XMM-Newton Calibration Technical Note

MOS optical loading

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1 Abstract

The MOS optical PSF has been analyzed with diagnostic frames acquired on the RGS calibration star AB Doradus in the THIN filter, with the aim to assess the MOS optical loading.

This analysis provides better constrains than the previous technical note (XMM-SOC-CAL-TN-0040, June 27, 2003), based on OPEN filter measurements and supersedes it.

2 Introduction

MOS diagnostics frames (integration time = 2.6s) were performed on the V=7 AB Dor star (spectal type: K1IIIp) in revolution 709 (RGS calibration observation). These data were used to characterize the optical PSF, by plotting the EEF (Encircled Energy Function) and estimating the fraction of the optical flux in the central pixels and to compare D. Lumb's model implemented in PHS tools (PHS Tools - EPIC Optical Loading, XMM-PS-TN-40, D. Lumb, Nov. 16, 2000).

3 Analysis

As AB Dor is also an X-ray source (!), a special dedicated processing ("deglitching") had to be applied to remove the X-ray photons from the optical diagnostics frames (integration time = 2.6s). The MOS1 and MOS2 optical PSFs though the THIN filter are shown in figures 1 & 2 respectively (averaging of all diagnostic frames after deglitching). Note that most X-ray events from the source have been removed, but not the cosmic rays splashes. Only the frames where no cosmic ray was impinging closer that 30 arcsec from the centre of the source were used for the analysis.

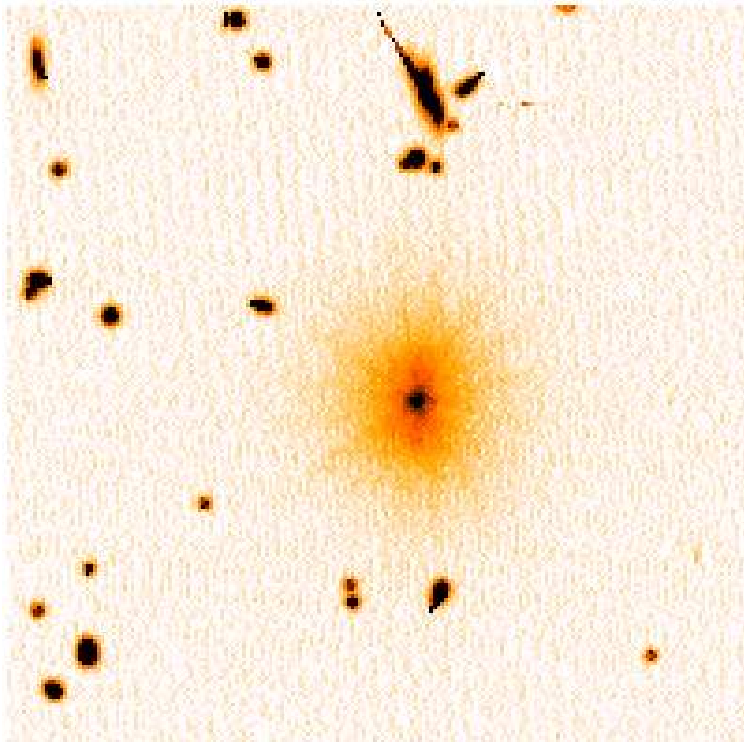

Figure 1: MOS1 optical PSF : AB Dor through THIN filter

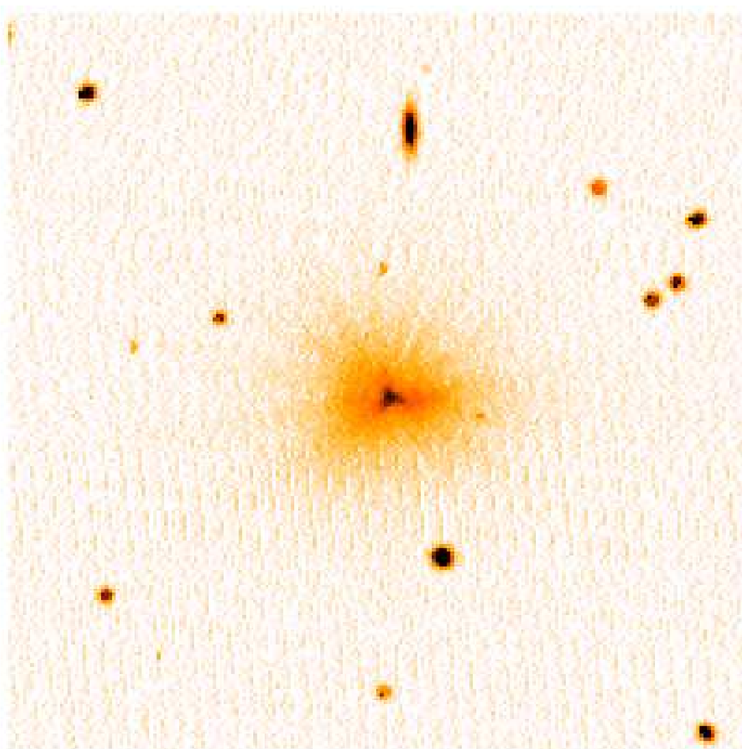

Figure 2: MOS2 optical PSF : AB Dor through THIN filter

4 Results

The derived optical EEF is plotted for MOS1 and MOS2 in figures 3 and 4 respectively. Although the optical PSFs display the same characteristics as in the X-ray regime (MOS2 PSF triangular and somewhat more peaked), the EEF are remarkably similar.

The core optical PSF is sligthly larger than the X-ray PSF, with a HEW (Half Equivalent Width) of about 11"(radius), vs 9". On the other hand the 80% or 90% EEF is more peaked than in X-ray (less scattered optical light in the PSF wings).

The optical loading in the central pixels is about 130 ADUs (123 ADUs for MOS1 and 137 ADUs for MOS2) and amounts to about 0.5% of the total optical flux for both MOSs.

It is also interesting to note that the MOS2 optical flux is 7% higher than MOS1. This is likely due to small variations from the filter transmission, (e.g. if 0.99 for MOS2, 0.9907 for MOS2) .

5 Impact on optical loading

The optical loading assessment performed by PHS tools, derived from D. Lumb's model (PHS Tools - EPIC Optical Loading, XMM-PS-TN-40, Nov 16. 2000) assumes that the fraction of light that is detected in the central pixel of the PSF distribution is 2% for MOSs (and 15% for EPIC-pn). It predicts for AB Dor a pixel loading of $\sim$ 1500ADUs, i.e. more than 10 times larger (11.5) than what is measured here on AB Dor.

This is due partly to the overestimation of the fraction of the optical flux in central pixel by a factor 4 (2% vs 0.5% found here), The other factor (about 3) is probably coming from an overestimation of the filter transmission, as the OPEN measurements in revolution 90 showed a good agreement with the model.

The optical loading assessment in PHS tools, is hence overestimated by a factor $\sim$10. The V-magnitude limits in Lumb (2000) can be decreased by more than 2.5 magnitudes in the THIN filter (table page vi).

For instance, the optical loading of a V=12 K-star (like AB Dor) will be of 1 ADU in the central pixels, while Lumb (2000) gives a limit of V=15.4 (but for 1 electron per CCD frame time)

A relative safe magnitude limit to observe with the THIN filter is V$\sim$11. This yields to about 3 ADUs of optical loading in the central pixels. This level of optical loading is corrected in the SAS, by a local background correction, using E3 and E4 energies. So only a minimal spectral distorsion is expected, due an increase of double events and some shot noise due to the increased "bumped' background.

For sources brighter than V=9, a "dead area" is the core of the PSF appears in THIN filter, when several adjacent pixel are all above the detection threshold (25 ADUs).

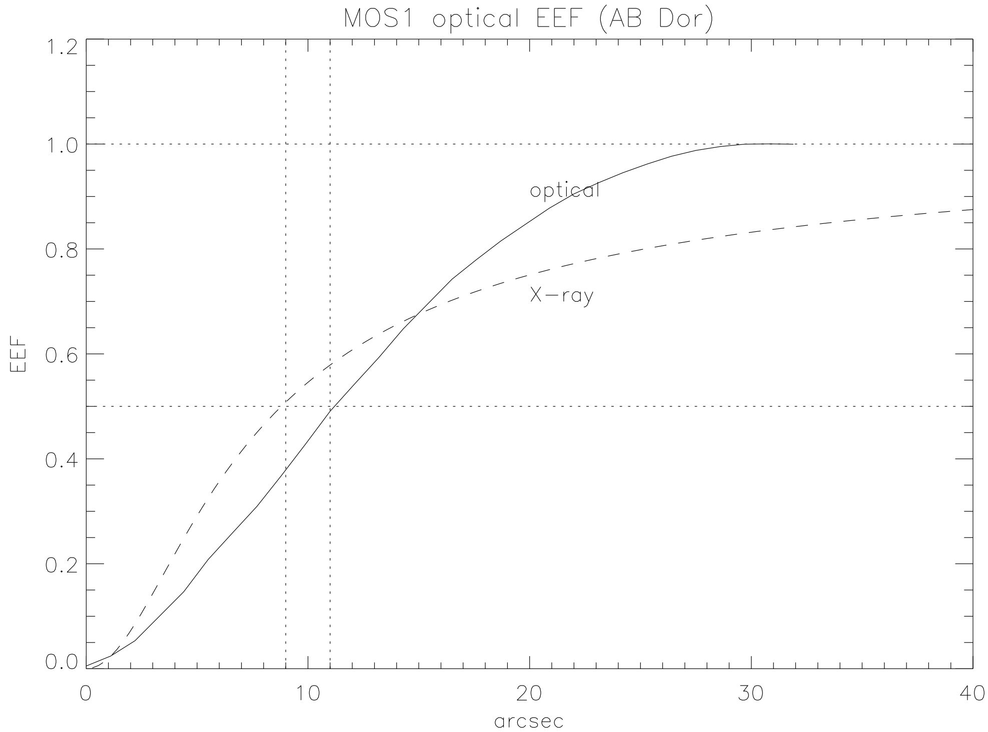

Figure 3: MOS1 optical EEF, compared to the X-ray EEF (dashed line)

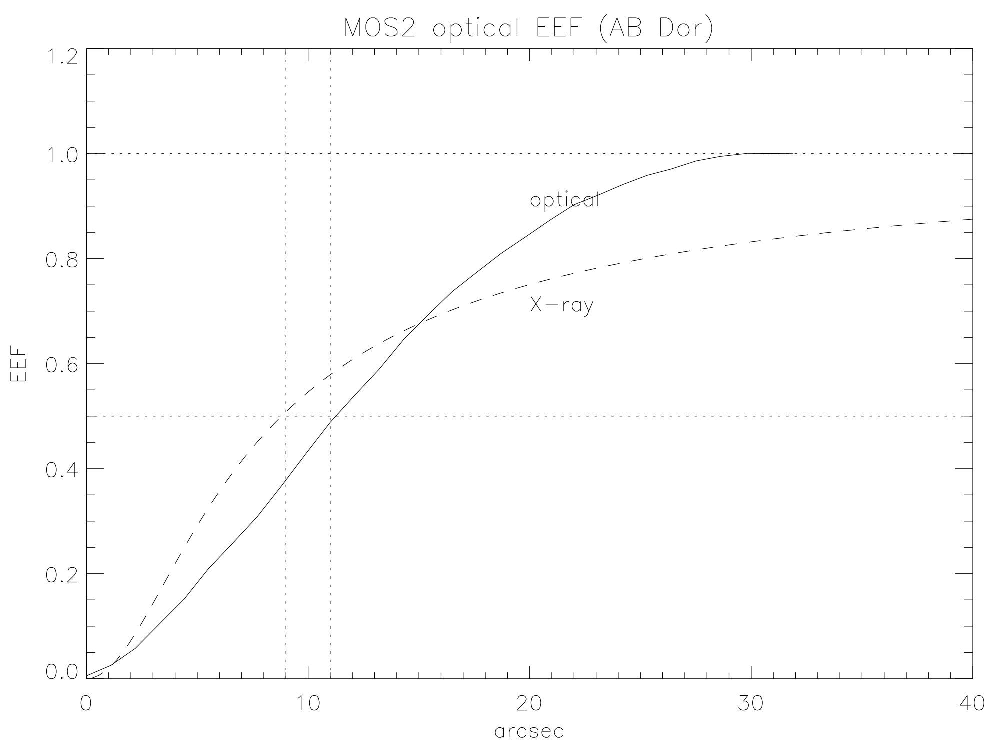

Figure 4: MOS2 optical EEF, compared to the X-ray EEF (dashed line)

6 Conclusion

Based on this measurement of the optical loading though the THIN filter and extrapolating to other filters by assuming an additional optical blocking of 10^2 and 10^5 for the MEDIUM and THICK filters respectively, the magnitude limits in the XMM-Newton User's Handbook shall be revised safely to :

- **THIN filter: V=12**
- **MEDIUM: V=7**
- **THICK V=0**

Acknowledgment

Thanks to Stephane Rives for acquiring these MOS diagnostic frames via manual OCRs.

References

PHS Tools - EPIC Optical Loading, XMM-PS-TN-40, Issue draft, D. Lumb, November 16, 2000

EPIC optical PSF, XMM-SOC-CAL-TN-0040, B. Altieri, June 27, 2003