What is happening in ESO 362-G018?

Agís-González, B. & Miniutti, G.

Centro de Astrobiología (CSIC/INTA); ESA P.O. Box: 78, E-28691, Villanueva de la Cañada, Madrid, Spain.

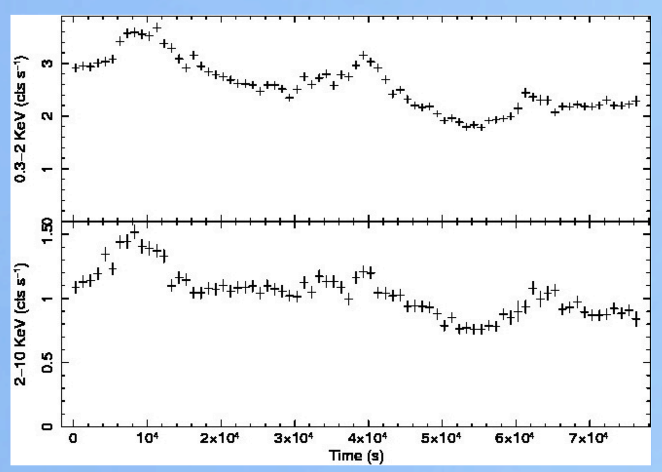
Introduction

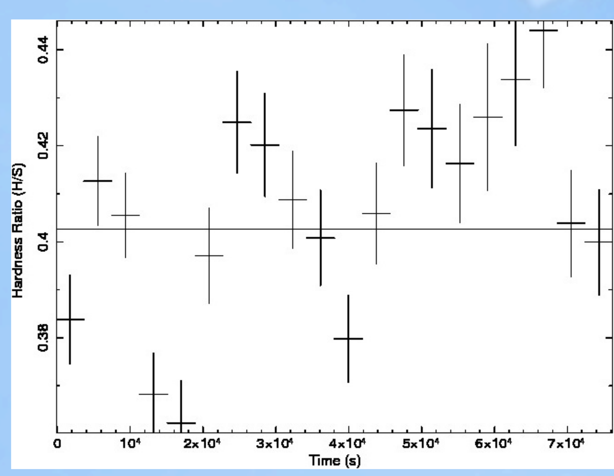
In recent years, X-ray absortpion variability has been detected in a growing number of AGN. In the most remarkable cases (e.g. NGC 1365 [1], [2]), the AGN has been seen to switch between Compton-thin and reflection-dominated (i.e. Compton thick) states on timescales as short as several hours, allowing to put constrains on the size of the primary X-ray source as well as on the absorber(s) location and geometry.
Here we present the results on the X-ray absorption variability in the Seyfert 1 galaxy ESO 362-G018. We analyse previous short Swift and XMM-Newton obtained on November 2005 and January 2006 respectively [3], as well as new XMM-Newton and Chandra pointings obtained in 2010 in the framework of our X-ray observing program of the source (see table).

Obs.number	Observatory	Observation Identifier	Start of obserservations (UT)	Net exposure (ks)	0.5-2 KeV counts	2-10 KeV counts
1	XRT	00035234002	2005-11-26	7.4	1315	1005
2	XMM 1	0312190701	2006-01-28	8.3	3028	2134
3	XMM 2	0610180101	2010-01-29	52.5	80398	43585
4	Chandra 1	11608	2010-05-18	10.1	6502	4240
5	Chandra 2	11609	2010-05-19	10.1	10359	5482
6	Chandra 3	11610	2010-05-21	10.1	5270	2917
7	Chandra 4	11611	2010-05-25	10.1	23923	8917
8	Chandra 5	11612	2010-06-03	10.1	15140	6074

The 2010 XMM-NEWTON observation

The extrapolation of the 2-12 KeV fit of a simple absorbed power law (and a gaussian emission line at ~6.4 KeV) reveals a strong soft below 1 KeV.

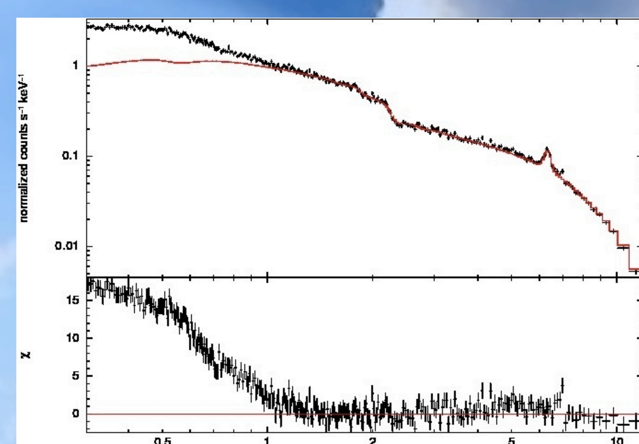




We begin our analysis by considering the longest, highest-quality observation of ESO 362-G18 corresponding to the XMM-Newton observation performed on 2010 January 29 (XMM2 in table above). To assess whether the source exhibits flux and/or spectral variability during the observation, we first extract soft (0.3-2 keV) and hard (2-10 keV) lightcurves. We show the lightcurves in the left panel of this figure, and their hard-to-soft ratio in the right panel. Flux variability at the ~35% level is clearly present in both bands. On the other hand, the hard-to-soft ratio lightcurve exhibits variation at the ~10-15% only. Although some spectral variability is likely to be present, we consider the analysis of the time-averaged spectrum of the source.

phabs*zxipcf*zpcfabs*(powerlaw+pexmon+(N*zgauss))

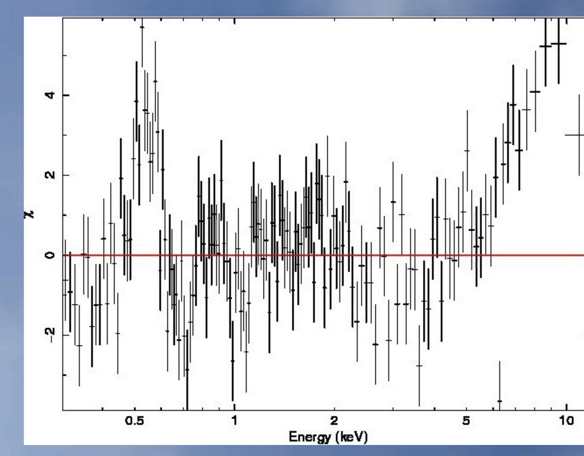
The resulting time-averaged XMM spectrum and the evoution of the residuals until getting the best-fitting model are showed here.



Absorbed Power Law ---> SOFT EXCESS

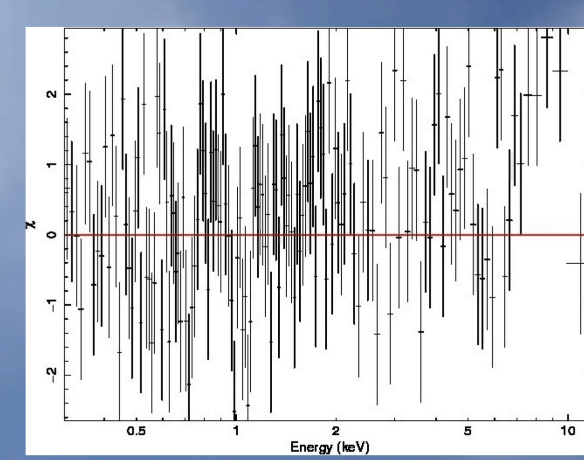
The extrapolation of the 2-12 KeV fit of a simple absorbed power law (and a gaussian emission line at ~6.4 KeV) reveals a strong soft excess below 1 KeV.

Adding distant reflection + partially covering warm absorber



Residuals in the 0.3-12 KeV band for the model consisting in a power law continuum (Γ=1.82) plus distant reflection, affected by absorption from the galactic column density as well as from an intrinsic partially covering warm absorber with $N_H \sim 4.8 \times 10^{22}$ cm^{-2} log(ξ) ~1.65, covering ~60% of the X-ray source.

Adding OVII emission + neutral partially covering absorber

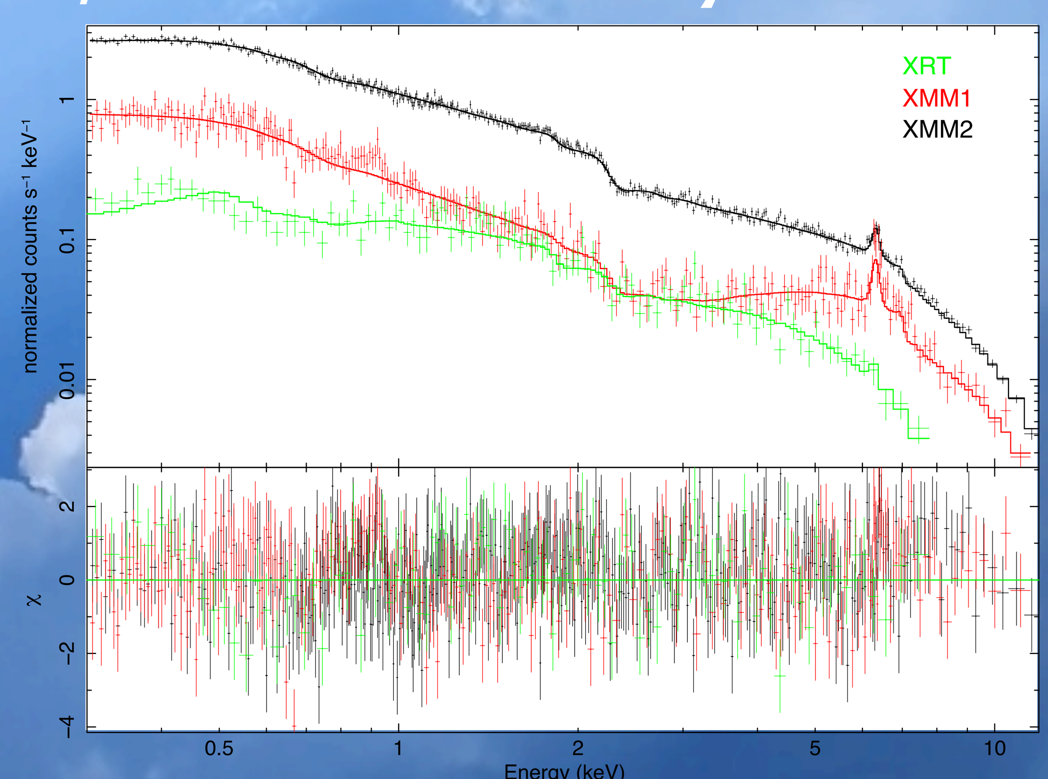


Same as above with the addition at ~0.561 KeV gaussian emission line to account for the likely OVII emission, and a a neutral partially covering absorber with $N_H \sim 42 \times 10^{22}$ cm^{-2} covering ~27% of the source.

Emission lines detected in RGS data

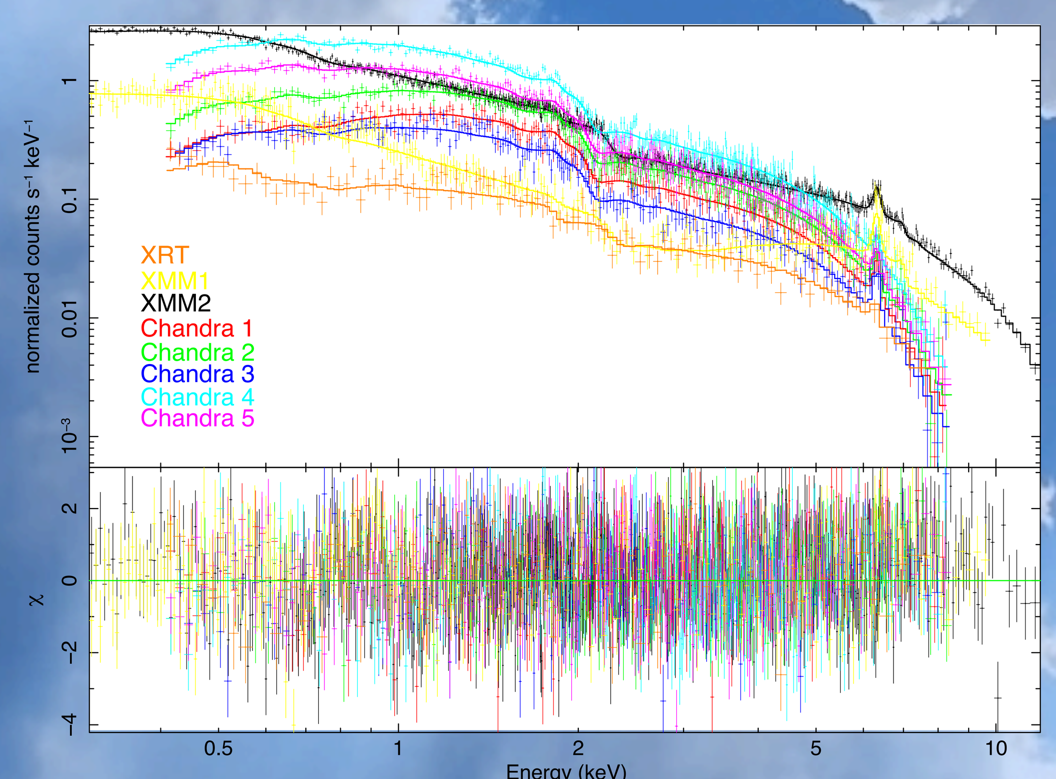
N VII k(alpha)~0.500 KeV;
O VII k(alpha)~0.561 KeV (f), ~0.569 KeV (i), ~ 0.574 KeV (r);
O VIII k(alpha)~0.654 KeV ; Ne IX k(alpha)~0.905 KeV (f)

2005/2006 Variability



Here we show the dramatic X-ray sepctral variability between the 2005 Swift (green), 2006 XMM-Newton (red) and 2010 XMM-Newton observations. The first two observations were performed two months apart. The 2010 XMM-Newton observation carried out four years apart.
The three spectra can be described by the model described above, considering a neutral column density of $N_H \sim 20 \times 10^{22}$ cm^{-2} for XRT and XMM1, with covering fractions of 0.17% and 0.79% respectively, and another column density of $N_H \sim 45 \times 10^{22}$ cm^{-2} for XMM2 covering ~28% of the source.

All Observations



Now we add the chandra pointings to the last best-fit. The warm absorber can only be constrained by teh long XMM2 observation. For the other observations, its paramenters are kept constant to those derived in XMM2. Moreover the chandra observations are constrained to have the same photon index, as the chandra do not have enough quality at high energy to provide good enough constraints on the photon index during the individual observations.

Obs. Number	Γ^a	Γ norm. $\cdot(10^{-3})$	zpcfabs n_H $(10^{22}\ cm^{-2})$	zpcfabs Covering Fraction[b]	zxipcf n_H $(10^{22}\ cm^{-2})$	zxipcf $\log(xi)$ [c]	zxipcf Covering Fraction[d]	χ^2/ d.o.f.
1 (XRT)	$1.62^{+0.05}_{-0.05}$	$3.13^{+1.01}_{-0.12}$	$20.42^{+4.10}_{-3.85}$	$UP = 0.28$	$6.51^{+0.51}_{-0.61}$	$1.90^{+0.45}_{-0.91}$	$0.52^{+0.01}_{-0.10}$	3256.77/3019=1.07876
2 (XMM 1)	$2.02^{+0.05}_{-0.05}$	$2.45^{+0.48}_{-0.40}$	"	$0.79^{+0.03}_{-0.04}$	"	"	"	"
3 (XMM 2)	$1.72^{+0.03}_{-0.01}$	$3.18^{+0.20}_{-0.24}$	$37.88^{+9.89}_{-9.36}$	$0.28^{+0.05}_{-0.05}$	"	"	"	"
4 (Chandra 1)	$2.00^{+0.04}_{-0.04}$	$3.61^{+0.25}_{-0.22}$	$0.39^{+0.06}_{-0.05}$	$0.67^{+0.03}_{-0.03}$	"	"	"	"
5 (Chandra 2)	"	$5.07^{+0.35}_{-0.31}$	"	$0.53^{+0.03}_{-0.04}$	"	"	"	"
6 (Chandra 3)	"	$2.38^{+0.08}_{-0.18}$	"	$0.50^{+0.04}_{-0.04}$	"	"	"	"
7 (Chandra 4)	"	$8.74^{+0.62}_{-0.49}$	"	$0.10^{+0.06}_{-0.06}$	"	"	"	"
8 (Chandra 5)	"	$6.09^{+0.43}_{-0.36}$	"	$0.22^{+0.05}_{-0.05}$	"	"	"	"

The detailed analysis of the long-timescales absorption variability in ESO 362-G018 suggests that the observed variability is due to cold absorbing structures (clouds) crossing the line of sight. Particularly three differents clouds, the previous ones in XRT and XMM1 and another new one along chandra set.

CONCLUSIONS: 3 clouds

$n_H = 20.42^{+4.10}_{-3.85}$

Cvr Frct

<0.28 — 2 months — $0.79^{+0.03}_{-0.04}$

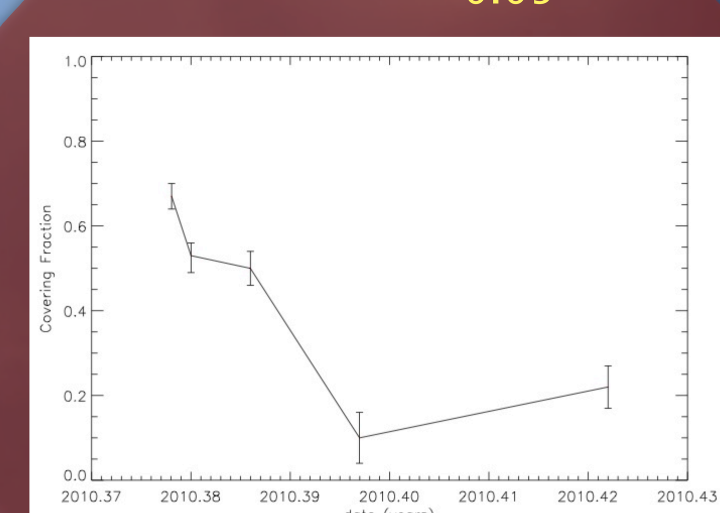
4 years

$n_H = 37.88^{+9.89}_{-9.36}$

Cvr Frct $= 0.28^{+0.05}_{-0.05}$

4 months

$n_H = 0.39^{+0.06}_{-0.05}$



15 days

ESO 362-G018 exhibits a transition from a mildly absorbed to a Compton-thin absorbed state in less than two months, as demonstrated by the November 2005 Swift and January 2006 XMM-Newton observations. We interpreted this change as due to a same cold cloud crossing the line of sight, doubling the covering fraction more than twice between the two observations. The quality of the swift data can only provide us an upper limit for the covering fraction.

Four years later, a long 2010 XMM-Newton observation catches the source in a relatively unabsorbed state, similar to the first Swift observation back in November 2005. We think this is probably another different cold absorber with higher column density.

A 2-weeks-long monitoring performed with Chandra a few months after the 2010 XMM-Newton observation catches again the source in a relatively unobscured spectral state. Again, the best-fit model provides another evidence for another cold absorber structure, but in this case with a small column density. The decrease of the covering fraction from May 19 to May 25 is from ~0.7 to ~ 0.0 (see Figures).

REFERENCES: [1] Risaliti, G., Elvis, M., Fabbiano, G., Baldi, A. & Zezas, A. 2005, ApJ Lett., 623, L93 [2] Risaliti, G., Salvati, M., Elvis, M., et al. 2009, MNRAS, 393, L1 [3] Winter, L. M. & Mushotzky, R. F. 2008, AAS/High Energy Astrophysics Division#10, 10#26.01