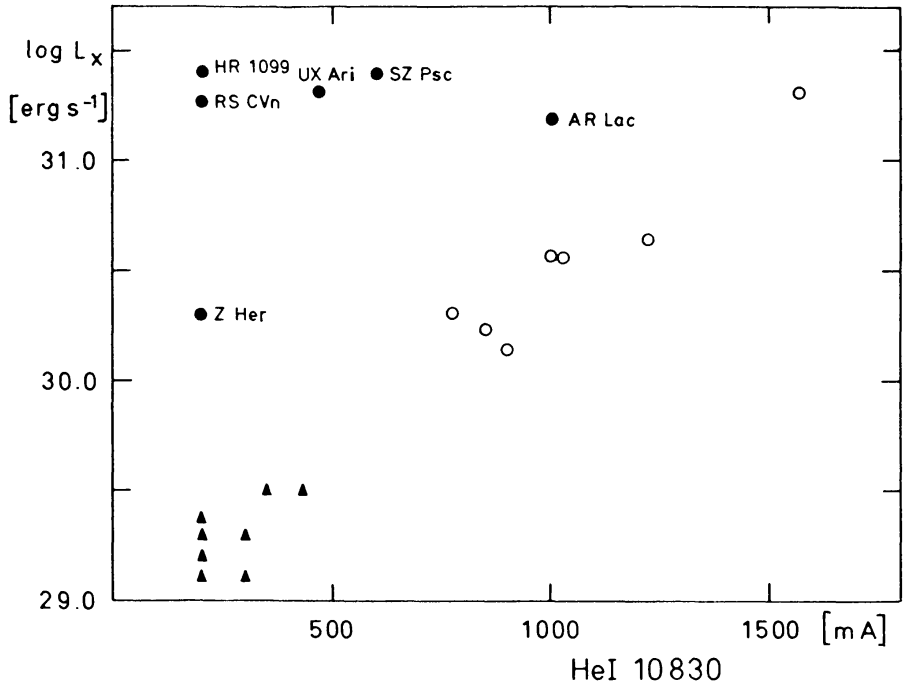

Fig. 1. The X-ray luminosity versus He I 10830 equivalent width for RS CVn binaries and very active F and G Main-Sequence stars. The full circles denote short-period RS CVns; open circles, long-period RS CVns; and filled triangles, the F and G Main-Sequence stars.

Figure 1 shows a plot of logL_x versus He I 10830 equivalent width. It discloses the existence of a close relation for long-period RS CVn binaries and very active Main-Sequence stars. The long-period RS CVn's consist of giants or subgiants that are responsible for the activity. This implies that the same phenomenon is responsible for the He I 10830 line in these highly active giants and in the Main-Sequence stars. The strong dependence of X-ray luminosity on the He I line in these stars shows a prepon-

derance of coronal excitation of the line. However, the short-period RS CVn binaries exhibit a different picture. Though the measurement of equivalent widths is rather difficult due to the fast rotation of these short period binaries, we should expect a very strong line due to their high X-ray luminosity; but, on the contrary, they have very weak He I 10830. The stars HR 1099 and UX Ari show Hα always in emission; and RS CVn, AR Lac, SZ Psc, and Z Her occasionally have emission indicating a high level of chromospheric activity. The reason for this discrepancy in these very active binaries may be due to the presence of an emitting region of He I 10830 which partially fills in the absorption. But HR 5110 shows He I 10830 in emission though Hα is in absorption; however, whether HR 5110 belongs to the RS CVn group is doubtful.

3. Conclusion

From the study of the behaviour of soft X-ray luminosity and He I 10830 line in RS CVn binaries and active Main-Sequence stars, we have arrived at the following conclusions. There exists a strong correlation between the X-ray luminosity and He I 10830 absorption line in very active Main-Sequence F and G stars and long-period RS CVn binaries. This is a strong indication of the coronal excitation of the line in these stars. The most active short-period RS CVn binaries deviate from this relationship. They show very weak He I 10830 for their high X-ray luminosity. The presence of a He I emitting region in the chromosphere of these binaries may account for this behaviour. However, to have a clear understanding of the behaviour of He I line in short-period binaries, they should be monitored simultaneously in Hα and He I 10830 lines over a few rotation periods. We should expect an anticorrelation between Hα emission and He I 10830 absorption because, when the chromosphere is very active, the He I line would be almost filled in by emission.

Acknowledgements

I should like to thank Dr H. W. Duerbeck for critically reading the manuscript and the Director of Sternwarte Bonn, Prof. Dr H. Schmidt, for the hospitality. I also wish to acknowledge an IAU Travel Grant.

References

Marilli, E. and Catalano, S.: 1984, *Astron. Astrophys.* **133**, 57.
Pallavicini, R., Golub, L., Rosner, R., Vaiana, G. S., Ayres, T. R., and Linsky, J. L.: 1981, *Astrophys. J.* **248**, 279.
Schrijver, C. T., Mewe, R., and Walter, F. M.: 1984, in Baliunas and W. Hartmann (eds.), *Cool Stars, Stellar Systems and the Sun*, p. 166.
Smith, M. A.: 1983, *Astron. J.* **88**, 1031.
Walter, F. M. and Bowyer, S.: 1981, *Astrophys. J.* **245**, 671.
Walter, F. M., Gibson, D. M., and Basri, G. S.: 1983, *Astrophys. J.* **267**, 665.
Zirin, H.: 1975, *Astrophys. J.* **199**, L163.
Zirin, H.: 1982, *Astrophys. J.* **260**, 655.