A New Black Hole Mass Estimate for Obscured AGNs

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More details can be found in
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ABSTRACT

- A major fraction of the neutral FeKα line core originates between the outer BLR and the inner dust torus.
- The neutral FeKα line core can be used as a potential indicator of the black hole mass for obscured AGNs.

1. INTRODUCTION

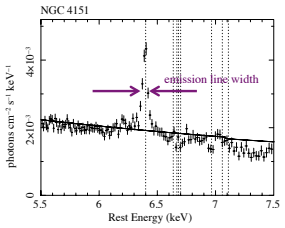
Importance of estimating M_{BH} in obscured AGNs

- Obscured AGNs are important targets for studying the black hole – galaxy coevolution because their host galaxies can be investigated free from the strong central emission from the AGN itself.
- Some types of obscured AGNs such as ULIRGs are of special importance because they have long been anticipated to be in the middle of the evolutionary sequence of AGNs (e.g., Sanders et al. 1988; Sanders & Mirabel 1996).

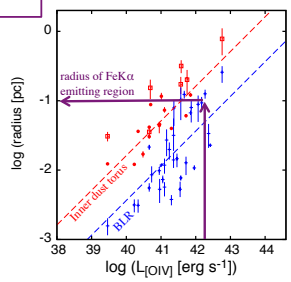
2. METHODS

A single-epoch black hole mass using narrow FeKα line width

$$M_{\mathrm{BH,FeK}\alpha} = f\frac{r_{\mathrm{FeK}\alpha}\sigma^2_{\mathrm{FeK}\alpha}}{G}$$



The X-ray spectrum in the FeKα energy band of NGC 4151 obtained by the Chandra HETG (Shu et al. 2010).



The radius-"isotropic" luminosity relations for the inner structures of AGNs (Koshida et al. 2014)

- The velocity of motion is obtained from the width of the neutral FeKα line core.
- The radius of the emitting region is obtained from the "isotropic" luminosity indicators via the radius – luminosity relation for the the neutral FeKα line core.

A preceding study for type-1 AGNs (Jiang, Wang, & Shu 2011)

- The width of the neutral FeKα line core for 10 AGNs were measured with Chandra HETG, which affords the best spectral resolution currently available in the FeKα energy band.
- The emitting region radius of the neutral FeK line core was assumed to be equal to the dust reverberation radius and was estimated via the correlation between the radius and the optical luminosity (Suganuma et al. 2006).
- The black hole mass using FeKα was compared with that estimated by the reverberation mapping observation of optical broad emission lines.
- The correlation between the two black hole mass estimates was statistically insignificant, which could be attributed to large uncertainties in the measurements of the FeKα line widths and small sample size.

3. DATA

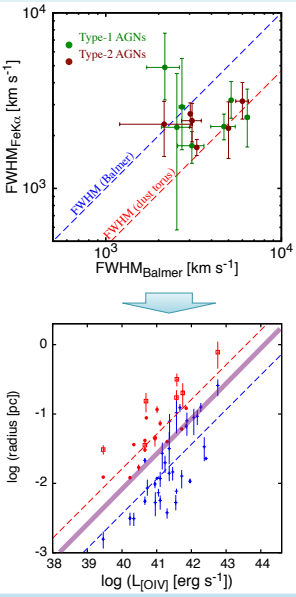
Targets including obscured AGNs

- 7 Type-1 AGNs whose black hole masses were estimated by the reverberation mapping observations of optical broad emission lines
- 7 Type-2 AGNs with the polarized broad optical emission lines or the black hole masses estimated by the VLBI observations of the water maser

Data for estimating M_{BH}

- The data for FWHM(FeKα) are taken from Shu et al. 2010, 2011, which were measured with Chandra HETG.
- The targets are further selected from the sample of Shu et al. 2010, for which the best FWHM constraint was obtained by the authors.
- The luminosity of the [O IV] λ25.89 μm emission line is used as an isotropic luminosity indicator.

4. RESULT – Neutral FeKα line emitting region



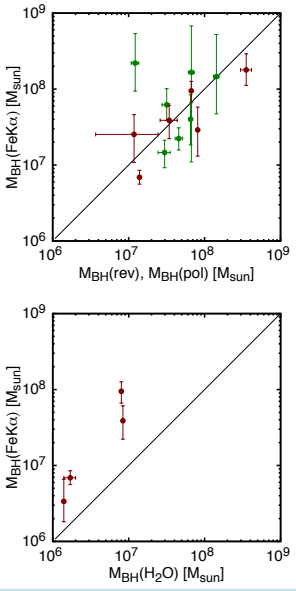
Location of the emitting region of the neutral FeKα line core

- Assuming the virial relation, the velocity width of the neutral FeKα line core is compared with that of the broad Balmer emission lines and that corresponding to the dust reverberation radius to examine the location of its emitting region.
- FWHM(Balmer) > FWHM(FeKα) > FWHM(dust reverberation radius) for most of the target AGNs
- A major fraction of the neutral FeKα line core is supposed to originate between the outer BLR and the inner dust torus.
- However, there appears no clear correlation between FWHM(FeKα) and FWHM(Balmer) as has been reported by previous studies (Nandra 2006; Shu et al. 2010, 2011).

The radius-luminosity relation for the neutral FeKα line region

$$\log r_{\mathrm{FeK}\alpha} = -1.57\ (\pm 0.19) + 0.5 \log L_{[\mathrm{OIV}]}/10^{41}\ \mathrm{erg\ s^{-1}}$$

5. RESULT – M_{BH} using neutral FeKα line core



M_{BH}(FeKα) compared with M_{BH}(optical broad line)

- The reverberation based M_{BH}(rev) is compared for 7 type-1 AGN.
- The single-epoch M_{BH}(pol) based on the polarized broad Balmer emission line is compared for 6 Type-2 AGNs.
- M_{BH}(FeKα) is consistent with M_{BH}(rev) and M_{BH}(pol) for most of the type-1 AGNs and all of the type-2 AGNs.
- M_{BH}(FeKα) is correlated with M_{BH}(pol) for the type-2 AGNs.

M_{BH}(FeKα) compared with M_{BH}(H_2O maser)

- The M_{BH}(H_2O) based on the VLBI observation of H_2O maser emission is compared for 4 Type-2 AGNs.
- M_{BH}(FeKα) is correlated with M_{BH}(H_2O).
- M_{BH}(FeKα) is systematically larger than M_{BH}(H_2O) by a factor of 5.
- M_{BH}(pol) is also measured for 3 targets; M_{BH}(pol) is also systematically larger than M_{BH}(H_2O) for them.

6. FUTURE PROSPECTS

Astro-H SXS

- Different origins such as the outer accretion disk, the BLR, the innermost dust torus, and/or their mixture for the neutral FeKα line core have been proposed (e.g., Yaqoob & Padmanabhan 2004; Nandra 2006; Bianchi et al. 2008; Liu et al. 2010; Ponti et al. 2013; Gandhi, Hönig & Kishimoto 2015). Those uncertainties will result in the possible error of this black hole mass estimate.
- The Astro-H SXS is capable of unprecedented energy-resolution spectroscopy with superior sensitivity at the FeKα band.
- It will enables us to study in more detail the origin of the neutral FeKα line core by examining the line profile of the neutral FeKα line and its time variation.
- It will enables us to measure the black hole mass with improved accuracy for a large number of obscured AGNs.

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