

Suzaku Spectral Study of IRAS 05189−2524

N. Anabuki, M. Uchino (Osaka Univ.), S. Teng, S. Veilleux (Univ. of Maryland), R. Fujimoto (Kanazawa Univ.), T. Nakagawa (ISAS/JAXA), and L. C. Gallo (Univ. of St Andrews)

We present a Suzaku observation of the ultraluminous infrared galaxy IRAS 05189−2524. We found a large flux drop both below and above 2 keV. Compared with previous XMM-Newton and Chandra observations, at least two time-varying emission components were discovered. The time-varying emission component in the 2–10 keV, which vanished at the time of Suzaku observation, might be power-law emission from an AGN transmitted through Compton-thin absorbing material. Although the soft X-ray emission of this galaxy has been thought to originate from a galactic scale diffuse plasma, at least the variable emission component is coming from a compact region. By analogy with Compton-thick Seyfert 2 galaxies, IRAS 05189−2524 was in a reflection-dominated phase during the Suzaku observation.

§1. Introduction

Obscured AGNs, which account for 75% of AGNs in the local universe, are of considerable significance to resolve the origin of cosmic X-ray background (CXB) and other issues on AGNs: the AGN structure, starburst-AGN connection, growth of the central supermassive black hole, etc. Among them, a type-2 (obscured) quasar is the key to understand such a class of AGNs.

Ultraluminous Infrared galaxies (ULIRGs) have an infrared luminosity $L_{\text{IR}} > 10^{12} L_\odot$, which is comparable to the bolometric luminosity of quasars. Thus, ULIRGs might be promising candidates of type-2 quasars if the primary heat source of the infrared emission is the AGN. However, whereas multi-wavelength observations have found signs of the starburst and/or AGN activity, the energy source of such a huge infrared emission is still controversial, because of the heavy extinction.\(^{1,2}\)

IRAS 05189−2524 is a nearby ($z = 0.043$) bright ULIRG optically classified as a Seyfert 2 galaxy,\(^{3}\) that is, an obscured AGN exists in this galaxy. The X-ray spectrum indicates archetypal characteristics of X-ray obscured (Compton-thin) AGNs.\(^{4,5,6,7}\) Although the absorbed AGN observed in the energy range below 10 keV has Seyfert class X-ray luminosity, the detection of hard X-ray emission above 10 keV by Beppo-SAX suggests the existence of deeply buried AGN in IRAS 05189−2524.\(^{8}\) Hence, IRAS 05189−2524 is regarded as a type-2 quasar candidate.

§2. Suzaku Observation and Results

We therefore performed broad-band X-ray observation of IRAS 05189−2524 with Suzaku for the purpose of (1) exploring deeply obscured AGN in the hard X-ray ($>10$ keV) band and estimating its intrinsic power and (2) investigating spectral change and constraining the origin of the X-ray emission.

The Suzaku observation was performed between 10–12 April 2006 with a net ex-
posure time of 78 ks. To improve the PIN detection efficiency, IRAS 05189−2524 was observed at the HXD nominal pointing position.

2.1. XIS Image and Spectra

The left panel of Fig. 1 shows 0.2−4.5 keV image of the IRAS 05189−2524 field with XIS1. We found that IRAS 05189−2524 was detected both below and above 2 keV. At least 5 X-ray sources, which have already been discovered, other than IRAS 05189−2524 were also detected.

To extract spectra of IRAS 05189−2524, we selected the region to be free of a quasar near IRAS 05189−2524. The extracted XIS spectra were shown in the right panel of Fig. 1. The spectra were fitted well with two absorbed power-laws. One is a steep ($\Gamma \approx 3.8$) power-law with the absorption column density of $N_H = 2 \times 10^{21}$ cm$^{-2}$ below 2 keV. And, the other is a flat power-law $\Gamma \approx 1.2$ with the absorption column density of $N_H = 4 \times 10^{22}$ cm$^{-2}$ above 2 keV. Though an APEC optically-thin thermal plasma model ($kT \sim 0.8$ keV, $Z \sim 0.02 - 0.06Z_{\odot}$) is also acceptable to the data below 2 keV, the provided abundance value is too low relative to a typical value of starburst galaxies. When we applied the double power-law model to the data, positive residuals around 0.9 keV and 6.7 keV in the rest frame appeared. These energies correspond to Ne IX line and Fe XXV K line, respectively. The 0.5−2 keV and 2−10 keV luminosities corrected only for Galactic absorption are $2 \times 10^{41}$ erg s$^{-1}$ and $5 \times 10^{41}$ erg s$^{-1}$, respectively.

Fig. 1. Left panel: 0.2−4.5 keV image around IRAS 05189−2524 with XIS1. Right panel: The XIS0, 1, 2, and 3 X-ray spectra of IRAS 05189−2524. The double absorbed power-law model is also described. Data/model ratio is shown in the lower panel.

2.2. X-ray Spectral Change in IRAS 05189−2524

Fig. 2 shows long-term flux variation of IRAS 05189−2524 from ASCA observation in 1995 to Suzaku observation in 2006. As seen in the figure, a large flux change was observed in both 0.5−2 keV and 2−10 keV band. In particular, the 2−10 keV emission was more than 10 times fainter than those in the previous observations.

To investigate the large flux change, we directly compare Suzaku spectra to XMM-Newton and Chandra spectra. The right panel of Fig.2 shows ratio of the
Suzaku observation of \textit{IRAS 05189–2524}

XMM-Newton, Chandra, and Suzaku data to best fit model of the Suzaku data. There are two time-varying component below and above 1 keV. The variable component in 2–10 keV was well reproduced by a moderately absorbed $N_H = 5 - 8 \times 10^{22} \text{ cm}^{-2}$ power-law ($\Gamma \sim 1.7$). The column densities to the variable component are summarized in Table I. For 0.2–1 keV, on the other hand, a steep power-law ($\Gamma \sim 4$) was fitted well to the data.

![Graph](image)

Fig. 2. Left panel: the 0.5–2 keV and 2–10 keV fluxes of \textit{IRAS 05189–2524} from 1995 to 2006. Right panel: ratio of XMM-Newton, Chandra, and Suzaku data to the best-fitting model of the Suzaku data.

<table>
<thead>
<tr>
<th>$N_H \times 10^{22} \text{ cm}^{-2}$</th>
<th>XMM-Newton</th>
<th>Chandra 1st.</th>
<th>Chandra 2nd.</th>
<th>Suzaku</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{ (cm$^{-2}$)}</td>
<td>5.3-6.0</td>
<td>6.5-7.8</td>
<td>6.4-7.1</td>
<td>($&gt; 1000 \ ?$)</td>
</tr>
</tbody>
</table>

\section*{§3. Discussion}

We found the large flux change in both 0.5–2 and 2–10 keV band. Here, we discuss the origin of the variable components and the emission component observed by Suzaku.

As shown in the previous section, the spectral shape of the time-varying component in the 2–10 keV band is similar to that of moderately absorbed Compton-thin Seyfert 2s. Although the transmitted X-ray emission was observed in the previous observations, it disappeared during Suzaku observation. This indicates that the transmitted X-ray emission was diluted due to the weakened AGN activity and/or that some thick absorbing material was enshrouding the nucleus along the line of sight.

The soft X-ray emission of \textit{IRAS 05189–2524}, on the other hand, has been thought to originate from the galactic scale diffuse emission commonly observed in ULIRGs. At least the time-varying component below 2 keV, however, is thought to be coming from a relatively compact region (e.g. around the AGN). It is consistent with the results of previous Chandra observations and suggest that the soft X-ray emission of \textit{IRAS 05189–2524} was point-like (core dominated).\textsuperscript{5,10,9}
Finally, the spectral shape observed by Suzaku, i.e., a steep power-law with Ne IX line in the soft band and a flat ($\Gamma \sim 1$) power-law with an Fe K line in the hard band, is analogous to that of Compton-thick Seyfert2s (e.g. NGC 1068, Mrk 3)\textsuperscript{12}.\textsuperscript{11} Therefore, IRAS 05189–2524 is now in a reflection dominated phase.

§4. Summary

We performed Suzaku observation of IRAS 05189–2524 in April 2006 with a net exposure time of 78 ksec, and IRAS 05189–2524 was detected in both 0.5–2 and 2–10 keV band. Ne IX and Fe XXV K lines were also detected. On the other hand, we found that the 2–10 keV flux change by more than one order of magnitude relative to those of previous observations. The spectrum obtained by Suzaku is analogous to Compton-thick AGNs indicating that IRAS 05189–2524 is now in a reflection-dominated phase, that is, the intrinsic AGN is diluted and/or is enshrouded by thick material along the line of sight.

References