Suzaku Discovery of a New Variable Component in MCG--6-30-15

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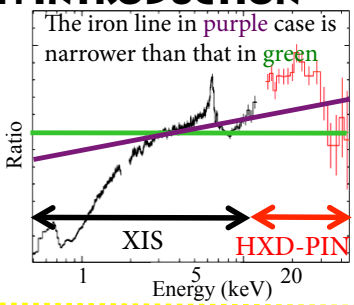
1. Introduction

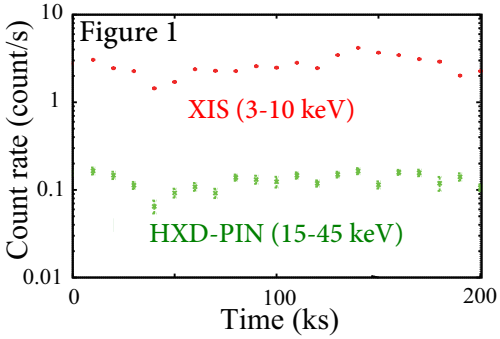


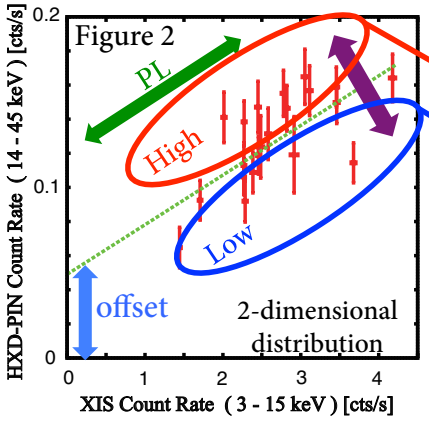
Suzaku spectra of MCG--6-30-15 exhibit a "broad iron line" feature [1,2] and a strong hard X-ray excess[3]. When fitted with a Power-Law (PL), a reflection and a relativistic line with R_{in}~ 2 R_g and Ω ~ 8π are required.
➔A highly spinning black hole and extremely strong reflection due to "Light-Bending"[3] are required.

When warm absorbers are invoked, neither the extremely broad iron line nor the strong reflection is needed[4,5]. However, the absorbers must have a fine-tuned geometry, making the scenario no less artificial.

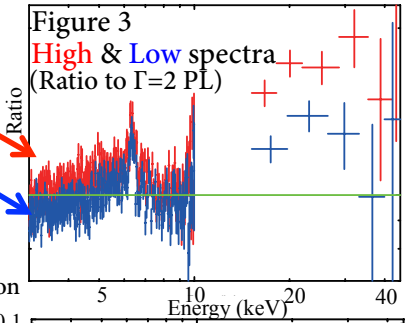
While the above two views both assume that the primary continuum is a single PL, the assumed continuum strongly affects the shape of a broad iron line (left figure).
To determine the primary continuum in a model-independent manner, we re-analyzed the same Suzaku data of MCG--6-30-15 by focusing on variations in the hard X-ray band.

2. Discovery of a Secondary Component Varying Independently

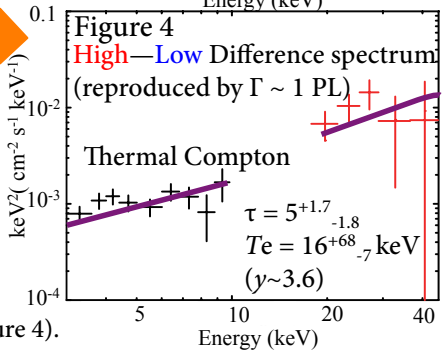




spectrum extraction

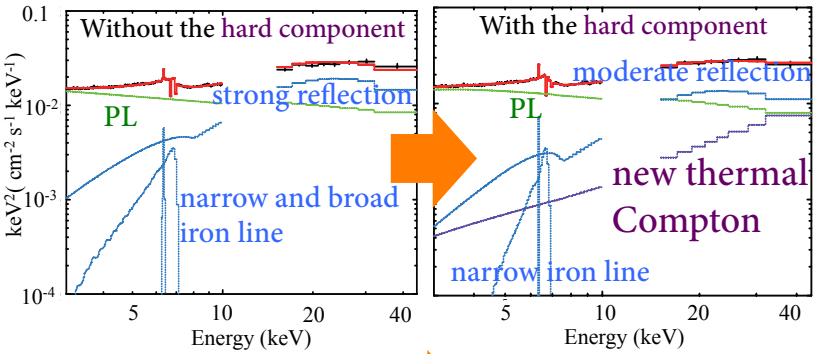


subtraction



- Variations in the XIS band did not fully follow those in the HXD-PIN band (Figure 1).
- A plot between the XIS (3-10 keV) and HXD-PIN (15-45 keV) count rates reveals significant data scatters around the best-fit linear relation. This can be explained by variations of a hard component (purple) that is independent of the dominant PL (Figure 2).
- By extracting High and Low spectra and subtracting the latter from the former, this hard component was found to be approximated by a Γ~1 PL (Figure 3,4).
- This new component can be reproduced by thermal Comptonization with a coronal temperature of 13 keV and an optical depth of 12; this condition differs significantly from that for the PL (Figure 4).

3. Re-analysis of Time-averaged Spectrum of MCG--6-30-15



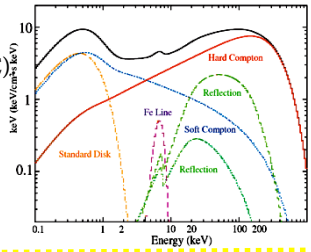
Extreme Kerr BH condition
- A inner radius of the disk R_{in}~2 R_g
- A solid angle of the reflection Ω~8π

Schwarzschild BH condition
- $R_{in} = 9.47^{+1.65}_{-1.93} R_g$
- $\Omega = 3.4\pi^{+0.6\pi}_{-0.4\pi}$

With the new component, the continuum is no longer expressed by a single PL. The result by Miniutti + (2007) [6] is model dependent.

4. Multi-Zone Comptonization(MZC)

- The typical black hole binary (BHB) Cyg X-1 was reported to exhibit at least two Compton components (right bottom[7]).
- Therefore, the corona of Cyg X-1 must consist of regions with different temperatures and/or optical depths (i.e., multiple *y* parameters of Comptonization).
- We named this condition Multi-Zone Comptonization (MZC).
- Our results implies that the MZC view holds also for AGNs.
- Marshall et al. (2003)[8] has already applied this MZC view to AGNs.



5. Conclusion

- We discovered a hard X-ray component in MCG-6-30-15 that varies independently of the dominant primary component.
- This component is interpreted as a thermal Comptonization radiation with a rather large *y*-parameter.
- Considering this component, the Suzaku spectrum no longer requires the extremely broad iron line or the strong reflection.
- The corona of MCG--6-30-15 is inferred to have multiple zones with different coronal temperatures and/or optical depths (i.e., MZC view), just like the case of Cyg X-1.

Reference

[1] Tanaka et al. 1995, nature, 375, 659
[2] Dovciak et al. 2004, MNRAS, 000,1
[3] Miniutti et al. 2007, PASJ, 59, S315
[4] L.Miller et al. 2009, MNRAS, 399, L69
[5] Miyakawa et al. 2009, PASJ, 61, 6, 1355
[6]Noda et al. 2011, PASJ, 63, 449-458
[7] Makishima et al. 2008, PASJ, 60, 585
[8]Marshall et al. 2003, APJ, 125, 459-464