Hitomi Results of NGC 1275: The Origin of Fe-Kα Line

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Abstract

A bright Fanaroff-Riley I type radio galaxy NGC 1275 dominates the center of the Perseus cluster of galaxies at a redshift of $z \sim 0.01756$ (Strauss et al. 1992, ApJS, 83, 29), and its radio lobes formed by the past jet activity were found to cause kpc-scale cavities in the intracluster medium (ICM) by *Chandra* and *XMM-Newton* observations (e.g., Fabian et al. 2006, MNRAS, 451, 3061). Hence, NGC 1275 is regarded as a promising candidate to study important topics such as the cooling flow (e.g., Fabian 1994, ARA&A, 32, 277) and interactions among the Active Galactic Nucleus (AGN), ICM, and galaxies (e.g., McNamara & Nulsen 2007 ARA&A, 45, 117).

During 2016 February–March, the *Hitomi* satellite (Takahashi et al. 2016, Proc. SPIE, 9905, 99050U) observed the Perseus cluster including NGC 1275 with an X-ray microcalorimeter called the Soft X-ray Spectrometer (SXS; Kelley et al. 2016, Proc. SPIE, 9905, 99050V) for the first time (The *Hitomi* collaboration, 2016, Nature, 535, 117). In the present study, we analyz the *Hitomi* datasets and archival datasets of other X-ray satellites, mainly aiming to reveal X-ray generation mechanism and the structure of the AGN region in NGC 1275. One of the most important mysteries is the origin of the Fe-Kα emission line at 6.4 keV (Churazov et al. 2003, ApJ, 590, 225; Yamazaki et al. 2013, PASJ, 65, 30). Possible sites of origin include an outer region of an accretion disk, a Broad Line Region (BLR), a dusty torus, and a rotating molecular disk toward outside within the AGN system. In addition, NGC 1275 was reported to have a few tens kpc-scale molecular clouds and Hα filaments outside the AGN (e.g., Salomé et al. 2006, A&A, 454, 437), and hence, they are also candidates of the Fe-Kα emitter.

By utilizing the unprecedented energy resolution of $\sim$ 5 eV at 6 keV achieved by the SXS, we significantly detect the Fe-Kα line with an equivalent width of $\sim$ 10 eV against a total X-ray continuum from the AGN and ICM ($\sim$ 25 eV against only the AGN continuum). We successfully limit its velocity width to $\sim$ 500–1400 km s^{-1} (FWHM) for the first time ever. Because the derived Fe-Kα velocity width is significantly narrower than that of broad Hα of $\sim$ 2750 km s^{-1} (Ho et al. 1997, ApJS, 112, 391), we can exclude a large contribution of Fe-Kα emission from an the accretion disk and the BLR. Furthermore, we perform Monte Carlo simulations which calculate the Fe-Kα intensity from the molecular clouds by utilizing the MONACO framework (Odaka et al. 2011, ApJ, 740, 103), and find that their contribution is also too small. Therefore, we suggest that the origin of the Fe-Kα line from NGC 1275 is likely from the dusty torus to the rotating molecular disk which extends to a few hundred pc scale (e.g., Scharwächter et al. 2013, MNRAS, 429, 2315). Further limitation of the Fe-Kα source in NGC 1275 and comparison with other type AGNs will be discussed in a forthcoming paper.

Key words: galaxies: active – galaxies: nuclei – galaxies individual (NGC 1275)