SPECTRAL STACKING ANALYSIS OF AN *XMM-NEWTON* INTERNATIONAL SURVEY (AXIS)

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ABSTRACT

We have performed an X-ray spectral stacking analysis over the identified *Active Galactic Nuclei* (AGN) from the *XMM-Newton* International Survey (AXIS). We have processed the data for 22 of the 36 fields of the sample ($\sim$ 200 identified AGN) using the latest available *XMM-Newton* software and calibration. Moreover, we optimised the spectral source extraction to maximise the signal to noise ratio. We separated *Broad Line Active Galactic Nuclei* (BLAGN) and *Narrow Emission Line Galaxies* (NELGs) spectra and constructed rest frame average spectra for both types. In this way, we can examine the overall spectra shape and features of both AGN types. We obtained that the NELGs average spectrum shows a much harder spectral slope than the BLAGN, likely due to a major absorption. However, only in the NELG average spectrum we can see a feature that could be the emission line Fe Kα. We also see a bump over 10keV, but it is possibly caused by a normalisation effect.

Key words: galaxies:active; galaxies: Seyfert; X-rays: galaxies.

1. INTRODUCTION

Attending to their optical characteristics, *Active Galactic Nuclei* (AGN) are often separated in two groups, type 1 and 2 AGN. In a simple manner, for type 1 AGN we usually see broad emission lines in their optical spectrum and an unabsorbed X-ray spectrum. On the other side, for type 2 AGN we only see narrow emission lines and an absorbed X-ray spectrum. The *Unified Model for AGN* considers both types to have the same basic structure but they are observed through different amounts of absorbing material due to different inclination angles. Following this model, the observed *X-ray Background* (XRB) have been reproduced using AGN spectra with different absorptions, since it has been found that the major contribution to the XRB at medium fluxes is due to a combination of type 1 and type 2 AGN. See for example Comastri et al. (1995), Gilli et al. (2001) and Ueda et al. (2003). Besides, the X-ray sources flux distribution shows that most of the XRB is generated by medium flux sources.

We report here preliminary results on the construction of an average spectrum of AGN over a well defined sample of the more representative sources in the XRB, the medium flux sources of the AXIS sample.

2. X-RAY SPECTRAL EXTRACTION

We processed the data for 22 fields of the 36 fields in the AXIS sample, but only considered in our analysis those AGN that are optically identified in these fields (about 260 sources) and with fluxes above $2 \times 10^{-14}\mathrm{ergs}^{-1}\mathrm{cm}^{-2}$. The good time intervals for the observations in these fields range from 10 to 100ks. In some cases, there are more than one observation of the same field, so we can obtain a rather good quality spectrum.

We processed the newest refinalised ODFs from the *XMM-Newton* archive using the *Science Analysis Software* (SAS) version 6.1.0, the latest software and calibration available at the time of our analysis. We processed the ODFs in order to obtain the calibrate images and event lists using the SAS pipeline chains `emchain` and `epchain` for the MOS and pn data, respectively. Then, we performed the source detection using the SAS tasks `eboxdetect` and `emldetect`. For the fields that have more than one observation, we use `emosaic` to merge the images and optimise the source detection.

We extracted the source spectra in circular regions maximising the *signal to noise ratio* (SNR) for all detectors. The background spectra were taken in annular regions centred in the source position. If any other source falls within this region, we excluded the source region from the background region. If the resulting background was statistically small or fell near bright sources, we substituted it by a circular source-free region. We merged the MOS1 and MOS 2 spectra for each observation and the spectra for the MOS and pn, separately, from different observations to maximise the SNR.

Table 1. Number of sources and redshift ranges

Source Type	Number of sources	Redshift range
BLAGN	168	0.17-2.99
NELGs	33	0.04-2.98

3. IDENTIFIED SAMPLE

After the spectral extraction, we selected only the sources with more than 100 source MOS+pn counts. That reduced the sample to 201 sources. Using the optical identifications from the AXIS programme, we divided the sample in two groups: BLAGN and NELGS in order to obtain their spectral characteristics separately. The samples characteristics are in Table 1.

4. STACKING PROCESS

At this point, we have the source and background spectra and the response matrices for each source. To perform our analysis we needed the unfolded spectra, i.e., the source spectra before entering the detectors. To obtain the unfolded spectrum for each source, we used XSPEC. We set a single power law model with a fixed spectral slope of 2. We applied this model to the non grouped spectra so the model does not affect significantly the resulting spectrum thanks to the narrow energy bins.

Then, we shifted each spectrum to the rest frame using the redshifts given by the optical identifications from the AXIS program. We need each spectrum to contribute in the same manner to the final average spectrum, so we need to normalise them. To achieve this, we forced the 2-10 keV fluxes to be the same for all the spectra. We excluded the 5-8 keV range in the 2-10 keV range because the Fe Kα line is expected to fall between these energies.

Since each spectrum has a different energy bins grid, we constructed a new one for the final spectrum. To select these new bins, we used the source spectra in counts, rebinned them to the new bins and added them all together without normalisation. Then, we chose the grid that distributes the counts in the most uniform way so as to assure a minimum number of real source counts (~ 100) in each new bin. We used this method as a quality check of the final grid.

Once we have the rest frame, normalised and rebinned spectra, we simply averaged them in a simple manner. Because of the quite large dispersion in the redshift distribution, some high energies could be reached only by a few spectra. We have only taken into account those spectral ranges to which at least 10 spectra contributed. The error bars were computed as the standard deviation of each bin divided by the square root of the number of spectra that contributes to that bin.

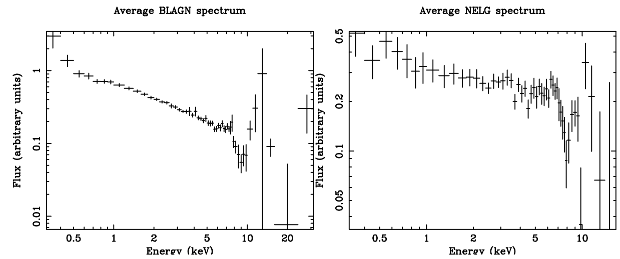

Figure 1. Average BLAGN and NELGs spectra in the full covered range

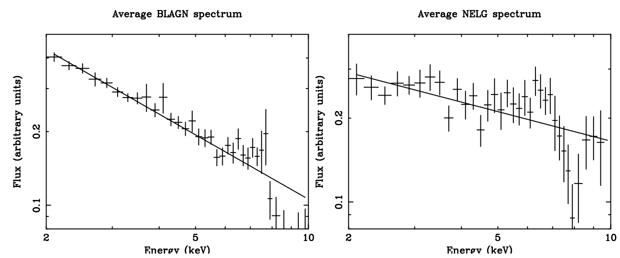

Figure 2. Average BLAGN and NELGs spectra in the 2-10 keV range along with the power law fit

5. PRELIMINARY RESULTS

The optimisation of the stacking process is still in progress. Our preliminary results are shown in Figure 1. The BLAGN average spectra extends up to 28 keV but NELGs spectrum only to 15 keV. This is due to the imposed restriction about the minimum number of spectra that has to contribute to each energy bin. For BLAGN we have many spectra with redshifts above 1, while most NELGs have redshifts below 1.

For the BLAGN average spectrum we fit a power law in the 2-10 keV obtaining an spectral slope of ~ 1.9 (see Figure 2). We see no clear evidence of the Fe Kα emission line. For the NELGs spectrum, we obtain a much flatter spectral slope of ~ 1.4 (see Figure 2) as expected due to absorption if NELGs correspond to type 2 AGN , with absorbed X-ray spectrum. We see a feature around 6.4 keV that could correspond to the Fe Kα line. In both spectra we see a bump starting at $\sim$ 10keV in BLAGN and at a little lower energy in NELGs. We have to test if this is a real spectral feature.

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