Effects of the ACIS-S contamination in the *Chandra* data of Ton S180

Agata Różańska[1], Aneta Siemiginowska[2] and Bożena Czerny[1]

[1]Copernicus Astronomical Center, Bartycka 18, 00-716 Warsaw, Poland

[2] Harvard Smithsonian Center for Astrophysics, 60 Garden St., MA02138, Cambridge, USA

We present implications of the ACIS-S contamination on the analysis of the ACIS-S/LETG data. In particular we show features present in the spectrum of a Narrow Line Seyfert 1 galaxy, Ton S180 observed in December 1999. Some absorption lines in the spectrum of Ton S180 are due to the ACIS-S contamination. However, we can also identify some low signal absorption lines related to the warm absorber in this source, which has significant implications on our understanding of the nature of NLS1. Here we focus on the difficulty of the analysis of contaminated ACIS-S data.

Chandra observations of Ton S180

Ton S180 ($z = 0.06198$, corresponding to 286 Mpc for Hubble constant 65 km s^{-1} Mpc^{-1}) is an extreme case of a Narrow Line Seyfert 1 galaxy (NLS1) with a steep soft X-ray spectrum of photon index $\Gamma = 2.68$ [1] and low Galactic absorption $N_H = 1.52 \times 10^{20}$ cm^{-2}; [2].

The source was observed with the *Chandra* satellite in Dec. 14, 1999, for about 80 ksec in Low-Energy Transmission Grating in ACIS-S/LETG configuration. The data appeared predominantly featureless and well represented by a single power law with some soft excess [3], [4]. We have reanalyzed *Chandra* data in some detail [5], using a new response matrix acisleg1D1999-07-22rmfN0002.fits and including any effects related to the contamination layer on ACIS-S.

We have detected several weak, narrow absorption lines due to the warm/hot material located at the line of sight to the source (so called warm absorber). Some of them occurred to be due to the contaminant accumulated on the ACIS-S detector. Below we present our identification of instrumental lines in Ton S180 and we emphasize that those lines can be also interpreted as the transitions in the warm absorber.

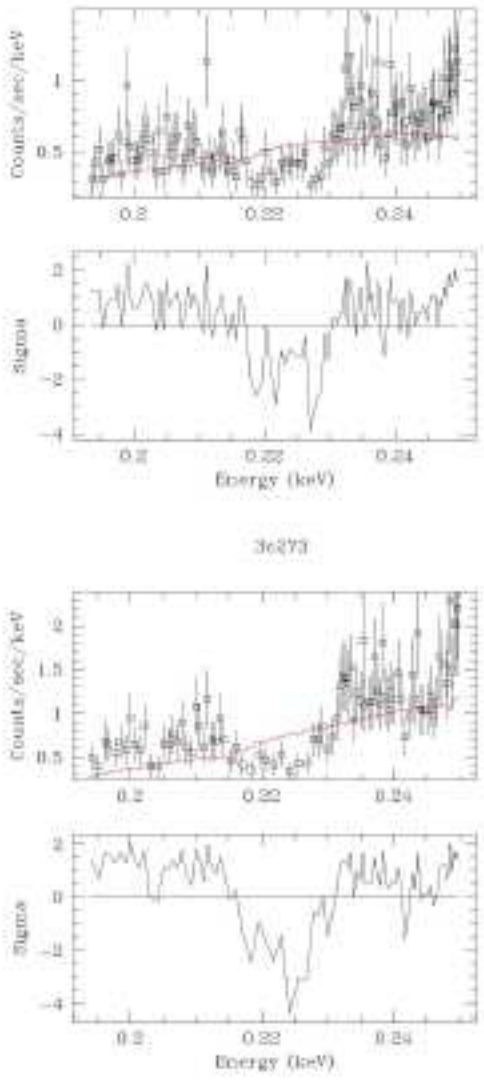

Figure 1: The comparison of *Chandra* data of Ton S180 to the *Chandra* data of 3c273 for energies between 0.20 to 0.24 keVs. Similar structure in residuals around 0.22 keV is present in both objects.

A contaminant

Since the beginning of the *Chandra* mission ACIS-S detector has been accumulating a layer of a contaminant which affects any measurements at low energies (below $\sim$ 0.8 keV). Detailed effects of the contaminant are still being investigated by the Chandra X-ray Center [*], however, it is clear that the overall degradation of ACIS quantum efficiency and presence of additional absorption features is time dependent.

[*]http://asc.harvard.edu/cal/Acis/Cal_prods/qe/Deg/index.html

Ton S180 was observed at the day 143 of the *Chandra* mission and based on the currently available calibration data we expect that the instrument shows maximum of $\sim$40-15 % degradation within 0.28-0.6 keV range (i.e. maximum $\sim$ 40 % in 0.28 keV and $\sim$ 15 % in 0.6 keV).

Identification of absorption lines

We have successfully fitted several absorption lines using standard Gaussian model for each line separately. Lines caused by the contaminant presented on *Chandra* mirrors should show up a common feature in all objects even those with different redshifts. To check whether lines are real or instrumental, we compare observations of Ton S180 with *Chandra* data of quasar 3c273 observed two weeks latter with the same configuration as Ton S180. Exemplary residuals in the soft range between 0.2-0.24 keV for both objects are shown in Fig. 1. In both cases local power-law was fitted with fixed value of Galactic absorption appropriate for each object. The same features around energy 0.22 keV are present as well in 3c273 with redshift 0.156 as in Ton S180. We have repeated such analysis in the whole energy range. All possible instrumental lines are listed in Table 1.

Some of the detected features are seen only in Ton S180 spectrum and therefore seem to be real, intrinsic to the source. For example, in Fig 2 we show that line CVI with observed energy 0.4428 keV which is detected in Ton S180 data is not seen in 3c273.

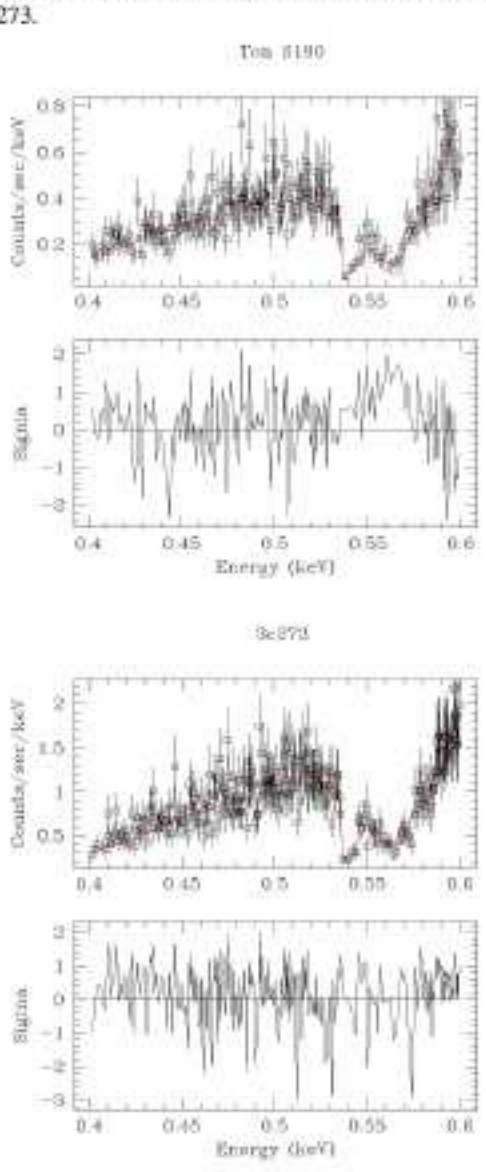

Figure 2: The comparison of *Chandra* data of Ton S180 to the *Chandra* data of 3c273 for energies between 0.4 to 0.6 keVs. Two sigma structure presented in Ton S180 around 0.44 keV is clearly absent in 3c273 data.

All instrumental lines detected in the Ton S180 observations are presented in Figs. 3 and 4. Full set of fitted lines is described in [5].

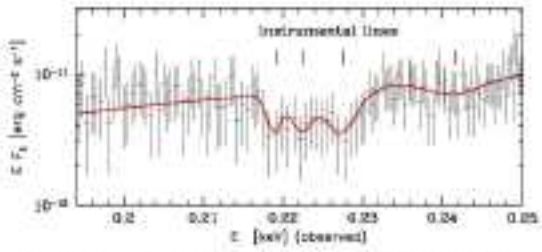

Figure 3: Observed spectrum with the best fit model for 0.19-0.25 keV

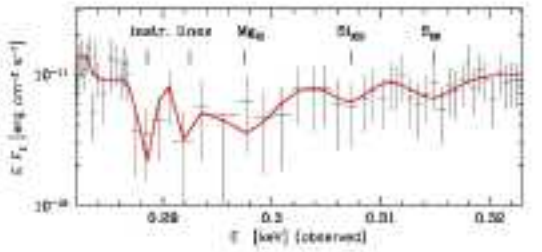

Figure 4: As Fig. 3, but for 0.282-0.32 keV

Table 1: Absorption lines fitted to the *Chandra* data of Ton S180

Observed energy [keV]	EW [eV]	Ion identification	Possible transition
$0.2186^{+0.001}_{-0.001}$	1.80 ± 0.87	instrumental	SiXIII (0.2190, 0.2436)
$0.2222^{+0.001}_{-0.001}$	2.05 ± 1.38	instrumental	FeXV (0.2207, 0.2344)
$0.2272^{+0.0005}_{-0.0005}$	3.02 ± 1.28	instrumental	SiX (0.2258, 0.2449)
$0.2414^{+0.0005}_{-0.0005}$	1.87 ± 1.08	instrumental	OX (0.2417, 0.2098)
$0.2864^{+0.0005}_{-0.0005}$	1.62 ± 0.93	instrumental	CV (0.2850, 0.3079)
$0.3803^{+0.001}_{-0.001}$	1.39 ± 1.17	instrumental	NVI (0.3767, 0.3996)

Lines are very faint. They usually have equivalent width (EW) less or about 2 eVs, and several of them are just marginal detections, as clearly seen from the line EW error.

There is another possibility to identify fitted lines. The same lines can be seen when radiation from the source passes through the highly ionized medium so called warm absorber. The names of possible transitions for all lines of interest are listed in the Table 1, last column. In parenthesis we have listed energy of the line centroid respectively in the observed and rest frame.

Discussion

- We have detected several absorption lines in the Ton S180 *Chandra* observations taken with ACIS-S/LETG configuration.
- At the first, those lines were identified with absorption on highly ionized medium presented on line of sight to the source.
- Than Herman Marshall suggested us that those lines can be due to the contaminant on the ACIS-S mirror.
- We have checked if the same lines are presented in the spectrum of object with different redshift.
- Comparing observations of Ton S180 ($z = 0.06198$) with observations of quasar 3c273 ($z = 0.156$) we found that six lines in Ton S180 are instrumental.
- Soft X-ray data of any AGN taken with ACIS-S/LETG configuration can posses absorption lines due to contaminant and the this fact complicates analyze of warm absorber in those objects.

References

[1] Comastri A. et al., 1998, A&A, 333, 31

[2] Stark, A.A. et al., 1992, ApJS, 79, 77

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[†]Address for correspondence: Copernicus Astronomical Center, Bartycka 18, 00-716 Warsaw, Poland