CHROMOSPHERIC PROPERTIES OF T TAURI STARS DETERMINED FROM EUV SPECTRA

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IUE spectra of six pre-main-sequence (PMS) stars are analysed and the resultant emission measure distributions compared with that of T Tau for which a chromospheric model has been calculated. The general shape and absolute level of the mean emission measure distributions are remarkably similar, indicating the relevance of the T Tau chromospheric model to other PMS stars. Evidence for the influence of large scale motions and/or stellar winds on the transition region and coronal emission measures is found. The relative importance of different energy balance terms is discussed.

1. INTRODUCTION

T Tauri stars are among the most chromospherically active stars known, showing EUV emission lines with surface fluxes $\sim 10^4 - 10^5$ times those of the quiet sun. However they are sufficiently distant that for most stars only low resolution spectroscopy can be attempted with the IUE satellite in the important 1200 - 2000 A wavelength range (see Gahm (1980) and Imhoff and Giampapa (1980) for general discussion of early IUE results). One of the few stars for which detailed investigation is possible is T Tau and Brown, Ferraz and Jordan (1982) have constructed chromospheric models for this star using high and low dispersion IUE spectra. In this paper we analyse low resolution spectra from the IUE data archive and compare the results with those for T Tau.

2. ANALYSIS

The stars studied are RW Aur (SWP 4838, 420 min), RU Lup (SWP 5548, 240 min; SWP 5569, 180 min), RY Tau (SWP 7034, 180 min), SCrA (SWP 1755, 200 min), DR Tau (SWP 7189, 292 min) and CoD-35^o 10525 (SWP 5436, 310 min). Emission measure (E_m) distributions have been calculated, including corrections for interstellar and circumstellar absorption, and compared with that of T Tau. The methods used to calculate these distributions are as described by Brown, Ferraz and Jordan (1982). Stellar parameters were taken from Giampapa et al. (1981) and Cohen and Kuhi (1979).

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The absolute level of the E_m distributions up to log $T_e \sim 4.8$ vary remarkably little from star to star, with values between one and ten times those of T Tau, even though the sample contains representatives of the main PMS subgroups. SCrA, DR Tau and CoD-35^o 10525, which all show the YY Orionis infall phenomenon to some extent, have enhanced MgII emission but roughly similar CIV emission to the other stars. The CIII 1908 intersystem line is probably near the low density limit as found in T Tau, but the SiIII 1892/CIII 1908 ratio suggests higher densities. These similarities suggest that the detailed modelling of T Tau has relevance to PMS stars in general and many of the results, particularly the use of two-component models, should hold for other stars.

The available x-ray data indicates that the E_m distribution above 10^6 K is much lower than expected from observations of the sun and other late-type dwarfs (Walter and Kuhi (1981)). Certainly a $^3/2$ power law does not seem applicable between the transition region and corona. In our sample of stars a related effect is that the CIV and NV emission measures show a downturn in the mean E_m distribution, which becomes more pronounced with increasing SiIII 1892/CIII 1908 ratio. Our interpretation is that the declining E_m distribution is associated with an increasing importance of large scale motions and/or outflow in the chromospheric energy balance. Since the energy input for these stars seems roughly the same and conduction is relatively unimportant, an increase in turbulent and flow energy leads to smaller radiative losses. Finally it should be noted that the fluorescent H_2 emission lines seen in the spectrum of T Tau (Brown et al., 1981) are also present in RU Lup and probably in RW Aur, indicating the likely presence of shocked H_2 molecules around these stars.

A full version of this work, hopefully including more stars, will be submitted to Mon.Not.R.astr.Soc..

REFERENCES

Brown, A., Ferraz, M. de M. and Jordan, C.: 1982, in preparation.

Brown, A., Jordan, C., Millar, T.J., Gondhalekar, P. and Wilson, R.: 1981, Nature, 290, pp.34-36.

Cohen, M. and Kuhi, L.V.: 1979, Astrophys.J.Suppl., 41, pp.743-843.

Gahm, G.F.: 1980, Proc.Symp. "The Universe at Ultraviolet Wavelengths: The First Two Years of IUE", Goddard Space Flight Centre, NASA-CP2171, pp.105-114.

Giampapa, M.S., Calvet, N., Imhoff, C.L. and Kuhi, L.V.: 1981, Astrophys.J., 251, pp.113-125.

Imhoff, C.L. and Giampapa, M.S.: 1980, Proc.Symp. "The Universe at Ultraviolet Wavelengths: The First Two Years of IUE", Goddard Space Flight Center, NASA-CP2127, pp.185-191.

Walter, F.M. and Kuhi, L.V.: 1981, Astrophys.J., 250, pp.254-261.

DISCUSSION

Walter: If one observes in X-rays most T-Tauri stars are emitters. It is only the most extreme cases like RU Lup and RW Aur that are not. There appears to be an anti-correlation with optical emission. This is something that most people do not appear to realize i.e. most T-Tauri stars do not have strong emission lines. If one looks at those in Taurus, for instance, about 80% are X-ray sources. They look just like RSCVn stars or any other kind of late-type rapidly rotating stars.

Brown: Are they at a level of 10^4-10^5 times the solar output?

Walter: They are at a few times 10^{30} ergs s^{-1} i.e. 10^3-10^4 times solar.

Brown: This is certainly not like the chromospheric-transition region-coronal emission measure distribution that one gets in stars like the Sun. Would you agree?

Walter: I certainly don't think they are distinguishable from RSCVn stars. The luminosities are similar and the X-ray emission measures are not an order of magnitude lower. They may be lower by a factor of two but they have a scatter of a factor of three to five. So they are really comparable.

Dupree: Does RW Aur have a He II λ1640 line? If so that could be used to indicate the presence of X-rays if, for instance, the X-rays were being absorbed in a massive shell.

Brown: I think it does but it is relatively weak.

Dupree: That might be worth looking into.

Brown: There might be other things there too since our data is low resolution.

Simon: What correction did you make for the UV lines before you did your emission measure analysis?

Brown: I took data from Giampapa et al and from Cohen and Kuhi and did a simple correction using a normal extinction law.

Gahm: I recall having seen N V in emission in RU Lupi. Would you like to comment on that?

Brown: Yes, it is there, but it is very weak.

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