HIGH RESOLUTION X-RAY SPECTROSCOPY OF COOL STARS USING LETGS

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ABSTRACT

I report on the survey of a number of X-ray spectra of cool stars of spectral type G and K. The relation between the X-ray luminosities (L_X) and the stellar radii is illustrated. Two spectra of Capella taken at different times show considerable difference in count rate. These spectra have been investigated. Temperature patterns by means of differential emission measure are given.

Key words: Cool Stars; Capella; X-rays; Spectra.

1. INTRODUCTION

Many cool stars with surface temperatures between 4000 and 7000 K are surrounded by hot plasma (coronae) with temperatures from 1 MK upto 30 MK or more. The hot coronal plasmas are strong X-ray emitters. Since the launches of two advanced high resolution X-ray satellites (CHANDRA and XMM-Newton) in 1999 these coronae can be studied into great detail. Both the satellites are equipped with grating devices, as described e.g. for XMM-Newton (1), resulting in high resolution spectra. An ensemble of six cool stars has been observed by LETGS aboard CHANDRA, among them Capella.

2. SPECTRAL ANALYSIS

I have fitted the total spectrum of the six stars, applying SPEX (2) in combination with MEKAL (3; 4). The fit model is a Collisional Ionization Equilibrium (CIE) model for optically thin plasmas. The ionization balance is derived from calculations by (5). During the fitting procedure emission measures and abundances were calculated for 10 equidistant fixed temperature bins. As an illustration of the quality of the procedure Fig. 1 shows the fitted model (red) together with the data (black) for the X-ray spectrum of λ And.

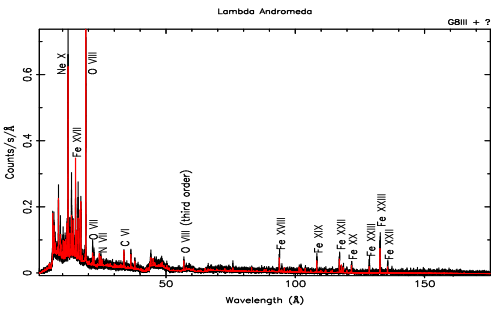

Figure 1. The LETGS spectrum (black) of λ Andromeda together with the model (red). Notice the completeness of the model and the very good agreement between the highly resolved line spectrum and the laboratory wavelengths of the model.

Here we will focus on the X-ray luminosities only. The luminosities obtained from these fits are shown in table 1. Fig. 2 reflects the relation between the X-ray luminosities and the stellar radius ($R_*/R_\odot$). This figure suggest a linear relation with R_*^2 for main sequence stars and a deviation from this trend for giant stars.

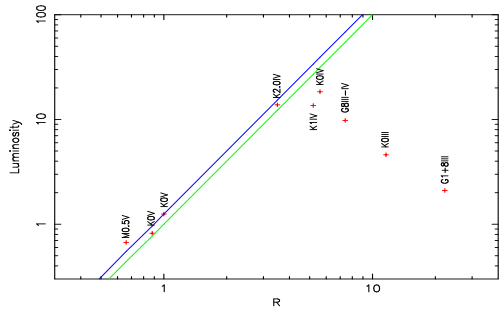

Figure 2. The relation between the X-ray luminosities and the stellar radii. The two straight lines indicate $(R/R_\odot)^2$ and $1.25 \times (R/R_\odot)^2$

Table 1. The fitted values of the X-ray luminosities L_X obtained by means of a multi-temperature fit to the data.

Parameters Spectral type	β Ceti K0III	λ And G8III+?	Capella G1III+G8III	UX Ari G5V+K0IV	HR1099 G5IV+K1IV	AB Dor K0V
$R/R_\odot$	11.6	7.4+?	13+9.2	0.93+4.7	1.3+3.9	1.0
L_X [10^{30}erg/s] (0.07-12.5keV)	4.2	9.80	2.06	18.4	13.6	1.25

3. CAPELLA

Capella has served as a calibration source for the two satellites, as Capella is considered to be a line rich and constant source. Its spectrum has been studied extensively in the past e.g., (6; 7). However, the LETGS-observation 5956 shows a considerably higher flux level than former observations (e.g., 1248). Fig. 3 shows the two light curves. Line flux ratios between the two observations (Fig. 4) show an increase for increasing formation temperature, indicating observation 5956 being the hotter. A differential emission measure modeling (DEM) applying SPEX confirms this conclusion (Fig. 5).

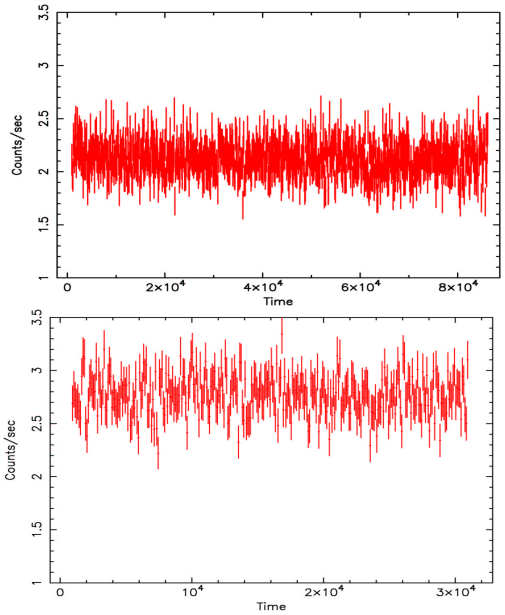

Figure 3. The lightcurves of the Capella observation 1248 (top panel) and 5956 (lower panel).

4. CONCLUSIONS

Main sequence stars suggest a relation between X-ray luminosities and stellar radii.
Capella shows variability in X-ray flux. Although no flares are recognized in the light curve, hotter plasma seems to be present in the higher count rate spectrum.

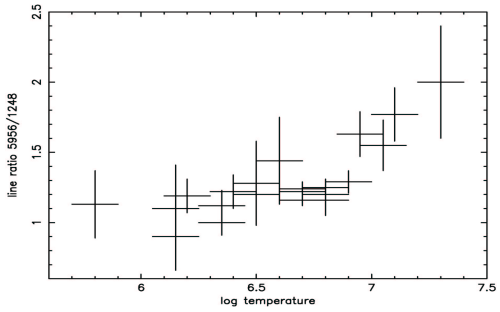

Figure 4. Line flux ratios 5956/1248 versus the optimal line formation temperature.

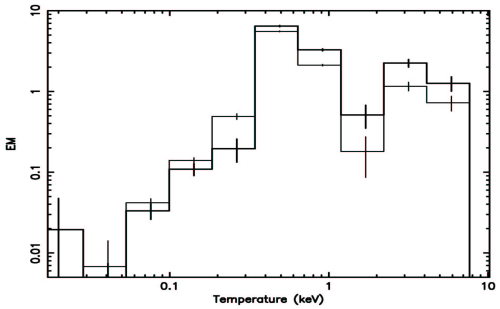

Figure 5. DEM-modeling. The thin line belongs to observation 1248 and the thick line to 5956.

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