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V4046 Sgr: X-rays from accretion shock

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Abstract. We present results of the X-ray monitoring of V4046 Sgr, a close classical T Tauri star binary, with both components accreting material. The 360 ks long XMM observation allowed us to measure the plasma densities at different temperatures, and to check whether and how the density varies with time. We find that plasma at temperatures of $1 - 4$ MK has high densities, and we observe correlated and simultaneous density variations of plasma, probed by O VII and Ne IX triplets. These results strongly indicate that all the inspected He-like triplets are produced by high-density plasma heated in accretion shocks, and located at the base of accretion flows.

Keywords. Accretion, Stars: pre-main sequence, X-rays: stars

1. Introduction

Classical T Tauri Stars (CTTS) are young low mass stars still accreting material from their circumstellar disks. Accreted material, impacting onto the stellar surface, forms strong shocks, where it is heated up to temperatures of a few MK, and then cools down radiating in the X-ray band. Inspecting the X-ray emission from CTTS allows us to infer important properties on post-shock plasma, and, as a consequence, on the accretion process (e.g. Kastner *et al.* 2002, Brickhouse *et al.* 2010).

This work is part of a large campaign of quasi-simultaneous X-ray/optical observations targeting V4046 Sgr, aimed at simultaneously constrain the properties of the shock-heated X-ray emitting plasma, the large scale magnetic field, and the accretion geometry (Donati *et al.* 2011, Argiroffi *et al.* 2012). V4046 Sgr is a close binary in which both components are accreting material from a circumbinary disk (Stempels & Gahm 2004 and references therein). Here we present the results, obtained from high resolution X-ray spectra gathered with XMM, specifically aimed at investigating the properties of the dense plasma heated in the accretion shock.

2. Plasma Density

Plasma density can be measured by the f/i ratio of He-like triplets. In the XMM/RGS spectrum of V4046 Sgr we measured the fluxes of N VI, O VII, and Ne IX, from which we derived the density $n_{\rm e}$ of the plasma at ~ 1, ~ 2, and ~ 4 MK, respectively (see fig. 1).

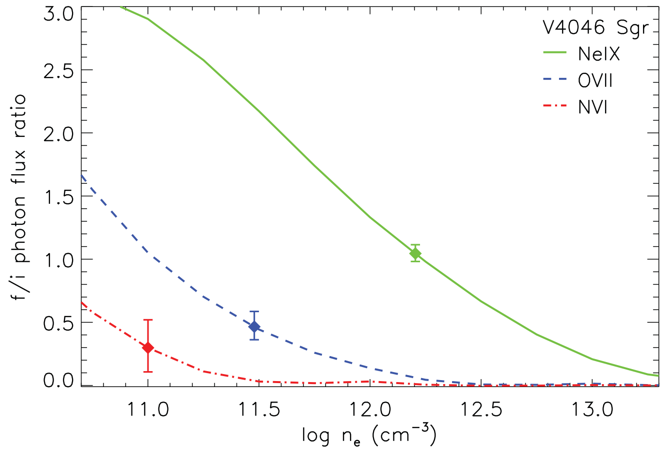

Figure 1. Predicted and observed f/i line ratios of He-like triplets vs plasma density.

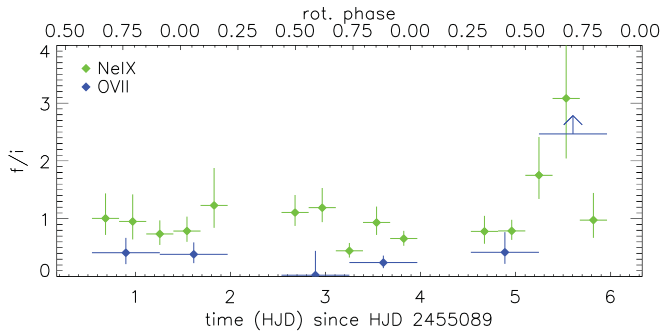

Figure 2. Time resolved f/i line ratios of O VII and Ne IX triplets.

Thanks to the very long XMM observation (360 ks) we searched for density variability by inspecting the f/i ratios of Ne IX and O VI collected on short time intervals (fig. 2). We found significant density variations in both O VII and Ne IX ratios. In particular, during the last part of the observation, both the f/i ratios increased, indicating that a simultaneous density decrease by a factor ~ 10 occurred in the plasma at 2 and 4 MK.

The high density observed indicates that the plasma at $1 - 4$ MK is plasma heated in the accretion shock. The correlated and simultaneous density variations of plasma probed by O VII and Ne IX strongly suggests that the two He-like triplets are produced by the same plasma component, likely located in the post-shock region at the base of the accretion stream.

References

Argiroffi, C., Maggio, A., Montmerle, T., *et al.* 2012, *ApJ*, 752, 100

Brickhouse, N. S., Cranmer, S. R., Dupree, A. K., Luna, G. J. M., & Wolk, S. 2010, *ApJ*, 710, 1835

Donati, J.-F., Gregory, S. G., Montmerle, T., *et al.* 2011, *MNRAS*, 417, 1747

Kastner, J. H., Huenemoerder, D. P., Schulz, N. S., Canizares, C. R., & Weintraub, D. A. 2002, *ApJ*, 567, 434

Stempels, H. C. & Gahm, G. F. 2004, *A&A*, 421, 1159