DOCUMENT

Time Dependent Sensitivity Degradation of the Optical Monitor (OM) grisms.

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1 INTRODUCTION

The sensitivity of the Optical Monitor (OM) on board XMM-Newton is affected by a time dependent degradation. This is due to two main effects: the degradation of the S-20 photocathode and the aging of the MCP. The first of these effects is known to be wavelength dependent.

This time dependent sensitivity degradation has been studied in the OM colour filters V, B, U, UVW1, UVM2 and UVW2. It has been described in XMM-SOC-CAL-TN-0207, where a correction factor is defined and computed. The correction factor, a polynomial function of the Modified Julian Date (MJD) of observation, is included in SAS so that measured rates of the detected sources in any of the filters are corrected and therefore referred to a common zero epoch. The CCF OM_PHOTONAT contains the coefficients used by SAS to compute the correction factor for the date of observation.

It is obvious that such a time dependent sensitivity loss must affect also data obtained with the OM grisms: Grism_1 (UV_grism) and Grism_2 (V_grism).

The characterisation of the sensitivity degradation in the grisms is very difficult due to the important level of noise and artefacts present in OM grisms data. Nevertheless, we have made a study presented in this document.

2 MEASURING THE TIME DEPENDENT SENSITIVITY DEGRADATION IN OM GRISMS

We have used spectra of the white dwarfs GD 153, Hz 2 and BPM 16274. These stars are used to measure the time dependent sensitivity degradation and to derive the correction for observations obtained with the colour filters. The first two stars are observed once per year and the third one twice. They are observed with all OM filters, including both grisms. The data are processed with SAS to extract the spectra of the stars obtained with the grisms automatically, e.g. the interactive task ***omgsource*** has not been used.

In order to increase the S/N of the extracted spectra, we have binned the wavelength dependent rates in 250 and 300 angstroms bands for the UV_grism and V_grism respectively. These bands are defined in Table 1.

UV_grism	2000	2400	2800	3200	3600	4000
V_grism	3500	4000	4500	5000	5500	6000

Table 1. Wavelength bins (angstroms) used to measure time dependent sensitivity loss in OM grisms.

As an example we give in Table 2 selected binned rates in a series of V_grism spectra corresponding to GD 153, one of our white dwarfs standards. We have avoided bins where contaminant artefacts were present. The decline with time of these binned rates can be seen clearly in most of the bins.

Lambda Year	3500	4000	4500	5000	5500	6000
2002.5	0.1743	0.2122	0.1548	0.0845	0.0403	0.0260
2003.0	0.1741	0.2107	0.1545	0.0857	0.0409	0.0274
2003.5	0.1727	0.2116	0.1527	0.0831	0.0383	0.0266
2004.5	0.1727	0.2118	0.1534	0.0837	0.0406	0.0268
2006.5	0.1714	0.2088	0.1499	0.0829	0.0395	0.0262
2007.0	0.1686	0.2090	0.1503	0.0804	0.0383	0.0264
2008.5	0.1688	0.2080	0.1505	0.0803	0.0376	0.0244
2011.5	0.1672	0.2055	0.1485	0.0806	0.0385	0.0248
2012.9	0.1648	0.2006	0.1469	0.0798	0.0374	0.0237
2013.5	0.1651	0.2043	0.1473	0.0811	0.0359	0.0235
2015.5	0.1646	0.2031	0.1487	0.0802	0.0383	0.0246
2016.5	0.1645	0.2026	0.1459	0.0796	0.0376	0.0240

Table 2. Binned rates of V_grism spectra of GD 153

Similar tables for both grisms, UV and V, allow us to make a linear fit of rates versus wavelength for all bins rates for each star and grism. We obtain then a set of rates for a zero epoch defined as year 2000 for all bins. The corresponding bin rates are then normalized to this zero epoch values.

Figures 1 and 2 show respectively for UV_grism and V_grism, the normalized rates computed for each bin for all three stars. Linear fits are displayed for each star and also a common fit to all data.

It could be argued that fitting all bins together for each star could induce an error due to different degradation at wavelengths as e.g. 3500 and 6000 angstroms. However, the big level of noise justifies this approach. We have indeed compared the sensitivity loss in different bins, and we have confirmed that they can be merged within the errors. Furthermore, when we study the time dependent sensitivity degradation in the colour filters, we can see that V, B and U filters show a decrease level different than UVW1, UVM2 and UVW2 considered together.

A similar reasoning can be used for the merging of data from the three stars, and their common fit presented in Figures 1 and 2.

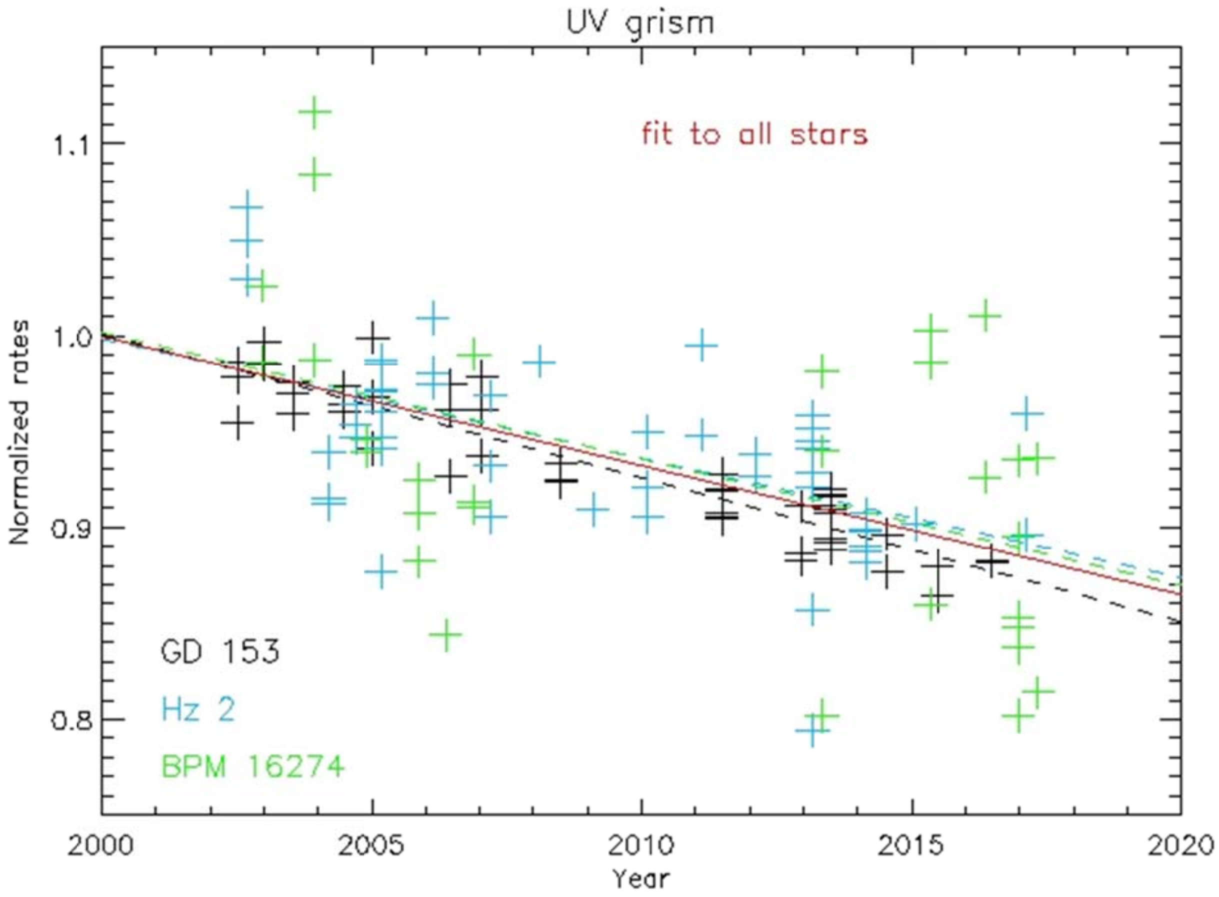

Figure 1. OM time dependent sensitivity degradation of UV_grism.

3 CORRECTION FOR THE TIME DEPENDENT SENSITIVITY DEGRADATION IN OM GRISMS

The linear fits shown in Figures 1 and 2 give us an approximate value of the degradation affecting OM grism spectra. As we have already said, the large amount of noise in grism data prevents us from deriving an accurate value. For this reason, we cannot offer an accurate correction for this effect.

However, users of the Optical Monitor on board XMM-Newton may be interested in comparing spectra of the same source obtained at very different epochs, since the life of the instrument is so long. We can provide an approximate correction as a factor to be multiplied by the spectrum or spectra as a function of the year of observation.

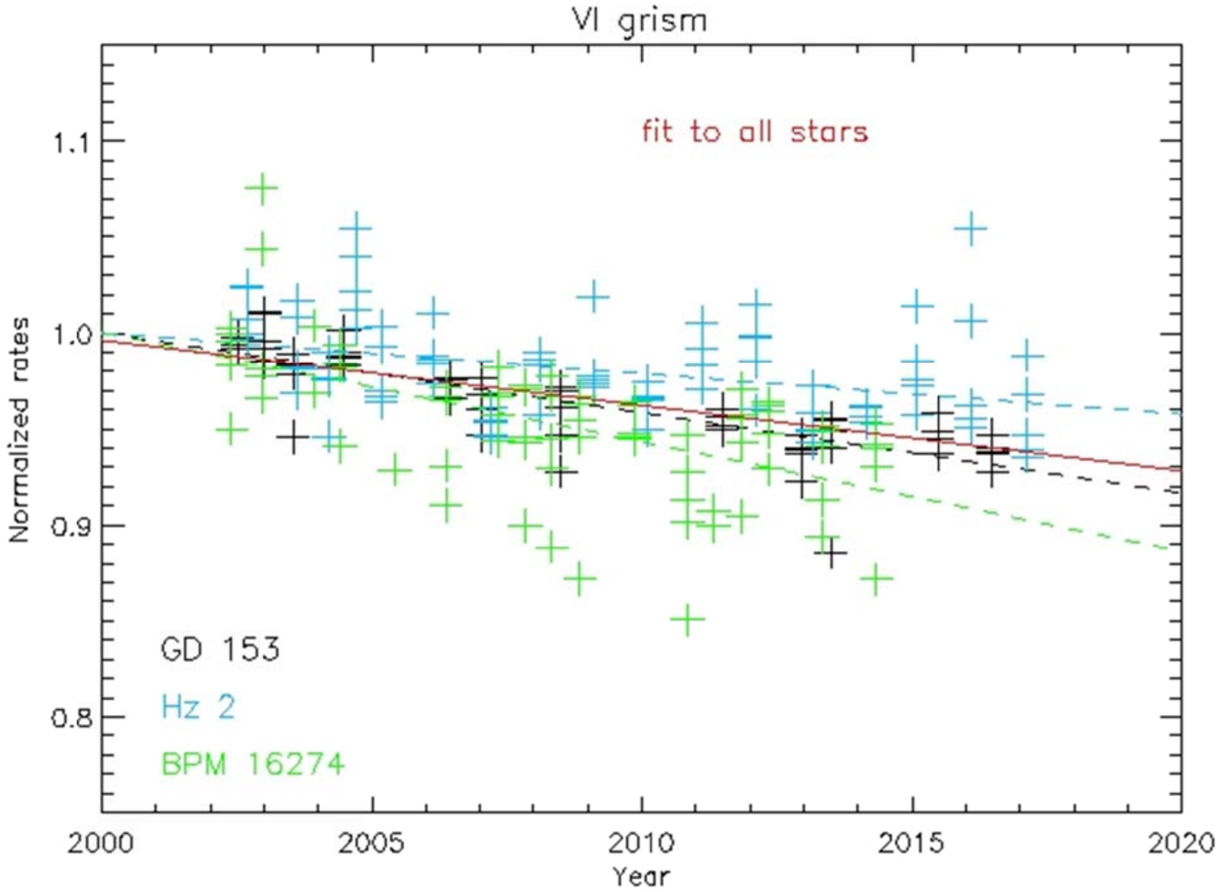

Figure 2. OM time dependent sensitivity degradation of V_grism.

The fitting obtained from Figures 1 and 2 allow us to obtain the degradation or its inverse, the correction factor.

The parameters of the fit are given in Tables 3 and 4.

We define: *Degradation = A1 + B1 x Year_of_Observation*

and: *Correction = A2 + B2 x Year_of_Observation*

To facilitate the correction we provide correction factors every two years in Table 5. They allow users to do an easy interpolation to obtain the correction factor for any epoch.

Grism	*A1*	*B1*
UV_grism	14.5138	-0.6758e-3
V_grism	7.8038	-0.3404e-3

Table 3. Linear fit coefficients of the time dependent sensitivity degradation of OM grism spectra.

Grism	*A2*	*B2*
UV_grism	-14.2218	0.7608e-3
V_grism	-6.1791	0.3590e-3

Table 4. Linear fit coefficients for the correction of the time dependent sensitivity degradation of OM grism spectra.

Year	*UV_Grism*	*V_Grism*
2000	1.00	1.00
2002	1.01	1.01
2004	1.02	1.02
2006	1.04	1.02
2008	1.05	1.03
2010	1.07	1.04
2012	1.08	1.04
2014	1.10	1.05
2016	1.12	1.06
2018	1.13	1.07
2020	1.15	1.07

Table 5. Correction factors for the time dependent sensitivity loss in OM grisms.

We show in Figure 3 an example in which two spectra of Hz 2 obtained with the V_Grism in 2002 and 2017 are compared. The 2017 spectrum has been corrected to 2002 for comparison. The correction is 5 % using table 5. One can see that the continuum levels at several wavelengths and also the core of the hydrogen lines are better matched after the correction. However, as we have pointed out the noise is very high.

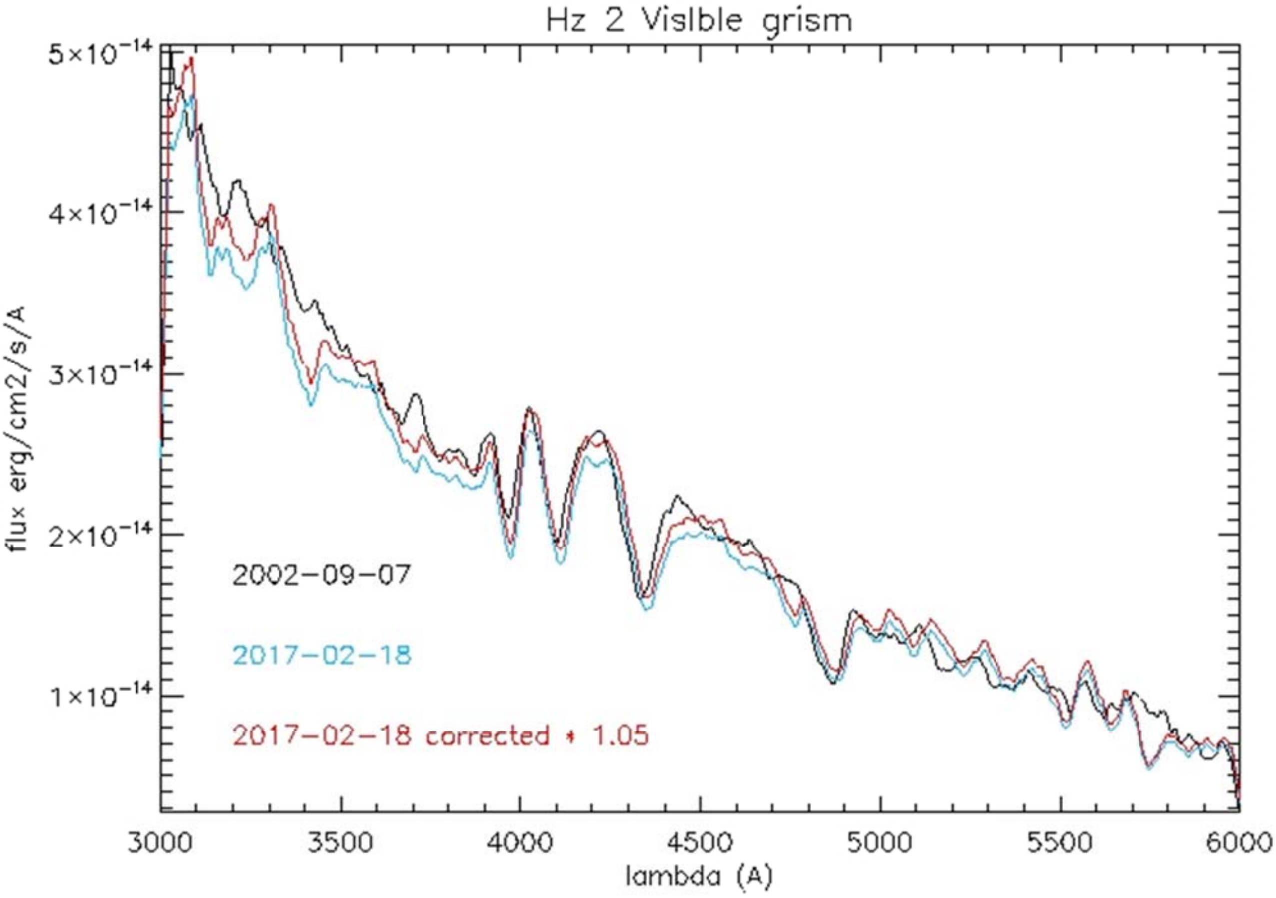

Figure 3. Comparison of V_grism spectra of Hz 2 obtained at different epochs (see text).

4 CONCLUSIONS

We have seen how the OM grisms are affected by time sensitivity degradation. It is small (less than 1% per year) but with the aging of the project this effect becomes more important. A precise measurement of the degradation is not feasible because the large amount of noise and artefacts in the spectra. Only a rough estimate could be done.

We have provided an approximate correction to allow users to compare spectra obtained at different epochs.

This correction will not be implemented in SAS, as it is the case for the point source photometry with the colour filters. A "watch out page" will be written to provide users with a simple way of correcting spectra as we have shown here.