SEDs for AGN: New Perspectives from the Archives

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Based on Vasudevan and Fabian (2007),

Fabian, Vasudevan and Gandhi (2008) and Vasudevan and Fabian (2008) (submitted)

Determining the broad-band emission from accreting supermassive black holes (SMBHs) in active galactic nuclei (AGN) is crucial for understanding the physical mechanisms at work in them. The optical-to-X-ray luminosity constitutes the bulk of the accretion luminosity from AGN, but the far-UV disc emission in particular has historically been hard to constrain. Bolometric corrections from SEDs are need for calculating the SMBH mass density from the X-ray background, and have many other useful applications.

We determine optical-to-X-ray spectral energy distributions (SEDs) for a sample of 54 AGN observed with the Far Ultraviolet Spectroscopic Explorer (FUSE). We also determine 29 new simultaneous SEDs for the reverberation mapped sample of AGN using the XMM-EPIC pn and Optical Monitor archives.

1. BACKGROUND

The X-ray background (XRB; Figure 1) is known to be the total emission from AGN (e.g. Alexander et al. 2004). The hard X-ray bolometric correction $\kappa_{2\text{-}10keV}$ expresses the ratio of the total accretion luminosity to that in X-rays, allowing us to determine the fraction of accretion power contributed by individual AGN to the X-ray background.

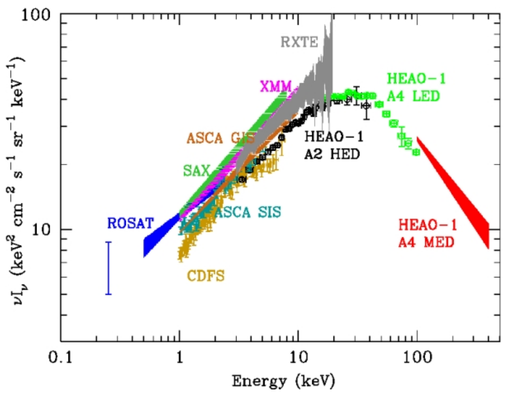

Figure 1: XRB spectrum from Gilli (2004)

The mean quasar Spectral Energy Distribution (SED) of Elvis et al. (1994) provides one value which probably includes a significant fraction of reprocessed IR, overestimating $\kappa_{2\text{-}10keV}$.

Marconi et al. (2004) propose a dependence of $\kappa_{2\text{-}10keV}$ on luminosity using the α_{OX}–2500Å luminosity relation and a template SED, excluding infrared emission from the total accretion luminosity (Figure 2).

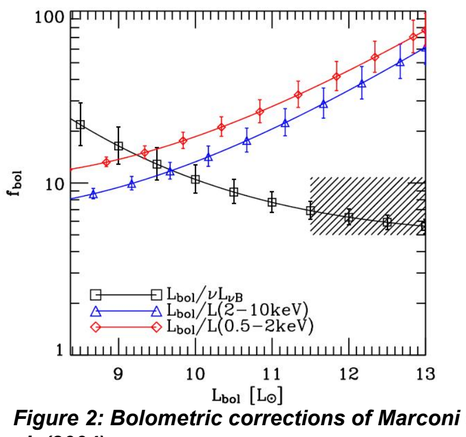

Figure 2: Bolometric corrections of Marconi et al. (2004)

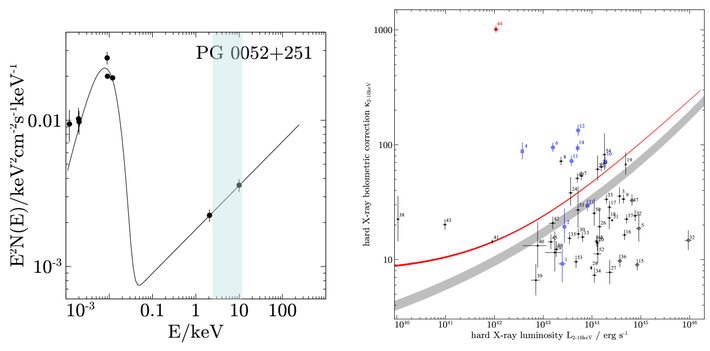

Figure 3: Example SED, and plot of bolometric correction against X-ray luminosity

2. CONSTRUCTING AGN SEDS

We have constructed optical—to—X-ray SEDs for 54 AGN in Vasudevan & Fabian (2007) and present the bolometric corrections obtained. Non-contemporaneous data from HST (optical), FUSE (far UV) and a variety of X-ray missions (mainly ASCA and XMM) are gathered from the literature to construct the SEDs.

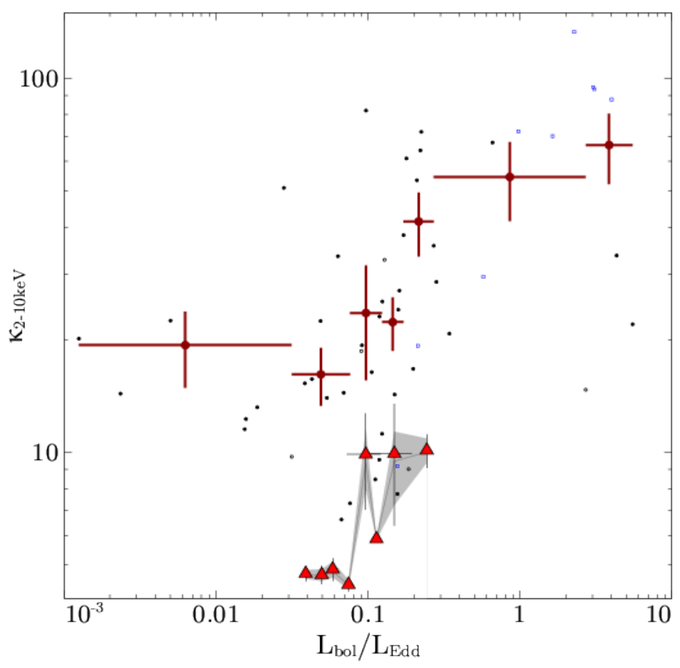

Figure 4: Bolometric correction against Eddington ratio (GX 339-4 results shown for comparison with red triangles)

The normalisation for the UV 'Big Blue Bump' feature is constrained using black hole mass estimates from the literature. No significant luminosity dependence of bolometric corrections is seen (Fig 3), but an Eddington ratio dependence may be present. The step change in bolometric correction and the change in SED shape (Fig 6) may be indicative of AGN in different accretion states, akin to those for Galactic black holes (bolometric corrections for the Galactic BH GX 339-4 shown in Fig 3).

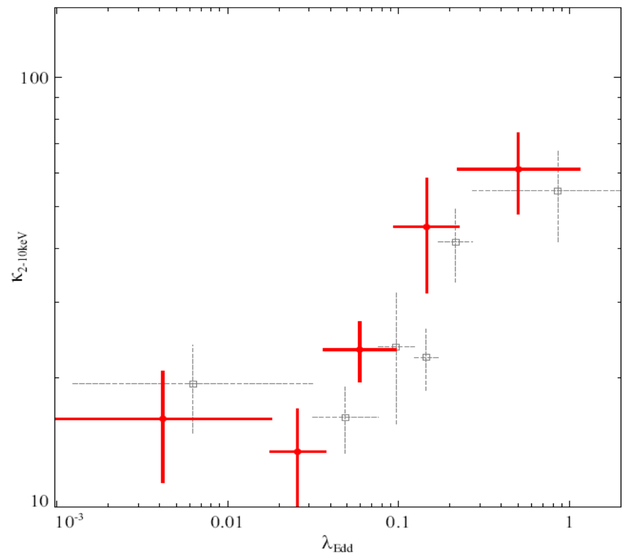

Figure 5: Bolometric correction against Eddington ratio for simultaneous SEDs (XMM PN+OM) for reverberation mapped AGN. Vasudevan and Fabian (2007) results in grey for comparison.

In Vasudevan and Fabian (2008 - submitted), we eliminate the systematic effects of using non-contemporaneous data and diverse mass estimates by constructing simultaneous SEDs using XMM Optical Monitor optical and UV points with PN X-ray observations, for the Reverberation Mapped sample of AGN (Peterson et al 2004) with good M_{BH} estimates. The results (Fig 5) reinforce the same trends as in the previous study.

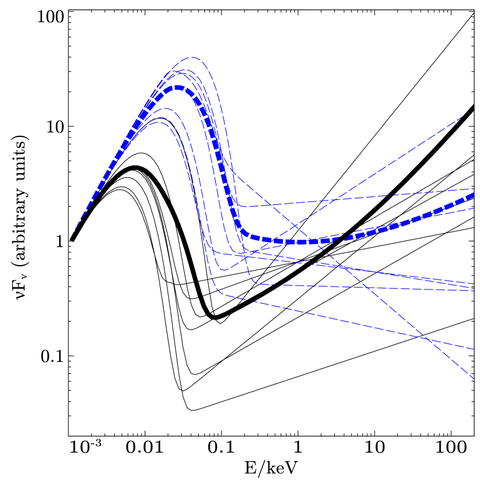

Figure 6: Average AGN SEDs (thick lines) for low (<0.1) Eddington ratios (black) and high (>0.1) Eddington ratios (blue).

The average SEDs can be used to calculate an effective Eddington limit for dusty gas (using CLOUDY). We investigate the column density of absorption (N_H) and Eddington ratios for the Chandra Deep Field (South), Lockman Hole and a local sample of SWIFT AGN, and find that the majority of sources with significant absorption lie in the sub-effective Eddington region (Fig 7).

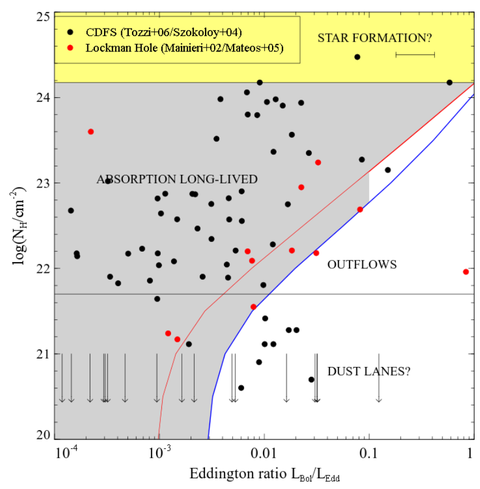

Figure 7: Absorption against Eddington ratio for CDF-S and Lockman Hole (from Fabian, Vasudevan and Gandhi 2008)

SUMMARY AND CONCLUSIONS: We find that the hard X-ray bolometric corrections show significant scatter when plotted against luminosity. However, we find evidence for increasing bolometric correction with Eddington ratio, indicating possible parallels with Galactic Black Hole (GBH) systems. This picture is reinforced when using simultaneous SEDs with mass estimates uniformly taken from reverberation mapping. The average AGN SEDs from this work can be used to derive an effective Eddington limit for dusty gas. Our comparison of this model with available data for three samples of AGN (local, Chandra Deep Field-South, Lockman Hole) suggests that long-lived absorption exists primarily in sub-effective Eddington ratio sources.

CURRENT AND FUTURE WORK: We are now working on simultaneous SED data from *Swift* for the 9-month *Swift*-BAT catalogue of AGN. We are currently working to determine the contribution of the host galaxy flux to the optical and UV photometry for these AGN, along with Richard Mushotzky, Stephen Holland and others at NASA/GSFC.