The hard X-ray perspective on the soft excess

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Vasudevan et al. (2014), ApJ, 785, 30

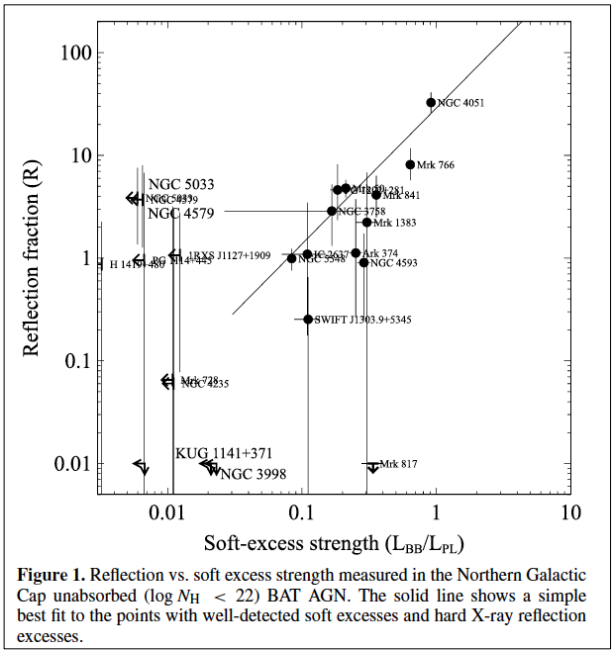


Figure 1. Reflection vs. soft excess strength measured in the Northern Galactic Cap unabsorbed (log N_H < 22) BAT AGN. The solid line shows a simple best fit to the points with well-detected soft excesses and hard X-ray reflection excesses.

The puzzle of the soft excess

- Feature seen below ~1 keV in ~a third of AGN (e.g., in the **58-month Northern Galactic Cap BAT AGN** – 17:30 talk in AGN session on Thursday)
- **NOT the tail of the UV accretion disc spectrum** emerging in hard X-rays
- Can model as a **black body** of roughly constant temperature (~0.1 keV)
- Diverse physical processes have been invoked (**reflection, absorption, Comptonisation, etc.) but detailed fits to the data often inconclusive**
- **BAT AGN** (Fig 1) show hints of a relation between soft excess and hard excess strength – a natural consequence of blurred, ionised reflection – **the only possible explanation?**

Not necessarily!

Ionised absorption (for example) could produce the appearance of a soft excess with a hard excess too (Fig 2). One model can be confused for the other.

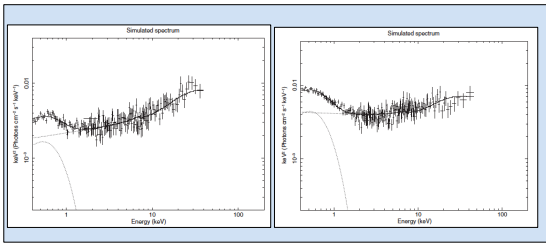


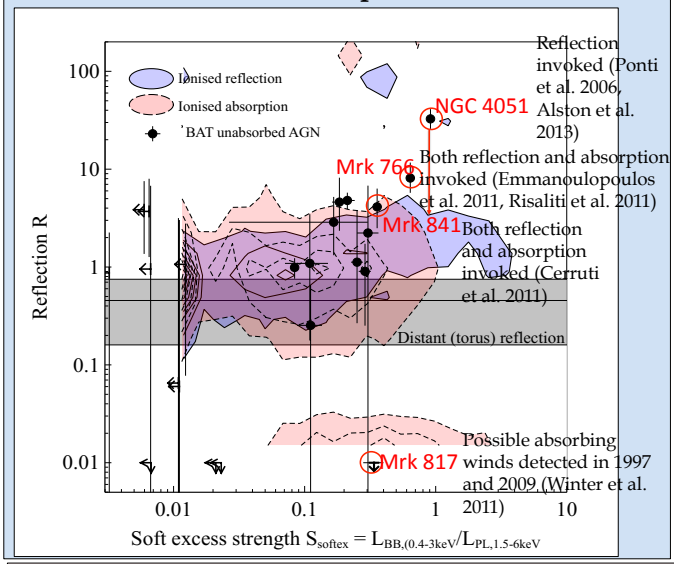
Fig 2: Faked spectra (XMM+NuSTAR, 10ks) from an ionised, blurred reflection model 'pexrav + kdblur(reflionx)' (left) and ionised absorber model 'swind1(pexrav)' (right).

THE KEY QUESTION:

Can we reduce the complexities of different soft-excess models down to just two observables, the *soft-excess strength* (S_{softex}, measured using a black body) and *hard-excess* strength (R, measured using 'pexrav'), and rule out some models even before attempting complex fits to high signal-to-noise data?

The answer: yes! We simulate >2000 short (10ks) XMM-NuSTAR and ASTRO-H spectra of two candidate models, ionised reflection and ionised absorption, stepping through a grid of all physically reasonable parameters. We measure their hard and soft excess strengths (Fig. 3). The two models exhibit different distributions in R-S_{softex} space with different trends (Fig. 4). The distributions are compared with the BAT AGN results (albeit using non-simultaneous hard- and soft-X-rays) from Fig. 1.

Fig. 3: R-S plot from different models, from >2000 simulated spectra



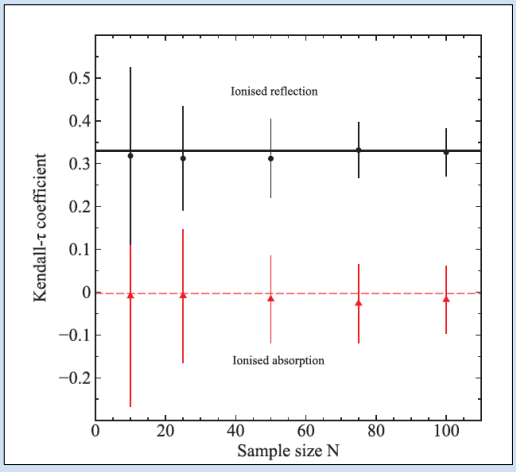


Fig. 4: Correlation coefficent between R and S_{softex} for the two models, for simulated samples

We use the expected distributions from the two models shown in Fig. 3 to simulate smaller samples, using a rejection method. For N <~20, the distributions from the two models become indistinguishable.

However, for AGN samples N>60, one should be able to clearly distinguish between a dominance of soft excesses driven by ionised reflection vs. (e.g.) ionised absorption. This amounts to ~600ks of NuSTAR +XMM time. ASTRO-H response matrices yield very similar results.

Conclusions and future work

- **Strong soft excesses (S_{softex}>1) coupled with strong hard excesses (R>1) are likely due to blurred ionised reflection**
- **Soft excesses without a hard excess at all are not likely to be due to reflection**
- A dominance of reflection-driven soft excesses yields a stronger R–S_{softex} correlation. Such a correlation should be visible in samples of 60 or more AGN
- Need to try this with other candidate models including Comptonisation (Done et al. 2012), magnetic reconnection (Zhong & Wang 2013)
- The results in Fig. 3 are dependent on the input parameter distributions for the candidate models, not yet taken into account in this work
- **Ripe for testing with upcoming broad-band X-ray missions (ASTRO-H, ASTROSAT) and with NuSTAR+XMM campaigns**