CORONAL STRUCTURE IN YOUNG FAST ROTATORS

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ABSTRACT

We present an analysis of high resolution *Chandra* spectra of three fast-rotating (P_{orb} $\leq$12 hr) late-type dwarfs with similar ages ∼30Myr. We have determined the temperature structure and chemical composition of the emitting plasma in their coronae ad analyse how rotation rate and spectral type can affect their coronal properties.

Key words: stars; fast rotators; coronae; abundances.

1. INTRODUCTION

The last four years—the beginning of the *Chandra* and *XMM-Newton* era— have seen early hints of abundance anomalies fleshed out into an interesting array of diverse abundance patterns in which active stars appear to show signs not only of low FIP element depletion, but also of high FIP element enhancements (e.g.; Drake 2003, and earlier references therein). These patterns of coronal abundance anomalies are telling us something about the dynamical structure and heating of coronal plasma; the challenge is to learn to read these patterns. The aim of the work we present is to analyse how rotation rate and spectral type affect the stellar coronal properties.

2. THE TARGETS AND THE DATA ANALYSIS

Our sample contains three fast-rotating (P_{orb} $\leq$12 hr) late-type dwarfs with similar ages ∼30Myr. Their physical parameters and spectra are shown in Table 1 and Fig. 1 respectively. AB Dor, Speedy Mic and RST 137B were relatively quiescent, showing no large flare events, excepting the moderate event on AB Dor midway through the observations. Pipeline-processed photon event lists were reduced using CIAO 3.2, and were analyzed using the IDL-based PINTofALE[1] software (Kashyap & Drake 2000). The analysis we have performed consisted of line identification and fitting, reconstruction of the plasma

Table 1. Summary of Stellar Parameters.

Star	Sp.Tp.	B-V	P_{rot}	v sin$i$ [km s^{-1}]	ObsID	Exp [s]
AB Dor	K0V	0.80	12hr	93	16	60
Speedy Mic	K3V	0.94	9hr	132	3491	70
RST137B	M0V	1.60	<9hr	50	16	60

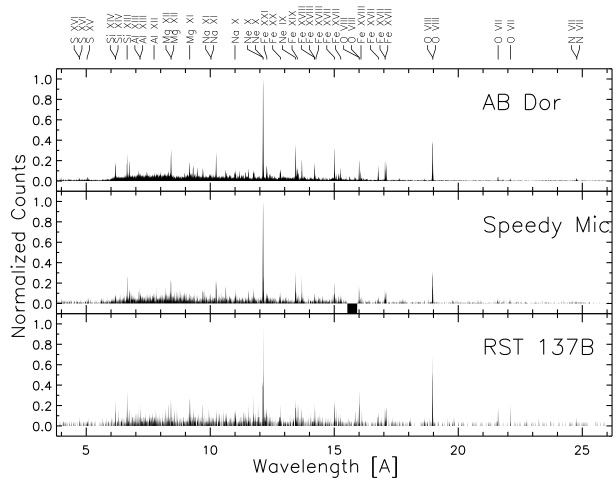

Figure 1. Chandra X-ray HETG-ACIS-S spectra. The strongest lines are identified.

emission measure distribution including allowance for blending of the diagnostic lines used, and finally, determination of the element abundances. Spectral line fluxes were measured by fitting modified Lorentzian functions. W use the "line-free" continuum spectral regions 2.4-3.4, 5.3-6.3 and 20.4-21.4 Åwhich serve as both temperature constrain and to provide an absolute normalisation for the DEM.

3. THERMAL STRUCTURE AND ABUNDANCES

In order to obtain the *differential emission measure* (DEM) we have performed a Markov-Chain Monte-Carlo analysis using a Metropolis algorithm (MCMC[M]) on the set of supplied line flux ratios (O, Ne, Mg, Si, Fe 17,

[1]Available from http://hea-www.harvard.edu/PINTofALE

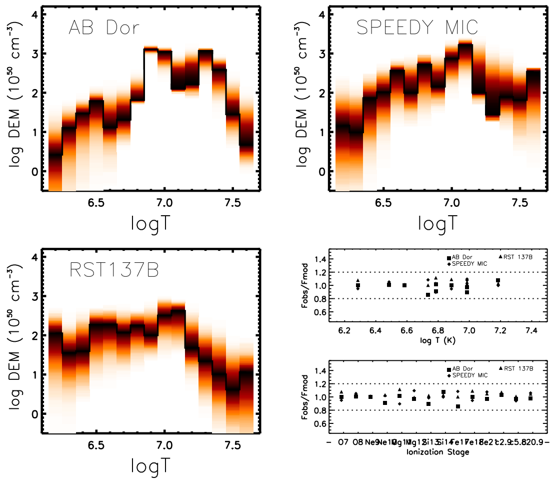

Figure 2. Top and bottom left: DEMs obtained for AB Dor, Speedy Mic and RST 137B. The thick solid line represents the best-fit DEM, while the shaded regions correspond to the 1-σ deviations present in each temperature bin. Bottom right: Comparison of observed and modelled line fluxes vs ionic species (bottom) and vs T_{max} (top) for the three objects.

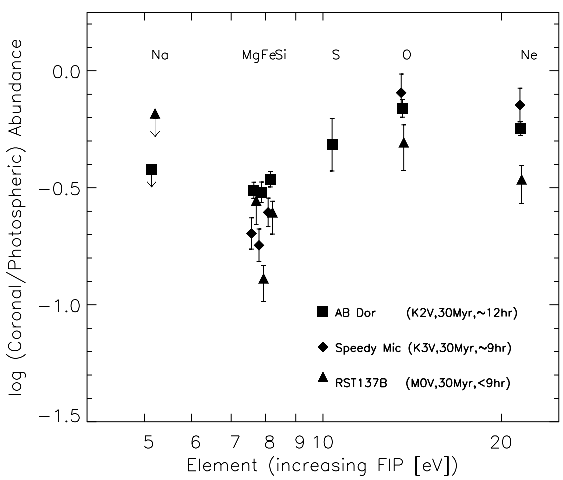

Figure 3. Comparison of coronal abundances vs FIP for AB Dor, Speedy Mic and RST 137B. The abundances were obtained from the abundance-independent DEM reconstruction and are relative to the solar photospheric mixture of Asplund et al. (2004) with the Ne from Drake & Testa (2005). The error bars represent statistical uncertainties only, true uncertainties are likely to be 0.1 dex

Fe 18 and Fe 21). Advantages of this method include the ability to estimate uncertainties and the avoidance of unnecessary smoothing constraints (Kashyap & Drake 1998). Based on the lines we use in our analysis we are able to obtain a well-constrained DEM(T_n) between log $T[K]$=6.2 and log $T[K]$=7.5 (see Fig. 2). We can evaluate the abundances, based on the derived DEM, of any element for which we have lines with measured fluxes (see Fig. 3).

4. CONCLUSIONS

AB Dor, Speedy Mic and RST 137B represent young ($\sim$30 Myr) rapidly rotating (P_{orb} $\leq$12 hr) with spectral type ranging from K0 V to M) V. As such, a comparison between their coronal properties provides an illuminating glimpse of any fundamental underlying differences in their magnetic dynamos and activity. Based on an analysis of high resolution *Chandra* X-ray spectra of these stars we draw the following conclusions.

1. The temperature strucutres of both AB Dor and Speedy Mic are fairly similar, showing a peak at log $T[K]$ $\sim$7.0. RST 137B shows a flatter DEM which also peaks at log $T[K]$ $\sim$7.0. AB Dor and Speedy Mic show more evidence of emitting plasma at log $T[K]$ >6.3. The slope for the DEM, between log $T[K]$=6.2 and log $T[K]$=7.0, seesm to be shallower as the rotational rate and spectral type increase.
2. Studies have shown that photospheric abundances for AB Dor and its ‘close’ companion RST 137B can be assumed as solar-like. Based on this, we observe that all three stars show evidence for an inverse-FIP effect showing depletion of the low FIP elements (<10 eV) relative to photospheric values. The fastest ratator of our sample, RST 137B, shows depletion in all the elements relative to those of AB Dor and Speedy Mic. Depletion in the low FIP elements only is observed in Speedy Mic.
3. Speedy Mic and RST 137B show much lower Fe abundances compare with AB Dor, than those of Si and Mg – elements that both have very similar FIP to Fe. This effect could be showing a mass dependency for the chemical fractionation (such as gravitational settling of the heavier Fe ions).

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