The Origin of Soft & Hard X-ray Excesses in Active Galactic Nuclei

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1. Introduction

- A primary emission in X-ray signals from Active Galactic Nuclei (AGNs) has been assumed to be a single Power Law (PL) as shown in Fig. 1, which is based on an assumption that a Compton corona is single and uniform.
- On the assumption, all spectral structures deviating from the PL are regarded as products by complicated absorptions or reflection due to materials surrounding a central super massive black hole (SMBH) [1,2].
- Although this interpretation for the primary X-ray emissions has been known to be too simple to explain a central engine of AGNs, there has been no ways to rightly determine primary-continuum shapes.
- Without the understandings of them, we can not discuss about a physical condition around SMBHs correctly.

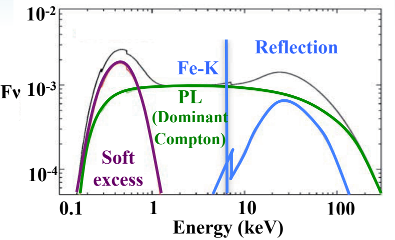

Fig. 1. A generally-known X-ray spectrum of type I AGNs.

2. Model-independent decomposition into variable and stable spectra (The C3PO method)

- To examine the primary-continuum shapes, first, we developed a novel timing method.
- We divided a 2−45 keV band of NGC 3516 observed by *Suzaku* in 2009 into 17 finer bands, and made 16 Count-Count Plots (CCPs) like shown in Fig. 2.
- All of the CCPs show linear correlations which can be explained by a function of $y=ax+b$.
- The 16 slopes can be converted into a variable spectra, while the 16 offsets into a stable spectra, as shown in Fig. 3. Hereafter, we call it Count-Count Correlation with Positive Offset (C3PO) method.

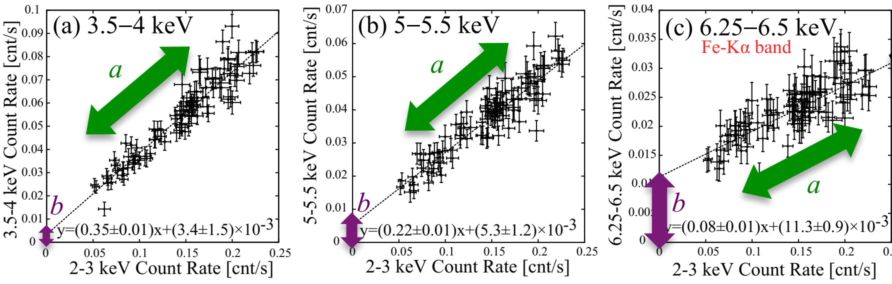

Fig. 2. Three of the 16 Count-Count Plots with a binning of 5 ks (which are equivalent to Flux-Flux Plots). Abscissas is NXB-subtracted count rate in 2-3 keV, while ordinate gives those in higher energy bands.

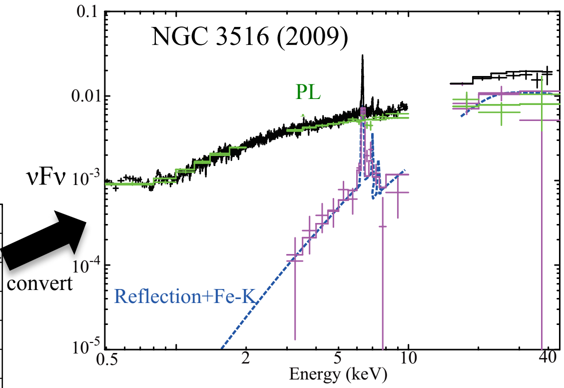

Fig. 3. A variable (green), stable (purple) and time-averaged spectrum (black), reproduced by a PL (green), reflection+Fe-K (blue), and sum of them, respectively.

Succeeded in decomposing the variable PL and the stable disk reflection, without any models! [3]

3. Discoveries of soft and hard stable components

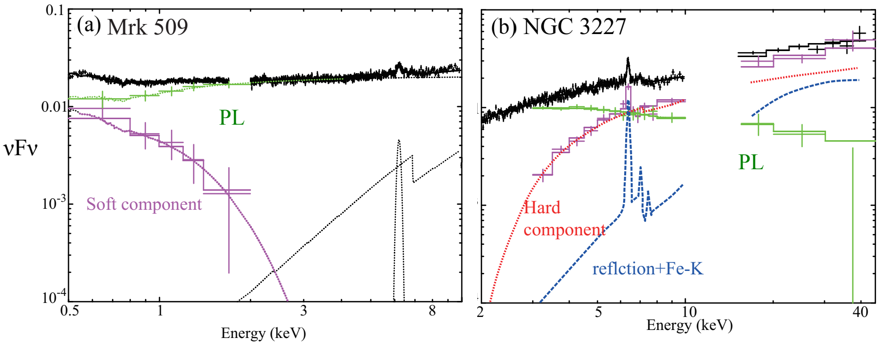

Fig. 4. Same as Fig. 3, but of the *Suzaku* data of (a) Mrk 509 and (b) NGC 3227. The stable component of Mrk 509 is reproduced by a soft PL (purple), while that of NGC 3227 by a reflection+Fe-K (blue) and a hard PL (red).

- Applying the C3PO method to a ~0.5−3 keV band, we obtained a result that several types of AGNs generally had a soft stable spectrum shown in Fig. 4(a)[4,5].
- In a ~3−45 keV band of many AGNs, not only a reflection+Fe-K but also a hard stable component are needed to explain the stable component obtained by the C3PO method as shown in Fig. 4(b)[3,6].
- Most part of the well-known "soft" and "hard X-ray excess" structures in AGNs are considered to be due to the discovered soft and hard stable components.

4. Variability of each component

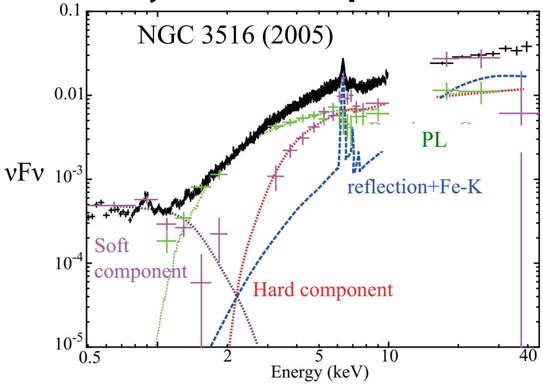

Fig. 5. Same as Fig. 3, but of the 2005 *Suzaku* data of NGC 3516. The stable component consists of a reflection+Fe-K (blue), soft (purple) and hard (red) ones.

- Figure 5 shows a result of the C3PO application to the 2005 *Suzaku* data of NGC 3516. It had both soft and hard stable components.
- From a comparison with the 2009 (Fig. 3), both the stable spectra must have decreased during four years, independently of the PL.

➔ Both are possibly primary components other than the PL.

5. Collaboration with optical telescopes

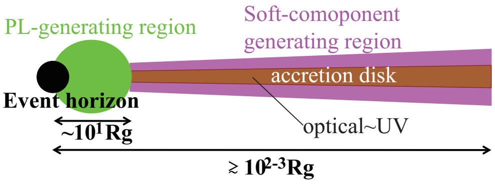

Fig. 6. Primary-continuum emitting regions shown by [7,8]. There are no ideas for a hard-component generating region.

- Although there are several reports like Fig. 6, the emission regions of the soft and hard component have not been understood yet.
- Primary emissions should have a variation timescale related with a distance between the emitting region and a SMBH, and synch with optical signals if generated near an accretion disk as [9].

To study the primary emission regions, we proposed multiple *Suzaku* observations of NGC 3516 in AO-8, which all will be followed up by several optical telescopes.

6. Conclusion

- We developed a novel timing method to decompose a X-ray signal into variable and stable components, model- independently.
- With the method, it was revealed that AGNs generally have multiple primary components, inversely of the previous assumption. Thus, a primary continuum of AGNs is commonly concave.
- The soft and hard X-ray excess structures in AGNs are possibly formed by the primary components.
- To examine primary-component emitting regions, we have proposed multiple *Suzaku* observations, followed up by optical telescopes.

7. Reference

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[9] Suganuma et al. 2006, ApJ, 639, 46