XMM-*NEWTON* OBSERVATIONS OF THE TAURUS-AURIGA STAR-FORMING REGION: THE FIELD AROUND SU AUR

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ABSTRACT

We present XMM-*Newton* observations of the Taurus-Auriga star-forming region, centered on the Classical T Tauri star SU Aur. Spatial analysis of the EPIC field resulted in the detection of 104 X-ray sources, 6 of which are identified with the known pre-main sequence stars in the field of view. The EPIC spectra of SU Aur show a hot corona, with temperatures up to $\sim$ 6 keV; the RGS spectrum shows a strong continuum and weak lines, due to the high temperature, and emission is suppressed above 15Å due to the high absorption. Spectral analysis of other bright sources is also presented.

Key words: Pre-main-sequence stars; star-forming regions; X-rays.

1. OBSERVATIONS AND DATA ANALYSIS

The Taurus-Auriga star-forming region (SFR) is one of the nearest ($d = 140$ pc) and most active regions of low-mass star formation. As part of the GT program, we have obtained an XMM-*Newton* observation of Taurus-Auriga centered on the Classical T Tauri (CTT) star SU Aur, using the EPIC MOS cameras and the RGS instrument, for a total duration of 130 ks. Data analysis was carried out using the standard tasks in SAS v.6.1.0.

Source detection was performed on the individual and merged MOS1+MOS2 datasets using the Wavelet Detection algorithm developed at Osservatorio Astronomico di Palermo (Damiani et al., 1997). We detected a total of 104 sources above a significance threshold of 5σ. With an identification radius of $6''$, all the 7 known pre-main sequence stars in the field of view are detected, although two of them are unresolved by XMM-*Newton*. Additional 6 sources are identified with other known stars in the field, while another 18 sources have a counterpart in the 2MASS catalog.

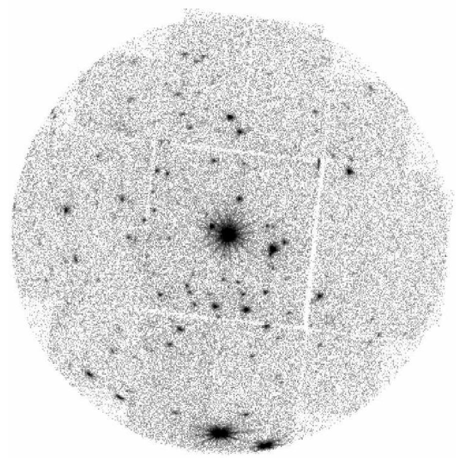

Figure 1. Combined MOS image of the SU Aur field

2. THE CTT STAR SU AUR

SU Aur is the brightest source in our field of view. During the observation it displayed a highly variable light curve, with three flares occurring at nearly equal intervals of $\sim$ 40 ks, lasting $\sim 15-20$ ks each (Fig. 2a).

The MOS spectra, integrated over the entire observation, are quite hard and show a strong Fe 6.7 keV line. A joint fit using a 3-temperature APEC model yields $T = 0.7$, 1.9, 5.9 keV, $EM = 1.2 \times 10^{53}$, 2.8×10^{53}, 1.2×10^{53} cm^{-3}, $N_H = 3.3 \times 10^{21}$ cm^{-2}, Fe= 0.8 Fe$_\odot$, O/Fe = 0.8, Ne/Fe = 2.8, Mg/Fe = 2.2, Si/Fe = 1.1, with $L_X \sim 8 \times 10^{30}$ erg s^{-1} in the 0.3 – 8 keV band.

The RGS spectrum shows only weak lines and a strong continuum, with the emission strongly reduced above $\sim$ 15Å. The characteristics of the RGS spectrum are due to the very hot plasma and the high column density: in fact, the observed spectrum is consistent with the one predicted from the MOS best-fit model. A 3-T global fit of the RGS spectrum confirms the presence of a dominant hot component at $\sim$ 5 keV, with $EM \sim 3.2 \times 10^{53}$ cm^{-3}. but with a significantly lower abundance of Ne

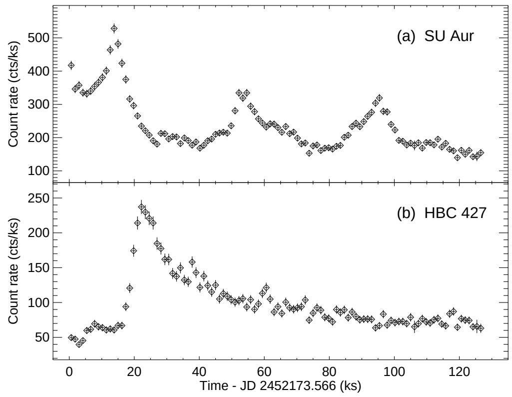

Figure 2. Combined MOS light curves of SU Aur (a) and HBC 427 (b)

(Ne/Fe = 1.1, Fe = 0.7 $Fe_\odot$).

Time-resolved spectral analysis shows that the quiescent spectrum is characterized by $T = 0.8$ and 2 keV, with $EM_2/EM_1 \sim 2$ and $Z \sim 0.6 Z_\odot$. During flares only the hot component varies, with T reaching ~ 3 keV during the first flare. A significant increase of Z to 1.1 $Z_\odot$ is also observed during the first flare.

Our results agree with previous *ASCA* and *Chandra* observations (Skinner & Walter, 1998; Smith et al., 2005), that found a dominant component at $\sim 30 - 40$ MK in quiescence. The hot temperature of SU Aur contrasts with the very low one (3 MK) found for the CTT star TW Hya, which, together with the very high density and Ne/Fe ratio, has been attributed to emission from an accretion shock (Kastner et al., 2002; Stelzer & Schmitt, 2004). However, high-resolution observations of other CTT stars also show the presence of hot plasma (Schmitt et al., 2005; Argiroffi et al., 2005), suggesting a magnetic origin for X-ray emission.

3. SPECTRAL ANALYSIS OF OTHER STARS

HBC 427: the Weak-lined T Tauri star HBC 427 displayed a long-lasting flare during the observation (Fig. 2b), with the count rate increasing by a factor of ~ 3.5 in ~ 2 hrs, and returning to the quiescent level ~ 19 hrs later. Time-resolved spectral analysis shows that the quiescent corona has $T \sim 0.8$ and 1.9 keV, increasing to ~ 3.4 keV at the top of the flare, and $Z \sim 0.1 - 0.3\, Z_\odot$, with $N_H \sim 3 \times 10^{20}$ cm^{-2}. The X-ray luminosity increases from $\sim 3 \times 10^{30}$ to $\sim 1.4 \times 10^{31}$ erg s^{-1} at the flare peak.

AB Aur: the Herbig Ae star AB Aur showed a nearly constant emission level during the observation. Spectral analysis gives $N_H \sim 8 \times 10^{20}$ cm^{-2}, $Z = 0.2\, Z_\odot$, $T_1 =$ 0.3 keV, $T_2 = 0.7$ keV, $EM_2/EM_1 \sim 0.5$. This star is significantly cooler than SU Aur and HBC 427, and generally than later-type pre-main sequence stars. The

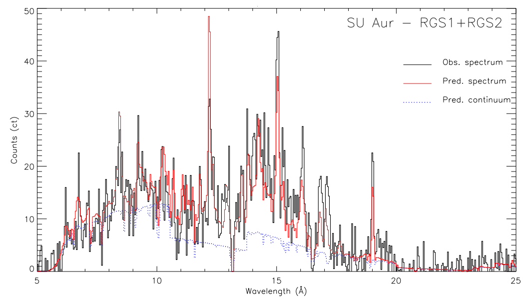

Figure 3. Comparison of the observed RGS1+RGS2 spectrum of SU Aur with the one predicted from the MOS best-fit model

X-ray luminosity $L_X \sim 2.3 \times 10^{29}$ erg s^{-1} is consistent with the value found in a previous ROSAT observation (Zinnecker & Preibisch, 1994).

HD 31305: HD 31305 is an A0 star with IR excess, with no indication of membership of the SFR in the literature; it was detected in a previous *ASCA* observation with a 0.5-10 keV count rate of ~ 15 cts/ks (Skinner & Walter, 1998). The light curve shows three flares, the strongest of which increased the count rate by a factor of ~ 4 in $\lesssim 1$ hr, followed by a decay of ~ 5 hrs. Spectral fitting of this flare and of the quiescent emission immediately after it gives $T = 1.5$ keV, $EM = 2.1 \times 10^{53}$ cm^{-3}, $Z = 0.1\, Z_\odot$, $N_H = 8 \times 10^{20}$ cm^{-2} in quiescence, and $T = 1.9$ keV, $EM = 3.5 \times 10^{53}$ cm^{-3}, $Z = 0.1\, Z_\odot$, $N_H = 4.5 \times 10^{20}$ cm^{-2} during the flare. These temperatures are similar to those of late-type stars, suggesting that the X-ray emission might be due to an unseen late-type companion, rather than to the A0 star itself.

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