A hard X-ray view of the soft-excess in AGN
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An excess of X-ray emission below 1 keV, called soft-excess, is detected in about 75% of Seyfert 1-1.5s (Scott et al. 2012). The origin of this feature remains debated, as several models have been suggested to explain it, including warm Comptonization and blurred ionized reflection. In order to constrain the origin of this component, we exploit the different behaviour of this models above 10 keV. Ionized reflection covers a broad energy range, from the soft X-rays to the hard X-rays, while Comptonization drops very quickly in the soft X-rays. We present here the results of a study done on 102 Seyfert 1s (68 1.1, 1.5, 1.5) and NLSy1s from the Swift BAT 7-month hard X-ray-Survey catalog. The joint spectral analysis of Swift/BAT and XMM-Newton data allows a hard X-ray view of the soft-excess, which is present in about 80% of the objects of our sample.

Soft-excess (SE)
Excess over the power-law emission below 1 keV which is very common in Type 1 AGN spectra.

Origin:
1. warm Comptonization (Walter & Fink 93, Magdziarz +98, Mehdipour +14, Di Gesu +14)
2. blurred ionized reflection (Ross & Fabian 05, Crummy +06, Fabian +09, De Marco +13): link expected between SE and the reflection hump at about 30 keV, because features of a single component (Vasudevan +14)

Sample and data analysis
• 102 Seyfert 1-1.5s and NLSy1s from 70-month Swift/BAT Hard X-ray Survey catalog, observed by XMM-Newton
• Fit 3-100 keV of XMM-Newton/PN-MOS and Swift/BAT data (XSPEC).

Spectral stacking
79 objects with SE and slightly absorbed classified in 4 groups of different q values
• group G1: q ≤ 0.25
• G2: 0.25 < q ≤ 0.4
• G3: 0.4 < q ≤ 0.6
• G4: q > 0.6

Normalized XMM-Newton/PN and Swift/BAT spectra stacked per groups (top panel; black: G1, red: G2, green: G3, blue: G4)

• Fit by a power-law between 2 and 10 keV to show the SE
• Ratios between the stacked spectra (bottom panel; black: G4/G1, red: G3/G1, green: G2/G1)

No higher reflection for stronger SE. Contradiction with ionized reflection hypothesis

Photon index q
• Correlation R-q (r=0.35, p=0.02, blue line and CI)

Contradiction with ionized reflection simulations (red line): R almost independent of q

Relation R – SE strength q

Possible anti-correlation R-q (r=0.33, p=0.03, blue line and 99.9% CI):

Contradiction with blurred ionized reflection simulations (relxill - García +14, Dauser +14):

1148 PN and BAT simulated spectra (with different R, q, λ, abundance, emissivity, and inclination values of relxill), fitted as described above for the objects

Expected correlation R-q (red line, r=0.32, p=0.05)

Coherent with Vasudevan’s simulations

Local reflection hypothesis: higher reflection strength emission lines below 1 keV

Photon index R

References

Conclusions
We explore the existence of connection between soft-excess and hard X-ray properties in AGN via a statistical and model-independent study, using a sample of Swift/BAT and XMM-Newton observations. We see that there is no evidence of a link between reflection and strength of the SE. Indeed, we find a possible anti-correlation between these parameters that is at odds with expectations from simulations of ionized reflection models (see Vasudevan +14 and this work). We also show this lack of link by stacking spectra per q values. We find a correlation between the R and q that is in contradiction with ionized reflection simulations. These arguments disfavor the ionized-reflection model as the origin of the SE. The possible correlation between R and q could be explained by a warm Comptonization scenario such as the one proposed in Mrk 509 by Petrucci +13, where a warm upper layer of the accretion disk Comptonizes the optical/UV photons from the disc to produce the SE, and participates in the cooling of the hot corona. This work suggests that the SE is, in most objects of our sample, better explained by warm Comptonization than by blurred ionized reflection.