Discovery of Dying Active Galactic Nucleus in Arp 187: Experience of Drastic Luminosity Decline within $10^4$ yr

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Abstract

Arp 187 is one of the fading active galactic nuclei (AGNs), whose AGN activity is currently decreasing in luminosity. We investigate the observational signatures of AGN in Arp 187, which trace various physical scales from less than 0.1 pc to the nearly 10 kpc, to estimate the long-term luminosity change over $10^4$ yr. The Very Large Array 5 GHz and 8 GHz images and the ALMA 133 GHz images reveal bimodal jet lobes with $\sim$5 kpc size and the absence of the central radio core. The 6dF optical spectrum shows that Arp 187 hosts a narrow line region with the estimated size of $\sim$1 kpc, and the line strengths give the AGN luminosity of $L_{\text{bol}} = 1.5 \times 10^{46}$ erg s$^{-1}$. On the other hand, the current AGN activity estimated from the AGN torus emission gives the upper bound of $L_{\text{bol}} < 2.2 \times 10^{46}$ erg s$^{-1}$. The absence of the radio core gives the more strict upper bound of the current AGN luminosity of $L_{\text{bol}} < 8.0 \times 10^{40}$ erg s$^{-1}$, suggesting that the central engine is already quenched. These multiwavelength signatures indicate that Arp 187 hosts a “dying” AGN; the central engine is already dead, but the large-scale AGN indicators are still observable as the remnant of the past AGN activity. The central engine has experienced the drastic luminosity decline by a factor of $\sim$10$^{3-5}$ fainter within $\sim$10$^4$ yr, which is roughly consistent with the viscous timescale of the inner part of the accretion disk within $\sim$500 yr.

Key words: galaxies: active – galaxies: nuclei

1. Introduction

One of the key questions in modern astronomy is how supermassive black holes (SMBHs) and their host galaxies coevolve (e.g., Alexander & Hickox 2012), leading to the tight correlation between the masses of SMBHs and their bulges in the present universe (e.g., Kormendy & Ho 2013). Active galactic nuclei (AGNs) are the best laboratories to understand this coevolution process, because they are in the stage where the mass accretion onto SMBHs occurs, releasing large amounts of gravitational energy as radiation (e.g., Soltan 1982; Yu & Tremaine 2002), until the SMBHs reach their achievable maximum mass limit of $M_{\text{BH}} \simeq 10^{10.5} M_\odot$ (Netzer 2003; McLure & Dunlop 2004; McConnell et al. 2011; Kormendy & Ho 2013; Trakhtenbrot 2014; Jun et al. 2015; Wu et al. 2015; Inayoshi & Haiman 2016; Ichikawa & Inayoshi 2017).

One of the biggest unknowns for this accretion process is how long such an AGN phase can last. Several authors indicate that the total AGN phase has a duration of $10^7-9$ yr (Marconi et al. 2004) and that one cycle of AGN should be at least over $10^7$ yr, as suggested from the observations (Schawinski et al. 2015) and simulations (e.g., Novak et al. 2011). This is also consistent with the results that there are various AGN indicators with different physical scales and that each AGN indicator has tight luminosity correlations with each other: AGN nucleus (X-ray) and the 10 pc scale AGN dusty torus (mid-infrared, hereafter MIR; Gandhi et al. 2009; Ichikawa et al. 2012; Asmus et al. 2015; Mateos et al. 2015; Ichikawa et al. 2017) and 1 kpc scale ionized gas region (so-called narrow line region or NLR; e.g., Netzer et al. 2006; Panessa et al. 2006; Berney et al. 2015; Ueda et al. 2015). This long lifetime of AGNs, however, makes it difficult for us to observe the scene where an AGN is now being quenched, or “dying,” which gives us the information on how rapidly the physics of accretion disk in an AGN is changing within the certain amount of time.

Recent observations, however, have discovered a key population of AGNs to resolve the issue above. Although they show the AGN signatures at large physical scale with $\geq 1$ kpc (e.g., NLR and/or radio jets), they lack the signatures at small physical scale with $<10$ pc (e.g., X-ray emission, the dust torus emission, and/or the radio core emission) or their luminosities are very faint even if they exist. They are thought to be in the transient stage where their central engine has been already fading, but the large-scale AGN indicators are still active because of the long light-crossing time (e.g., $>10^4$ yr). They are called fading AGNs, and $\sim$20 such sources have been
reported (Schawinski et al. 2010; Schirmer et al. 2013, 2016; Schweizer et al. 2013; Ichikawa et al. 2016; Kawamuro et al. 2017; Keel et al. 2017; Sartori et al. 2018a; Villar-Martín et al. 2018; Wylezalek et al. 2018).

Among them, Arp 187 located at $z = 0.040$ ($D_L = 178$ Mpc, $1'' = 798$ pc) is one of the most promising dying AGN candidates. Dying is the final phase of a fading AGN whose current central engine is already quenched but whose large-scale AGN indicators are still alive because of the photon time delay. Ichikawa et al. (2016) used a jet lobe size discovered by the Atacama Large Millimeter/submillimeter Array (ALMA) cycle-0 observation (Ueda et al. 2014) for estimating the upper limit of the quenching time of the fading AGN. Assuming a jet angle to the line of sight of 90° and a typical expansion speed of radio lobes (0.1c; e.g., Murgia et al. 1999; Nagai et al. 2006), this gives the kinematic age of $\sim 8 \times 10^4$ yr.

We also confirm no additional radio lobes in the field of view (FOV) of the VLA and ALMA observations. The FOV of the VLA observation at 4.86 GHz is 9.3 arcmin, which is the largest among the three observations. This corresponds to the physical size of 221 kpc in radius. If there are radio lobes outside the FOV, the lower limit of their kinematic age is $6.6 \times 10^6$ yr. Thus, Arp 187 has not launched the jet over $6.6 \times 10^6$ yr before the current 5 kpc size one, or the larger radio lobes, if any, already become undetectable because of rapid energy loss (e.g., Godfrey et al. 2017).

We also convolved these maps to $0''/47$ angular resolution to make spectral energy distributions (SEDs) of the jet lobes. The peak and total flux densities of the eastern and western lobes are summarized in Table 1. Each peak flux density is measured at the emission peak at 4.86 GHz, using the beam-matched maps. The radio SEDs of the lobes are shown in Figure 1. The spectral index $\alpha$ was estimated from two points at 4.86 GHz and 8.44 GHz by using a fitting function of $S_\nu \propto \nu^{-\alpha}$. The SED shows a steep spectral index of $\alpha \approx -0.84$ for the eastern lobe (the red dashed line), and the flux point at 133 GHz is nearly on the extrapolated line from the VLA bands. This is consistent with optically thin synchrotron radiation that is expected for the jet emission. On the other hand, the flux density of the western lobes at 113 GHz is smaller than what is expected from the flux densities at 4.86 GHz and 8.44 GHz, assuming that the SED can be fitted by $S_\nu \propto \nu^{-\alpha}$ (the black dashed line). This suggests the spectral aging for the western jet (e.g., Jamrozy et al. 2008; Saikia & Jamrozy 2009), but the exact age cannot be determined on the basis of the current SED sampling.

There is no clear emission in the nucleus (jet core) at 4.86 GHz and 8.44 GHz, although the faint emission is seen at 133 GHz. This is not due to the dynamical range limit of VLA. The $3\sigma$ upper limits of the flux densities measured in the non-beam-matched images are 0.84 mJy at 4.86 GHz and 0.60 mJy at 8.44 GHz. Assuming the spectral index of the jet core of $\alpha = -0.5$, the 133 GHz flux density is expected to be 0.16 mJy according to the upper limit of the 8.44 GHz flux density. However, the observed 133 GHz flux density is $\ll 0.052$ mJy, which is three times lower than that extrapolated from the 8.44 GHz flux density. The non-detection of the continuum emission at 4.86 GHz and 8.44 GHz cannot be explained by free–free absorption, which causes the flux excess at high frequency. Thus, the non-detection at several GHz and strong constraint on the 133 GHz flux density lead to the conclusion of the presence of a significantly faint core in Arp 187.

2. Analysis and Results

2.1. Radio Continuum Emission: Existence of Radio Jet Lobe

The Band 4 continuum observation of Arp 187 was performed using the ALMA 12 m array on 2016 July 25 (Cycle 3; ID = 2015.1.01005.S). We used four SPlectral Windows (SPWs) with Time Domain Mode. The center frequency of the four SPWs is 133 GHz, and the total bandwidth is 8 GHz. The number of 12 m antennas was 36. The baseline lengths range from 15 m to 1124 m. Data calibration and imaging were performed using the Common Astronomy Software Applications package (CAS A, ver. 4.5.3). We used the delivered calibrated $uv$ data and made the continuum map by clipping the visibility ($uv$ distance $\geq 10\lambda$). The synthesized beam size is $0''/46 \times 0''/39$ (position angle (PA) = $-82^\circ/7$) by adopting Briggs weighting of the visibility (robust = 0.5), and the rms noise level is 0.013 mJy beam$^{-1}$. We regard the accuracy of the absolute flux calibration as 5% throughout this article according to the ALMA Cycle 3 Technical Handbook.\footnote{A. Remijan et al., 2015, ALMA Cycle 3 Technical Handbook Version 1.0, ALMA.}

In addition, we used archival calibrated $uv$ data obtained with VLA C- and X-bands, and made the continuum maps using CASA. We clipped the visibilities before imaging so that all the VLA and ALMA data have the same shortest UV range. The synthesized beam size of the 4.86 GHz map is $0''/43 \times 0''/34$ (PA = $-4^\circ/9$) by adopting uniform weighting of the visibility, and the rms noise level is $0.28$ mJy beam$^{-1}$. The synthesized beam size of the 8.44 GHz map is $0''/56 \times 0''/22$ (PA = $34^\circ/1$) by adopting Briggs weighting of the visibility (robust = 0.5), and the rms noise level is $0.20$ mJy beam$^{-1}$.

The radio continuum maps are shown in Figure 1. They clearly show the structure of the jet lobes, which are located at both sides of the nucleus. The projected distance between the lobe cores is $\sim 5$ kpc. We estimate the kinematic age of the lobes, assuming the jet angle to the line of sight of 90° and a typical expansion speed of radio lobes (0.1c; e.g., Murgia et al. 1999; Nagai et al. 2006). This gives the kinematic age of $\sim 8 \times 10^4$ yr.

2.2. 6dF Optical Spectra

We perform the spectral measurements to investigate the properties of the NLR. We first obtained the archival optical spectrum of Arp 187 from the 6dF galaxy survey (Jones et al. 2009). The spectrum covers a range from 3900 Å to

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Radio continuum maps of Arp 187 at VLA 4.86 GHz (left), VLA 8.44 GHz (middle), and ALMA 133 GHz (right). The ellipse in the bottom-left corner shows the beam size measured in each map. The center of each panel corresponds to the peak in the K-band image (Rotheberg & Joseph 2004). The length of each panel is 10″, which corresponds to ~8 kpc. The scale in the left panel shows the separation of the two lobe cores (~5 kpc). The contour levels are 0.28 mJy beam$^{-1}$ × (5, 6, 9, 12, 15, 18, 21, 24, 27, 30) for the 4.86 GHz map, 0.20 mJy beam$^{-1}$ × (3, 4, 5, 7, 9, 11, 13, 15, 20) for the 8.44 GHz map, and 0.013 mJy beam$^{-1}$ × (3, 6, 9, 15, 21, 27, 33, 39, 45, 51) for the 133 GHz map.

**Figure 1.**

| Frequency | Eastern Lobe | Western Lobe |
|-----------|--------------|--------------|
|           | Peak | Total | Peak | Total |
| 4.86 GHz  | 12.0 | 190 | 13.2 | 160 |
| 8.44 GHz  | 7.53 | 92 | 9.54 | 100 |
| 133 GHz   | 0.662 | 5.3 | 0.704 | 7.2 |

**Table 1.**

Note. The unit of the flux density is mJy. These values are measured in the beam-matched images (θ = 0.047).

SEDs of the jet lobes. The spectral indexes estimated from two points at 4.86 GHz and 8.44 GHz are log$\nu_f = 9.20 - 0.84\log \nu$ for the eastern lobe (red) and log$\nu_f = 6.80 - 0.59\log \nu$ for the western lobe (black). The errors of the flux densities are smaller than the size of symbols.

**Figure 2.**

7500 Å with a fiber aperture of 6.7 arcsec (equivalent to 5.3 kpc). Because the 6dF spectra are not flux calibrated on a nightly basis, we have normalized the spectrum according to the 6dF optical photometry at the R band of $R = 14.33$ mag.

Figure 3 shows the optical spectrum of Arp 187 in the left panel (solid black line). The observed spectrum does not show any features of the big blue bump originating from the AGN accretion disk or the broad emission lines (e.g., Malkan & Sargent 1982; Vanden Berk et al. 2001). Thus, we conclude that Arp 187 is at least not a type-1 AGN.

We then perform the spectral fitting to obtain the properties of the NLR. For the spectral fitting, we follow the routine in Bae et al. (2017) and later Toba et al. (2017), where they have performed the spectral fitting to the SDSS spectra. We first subtract the stellar continuum from the spectrum using a best-fit stellar template based on the wide range of the stellar population models (MILES; Sánchez-Blázquez et al. 2006) with solar metallicity and the age spanning from 60 Mys to 12.6 Gyr. To obtain the qualified stellar continuum, we mask the strong emission lines of Hβ, [O I], [N II], Hα, and [S II] with the masking width of 1300 km s$^{-1}$, which corresponds to FWHM ∼ 1000 km s$^{-1}$. We also mask the [O III] doublet with the masking width of 3000 km s$^{-1}$ to avoid the possible contamination from the strong outflow originated from the [O III] emission lines. In addition, because some of the telluric absorptions are not well removed, we also masked those wavelength bands from the stellar spectral fitting.

From the starlight-subtracted spectrum as shown in gray line at the zero flux level in Figure 3, we then fit the Hα, Hβ, [N II]-doublet, [O I]6300 using a single Gaussian function and [O III] doublet ([O III]4959, 5007) with double-Gaussian function using the IDL/MPFIT code, which is a χ$^2$-minimization routine (Markwardt 2009). We assume that the [O III] doublet and the other narrow lines have independent kinematics, whereas the [O III] doublet has the same velocity and velocity dispersion as each other. The observed spectrum (black line) and the fitting results are compiled for the entire spectral range (Figure 3, left panel) and for each line (Figure 3, right panel).

**2.2.1. Existence of NLR**

We first apply the emission-line diagnostics, which give a separation between the NLR ionized by AGN and the H II region in the starburst galaxies (Veilleux & Osterbrock 1987; Kewley et al. 2006). Figure 4 shows that Arp 187 is classified
as an AGN. Thus, it shows that Arp 187 hosts the NLR, one of the large-scale AGN indicators.

Because the diagnostic shows that [O III]λ5007 (hereafter, [O III]) emission is dominated from the NLR, we then measure the [O III] luminosity ($L_{[O III]}$), and [O I]λ6300 (hereafter, [O I]) luminosity ($L_{[O I]}$) to estimate the AGN bolometric luminosity because $L_{[O I]}$ alone (e.g., Heckman et al. 2004, 2005; LaMassa et al. 2013; Ueda et al. 2015) or the combination of $L_{[O III]}$ and $L_{[O I]}$ (e.g., Netzer 2009) is often used as a proxy for AGN power. The observed [O III] and [O I] luminosities are $L_{[O III]} = 6.2 \times 10^{40}$ erg s$^{-1}$ and $L_{[O I]} = 3.8 \times 10^{40}$ erg s$^{-1}$. We also calculate an extinction-corrected, intrinsic luminosity of [O III] ($L_{[O III]}^{\text{int}}$) and [O I] ($L_{[O I]}^{\text{int}}$) luminosities from the Balmer decrement of Hβ/Hα (e.g., Calzetti et al. 1994; Domínguez et al. 2013). The values are $L_{[O III]}^{\text{int}} = 3.2 \times 10^{42}$ erg s$^{-1}$ and $L_{[O I]}^{\text{int}} = 2.0 \times 10^{42}$ erg s$^{-1}$. We calculate the AGN bolometric luminosity $L_{\text{bol}}$ using the both lines (Netzer 2009; Matsuoka & Woo 2015) by

$$\log L_{\text{bol}} = 3.8 + 0.25 \log L_{[O III]}^{\text{int}} + 0.75 L_{[O I]}^{\text{int}}. \quad (1)$$

The estimated value is $\log(L_{\text{bol}}/$ erg s$^{-1}) = 46.2$, which reaches to the typical luminosity of the SDSS quasars at $z \sim 1–2$ (e.g., Shen et al. 2011).

#### 2.2.2. NLR Size

The size of the NLR is also an important indicator to estimate the fading timescale of AGN for Arp 187. Because the integral field unit (IFU) observations are still not available, we estimate the NLR size from the empirical relationship between the [O III] emission size and the [O III] luminosity.

The [O III] emission sizes have been measured from either narrowband imaging (Bennert et al. 2002; Schmitt et al. 2003), long-slit spectroscopy (Fracchetti et al. 2003; Bennert et al. 2006; Greene et al. 2011; Hainline et al. 2013), or the IFU observations (Humphrey et al. 2010; Husemann et al. 2013; Liu et al. 2013; Karouzos et al. 2016; Bae et al. 2017). The narrowband imaging is more often used for studying the NLR morphology, whereas the long-slit spectroscopy and IFU have an advantage to reach shallower sensitivity limits.

We first estimate the NLR sizes ($R_{\text{NLR}}$) using the size–luminosity relations of Bae et al. (2017) obtained from the IFU observations of nearby type-2 Seyferts and quasars. This relation has two advantages; (1) their study uses the extinction-uncorrected [O III] luminosity for the size–luminosity relation to reduce the uncertainty of the extinction correction to estimate the intrinsic [O III] luminosity, and (2) they estimate the NLR size on the basis of the line diagnostic diagrams discussed in Section 2.2, which pick up the region where the [O III] emission is dominated from AGN. The size–luminosity
1.5 10^{12} \text{m}^{-4} 3.0 10^{21} 0 43 6.7 10^0 40 as shown in Figure 3. We apply the relation according to the relation of Bae et al. (2017) to the luminosity relations obtained by LaMassa et al. (2010) and Mateos et al. (2012), respectively.

The estimated NLR size is \( R_{\text{NLR}} \approx 530 \text{ pc} \).

We also estimate the [O iii] emitting sizes \( (R_{\text{O iii}}) \) using the size–luminosity relations from the literature. Note that the relation is based on the [O iii] emission size; therefore, the estimated size should be the upper bound of the NLR size because the NLR should fulfill the certain emission-line ratios as shown in Figure 3. We apply the relation according to the narrowband imaging observations of the quasar population (Schmitt et al. 2003) by

\[
\log \left( \frac{R_{\text{NLR}}}{\text{pc}} \right) = 0.41 \times \log \left( \frac{L_{\text{O III}}}{\text{erg s}^{-1}} \right) - 14.00. \tag{2}
\]

This gives \( R_{\text{NLR}} < R_{\text{O iii}} \approx 1.4 \text{ kpc} \), which is \( \approx 2.5 \) times larger than \( R_{\text{NLR}} \) obtained above. This result is in good agreement with the previous IFU studies (Karlozos et al. 2016; Bae et al. 2017), who reported that \( R_{\text{O iii}} \) is on average a few times larger than \( R_{\text{NLR}} \). In this study, we assume \( R_{\text{NLR}} = 530 – 1400 \text{ pc} \) as the possible NLR size range.

2.3. Spitzer/IRS Spectra

Because the detailed spectral analysis of Arp 187 obtained from the Spitzer/InfraRed Spectrograph (IRS) is compiled in Ichikawa et al. (2016), here we provide a brief summary of the findings. We have found that the thermal emission from the AGN is already weak in Arp 187, with an upper bound of the 12 \( \mu \text{m} \) luminosity of \( L_{12\mu\text{m}} < 1.5 \times 10^{42} \text{ erg s}^{-1} \). This is equivalent to \( L_{\text{bol}} \approx 2.2 \times 10^{43} \text{ erg s}^{-1} \) using the relation of \( L_{12\mu\text{m}} \) and 14–195 keV luminosities (Ichikawa et al. 2017) and the bolometric correction of \( L_{\text{bol}}/L_{14-195} = 8.47 \) (Ricci et al. 2017b; Ichikawa et al. 2019). The spectrum of Arp 187 shows a marginal detection of the [O iv] 25.89 \( \mu \text{m} \) line at \( S/N \approx 3 \), which is also a widely used AGN indicator. The [O iv] luminosity is obtained with \( L_{\text{O iv}} = 6.7 \times 10^{40} \text{ erg s}^{-1} \), which is equivalent to \( L_{2-10} = 3.0 \times 10^{43} \text{ erg s}^{-1} \) according to the luminosity relations obtained by LaMassa et al. (2010). Because the ionization potential of [O iv] is higher \( (E_P=54.9 \text{ eV}) \) than other typical NLR indicators, including [O iii] line (e.g., Rigby et al. 2009), the emission size is expected to be smaller than that of [O iii] (Komossa et al. 2008; Toba et al. 2017), which is 0.5–1.4 kpc in this study. Thus, we take the emission size of \( \approx 1.4 \text{ kpc} \) as a fiducial value.

2.4. WISE Colors

IR color–color selection is useful to identify AGN candidates using the feature of the MIR bump originated from the AGN torus. Figure 5 shows the location of Arp 187 on the WISE color–color plane. It is known that increasing levels of AGN contribution to the MIR emission moves sources upward in the color–color plane with the color cut of \( W1 – W2 > 0.8 \) (orange area; Stern et al. 2012) and also within the AGN wedge (blue area; Mateos et al. 2012). The figure clearly shows that Arp 187 does not fulfill either of the criteria above, indicating either (1) Arp 187 does not host AGN or (2) the AGN activity is quite weak even if it exists (on average \( L_{14-195} < 10^{43} \text{ erg s}^{-1} \), as suggested by Ichikawa et al. 2017).

2.5. WISE IR Time Variability

It is worthwhile to trace the IR luminosity drop from the AGN torus after the AGN quenching. Because Arp 187 is bright enough to be detected in the single exposure with the WISE mission, we have collected both cryogenic (WISE All sky database) and postcryogenic multiepoch photometry (WISE 3 band and Post-Cryo database) from the ALLWISE (Wright et al. 2010; Mainzer et al. 2011) covering the observation between 2010 January and 2011 February (MJD = 55000 = 200–600), and the most recent NEOWISE (Mainzer et al. 2014) data release 2018 covering the observation between 2013 December 13 and 2017 December 13, UTC (MJD = 55000 = 1600–3100). WISE has a 90 minute orbit and conducts \( \approx 12 \) observations of a source over a \( \approx 1 \) day period, and a given location is observed every 6 months.

In this study, we used standard aperture magnitude \( w1/2\text{mag} \). We applied a cross-matching radius of 2 arcsec, according to the positional accuracy with the 2MASS catalog (see also Ichikawa et al. 2012, 2017). After this matching, 26 and 122 data points were obtained from the ALLWISE and NEOWISE epoch, respectively. Then we select good quality single-epoch data points according to the good quality frame score \( \text{qual}_\text{frame} > 0 \) and \( \text{qi}_\text{fact} > 0 \), locating them with enough distance from the South Atlantic Anomalies \( \text{sa}_\text{A}_\text{A} > 0 \), and avoiding the possible contamination from the moon \( \text{moon}_\text{mask} = 0 \). This reduces the sample into 24 (ALLWISE) and 109 (NEOWISE), respectively. Finally, we applied the aperture measurement quality flag \( w1/2\text{flag} = 0 \) in order to avoid the contamination in the aperture. The final data points are 10 (W1) and 8 (W2) for ALLWISE 43 (W1) and 21 (W2) for NEOWISE. All the data points fulfill the flux quality \( \text{ph}_\text{qual} = 1 \), with a signal-to-noise ratio larger than 10.0. We also checked sources of contamination and/or biased flux due to proximity to an image artifact (e.g., diffraction spikes, scattered-light halos, and/or optical ghosts), using the contamination flag \( \text{cc}_\text{flags} = 0 \). All the data points are \( \text{cc}_\text{flags} = 0 \), that are unaffected by known artifacts.

Figure 6 shows the light curve of W1 (3.4 \( \mu \text{m} \)) and W2 (4.6 \( \mu \text{m} \)). The light curves in the W1 and W2 span a baseline of roughly 2800 days \( \approx 7.7 \text{ yr} \). Each observation is shown in blue, and binned observations within 1 day are also shown in orange.
As shown in Figure 6, no clear variability is detected in the ALLWISE and NEOWISE epochs, and also between the two epochs. Actually, the ALLWISE catalog provides a variability flag (var_flag) and its value is var_flag = 0, suggesting that the significant variability between different exposures are not detected during the ALLWISE survey, which shows the consistent result.

2.6. Relationship between 12 µm and [O III] Luminosities

It is widely known that both 12 µm and the [O III] luminosities are good proxies for AGN power, and it is a natural consequence that there is a luminosity correlations between 12 µm and the [O III] luminosities (e.g., Toba et al. 2014).

Figure 7 shows the relationship between 12 µm and [O III] λ5007 luminosities using the SDSS DR12 type-2 AGN sample with the cross-matching by the WISE W3 (12 µm) band. As expected, the two AGN indicators have a nice luminosity correlation. However, Arp 187 does not follow the luminosity relation and is located at the right bottom in the plane, suggesting that Arp 187 is in the locus of a dying AGN. Ichikawa & Tazaki (2017) estimated the typical cooling timescale of the dusty torus once the AGN is suddenly quenched. The thermal MIR dust emission from AGN should decay times of 10−100 yr, mainly depending on the time-lag caused by the light-travel time from the nucleus to the dust sublimation radius, whereas the L_{O III} remains the same luminosity for over >10^7 yr because of its larger physical size. Ichikawa & Tazaki (2017) also calculated how those dying AGNs move in the luminosity–luminosity plane of the two AGN indicators, and showed that those dying AGNs should locate at the bottom right of the luminosity relation. The location of Arp 187 in Figure 7 is consistent with the idea, and below the relationship of the line after 30 yr of AGN quenching (the orange dashed line).

2.7. X-Ray Observations

Although the X-ray observations give us the current AGN activity without the concern of the obscuration up to log N_H ≈ 24 (e.g., Ricci et al. 2015, 2017a), we have not found any previous X-ray observations for Arp 187, and therefore only the upper bounds obtained from the available all sky X-ray surveys.

Arp 187 is not in the catalog of Swift/BAT 105 month all sky survey with the limiting flux at the 14−195 keV band of f_{lim} = 8.0 × 10^{-12} erg s^{-1} cm^{-2} (Oh et al. 2018). This gives a very shallow upper bound of L_{14−195} < 2.8 × 10^{43} erg s^{-1}, which is equivalent to L_{bol} < 2.4 × 10^{44} erg s^{-1} under the assumption of L_{bol}/L_{14−195} = 8.47 (Ricci et al. 2017b). The ROSAT All Sky Survey also shows non-detection at the energy range of 0.5−20 keV (f_{lim} = 2.5 × 10^{-12} erg s^{-1} cm^{-2}; Voges et al. 1999). This also gives a shallow upper bound of L_{0.5−2} < 8.8 × 10^{42} erg s^{-1}, which is equivalent to L_{bol} < 2.8 × 10^{44} erg s^{-1} using L_{2−10}/L_{0.5−2} = 1.57 under the assumption of the photon index Γ = 1.8 (Ricci et al. 2017a) and L_{bol}/L_{2−10} = 20 (Ricci et al. 2017b).
Other X-ray catalogs, such as the third XMM-Newton serendipitous source catalog (3XMM-DR7; Rosen et al. 2016) and the Chandra Source Catalog (CSC Release 2.0; Evans et al. 2010), do not contain the observations of Arp 187.

### 2.8. Black Hole Fundamental Plane

The fundamental plane of the black hole gives a relationship among three physical quantities of $L_{2-10}$, core $L_{50Gr}$, and the black hole mass $M_{BH}$ (e.g., Merloni et al. 2003; Falcke et al. 2004; Yuan & Narayan 2014). Ichikawa et al. (2016) discussed that once the upper bound of $L_{50Gr}$ is given, we can estimate the upper bound of $L_{2-10}$, because the black hole mass in Arp 187 is estimated to be $M_{BH} = 6.7 \times 10^8 M_\odot$. The upper bound of $L_{50Gr} \leq 3.7 \times 10^{37}$ erg s$^{-1}$ obtained by the VLA observation gives $L_{2-10} \leq 4.0 \times 10^{39}$ erg s$^{-1}$ using the relation of Yuan & Cui (2005). This is equivalent to $L_{bol} \leq 8.0 \times 10^{39}$ erg s$^{-1}$, indicating that the central engine is already quenched.

### 3. Discussion

#### 3.1. AGN Indicators and Scenarios of Current AGN Activity

Our multiwavelength measurements of the AGN indicators show that we have successfully found the large-scale (>100 pc) AGN indicators but not the indicators for the small-scale ones with <10 pc. Table 2 summarizes the AGN indicators for Arp 187.

There are two possible scenarios that can account for these seemingly contradictory results between the larger (>100 pc) and smaller (<10 pc) scales. One is that the AGN activity still exists but the emission is highly obscured along the line of sight, while being unobscured toward the jet and/or the NLR direction (e.g., Sartori et al. 2018a). The other is that the AGN activity in Arp 187 has already been quenched, whereas the NLRs still remain bright because of the light-travel time from the central engine. The first scenario is unlikely for Arp 187 for two reasons. One is the absence of the AGN torus emission in the Spitzer/IRS spectra, as well as the other torus indicators obtained from WISE. If the central engine is highly obscured, then most of the emission is absorbed by the dust, and then it re-emits and produces the bump in the MIR (e.g., Ichikawa et al. 2014), which we cannot find. Another point is the absence of the jet core, which is irrelevant to the concern of absorption and its existence is the ubiquitous trend for AGN (Blandford & Königl 1979; Hada et al. 2011), although there are some rare exceptions (Cordey 1987; Dwarkanath & Kale 2009). Thus, our results prefer the scenario of a dying AGN.

One might argue that the absence of the big blue bump and the broad emission-line region (BLR) is due to the absorption by the dusty torus (e.g., Antonucci 1993; Nagar et al. 2002). It is true in general, but because the torus emission is already weak for Arp 187, as discussed in Section 2.3, the most plausible explanation is that the central engine including the accretion disk and the BLR becomes already very faint or might be diminished.

The disappearing timescale of the BLR is poorly known at present. One possible implication of this comes from the observations of changing-look AGNs, which show the AGN type change in a human timescale (e.g., Tohline & Osterbrock 1976; Antonucci & Cohen 1983; Allin et al. 1985; LaMassa et al. 2015; MacLeod et al. 2016; Ruan et al. 2016; Yang et al. 2018). One of the findings of the ~10 yr long monitoring of changing-look AGNs is that the BLR can disappear within a few years, whereas the physical mechanism of the disappearance is still under debate (Lawrence 2018). Thus, in this paper we compile the timescale of BLR as 1–10 yr in Table 2.

### Table 2

AGN Indicators and Their Estimated Luminosities

| Type of AGN Indicators | AGN Sign | $\log(L_{AGN}/\text{erg s}^{-1})$ | $\log(L_{bol}/\text{erg s}^{-1})$ | $\log(\lambda_{Edd})$ | Size (radius) | $t_{\text{retro}}$ | References |
|------------------------|----------|---------------------------------|---------------------------------|----------------------|--------------|----------------|-------------|
| jet lobe               | ✓        | ...                             | ...                             | ...                  | 2.5 kpc      | $8.1 \times 10^8$ yr | Section 2.1 |
| NLR ([O III]λ5007)     | ✓        | $\log L_{5007}^{\text{[O III]}} = 42.51$ | 46.15                           | $-0.77$             | 0.5–1.4 kpc  | $(1.7–4.6) \times 10^7$ yr | Section 2.2 |
| NLR ([O IV]25.89 μm)   | ✓        | $\log L_{25.8}^{\text{[O IV]}} = 40.83$ | 44.78                           | $-2.15$             | $\leq 1.4$ kpc | $\leq 4.6 \times 10^3$ yr | Section 2.3 |

#### Small-scale AGN Indicators (<10 pc)

| AGN Sign | $\log(L_{bol}/\text{erg s}^{-1})$ | Size (radius) | References |
|----------|---------------------------------|--------------|-------------|
| Dust torus (Spitzer/IRS Spec) X | $\log L_{2-10} < 42.18$ | $< 3.34^a$ | $\leq 10$ pc | Section 2.3 |
| Dust torus (WISE IR colors) X | ... | ... | $10–100$ yr | Section 2.4 |
| Dust torus (WISE IR light curve) X | ... | ... | $10–100$ yr | Section 2.5 |
| Dust torus ([O III]) versus $L_{2-10}$ X | $\log L_{2-10} < 42.18$ | $< 3.34^a$ | $\leq 10$ pc | $> 30$ yr | Section 2.6 |
| Jet core X | $\log L_{50Gr} < 37.57$ | ... | $< 1$ pc | Current Section 2.1 |
| BLR (optical Spec) X | ... | ... | $< 0.1$ pc | Current (1–10 yr) | Section 2.2 |
| Electron corona (X-ray) X | $\log L_{2-10} < 43.44$ | $< 44.38^a$ | $< -2.55$ | $< 0.1$ pc | Current Section 2.7 |

#### Other Relations

| AGN Sign | $\log(L_{bol}/\text{erg s}^{-1})$ | $t_{\text{retro}}$ | References |
|----------|---------------------------------|----------------|-------------|
| BH fundamental plane (FP) | $\log L_{2-10} < 39.60$ | $< 40.90^a$ | $< -6.03$ | Current Section 2.8 |
3.2. Luminosity Decline and Corresponding Timescales

One of our goals is to constrain how rapidly the AGN has faded in Arp 187. We summarize the long-term luminosity decline of Arp 187 in Figure 8. This figure shows that the AGN has experienced the drastic luminosity decline by the factor of $10^{−3}$ within $\sim 10^4$ yr.

One question arises as to how to describe the sudden quenching of AGN within $\sim 10^7$ yr and how this timescale is connected to the physical properties of the accretion disk of AGN. We here consider three possible timescales: the orbital, thermal, and the viscous timescales, by following the discussions of Czerny (2006) and Stern et al. (2018). If the accretion flow is roughly Keplerian, the dynamical timescale of the accretion disk is given by $t_{\text{dyn}} \sim 1/\Omega$, where $\Omega$ is the Keplerian orbital angular frequency. The thermal timescale, which is corresponding to the disk cooling, is given by $t_{\text{th}} \sim 1/\alpha \Omega$, where $\alpha$ is the viscosity parameter (Shakura & Sunyaev 1973; Kato et al. 2008). The viscous timescale is also given by $t_{\text{vis}} \sim (h/R)^2 t_{\text{th}}$, where $h/R$ is the disk aspect ratio. The numerical simulations derive the estimation of $\alpha \sim 0.03$ (Hirose et al. 2009; Davis et al. 2010); therefore, we use $\alpha_{0.03} = \alpha/0.03$ as the fiducial value. The disk aspect ratio is typically very small, and we assume $h/R \sim 0.05$ by following Stern et al. (2018).

We first determine the boundary accretion disk radius $R$, within which it emits the UV radiation, where UV represents the wavelength of $\lambda < 3500 \text{Å}$, and the typical wavelength range of the big blue bump (e.g., Malkan & Sargent 1982; Vanden Berk et al. 2001). Using the obtained parameter for Arp 187, the BH is estimated to be $M_{\text{BH}} = 6.7 \times 10^8 M_\odot$, and the maximum Eddington ratio in this study is $\lambda_{\text{Edd}} = 0.17$ obtained from the NLR. The gravitational radius is given by $R_g = 2GM_{\text{BH}}/c^2 \sim 13 \text{ au}$. The AGN bolometric luminosity is governed by $L_{\text{bol}} = \eta M c^2$, where $\eta$ is the radiation efficiency. The typical value is estimated as $\eta \sim 0.1$ (Soltan 1982). The mass accretion rate $\dot{M}$ is therefore given by

$$\dot{M} \approx 2.8 M_\odot yr^{-1} \eta_{0.1}^{-1} M_{\text{BH},0} \lambda_{\text{Edd},0.17}^{-2.9}.$$  

Here, $\eta_{0.1} = \eta/0.1$, $M_{\text{BH},0} = M_{\text{BH}}/6.7 \times 10^8 M_\odot$, and $\lambda_{\text{Edd},0.17} = \lambda_{\text{Edd}}/0.17$.

Assuming a standard thin-disk AGN model, the disk radius $R$ is linked to the disk temperature $T$ in Equation (3.57) of Kato et al. (2008) written by

$$R = \frac{3GM_{\text{BH}}}{8\pi\sigma T^4},$$  

where $\sigma$ is a is a Stefan–Boltzmann constant. Combining Equation (5) and (4) with Wien’s law ($\lambda/\bar{\lambda} = 2.9 \times 10^7/T$), the typical radius $R$ can be given by

$$R = 100 M_{\text{BH},0}^{-1/3} M_{\text{BH}}^{-1/3} \lambda_{\text{Edd},0.17}^{-1/3} \lambda_{3500}^{-4/3} \text{au}.$$  

where $\lambda_{3500} = \lambda/3500$ Å. Thus we apply $R_{100} = R/100R_g$ as a fiducial value for the UV-emitting disk size.

We can then parameterize the disk timescales as

$$t_{\text{dyn}} \sim 100 \text{ day} \times M_{\text{BH},0}^{3/2} R_{100}^{3/2},$$  

$$t_{\text{th}} \sim 10 \text{ yr} \times M_{\text{BH},0}^{1/2} R_{100}^{3/2},$$  

$$t_{\text{vis}} \sim 1.6 \times 10^4 \text{ yr} \times \left(\frac{h/R}{0.05}\right)^2 M_{\text{BH},0}^{-1/2} R_{100}^{3/2}.$$  

Because Arp 187 has not shown the big blue bump and the torus emission (whose source of nutrition is the UV photons)
### Table 3: Observational Properties of Dying AGN, Fading AGN, and Changing-looking Quasars

| Definition | Dying AGN (Arp 187) | Fading AGN | Changing-look Quasar |
|------------|----------------------|------------|----------------------|
| Small-scale (<10 pc) AGN signs | AgN whose current (small-scale) AGN signature is dead, but past AGN signature is still alive | AGN with weaker current $L_{\text{AGN}}$ compared to that of past AGN signatures | Quasars with broad Balmer line (dis)appearance associated with continuum change by a factor of $\sim 10$ |
| Large-scale (>100 pc) AGN signs | Alive | Alive | Alive |
| Jet core features | No | Yes ($?^{(B1)}$) | ... |
| Jet lobe features | Yes | $10^{-5}$ | $10^{-4}$ |
| $\Delta L_{\text{AGN}}$ (current) | $\leq 10^{49}$ yr | $10^{45}$ yr (using EELR($^{(c)}$)) | $\sim 10$ yr ($^{(C1,C3,C4,C8)}$) |
| $\Delta L_{\text{AGN}}$ (before fading) | $< 10^{46}$ erg s$^{-1}$ | $10^{43}$ erg s$^{-1}$ | $> 10^{44}$ erg s$^{-1}$ |
| Redshift ($z$) | 0.04 | $0.01-0.3^{(B5,B10)}$ | 0.01-1.0$^{(C3,C4,C6)}$ |
| Origin of variability | Viscous | Viscous | Unknown (thermal$^{(E-C10)}$ or Magnetically elevated disk$^{(E-C7)}$) |
| Host galaxies | Merger remnant | Merger system/remnants ($?^{(B5)}$) | ... |
| Number of sources found | $\geq 20$ sources ($^{B1\text{-}B13}$) | $> 40$ sources ($^{C1\text{-}C6}$) | ... |
| Most known object names | Arp 187 ($^{A1}$) | IC 2497 (Hanny’s Voorwerp)$^{(B1\text{-}B8)}$ | SDSS J0159+0033$^{(C1)}$ |
| (NGC 7252$^{(A2)}$) | Teacup galaxy ($^{B5,B6,B12}$, etc.) | SDSS J0111+5442$^{(C2)}$, etc. |

Note. (1) EELR stands for extended AGN photoionized emission-line region with the physical scale of $\sim 10$ kpc. (2) Observed or inferred AGN luminosity decline. (b) The timescale of the AGN luminosity decline of $\Delta L_{\text{AGN}}$, “…,” in the column represents that there are no clear observations or consensus from the literature.

### References
- Dying AGN: (A1) Ichikawa et al. (2016), (A2) Schweizer et al. (2013); Fading AGN: (B1) Józsa et al. (2009), (B2) Lintott et al. (2009), (B3) Schawinski et al. (2010), (B4-B6) Keel et al. (2012, 2015, 2017), (B7, B8) Sartori et al. (2018a, 2018b), (B9, B10) Schirmer et al. (2013, 2016), (B11) Kawamuro et al. (2017), (B12) Villar-Martín et al. (2018), (B13) Wylezalek et al. (2018); Changing-looking quasar: (C1) LaMassa et al. (2015), (C2) Runnoe et al. (2016), (C3) Ruan et al. (2016), (C4) MacLeod et al. (2016), (C5) Gezari et al. (2017), (C6) Yang et al. (2018), (C7) Dexter & Beggeman (2019), (C8) Noda & Done (2018), (C9) Ross et al. (2018), (C10) Stern et al. (2018).

For at least the last 10 yr (see also Figure 8), the dynamical and thermal timescales are unlikely and too short to be happening. On the other hand, the viscous timescale seems to be a little longer compared to the quenching timescale of $< 10^4$ yr. However, because the NLR traces higher energy UV photons with $> 10^6$ eV, the corresponding disk region becomes more inner with $R \lesssim 10^3 R_\odot$, whose viscous timescale is $\lesssim 5000$ yr. This is consistent with our strongest upper bound of $\sim 3000$ yr (see Table 2). Thus, our rough estimation suggests that the viscous timescale most closely matches the observed quenching timescale.

#### 3.3. Comparison between Dying AGN and Fading AGN

The absence of small-scale AGN signatures and the timescale discussed in Section 3.2 support that Arp 187 has been in a later fading phase, or dying phase, compared to other fading AGNs because the UV-emitting region in Arp 187 likely disappeared, and the large-scale AGN indicators are observable as remnant signs of an AGN. On the other hand, the previously reported fading AGNs are considered to be earlier fading stage because they still host clear UV, MIR, or X-ray emission in the core, suggesting that the UV-emitting region is still alive (e.g., Keel et al. 2015, 2017; Sartori et al. 2018a). We have summarized the comparison of properties of our dying AGN and fading AGN in Table 3.

One important question is how many such dying AGNs have been already reported in the population of fading AGNs from the literature. Although most fading AGNs still show MIR or X-ray emission in the core, one fading AGN in NGC 7252 might fulfill dying the AGN criterion. Schweizer et al. (2013) showed that NGC 7252 hosts large [O III]$\lambda 5007$ bright nebulae that belong to a stream of tidal-tail gas falling back to the host galaxy. The bright [O III] nebula require the AGN luminosity larger than $L_{\text{bol}} > 5 \times 10^{42}$ erg s$^{-1}$, whereas the current X-ray upper bound gives $L_{\text{bol}} < 5 \times 10^{40}$ erg s$^{-1}$. Considering the nebulae distance, NGC 7252 might have experienced a luminosity decline by two orders of magnitude over the past 10$^4$-yr, and the current AGN activity is well below $L_{\text{bol}} < 10^{42}$ erg s$^{-1}$, suggesting that the central engine is already dead.

Note that the past inferred AGN luminosity is completely different between Arp 187 and NGC 7252. Arp 187 reached a quasar-like luminosity with $L_{\text{bol}} > 10^{46}$ erg s$^{-1}$, whereas that of NGC 7252 is well below the quasar level or, more likely, Seyfert level luminosity with $L_{\text{bol}} > 5 \times 10^{42}$ erg s$^{-1}$. Schweizer et al. (2013) also reported that the central gas disk of NGC 7252 contains the large amount of molecular gas with $> 10^9 M_\odot$, suggesting that the AGN feedback activity has failed to remove the gas in the host galaxy. Therefore, the gas content difference between NGC 7252 and Arp 187 would be a good testbed to investigate the effect of AGN feedback because these two galaxies have already experienced the one cycle of AGN activity for at least 10$^5$ yr (Schawinski et al. 2015) but with different AGN luminosity.
3.4. Comparison of the Causes of Luminosity Changes between Dying AGNs and Changing-look Quasars

It is worthwhile to note the difference of the accretion mechanism between our dying AGN in Arp 187 and a recently discovered class of “changing-look quasars,” in which the strong UV bump and broad emission lines associated with optically bright quasars either appear or disappear on time-scales of years (e.g., LaMassa et al. 2015; MacLeod et al. 2016; Gezari et al. 2017; Yang et al. 2018). The physical processes causing these changing-look phenomena are hotly debated, but the physical changes in the accretion disk is the likely cause rather than changes in obscuration (e.g., LaMassa et al. 2017; Lawrence 2018; Dexter & Begelman 2019).

Stern et al. (2018) recently discovered one changing-look quasar, WISE J1052+1519, and carefully discussed the possible disk timescales matching the year timescale. They found that the dynamical timescale is several weeks, which is therefore too short, whereas the viscous timescale, which would be responsible for the luminosity change of dying AGN, is far too long. Instead, a few-years-long thermal timescale would be a plausible one, matching the observed year scale variability. The similar origin is also proposed for a different changing-look AGN Mrk 1018 (Noda & Done 2018). Therefore, both dying and changing-look AGNs show the luminosity change, but their luminosity changes are likely based on the different physical mechanisms of the accretion disk. Those property differences between dying AGNs and changing-look quasars are also summarized in Table 3.

3.5. Comparison between Dying AGN and Remnant Radio Sources

Our study suggests that the absence of radio core at the center of galaxies would be a good indicator for searching for a dying AGNs. Although they are very rare, some authors have already found candidates of radio galaxies without clear radio core signs, or so-called remnant radio sources. Corey (1987) showed that IC 2476 has double radio lobes with a separation of 560 kpc, but without a clear radio core at the location of the host galaxy. In addition, Dwarakanath & Kale (2009) have conducted a search for remnant radio sources using VLA 74 MHz survey (VLSS; 80 arcsec spatial resolution) and NRAO VLA Sky Survey (NVSS; 45 arcsec spatial resolution) through the search of very steep radio sources whose spectral index is $\alpha < -1.8$ (where $f_{\nu} \propto \nu^{\alpha}$) between 74 MHz and 1.4 GHz. Of the $\sim 10^4$ parent sample, they found 10 such candidates and the spectral age estimation of jet lobes gives the fading age of $> 10$ Myr.

The timescale found in remnant radio sources is at least two orders of magnitude longer than the fading phase traced for Arp 187. This discrepancy is natural because their steep spectral selection method is sensitive to longer jet age with $> 10^7$ yr at the frequency of $\sim 100$ MHz (e.g., Jamrozy et al. 2008) and their moderate spectral resolution of 80 arcsec is equivalent to the physical angular size of $\sim 260$ kpc, or the corresponding kinematic age of $t_{\text{dyn}} \sim 8 \times 10^6$ yr at $z \sim 0.2$, where most of the samples are found. Thus, previous radio studies are sensitive to trace much longer AGN activities with $> 10$ Myr. Considering the typical quasar lifetime of $\sim 30$ Myr (e.g., Hopkins et al. 2006; Inayoshi et al. 2018), remnant radio sources are more suitable to trace a comparable timescale of the AGN lifetime rather than the AGN fading timescale traced in this study.

Recently, higher spatial resolution surveys are ongoing using Low-Frequency Array (LOFAR; van Haarlem et al. 2013). LOFAR covers the largely unexplored low-frequency range between 10–240 MHz, and has the resolution of $\sim 6$ arcsec at 150 MHz. This would give an opportunity to search for smaller, which is equivalent to younger, dying radio sources at the age of $\sim 1$ Myr. The initial-stage surveys have already found new remnant radio source candidates (e.g., Mahatma et al. 2018), and future LOFAR surveys would give us a more statistically significant number of such younger remnant radio sources and would help to create a more complete picture of both of AGN lifetime and dying phase (also see a recent review by Morganti 2017).

3.6. Future Observations

There is some room for the further constraints of the AGN activities of Arp 187. JWST/MIRI will give us the nuclear MIR spectra with the least host galaxy contamination with great sensitivity. The X-ray satellite NuSTAR is going to constrain the current AGN activity. Recently, thanks to the great sensitivity at $E > 10$ keV, NuSTAR revealed that a fading AGN candidate in IC 2497 is actually a Compton-thick AGN (Sartori et al. 2018a), whose nuclear X-ray emission could not be discovered in the previous X-ray satellites such as Chandra, XMM/Newton, and even with Suzaku (Schwinski et al. 2010). Although the same discovery is unlikely for Arp 187, because the MIR emission is known to be considerably weak, NuSTAR will constrain the nuclear activity down to $\log(L_{2-10\text{ keV}}/\text{erg s}^{-1}) \simeq 42$ even with the Compton-thick absorption of $\log N_{\text{HI}} \simeq 24.3$. Finally, the optical or near-IR IFU will also give us the detailed NLR size which is poorly constrained with the current study.

4. Conclusion

We have compiled the multiwavelength AGN signatures of dying AGN candidate Arp 187, on the basis of the combinations of the newly conducted ALMA observations and the archival VLA 5–10 GHz data, 6dF optical spectrum, NEOWISE, and ALLWISE IR data. Our results show that the AGN in Arp 187 is a bona fide dying AGN, whose central engine is already dead, but the large-scale AGN indicators are still observable as the remnant of the past AGN activity. The central engine of Arp 187 has experienced the drastic luminosity decline by a factor of $10^{3-5}$ within the last $10^8$ yr. Our rough estimation suggests that the viscous timescale most closely matches the obtained timescale in this study. This supports that Arp 187 has been in a later fading phase whose UV-emitting region in the accretion disk is likely to be almost disappeared, whereas other fading AGNs show clear signs that the UV-emitting region is still alive.

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