COMMENT ON “THE DUST SUBLIMATION RADIUS AS AN OUTER ENVELOPE TO THE BULK OF THE NARROW FeKα LINE EMISSION IN TYPE 1 AGN”

Takeo Minezaki and Kyoko Matsumiha

ABSTRACT

Recently, Gandhi, Hönig, and Kishimoto submitted a manuscript to the arXiv e-print service on the location of the emitting region of the narrow FeKα line that appears in the X-ray spectra of active galactic nuclei (AGNs). This method is applicable to obscured AGNs. To construct their method, MM15 first examined the location of the FeKα line emitting region, which was estimated from the velocity width of the neutral FeKα line core, assuming the virial relation. They compared the location of the FeKα line emitting region with the reverberation radius of the optical broad emission line and that of the near-infrared thermal emission from the inner dust torus. MM15 concluded that the major fraction of the neutral FeKα line core originates between the outer broad emission-line region (BLR) and the inner dust torus.

Immediately after MM15’s manuscript appeared in the arXiv e-print service as arXiv:1501.07522, Gandhi, Hönig, and Kishimoto submitted a manuscript to the Astrophysical Journal Letters and to the arXiv e-print service on the location of the emitting region of the neutral FeKα line core (arXiv:1502.02661; hereafter GHK15). They also estimated the location of the FeKα line emitting region from the velocity width of the neutral FeKα line core assuming the virial relation and compared it with the radii of the BLR and the inner dust torus. They concluded that the dust sublimation radius forms an outer envelope to the bulk of the FeKα line emitting region, which was taken from Shu et al. (2010). Also assuming the virial relation, GHK15 calculated the distance from the central engine of the FeKα line emitting region as $R_{\text{Fe}} = (1/f') \times \ldots$

1. INTRODUCTION

Minezaki & Matsumiha (2015; hereafter MM15) proposed a new method for estimating the mass of a supermassive black hole using the narrow core of the neutral FeKα emission line in the X-ray spectra of active galactic nuclei (AGNs). This method is applicable to obscured AGNs. To construct their method, MM15 first examined the location of the FeKα line emitting region, which was estimated from the velocity width of the neutral FeKα line core, assuming the virial relation. They compared the location of the FeKα line emitting region with the reverberation radius of the optical broad emission line and that of the near-infrared thermal emission from the inner dust torus. MM15 concluded that the major fraction of the neutral FeKα line core originates between the outer broad emission-line region (BLR) and the inner dust torus.

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$GM_{BH}/(\text{FWHM}_{	ext{FeK}\alpha})^2$, where the factor $f'$ is determined from the cloud kinematics in the the FeK$\alpha$ line emitting region. They assumed $f' = 3/4$ in the $R_{Fe}$ calculation. Next, they compared $R_{Fe}$ with the BLR location, $R_{BLR}$, obtained from the reverberation radius of the broad H$\beta$ emission line.

For almost all of GHK15’s targets, the black hole mass in the $R_{Fe}$ calculation was obtained from the reverberation of the broad H$\beta$ emission line as $M_{BH} = f \times R_{BLR}(\sigma_{H\beta})^2 / G$, where $\sigma_{H\beta}$ is the velocity dispersion of the broad H$\beta$ emission line and $f$ is the virial factor. Because the FWHM of the broad H$\beta$ emission line is basically proportional to its velocity dispersion, $\sigma_{H\beta}$, the comparison of $R_{Fe}$ and $R_{BLR}$ in GHK15 can be equated with that of the FWHMs of the neutral FeK$\alpha$ line core and the broad H$\beta$ emission line, as performed by MM15 and previous studies.

We note that MM15 and GHK15 assumed slightly different kinematics of the FeK$\alpha$ emitting region and BLR. If the FWHMs of the emission lines are compared in order to locate the FeK$\alpha$ emitting region relative to the BLR, the FeK$\alpha$ emitting region and BLR are implicitly assumed to have the same kinematics. On the other hand, if $R_{Fe}$ is calculated from $M_{BH}$, the kinematics of the FeK$\alpha$ emitting region are assumed as $f' = 3/4$.

2.3. Comparison with the Inner Radius of the Dust Torus

MM15 examined the location of the FeK$\alpha$ emitting region relative to the dust reverberation radius in the velocity domain. To estimate the FWHM at the dust reverberation radius, they scaled the FWHM of the broad H$\beta$ emission line according to the virial relation. The calculation was based on the systematic difference between the reverberation radii of the broad H$\beta$ emission line and the near-infrared dust emission, which was derived by fitting the reverberation data of many AGNs (Koshida et al. 2014).

On the other hand, GHK15 compared $R_{Fe}$ with the inner radius of the dust torus ($R_{dust}$), which was measured by the dust reverberation (Koshida et al. 2014) or the near-infrared interferometry (Kishimoto et al. 2009, 2011, 2013). These two measures of $R_{dust}$ are known to systematically differ by about a factor of two (e.g., Kishimoto et al. 2009, Hönig & Kishimoto 2011, Koshida et al. 2014, Hönig et al. 2014), but GHK15 collected both types of data as the dust sublimation radius. The method of comparing the inner radius of the dust torus with the FeK$\alpha$ emitting region is a major point of difference between the MM15 and GHK15 papers; MM15 based the comparison on the scaling relation of the dust reverberation radius, whereas GHK15 based it on individually measured values.

2.4. Results

For almost all their target AGNs, MM15 found that the FWHM of the neutral FeK$\alpha$ line core falls between the FWHM of the broad Balmer emission lines and its corresponding value at the dust reverberation radius, indicating that the major fraction of the neutral FeK$\alpha$ line core originates between the outer BLR and the inner dust torus. GHK15 found that $R_{Fe}$ is never much larger than $R_{dust}$, indicating that the dust sublimation radius forms an outer envelope to the bulk of the FeK$\alpha$ emission. This is the key result of GHK15, who compared $R_{Fe}$ with $R_{dust}$.

Clearly, the results of MM15 and GHK15 are consistent at the outer boundary of the FeK$\alpha$ line emitting region. For MM15’s sole outlier, NGC 7469, the FWHM of the neutral FeK$\alpha$ line core exceeded that of the broad Balmer emission line. Among MM15’s targets, the FWHM of the neutral FeK$\alpha$ line core was never much smaller than its corresponding value at the dust reverberation radius.

The results of MM15 and GHK15 also appear consistent at the inner boundary of the FeK$\alpha$ line emitting region, at least for the AGNs with the best FWHM constraints reported by Shu et al. (2010). GHK15 argued that in these AGNs, $R_{Fe}$ matches $R_{dust}$ well. In fact, among the targets with the best FWHM constraints, the $R_{Fe}$ of NGC 3516 was smaller than $R_{dust}$ but larger than $R_{BLR}$, while the $R_{Fe}$ of NGC 7469 was much smaller than $R_{dust}$ and was even smaller than $R_{BLR}$. As noted, NGC 7469, whose FeK$\alpha$ line emitting region was determined as smaller than the BLR, was the sole exception in MM15’s target AGNs.

The situation is somewhat unclear for the other targets in GHK15, because of the large uncertainties in the FWHMs of their neutral FeK$\alpha$ lines. Their $R_{Fe}$ data were significantly scattered from $R_{dust}$ to much smaller values. GHK15 suggested that the large uncertainties in the FWHM data are not simply caused by low signal-to-noise ratios in the X-ray spectra but reflect multiple source regions of the neutral FeK$\alpha$ lines. As indicated in both studies, substantial progress is expected in the near future by the ASTRO-H X-ray satellite (Takahashi et al. 2010), which is capable of unprecedented energy-resolution spectroscopy with superior sensitivity.

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