

X-ray Winds In Nearby-to-distant Galaxies (X-WING) - I: Legacy Surveys of Galaxies with Ultrafast Outflows and Warm Absorbers in $z \sim 0-4$

SATOSHI YAMADA ¹, TAIKI KAWAMURO ¹, MISAKI MIZUMOTO ², CLAUDIO RICCI ^{3,4}, SHOJI OGAWA ⁵,
HIROFUMI NODA ⁶, YOSHIHIRO UEDA ⁷, TERUAKI ENOTO ⁸, MITSURU KOKUBO ⁹, TAKEO MINEZAKI ¹⁰,
HIROAKI SAMEISHIMA ¹⁰, TAKASHI HORIUCHI ¹⁰ AND SHOICHIRO MIZUKOSHI ¹⁰

¹*RIKEN Cluster for Pioneering Research, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan; satoshi.yamada@riken.jp*

²*Science Education Research Unit, University of Teacher Education Fukuoka, 1-1 Akama-bunkyo-machi, Munakata, Fukuoka 811-4192, Japan*

³*Instituto de Estudios Astrofísicos, Facultad de Ingeniería y Ciencias, Universidad Diego Portales, Av. Ejército Libertador 441, Santiago, Chile*

⁴*Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing 100871, China*

⁵*Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), 3-1-1 Yoshinodai, Chuo-ku, Sagami, Kanagawa 252-5210, Japan*

⁶*Astronomical Institute, Tohoku University, 6-3 Aramaki-aoba, Aoba-ku, Sendai, Miyagi 980-8578, Japan*

⁷*Department of Astronomy, Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan*

⁸*Division of Physics and Astronomy, Graduate School of Science, Kyoto University, Kitashirakawa, Sakyo-ku, Kyoto 606-8502, Japan*

⁹*National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan*

¹⁰*Institute of Astronomy, School of Science, the University of Tokyo, 2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan*

(Received March 4, 2024; Revised May 2, 2024; Accepted May 3, 2024)

ABSTRACT

As an inaugural investigation under the X-ray Winds In Nearby-to-distant Galaxies (X-WING) program, we assembled a dataset comprising 132 active galactic nuclei (AGNs) spanning redshifts $z \sim 0-4$ characterized by blueshifted absorption lines indicative of X-ray winds. Through an exhaustive review of previous research, we compiled the outflow parameters for 576 X-ray winds, encompassing key attributes such as outflow velocities (V_{out}), ionization parameters (ξ), and hydrogen column densities. By leveraging the parameters V_{out} and ξ , we systematically categorized the winds into three distinct groups: ultrafast outflows (UFOs), low-ionization parameter (low-IP) UFOs, and warm absorbers. Strikingly, a discernible absence of linear correlations in the outflow parameters, coupled with distributions approaching instrumental detection limits, was observed. Another notable finding was the identification of a velocity gap around $V_{\text{out}} \sim 10,000 \text{ km s}^{-1}$. This gap was particularly evident in the winds detected via absorption lines within the $\lesssim 2 \text{ keV}$ band, indicating disparate origins for low-IP UFOs and warm absorbers. In cases involving Fe XXV/Fe XXVI lines, where the gap might be attributed to potential confusion between emission/absorption lines and the Fe K-edge, the possibility of UFOs and galactic-scale warm absorbers being disconnected is considered. An examination of the outflow and dust sublimation radii revealed a distinction: UFOs appear to consist of dust-free material, whereas warm absorbers likely comprise dusty gas. From 2024, the X-Ray Imaging and Spectroscopy Mission (XRISM) is poised to alleviate observational biases, providing insights into the authenticity of the identified gap, a pivotal question in comprehending AGN feedback from UFOs.

Keywords: Black hole physics (159); Active galactic nuclei (16); X-ray active galactic nuclei (2035); Supermassive black holes (1663); Observational astronomy (1145)

1. INTRODUCTION

Outflows stemming from supermassive black holes (SMBHs) are pivotal in not only shaping the active galactic nucleus (AGN) structure (e.g., Krolik & Begel-

man 1986; Antonucci 1993; Buchner et al. 2015; Ramos Almeida & Ricci 2017; García-Burillo et al. 2021; Kawamuro et al. 2021) but also influencing the evolution of host galaxies by injecting energy and momentum into

the interstellar medium (e.g., Silk & Rees 1998; Di Matteo et al. 2005; Fabian 2012; Cicone et al. 2014; Harrison 2017). Theoretical studies posit that AGN outflows can curb star formation in galaxies (e.g., Fabian 2012; Zubovas & King 2012), potentially elucidating the observed correlation between the SMBH mass (M_{BH}) and velocity dispersion of the host galaxy (e.g., Kormendy & Ho 2013). Owing to the multiphase nature of outflows (e.g., Laha et al. 2021), comprehending their complete structure and feedback impact across various spatial scales or under different physical conditions remains challenging. Consequently, extensive multi-wavelength studies on multiphase outflows have been conducted (e.g., Fiore et al. 2017; Fluetsch et al. 2019, 2021; Yamada et al. 2021, 2023; Izumi et al. 2023).

Various components of multiphase outflows are discernible across different wavelengths. In X-rays, highly ionized ultrafast outflows (UFOs; Tombesi et al. 2010a; Gofford et al. 2015) and slower outflows of warm absorbers (McKernan et al. 2007; Laha et al. 2014) are observed. In ultraviolet (UV) and optical bands, broad absorption line (BAL) outflows (Mehdipour et al. 2023b; Temple et al. 2023), ionized (Fischer et al. 2013; Rojas et al. 2020; Ruschel-Dutra et al. 2021) and neutral outflows (Rupke et al. 2005, 2017; Fluetsch et al. 2021) are identified. In the near/mid-infrared (IR) band, warm ionized (Müller-Sánchez et al. 2011; Bianchin et al. 2022), hot molecular (Davies et al. 2014; Riffel et al. 2023), and dusty outflows¹ (López-Gonzaga et al. 2016; Hönig 2019) are detected. In the far-IR and submillimeter range, warm OH (Stone et al. 2016; González-Alfonso et al. 2017) and cold molecular outflows (Cicone et al. 2014; Janssen et al. 2016; Lutz et al. 2020) are observed. In the radio domain, H I neutral outflows (Morganti et al. 2005, 2016) and relativistic jets (Rafferty et al. 2006; Smolčić et al. 2017) are identified. Given the fast nature of UFOs ($\sim 0.1\text{--}0.3c$) launched from the proximity of an SMBH ($\sim 10\text{--}100r_s$; r_s being the Schwarzschild radius), a comparative analysis of UFOs and outer multiphase outflows becomes imperative to comprehend the energetics of multiscale outflows.

Fiore et al. (2017) conducted an investigation of multiphase outflows (UFOs, BALs, optical ionized outflows, and warm/cold molecular outflows) by compiling multi-wavelength observations of 94 AGN host galaxies at red-

shifts $z \sim 0\text{--}6$. They identified scaling relationships between outflow properties, AGN characteristics, and host galaxy properties, such as outflow rates, AGN luminosities, and star-formation rates. However, owing to differing outflow types in various samples, the energetic aspects of individual object multiphase outflows remained unclear. Numerous studies (e.g., Tombesi et al. 2015; Mizumoto et al. 2019b; Nardini & Zubovas 2018; Smith et al. 2019; Bonanomi et al. 2023) have investigated the relationships between outflow rates and velocities (or distances from the center) of multiphase outflows, revealing substantial dispersions in these parameters. To discern potential physical relationships, constructing a larger sample of AGNs with multiphase outflows and comparing its properties with those of outflows, AGNs, and host galaxies is imperative.

Furthermore, in the realm of X-ray outflows, the relationship between UFOs and warm absorbers remains an open question. The fundamental properties of these outflows are dictated by their velocities (V_{out}) and ionization parameters (ξ) and the hydrogen column densities of the ionized gas (N_{H}). The ionization parameter is defined as $\xi = L_{\text{ion}}/n_{\text{H}}r^2$, where L_{ion} represents ionizing luminosity in the 13.6 eV to 13.6 keV band or the 1–1000 Ryd range, n_{H} is the hydrogen number density, and r is the distance from the source. Some theoretical models predict a positive correlation between V_{out} and ξ for X-ray winds (i.e., UFOs and outflowing warm absorbers) in scenarios such as the radiative-driven wind model (see e.g., King & Pounds 2003; King 2010) and magnetohydrodynamically (MHD) driven model (e.g., Blandford & Payne 1982; Fukumura et al. 2010, 2017). While prior X-ray observations of approximately 50 X-ray winds in several tens of AGNs (e.g., Tombesi et al. 2013a; Laha et al. 2014) support a positive correlation, elucidating the impact of observational biases and direct connection between UFOs and warm absorbers remains challenging. Thus, expanding the sample size of X-ray winds is crucial for mitigating observational biases and comprehensively understanding their structure.

To amass the largest database of UFOs and larger-scale multiphase outflows, we initiated the X-ray Winds In Nearby-to-distant Galaxies (X-WING) project. The X-WING sample comprises AGNs exhibiting X-ray winds (UFOs and warm absorbers). It encompasses AGNs with warm absorbers where UFOs have not been detected, as they can also be potential candidates for AGNs with UFOs, some of which may be detectable via high-resolution X-ray spectroscopy with the X-Ray Imaging and Spectroscopy Mission (XRISM) launched in September 2023. We intend to present a comprehensive database of AGN multiphase outflows, along

¹ While dust emission displaying no emission/absorption lines makes it challenging to measure its velocity, some studies suggest that polar dust are outflowing by optical spectropolarimetry (Yoshida et al. 2011) and IR emission models (e.g., Hönig & Kishimoto 2017; Stalevski et al. 2019; Venanzi et al. 2020; Alonso-Herrero et al. 2021; Yamada et al. 2023).

with host galaxy properties, across three papers. This database will facilitate investigations into the structures, driving mechanisms, and energetics of X-ray winds and other multiphase outflows.

In this study (Paper I), we meticulously examined previous studies on X-ray winds, presenting the most extensive database of outflow parameters for 576 X-ray winds in 132 AGNs to date and discussing their characteristics. The subsequent sections are organized as follows. Section 2 details X-WING and X-ray wind databases. Section 3 reports X-ray wind properties (V_{out} , ξ , and N_{H}) and potential biases in our results (Sections 3.1–3.3). Section 3.4 explores the location and driving mechanism of X-ray winds, while Section 3.5 discusses anticipated new findings using XRISM. Finally, Section 4 summarizes the main conclusions. Paper II will present UV-to-radio spectral energy distribution (SED) fitting results and compare AGN and host activities with X-ray wind outflow rates. Paper III will present a catalog of multiphase outflow rates and discuss the energetics of all outflows (S. Yamada et al., in preparation). Throughout this study, $\log V_{\text{out}}$, $\log \xi$, and $\log N_{\text{H}}$ represent the logarithms of V_{out} , ξ , and N_{H} in km s^{-1} , $\text{erg s}^{-1} \text{ cm}$, and cm^{-2} , respectively. We adopt the cosmological parameters $H_0 = 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$, $\Omega_{\text{M}} = 0.3$, and $\Omega_{\Lambda} = 0.7$.

2. SAMPLE AND X-RAY WIND CATALOG

2.1. X-WING AGNs

We attempted to identify all galaxies wherein X-ray winds (UFOs and outflowing warm absorbers) were reported by the end of 2023, as detected by their X-ray blueshifted ionized absorption lines. In this study, we focused on the X-ray instruments utilized to identify X-ray winds over the past 20 years. (1) Chandra/High Energy Transmission Grating Spectrometer (HETGS), (2) Chandra/Low Energy Transmission Grating Spectrometer (LETGS), (3) Chandra/Advanced CCD Imaging Spectrometer (ACIS), (4) XMM-Newton/Reflection Grating Spectrometer (RGS), (5) XMM-Newton/European Photon Imaging Camera (EPIC) PN, (6) XMM-Newton/EPIC MOS, (7) Nuclear Spectroscopic Telescope Array (NuSTAR)/Focal Plane Modules (FPM), (8) Suzaku/X-ray Imaging Spectrometer (XIS), and (9) Swift/X-Ray Telescope (XRT). The description and performance of these instruments are summarized in Appendix A.1 and Table A1. Based on studies using these instruments, we first referred to the following papers.

1. Tombesi et al. (2010a, 2011a, 2012a, 2013a): UFOs detected with XMM-Newton/PN and/or

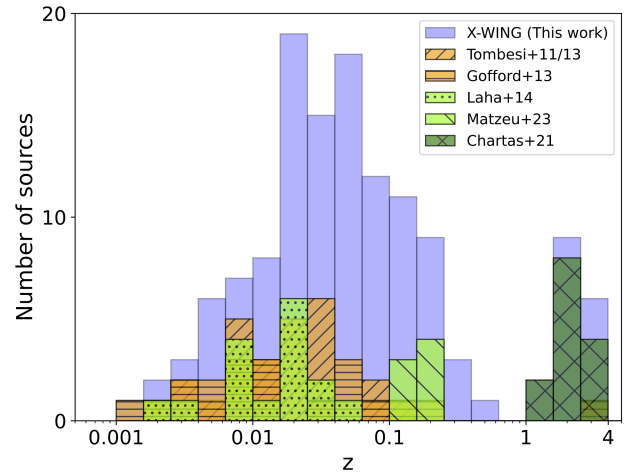


Figure 1. Histogram of redshift for the whole X-WING sample, compared with the sample of Tombesi et al. (2011a, 2013a), Gofford et al. (2013), Laha et al. (2014), Matzeu et al. (2023), and Chartas et al. (2021).

outflowing warm absorbers reported in the prior studies with Chandra/HETGS, LETGS, XMM-Newton/RGS, PN, and MOS, in 26 out of 42 local radio-quiet AGNs;

2. Gofford et al. (2013, 2015): UFOs detected with Suzaku/XIS in 20 out of 51 local AGNs;
3. Laha et al. (2014, 2016): outflowing warm absorbers detected with XMM-Newton/RGS and PN in 16 out of 26 local AGNs;
4. Matzeu et al. (2023): UFOs in the $0.1 \lesssim z \lesssim 0.4$ galaxies detected with XMM-Newton/PN and MOS in 7 out of 22 sources, as part of the Supermassive Black hole Winds in the x-rAYS (SUBWAYS) program;
5. Chartas et al. (2021) reported the detection of UFOs using Chandra/ACIS and XMM-Newton/PN and MOS in a sample of 14 Quasistellar Objects (QSOs), with 12 of them being lensed QSOs. These objects span a redshift range of 1.41–3.91.

In these studies, the significance thresholds of UFO detections utilized are typically at $\gtrsim 3\sigma$ level, except for some sources ($\sim 2\sigma$, see Section 2.2). In addition to the works, various systematic surveys (e.g., McKernan et al. 2007; Patrick et al. 2012; Tombesi et al. 2014; Mehdipour & Costantini 2019) have contributed to our understanding of the field. Following this, we conducted a comprehensive review of previous investigations into X-ray

winds using data from Chandra, XMM-Newton, NuSTAR, Suzaku, and Swift, spanning the period from approximately 2000 to 2023. From a compilation of 287 papers, we identified 132 galaxies within the redshift range of $z \sim 0-4$, as detailed in Appendix B and Table B2. For a subset of six out of the 132 AGNs, blueshifted absorption lines were not discerned through spectral fitting but were detected using spectral variability, as reported by Igo et al. (2020). This study estimated the outflow velocities (V_{out}) for several tens of targets, and we referenced their findings solely for the six AGNs categorized as X-WING candidates in Table B2. To provide context, Figure 1 compares the redshift distribution of X-WING AGNs with those from prior studies. Notably, our sample size is 4–10 times larger than those in previous systematic surveys, owing to extensive follow-up observations of X-ray winds over the past 20 years.

In addition, we present an overview of the fundamental properties of these designated targets. The redshifts and luminosity distances (D_L) were predominantly obtained from the CDS Portal (derived from SIMBAD)². For nearby objects within a distance of <50 Mpc, we referenced the most recent redshift-independent distances as determined by Koss et al. (2022a).

To categorize their optical AGN types, we employed a classification system distinguishing between narrow-line Seyfert 1 (NLSy1), Seyfert 1.0, 1.2, 1.5, 1.8, 1.9, and 2.0 for local AGNs, and high- z QSOs for AGNs at $z > 1$ (e.g., Véron-Cetty & Véron 2010). The determination of the black hole masses (M_{BH}) was primarily grounded in reverberation mapping studies (e.g., Woo & Urry 2002; Bentz & Katz 2015; Du et al. 2015; Bentz et al. 2023; Woo et al. 2024), assuming a standard virial factor of 4.3 (Grier et al. 2013) for measurements relying on the velocity dispersions of broad emission lines (e.g., $H\beta$). In instances where M_{BH} was unspecified, we consulted the values adopted in the BAT AGN Spectroscopic Survey (BASS) project (Koss et al. 2022a,b) or references focusing on X-ray winds.

We have compiled the observed 2–10 keV fluxes (F_{2-10}) and intrinsic (deabsorbed) 2–10 keV luminosities (L_{2-10}) for our designated targets, primarily from the BASS catalog (Ricci et al. 2017a) and XMM-Newton works (e.g., Bianchi et al. 2009), as the typical or time-averaged fluxes. It is noteworthy that approximately 10% of our targets were classified as changing-look AGNs, demonstrating substantial alterations in optical types and/or significant variations in line-of-sight N_{H} (Lyu et al. e.g., 2022; also refer to Noda & Done

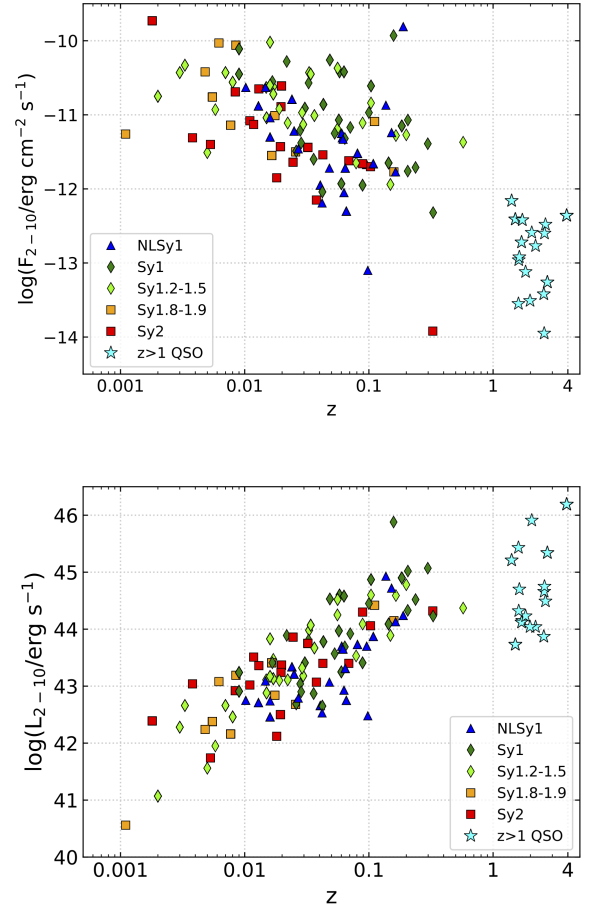


Figure 2. (Top) logarithmic observed 2–10 keV flux (F_{2-10}) vs. z . (Bottom) logarithmic intrinsic AGN luminosity in the 2–10 keV band (L_{2-10}) vs. z . Symbols mark optical classification of NLSy1 (blue triangle), Seyfert 1.0 (green diamond), 1.2–1.5 (light-green diamond), 1.8–1.9 (orange square), 2.0 (red square), and $z > 1$ QSOs (cyan star).

2018; Ricci & Trakhtenbrot 2023). Detailed discussions on these changing-look AGNs will be provided in X-WING Paper II.

For QSOs with redshifts exceeding 1, the 2–10 keV flux (F_{2-10}) was not adjusted for lensing magnification. In contrast, corrected values were applied for L_{2-10} and L_{ion} , considering the magnification factors stipulated in Chartas et al. (2007b, 2021). All luminosities cited in the references were transformed into values under the assumption that D_L was employed. We also examined the reported number of X-ray winds (refer to Section 2.2) and investigated the presence or absence of UFOs (where $V_{\text{out}} \geq 10,000$ km s^{−1}; see Section 3.1). In conclusion, these findings have been succinctly summarized in Table B2.

² <http://cdsportal.u-strasbg.fr/>

To date, X-WING is the largest catalog of AGNs with X-ray winds (see Figure 1). Figure 2 shows the $\log F_{2-10-z}$ and $\log L_{2-10-z}$ plots. The X-WING AGNs cover a wide range of F_{2-10} ($\sim 10^{-14}$ – $10^{-9.5}$ erg cm $^{-2}$ s $^{-1}$), L_{2-10} ($\sim 10^{40}$ – 10^{46} erg s $^{-1}$), and redshifts (~ 0 – 4). Therefore, the X-WING database reduces detection biases, helping us to understand the general properties of X-ray winds.

2.2. X-ray Winds

In Table B3, we have presented data on 576 X-ray winds, including their outflow parameters: V_{out} , ξ , and N_{H} (refer to Section 1). We have also endeavored to compile L_{ion} values. The determination of photoionization parameters in previous studies followed the expression $U = Q/(4\pi r^2 n_e)$, where Q represents the ionizing photon rate, r is the distance from the source, and n_e is the electron density (Netzer 1987, 1996). For 40 out of the 576 X-ray winds, we employed an assumed conversion between $\log U$ and $\log \xi$ using the relation $\log U = \log \xi - 1.75$, based on a typical AGN SED (e.g., Proga & Kallman 2004). Additionally, Table B3 provides information on the start dates of observations, the instruments employed for line detection, outflow types of the X-ray winds (discussed in Section 3.1), the chosen X-ray wind model (refer to Appendix A.2), and the methodology for line detection, whether with or without the Fe XXV He α (6.697 keV)/Fe XXVI Ly α (6.966 keV) lines (refer to Section 3.3). For all X-ray winds, individual OBSIDs underwent scrutiny, and in cases where outflows were reported redundantly, priority was given to the most recent or detailed analyses, which often involved broadband spectra and the latest X-ray models. Finally, we have compiled a summary of the OBSIDs, including references and pertinent papers on duplicated reports, in Table B4.

Verification was conducted to ensure that nearly all reported winds were accounted for in the 287 references by identifying the presence of blueshifted absorption lines. However, assessing the significance of these absorption lines proved challenging due to variations in the methodology employed for line detection across the references (refer to Appendix A). In this investigation, we meticulously compiled data on all potentially existing X-ray winds within our catalog. Despite its limited occurrence, the catalog encompasses values associated with $\sim 2\sigma$ line detection (as exemplified by Lanzuisi et al. 2016) and V_{out} for the six X-WING candidates (outlined in Section 2.1). For most of the X-WING candidates, only V_{out} were constrained but not ξ and N_{H} .

We also presented additional information on the uncertain wind candidates selected by three primary crite-

ria. Initially, we classified Compton-thick (CT) AGNs with a column density of neutral absorbers exceeding 10^{24} cm $^{-2}$ as highly ambiguous candidates. This classification arises due to the potential artifacts caused by strong Fe K α line and Fe-K edge features. Using the results from broad X-ray spectral fittings (e.g., Ricci et al. 2017a; Yamada et al. 2021), we identified two CT AGNs, NGC 1068 and NGC 6240 in our sample. These AGNs exhibit complex X-ray spectra due to the multi-layer absorption (NGC 1068; Bauer et al. 2015) and mixed emission from two AGNs (NGC 6240; Puccetti et al. 2016). Secondly, we scrutinized AGNs whose X-ray wind features were low significance (i.e., $\sim 2\sigma$ levels), PG 1202+281 (Matzeu et al. 2023) and PG 1247+268 (Lanzuisi et al. 2016). The significance of the absorption line in PG 0844+349 is also controversial (Pounds et al. 2003a; Brinkmann et al. 2006). Finally, we investigated cases with no explicit discussion of the detection significance. Considering the look-elsewhere effect, it would be challenging to indicate how much these winds are reliable. These sources should be considered as AGNs with uncertain X-ray winds, denoted by “(*)” in column (10) of Table B2. Notably, these AGNs (18) and their X-ray wind detections (24) represent a small fraction (13.6% and 4.2%) of the entire sample. To reduce the impact of the look-elsewhere effect on the wind detection significance as much as possible, we primarily referred to the results for the entire sample based on the X-ray spectral fitting with the ionized absorber models (e.g., XSTAR and SPEX; see Appendix A.2), which can detect the multiple absorption line features. For a more quantitative evaluation, we plan to reanalyze all the archival data in the entire sample by a uniformed method with a simple Gaussian model, XSTAR, and SPEX (S. Yamada et al., in preparation). The main conclusions of this study are nearly unchanged regardless of the presence of a small fraction of low-significance winds, and we thus utilize the whole sample in the following analysis.

Since we referred to the wind parameters from the various previous works, this study does not present a secured wind catalog but provides the largest database of X-ray wind candidates to date. The primary strength of this catalog lies in its ability to provide a more comprehensive representation of the general characteristics of X-ray winds, which have been extensively surveyed over time with X-ray instruments, in comparison to previous works. To enhance clarity, whenever literature presented 1σ errors, we standardized them to values at the 90% confidence level by applying a multiplication factor of 1.645. Consequently, all errors and upper/lower limits in this study are consistently presented at the 90% confidence level.

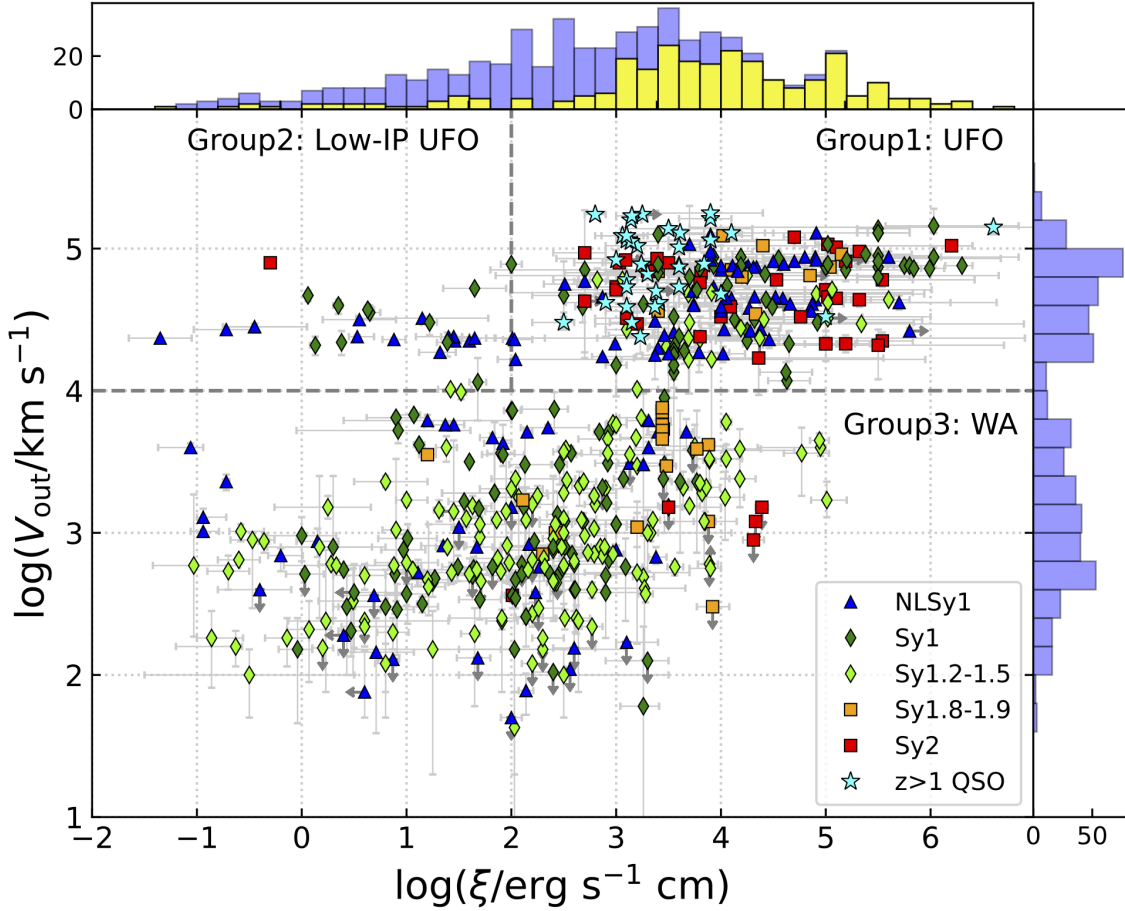


Figure 3. Logarithmic V_{out} vs. logarithmic ξ . Symbols indicate the optical classification. Dashed lines show the thresholds of the three groups of X-ray winds: UFO, low-IP UFO, and warm absorber (WA). The top and right histograms indicate the distributions of the parameters. The yellow histogram represents the UFOs and low-IP UFOs (i.e., with $\log V_{\text{out}} \geq 4$).

3. RESULTS AND DISCUSSION

3.1. X-ray Wind Properties

To comprehend the characteristics of X-ray winds in the X-WING catalog, we have generated three comparison plots illustrating the relationships between the three outflow parameters (V_{out} , ξ , and N_{H}) in Figures 3 and 4. The data points representing the winds are categorized based on optical AGN types: narrow-line Seyfert 1 (NLSy1), Seyfert 1.0, 1.2–1.5, 1.8–1.9, 2.0, and $z > 1$ type-1 QSOs. Notably, Seyfert 1.8–2.0 galaxies exhibit large values at V_{out} , ξ , and N_{H} . Conversely, NLSy1 and Seyfert 1.0–1.5 demonstrate broader distributions across these parameters. It is worth considering that many Seyfert 1.8–2.0 galaxies host obscured AGNs with high inclination angles, making it challenging to detect their warm absorbers with low ξ and N_{H} in the soft X-ray band. This difficulty arises because soft X-ray fluxes are often heavily obscured by neutral absorbers in the broad-line regions (BLRs) and dusty tori. A similar de-

tection bias may be introduced for high- z QSOs, as the rest-frame soft X-rays become invisible due to redshift. Despite the potential bias introduced by these sources, we have verified that even excluding these sources from the following analysis (Seyfert 1.8–2.0 galaxies and high- z QSOs), the primary outcomes in this study remain unaltered.

High-luminosity AGNs with $L_{2-10} > 10^{44}$ erg s $^{-1}$ at $z < 1$ have a similar distribution in wind parameters to the high- z QSOs, with the advantage of also having low-velocity measurements, which are precluded to high- z QSOs. We found a possibility that they have a higher fraction of UFOs relative to the low-velocity winds compared with lower-luminosity AGNs. We will present proper bolometric AGN luminosities (L_{bol}) by the multiwavelength SED analysis and discuss the potential dependence of the L_{2-10} , L_{bol} , and Eddington ratio (λ_{Edd}) on the wind parameters in Paper II.

In the $\log V_{\text{out}} - \log \xi$ plot (Figure 3), we found a double-peaked distribution of V_{out} (see also Section 3.3). For

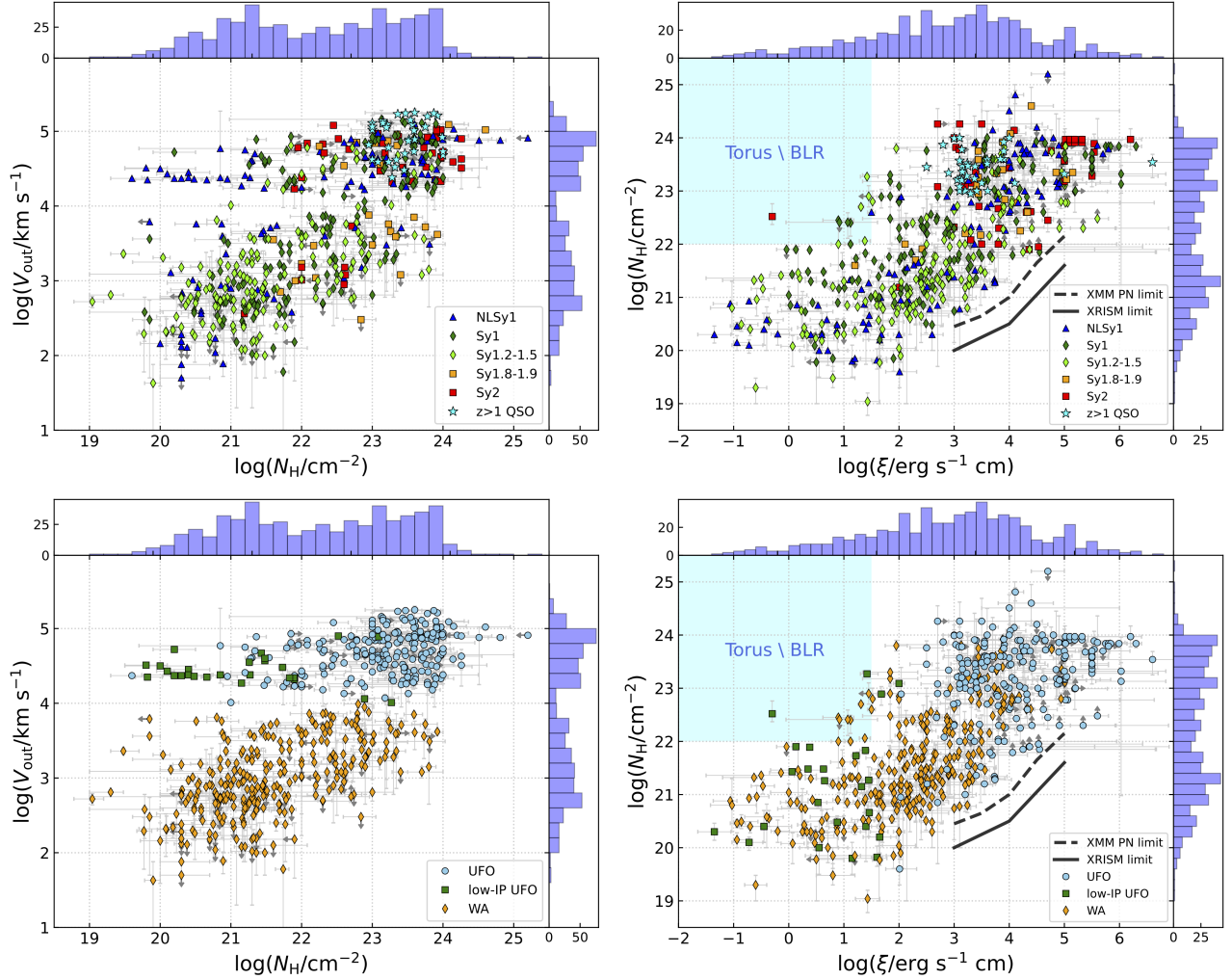


Figure 4. (Top-left) $\log V_{\text{out}}$ vs. $\log \xi$. (Top right) $\log N_{\text{H}}$ versus $\log \xi$. Symbols indicate the optical classification. The cyan region shows typical values for BLRs or tori. (Bottom-left) $\log V_{\text{out}}$ vs. $\log \xi$. (Bottom right) $\log N_{\text{H}}$ versus $\log \xi$. Symbols mark the outflow groups: UFO, low-IP UFO, and WA, as classified in Figure 3.

the distribution of $\log(V_{\text{out}}/\text{km s}^{-1}) > 4$ (yellow histogram), most winds have $\log(\xi/\text{erg s}^{-1} \text{ cm}) \geq 2$. For convenience, we categorized X-ray winds into three groups:

- (1) UFOs, with $\log V_{\text{out}} \geq 4$ and $\log \xi \geq 2$;
- (2) low-ionization-parameter (low- ξ or low-IP) UFOs, with $\log V_{\text{out}} \geq 4$ but $\log \xi < 2$;
- (3) and warm absorbers, with $\log V_{\text{out}} < 4$.

While the term “warm” absorbers conventionally denote ionized gas at a temperature of approximately $\sim 10^5$ K higher than cold neutral gas yet considerably cooler than the thermal plasma (e.g., Reynolds & Fabian 1995), our study extends this definition to encompass absorbers at both higher and lower temperatures, characterized solely by their modest V_{out} . In a seminal work, Tombesi

et al. (2013a) highlighted a potential correlation between $\log V_{\text{out}}$ and $\log \xi$ within X-ray winds (UFOs and warm absorbers) across 35 Seyfert 1 galaxies. Subsequently, Laha et al. (2014) conducted a follow-up investigation focusing on warm absorbers in 26 Seyfert galaxies. Their findings revealed a shallow slope in the $\log V_{\text{out}} - \log \xi$ linear regression, deviating from the distribution observed for UFOs. Both studies acknowledged the potential influence of observational biases stemming from instrumental performance, such as energy resolution and detection sensitivities. Recent research has unveiled the existence of low-IP UFOs (as seen in, e.g., Gupta et al. 2013a; Serafinelli et al. 2019), introducing complexity to their distribution. Even with the exclusion of low-IP UFOs, our outcomes reveal a substantial dispersion of X-ray winds within the X-WING AGNs. Similarly, the distribution in the $\log V_{\text{out}} - \log N_{\text{H}}$ plane (left panels of

Figure 4) does not imply a straightforward linear correlation, even upon excluding low-IP UFOs exhibiting $\log V_{\text{out}} > 4$ and $\log(N_{\text{H}}/\text{cm}^{-2}) \lesssim 22$ (also evident in the right-bottom panel).

Certain investigations posit that low-IP UFOs may originate in proximity to the SMBH and extend to a larger scale of approximately ~ 100 pc (e.g., [Serafinelli et al. 2019](#)). Notably, low-IP UFOs exhibit small ionization parameters (ξ) (proportional to r^{-2} or indicative of substantial distances) and hydrogen column densities (N_{H}) even at high velocities exceeding $10,000 \text{ km s}^{-1}$. The low-IP UFOs are detected in NLSy1 and Seyfert 1 galaxies, except for 1ES 1927+654, a Seyfert 2 galaxy exhibiting little X-ray obscuration ([Gallo et al. 2013](#)).

In contrast to the $\log V_{\text{out}}\text{--}\log \xi$ and $\log V_{\text{out}}\text{--}\log N_{\text{H}}$ plots, the distribution of $\log \xi\text{--}\log N_{\text{H}}$ (depicted in the right panels of Figure 4) exhibits a potential linear correlation. Nonetheless, the dispersion of N_{H} within each ξ bin (approximately 3–4 dex) surpasses that observed in prior studies (around 2 dex; e.g., [Tombesi et al. 2013a](#)). This variance likely hinges on observational biases. Here, we examine two biased regions characterized by low- ξ ($\lesssim 10^3 \text{ erg s}^{-1} \text{ cm}$) and high- ξ ($\gtrsim 10^3 \text{ erg s}^{-1} \text{ cm}$) lines, detectable in the $\lesssim 2 \text{ keV}$ and $\sim 6 \text{ keV}$ bands, respectively (see e.g., [Gallo et al. 2023](#)). The cyan-shaded region, indicative of low ξ and high N_{H} , is dominated by clouds optically thicker than typical X-ray winds, essentially comprising BLRs or tori. Consequently, absorption line features are scarce due to the obscuration of the soft continuum in the presence of such clouds in the line of sight (e.g., Seyfert 2). For these obscured AGNs, challenges arise in identifying X-ray winds due to the contribution of optically thin thermal emission from the plasma in the host galaxy ([Smith et al. 2001](#)) and AGN-scattered emission (e.g., [Kawamuro et al. 2016](#); [Gupta et al. 2021](#)). Conversely, in the vacant area, the lines corresponding to high- ξ and low- N_{H} are weak in the $\gtrsim 6 \text{ keV}$ band. This weakness stems from the low N_{H} of ionized gas, resulting in feeble line features, potentially observed as “bare” AGNs (e.g., [Walton et al. 2013](#); [Nandi et al. 2023a](#); [Porquet et al. 2024](#)). A recent X-ray simulation of the radiation-hydrodynamic AGN model ([Wada et al. 2016](#); [Ogawa et al. 2022](#)) also indicates that edge-on (low- ξ /high- N_{H}) and face-on (high- ξ /low- N_{H}) AGNs display no visible absorption lines, whereas AGNs with moderate inclination angles exhibit absorption features. In our sample, where X-ray winds were predominantly detected in AGNs with moderate inclination angles, no distinct variations were noted in the distributions among optical types (Seyfert 1–2). This implies that the dependence of AGNs on inclination angle is not stringent. In

essence, the $\log \xi\text{--}\log N_{\text{H}}$ distribution primarily underscores rough disparities between edge-on, face-on, and other AGNs, with the breadth of the distribution of detected X-ray winds being determined by detection sensitivity (see Section 3.2).

3.2. Detection Biases

To assess the observational biases of X-ray winds in the X-WING catalog attributed to instrumental performance (energy resolution and detection sensitivities), we categorized plots for the three parameters (V_{out} , ξ , and N_{H}) based on the X-ray instruments (refer to Figure 5). Following [Kaastra et al. \(2014a\)](#), the signal-to-noise (S/N) ratio for line detection is calculated as:

$$\text{S/N} = \sqrt{A(E)tF(E)} \times W / \sqrt{\max(\Delta E, W)}, \quad (1)$$

where $A(E)$ denotes the effective area, t is the exposure time, $F(E)$ is the photon flux, W represents the equivalent width (EW), and ΔE is the energy resolution of the instruments. The value of $\sqrt{A(E)/\Delta E}$ ($\propto \text{S/N}$ for weak lines with $W \lesssim \Delta E$) mirrors the instruments’ capability to detect absorption lines. Consequently, it is anticipated that weak lines are most easily detectable with Chandra/HETGS and XMM-Newton/RGS in the $\sim 1 \text{ keV}$ band, and with XMM-Newton/PN, MOS, and Suzaku/XIS in the $\sim 6 \text{ keV}$ band (refer to Appendix A and Table A1).

For winds exhibiting $\log \xi \gtrsim 4$ or $\log N_{\text{H}} \gtrsim 23$, the determination of small V_{out} values was restricted by XMM-Newton/PN, MOS, and Suzaku/XIS, with many of these values presented as upper limits ($\log V_{\text{out}} \lesssim 3$; refer to the top and bottom left panels of Figure 5). Using the equation for the line shift of an outflow in the rest-frame, $z_{\text{out}} = \sqrt{(1 + V_{\text{out}}/c)/(1 - V_{\text{out}}/c)} - 1$ (e.g., [Danehkar et al. 2018b](#)), the line energies of Fe XXV He α and Fe XXVI Ly α ($E_{\text{rest}} = 6.70\text{--}6.97 \text{ keV}$) are blueshifted to $E = 6.72\text{--}6.99 \text{ keV}$ if $\log(V_{\text{out}}/\text{km s}^{-1}) \sim 3$. Given that some studies reported the presence of ionized absorbers with no velocity shift (e.g., [Blustin et al. 2005](#); [Tombesi et al. 2013a](#); [Laha et al. 2014](#)), the observational biases could impact the detection of slower winds in the $\log V_{\text{out}} \lesssim 3$ region (with $\log \xi \gtrsim 4$ or $\log N_{\text{H}} \gtrsim 23$) due to the limited energy resolutions of XMM-Newton and Suzaku (130 eV; see Table A1).

In Section 3.1, we delve into potential biased regions in the $\log \xi\text{--}\log N_{\text{H}}$ plot. The winds located in the upper-left region (cyan-shaded area) in the bottom-right panel of Figure 5 pose challenges in detection due to soft X-ray obscuration caused by neutral absorbers. Conversely, the winds in the lower-right region are expected to be invisible, marked by weak lines with small N_{H} . To assess the detection limits, we computed the expected limits for ionized absorption lines using XMM-Newton/PN

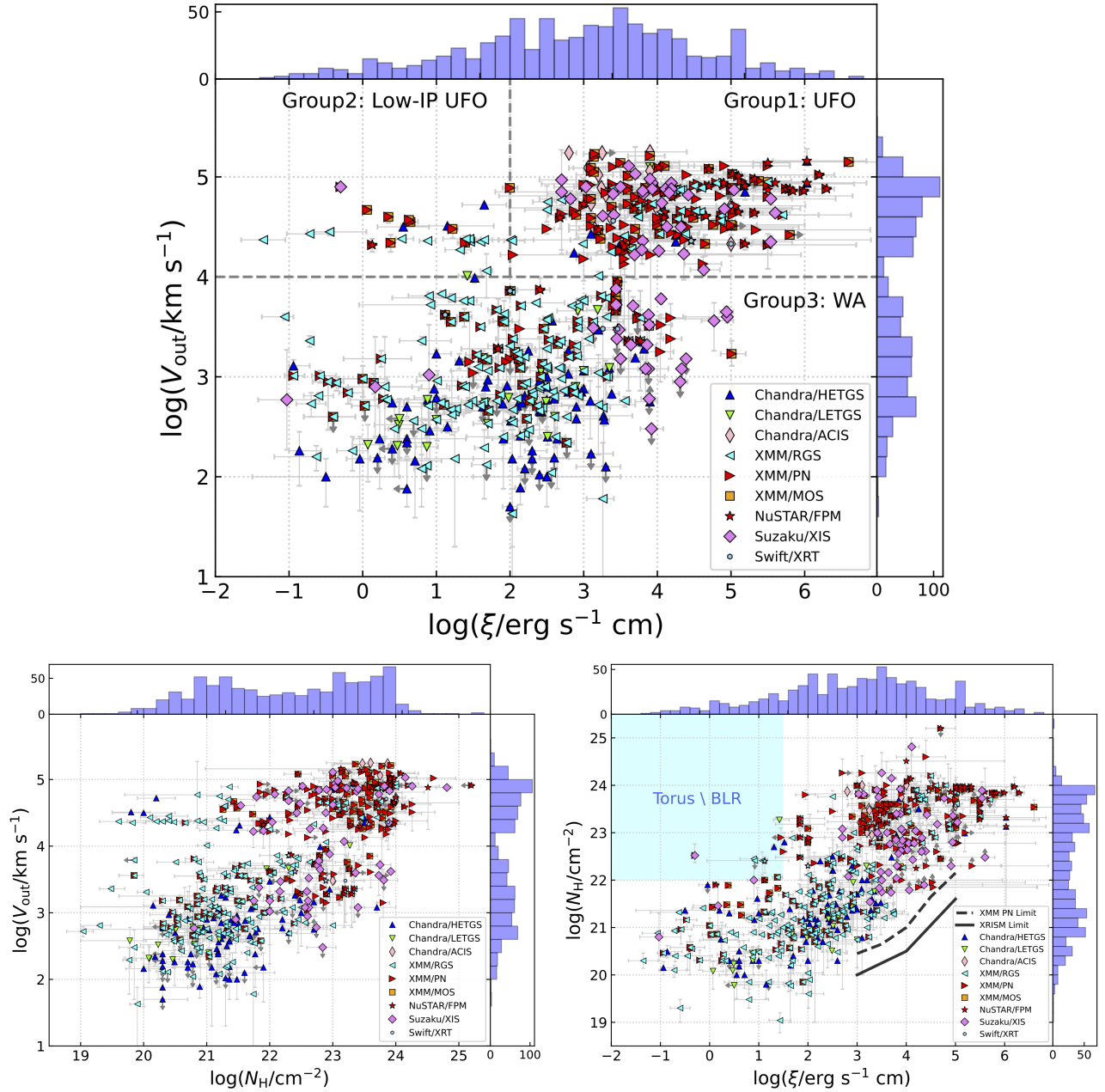


Figure 5. Same as in Figures 3 and top panels of Figure 4, but symbols mark the instrument of observations of X-ray outflows. The dashed and solid curves indicate the simulated limitations of the 3σ detection of the X-ray winds with XMM-Newton/PN and XRISM/Resolve, respectively.

and compared them with simulations for the latest instrument, XRISM/Resolve. Given the complexity of spectral features in the soft X-ray band, arising from numerous unresolved absorption lines in the cyan region due to ionized absorbers with low ξ and high N_{H} , we specifically simulated detection limits for winds with high ξ and low N_{H} . The S/N ratio of line detection was determined using Equation 1. We adopted an instrumental performance ($A(E) = 210 \text{ cm}^2$ and $\Delta E = 5 \text{ eV}$)

detailed in Appendix A and assumed observational settings (exposure time and photon flux) based on a nearby ($D_{\text{L}} = 19.0 \text{ Mpc}$) Seyfert 1.5 galaxy NGC 4151, one of the brightest X-ray sources in the X-WING sample, selected as an early release target for XRISM observations. The 2–10 keV flux is $5 \times 10^{-11} \text{ erg s}^{-1} \text{ cm}^{-2}$ (Ricci et al. 2017a), and $t = 180 \text{ ksec}$. A typical photon index of 1.8 (Ueda et al. 2014; Ricci et al. 2017a) was assumed for the conversion between the photon

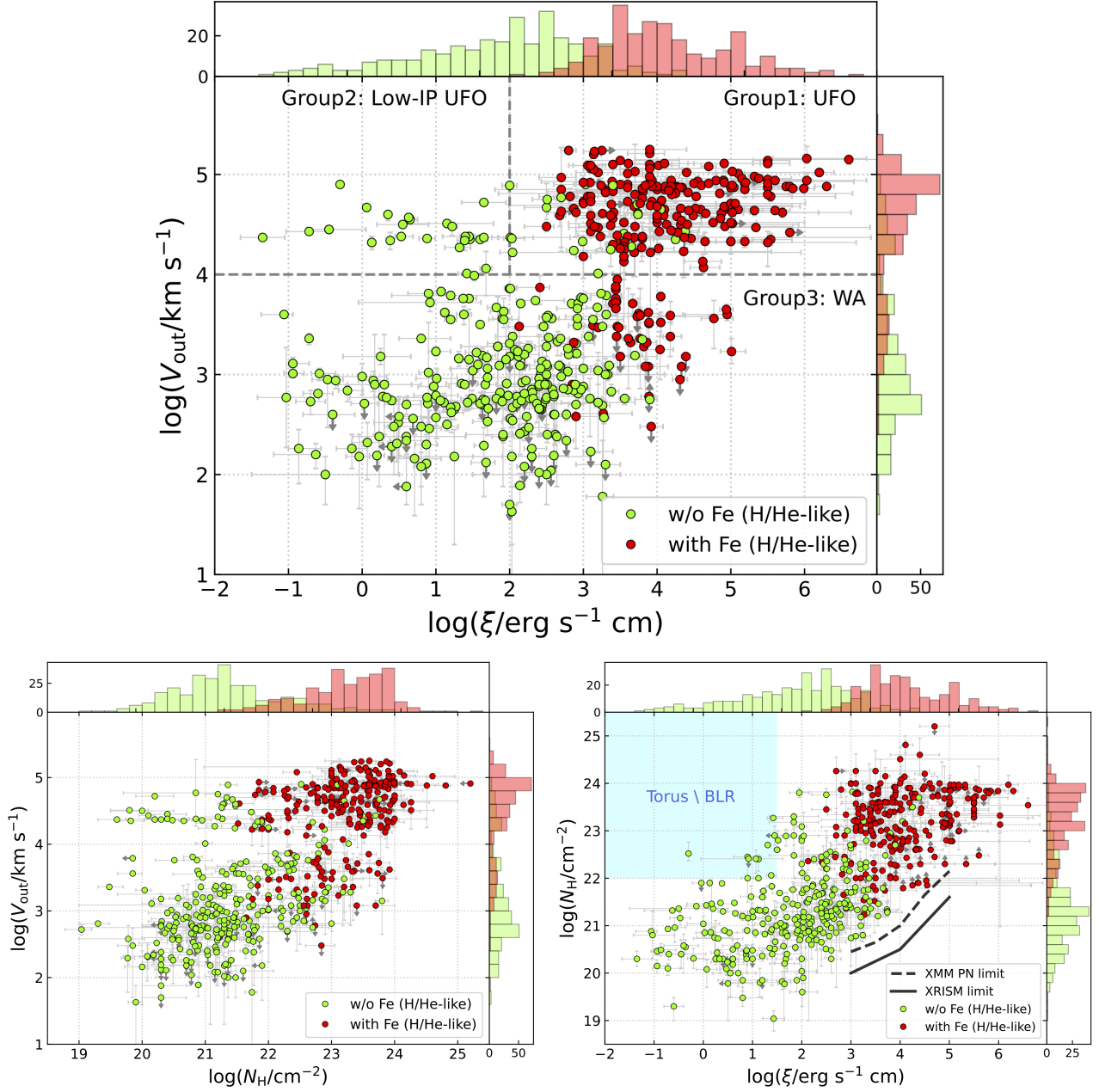


Figure 6. Same as in Figure 5, but the symbols mark the methods of the detection of X-ray winds, utilized by the blueshifted Fe-K absorption lines Fe XXVI Ly α and Fe XXV He β above the rest-frame 6 keV band (red) or blueshifted absorption lines below the 6 keV band (light green).

flux and the observed 2–10 keV flux. The EWs of Fe XXV He α and Fe XXVI Ly α in the ranges $\log \xi = 3\text{--}5$ and $\log N_{\text{H}} = 20\text{--}24$ were simulated using the XSPEC model `mtable{xout_mtable.fits}*powerlaw`. The `mtable{xout_mtable.fits}` is the ionized absorption model generated by Ogawa et al. (2021) with XSTAR version 2.54a (Kallman & Bautista 2001; Bautista & Kallman 2001). The larger EWs from the two lines were utilized in each $\log \xi$ and $\log N_{\text{H}}$ bin. Based on these values,

we plotted the 3σ detection limit curves using XMM-Newton/PN (dashed line) and XRISM/Resolve (solid line) in the bottom panel of Figure 5. The limits of XMM-Newton/PN align with the plotted data (red triangles), suggesting that the X-ray winds reported in previous works are influenced by the detection bias. The detection limit curve (solid line) indicates a reduction in this bias with XRISM.

To summarize, our catalog reveals that observational biases have influenced the analysis of X-ray winds in two distinct ways. Firstly, slow winds ($\log V_{\text{out}} \lesssim 3$) with $\log \xi \gtrsim 4$ or $\log N_{\text{H}} \gtrsim 23$ remain unexplored due to limitations in energy resolution. Secondly, the $\log \xi$ – $\log N_{\text{H}}$ distribution solely represents the detectable region of X-ray winds (also discussed by Tombesi et al. 2013a), aligning with expectations based on the instrumental performances of line detections (specifically, $\sqrt{A(E)/\Delta E}$). These biases exhibit apparent correlations with the outflow parameters. Whether the existence of empty regions is attributed to detection bias or intrinsic characteristics, our data indicate that simple linear correlations cannot be universally applied to all targets.

The considerable dispersion observed among the outflow parameters (V_{out} , ξ , and N_{H}) may be attributed to their dependence on additional factors, such as inclination angles, AGN luminosities, and M_{BH} . Some observations suggest clear correlations among the outflow parameters of specific objects (as seen in Pounds & King 2013). Given the diverse measurement methodologies employed in our catalog, further investigations into the systematic spectral analysis of X-WING sources using a standardized approach are essential to explore potential object-specific physical correlations.

3.3. Is the Velocity Gap Real?

We thoroughly examine the observational biases associated with the outflow parameters, taking into account both AGN types (Section 3.1) and instrumental constraints, namely, energy resolution and effective area (Section 3.2). Despite these considerations, our data, as depicted in Figures 3 and 5, reveal a compelling phenomenon—a conspicuous gap occurring around $V_{\text{out}} \sim 10,000 \text{ km s}^{-1}$. This phenomenon remains unexplained by the aforementioned biases. In Figure 6, we categorize X-ray winds based on the detection methods employed, specifically those utilizing Fe XXV/Fe XXVI lines (above 6 keV). Strikingly, both methods, utilizing the Fe XXV/Fe XXVI lines (depicted as red circles) and employing other lines in the $\lesssim 2 \text{ keV}$ band (represented by light green circles), consistently indicate the existence of a gap around $\sim 10,000 \text{ km s}^{-1}$ (top and bottom left panels of Figure 6). The origin of this velocity gap between these two detection methods will now be explored.

For X-ray winds detected in the $\lesssim 2 \text{ keV}$ band (or those without the Fe XXV/Fe XXVI lines; represented by light green circles), the observed gap appears to be genuine. Numerous prior studies identified blueshifted lines, as exemplified by the low- ξ UFOs detected with gratings such as Chandra/HETGS, LETGS, and XMM-

Newton/RGS. These detections involved identifying multiple blueshifted lines in the rest-frame 0.5–2 keV band, originating from ions such as C V, C VI, N IV, N V, N VI, N VII, O V, O VI, O VII, O VIII, Ne VII, Ne VIII, Ne IX, Ne X, Si XIV, Fe XVII, Fe XX, and Fe XXI (e.g., Gupta et al. 2013a, 2015; Pounds 2014; Reeves et al. 2018b, 2020; Sanfrutos et al. 2018; Krongold et al. 2021; Xu et al. 2021, 2022). Despite potential complexities in the $A(E)$ functions of these grating arrays (e.g., den Herder et al. 2001; Canizares et al. 2005), the measurement of V_{out} through the identification of sets of blueshifted lines is likely less susceptible to such effects. Given the absence of other artifacts in the $\lesssim 2 \text{ keV}$ band, the observed velocity gap between low-IP UFOs and warm absorbers appears to be authentic. This suggests that the underlying physical mechanisms governing low-IP UFOs and warm absorbers are distinct. For instance, low-IP UFOs might be entrained as clumpy outflows at a scale of $\sim 100 \text{ pc}$ (as proposed by Serafinelli et al. 2019), with velocities possibly reaching the theoretical limit determined by the terminal velocity from the accretion disk (Luminari et al. 2021). However, this scenario does not seem to be a plausible origin for warm absorbers (see Section 3.4).

However, the methodology relying on Fe XXV/Fe XXVI lines might be susceptible to artifacts. The rest-frame energies of the Fe XXV He α (6.966 keV) and Fe XXVI Ly α (6.697 keV) lines with $\log V_{\text{out}} = 4$ are 6.92 keV and 7.20 keV, respectively. Remarkably, the average of these two lines (7.06 keV) aligns precisely with the energy of the Fe K β emission line (7.06 keV) originating from BLRs or tori. This alignment poses challenges for detecting distinct absorption lines with CCD detectors featuring a resolution of $\gtrsim 130 \text{ eV}$ (refer to Table A1). Additionally, the presence of the Fe K-edge at 7.11 keV diminishes the significance of the blueshifted Fe XXVI Ly α absorption line. Such degeneracies make the identification of higher- ξ winds with $\log V_{\text{out}} = 4$ challenging, except in instances where deep absorption lines are detectable (Reeves et al. 2010; Giusini et al. 2011; Walton et al. 2018, 2020). Given that the contribution of Fe K β line and Fe K-edge are less for unobscured AGNs, which are predominant in our sample (e.g., Seyfert 1.0–1.5), these potential artifacts might not be the primary source of these issues. It is cautions that the detection of X-ray winds may be affected by the utilized instruments, models, and potential look-elsewhere effect (see Section 2.2). If these artifacts and potential biases are not the main contributors, the spatial disconnection between UFOs and galactic-scale warm absorbers could be substantial, indicating a possible distinction in their driving mechanisms (refer to

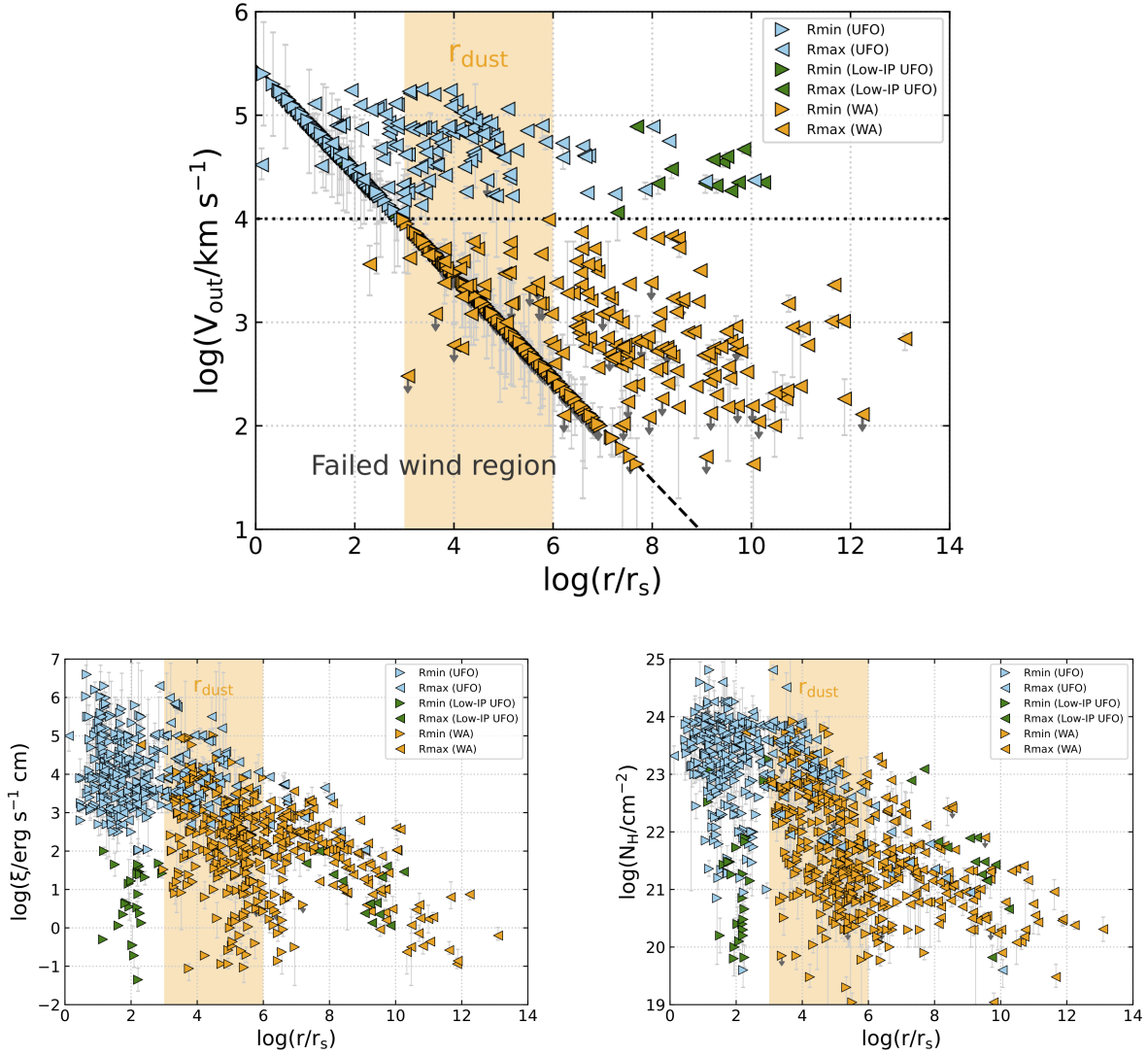


Figure 7. (Top) logarithmic V_{out} vs. logarithmic outflow radius normalized by Schwarzschild radius (r/r_s). The dashed line shows the minimum outflow radius assuming the escape velocity, whereas the dotted line represents the threshold of the UFO and warm absorber. (bottom left) Logarithmic ξ vs. $\log(r/r_s)$. (bottom right) Logarithmic N_{H} vs. $\log(r/r_s)$. The symbols mark the minimum or maximum outflow radii ($r = r_{\text{min}}$ or r_{max}) of the UFO (light blue), low- ξ UFO (green), and warm absorber (orange). The orange-filled region indicates the sublimation radii of the X-WING AGNs.

Section 3.4). This spatial disconnection holds significant implications for determining the reality of the V_{out} gap (i.e., disconnection), representing a crucial aspect in comprehending the AGN feedback from UFOs. Consequently, systematic surveys of X-ray winds utilizing XRISM are imperative to provide definitive answers.

3.4. Locations of the X-ray Winds

Determining the location of X-ray winds holds significance in unraveling the mechanisms propelling them forward. Specifically, comparing the distances between the winds and the dust sublimation radius allows an assess-

ment of their nature, distinguishing between dust-free and dusty gases (e.g., Mehdipour et al. 2012). Theoretically, owing to the considerably larger cross-section of dust compared to Thomson scattering, it is anticipated that radiation pressure from the AGN with λ_{Edd} surpassing the effective pressure ($\lambda_{\text{Edd}}^{\text{eff}} \sim 0.02$) can accelerate dusty gas outflows (Fabian et al. 2008; Wada 2015; Ishibashi et al. 2018). Recent observational investigations indicate a significant decrease in the covering fractions of obscurers at $\lambda_{\text{Edd}} \gtrsim \lambda_{\text{Edd}}^{\text{eff}}$ for Swift/BAT AGNs (e.g., Ricci et al. 2017b, 2022, 2023; Yamada et al. 2020;

Ananna et al. 2022), as well as heavily obscured AGNs in late mergers (e.g., Yamada et al. 2019, 2021, 2024). This lends support to the notion that dusty outflows possess sufficient strength to disperse circumnuclear material. Moreover, considering the well-established impact of dust on the velocity dispersion gap between broad-line regions (BLRs) and narrow-line regions (Netzer & Laor 1993), it might offer an explanation for the observed $\log V_{\text{out}} \sim 4$ gap (Section 3.3). While various plausible scenarios exist for the driving mechanisms of X-ray winds (see e.g., Fukumura et al. 2022; Gallo et al. 2023), we initially explore the possibility of radiation pressure on dusty gas being the primary driver for UFOs or warm absorbers.

The minimum and maximum distances of the X-ray winds (r_{min} and r_{max}) can be estimated by using the equations in Section 2.1 of Gofford et al. (2015):

$$r_{\text{min}} = 2GM_{\text{BH}}/V_{\text{out}}^2, \text{ and} \quad (2)$$

$$r_{\text{max}} = L_{\text{ion}}/\xi N_{\text{H}}. \quad (3)$$

The dust sublimation radius (r_{dust}) at 1500 K can be calculated as

$$r_{\text{dust}} = 0.4 \times (L_{\text{bol,AGN}}/10^{45} \text{ erg s}^{-1})^{1/2} \text{ pc}, \quad (4)$$

where $L_{\text{bol,AGN}}$ denotes bolometric AGN luminosity (e.g., Nenkova et al. 2008a,b). We note that a dust-free outflow may exist at $r > r_{\text{dust}}$ if it does not mix with the surrounding dust, whereas dust outflows are known to exist even in the pc region, as observed by IR interferometric observations (e.g., Gámez Rosas et al. 2022) and are expected to contain dust at $r > r_{\text{dust}}$. Here, we roughly estimated r_{dust} in our sample assuming $L_{\text{bol,AGN}} = 20L_{2-10}$ (e.g., Vasudevan & Fabian 2007) and obtained a range of $\log(r_{\text{dust}}/r_s) = 3.08\text{--}6.06$. If adopting luminosity-dependent bolometric corrections derived from Equation 3 in Duras et al. (2020), the values are almost unchanged, $\log(r_{\text{dust}}/r_s) = 3.03\text{--}6.02$. This typical range ($\sim 3\text{--}6$) aligns with the values derived from $L_{\text{bol,AGN}}$ through UV-to-radio SED fitting, as detailed in Paper II. While Seyfert 2 galaxies are not prevalent in our sample (Section 3.1), it is essential to exercise caution when considering anisotropic radiation from the disk. In scenarios where such radiation is assumed, the dust sublimation radius (r_{dust}) at the edge-on angle should theoretically be smaller than the values employed in our analysis, assuming isotropic radiation (e.g., Czerny & Hryniewicz 2011; Baskin & Laor 2018; Kudoh et al. 2023).

We conducted a comparative analysis of the distances of the X-ray winds (UFOs, low-IP UFOs, and warm absorbers) with the dust sublimation radii, as illustrated in

Figure 7. In all the panels, the considerable disparities between r_{min} and r_{max} pose challenges in elucidating the relationship between the location and outflow parameters. In pursuing our primary objective, we specifically concentrate on comparing these radii with r_{dust} in this investigation. While the locations of low-IP UFOs exhibit minimal constraints, their scale is presumed to be extensive, as inferred from the variability of V_{out} and N_{H} (approximately 100 pc; Serafinelli et al. 2019), as previously discussed in Paper II. The presence of outflows exhibiting $r_{\text{max}} < r_{\text{min}}$ indicates that either they are failed winds, or the wind stream line flows nearly perpendicular to the line of sight, resulting in the observation being limited to the tangential components of V_{out} (e.g., Gofford et al. 2015). Typically, the locations of the UFOs exhibit $r_{\text{max}} \lesssim r_{\text{dust}}$, signifying that UFOs predominantly consist of dust-free gases. The warm absorbers were situated at $r_{\text{min}} \gtrsim r_{\text{dust}}$. However, considering that failed winds are present in dust tori (e.g., Wada 2012; Wada et al. 2016; Izumi et al. 2018) or dusty gas around the outer accretion disk (e.g., Czerny & Hryniewicz 2011; Baskin & Laor 2018), the locations of warm absorbers can be $r < r_{\text{dust}}$ (e.g., Reeves et al. 2017). Thus, determining whether individual warm absorbers are dust-free (at $r < r_{\text{dust}}$) or dusty (at $r > r_{\text{dust}}$) becomes challenging. Independently, Mehdipour & Costantini (2018) conducted high-resolution X-ray and mid-IR spectroscopy of IC 4329A, suggesting the presence of dust in the wind through the spectral shape of X-ray absorption (O, Si, and Fe edge features) (e.g., Lee et al. 2001, 2013; Sako et al. 2003). Although XRISM may identify the absorption features of dust (e.g., Ricci & Paltani 2023; Vander Meulen et al. 2023), this technique is limited to the brightest AGNs. Alternatively, the variability timescales of the X-ray winds, systematically measured by reanalyzing approximately 20 years of observations (Table B4) with a uniform model, could provide better constraints on their locations (e.g., Serafinelli et al. 2019). Furthermore, XRISM can efficiently detect the variability of UFOs due to its high sensitivity to line detection.

Our results suggest that UFOs are primarily composed of dust-free gas, challenging the notion that radiation pressure on dusty gas is the main driving mechanism. There are two plausible models for the driving mechanisms of UFOs. The first is a radiation pressure-driven wind, where sufficiently high UV and soft X-ray fluxes can accelerate weakly ionized plasma through enhanced force multipliers (e.g., Proga et al. 2000; Sim et al. 2008; Hagino et al. 2015; Nomura & Ohsuga 2017; Mizumoto et al. 2021). The second model involves an MHD-driven wind, where plasma is loaded onto a global poloidal mag-

netic field and accelerated by the Lorentz force (e.g., Blandford & Payne 1982; Ferreira 1997; Fukumura et al. 2010, 2017; Jacquemin-Ide et al. 2021). XRISM can distinguish between these two models by observing the differences in their broad asymmetric UFO line spectra. For example, the former exhibits an extended red tail, and the latter shows a blue tail (e.g., Fukumura et al. 2022). In contrast, warm absorbers would mainly be dusty winds if they did not fail at small scales. The radiation pressure on dusty gas can play a crucial role in launching winds from the dusty region, such as the torus or outer accretion disk. Notably, thermally driven winds due to Compton heating (e.g., King et al. 2012; Mizumoto & Ebisawa 2017) can also launch winds from dusty regions. These warm absorber scenarios result in similar spectral features that are challenging to distinguish using X-ray observations alone. A third possibility is that warm absorbers are shocked winds from the UFOs (e.g., King & Pounds 2015). This scenario can be verified by testing whether the observed gap at $V_{\text{out}} \sim 10,000 \text{ km s}^{-1}$ is real or not. In addition, if the UFOs and warm absorbers are spatially disconnected, another question also arises as to where UFOs are blowing towards, such as BLRs or outer regions. In conclusion, further studies employing XRISM are required to determine the most plausible mechanisms of UFOs and warm absorbers and comprehend the whole structure of X-ray winds.

3.5. The Era of Calorimeter Spectrometers with XRISM

In conclusion, we reflect on the accomplishments of X-ray observations to date and anticipate new frontiers that XRISM will unveil in the near future. Through extensive X-ray observations and a plethora of studies, we have unveiled a greater diversity of X-ray winds than previously recognized. Notably, a crucial revelation is that V_{out} , ξ , and N_{H} exhibit no clear correlation, albeit acknowledging that these results are currently influenced by instrumental limitations (discussed in Sections 3.2 and 3.3).

Owing to its high-energy resolution in the $\sim 6 \text{ keV}$ band ($\Delta E \lesssim 5 \text{ eV}$), XRISM/Resolve reduces these observational biases. Based on the simulations in this study, the XRISM solves the following problems:

- (1) XRISM/Resolve will detect Fe XXV/Fe XXVI lines with small velocities thanks to the highest energy resolution ($\lesssim 5 \text{ eV}$) at 6 keV . Considering that its $E/\Delta E$ (~ 1000) is comparable to that of Chandra/HETGS, XRISM would reduce the biases for the slow winds from $\log V_{\text{out}} \lesssim 3$ to ~ 2 for high- ξ and high- N_{H} values (Section 3.2).

- (2) The Fe XXV/Fe XXVI lines with small EWs will be more detected with XRISM, particularly for the winds in the low- ξ /high- N_{H} and high- ξ /low- N_{H} regions, as described by the detection limit curve (Section 3.2).
- (3) Since XRISM observations are less affected by the artifacts, XRISM will solve whether the gap is real or not, and furthermore, whether the UFOs can drive AGN feedback to the galaxies (Section 3.3).
- (4) Its high sensitivity of line detections will help us to monitor the variability of UFOs and constrain their distances from the SMBH (Section 3.4).

For the simulation on the detection limit curve, we assumed $A(E) \geq 210 \text{ cm}^2$ of the designed plan. The current status demonstrates $\sim 180 \text{ cm}^2$ even if the gate valve is closed (see Appendix A.1). The operation of the gate valve will continue in the future, and if it opens, these anticipated results will be better.

Furthermore, XRISM is poised to unravel the intricacies of nuclear structures, encompassing accretion disks, BLRs, tori, UFOs, and warm absorbers by identifying their various emission/absorption lines and conducting narrow Fe K α reverberation mapping (e.g., Zoghbi et al. 2019; Noda et al. 2023). It promises to offer novel insights into the driving mechanisms of X-ray winds (e.g., Gallo et al. 2023 and the cited references). The work by Parker et al. (2022) emphasizes the existing degeneracy between reflection and wind components, heightening uncertainties in outflow properties. XRISM is anticipated to alleviate this degeneracy (see also, e.g., Gallo & Fabian 2011, 2013; Fabian et al. 2020; Middei et al. 2023). With XRISM observations commencing in December 2023, updates are expected in the near future. Additionally, new challenges will surface, and the landscape will evolve with the advent of the New Advanced Telescope for High Energy Astrophysics (NewAthena), representing the next generation of X-ray telescopes.

4. CONCLUSION

This study marks the inaugural findings of the X-WING program, assembling a dataset comprising 132 AGNs with reported X-ray winds up to the conclusion of 2023. These winds were identified through the detection of blueshifted ionized absorption lines using instruments such as Chandra, XMM-Newton, NuSTAR, Suzaku, and Swift. Our X-WING database encompasses 576 X-ray winds, providing detailed parameters including V_{out} , ξ , and N_{H} . Additionally, we compile information on the OBSIDs, the applied X-ray fitting model, references, and relevant papers addressing duplicate reports. The X-ray

winds are categorized into three distinct outflow groups, UFOs, low-IP UFOs, and warm absorbers, based on the values of V_{out} and ξ . Despite the presence of low-IP UFOs, the comparison among V_{out} , ξ , and N_{H} reveals the absence of straightforward linear correlations (Sections 2 and 3.1).

The distributions of V_{out} , ξ , and N_{H} can be reproduced using the detection limits anticipated using the instrumental performance ($A(E)$ and ΔE). This substantiates the notion that their distributions were subject to observational biases, even when employing the most extensive catalog available in the X-WING database. We determined a velocity gap of approximately $V_{\text{out}} \sim 10,000 \text{ km s}^{-1}$. The gap between the winds detected by the absorption lines in the $\lesssim 2 \text{ keV}$ band suggested different origins for low-IP UFOs and warm absorbers. Although the gap detected by the Fe XXV/Fe XXVI lines can be due to confusion of the emission/absorption lines and the Fe K-edge, there is another possibility that the UFOs and galactic-scale warm absorbers might be disconnected (Sections 3.2 and 3.3).

The minimum and maximum radii of the winds suggest that UFOs are dust-free, whereas warm absorbers likely comprise dusty gas. The location can be $r < r_{\text{min}}$ for failed winds whose distances must be measured by their time variabilities. From 2024, calorimeter spec-

trometers with XRISM will reduce biases and clarify the diversity of the winds. The XRISM determines whether the V_{out} gap between UFOs and warm absorbers is real, which is a key question for understanding AGN feedback from UFOs (Sections 3.4 and 3.5).

We deeply appreciate the anonymous referee for very constructive comments and suggestions, which improved the quality of this manuscript. This study was financially supported by the Japan Society for the Promotion of Science (JSPS) KAKENHI grant number 22K20391, 23K13154 (S.Y.), 23K13153 (T.K.), 21K13958 (M.M.), 24K17104 (S.O.), 19K21884, 20H01941, 20H01947, 20KK0071 (H.N.), 20H01946 (Y.U.), 22K03683 (H.S.), and 23KJ0450 (S.M.). S.Y. and T.K. are grateful for support from the RIKEN Special Postdoctoral Researcher Program. C.R. is grateful for the support from the Fondecyt Regular grant 1230345 and the ANID BASAL project FB210003. This paper employs a list of Chandra datasets, obtained by the Chandra X-ray Observatory, contained in DOI: 10.25574.

Facilities: NuSTAR, Chandra, XMM-Newton, Suzaku, Swift, XRISM.

Software: HEASoft (v6.31), XSPEC (v12.10.1; Arnaud 1996), SAS (v17.0.0; Gabriel et al. 2004).

APPENDIX

A. X-RAY INSTRUMENTS AND MODELS

A.1. X-ray Instruments

In this study, we focused on X-ray instruments that have been mainly utilized for identifying X-ray winds over the past 20 years. The basic explanations of the X-ray instruments used in this study (see Section 2) are as follows.

1. Chandra/HETGS (Canizares et al. 2005). The HETGS consists of two sets of gratings: the Medium Energy Grating (MEG) and the High Energy Gratings (HEG). The grating provides spectral resolving powers of up to 1000 over the range 0.4–8 keV.
2. Chandra/LETGS (Brinkman et al. 2000). The LETGS is of a similar design to the HETGS but is optimized for energies less than 1 keV.
3. Chandra/ACIS (Garmire et al. 2003). ACIS is arranged as an array of ten CCDs, one as a two by two array (ACIS-I), and one as a one by six array (ACIS-S). The two CCDs on ACIS-S are

back-illuminated (BI) and the others on ACIS-I and ACIS-S are front-illuminated (FI).

4. XMM-Newton/RGS (den Herder et al. 2001), consisting of two identical RGS grating arrays (RGS1 and RGS2).
5. XMM-Newton/EPIC PN and MOS. There are three EPIC detectors; one contains twelve PN CCDs (Strüder et al. 2001), while the two use seven MOS CCDs (MOS1 and MOS2; Turner et al. 2001).
6. NuSTAR/FPM (Harrison et al. 2013), consisting of two coaligned X-ray telescopes coupled with FPMA and FPMB.
7. Suzaku/XIS (Mitsuda et al. 2007), consisting of four X-ray CCD cameras, XIS-0, XIS-1, XIS-2, and XIS-3. The XIS-0, 2, 3 are FI cameras and XIS-1 is BI. The XIS-2 data were not available after 2006 November because the malfunction had occurred.

8. Swift/XRT (Evans et al. 2009), a CCD imaging spectrometer designed to follow-up the X-ray transients and variable sources.

For Chandra, HETGS is most commonly used with ACIS-S, whereas LETGS is used with ACIS-S and a High Resolution Camera spectroscopic array (HRC-S) (e.g., Brinkman et al. 2000; Canizares et al. 2005). In Table A1, we summarize the basic performance of the energy bands, wavelength ranges, energy resolutions (ΔE), spectral resolving powers ($E/\Delta E$), effective areas $A(E)$, ratios of $A(E)/\Delta E$, and references.

In September 2023, the X-ray observatory XRISM (Tashiro et al. 2018) was launched. The XRISM payload comprises two instruments: Resolve and Xtend. Resolve is an X-ray microcalorimeter with a 6-by-6-pixel detector, which is capable of high-energy-resolution spectroscopy. Xtend, an array of four CCD detectors, has the imaging-spectroscopic capability of a wide FoV (38×38 arcmin²) and medium energy resolution. Based on the ground calibration, the expected performances were as follows: in the 6 keV band, $A(E) \geq 210$ cm² and $\Delta E \leq 7$ eV for Resolve and $A(E) \geq 300$ cm² and $\Delta E \leq 250$ eV for Xtend.³ According to the recent XRISM first-light observations⁴, Resolve reaches a resolution of 5 eV. However, the gate valve of the Resolve instrument (X-ray aperture door) did not open in January 2024, which lowered the effective area.⁵ The public ancillary response files of Resolve for GO Cycle 1 proposers demonstrate $A(E) \sim 180$ cm² assuming a closed gate valve. To make it easier to apply the simulated results in both cases of the gate valve, we adopted a typical value of $A(E) = 210$ cm² and $\Delta E = 5$ eV for the spectral simulation of Resolve (Section 3.3).

A.2. X-ray Models of the Outflowing Ionized Absorbers

Various models for outflowing ionized absorbers have been employed in the literature, with a comprehensive summary provided in Table B3. The XSTAR code, introduced by Kallman et al. (1996); Kallman & Bautista (2001); Kallman et al. (2004), played a prominent role in generating models for photoionized absorbers, accounting for 270 out of 576 analyzed winds. Studies have utilized XSTAR photoionization models to characterize outflowing ionized absorbers without scatter-

ing (warmabs), those with scattering off the outflowing absorber (windabs), and scenarios involving partial covering of partially ionized absorbing material (zxipcf; Reeves et al. 2008). Additionally, Danehkar et al. (2018a) introduced the MPLXSTAR model, a parallel implementation involving multiple XSTAR runs. Another simulation code, CLOUDY (Ferland et al. 1998, 2013), was also enlisted for photoionization simulations. In SPEX (Kaastra et al. 1996), the xabs model, a photoionized absorption model, was prominently employed in numerous studies, encompassing 130 out of 576 examined winds. In this approach, the photoionization equilibrium was pre-calculated for a grid of ξ values using an external code (such as XSTAR or CLOUDY). Conversely, the photoionized absorption/emission model pion within SPEX performs self-consistent calculations of photoionization equilibrium using available plasma routines. Note that these models, specifically XSTAR and CLOUDY, have undergone multiple updates. Some investigations have opted for the PHotoionized Absorption Spectral Engine (PHASE; Krongold et al. 2003), employing a model assuming a geometry featuring a central source emitting an ionizing continuum, interacting with clouds of gas computed using CLOUDY. Additionally, ABSORI (Done et al. 1992; Zdziarski et al. 1995), the XSPEC model for ionized absorbing plasma, has found utility in sources displaying absorption edges.

Additionally, the absorption measure distribution (AMD; Holczer et al. 2007) method was adopted to reconstruct the actual distribution of the column density in the plasma as a continuous function of ξ . Igo et al. (2020) calculated the fractional excess variance (FEV; Vaughan et al. 2003) spectra to search for UFOs (Section 2.1). Some studies have identified absorption line candidates using the Gaussian model or by judging from the residual in the spectral fittings.

B. DATABASE OF X-WING SAMPLE AND X-RAY WINDS

The main information on the X-WING Sample (Section 2.1) is summarized in Table B2. The X-ray wind database (section 2.2) is presented in Tables B3 and B4.

³ https://xrism.isas.jaxa.jp/research/analysis/manuals/xrqr_v1.pdf

⁴ <https://heasarc.gsfc.nasa.gov/docs/xrism/>

⁵ <https://heasarc.gsfc.nasa.gov/docs/xrism/proposals/index.html>

Table A1. X-ray Instruments Utilized in the Previous Works for Detecting X-ray Winds

Facility	Instrument	Band (keV)	Wavelength (Å)	ΔE (eV)	$E/\Delta E$	$A(E)$ (cm ²)	$A(E)/\Delta E$ (cm ² /eV)	Ref.
Performance at the 1 keV Band								
Chandra	HETGS (w/ ACIS-S)	0.4–10	1.2–31	1	1000	59	59.0	1,2
	LETGS (w/ ACIS-S)	0.2–10	1.2–62	4	250	23	5.8	1,3
	LETGS (w/ HRC-S)	0.07–10	1.2–175	4	250	24	6.0	1,3
	ACIS-I	0.2–10	1.2–62	60	17	367	6.1	1,4
	ACIS-S (FI)	0.2–10	1.2–62	60	17	367	6.1	1,4
	ACIS-S (BI)	0.2–10	1.2–62	120	8	555	4.6	1,4
XMM-Newton	RGS ($\times 2$; RGS1+RGS2)	0.35–2.5	5.0–35	3	333	185	61.7	5,6,7
	PN	0.15–12	1.0–83	70	14	1227	17.5	5,8
	MOS ($\times 2$; MOS1+MOS2)	0.15–12	1.0–83	80	13	1844	23.1	5,8
Suzaku	XIS ($\times 4$; XIS 0+1+2+3)	0.2–12	1.0–62	50	20	1100	22.0	6,9,10
Performance at the 6 keV Band								
Chandra	HETGS (w/ ACIS-S)	0.4–10	1.2–31	29	207	25	0.9	1,2,6
	LETGS (w/ ACIS-S)	0.2–10	1.2–62	150	40	20	0.1	1,3,6
	LETGS (w/ HRC-S)	0.07–10	1.2–175	150	40	4	0.03	1,3,6
	ACIS-I	0.2–10	1.2–62	130	46	235	1.8	1,4,6
	ACIS-S (FI)	0.2–10	1.2–62	130	46	235	1.8	1,4,6
	ACIS-S (BI)	0.2–10	1.2–62	170	35	205	1.2	1,4,6
XMM-Newton	PN	0.15–12	1.0–83	130	46	851	6.5	5,6
	MOS ($\times 2$; MOS1+MOS2)	0.15–12	1.0–83	130	46	1536	11.8	5,6
NuSTAR	FPM ($\times 2$; FPMA+FPMB)	3–79	0.16–4	400	15	800	2.0	11,12
Suzaku	XIS ($\times 4$; XIS 0+1+2+3)	0.2–12	1.0–62	130	46	1000	7.7	9,10
Swift	XRT	0.2–10	1.2–62	140	43	20 [†]	~ 0.1	13

NOTE—References: (1) Chandra Pocket Guide (https://cxc.harvard.edu/cdo/pocket_guide.pdf). (2-3) Chapters 8 and 9 of The Chandra Proposer's Observatory Guide (<https://cxc.harvard.edu/proposer/POG/html/index.html>). (4) HEASARC for Chandra (<https://heasarc.gsfc.nasa.gov/docs/chandra/chandra.html>). (5) XMM-Newton Users Handbook (https://xmm-tools.cosmos.esa.int/external/xmm_user_support/documentation/uhb/basics.html). (6) HEASARC (<https://heasarc.gsfc.nasa.gov/docs/heasarc/missions/comparison.html>) (7) XMM-Newton Calibration technical notes (<https://xmmweb.esac.esa.int/docs/documents/CAL-TN-0030.pdf>) (8) HEASARC for XMM-Newton (<https://heasarc.gsfc.nasa.gov/docs/xmm/xmm.html>) (9) The Suzaku Web Page (<https://space.mit.edu/XIS/about/>). (10) Mitsuda et al. (2007); (11) NuSTAR Observatory guide (https://heasarc.gsfc.nasa.gov/docs/nustar/nustar_obsguide.pdf) (12) Harrison et al. (2013); (13) The SWIFT XRT data reduction guide (https://swift.gsfc.nasa.gov/analysis/xrt_swguide.v1.2.pdf). For Swift/XRT, the symbol [†] indicates $A(E)$ at 8.1 keV.

Table B2. Target Information in the X-WING Sample

ID	Object	z	D_L	Class	F_{2-10}	$\log L_{2-10}$	$\log M_{BH}$	Method	N_w	UFO	References (3-4,5,6-7,8-9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Nearby ($z < 1$) Galaxies											
1	1E 0754.6+3928	0.0960	440.7	NLS1	2.2	43.70	8.02	RM	4	Y	(Md20;Md20;Md20;Se07)
2	1ES 1927+654	0.0194	84.4	2.0	3.7	42.50	6.00	Ms	2(*)	n	(Ri20;VC10;Ga13;Ri20)
3	1H 0323+342	0.0630	282.7	NLS1	0.9	42.93	6.76	Hb	2(*)	n	(Me19;Pl14;Ri17;K22A)
4	1H 0419-577	0.1040	480.0	1.5	14.3	44.60	8.34	Hb	1	Y	(To10;VC10;Ri17;K22A)
5	1H 0707-495	0.0406	179.3	NLS1	1.1	42.66	6.31	Hb	9	Y	(Xu21;Xu21;Bi09;Bi09)
6	1H 1934-063	0.0102	44.7	NLS1	23.2	42.75	6.61	Hb	2	n	(Xu22;Xu22;Ri17;K22A)
7	2MASSI J0918486+211717	0.1490	708.0	1.5	1.2	43.89	7.35	Hb	2	Y	(Po07;VC10;Bi09;Sh11)
8	2MASS J1051+3539	0.1590	760.2	1.9	1.7	44.15	8.40	Hb	1	Y	(Ma23;VC10;Bi09;Ma23)
9	2MASS J1653+2349	0.1030	475.1	2.0	2.0	44.06	8.17	Vdisp	1	Y	(Ma23;VC10;Ri17;K22B)
10	3C 105	0.0890	406.6	2.0	2.2	44.30	8.59	Vdisp	1	Y	(To14;To14;Ri17;K22B)
11	3C 111	0.0485	215.4	1.0	55.5	44.53	8.45	Hb	3	Y	(To14;To14;Ri17;K22A)
12	3C 120	0.0330	144.9	1.5	36.9	43.98	7.74	RM	4	Y	(Me19;Me19;Ri17;Be15)
13	3C 273	0.1580	755.0	1.0	117.8	45.88	8.84	RM	1(*)	n	(Me19;Me19;Ri17;Be15)
14	3C 382	0.0580	259.3	1.0	37.8	44.60	8.85	RM	5	n	(Me19;Me19;Ri17;Be15)
15	3C 390.3	0.0560	250.0	1.5	42.6	44.52	8.71	RM	4	Y	(Me19;Me19;Ri17;Be15)
16	3C 445	0.0558	249.1	1.5	6.4	44.25	7.89	Hb	2	n	(To14;To14;Ri17;K22A)
17	3C 59	0.1110	514.7	1.8	8.2	44.42	8.90	Ha	2(*)	n	(Me19;Me19;Ri17;Si07)
18	4C +31.63	0.2980	1540.8	1.0	4.1	45.07	8.52	Hb	1(*)	n	(Me19;Me19;Ri17;K22A)
19	4C +34.47	0.2060	1013.0	1.0	8.5	45.02	8.30	Hb	1	n	(Me19;Me19;Ri17;K22A)
20	4C +74.26	0.1040	480.0	1.0	24.4	44.87	9.83	Hb	5	Y	(Me19;Me19;Ri17;K22A)
21	Ark 120	0.0327	143.6	1.0	27.0	43.81	8.07	RM	1	Y	(To10;VC10;Ri17;Be15)
22	Ark 564	0.0240	104.7	NLS1	16.3	43.34	6.27	Hb	11	Y	(La14;Ni09;Bi09;Bi09)
23	CBS 126	0.0789	358.0	1.2	2.2	43.53	7.93	Hb	1	n	(NED;VC10;Ch19;Ch19)
24	Centaurus A	0.0018	3.7	2.0	184.9	42.39	8.29	Vdisp	3	n	(To14;To14;Ri17;K22B)
25	ESO 075-41	0.0280	122.5	1.0	6.1	43.04	8.07	Hb	1(*)	n	(Me19;Me19;Ri17;K22A)
26	ESO 103-35	0.0130	56.2	2.0	22.3	43.36	7.37	Vdisp	1	Y	(Ta16;Ta16;Ri17;K22B)
27	ESO 113-10	0.0257	112.2	1.8	3.1	42.68	6.74	Xvar	2	n	(NED;VC10;Bi09;Po12)
28	ESO 323-77	0.0150	65.0	1.2	9.2	42.88	6.52	Ha	8	n	(To10;VC10;Ri17;K22A)
29	ESO 33-2	0.0181	78.6	2.0	1.4	42.12	7.60	Vdisp	1	n	(Wa21;VC10;Ri17;K22B)
30	GRS 1734-292	0.0218	94.9	1.0	51.9	43.89	7.84	Ha	1	n	(K22A;VC10;Ri17;K22A)
31	I Zw 1	0.0611	273.8	NLS1	4.9	43.65	6.97	RM	3	Y	(Mi19;Mi19;Bi09;Hu19)
32	IC 4329A	0.0160	69.4	1.2	96.3	43.83	7.78	RM	6	Y	(La14;La14;Ri17;Be23)
33	IC 5063	0.0110	45.9	2.0	8.3	43.02	7.74	Vdisp	1	Y	(Mi19;Mi19;Ri17;Wo02)
34	III Zw 2	0.0890	367.6	1.2	7.7	44.09	8.07	RM	1(*)	n	(Me19;Me19;Ri17;Be15)
35	IRAS F00183-7111	0.3270	1715.6	2.0	0.01	44.32	8.66	Ms	1	Y	(Iw17;VC10;Iw17;RV)
36	IRAS 00521-7054	0.0689	310.5	2.0	2.4	43.40	7.70	others	1	Y	(Wa19;Wa19;Ri14;Wa19)
37	IRAS 04416+1215	0.0889	406.1	1.0	1.1	43.41	6.78	RM	3(*)	Y	(Tr22;Tr22;Tr22;Du15)
38	IRAS 05054+1718(W)	0.0175	76.0	1.9	9.8	42.84	7.27	Ms	2	Y	(Ya21;Bo23;Ya21;Ya21)
39	IRAS 05078+1626	0.0170	73.8	1.5	24.0	43.47	6.88	RM	1	n	(La14;La14;Ri17;Be15)
40	IRAS 05189-2524	0.0426	188.4	2.0	2.9	43.40	7.40	Vdisp	1	Y	(Sm19;Sm19;Ri17;K22A)
41	IRAS 09149-6206	0.0573	256.1	1.0	8.5	43.97	8.63	Hb	6	n	(Wa20;VC10;Ri17;K22A)
42	IRAS 11119+3257	0.1890	920.2	NLS1	155.9	44.24	8.00	Ha	2	Y	(Mi19;Pn19;Te10;Pn19)
43	IRAS 13197-1627	0.0165	71.6	1.8	2.8	43.41	8.37	Vdisp	5	n	(Wa18;Wa18;Ri17;K22A)
44	IRAS 13224-3809	0.0658	295.8	NLS1	0.5	42.75	6.82	Hb	10	Y	(Pi18;Pi18;Bi09;Bi09)
45	IRAS 13349+2438	0.1085	502.3	NLS1	2.2	43.87	8.62	RM	9	Y	(Pa18;Lo03;Bi09;Bi09)
46	IRAS 17020+4544	0.0604	270.5	NLS1	5.6	43.70	6.77	Hb	10	n	(Sa18;Sa18;Bi09;Bi09)
47	IRAS 18325-5926	0.0198	86.1	2.0	24.5	43.37	7.76	Vdisp	6	Y	(Mo11;Mo11;Ri17;K22B)
48	IRAS 23226-3843	0.0359	158.0	1.0	2.5	42.87	6.95	others	2	Y?	(Ko23;VC10;Ri17;Wa07)
49	LBQS 1338-0038	0.2375	1189.0	1.0	2.0	44.52	7.74	Hb	1	Y	(Ma23;VC10;Ma23;Sh11)

Table B2 *continued*

Table B2 (continued)

ID	Object	z	D_L	Class	F_{2-10}	$\log L_{2-10}$	$\log M_{BH}$	Method	N_w	UFO	References (3-4,5,6-7,8-9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
50	MCG-01-24-12	0.0196	85.2	2.0	12.9	43.24	7.66	Vdisp	1	Y	(Md21;Md21;Ri17;K22A)
51	MCG-03-58-007	0.0323	141.8	2.0	3.7	43.75	8.00	Vdisp	18	Y	(Br22;Br22;Br22;Br18)
52	MCG-5-23-16	0.0085	36.2	1.9	87.5	43.19	7.65	Vdisp	2	Y	(To10;Br07;Ri17;K22B)
53	MCG-6-30-15	0.0070	30.4	1.5	36.8	42.66	6.30	RM	10	n	(La14;La14;Ri17;Be15)
54	MR 2251-178	0.0630	282.7	1.0	37.6	44.58	8.19	Hb	11	Y	(La14;La14;Ri17;K22A)
55	Mrk 1040(=NGC 931)	0.0167	72.4	1.0	28.5	43.41	7.41	Hb	1	n	(Re17;VC10;Ri17;K22A)
56	Mrk 1044	0.0160	69.4	NLS1	5.0	42.46	6.45	RM	8	n	(Kr21;Kr21;Ri17;Du15)
57	Mrk 1048(=NGC 985)	0.0430	190.2	1.0	13.8	43.78	7.33	RM	19	n	(Eb21;Eb21;Ri17;U22)
58	Mrk 205	0.0708	319.4	1.0	6.8	43.92	8.57	Hb	1	Y	(To10;VC10;Ri17;K22A)
59	Mrk 231	0.0422	186.6	1.0	0.9	42.65	7.87	Rd	3	Y	(Mi19;Mi19;Ya21;Gr23)
60	Mrk 273	0.0378	166.6	2.0	0.7	43.07	8.35	Vdisp	1	Y	(Mi19;Mi19;Ya21;Ya21)
61	Mrk 279	0.0305	133.7	1.0	12.3	43.41	7.43	RM	6	Y	(To10;VC10;Ri17;Be15)
62	Mrk 290	0.0296	129.6	1.5	7.4	43.18	7.28	RM	5	Y	(To10;VC10;Ri17;Be15)
63	Mrk 335	0.0250	109.1	NLS1	6.0	43.21	7.23	RM	10	Y	(Ga19;Ga19;Ri17;Be15)
64	Mrk 509	0.0340	149.4	1.2	35.3	44.07	8.05	RM	15	Y	(La14;La14;Ri17;Be15)
65	Mrk 590	0.0260	113.6	1.0	3.2	42.69	7.57	RM	6	n	(Gu15;Gu15;Ri17;Be15)
66	Mrk 6	0.0190	82.6	1.5	11.9	43.10	8.10	RM	1(*)	n	(Me19;Me19;Ri17;Be15)
67	Mrk 704	0.0290	127.0	1.2	10.7	43.32	7.56	RM	3	n	(La14;La14;Ri17;Be15)
68	Mrk 766	0.0129	55.8	NLS1	13.2	42.71	6.82	RM	11	Y	(La14;Ni09;Ri17;Be15)
69	Mrk 79(=UGC 3973)	0.0222	96.7	1.2	7.7	43.11	7.61	RM	2	Y	(To10;VC10;Ri17;Be15)
70	Mrk 841	0.0364	160.2	1.5	9.7	43.67	7.66	RM	5	Y	(To10;VC10;Ri17;U22)
71	Mrk 896	0.0270	118.0	NLS1	3.5	42.79	6.35	Hb	1(*)	n	(Me19;Pg03;Bi09;Bi09)
72	NGC 1068	0.0038	14.4	2.0	4.9	43.04	7.23	maser	1(*)	Y	(Mi19;Mi19;Ri17;Ga23)
73	NGC 1365	0.0055	19.6	1.8	17.4	42.38	6.26	Rd	10	n	(Br14;Br14;Ri17;Gr23)
74	NGC 1566	0.0050	17.9	1.5	3.1	41.56	6.92	Vdisp	2	n	(Pa19;VC10;Ri17;Wo02)
75	NGC 2992	0.0077	38.0	1.9	7.3	42.16	7.48	Hb	5	Y	(Lu23;VC10;Ri17;Gu21)
76	NGC 3227	0.0030	22.9	1.5	36.9	42.28	6.68	RM	8	n	(La14;La14;Ri17;Be15)
77	NGC 3516	0.0080	38.9	1.5	27.5	42.46	7.40	RM	9	n	(La14;La14;Ri17;Be15)
78	NGC 3783	0.0090	38.5	1.0	76.9	43.24	7.08	RM	20	n	(La14;La14;Ri17;Be15)
79	NGC 4051	0.0020	11.0	1.5	17.6	41.07	5.89	RM	37	Y	(La14;La14;Ri17;Be15)
80	NGC 4151	0.0033	19.0	1.5	47.2	42.66	7.37	RM	5	Y	(To10;VC10;Ri17;Be15)
81	NGC 4388	0.0084	18.1	2.0	20.4	42.92	6.92	maser	2	n	(Sh08;Sh08;Ri17;Ku11)
82	NGC 4395	0.0011	4.8	1.8	5.5	40.56	5.45	RM	1	n	(Na23;VC10;Ri17;Be15)
83	NGC 4507	0.0118	51.0	2.0	7.4	43.51	7.81	Vdisp	1	Y	(To10;Mt04;Ri17;K22B)
84	NGC 4593	0.0090	37.2	1.0	35.7	42.91	6.91	RM	11	n	(La14;La14;Ri17;Be15)
85	NGC 5506	0.0062	26.4	1.9	92.7	43.08	7.24	Vdisp	1	Y	(Bi05;Bi05;Ri17;K22B)
86	NGC 5548	0.0170	73.8	1.5	19.1	43.13	7.69	RM	19	n	(La14;La14;Ri17;Be15)
87	NGC 6240	0.0245	106.9	2.0	2.3	43.86	8.53	Vdisp	2(*)	Y	(Mi19;Mi19;Ya21;En10)
88	NGC 6860	0.0149	64.5	1.5	23.3	43.11	7.71	Vdisp	2	n	(Wi10;Wi10;Ri17;K22B)
89	NGC 7469	0.0160	69.4	1.2	25.4	43.17	6.96	RM	13	n	(La14;La14;Ri17;Be15)
90	NGC 7582	0.0053	22.5	2.0	4.0	41.74	7.08	Vdisp	1	Y	(To10;Bi09;Rv15;K22B)
91	PDS 456	0.1840	893.2	1(QSO)	7.0	44.90	8.23	VLTI	30	Y	(Na15;Re09;Bi09;GR24)
92	PG 0804+761	0.1000	460.3	1.0	10.8	44.45	8.73	RM	1	Y	(Ma23;VC10;Ri17;Be15)
93	PG 0844+349	0.0640	287.4	1.0	4.8	43.69	7.86	RM	1(*)	Y	(Po03;VC10;Bi09;Be15)
94	PG 0947+396	0.2055	1010.3	1.0	1.7	44.33	8.21	RM	1	Y	(Ma23;VC10;Bi09;Wo24)
95	PG 1114+445	0.1440	682.1	1.0	2.2	44.09	8.59	Hb	11	Y	(Ma23;VC10;Bi09;Bi09)
96	PG 1126-041	0.0600	268.7	1.0	1.2	43.25	8.10	Vdisp	8	Y	(Gi11;VC10;Gi11;Gi11)
97	PG 1202+281	0.1650	791.8	1.2	5.2	44.59	8.06	RM	1(*)	Y	(Ma23;VC10;Ri17;Wo24)
98	PG 1211+143	0.0809	367.6	NLS1	3.0	43.73	8.16	RM	17	Y	(To10;Ni09;Bi09;Pe04)
99	PG 1402+261	0.1640	786.5	NLS1	1.7	44.13	7.53	RM	1	Y	(Re04;Re04;Bi09;Hu21)
100	PG 1404+226	0.0980	450.5	NLS1	0.1	42.48	6.83	RM	1	n	(Da05;Da05;Bi09;Hu21)
101	PG 1448+273	0.0645	289.7	NLS1	1.9	43.31	7.00	RM	6	Y	(Ko20;Ko20;Bi09;Hu21)
102	PKS 0405-12	0.5740	3345.6	1.2	4.3	44.37	9.47	others	1(*)	n	(Me19;Me19;Me19;Wo02)

Table B2 continued

Table B2 (*continued*)

ID	Object	z	D_L	Class	F_{2-10}	$\log L_{2-10}$	$\log M_{BH}$	Method	N_w	UFO	References (3-4,5,6-7,8-9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
103	PKS 0921-213	0.0530	236.1	1.0	5.6	43.57	8.40	Hb	1(*)	n	(Me19;Me19;Ri17;K22A)
104	PKS 1549-79	0.1522	724.6	NLS1	5.7	44.72	8.43	Vdisp	2	Y	(To14;Ho06;Ri17;K22B)
105	PKS 2135-14	0.2000	980.1	1.5	5.4	44.78	9.10	Hb	1(*)	n	(Me19;Me19;Ri17;K22A)
106	SWIFT J2127.4+5654	0.0147	63.7	NLS1	23.5	43.09	7.15	Hb	1	Y	(Sa13;Sa13;Ri17;K22A)
107	Ton 28	0.3290	1727.8	1.0	0.5	44.23	7.57	RM	1	Y	(Na19;VC10;Na19;Be15)
108	Ton S180	0.0620	278.0	NLS1	4.7	43.65	7.06	RM	1	n	(Ma20;Ma20;Bi09;Bi09)
109	WKK 4438	0.0160	69.4	NLS1	9.2	42.74	6.30	Hb	1	Y	(Ji18;Ji18;Ri17;Ji18)
High- z ($z > 1$) Galaxies											
110	APM 08279+5255	3.91	34896	QSO	0.4	46.19	9.87	RM	12	Y	(Ch21;Ch21;Ch21;Be15)
111	CXOCDFS J0332-2747	2.579	21180	QSO	0.01	44.66	9.41	Ms	1	Y?	(Wn05;Wn05;To06;RC)
112	H 1413+117	2.56	20992	QSO	0.04	43.87	8.60	CIV	2	Y?	(Ch07;Ch07;Ru21;OD15)
113	HS 0810+2554	1.51	11000	QSO	0.4	43.73	8.60	Hb	5	Y	(Ch21;Ch21;Ch21;Ch21)
114	HS 1700+6416	2.735	22740	QSO	0.1	45.34	10.20	CIV	4	Y	(Ch21;Ch21;Ch21;Ch21)
115	MG J0414+0534	2.64	21789	QSO	0.3	44.49	9.00	Hb	1	Y	(Ch21;Ch21;Ch21;Ch21)
116	PG 1115+080	1.72	12914	QSO	0.4	44.15	8.80	Hb	2	Y	(Ch21;Ch21;Ch21;Ch21)
117	PG 1247+268	2.048	15997	QSO	0.3	45.91	9.80	CIV	1(*)	Y?	(La16;La16;Bi09;Sh11)
118	PID352	1.6	11814	QSO	0.03	45.43	8.70	Ms	1	Y	(Ch21;Ch21;Ch21;Vi15)
119	Q 2237+0305	1.695	12683	QSO	0.2	44.12	9.10	Hb	2	Y	(Ch21;Ch21;Ch21;Ch21)
120	SDSS J0904+1512	1.826	13899	QSO	0.1	44.23	9.30	CIV	1	Y	(Ch21;Ch21;Ch21;Ch21)
121	SDSS J0921+2854	1.41	10107	QSO	0.7	45.21	8.90	CIV	2	Y	(Ch21;Ch21;Ch21;Ch21)
122	SDSS J1029+2623	2.197	17430	QSO	0.2	44.04	8.80	CIV	1	Y	(Ch21;Ch21;Ch21;Ch21)
123	SDSS J1128+2402	1.608	11886	QSO	0.1	44.32	8.70	CIV	1	Y	(Ch21;Ch21;Ch21;Ch21)
124	SDSS J1353+1138	1.627	12060	QSO	0.1	44.70	9.40	CIV	1	Y	(Ch21;Ch21;Ch21;Ch21)
125	SDSS J1442+4055	2.593	21320	QSO	0.3	44.75	9.70	CIV	1	Y	(Ch21;Ch21;Ch21;Ch21)
126	SDSS J1529+1038	1.984	15388	QSO	0.03	44.04	8.90	CIV	1	Y	(Ch21;Ch21;Ch21;Ch21)
X-WING Candidates											
127	MCG-02-14-009	0.0285	124.7	1.0	4.2	42.90	7.13	Xvar	1	Y?	(Ka16;Ka16;Ri17;Po12)
128	NGC 7213	0.0058	22.0	1.5	11.8	41.95	7.13	Hb	1	Y?	(La14;La14;Ri17;K22A)
129	NGC 7314	0.0048	16.8	1.9	38.4	42.24	6.30	Vdisp	1	Y?	(Zo13;Zo13;Ri17;K22B)
130	PG 1244+026	0.0481	213.5	NLS1	1.9	43.07	6.52	Hb	1	Y?	(SIM;A114;Bi09;Bi09)
131	PKS 0558-504	0.1370	646.0	NLS1	13.6	44.93	7.62	Hb	1	Y?	(Gh16;Gh16;Ri17;K22A)
132	RE J1034+396	0.0420	185.6	NLS1	0.6	42.53	6.81	Hb	1	Y?	(Jn20;Jn20;Bi09;Bi09)

Table B2 *continued*

Table B2 (*continued*)

ID	Object	z	D_L	Class	F_{2-10}	$\log L_{2-10}$	$\log M_{BH}$	Method	N_w	UFO	References (3-4,5,6-7,8-9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

NOTE—Columns: (1)–(2) ID and object name; (3) redshift; (4) Light distance: For the closest objects at $D_L < 50$ Mpc, we adopted redshift-independent distance measurements (Koss et al. 2022a). (5) Optical Classes (6)–(7) observed 2–10 keV fluxes (F_{2-10}) in units of 10^{-12} erg cm $^{-2}$ s $^{-1}$ and logarithmic intrinsic AGN luminosity in the 2–10 keV band in units of erg s $^{-1}$, many of which are referred from Ricci et al. (2017a) and Bianchi et al. (2009); (8) as logarithmic M_{BH} in units of M_\odot . (9) Methods of M_{BH} estimation: reverberation mapping (RM), H $_2$ O megamesar (maser), broad emission lines of H α (Ha), H β (Hb), and C iv (CIV), near-infrared interferometric observations of the BLR with Very Large Telescope Interferometer (VLTI); stellar velocity dispersion (Vdisp), stellar mass to M_{BH} ratio (Ms), X-ray variability (Xvar), and others (others); (10) Number of X-ray winds reported in the study. The symbol (*) marks the uncertain AGNs with X-ray winds as explained in Section 2.2. (11) Flag for the presence of UFOs with Fe xxv/Fe xxvi lines detected in the >6 keV band (Section 3.3). “Y” means the AGNs with UFOs. “Y?” denotes that the AGNs with UFO candidates, all of which only V_{out} were constrained (but not ξ and N_H ; see also Section 2.2). “n” indicates AGNs with warm absorbers but no UFOs; (12) References for the data in columns (3)–(4), (5), (6)–(7), and (8)–(9) are listed below, while information in columns (10)–(11) is derived from Tables B3 and B4.

References: (Al14) Alston et al. (2014); (Be15) Bentz & Katz (2015); (Be23) Bentz et al. (2023); (Bi09) Bianchi et al. (2009); (Bl05) Blustin et al. (2005); (Bo23) Bonanomi et al. (2023); (Br07) Braitto et al. (2007); (Br14) Braitto et al. (2014); (Br18) Braitto et al. (2018); (Br22) Braitto et al. (2022); (Ch07) Chartas et al. (2007b); (Ch19) Cheng et al. (2019); (Ch21) Chartas et al. (2021); (Da05) Dasgupta et al. (2005); (Du15) Du et al. (2015); (Eb21) Ebrero et al. (2021); (En10) Engel et al. (2010); (Ga13) Gallo et al. (2013); (Ga19) Gallo et al. (2019); (Ga23) Gallimore & Impellizzeri (2023); (Gh16) Ghosh et al. (2016); (Gi11) Giustini et al. (2011); (GR24) GRAVITY Collaboration et al. (2024); (Gu15) Gupta et al. (2015); (Gu21) Guolo et al. (2021); (Ho06) Holt et al. (2006); (Hu19) Huang et al. (2019); (Hu21) Hu et al. (2021); (Iw17) Iwasawa et al. (2017); (Ji18) Jiang et al. (2018b); (Ji18) Jiang et al. (2018a); (Jn20) Jin et al. (2020); (K22A) Koss et al. (2022a); (K22B) Koss et al. (2022b); (Ka16) Kara et al. (2016); (Ka21) Kara et al. (2021); (Ko20) Kosec et al. (2020); (Ko23) Kollatschny et al. (2023); (Kr21) Krongold et al. (2021); (Ku11) Kuo et al. (2011); (La14) Laha et al. (2014); (La16) Lanzuisi et al. (2016); (Lo03) Longinotti et al. (2003); (Lu23) Luminari et al. (2023); (Ma20) Matzeu et al. (2020); (Ma23) Matzeu et al. (2023); (Md20) Middei et al. (2020); (Md21) Middei et al. (2021); (Me19) Mehdipour & Costantini (2019); (Mi19) Mizumoto et al. (2019b); (Mo11) Mocz et al. (2011); (Mt04) Matt et al. (2004); (NED) NASA/IPAC Extragalactic Database; (Na15) Nardini et al. (2015); (Na19) Nardini et al. (2019); (Na23) Nandi et al. (2023b); (Ni09) Nikolajuk et al. (2009); (OD15) O’Dowd et al. (2015); (Pa18) Parker et al. (2018a); (Pa19) Parker et al. (2019a); (Pe04) Peterson et al. (2004); (Pg03) Page et al. (2003); (Pi18) Pinto et al. (2018); (Pl14) Paliya et al. (2014); (Pn19) Pan et al. (2019); (Po03) Pounds et al. (2003a); (Po07) Pounds & Wilkes (2007); (Po12) Ponti et al. (2012); (RC) Reines & Volonteri (2015) and Corral et al. (2016); (RV) Reines & Volonteri (2015) and Vika et al. (2017); (Re04) Reeves et al. (2004b); (Re09) Reeves et al. (2009b); (Re17) Reeves et al. (2017); (Ri14) Ricci et al. (2014); (Ri17) Ricci et al. (2017a); (Ri20) Ricci et al. (2020); (Ru21) Ruiz et al. (2021); (Rv15) Rivers et al. (2015); (SIM) Simbad; (Sa13) Sanfrutos et al. (2013); (Sa18) Sanfrutos et al. (2018); (Se07) Sergeev et al. (2007); (Sh08) Shirai et al. (2008); (Sh11) Shen et al. (2011); (Si07) Sikora et al. (2007); (Sm19) Smith et al. (2019); (Ta16) Tatum et al. (2016); (Te10) Teng & Veilleux (2010); (To06) Tozzi et al. (2006); (To10) Tombesi et al. (2010b); (To14) Tombesi et al. (2014); (Tr22) Tortosa et al. (2022); (U22) U et al. (2022); (VC10) Véron-Cetty & Véron (2010); (Vi15) Vignali et al. (2015); (Wa07) Wang & Zhang (2007); (Wa18) Walton et al. (2018); (Wa19) Walton et al. (2019); (Wa20) Walton et al. (2020); (Wa21) Walton et al. (2021); (Wi10) Winter & Mushotzky (2010); (Wn05) Wang et al. (2005); (Wo02) Woo & Urry (2002); (Wo24) Woo et al. (2024); (Xu21) Xu et al. (2021); (Xu22) Xu et al. (2022); (Ya21) Yamada et al. (2021); (Zo13) Zoghbi et al. (2013).

(This table is available in its entirety in machine-readable form.)

Table B3. X-ray Wind Properties

ID	Object	Start date	Inst.	Fe-K	$\log N_{\text{H}}$	$\log V_{\text{out}}$	$\log \xi$	$\log L_{\text{ion}}$	Type	Model
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1a	1E 0754.6+3928	2006-04-18	P	Y	$23.11^{+0.25}_{-0.41}$	$4.84^{+0.04}_{-0.04}$	$3.40^{+0.30}_{-0.30}$	44.11	UFO	XSTAR
1b	1E 0754.6+3928	2006-04-18	P	Y	$23.41^{+0.27}_{-0.51}$	$3.71^{+0.09}_{-0.12}$	$3.40^{+0.10}_{-0.10}$	44.11	WA	XSTAR
1c	1E 0754.6+3928	2006-04-18	P	n	$22.85^{+0.06}_{-0.07}$	<3.18	$2.00^{+0.05}_{-0.05}$	44.11	WA	XSTAR
1d	1E 0754.6+3928	2006-10-22	P	n	$22.60^{+0.05}_{-0.06}$	<3.04	$1.50^{+0.07}_{-0.07}$	44.11	WA	XSTAR
2a	1ES 1927+654	2011-04-16to2011-05-20	PSu	n	$23.82^{+0.09}_{-0.05}$	$4.90^{+0.01}_{-0.01}$	$3.03^{+0.11}_{-0.16}$	(non)	UFO	zxipcf
2b	1ES 1927+654	2011-04-16to2011-05-20	PSu	n	$22.52^{+0.24}_{-0.15}$	$4.90^{+0.01}_{-0.01}$	$-0.30^{+0.01}_{-0.01}$	(non)	LIP	zxipcf
3a	1H 0323+342	2015-08-23	RPM	n	$20.86^{+0.07}_{-0.08}$	$2.94^{+0.09}_{-0.11}$	$0.15^{+0.20}_{-0.20}$	(non)	WA	xabs
3b	1H 0323+342	2015-08-23	RPM	n	$20.95^{+0.14}_{-0.20}$	$2.92^{+0.13}_{-0.18}$	$2.17^{+0.03}_{-0.03}$	(non)	WA	xabs
4a	1H 0419-577	2002-09-25	P	Y	<23.61	$4.37^{+0.06}_{-0.07}$	$3.69^{+0.87}_{-0.87}$	44.60	UFO	XSTAR
5a	1H 0707-495	2000-10-21to2019-10-11	RP	Y	$22.26^{+0.16}_{-0.26}$	$4.73^{+0.02}_{-0.03}$	$3.93^{+0.08}_{-0.10}$	44.15	UFO	xabs

NOTE—Columns: (1) Detection ID of outflow components (2) Object names (3) Start date of observation. The start dates of the oldest and latest observations are shown when multiple observations are used to identify the ionized outflows. (4) Instruments of observation (A=Chandra/ACIS, F=NuSTAR/FPM, H=Chandra/HETGS, L=Chandra/LETGS, M=XMM-Newton/MOS, P=XMM-Newton/PN, R=XMM-Newton/RGS, Su=Suzaku/XIS, and Sw=Swift/XRT). (5) The method of outflow detection utilizes blueshifted Fe-K absorption lines, Fe XXV/Fe XXVI $K\alpha/K\beta$ above the rest-frame 6 keV band (Y) or absorption lines below the 6 keV band (n). (6)–(8) Logarithmic N_{H} of the ionized outflows in units of cm^{-2} , V_{out} in units of km s^{-1} , and ξ in units of $\text{erg s}^{-1} \text{ cm}$. (*) indicates that the values are presented assuming $\log U = \log \xi - 1.75$ (Section 2.2). When the uncertainties of V_{out} or N_{H} are not constrained, we assume that they are ± 0.5 , which are conservative values larger than the typical errors (~ 0.1 – 0.2) in Figures 3–7. (9) Logarithmic ionizing luminosity in units of erg s^{-1} . (10) Outflow-type UFO, low- ξ UFO (LIP) and warm absorber (WA). The OBSIDs and the references for each ID are listed in Table B4. (11) The types of the X-ray fitting models of the X-ray winds (see Appendix A).

(This table is available in its entirety in machine-readable form.)

Table B4. Observations and References of the X-ray Winds

ID	Object	OBSID	Ref1	Ref2	Ref3	Ref4	Ref5	Ref6	Ref7	Ref8	Ref9
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1a	1E 0754.6+3928	305990101	Mid20								
1b	1E 0754.6+3928	305990101	Mid20								
1c	1E 0754.6+3928	305990101	Mid20								
1d	1E 0754.6+3928	406740101	Mid20								
2a	1ES 1927+654	0671860201+706006010	Gal13b								
2b	1ES 1927+654	0671860201+706006010	Gal13b								
3a	1H 0323+342	764670101	Meh19								
3b	1H 0323+342	764670101	Meh19								
4a	1H 0419-577	148000201	Tom12a	Tom11a	Tom10a	DiG14					
5a	1H 0707-495	16 OBSIDs	XuY21	Par21	Kos18	Hag16	Dau12	Gal04			

Table B4 *continued*

Table B4 (continued)

ID	Object	OBSID	Ref1	Ref2	Ref3	Ref4	Ref5	Ref6	Ref7	Ref8	Ref9
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

NOTE—Columns: (1) Detection ID of outflow components (2) Object names (3) OBSIDs; (4) References for the adopted X-ray winds (5)–(12) pertinent papers on duplicated reports.

References: (And10) Andrade-Velázquez et al. (2010); (Bal11) Ballo et al. (2011); (Bal15) Ballo et al. (2015); (Bal24) Baldini et al. (2024); (Beh03) Behar et al. (2003); (Beh10) Behar et al. (2010); (Beh17) Behar et al. (2017); (Ber20) Bertola et al. (2020); (Beu15) Beuchert et al. (2015); (Beu17) Beuchert et al. (2017); (Blu02) Blustin et al. (2002); (Blu03) Blustin et al. (2003); (Blu05) Blustin et al. (2005); (Blu07) Blustin et al. (2007); (Blu09) Blustin & Fabian (2009); (Boi19) Boissay-Malaquin et al. (2019); (Bon23) Bonanomi et al. (2023); (Bra07) Braitto et al. (2007); (Bra11) Braitto et al. (2011); (Bra14) Braitto et al. (2014); (Bra18) Braitto et al. (2018); (Bra21) Braitto et al. (2021); (Bra22) Braitto et al. (2022); (Bre12) Brenneman et al. (2012); (Bre13) Brenneman et al. (2013); (Bri06) Brinkmann et al. (2006); (Cap09) Cappi et al. (2009); (Cap16) Cappi et al. (2016); (Cha02) Chartas et al. (2002); (Cha03) Chartas et al. (2003); (Cha07a) Chartas et al. (2007a); (Cha07b) Chartas et al. (2007b); (Cha09) Chartas et al. (2009); (Cha14) Chartas et al. (2014); (Cha16) Chartas et al. (2016); (Cha18) Chartas & Canas (2018); (Cha21) Chartas et al. (2021); (Chi11) Chiang & Fabian (2011); (Chi12) Chiang et al. (2012); (Col01) Collinge et al. (2001); (Cos07a) Costantini et al. (2007a); (Cos07b) Costantini et al. (2007b); (Cos10) Costantini et al. (2010); (Dad05) Dadina et al. (2005); (Dad18) Dadina et al. (2018); (Dan18) Danehkar et al. (2018b); (Das05) Dasgupta et al. (2005); (Dau12) Dauser et al. (2012); (Det08) Detmers et al. (2008); (Det10) Detmers et al. (2010); (Det11) Detmers et al. (2011); (DiG14) Di Gesu et al. (2014); (DiG15) Di Gesu et al. (2015); (DiG16) Di Gesu & Costantini (2016); (Ebr10) Ebrero et al. (2010); (Ebr11a) Ebrero et al. (2011a); (Ebr11b) Ebrero et al. (2011b); (Ebr13) Ebrero et al. (2013); (Ebr16a) Ebrero et al. (2016a); (Ebr16b) Ebrero et al. (2016b); (Ebr21) Ebrero et al. (2021); (Fer15) Feruglio et al. (2015); (Gal04) Gallo et al. (2004); (Gal13b) Gallo et al. (2013); (Gal13c) Gallo & Fabian (2013); (Gal15) Gallo et al. (2015); (Gal19) Gallo et al. (2019); (Gan22) Gandhi et al. (2022); (Gib05) Gibson et al. (2005); (Gib07) Gibson et al. (2007); (Giu11) Giustini et al. (2011); (Giu23) Giustini et al. (2023); (Gof11) Gofford et al. (2011); (Gof13) Gofford et al. (2013); (Gof14) Gofford et al. (2014); (Gof15) Gofford et al. (2015); (Gup13a) Gupta et al. (2013a); (Gup13b) Gupta et al. (2013b); (Gup15) Gupta et al. (2015); (Hag15) Hagino et al. (2015); (Hag16) Hagino et al. (2016); (Hag17) Hagino et al. (2017); (Hol05) Holczer et al. (2005); (Hol07) Holczer et al. (2007); (Hol10) Holczer et al. (2010); (Hol12) Holczer & Behar (2012); (Igo20) Igo et al. (2020); (Iwa16) Iwasawa et al. (2016); (Iwa17) Iwasawa et al. (2017); (Jia18a) Jiang et al. (2018a); (Jia18b) Jiang et al. (2018b); (Jia22) Jiang et al. (2022); (Jim08) Jiménez-Bailón et al. (2008); (Kaa02) Kaastra et al. (2002); (Kaa04) Kaastra et al. (2004); (Kaa11) Kaastra et al. (2011); (Kaa12) Kaastra et al. (2012); (Kaa14b) Kaastra et al. (2014b); (Kaa14c) Kaastra et al. (2014c); (Kar17) Kara et al. (2017); (Kar21) Kara et al. (2021); (Kas00) Kaspi et al. (2000); (Kas01) Kaspi et al. (2001); (Kas02) Kaspi et al. (2002); (Kas04) Kaspi et al. (2004); (Kas06) Kaspi & Behar (2006); (Kin12) King et al. (2012); (Kol20) Kollatschny et al. (2020); (Kol23) Kollatschny et al. (2023); (Kos18) Kosec et al. (2018); (Kos20) Kosec et al. (2020); (Kra05) Kraemer et al. (2005); (Kro03) Krongold et al. (2003); (Kro05a) Krongold et al. (2005a); (Kro05b) Krongold et al. (2005b); (Kro07) Krongold et al. (2007); (Kro09) Krongold et al. (2009); (Kro10) Krongold et al. (2010); (Kro21) Krongold et al. (2021); (Lah11) Laha et al. (2011); (Lah13) Laha et al. (2013); (Lah14) Laha et al. (2014); (Lah16) Laha et al. (2016); (Lan12) Lanzuisi et al. (2012); (Lan16) Lanzuisi et al. (2016); (Lau21) Laurenti et al. (2021); (Lee13) Lee et al. (2013); (Lob11) Lobban et al. (2011); (Lob16) Lobban et al. (2016); (Lon03) Longinotti et al. (2003); (Lon10) Longinotti et al. (2010); (Lon13) Longinotti et al. (2013); (Lon15) Longinotti et al. (2015); (Lon19) Longinotti et al. (2019); (Lum18) Luminari et al. (2018); (Lum23) Luminari et al. (2023); (Mal18) Mallick et al. (2018); (Mao17) Mao et al. (2017); (Mao19) Mao et al. (2019); (Mao22) Mao et al. (2022); (Mar06) Markowitz et al. (2006); (Mar09) Markowitz et al. (2009); (Mari18) Marinucci et al. (2018); (Mas03) Mason et al. (2003); (Mat16) Matzeu et al. (2016); (Mat17) Matzeu et al. (2017); (Mat19) Matzeu et al. (2019); (Mat20) Matzeu et al. (2020); (Mat23) Matzeu et al. (2023); (Mats04) Matsumoto et al. (2004); (Matt04) Matt et al. (2004); (McK03) McKernan et al. (2003); (McK07) McKernan et al. (2007); (Meh10) Mehdipour et al. (2010); (Meh12) Mehdipour et al. (2012); (Meh17) Mehdipour et al. (2017); (Meh18) Mehdipour et al. (2018); (Meh19) Mehdipour & Costantini (2019); (Meh23) Mehdipour et al. (2023a); (Mid20) Middei et al. (2020); (Mid21) Middei et al. (2021); (Mid23) Midooka et al. (2023); (Min07) Miniutti et al. (2007); (Min14) Miniutti et al. (2014); (Miz17) Mizumoto & Ebisawa (2017); (Miz19a) Mizumoto et al. (2019a); (Miz19b) Mizumoto et al. (2019b); (Miz21) Mizumoto et al. (2021); (Moc23) Mochizuki et al. (2023); (Moc11) Mocz et al. (2011); (Mon22) Mondal et al. (2022); (Nar14) Nardini et al. (2014); (Nar15) Nardini et al. (2015); (Nar18) Nardini & Zubovas (2018); (Nar19) Nardini et al. (2019); (Net03) Netzer et al. (2003); (Ogl04) Ogle et al. (2004); (Ogo22) Ogorzalek et al. (2022); (Pag03) Page et al. (2003); (Pap07) Papadakis et al. (2007); (Pap16) Papadakis et al. (2016); (Par17a) Parker et al. (2017a); (Par17b) Parker et al. (2017b); (Par18a) Parker et al. (2018a); (Par18b) Parker et al. (2018b); (Par19a) Parker et al. (2019a); (Par19b) Parker et al. (2019b); (Par20) Parker et al. (2020); (Par21) Parker et al. (2021); (Pat12) Patrick et al. (2012); (Per18) Peretz et al. (2018); (Pin18) Pinto et al. (2018); (Pon09) Ponti et al. (2009); (Pou03a) Pounds et al. (2003a); (Pou03b) Pounds et al. (2003b); (Pou04) Pounds et al. (2004); (Pou06) Pounds & Page (2006); (Pou07a) Pounds & Reeves (2007); (Pou07b) Pounds & Wilkes (2007); (Pou09) Pounds & Reeves (2009); (Pou11) Pounds & Vaughan (2011); (Pou12) Pounds & Vaughan (2012); (Pou13) Pounds & King (2013); (Pou14) Pounds (2014); (Pou16a) Pounds et al. (2016a); (Pou16b) Pounds et al. (2016b); (Pou18) Pounds et al. (2018); (Ree03) Reeves et al. (2003); (Ree04a) Reeves et al. (2004a); (Ree04b) Reeves et al. (2004b); (Ree05) Reeves et al. (2005); (Ree08) Reeves et al. (2008); (Ree09a) Reeves et al. (2009a); (Ree09b) Reeves et al. (2009b); (Ree10) Reeves et al. (2010); (Ree13) Reeves et al. (2013); (Ree14) Reeves et al. (2014); (Ree16) Reeves et al. (2016); (Ree17) Reeves et al. (2017); (Ree18a) Reeves et al. (2018a); (Ree18b) Reeves et al. (2018b); (Ree19) Reeves & Braitto (2019); (Ree20) Reeves et al. (2020); (Ree23) Reeves et al. (2023); (Ris05) Risaliti et al. (2005); (Ris11) Risaliti et al. (2011); (Sae09) Saez et al. (2009); (Sae11) Saez & Chartas (2011); (Sak01) Sako et al. (2001); (Sak03) Sako et al. (2003); (San16) Sanfrutos et al. (2016); (San18) Sanfrutos et al. (2018); (Sco14) Scott et al. (2014); (Ser19) Serafinelli et al. (2019); (Ser23) Serafinelli et al. (2023); (Shi08) Shirai et al. (2008); (Smi07) Smith et al. (2007); (Smi08) Smith et al. (2008); (Smi19) Smith et al. (2019); (Ste03a) Steenbrugge et al. (2003a); (Ste03b) Steenbrugge et al. (2003b); (Ste05a) Steenbrugge et al. (2005a); (Ste05b) Steenbrugge et al. (2005b); (Ste09) Steenbrugge et al. (2009); (Ter09) Terashima et al. (2009); (Tom10a) Tombesi et al. (2010a); (Tom10b) Tombesi et al. (2010b); (Tom11a) Tombesi et al. (2011a); (Tom11b) Tombesi et al. (2011b); (Tom12a) Tombesi et al. (2012a); (Tom12b) Tombesi et al. (2012b); (Tom13a) Tombesi et al. (2013a); (Tom13b) Tombesi et al. (2013b); (Tom14a) Tombesi et al. (2014); (Tom14b) Tombesi & Cappi (2014); (Tom15) Tombesi et al. (2015); (Tom16) Tombesi et al. (2016); (Tom17a) Tombesi et al. (2017a); (Tom17b) Tombesi et al. (2017b); (Tor10) Torresi et al. (2010); (Tor12) Torresi et al. (2012); (Tor17) Tortosa et al. (2017); (Tor22) Tortosa et al. (2022); (Tur05) Turner et al. (2005); (Tur08) Turner et al. (2008); (Tur18) Turner et al. (2018); (Urs16) Ursini et al. (2016); (Urs18) Ursini et al. (2018); (Urs19) Ursini et al. (2019); (Ven18) Venturi et al. (2018); (Vig15) Vignali et al. (2015); (Wal18) Walton et al. (2018); (Wal19) Walton et al. (2019); (Wal20) Walton et al. (2020); (Wal21) Walton et al. (2021); (Wan05) Wang et al. (2005); (Win10) Winter & Mushotzky (2010); (XuY21) Xu et al. (2021); (XuY22) Xu et al. (2022); (XuY23) Xu et al. (2023); (Yaq03a) Yaqoob et al. (2003a); (Yaq03b) Yaqoob et al. (2003b); (You05) Young et al. (2005); (Zha11) Zhang et al. (2011); (Zhe08) Zheng & Wang (2008); (Zog10) Zoghbi et al. (2010); (Zog19) Zoghbi et al. (2019).

(This table is available in its entirety in machine-readable form.)

REFERENCES

- Alonso-Herrero, A., García-Burillo, S., Hönig, S. F., et al. 2021, *A&A*, 652, A99, doi: [10.1051/0004-6361/202141219](https://doi.org/10.1051/0004-6361/202141219)
- Alston, W. N., Done, C., & Vaughan, S. 2014, *MNRAS*, 439, 1548, doi: [10.1093/mnras/stu005](https://doi.org/10.1093/mnras/stu005)
- Ananna, T. T., Urry, C. M., Ricci, C., et al. 2022, *ApJL*, 939, L13, doi: [10.3847/2041-8213/ac9979](https://doi.org/10.3847/2041-8213/ac9979)
- Andrade-Velázquez, M., Krongold, Y., Elvis, M., et al. 2010, *ApJ*, 711, 888, doi: [10.1088/0004-637X/711/2/888](https://doi.org/10.1088/0004-637X/711/2/888)
- Antonucci, R. 1993, *ARA&A*, 31, 473, doi: [10.1146/annurev.aa.31.090193.002353](https://doi.org/10.1146/annurev.aa.31.090193.002353)
- Arnaud, K. A. 1996, *Astronomical Society of the Pacific Conference Series*, Vol. 101, *XSPEC: The First Ten Years*, ed. G. H. Jacoby & J. Barnes, 17
- Baldini, P., Lanzuisi, G., Brusa, M., et al. 2024, arXiv e-prints, arXiv:2402.16966, doi: [10.48550/arXiv.2402.16966](https://doi.org/10.48550/arXiv.2402.16966)
- Ballo, L., Braitto, V., Reeves, J. N., Sambruna, R. M., & Tombesi, F. 2011, *MNRAS*, 418, 2367, doi: [10.1111/j.1365-2966.2011.19629.x](https://doi.org/10.1111/j.1365-2966.2011.19629.x)
- Ballo, L., Severgnini, P., Braitto, V., et al. 2015, *A&A*, 581, A87, doi: [10.1051/0004-6361/201526571](https://doi.org/10.1051/0004-6361/201526571)
- Baskin, A., & Laor, A. 2018, *MNRAS*, 474, 1970, doi: [10.1093/mnras/stx2850](https://doi.org/10.1093/mnras/stx2850)
- Bauer, F. E., Arévalo, P., Walton, D. J., et al. 2015, *ApJ*, 812, 116, doi: [10.1088/0004-637X/812/2/116](https://doi.org/10.1088/0004-637X/812/2/116)
- Bautista, M. A., & Kallman, T. R. 2001, *ApJS*, 134, 139, doi: [10.1086/320363](https://doi.org/10.1086/320363)
- Behar, E., Kaspi, S., Reeves, J., et al. 2010, *ApJ*, 712, 26, doi: [10.1088/0004-637X/712/1/26](https://doi.org/10.1088/0004-637X/712/1/26)
- Behar, E., Rasmussen, A. P., Blustin, A. J., et al. 2003, *ApJ*, 598, 232, doi: [10.1086/378853](https://doi.org/10.1086/378853)
- Behar, E., Peretz, U., Kriss, G. A., et al. 2017, *A&A*, 601, A17, doi: [10.1051/0004-6361/201629943](https://doi.org/10.1051/0004-6361/201629943)
- Bentz, M. C., & Katz, S. 2015, *PASP*, 127, 67, doi: [10.1086/679601](https://doi.org/10.1086/679601)
- Bentz, M. C., Onken, C. A., Street, R., & Valluri, M. 2023, *ApJ*, 944, 29, doi: [10.3847/1538-4357/acab62](https://doi.org/10.3847/1538-4357/acab62)
- Bertola, E., Dadina, M., Cappi, M., et al. 2020, *A&A*, 638, A136, doi: [10.1051/0004-6361/202037742](https://doi.org/10.1051/0004-6361/202037742)
- Beuchert, T., Markowitz, A. G., Krauß, F., et al. 2015, *A&A*, 584, A82, doi: [10.1051/0004-6361/201526790](https://doi.org/10.1051/0004-6361/201526790)
- Beuchert, T., Markowitz, A. G., Dauser, T., et al. 2017, *A&A*, 603, A50, doi: [10.1051/0004-6361/201630293](https://doi.org/10.1051/0004-6361/201630293)
- Bianchi, S., Guainazzi, M., Matt, G., Fonseca Bonilla, N., & Ponti, G. 2009, *A&A*, 495, 421, doi: [10.1051/0004-6361:200810620](https://doi.org/10.1051/0004-6361:200810620)
- Bianchin, M., Riffel, R. A., Storchi-Bergmann, T., et al. 2022, *MNRAS*, 510, 639, doi: [10.1093/mnras/stab3468](https://doi.org/10.1093/mnras/stab3468)
- Blandford, R. D., & Payne, D. G. 1982, *MNRAS*, 199, 883, doi: [10.1093/mnras/199.4.883](https://doi.org/10.1093/mnras/199.4.883)
- Blustin, A. J., Branduardi-Raymont, G., Behar, E., et al. 2002, *A&A*, 392, 453, doi: [10.1051/0004-6361:20020914](https://doi.org/10.1051/0004-6361:20020914)
- Blustin, A. J., & Fabian, A. C. 2009, *MNRAS*, 399, L169, doi: [10.1111/j.1745-3933.2009.00746.x](https://doi.org/10.1111/j.1745-3933.2009.00746.x)
- Blustin, A. J., Page, M. J., Fuerst, S. V., Branduardi-Raymont, G., & Ashton, C. E. 2005, *A&A*, 431, 111, doi: [10.1051/0004-6361:20041775](https://doi.org/10.1051/0004-6361:20041775)
- Blustin, A. J., Branduardi-Raymont, G., Behar, E., et al. 2003, *A&A*, 403, 481, doi: [10.1051/0004-6361:20030236](https://doi.org/10.1051/0004-6361:20030236)
- Blustin, A. J., Kriss, G. A., Holczer, T., et al. 2007, *A&A*, 466, 107, doi: [10.1051/0004-6361:20066883](https://doi.org/10.1051/0004-6361:20066883)
- Boissay-Malaquin, R., Danekhar, A., Marshall, H. L., & Nowak, M. A. 2019, *ApJ*, 873, 29, doi: [10.3847/1538-4357/ab0082](https://doi.org/10.3847/1538-4357/ab0082)
- Bonanomi, F., Ciccone, C., Severgnini, P., et al. 2023, *A&A*, 673, A46, doi: [10.1051/0004-6361/202245630](https://doi.org/10.1051/0004-6361/202245630)
- Braitto, V., Reeves, J. N., Gofford, J., et al. 2014, *ApJ*, 795, 87, doi: [10.1088/0004-637X/795/1/87](https://doi.org/10.1088/0004-637X/795/1/87)
- Braitto, V., Reeves, J. N., Sambruna, R. M., & Gofford, J. 2011, *MNRAS*, 414, 2739, doi: [10.1111/j.1365-2966.2011.18590.x](https://doi.org/10.1111/j.1365-2966.2011.18590.x)
- Braitto, V., Reeves, J. N., Dewangan, G. C., et al. 2007, *ApJ*, 670, 978, doi: [10.1086/521916](https://doi.org/10.1086/521916)
- Braitto, V., Reeves, J. N., Matzeu, G. A., et al. 2018, *MNRAS*, 479, 3592, doi: [10.1093/mnras/sty1697](https://doi.org/10.1093/mnras/sty1697)
- Braitto, V., Reeves, J. N., Severgnini, P., et al. 2021, *MNRAS*, 500, 291, doi: [10.1093/mnras/staa3264](https://doi.org/10.1093/mnras/staa3264)
- Braitto, V., Reeves, J. N., Matzeu, G., et al. 2022, *ApJ*, 926, 219, doi: [10.3847/1538-4357/ac3763](https://doi.org/10.3847/1538-4357/ac3763)
- Brenneman, L. W., Elvis, M., Krongold, Y., Liu, Y., & Mathur, S. 2012, *ApJ*, 744, 13, doi: [10.1088/0004-637X/744/1/13](https://doi.org/10.1088/0004-637X/744/1/13)
- Brenneman, L. W., Risaliti, G., Elvis, M., & Nardini, E. 2013, *MNRAS*, 429, 2662, doi: [10.1093/mnras/sts555](https://doi.org/10.1093/mnras/sts555)
- Brinkman, A. C., Gunsing, C. J. T., Kaastra, J. S., et al. 2000, *ApJL*, 530, L111, doi: [10.1086/312504](https://doi.org/10.1086/312504)
- Brinkmann, W., Wang, T., Grupe, D., & Raeth, C. 2006, *A&A*, 450, 925, doi: [10.1051/0004-6361:20053751](https://doi.org/10.1051/0004-6361:20053751)
- Buchner, J., Georgakakis, A., Nandra, K., et al. 2015, *ApJ*, 802, 89, doi: [10.1088/0004-637X/802/2/89](https://doi.org/10.1088/0004-637X/802/2/89)
- Canizares, C. R., Davis, J. E., Dewey, D., et al. 2005, *PASP*, 117, 1144, doi: [10.1086/432898](https://doi.org/10.1086/432898)
- Cappi, M., Tombesi, F., Bianchi, S., et al. 2009, *A&A*, 504, 401, doi: [10.1051/0004-6361/200912137](https://doi.org/10.1051/0004-6361/200912137)
- Cappi, M., De Marco, B., Ponti, G., et al. 2016, *A&A*, 592, A27, doi: [10.1051/0004-6361/201628464](https://doi.org/10.1051/0004-6361/201628464)

- Chartas, G., Brandt, W. N., & Gallagher, S. C. 2003, *ApJ*, 595, 85, doi: [10.1086/377299](https://doi.org/10.1086/377299)
- Chartas, G., Brandt, W. N., Gallagher, S. C., & Garmire, G. P. 2002, *ApJ*, 579, 169, doi: [10.1086/342744](https://doi.org/10.1086/342744)
- Chartas, G., Brandt, W. N., Gallagher, S. C., & Proga, D. 2007a, *AJ*, 133, 1849, doi: [10.1086/512364](https://doi.org/10.1086/512364)
- Chartas, G., & Canas, M. H. 2018, *ApJ*, 867, 103, doi: [10.3847/1538-4357/aae438](https://doi.org/10.3847/1538-4357/aae438)
- Chartas, G., Cappi, M., Hamann, F., et al. 2016, *ApJ*, 824, 53, doi: [10.3847/0004-637X/824/1/53](https://doi.org/10.3847/0004-637X/824/1/53)
- Chartas, G., Eracleous, M., Dai, X., Agol, E., & Gallagher, S. 2007b, *ApJ*, 661, 678, doi: [10.1086/516816](https://doi.org/10.1086/516816)
- Chartas, G., Hamann, F., Eracleous, M., et al. 2014, *ApJ*, 783, 57, doi: [10.1088/0004-637X/783/1/57](https://doi.org/10.1088/0004-637X/783/1/57)
- Chartas, G., Saez, C., Brandt, W. N., Giustini, M., & Garmire, G. P. 2009, *ApJ*, 706, 644, doi: [10.1088/0004-637X/706/1/644](https://doi.org/10.1088/0004-637X/706/1/644)
- Chartas, G., Cappi, M., Vignali, C., et al. 2021, *ApJ*, 920, 24, doi: [10.3847/1538-4357/ac0ef2](https://doi.org/10.3847/1538-4357/ac0ef2)
- Cheng, H., Yuan, W., Liu, H.-Y., et al. 2019, *MNRAS*, 487, 3884, doi: [10.1093/mnras/stz1532](https://doi.org/10.1093/mnras/stz1532)
- Chiang, C.-Y., & Fabian, A. C. 2011, *MNRAS*, 414, 2345, doi: [10.1111/j.1365-2966.2011.18553.x](https://doi.org/10.1111/j.1365-2966.2011.18553.x)
- Chiang, C.-Y., Reis, R. C., Fabian, A. C., Grupe, D., & Tsuruta, S. 2012, *MNRAS*, 425, 1299, doi: [10.1111/j.1365-2966.2012.21532.x](https://doi.org/10.1111/j.1365-2966.2012.21532.x)
- Cicone, C., Maiolino, R., Sturm, E., et al. 2014, *A&A*, 562, A21, doi: [10.1051/0004-6361/201322464](https://doi.org/10.1051/0004-6361/201322464)
- Collinge, M. J., Brandt, W. N., Kaspi, S., et al. 2001, *ApJ*, 557, 2, doi: [10.1086/321635](https://doi.org/10.1086/321635)
- Corral, A., Georgantopoulos, I., Comastri, A., et al. 2016, *A&A*, 592, A109, doi: [10.1051/0004-6361/201527624](https://doi.org/10.1051/0004-6361/201527624)
- Costantini, E., Gallo, L. C., Brandt, W. N., Fabian, A. C., & Boller, T. 2007a, *MNRAS*, 378, 873, doi: [10.1111/j.1365-2966.2007.11646.x](https://doi.org/10.1111/j.1365-2966.2007.11646.x)
- Costantini, E., Kaastra, J. S., Korista, K., et al. 2010, *A&A*, 512, A25, doi: [10.1051/0004-6361/200912555](https://doi.org/10.1051/0004-6361/200912555)
- Costantini, E., Kaastra, J. S., Arav, N., et al. 2007b, *A&A*, 461, 121, doi: [10.1051/0004-6361:20065390](https://doi.org/10.1051/0004-6361:20065390)
- Czerny, B., & Hryniewicz, K. 2011, *A&A*, 525, L8, doi: [10.1051/0004-6361/201016025](https://doi.org/10.1051/0004-6361/201016025)
- Dadina, M., Cappi, M., Malaguti, G., Ponti, G., & de Rosa, A. 2005, *A&A*, 442, 461, doi: [10.1051/0004-6361:20042487](https://doi.org/10.1051/0004-6361:20042487)
- Dadina, M., Vignali, C., Cappi, M., et al. 2018, *A&A*, 610, L13, doi: [10.1051/0004-6361/201732406](https://doi.org/10.1051/0004-6361/201732406)
- Danehkar, A., Nowak, M. A., Lee, J. C., & Smith, R. K. 2018a, *PASP*, 130, 024501, doi: [10.1088/1538-3873/aa9dff](https://doi.org/10.1088/1538-3873/aa9dff)
- Danehkar, A., Nowak, M. A., Lee, J. C., et al. 2018b, *ApJ*, 853, 165, doi: [10.3847/1538-4357/aaa427](https://doi.org/10.3847/1538-4357/aaa427)
- Dasgupta, S., Rao, A. R., Dewangan, G. C., & Agrawal, V. K. 2005, *ApJL*, 618, L87, doi: [10.1086/427799](https://doi.org/10.1086/427799)
- Dauser, T., Svoboda, J., Schartel, N., et al. 2012, *MNRAS*, 422, 1914, doi: [10.1111/j.1365-2966.2011.20356.x](https://doi.org/10.1111/j.1365-2966.2011.20356.x)
- Davies, R. I., Maciejewski, W., Hicks, E. K. S., et al. 2014, *ApJ*, 792, 101, doi: [10.1088/0004-637X/792/2/101](https://doi.org/10.1088/0004-637X/792/2/101)
- den Herder, J. W., Brinkman, A. C., Kahn, S. M., et al. 2001, *A&A*, 365, L7, doi: [10.1051/0004-6361:20000058](https://doi.org/10.1051/0004-6361:20000058)
- Detmers, R. G., Kaastra, J. S., Costantini, E., McHardy, I. M., & Verbunt, F. 2008, *A&A*, 488, 67, doi: [10.1051/0004-6361:200809862](https://doi.org/10.1051/0004-6361:200809862)
- Detmers, R. G., Kaastra, J. S., Costantini, E., et al. 2010, *A&A*, 516, A61, doi: [10.1051/0004-6361/200913879](https://doi.org/10.1051/0004-6361/200913879)
- Detmers, R. G., Kaastra, J. S., Steenbrugge, K. C., et al. 2011, *A&A*, 534, A38, doi: [10.1051/0004-6361/201116899](https://doi.org/10.1051/0004-6361/201116899)
- Di Gesu, L., & Costantini, E. 2016, *A&A*, 594, A88, doi: [10.1051/0004-6361/201628670](https://doi.org/10.1051/0004-6361/201628670)
- Di Gesu, L., Costantini, E., Piconcelli, E., et al. 2014, *A&A*, 563, A95, doi: [10.1051/0004-6361/201322916](https://doi.org/10.1051/0004-6361/201322916)
- Di Gesu, L., Costantini, E., Ebrero, J., et al. 2015, *A&A*, 579, A42, doi: [10.1051/0004-6361/201525934](https://doi.org/10.1051/0004-6361/201525934)
- Di Matteo, T., Springel, V., & Hernquist, L. 2005, *Nature*, 433, 604, doi: [10.1038/nature03335](https://doi.org/10.1038/nature03335)
- Done, C., Mulchaey, J. S., Mushotzky, R. F., & Arnaud, K. A. 1992, *ApJ*, 395, 275, doi: [10.1086/171649](https://doi.org/10.1086/171649)
- Du, P., Hu, C., Lu, K.-X., et al. 2015, *ApJ*, 806, 22, doi: [10.1088/0004-637X/806/1/22](https://doi.org/10.1088/0004-637X/806/1/22)
- Duras, F., Bongiorno, A., Ricci, F., et al. 2020, *A&A*, 636, A73, doi: [10.1051/0004-6361/201936817](https://doi.org/10.1051/0004-6361/201936817)
- Ebrero, J., Costantini, E., Kaastra, J. S., de Marco, B., & Dadina, M. 2011a, *A&A*, 535, A62, doi: [10.1051/0004-6361/201117650](https://doi.org/10.1051/0004-6361/201117650)
- Ebrero, J., Costantini, E., Kaastra, J. S., et al. 2010, *A&A*, 520, A36, doi: [10.1051/0004-6361/201014091](https://doi.org/10.1051/0004-6361/201014091)
- Ebrero, J., Domček, V., Kriss, G. A., & Kaastra, J. S. 2021, *A&A*, 653, A125, doi: [10.1051/0004-6361/202040045](https://doi.org/10.1051/0004-6361/202040045)
- Ebrero, J., Kaastra, J. S., Kriss, G. A., de Vries, C. P., & Costantini, E. 2013, *MNRAS*, 435, 3028, doi: [10.1093/mnras/stt1497](https://doi.org/10.1093/mnras/stt1497)
- Ebrero, J., Kriss, G. A., Kaastra, J. S., & Ely, J. C. 2016a, *A&A*, 586, A72, doi: [10.1051/0004-6361/201527495](https://doi.org/10.1051/0004-6361/201527495)
- Ebrero, J., Kriss, G. A., Kaastra, J. S., et al. 2011b, *A&A*, 534, A40, doi: [10.1051/0004-6361/201117067](https://doi.org/10.1051/0004-6361/201117067)
- Ebrero, J., Kaastra, J. S., Kriss, G. A., et al. 2016b, *A&A*, 587, A129, doi: [10.1051/0004-6361/201527808](https://doi.org/10.1051/0004-6361/201527808)
- Engel, H., Davies, R. I., Genzel, R., et al. 2010, *A&A*, 524, A56, doi: [10.1051/0004-6361/201015338](https://doi.org/10.1051/0004-6361/201015338)
- Evans, P. A., Beardmore, A. P., Page, K. L., et al. 2009, *MNRAS*, 397, 1177, doi: [10.1111/j.1365-2966.2009.14913.x](https://doi.org/10.1111/j.1365-2966.2009.14913.x)

- Fabian, A. C. 2012, *ARA&A*, 50, 455,
doi: [10.1146/annurev-astro-081811-125521](https://doi.org/10.1146/annurev-astro-081811-125521)
- Fabian, A. C., Vasudevan, R. V., & Gandhi, P. 2008, *MNRAS*, 385, L43, doi: [10.1111/j.1745-3933.2008.00430.x](https://doi.org/10.1111/j.1745-3933.2008.00430.x)
- Fabian, A. C., Reynolds, C. S., Jiang, J., et al. 2020, *MNRAS*, 493, 2518, doi: [10.1093/mnras/staa482](https://doi.org/10.1093/mnras/staa482)
- Ferland, G. J., Korista, K. T., Verner, D. A., et al. 1998, *PASP*, 110, 761, doi: [10.1086/316190](https://doi.org/10.1086/316190)
- Ferland, G. J., Porter, R. L., van Hoof, P. A. M., et al. 2013, *RMxAA*, 49, 137, doi: [10.48550/arXiv.1302.4485](https://doi.org/10.48550/arXiv.1302.4485)
- Ferreira, J. 1997, *A&A*, 319, 340,
doi: [10.48550/arXiv.astro-ph/9607057](https://doi.org/10.48550/arXiv.astro-ph/9607057)
- Feruglio, C., Fiore, F., Carniani, S., et al. 2015, *A&A*, 583, A99, doi: [10.1051/0004-6361/201526020](https://doi.org/10.1051/0004-6361/201526020)
- Fiore, F., Feruglio, C., Shankar, F., et al. 2017, *A&A*, 601, A143, doi: [10.1051/0004-6361/201629478](https://doi.org/10.1051/0004-6361/201629478)
- Fischer, T. C., Crenshaw, D. M., Kraemer, S. B., & Schmitt, H. R. 2013, *ApJS*, 209, 1,
doi: [10.1088/0067-0049/209/1/1](https://doi.org/10.1088/0067-0049/209/1/1)
- Fluetsch, A., Maiolino, R., Carniani, S., et al. 2019, *MNRAS*, 483, 4586, doi: [10.1093/mnras/sty3449](https://doi.org/10.1093/mnras/sty3449)
- . 2021, *MNRAS*, 505, 5753, doi: [10.1093/mnras/stab1666](https://doi.org/10.1093/mnras/stab1666)
- Fukumura, K., Dadina, M., Matzeu, G., et al. 2022, *ApJ*, 940, 6, doi: [10.3847/1538-4357/ac9388](https://doi.org/10.3847/1538-4357/ac9388)
- Fukumura, K., Kazanas, D., Contopoulos, I., & Behar, E. 2010, *ApJ*, 715, 636, doi: [10.1088/0004-637X/715/1/636](https://doi.org/10.1088/0004-637X/715/1/636)
- Fukumura, K., Kazanas, D., Shrader, C., et al. 2017, *Nature Astronomy*, 1, 0062, doi: [10.1038/s41550-017-0062](https://doi.org/10.1038/s41550-017-0062)
- Gabriel, C., Denby, M., Fyfe, D. J., et al. 2004, *Astronomical Society of the Pacific Conference Series*, Vol. 314, *The XMM-Newton SAS - Distributed Development and Maintenance of a Large Science Analysis System: A Critical Analysis*, ed. F. Ochsenbein, M. G. Allen, & D. Egret, 759
- Gallimore, J. F., & Impellizzeri, C. M. V. 2023, *ApJ*, 951, 109, doi: [10.3847/1538-4357/acd846](https://doi.org/10.3847/1538-4357/acd846)
- Gallo, L. C., & Fabian, A. C. 2011, *MNRAS*, 418, L59,
doi: [10.1111/j.1745-3933.2011.01143.x](https://doi.org/10.1111/j.1745-3933.2011.01143.x)
- . 2013, *MNRAS*, 434, L66, doi: [10.1093/mnras/slt080](https://doi.org/10.1093/mnras/slt080)
- Gallo, L. C., MacMackin, C., Vasudevan, R., et al. 2013, *MNRAS*, 433, 421, doi: [10.1093/mnras/stt735](https://doi.org/10.1093/mnras/stt735)
- Gallo, L. C., Miller, J. M., & Costantini, E. 2023, *arXiv e-prints*, arXiv:2302.10930,
doi: [10.48550/arXiv.2302.10930](https://doi.org/10.48550/arXiv.2302.10930)
- Gallo, L. C., Tanaka, Y., Boller, T., et al. 2004, *MNRAS*, 353, 1064, doi: [10.1111/j.1365-2966.2004.08248.x](https://doi.org/10.1111/j.1365-2966.2004.08248.x)
- Gallo, L. C., Wilkins, D. R., Bonson, K., et al. 2015, *MNRAS*, 446, 633, doi: [10.1093/mnras/stu2108](https://doi.org/10.1093/mnras/stu2108)
- Gallo, L. C., Gonzalez, A. G., Waddell, S. G. H., et al. 2019, *MNRAS*, 484, 4287, doi: [10.1093/mnras/stz274](https://doi.org/10.1093/mnras/stz274)
- Gómez Rosas, V., Isbell, J. W., Jaffe, W., et al. 2022, *Nature*, 602, 403, doi: [10.1038/s41586-021-04311-7](https://doi.org/10.1038/s41586-021-04311-7)
- Gandhi, P., Kawamuro, T., Díaz Trigo, M., et al. 2022, *Nature Astronomy*, 6, 1364,
doi: [10.1038/s41550-022-01857-y](https://doi.org/10.1038/s41550-022-01857-y)
- García-Burillo, S., Alonso-Herrero, A., Ramos Almeida, C., et al. 2021, *A&A*, 652, A98,
doi: [10.1051/0004-6361/202141075](https://doi.org/10.1051/0004-6361/202141075)
- Garmire, G. P., Bautz, M. W., Ford, P. G., Nousek, J. A., & Ricker, George R., J. 2003, in *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, Vol. 4851, *X-Ray and Gamma-Ray Telescopes and Instruments for Astronomy*, ed. J. E. Truemper & H. D. Tananbaum, 28–44, doi: [10.1117/12.461599](https://doi.org/10.1117/12.461599)
- Ghosh, R., Dewangan, G. C., & Raychaudhuri, B. 2016, *MNRAS*, 456, 554, doi: [10.1093/mnras/stv2682](https://doi.org/10.1093/mnras/stv2682)
- Gibson, R. R., Canizares, C. R., Marshall, H. L., Young, A. J., & Lee, J. C. 2007, *ApJ*, 655, 749,
doi: [10.1086/510441](https://doi.org/10.1086/510441)
- Gibson, R. R., Marshall, H. L., Canizares, C. R., & Lee, J. C. 2005, *ApJ*, 627, 83, doi: [10.1086/430199](https://doi.org/10.1086/430199)
- Giustini, M., Cappi, M., Chartas, G., et al. 2011, *A&A*, 536, A49, doi: [10.1051/0004-6361/201117732](https://doi.org/10.1051/0004-6361/201117732)
- Giustini, M., Rodríguez Hidalgo, P., Reeves, J. N., et al. 2023, *A&A*, 679, A73, doi: [10.1051/0004-6361/202244270](https://doi.org/10.1051/0004-6361/202244270)
- Gofford, J., Reeves, J. N., McLaughlin, D. E., et al. 2015, *MNRAS*, 451, 4169, doi: [10.1093/mnras/stv1207](https://doi.org/10.1093/mnras/stv1207)
- Gofford, J., Reeves, J. N., Tombesi, F., et al. 2013, *MNRAS*, 430, 60, doi: [10.1093/mnras/sts481](https://doi.org/10.1093/mnras/sts481)
- Gofford, J., Reeves, J. N., Turner, T. J., et al. 2011, *MNRAS*, 414, 3307,
doi: [10.1111/j.1365-2966.2011.18634.x](https://doi.org/10.1111/j.1365-2966.2011.18634.x)
- Gofford, J., Reeves, J. N., Braito, V., et al. 2014, *ApJ*, 784, 77, doi: [10.1088/0004-637X/784/1/77](https://doi.org/10.1088/0004-637X/784/1/77)
- González-Alfonso, E., Fischer, J., Spoon, H. W. W., et al. 2017, *ApJ*, 836, 11, doi: [10.3847/1538-4357/836/1/11](https://doi.org/10.3847/1538-4357/836/1/11)
- GRAVITY Collaboration, Amorim, A., Bourdarot, G., et al. 2024, *arXiv e-prints*, arXiv:2401.07676,
doi: [10.48550/arXiv.2401.07676](https://doi.org/10.48550/arXiv.2401.07676)
- Grier, C. J., Martini, P., Watson, L. C., et al. 2013, *ApJ*, 773, 90, doi: [10.1088/0004-637X/773/2/90](https://doi.org/10.1088/0004-637X/773/2/90)
- Guolo, M., Ruschel-Dutra, D., Grupe, D., et al. 2021, *MNRAS*, 508, 144, doi: [10.1093/mnras/stab2550](https://doi.org/10.1093/mnras/stab2550)
- Gupta, A., Mathur, S., & Krongold, Y. 2015, *ApJ*, 798, 4,
doi: [10.1088/0004-637X/798/1/4](https://doi.org/10.1088/0004-637X/798/1/4)
- Gupta, A., Mathur, S., Krongold, Y., & Nicastro, F. 2013a, *ApJ*, 772, 66, doi: [10.1088/0004-637X/772/1/66](https://doi.org/10.1088/0004-637X/772/1/66)
- . 2013b, *ApJ*, 768, 141,
doi: [10.1088/0004-637X/768/2/141](https://doi.org/10.1088/0004-637X/768/2/141)

- Gupta, K. K., Ricci, C., Tortosa, A., et al. 2021, *MNRAS*, 504, 428, doi: [10.1093/mnras/stab839](https://doi.org/10.1093/mnras/stab839)
- Hagino, K., Done, C., Odaka, H., Watanabe, S., & Takahashi, T. 2017, *MNRAS*, 468, 1442, doi: [10.1093/mnras/stx559](https://doi.org/10.1093/mnras/stx559)
- Hagino, K., Odaka, H., Done, C., et al. 2015, *MNRAS*, 446, 663, doi: [10.1093/mnras/stu2095](https://doi.org/10.1093/mnras/stu2095)
- . 2016, *MNRAS*, 461, 3954, doi: [10.1093/mnras/stw1579](https://doi.org/10.1093/mnras/stw1579)
- Harrison, C. M. 2017, *Nature Astronomy*, 1, 0165, doi: [10.1038/s41550-017-0165](https://doi.org/10.1038/s41550-017-0165)
- Harrison, F. A., Craig, W. W., Christensen, F. E., et al. 2013, *ApJ*, 770, 103, doi: [10.1088/0004-637X/770/2/103](https://doi.org/10.1088/0004-637X/770/2/103)
- Holczer, T., & Behar, E. 2012, *ApJ*, 747, 71, doi: [10.1088/0004-637X/747/1/71](https://doi.org/10.1088/0004-637X/747/1/71)
- Holczer, T., Behar, E., & Arav, N. 2010, *ApJ*, 708, 981, doi: [10.1088/0004-637X/708/2/981](https://doi.org/10.1088/0004-637X/708/2/981)
- Holczer, T., Behar, E., & Kaspi, S. 2005, *ApJ*, 632, 788, doi: [10.1086/444492](https://doi.org/10.1086/444492)
- . 2007, *ApJ*, 663, 799, doi: [10.1086/518416](https://doi.org/10.1086/518416)
- Holt, J., Tadhunter, C., Morganti, R., et al. 2006, *MNRAS*, 370, 1633, doi: [10.1111/j.1365-2966.2006.10604.x](https://doi.org/10.1111/j.1365-2966.2006.10604.x)
- Hönig, S. F. 2019, *ApJ*, 884, 171, doi: [10.3847/1538-4357/ab4591](https://doi.org/10.3847/1538-4357/ab4591)
- Hönig, S. F., & Kishimoto, M. 2017, *ApJL*, 838, L20, doi: [10.3847/2041-8213/aa6838](https://doi.org/10.3847/2041-8213/aa6838)
- Hu, C., Li, S.-S., Yang, S., et al. 2021, *ApJS*, 253, 20, doi: [10.3847/1538-4365/abd774](https://doi.org/10.3847/1538-4365/abd774)
- Huang, Y.-K., Hu, C., Zhao, Y.-L., et al. 2019, *ApJ*, 876, 102, doi: [10.3847/1538-4357/ab16ef](https://doi.org/10.3847/1538-4357/ab16ef)
- Igo, Z., Parker, M. L., Matzeu, G. A., et al. 2020, *MNRAS*, 493, 1088, doi: [10.1093/mnras/staa265](https://doi.org/10.1093/mnras/staa265)
- Ishibashi, W., Fabian, A. C., Ricci, C., & Celotti, A. 2018, *MNRAS*, 479, 3335, doi: [10.1093/mnras/sty1620](https://doi.org/10.1093/mnras/sty1620)
- Iwasawa, K., Fabian, A. C., Kara, E., et al. 2016, *A&A*, 592, A98, doi: [10.1051/0004-6361/201528030](https://doi.org/10.1051/0004-6361/201528030)
- Iwasawa, K., Spoon, H. W. W., Comastri, A., et al. 2017, *A&A*, 606, A117, doi: [10.1051/0004-6361/201730950](https://doi.org/10.1051/0004-6361/201730950)
- Izumi, T., Wada, K., Fukushige, R., Hamamura, S., & Kohno, K. 2018, *ApJ*, 867, 48, doi: [10.3847/1538-4357/aac20b](https://doi.org/10.3847/1538-4357/aac20b)
- Izumi, T., Wada, K., Imanishi, M., et al. 2023, *Science*, 382, 554, doi: [10.1126/science.adf0569](https://doi.org/10.1126/science.adf0569)
- Jacquemin-Ide, J., Lesur, G., & Ferreira, J. 2021, *A&A*, 647, A192, doi: [10.1051/0004-6361/202039322](https://doi.org/10.1051/0004-6361/202039322)
- Janssen, A. W., Christopher, N., Sturm, E., et al. 2016, *ApJ*, 822, 43, doi: [10.3847/0004-637X/822/1/43](https://doi.org/10.3847/0004-637X/822/1/43)
- Jiang, J., Dauser, T., Fabian, A. C., et al. 2022, *MNRAS*, 514, 1107, doi: [10.1093/mnras/stac1144](https://doi.org/10.1093/mnras/stac1144)
- Jiang, J., Walton, D. J., Parker, M. L., & Fabian, A. C. 2018a, *MNRAS*, 481, 639, doi: [10.1093/mnras/sty2344](https://doi.org/10.1093/mnras/sty2344)
- Jiang, J., Parker, M. L., Fabian, A. C., et al. 2018b, *MNRAS*, 477, 3711, doi: [10.1093/mnras/sty836](https://doi.org/10.1093/mnras/sty836)
- Jiménez-Bailón, E., Krongold, Y., Bianchi, S., et al. 2008, *MNRAS*, 391, 1359, doi: [10.1111/j.1365-2966.2008.13976.x](https://doi.org/10.1111/j.1365-2966.2008.13976.x)
- Jin, C., Done, C., & Ward, M. 2020, *MNRAS*, 495, 3538, doi: [10.1093/mnras/staa1356](https://doi.org/10.1093/mnras/staa1356)
- Kaastra, J. S., Mewe, R., & Nieuwenhuijzen, H. 1996, in *UV and X-ray Spectroscopy of Astrophysical and Laboratory Plasmas*, 411–414
- Kaastra, J. S., Steenbrugge, K. C., Raassen, A. J. J., et al. 2002, *A&A*, 386, 427, doi: [10.1051/0004-6361:20020235](https://doi.org/10.1051/0004-6361:20020235)
- Kaastra, J. S., Raassen, A. J. J., Mewe, R., et al. 2004, *A&A*, 428, 57, doi: [10.1051/0004-6361:20041434](https://doi.org/10.1051/0004-6361:20041434)
- Kaastra, J. S., de Vries, C. P., Steenbrugge, K. C., et al. 2011, *A&A*, 534, A37, doi: [10.1051/0004-6361/201116870](https://doi.org/10.1051/0004-6361/201116870)
- Kaastra, J. S., Detmers, R. G., Mehdipour, M., et al. 2012, *A&A*, 539, A117, doi: [10.1051/0004-6361/201118161](https://doi.org/10.1051/0004-6361/201118161)
- Kaastra, J. S., Terashima, Y., Kallman, T., et al. 2014a, *arXiv e-prints*, arXiv:1412.1171, doi: [10.48550/arXiv.1412.1171](https://doi.org/10.48550/arXiv.1412.1171)
- Kaastra, J. S., Kriss, G. A., Cappi, M., et al. 2014b, *Science*, 345, 64, doi: [10.1126/science.1253787](https://doi.org/10.1126/science.1253787)
- Kaastra, J. S., Ebrero, J., Arav, N., et al. 2014c, *A&A*, 570, A73, doi: [10.1051/0004-6361/201424662](https://doi.org/10.1051/0004-6361/201424662)
- Kallman, T., & Bautista, M. 2001, *ApJS*, 133, 221, doi: [10.1086/319184](https://doi.org/10.1086/319184)
- Kallman, T. R., Liedahl, D., Osterheld, A., Goldstein, W., & Kahn, S. 1996, *ApJ*, 465, 994, doi: [10.1086/177485](https://doi.org/10.1086/177485)
- Kallman, T. R., Palmeri, P., Bautista, M. A., Mendoza, C., & Krolik, J. H. 2004, *ApJS*, 155, 675, doi: [10.1086/424039](https://doi.org/10.1086/424039)
- Kara, E., Alston, W. N., Fabian, A. C., et al. 2016, *MNRAS*, 462, 511, doi: [10.1093/mnras/stw1695](https://doi.org/10.1093/mnras/stw1695)
- Kara, E., García, J. A., Lohfink, A., et al. 2017, *MNRAS*, 468, 3489, doi: [10.1093/mnras/stx792](https://doi.org/10.1093/mnras/stx792)
- Kara, E., Mehdipour, M., Kriss, G. A., et al. 2021, *ApJ*, 922, 151, doi: [10.3847/1538-4357/ac2159](https://doi.org/10.3847/1538-4357/ac2159)
- Kaspi, S., & Behar, E. 2006, *ApJ*, 636, 674, doi: [10.1086/498126](https://doi.org/10.1086/498126)
- Kaspi, S., Brandt, W. N., Netzer, H., et al. 2000, *ApJL*, 535, L17, doi: [10.1086/312697](https://doi.org/10.1086/312697)
- Kaspi, S., Netzer, H., Chelouche, D., et al. 2004, *ApJ*, 611, 68, doi: [10.1086/422161](https://doi.org/10.1086/422161)
- Kaspi, S., Brandt, W. N., Netzer, H., et al. 2001, *ApJ*, 554, 216, doi: [10.1086/321333](https://doi.org/10.1086/321333)
- Kaspi, S., Brandt, W. N., George, I. M., et al. 2002, *ApJ*, 574, 643, doi: [10.1086/341113](https://doi.org/10.1086/341113)
- Kawamuro, T., Ricci, C., Izumi, T., et al. 2021, *ApJS*, 257, 64, doi: [10.3847/1538-4365/ac2891](https://doi.org/10.3847/1538-4365/ac2891)

- Kawamuro, T., Ueda, Y., Tazaki, F., Ricci, C., & Terashima, Y. 2016, *ApJS*, 225, 14, doi: [10.3847/0067-0049/225/1/14](https://doi.org/10.3847/0067-0049/225/1/14)
- King, A., & Pounds, K. 2015, *ARA&A*, 53, 115, doi: [10.1146/annurev-astro-082214-122316](https://doi.org/10.1146/annurev-astro-082214-122316)
- King, A. L., Miller, J. M., & Raymond, J. 2012, *ApJ*, 746, 2, doi: [10.1088/0004-637X/746/1/2](https://doi.org/10.1088/0004-637X/746/1/2)
- King, A. R. 2010, *MNRAS*, 402, 1516, doi: [10.1111/j.1365-2966.2009.16013.x](https://doi.org/10.1111/j.1365-2966.2009.16013.x)
- King, A. R., & Pounds, K. A. 2003, *MNRAS*, 345, 657, doi: [10.1046/j.1365-8711.2003.06980.x](https://doi.org/10.1046/j.1365-8711.2003.06980.x)
- Kollatschny, W., Grupe, D., Parker, M. L., et al. 2020, *A&A*, 638, A91, doi: [10.1051/0004-6361/202037897](https://doi.org/10.1051/0004-6361/202037897)
- . 2023, *A&A*, 670, A103, doi: [10.1051/0004-6361/202244786](https://doi.org/10.1051/0004-6361/202244786)
- Kormendy, J., & Ho, L. C. 2013, *ARA&A*, 51, 511, doi: [10.1146/annurev-astro-082708-101811](https://doi.org/10.1146/annurev-astro-082708-101811)
- Kosec, P., Buisson, D. J. K., Parker, M. L., et al. 2018, *MNRAS*, 481, 947, doi: [10.1093/mnras/sty2342](https://doi.org/10.1093/mnras/sty2342)
- Kosec, P., Zoghbi, A., Walton, D. J., et al. 2020, *MNRAS*, 495, 4769, doi: [10.1093/mnras/staa1425](https://doi.org/10.1093/mnras/staa1425)
- Koss, M. J., Ricci, C., Trakhtenbrot, B., et al. 2022a, *ApJS*, 261, 2, doi: [10.3847/1538-4365/ac6c05](https://doi.org/10.3847/1538-4365/ac6c05)
- Koss, M. J., Trakhtenbrot, B., Ricci, C., et al. 2022b, *ApJS*, 261, 6, doi: [10.3847/1538-4365/ac650b](https://doi.org/10.3847/1538-4365/ac650b)
- Kraemer, S. B., George, I. M., Crenshaw, D. M., et al. 2005, *ApJ*, 633, 693, doi: [10.1086/466522](https://doi.org/10.1086/466522)
- Krolik, J. H., & Begelman, M. C. 1986, *ApJL*, 308, L55, doi: [10.1086/184743](https://doi.org/10.1086/184743)
- Krongold, Y., Nicastro, F., Brickhouse, N. S., et al. 2003, *ApJ*, 597, 832, doi: [10.1086/378639](https://doi.org/10.1086/378639)
- Krongold, Y., Nicastro, F., Brickhouse, N. S., Elvis, M., & Mathur, S. 2005a, *ApJ*, 622, 842, doi: [10.1086/427621](https://doi.org/10.1086/427621)
- Krongold, Y., Nicastro, F., Elvis, M., et al. 2007, *ApJ*, 659, 1022, doi: [10.1086/512476](https://doi.org/10.1086/512476)
- . 2005b, *ApJ*, 620, 165, doi: [10.1086/425293](https://doi.org/10.1086/425293)
- Krongold, Y., Jiménez-Bailón, E., Santos-Lleo, M., et al. 2009, *ApJ*, 690, 773, doi: [10.1088/0004-637X/690/1/773](https://doi.org/10.1088/0004-637X/690/1/773)
- Krongold, Y., Elvis, M., Andrade-Velazquez, M., et al. 2010, *ApJ*, 710, 360, doi: [10.1088/0004-637X/710/1/360](https://doi.org/10.1088/0004-637X/710/1/360)
- Krongold, Y., Longinotti, A. L., Santos-Lleo, M., et al. 2021, *ApJ*, 917, 39, doi: [10.3847/1538-4357/ac0977](https://doi.org/10.3847/1538-4357/ac0977)
- Kudoh, Y., Wada, K., Kawakatu, N., & Nomura, M. 2023, *ApJ*, 950, 72, doi: [10.3847/1538-4357/accc2b](https://doi.org/10.3847/1538-4357/accc2b)
- Kuo, C. Y., Braatz, J. A., Condon, J. J., et al. 2011, *ApJ*, 727, 20, doi: [10.1088/0004-637X/727/1/20](https://doi.org/10.1088/0004-637X/727/1/20)
- Laha, S., Dewangan, G. C., Chakravorty, S., & Kembhavi, A. K. 2013, *ApJ*, 777, 2, doi: [10.1088/0004-637X/777/1/2](https://doi.org/10.1088/0004-637X/777/1/2)
- Laha, S., Dewangan, G. C., & Kembhavi, A. K. 2011, *ApJ*, 734, 75, doi: [10.1088/0004-637X/734/2/75](https://doi.org/10.1088/0004-637X/734/2/75)
- Laha, S., Guainazzi, M., Chakravorty, S., Dewangan, G. C., & Kembhavi, A. K. 2016, *MNRAS*, 457, 3896, doi: [10.1093/mnras/stw211](https://doi.org/10.1093/mnras/stw211)
- Laha, S., Guainazzi, M., Dewangan, G. C., Chakravorty, S., & Kembhavi, A. K. 2014, *MNRAS*, 441, 2613, doi: [10.1093/mnras/stu669](https://doi.org/10.1093/mnras/stu669)
- Laha, S., Reynolds, C. S., Reeves, J., et al. 2021, *Nature Astronomy*, 5, 13, doi: [10.1038/s41550-020-01255-2](https://doi.org/10.1038/s41550-020-01255-2)
- Lanzuisi, G., Giustini, M., Cappi, M., et al. 2012, *A&A*, 544, A2, doi: [10.1051/0004-6361/201219481](https://doi.org/10.1051/0004-6361/201219481)
- Lanzuisi, G., Perna, M., Comastri, A., et al. 2016, *A&A*, 590, A77, doi: [10.1051/0004-6361/201628325](https://doi.org/10.1051/0004-6361/201628325)
- Laurenti, M., Luminari, A., Tombesi, F., et al. 2021, *A&A*, 645, A118, doi: [10.1051/0004-6361/202039409](https://doi.org/10.1051/0004-6361/202039409)
- Lee, J. C., Ogle, P. M., Canizares, C. R., et al. 2001, *ApJL*, 554, L13, doi: [10.1086/320912](https://doi.org/10.1086/320912)
- Lee, J. C., Kriss, G. A., Chakravorty, S., et al. 2013, *MNRAS*, 430, 2650, doi: [10.1093/mnras/stt050](https://doi.org/10.1093/mnras/stt050)
- Lobban, A. P., Pounds, K., Vaughan, S., & Reeves, J. N. 2016, *ApJ*, 831, 201, doi: [10.3847/0004-637X/831/2/201](https://doi.org/10.3847/0004-637X/831/2/201)
- Lobban, A. P., Reeves, J. N., Miller, L., et al. 2011, *MNRAS*, 414, 1965, doi: [10.1111/j.1365-2966.2011.18513.x](https://doi.org/10.1111/j.1365-2966.2011.18513.x)
- Longinotti, A. L., Cappi, M., Nandra, K., Dadina, M., & Pellegrini, S. 2003, *A&A*, 410, 471, doi: [10.1051/0004-6361:20031124](https://doi.org/10.1051/0004-6361:20031124)
- Longinotti, A. L., Krongold, Y., Guainazzi, M., et al. 2015, *ApJL*, 813, L39, doi: [10.1088/2041-8205/813/2/L39](https://doi.org/10.1088/2041-8205/813/2/L39)
- Longinotti, A. L., Costantini, E., Petrucci, P. O., et al. 2010, *A&A*, 510, A92, doi: [10.1051/0004-6361/200912925](https://doi.org/10.1051/0004-6361/200912925)
- Longinotti, A. L., Krongold, Y., Kriss, G. A., et al. 2013, *ApJ*, 766, 104, doi: [10.1088/0004-637X/766/2/104](https://doi.org/10.1088/0004-637X/766/2/104)
- Longinotti, A. L., Kriss, G., Krongold, Y., et al. 2019, *ApJ*, 875, 150, doi: [10.3847/1538-4357/ab125a](https://doi.org/10.3847/1538-4357/ab125a)
- López-Gonzaga, N., Burtscher, L., Tristram, K. R. W., Meisenheimer, K., & Schartmann, M. 2016, *A&A*, 591, A47, doi: [10.1051/0004-6361/201527590](https://doi.org/10.1051/0004-6361/201527590)
- Luminari, A., Nicastro, F., Elvis, M., et al. 2021, *A&A*, 646, A111, doi: [10.1051/0004-6361/202039396](https://doi.org/10.1051/0004-6361/202039396)
- Luminari, A., Piconcelli, E., Tombesi, F., et al. 2018, *A&A*, 619, A149, doi: [10.1051/0004-6361/201833623](https://doi.org/10.1051/0004-6361/201833623)
- Luminari, A., Marinucci, A., Bianchi, S., et al. 2023, *ApJ*, 950, 160, doi: [10.3847/1538-4357/acd2d8](https://doi.org/10.3847/1538-4357/acd2d8)
- Lutz, D., Sturm, E., Janssen, A., et al. 2020, *A&A*, 633, A134, doi: [10.1051/0004-6361/201936803](https://doi.org/10.1051/0004-6361/201936803)
- Lyu, B., Wu, Q., Yan, Z., Yu, W., & Liu, H. 2022, *ApJ*, 927, 227, doi: [10.3847/1538-4357/ac5256](https://doi.org/10.3847/1538-4357/ac5256)
- Mallick, L., Alston, W. N., Parker, M. L., et al. 2018, *MNRAS*, 479, 615, doi: [10.1093/mnras/sty1487](https://doi.org/10.1093/mnras/sty1487)

- Mao, J., Kaastra, J. S., Mehdipour, M., et al. 2017, *A&A*, 607, A100, doi: [10.1051/0004-6361/201731378](https://doi.org/10.1051/0004-6361/201731378)
- Mao, J., Mehdipour, M., Kaastra, J. S., et al. 2019, *A&A*, 621, A99, doi: [10.1051/0004-6361/201833191](https://doi.org/10.1051/0004-6361/201833191)
- Mao, J., Kriss, G. A., Landt, H., et al. 2022, *ApJ*, 940, 41, doi: [10.3847/1538-4357/ac99de](https://doi.org/10.3847/1538-4357/ac99de)
- Marinucci, A., Bianchi, S., Braitto, V., et al. 2018, *MNRAS*, 478, 5638, doi: [10.1093/mnras/sty1436](https://doi.org/10.1093/mnras/sty1436)
- Markowitz, A., Reeves, J. N., & Braitto, V. 2006, *ApJ*, 646, 783, doi: [10.1086/505107](https://doi.org/10.1086/505107)
- Markowitz, A., Reeves, J. N., George, I. M., et al. 2009, *ApJ*, 691, 922, doi: [10.1088/0004-637X/691/2/922](https://doi.org/10.1088/0004-637X/691/2/922)
- Mason, K. O., Branduardi-Raymont, G., Ogle, P. M., et al. 2003, *ApJ*, 582, 95, doi: [10.1086/344562](https://doi.org/10.1086/344562)
- Matsumoto, C., Leighly, K. M., & Marshall, H. L. 2004, *ApJ*, 603, 456, doi: [10.1086/381666](https://doi.org/10.1086/381666)
- Matt, G., Bianchi, S., D’Ammando, F., & Martocchia, A. 2004, *A&A*, 421, 473, doi: [10.1051/0004-6361:20047045](https://doi.org/10.1051/0004-6361:20047045)
- Matzeu, G. A., Reeves, J. N., Braitto, V., et al. 2017, *MNRAS*, 472, L15, doi: [10.1093/mnrasl/slx129](https://doi.org/10.1093/mnrasl/slx129)
- Matzeu, G. A., Reeves, J. N., Nardini, E., et al. 2016, *MNRAS*, 458, 1311, doi: [10.1093/mnras/stw354](https://doi.org/10.1093/mnras/stw354)
- Matzeu, G. A., Braitto, V., Reeves, J. N., et al. 2019, *MNRAS*, 483, 2836, doi: [10.1093/mnras/sty3327](https://doi.org/10.1093/mnras/sty3327)
- Matzeu, G. A., Nardini, E., Parker, M. L., et al. 2020, *MNRAS*, 497, 2352, doi: [10.1093/mnras/staa2076](https://doi.org/10.1093/mnras/staa2076)
- Matzeu, G. A., Brusa, M., Lanzuisi, G., et al. 2023, *A&A*, 670, A182, doi: [10.1051/0004-6361/202245036](https://doi.org/10.1051/0004-6361/202245036)
- McKernan, B., Yaqoob, T., George, I. M., & Turner, T. J. 2003, *ApJ*, 593, 142, doi: [10.1086/376555](https://doi.org/10.1086/376555)
- McKernan, B., Yaqoob, T., & Reynolds, C. S. 2007, *MNRAS*, 379, 1359, doi: [10.1111/j.1365-2966.2007.11993.x](https://doi.org/10.1111/j.1365-2966.2007.11993.x)
- Mehdipour, M., Branduardi-Raymont, G., & Page, M. J. 2010, *A&A*, 514, A100, doi: [10.1051/0004-6361/200913049](https://doi.org/10.1051/0004-6361/200913049)
- . 2012, *A&A*, 542, A30, doi: [10.1051/0004-6361/201218896](https://doi.org/10.1051/0004-6361/201218896)
- Mehdipour, M., & Costantini, E. 2018, *A&A*, 619, A20, doi: [10.1051/0004-6361/201833706](https://doi.org/10.1051/0004-6361/201833706)
- . 2019, *A&A*, 625, A25, doi: [10.1051/0004-6361/201935205](https://doi.org/10.1051/0004-6361/201935205)
- Mehdipour, M., Kriss, G. A., Kaastra, J. S., Costantini, E., & Mao, J. 2023a, *ApJL*, 952, L5, doi: [10.3847/2041-8213/ace053](https://doi.org/10.3847/2041-8213/ace053)
- Mehdipour, M., Kaastra, J. S., Kriss, G. A., et al. 2017, *A&A*, 607, A28, doi: [10.1051/0004-6361/201731175](https://doi.org/10.1051/0004-6361/201731175)
- Mehdipour, M., Kaastra, J. S., Costantini, E., et al. 2018, *A&A*, 615, A72, doi: [10.1051/0004-6361/201832604](https://doi.org/10.1051/0004-6361/201832604)
- Mehdipour, M., Kriss, G. A., Brusa, M., et al. 2023b, *A&A*, 670, A183, doi: [10.1051/0004-6361/202245047](https://doi.org/10.1051/0004-6361/202245047)
- Middei, R., Nardini, E., Matzeu, G. A., et al. 2023, *A&A*, 680, A50, doi: [10.1051/0004-6361/202347963](https://doi.org/10.1051/0004-6361/202347963)
- Middei, R., Tombesi, F., Vagnetti, F., et al. 2020, *A&A*, 635, A18, doi: [10.1051/0004-6361/201936701](https://doi.org/10.1051/0004-6361/201936701)
- Middei, R., Matzeu, G. A., Bianchi, S., et al. 2021, *A&A*, 647, A102, doi: [10.1051/0004-6361/202039984](https://doi.org/10.1051/0004-6361/202039984)
- Midooka, T., Mizumoto, M., & Ebisawa, K. 2023, *ApJ*, 954, 47, doi: [10.3847/1538-4357/ace71a](https://doi.org/10.3847/1538-4357/ace71a)
- Miniutti, G., Ponti, G., Dadina, M., Cappi, M., & Malaguti, G. 2007, *MNRAS*, 375, 227, doi: [10.1111/j.1365-2966.2006.11291.x](https://doi.org/10.1111/j.1365-2966.2006.11291.x)
- Miniutti, G., Sanfrutos, M., Beuchert, T., et al. 2014, *MNRAS*, 437, 1776, doi: [10.1093/mnras/stt2005](https://doi.org/10.1093/mnras/stt2005)
- Mitsuda, K., Bautz, M., Inoue, H., et al. 2007, *PASJ*, 59, S1, doi: [10.1093/pasj/59.sp1.S1](https://doi.org/10.1093/pasj/59.sp1.S1)
- Mizumoto, M., & Ebisawa, K. 2017, *MNRAS*, 466, 3259, doi: [10.1093/mnras/stw3364](https://doi.org/10.1093/mnras/stw3364)
- Mizumoto, M., Ebisawa, K., Tsujimoto, M., et al. 2019a, *MNRAS*, 482, 5316, doi: [10.1093/mnras/sty3056](https://doi.org/10.1093/mnras/sty3056)
- Mizumoto, M., Izumi, T., & Kohno, K. 2019b, *ApJ*, 871, 156, doi: [10.3847/1538-4357/aaf814](https://doi.org/10.3847/1538-4357/aaf814)
- Mizumoto, M., Nomura, M., Done, C., Ohsuga, K., & Odaka, H. 2021, *MNRAS*, 503, 1442, doi: [10.1093/mnras/staa3282](https://doi.org/10.1093/mnras/staa3282)
- Mochizuki, Y., Mizumoto, M., & Ebisawa, K. 2023, *MNRAS*, 525, 922, doi: [10.1093/mnras/stad2329](https://doi.org/10.1093/mnras/stad2329)
- Mocz, P., Lee, J. C., Iwasawa, K., & Canizares, C. R. 2011, *ApJ*, 729, 30, doi: [10.1088/0004-637X/729/1/30](https://doi.org/10.1088/0004-637X/729/1/30)
- Mondal, S., Adhikari, T. P., Hryniewicz, K., Stalin, C. S., & Pandey, A. 2022, *A&A*, 662, A77, doi: [10.1051/0004-6361/202243084](https://doi.org/10.1051/0004-6361/202243084)
- Morganti, R., Tadhunter, C. N., & Oosterloo, T. A. 2005, *A&A*, 444, L9, doi: [10.1051/0004-6361:200500197](https://doi.org/10.1051/0004-6361:200500197)
- Morganti, R., Veilleux, S., Oosterloo, T., Teng, S. H., & Rupke, D. 2016, *A&A*, 593, A30, doi: [10.1051/0004-6361/201628978](https://doi.org/10.1051/0004-6361/201628978)
- Müller-Sánchez, F., Prieto, M. A., Hicks, E. K. S., et al. 2011, *ApJ*, 739, 69, doi: [10.1088/0004-637X/739/2/69](https://doi.org/10.1088/0004-637X/739/2/69)
- Nandi, P., Chatterjee, A., Jana, A., et al. 2023a, *ApJS*, 269, 15, doi: [10.3847/1538-4365/acf4f9](https://doi.org/10.3847/1538-4365/acf4f9)
- Nandi, P., Stalin, C. S., Saikia, D. J., et al. 2023b, *ApJ*, 950, 81, doi: [10.3847/1538-4357/accf1e](https://doi.org/10.3847/1538-4357/accf1e)
- Nardini, E., Lusso, E., & Bisogni, S. 2019, *MNRAS*, 482, L134, doi: [10.1093/mnrasl/sly204](https://doi.org/10.1093/mnrasl/sly204)
- Nardini, E., Reeves, J. N., Porquet, D., et al. 2014, *MNRAS*, 440, 1200, doi: [10.1093/mnras/stu333](https://doi.org/10.1093/mnras/stu333)
- Nardini, E., & Zubovas, K. 2018, *MNRAS*, 478, 2274, doi: [10.1093/mnras/sty1144](https://doi.org/10.1093/mnras/sty1144)

- Nardini, E., Reeves, J. N., Gofford, J., et al. 2015, *Science*, 347, 860, doi: [10.1126/science.1259202](https://doi.org/10.1126/science.1259202)
- Nenkova, M., Sirocky, M. M., Ivezić, Ž., & Elitzur, M. 2008a, *ApJ*, 685, 147, doi: [10.1086/590482](https://doi.org/10.1086/590482)
- Nenkova, M., Sirocky, M. M., Nikutta, R., Ivezić, Ž., & Elitzur, M. 2008b, *ApJ*, 685, 160, doi: [10.1086/590483](https://doi.org/10.1086/590483)
- Netzer, H. 1987, *MNRAS*, 225, 55, doi: [10.1093/mnras/225.1.55](https://doi.org/10.1093/mnras/225.1.55)
- . 1996, *ApJ*, 473, 781, doi: [10.1086/178190](https://doi.org/10.1086/178190)
- Netzer, H., & Laor, A. 1993, *ApJL*, 404, L51, doi: [10.1086/186741](https://doi.org/10.1086/186741)
- Netzer, H., Kaspi, S., Behar, E., et al. 2003, *ApJ*, 599, 933, doi: [10.1086/379508](https://doi.org/10.1086/379508)
- Nikolajuk, M., Czerny, B., & Gurynowicz, P. 2009, *MNRAS*, 394, 2141, doi: [10.1111/j.1365-2966.2009.14478.x](https://doi.org/10.1111/j.1365-2966.2009.14478.x)
- Noda, H., & Done, C. 2018, *MNRAS*, 480, 3898, doi: [10.1093/mnras/sty2032](https://doi.org/10.1093/mnras/sty2032)
- Noda, H., Mineta, T., Minezaki, T., et al. 2023, *ApJ*, 943, 63, doi: [10.3847/1538-4357/aca963](https://doi.org/10.3847/1538-4357/aca963)
- Nomura, M., & Ohsuga, K. 2017, *MNRAS*, 465, 2873, doi: [10.1093/mnras/stw2877](https://doi.org/10.1093/mnras/stw2877)
- O'Dowd, M. J., Bate, N. F., Webster, R. L., Labrie, K., & Rogers, J. 2015, *ApJ*, 813, 62, doi: [10.1088/0004-637X/813/1/62](https://doi.org/10.1088/0004-637X/813/1/62)
- Ogawa, S., Ueda, Y., Tanimoto, A., & Yamada, S. 2021, *ApJ*, 906, 84, doi: [10.3847/1538-4357/abccce](https://doi.org/10.3847/1538-4357/abccce)
- Ogawa, S., Ueda, Y., Wada, K., & Mizumoto, M. 2022, *ApJ*, 925, 55, doi: [10.3847/1538-4357/ac3cb9](https://doi.org/10.3847/1538-4357/ac3cb9)
- Ogle, P. M., Mason, K. O., Page, M. J., et al. 2004, *ApJ*, 606, 151, doi: [10.1086/382744](https://doi.org/10.1086/382744)
- Ogorzalek, A., King, A. L., Allen, S. W., Raymond, J. C., & Wilkins, D. R. 2022, *MNRAS*, 516, 5027, doi: [10.1093/mnras/stac2389](https://doi.org/10.1093/mnras/stac2389)
- Page, K. L., O'Brien, P. T., Reeves, J. N., & Breeveld, A. A. 2003, *MNRAS*, 340, 1052, doi: [10.1046/j.1365-8711.2003.06403.x](https://doi.org/10.1046/j.1365-8711.2003.06403.x)
- Paliya, V. S., Sahayanathan, S., Parker, M. L., et al. 2014, *ApJ*, 789, 143, doi: [10.1088/0004-637X/789/2/143](https://doi.org/10.1088/0004-637X/789/2/143)
- Pan, X., Zhou, H., Liu, W., et al. 2019, *ApJ*, 883, 173, doi: [10.3847/1538-4357/ab40b5](https://doi.org/10.3847/1538-4357/ab40b5)
- Papadakis, I. E., Brinkmann, W., Page, M. J., McHardy, I., & Uttley, P. 2007, *A&A*, 461, 931, doi: [10.1051/0004-6361:20065527](https://doi.org/10.1051/0004-6361:20065527)
- Papadakis, I. E., Nicastro, F., & Panagiotou, C. 2016, *A&A*, 591, A102, doi: [10.1051/0004-6361/201527497](https://doi.org/10.1051/0004-6361/201527497)
- Parker, M. L., Matzeu, G. A., Guainazzi, M., et al. 2018a, *MNRAS*, 480, 2365, doi: [10.1093/mnras/sty2020](https://doi.org/10.1093/mnras/sty2020)
- Parker, M. L., Matzeu, G. A., Matthews, J. H., et al. 2022, *MNRAS*, 513, 551, doi: [10.1093/mnras/stac877](https://doi.org/10.1093/mnras/stac877)
- Parker, M. L., Reeves, J. N., Matzeu, G. A., Buisson, D. J. K., & Fabian, A. C. 2018b, *MNRAS*, 474, 108, doi: [10.1093/mnras/stx2803](https://doi.org/10.1093/mnras/stx2803)
- Parker, M. L., Pinto, C., Fabian, A. C., et al. 2017a, *Nature*, 543, 83, doi: [10.1038/nature21385](https://doi.org/10.1038/nature21385)
- Parker, M. L., Alston, W. N., Buisson, D. J. K., et al. 2017b, *MNRAS*, 469, 1553, doi: [10.1093/mnras/stx945](https://doi.org/10.1093/mnras/stx945)
- Parker, M. L., Schartel, N., Grupe, D., et al. 2019a, *MNRAS*, 483, L88, doi: [10.1093/mnrasl/sly224](https://doi.org/10.1093/mnrasl/sly224)
- Parker, M. L., Longinotti, A. L., Schartel, N., et al. 2019b, *MNRAS*, 490, 683, doi: [10.1093/mnras/stz2566](https://doi.org/10.1093/mnras/stz2566)
- Parker, M. L., Matzeu, G. A., Alston, W. N., et al. 2020, *MNRAS*, 498, L140, doi: [10.1093/mnrasl/slaa144](https://doi.org/10.1093/mnrasl/slaa144)
- Parker, M. L., Alston, W. N., Härer, L., et al. 2021, *MNRAS*, 508, 1798, doi: [10.1093/mnras/stab2434](https://doi.org/10.1093/mnras/stab2434)
- Patrick, A. R., Reeves, J. N., Porquet, D., et al. 2012, *MNRAS*, 426, 2522, doi: [10.1111/j.1365-2966.2012.21868.x](https://doi.org/10.1111/j.1365-2966.2012.21868.x)
- Peretz, U., Behar, E., Kriss, G. A., et al. 2018, *A&A*, 609, A35, doi: [10.1051/0004-6361/201731655](https://doi.org/10.1051/0004-6361/201731655)
- Peterson, B. M., Ferrarese, L., Gilbert, K. M., et al. 2004, *ApJ*, 613, 682, doi: [10.1086/423269](https://doi.org/10.1086/423269)
- Pinto, C., Alston, W., Parker, M. L., et al. 2018, *MNRAS*, 476, 1021, doi: [10.1093/mnras/sty231](https://doi.org/10.1093/mnras/sty231)
- Ponti, G., Papadakis, I., Bianchi, S., et al. 2012, *A&A*, 542, A83, doi: [10.1051/0004-6361/201118326](https://doi.org/10.1051/0004-6361/201118326)
- Ponti, G., Cappi, M., Vignali, C., et al. 2009, *MNRAS*, 394, 1487, doi: [10.1111/j.1365-2966.2009.14411.x](https://doi.org/10.1111/j.1365-2966.2009.14411.x)
- Porquet, D., Hagen, S., Grosso, N., et al. 2024, *A&A*, 681, A40, doi: [10.1051/0004-6361/202347202](https://doi.org/10.1051/0004-6361/202347202)
- Pounds, K., Lobban, A., Reeves, J., & Vaughan, S. 2016a, *MNRAS*, 457, 2951, doi: [10.1093/mnras/stw165](https://doi.org/10.1093/mnras/stw165)
- Pounds, K. A. 2014, *MNRAS*, 437, 3221, doi: [10.1093/mnras/stt2113](https://doi.org/10.1093/mnras/stt2113)
- Pounds, K. A., & King, A. R. 2013, *MNRAS*, 433, 1369, doi: [10.1093/mnras/stt807](https://doi.org/10.1093/mnras/stt807)
- Pounds, K. A., King, A. R., Page, K. L., & O'Brien, P. T. 2003a, *MNRAS*, 346, 1025, doi: [10.1111/j.1365-2966.2003.07164.x](https://doi.org/10.1111/j.1365-2966.2003.07164.x)
- Pounds, K. A., Lobban, A., Reeves, J. N., Vaughan, S., & Costa, M. 2016b, *MNRAS*, 459, 4389, doi: [10.1093/mnras/stw933](https://doi.org/10.1093/mnras/stw933)
- Pounds, K. A., Nixon, C. J., Lobban, A., & King, A. R. 2018, *MNRAS*, 481, 1832, doi: [10.1093/mnras/sty2359](https://doi.org/10.1093/mnras/sty2359)
- Pounds, K. A., & Page, K. L. 2006, *MNRAS*, 372, 1275, doi: [10.1111/j.1365-2966.2006.10929.x](https://doi.org/10.1111/j.1365-2966.2006.10929.x)
- Pounds, K. A., & Reeves, J. N. 2007, *MNRAS*, 374, 823, doi: [10.1111/j.1365-2966.2006.11170.x](https://doi.org/10.1111/j.1365-2966.2006.11170.x)
- . 2009, *MNRAS*, 397, 249, doi: [10.1111/j.1365-2966.2009.14971.x](https://doi.org/10.1111/j.1365-2966.2009.14971.x)

- Pounds, K. A., Reeves, J. N., King, A. R., & Page, K. L. 2004, *MNRAS*, 350, 10, doi: [10.1111/j.1365-2966.2004.07639.x](https://doi.org/10.1111/j.1365-2966.2004.07639.x)
- Pounds, K. A., Reeves, J. N., King, A. R., et al. 2003b, *MNRAS*, 345, 705, doi: [10.1046/j.1365-8711.2003.07006.x](https://doi.org/10.1046/j.1365-8711.2003.07006.x)
- Pounds, K. A., & Vaughan, S. 2011, *MNRAS*, 413, 1251, doi: [10.1111/j.1365-2966.2011.18211.x](https://doi.org/10.1111/j.1365-2966.2011.18211.x)
- . 2012, *MNRAS*, 423, 165, doi: [10.1111/j.1365-2966.2012.20753.x](https://doi.org/10.1111/j.1365-2966.2012.20753.x)
- Pounds, K. A., & Wilkes, B. J. 2007, *MNRAS*, 380, 1341, doi: [10.1111/j.1365-2966.2007.12205.x](https://doi.org/10.1111/j.1365-2966.2007.12205.x)
- Proga, D., & Kallman, T. R. 2004, *ApJ*, 616, 688, doi: [10.1086/425117](https://doi.org/10.1086/425117)
- Proga, D., Stone, J. M., & Kallman, T. R. 2000, *ApJ*, 543, 686, doi: [10.1086/317154](https://doi.org/10.1086/317154)
- Puccetti, S., Comastri, A., Bauer, F. E., et al. 2016, *A&A*, 585, A157, doi: [10.1051/0004-6361/201527189](https://doi.org/10.1051/0004-6361/201527189)
- Rafferty, D. A., McNamara, B. R., Nulsen, P. E. J., & Wise, M. W. 2006, *ApJ*, 652, 216, doi: [10.1086/507672](https://doi.org/10.1086/507672)
- Ramos Almeida, C., & Ricci, C. 2017, *Nature Astronomy*, 1, 679, doi: [10.1038/s41550-017-0232-z](https://doi.org/10.1038/s41550-017-0232-z)
- Reeves, J., Done, C., Pounds, K., et al. 2008, *MNRAS*, 385, L108, doi: [10.1111/j.1745-3933.2008.00443.x](https://doi.org/10.1111/j.1745-3933.2008.00443.x)
- Reeves, J. N., & Braitto, V. 2019, *ApJ*, 884, 80, doi: [10.3847/1538-4357/ab41f9](https://doi.org/10.3847/1538-4357/ab41f9)
- Reeves, J. N., Braitto, V., Chartas, G., et al. 2020, *ApJ*, 895, 37, doi: [10.3847/1538-4357/ab8cc4](https://doi.org/10.3847/1538-4357/ab8cc4)
- Reeves, J. N., Braitto, V., Nardini, E., et al. 2016, *ApJ*, 824, 20, doi: [10.3847/0004-637X/824/1/20](https://doi.org/10.3847/0004-637X/824/1/20)
- . 2018a, *ApJL*, 854, L8, doi: [10.3847/2041-8213/aaaae1](https://doi.org/10.3847/2041-8213/aaaae1)
- Reeves, J. N., Braitto, V., Porquet, D., et al. 2023, *ApJ*, 952, 52, doi: [10.3847/1538-4357/acdb78](https://doi.org/10.3847/1538-4357/acdb78)
- Reeves, J. N., Gofford, J., Braitto, V., & Sambruna, R. 2010, *ApJ*, 725, 803, doi: [10.1088/0004-637X/725/1/803](https://doi.org/10.1088/0004-637X/725/1/803)
- Reeves, J. N., Lobban, A., & Pounds, K. A. 2018b, *ApJ*, 854, 28, doi: [10.3847/1538-4357/aaa776](https://doi.org/10.3847/1538-4357/aaa776)
- Reeves, J. N., Nandra, K., George, I. M., et al. 2004a, *ApJ*, 602, 648, doi: [10.1086/381091](https://doi.org/10.1086/381091)
- Reeves, J. N., O’Brien, P. T., & Ward, M. J. 2003, *ApJL*, 593, L65, doi: [10.1086/378218](https://doi.org/10.1086/378218)
- Reeves, J. N., Porquet, D., Braitto, V., et al. 2013, *ApJ*, 776, 99, doi: [10.1088/0004-637X/776/2/99](https://doi.org/10.1088/0004-637X/776/2/99)
- Reeves, J. N., Porquet, D., & Turner, T. J. 2004b, *ApJ*, 615, 150, doi: [10.1086/424478](https://doi.org/10.1086/424478)
- Reeves, J. N., Pounds, K., Uttley, P., et al. 2005, *ApJL*, 633, L81, doi: [10.1086/498568](https://doi.org/10.1086/498568)
- Reeves, J. N., Sambruna, R. M., Braitto, V., & Eracleous, M. 2009a, *ApJL*, 702, L187, doi: [10.1088/0004-637X/702/2/L187](https://doi.org/10.1088/0004-637X/702/2/L187)
- Reeves, J. N., O’Brien, P. T., Braitto, V., et al. 2009b, *ApJ*, 701, 493, doi: [10.1088/0004-637X/701/1/493](https://doi.org/10.1088/0004-637X/701/1/493)
- Reeves, J. N., Braitto, V., Gofford, J., et al. 2014, *ApJ*, 780, 45, doi: [10.1088/0004-637X/780/1/45](https://doi.org/10.1088/0004-637X/780/1/45)
- Reeves, J. N., Braitto, V., Behar, E., et al. 2017, *ApJ*, 837, 23, doi: [10.3847/1538-4357/aa5da1](https://doi.org/10.3847/1538-4357/aa5da1)
- Reines, A. E., & Volonteri, M. 2015, *ApJ*, 813, 82, doi: [10.1088/0004-637X/813/2/82](https://doi.org/10.1088/0004-637X/813/2/82)
- Reynolds, C. S., & Fabian, A. C. 1995, *MNRAS*, 273, 1167, doi: [10.1093/mnras/273.4.1167](https://doi.org/10.1093/mnras/273.4.1167)
- Ricci, C., & Paltani, S. 2023, *ApJ*, 945, 55, doi: [10.3847/1538-4357/acb5a6](https://doi.org/10.3847/1538-4357/acb5a6)
- Ricci, C., Tazaki, F., Ueda, Y., et al. 2014, *ApJ*, 795, 147, doi: [10.1088/0004-637X/795/2/147](https://doi.org/10.1088/0004-637X/795/2/147)
- Ricci, C., & Trakhtenbrot, B. 2023, *Nature Astronomy*, 7, 1282, doi: [10.1038/s41550-023-02108-4](https://doi.org/10.1038/s41550-023-02108-4)
- Ricci, C., Trakhtenbrot, B., Koss, M. J., et al. 2017a, *ApJS*, 233, 17, doi: [10.3847/1538-4365/aa96ad](https://doi.org/10.3847/1538-4365/aa96ad)
- . 2017b, *Nature*, 549, 488, doi: [10.1038/nature23906](https://doi.org/10.1038/nature23906)
- Ricci, C., Kara, E., Loewenstein, M., et al. 2020, *ApJL*, 898, L1, doi: [10.3847/2041-8213/ab91a1](https://doi.org/10.3847/2041-8213/ab91a1)
- Ricci, C., Ananna, T. T., Temple, M. J., et al. 2022, *ApJ*, 938, 67, doi: [10.3847/1538-4357/ac8e67](https://doi.org/10.3847/1538-4357/ac8e67)
- Ricci, C., Ichikawa, K., Stalevski, M., et al. 2023, *ApJ*, 959, 27, doi: [10.3847/1538-4357/ad0733](https://doi.org/10.3847/1538-4357/ad0733)
- Riffel, R. A., Storchi-Bergmann, T., Riffel, R., et al. 2023, *MNRAS*, 521, 1832, doi: [10.1093/mnras/stad599](https://doi.org/10.1093/mnras/stad599)
- Risaliti, G., Bianchi, S., Matt, G., et al. 2005, *ApJL*, 630, L129, doi: [10.1086/491646](https://doi.org/10.1086/491646)
- Risaliti, G., Nardini, E., Salvati, M., et al. 2011, *MNRAS*, 410, 1027, doi: [10.1111/j.1365-2966.2010.17503.x](https://doi.org/10.1111/j.1365-2966.2010.17503.x)
- Rivers, E., Baloković, M., Arévalo, P., et al. 2015, *ApJ*, 815, 55, doi: [10.1088/0004-637X/815/1/55](https://doi.org/10.1088/0004-637X/815/1/55)
- Rojas, A. F., Sani, E., Gavignaud, I., et al. 2020, *MNRAS*, 491, 5867, doi: [10.1093/mnras/stz3386](https://doi.org/10.1093/mnras/stz3386)
- Ruiz, A., Georgantopoulos, I., & Corral, A. 2021, *A&A*, 645, A74, doi: [10.1051/0004-6361/202039431](https://doi.org/10.1051/0004-6361/202039431)
- Rupke, D. S., Veilleux, S., & Sanders, D. B. 2005, *ApJS*, 160, 115, doi: [10.1086/432889](https://doi.org/10.1086/432889)
- Rupke, D. S. N., Gültekin, K., & Veilleux, S. 2017, *ApJ*, 850, 40, doi: [10.3847/1538-4357/aa94d1](https://doi.org/10.3847/1538-4357/aa94d1)
- Ruschel-Dutra, D., Storchi-Bergmann, T., Schnorr-Müller, A., et al. 2021, *MNRAS*, 507, 74, doi: [10.1093/mnras/stab2058](https://doi.org/10.1093/mnras/stab2058)
- Saez, C., & Chartas, G. 2011, *ApJ*, 737, 91, doi: [10.1088/0004-637X/737/2/91](https://doi.org/10.1088/0004-637X/737/2/91)
- Saez, C., Chartas, G., & Brandt, W. N. 2009, *ApJ*, 697, 194, doi: [10.1088/0004-637X/697/1/194](https://doi.org/10.1088/0004-637X/697/1/194)
- Sako, M., Kahn, S. M., Behar, E., et al. 2001, *A&A*, 365, L168, doi: [10.1051/0004-6361:20000081](https://doi.org/10.1051/0004-6361:20000081)

- Sako, M., Kahn, S. M., Branduardi-Raymont, G., et al. 2003, *ApJ*, 596, 114, doi: [10.1086/377575](https://doi.org/10.1086/377575)
- Sanfrutos, M., Longinotti, A. L., Krongold, Y., Guainazzi, M., & Panessa, F. 2018, *ApJ*, 868, 111, doi: [10.3847/1538-4357/aae923](https://doi.org/10.3847/1538-4357/aae923)
- Sanfrutos, M., Miniutti, G., Agís-González, B., et al. 2013, *MNRAS*, 436, 1588, doi: [10.1093/mnras/stt1675](https://doi.org/10.1093/mnras/stt1675)
- Sanfrutos, M., Miniutti, G., Krongold, Y., Agís-González, B., & Longinotti, A. L. 2016, *MNRAS*, 457, 510, doi: [10.1093/mnras/stv2976](https://doi.org/10.1093/mnras/stv2976)
- Scott, A. E., Brandt, W. N., Behar, E., et al. 2014, *ApJ*, 797, 105, doi: [10.1088/0004-637X/797/2/105](https://doi.org/10.1088/0004-637X/797/2/105)
- Serafinelli, R., Tombesi, F., Vagnetti, F., et al. 2019, *A&A*, 627, A121, doi: [10.1051/0004-6361/201935275](https://doi.org/10.1051/0004-6361/201935275)
- Serafinelli, R., Marinucci, A., De Rosa, A., et al. 2023, *MNRAS*, 526, 3540, doi: [10.1093/mnras/stad2801](https://doi.org/10.1093/mnras/stad2801)
- Sergeev, S. G., Klimanov, S. A., Chesnok, N. G., & Pronik, V. I. 2007, *Astronomy Letters*, 33, 429, doi: [10.1134/S1063773707070018](https://doi.org/10.1134/S1063773707070018)
- Shen, Y., Richards, G. T., Strauss, M. A., et al. 2011, *ApJS*, 194, 45, doi: [10.1088/0067-0049/194/2/45](https://doi.org/10.1088/0067-0049/194/2/45)
- Shirai, H., Fukazawa, Y., Sasada, M., et al. 2008, *PASJ*, 60, S263, doi: [10.1093/pasj/60.sp1.S263](https://doi.org/10.1093/pasj/60.sp1.S263)
- Sikora, M., Stawarz, L., & Lasota, J.-P. 2007, *ApJ*, 658, 815, doi: [10.1086/511972](https://doi.org/10.1086/511972)
- Silk, J., & Rees, M. J. 1998, *A&A*, 331, L1, doi: [10.48550/arXiv.astro-ph/9801013](https://doi.org/10.48550/arXiv.astro-ph/9801013)
- Sim, S. A., Long, K. S., Miller, L., & Turner, T. J. 2008, *MNRAS*, 388, 611, doi: [10.1111/j.1365-2966.2008.13466.x](https://doi.org/10.1111/j.1365-2966.2008.13466.x)
- Smith, R. A. N., Page, M. J., & Branduardi-Raymont, G. 2007, *A&A*, 461, 135, doi: [10.1051/0004-6361:20065348](https://doi.org/10.1051/0004-6361:20065348)
- . 2008, *A&A*, 490, 103, doi: [10.1051/0004-6361:200810151](https://doi.org/10.1051/0004-6361:200810151)
- Smith, R. K., Brickhouse, N. S., Liedahl, D. A., & Raymond, J. C. 2001, *ApJL*, 556, L91, doi: [10.1086/322992](https://doi.org/10.1086/322992)
- Smith, R. N., Tombesi, F., Veilleux, S., Lohfink, A. M., & Luminari, A. 2019, *ApJ*, 887, 69, doi: [10.3847/1538-4357/ab4ef8](https://doi.org/10.3847/1538-4357/ab4ef8)
- Smolčić, V., Novak, M., Delvecchio, I., et al. 2017, *A&A*, 602, A6, doi: [10.1051/0004-6361/201730685](https://doi.org/10.1051/0004-6361/201730685)
- Stalevski, M., Tristram, K. R. W., & Asmus, D. 2019, *MNRAS*, 484, 3334, doi: [10.1093/mnras/stz220](https://doi.org/10.1093/mnras/stz220)
- Steenbrugge, K. C., Fenovčík, M., Kaastra, J. S., Costantini, E., & Verbunt, F. 2009, *A&A*, 496, 107, doi: [10.1051/0004-6361/200810416](https://doi.org/10.1051/0004-6361/200810416)
- Steenbrugge, K. C., Kaastra, J. S., de Vries, C. P., & Edelson, R. 2003a, *A&A*, 402, 477, doi: [10.1051/0004-6361:20030261](https://doi.org/10.1051/0004-6361:20030261)
- Steenbrugge, K. C., Kaastra, J. S., Sako, M., et al. 2005a, *A&A*, 432, 453, doi: [10.1051/0004-6361:20041542](https://doi.org/10.1051/0004-6361:20041542)
- Steenbrugge, K. C., Kaastra, J. S., Blustin, A. J., et al. 2003b, *A&A*, 408, 921, doi: [10.1051/0004-6361:20031021](https://doi.org/10.1051/0004-6361:20031021)
- Steenbrugge, K. C., Kaastra, J. S., Crenshaw, D. M., et al. 2005b, *A&A*, 434, 569, doi: [10.1051/0004-6361:20047138](https://doi.org/10.1051/0004-6361:20047138)
- Stone, M., Veilleux, S., Meléndez, M., et al. 2016, *ApJ*, 826, 111, doi: [10.3847/0004-637X/826/2/111](https://doi.org/10.3847/0004-637X/826/2/111)
- Strüder, L., Briel, U., Dennerl, K., et al. 2001, *A&A*, 365, L18, doi: [10.1051/0004-6361:20000066](https://doi.org/10.1051/0004-6361:20000066)
- Tashiro, M., Maejima, H., Toda, K., et al. 2018, in *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, Vol. 10699, *Space Telescopes and Instrumentation 2018: Ultraviolet to Gamma Ray*, ed. J.-W. A. den Herder, S. Nikzad, & K. Nakazawa, 1069922, doi: [10.1117/12.2309455](https://doi.org/10.1117/12.2309455)
- Tatum, M. M., Turner, T. J., Miller, L., et al. 2016, *ApJ*, 818, 12, doi: [10.3847/0004-637X/818/1/12](https://doi.org/10.3847/0004-637X/818/1/12)
- Temple, M. J., Matthews, J. H., Hewett, P. C., et al. 2023, *MNRAS*, 523, 646, doi: [10.1093/mnras/stad1448](https://doi.org/10.1093/mnras/stad1448)
- Teng, S. H., & Veilleux, S. 2010, *ApJ*, 725, 1848, doi: [10.1088/0004-637X/725/2/1848](https://doi.org/10.1088/0004-637X/725/2/1848)
- Terashima, Y., Gallo, L. C., Inoue, H., et al. 2009, *PASJ*, 61, S299, doi: [10.1093/pasj/61.sp1.S299](https://doi.org/10.1093/pasj/61.sp1.S299)
- Tombesi, F., & Cappi, M. 2014, *MNRAS*, 443, L104, doi: [10.1093/mnrasl/slu091](https://doi.org/10.1093/mnrasl/slu091)
- Tombesi, F., Cappi, M., Reeves, J. N., & Braitto, V. 2012a, *MNRAS*, 422, L1, doi: [10.1111/j.1745-3933.2012.01221.x](https://doi.org/10.1111/j.1745-3933.2012.01221.x)
- Tombesi, F., Cappi, M., Reeves, J. N., et al. 2013a, *MNRAS*, 430, 1102, doi: [10.1093/mnras/sts692](https://doi.org/10.1093/mnras/sts692)
- . 2011a, *ApJ*, 742, 44, doi: [10.1088/0004-637X/742/1/44](https://doi.org/10.1088/0004-637X/742/1/44)
- . 2010a, *A&A*, 521, A57, doi: [10.1051/0004-6361/200913440](https://doi.org/10.1051/0004-6361/200913440)
- Tombesi, F., Meléndez, M., Veilleux, S., et al. 2015, *Nature*, 519, 436, doi: [10.1038/nature14261](https://doi.org/10.1038/nature14261)
- Tombesi, F., Reeves, J. N., Reynolds, C. S., García, J., & Lohfink, A. 2013b, *MNRAS*, 434, 2707, doi: [10.1093/mnras/stt1213](https://doi.org/10.1093/mnras/stt1213)
- Tombesi, F., Sambruna, R. M., Marscher, A. P., et al. 2012b, *MNRAS*, 424, 754, doi: [10.1111/j.1365-2966.2012.21266.x](https://doi.org/10.1111/j.1365-2966.2012.21266.x)
- Tombesi, F., Sambruna, R. M., Reeves, J. N., et al. 2010b, *ApJ*, 719, 700, doi: [10.1088/0004-637X/719/1/700](https://doi.org/10.1088/0004-637X/719/1/700)
- Tombesi, F., Sambruna, R. M., Reeves, J. N., Reynolds, C. S., & Braitto, V. 2011b, *MNRAS*, 418, L89, doi: [10.1111/j.1745-3933.2011.01149.x](https://doi.org/10.1111/j.1745-3933.2011.01149.x)
- Tombesi, F., Tazaki, F., Mushotzky, R. F., et al. 2014, *MNRAS*, 443, 2154, doi: [10.1093/mnras/stu1297](https://doi.org/10.1093/mnras/stu1297)
- Tombesi, F., Veilleux, S., Meléndez, M., et al. 2017a, *ApJ*, 850, 151, doi: [10.3847/1538-4357/aa9579](https://doi.org/10.3847/1538-4357/aa9579)
- Tombesi, F., Reeves, J. N., Kallman, T., et al. 2016, *ApJ*, 830, 98, doi: [10.3847/0004-637X/830/2/98](https://doi.org/10.3847/0004-637X/830/2/98)

- Tombesi, F., Mushotzky, R. F., Reynolds, C. S., et al. 2017b, *ApJ*, 838, 16, doi: [10.3847/1538-4357/aa6342](https://doi.org/10.3847/1538-4357/aa6342)
- Torresi, E., Grandi, P., Costantini, E., & Palumbo, G. G. C. 2012, *MNRAS*, 419, 321, doi: [10.1111/j.1365-2966.2011.19694.x](https://doi.org/10.1111/j.1365-2966.2011.19694.x)
- Torresi, E., Grandi, P., Longinotti, A. L., et al. 2010, *MNRAS*, 401, L10, doi: [10.1111/j.1745-3933.2009.00773.x](https://doi.org/10.1111/j.1745-3933.2009.00773.x)
- Tortosa, A., Marinucci, A., Matt, G., et al. 2017, *MNRAS*, 466, 4193, doi: [10.1093/mnras/stw3301](https://doi.org/10.1093/mnras/stw3301)
- Tortosa, A., Ricci, C., Tombesi, F., et al. 2022, *MNRAS*, 509, 3599, doi: [10.1093/mnras/stab3152](https://doi.org/10.1093/mnras/stab3152)
- Tozzi, P., Gilli, R., Mainieri, V., et al. 2006, *A&A*, 451, 457, doi: [10.1051/0004-6361:20042592](https://doi.org/10.1051/0004-6361:20042592)
- Turner, M. J. L., Abbey, A., Arnaud, M., et al. 2001, *A&A*, 365, L27, doi: [10.1051/0004-6361:20000087](https://doi.org/10.1051/0004-6361:20000087)
- Turner, T. J., Kraemer, S. B., George, I. M., Reeves, J. N., & Bottorff, M. C. 2005, *ApJ*, 618, 155, doi: [10.1086/425961](https://doi.org/10.1086/425961)
- Turner, T. J., Reeves, J. N., Braito, V., et al. 2018, *MNRAS*, 481, 2470, doi: [10.1093/mnras/sty2447](https://doi.org/10.1093/mnras/sty2447)
- Turner, T. J., Reeves, J. N., Kraemer, S. B., & Miller, L. 2008, *A&A*, 483, 161, doi: [10.1051/0004-6361:20078808](https://doi.org/10.1051/0004-6361:20078808)
- U, V., Barth, A. J., Vogler, H. A., et al. 2022, *ApJ*, 925, 52, doi: [10.3847/1538-4357/ac3d26](https://doi.org/10.3847/1538-4357/ac3d26)
- Ueda, Y., Akiyama, M., Hasinger, G., Miyaji, T., & Watson, M. G. 2014, *ApJ*, 786, 104, doi: [10.1088/0004-637X/786/2/104](https://doi.org/10.1088/0004-637X/786/2/104)
- Ursini, F., Bassani, L., Malizia, A., et al. 2019, *A&A*, 629, A54, doi: [10.1051/0004-6361/201936273](https://doi.org/10.1051/0004-6361/201936273)
- Ursini, F., Petrucci, P. O., Matt, G., et al. 2016, *MNRAS*, 463, 382, doi: [10.1093/mnras/stw2022](https://doi.org/10.1093/mnras/stw2022)
- . 2018, *MNRAS*, 478, 2663, doi: [10.1093/mnras/sty1258](https://doi.org/10.1093/mnras/sty1258)
- Vander Meulen, B., Camps, P., Stalevski, M., & Baes, M. 2023, *A&A*, 674, A123, doi: [10.1051/0004-6361/202245783](https://doi.org/10.1051/0004-6361/202245783)
- Vasudevan, R. V., & Fabian, A. C. 2007, *MNRAS*, 381, 1235, doi: [10.1111/j.1365-2966.2007.12328.x](https://doi.org/10.1111/j.1365-2966.2007.12328.x)
- Vaughan, S., Edelson, R., Warwick, R. S., & Uttley, P. 2003, *MNRAS*, 345, 1271, doi: [10.1046/j.1365-2966.2003.07042.x](https://doi.org/10.1046/j.1365-2966.2003.07042.x)
- Venanzi, M., Hönig, S., & Williamson, D. 2020, *ApJ*, 900, 174, doi: [10.3847/1538-4357/aba89f](https://doi.org/10.3847/1538-4357/aba89f)
- Venturi, G., Nardini, E., Marconi, A., et al. 2018, *A&A*, 619, A74, doi: [10.1051/0004-6361/201833668](https://doi.org/10.1051/0004-6361/201833668)
- Véron-Cetty, M. P., & Véron, P. 2010, *A&A*, 518, A10, doi: [10.1051/0004-6361/201014188](https://doi.org/10.1051/0004-6361/201014188)
- Vignali, C., Iwasawa, K., Comastri, A., et al. 2015, *A&A*, 583, A141, doi: [10.1051/0004-6361/201525852](https://doi.org/10.1051/0004-6361/201525852)
- Vika, M., Ciesla, L., Charmandaris, V., Xilouris, E. M., & Lebouteiller, V. 2017, *A&A*, 597, A51, doi: [10.1051/0004-6361/201629031](https://doi.org/10.1051/0004-6361/201629031)
- Wada, K. 2012, *ApJ*, 758, 66, doi: [10.1088/0004-637X/758/1/66](https://doi.org/10.1088/0004-637X/758/1/66)
- . 2015, *ApJ*, 812, 82, doi: [10.1088/0004-637X/812/1/82](https://doi.org/10.1088/0004-637X/812/1/82)
- Wada, K., Schartmann, M., & Meijerink, R. 2016, *ApJL*, 828, L19, doi: [10.3847/2041-8205/828/2/L19](https://doi.org/10.3847/2041-8205/828/2/L19)
- Walton, D. J., Nardini, E., Fabian, A. C., Gallo, L. C., & Reis, R. C. 2013, *MNRAS*, 428, 2901, doi: [10.1093/mnras/sts227](https://doi.org/10.1093/mnras/sts227)
- Walton, D. J., Brightman, M., Risaliti, G., et al. 2018, *MNRAS*, 473, 4377, doi: [10.1093/mnras/stx2659](https://doi.org/10.1093/mnras/stx2659)
- Walton, D. J., Nardini, E., Gallo, L. C., et al. 2019, *MNRAS*, 484, 2544, doi: [10.1093/mnras/stz115](https://doi.org/10.1093/mnras/stz115)
- Walton, D. J., Alston, W. N., Kosec, P., et al. 2020, *MNRAS*, 499, 1480, doi: [10.1093/mnras/staa2961](https://doi.org/10.1093/mnras/staa2961)
- Walton, D. J., Baloković, M., Fabian, A. C., et al. 2021, *MNRAS*, 506, 1557, doi: [10.1093/mnras/stab1290](https://doi.org/10.1093/mnras/stab1290)
- Wang, J.-M., & Zhang, E.-P. 2007, *ApJ*, 660, 1072, doi: [10.1086/513685](https://doi.org/10.1086/513685)
- Wang, J. X., Wang, T. G., Tozzi, P., et al. 2005, *ApJL*, 631, L33, doi: [10.1086/496970](https://doi.org/10.1086/496970)
- Winter, L. M., & Mushotzky, R. 2010, *ApJ*, 719, 737, doi: [10.1088/0004-637X/719/1/737](https://doi.org/10.1088/0004-637X/719/1/737)
- Woo, J.-H., & Urry, C. M. 2002, *ApJ*, 579, 530, doi: [10.1086/342878](https://doi.org/10.1086/342878)
- Woo, J.-H., Wang, S., Rakshit, S., et al. 2024, *ApJ*, 962, 67, doi: [10.3847/1538-4357/ad132f](https://doi.org/10.3847/1538-4357/ad132f)
- Xu, Y., Pinto, C., Rogantini, D., et al. 2023, *MNRAS*, 523, 2158, doi: [10.1093/mnras/stad1565](https://doi.org/10.1093/mnras/stad1565)
- Xu, Y., Pinto, C., Bianchi, S., et al. 2021, *MNRAS*, 508, 6049, doi: [10.1093/mnras/stab2984](https://doi.org/10.1093/mnras/stab2984)
- Xu, Y., Pinto, C., Kara, E., et al. 2022, *MNRAS*, 513, 1910, doi: [10.1093/mnras/stac1058](https://doi.org/10.1093/mnras/stac1058)
- Yamada, S., Ueda, Y., Tanimoto, A., et al. 2021, *ApJS*, 257, 61, doi: [10.3847/1538-4365/ac17f5](https://doi.org/10.3847/1538-4365/ac17f5)
- . 2019, *ApJ*, 876, 96, doi: [10.3847/1538-4357/ab14f0](https://doi.org/10.3847/1538-4357/ab14f0)
- . 2020, *ApJ*, 897, 107, doi: [10.3847/1538-4357/ab94b1](https://doi.org/10.3847/1538-4357/ab94b1)
- Yamada, S., Ueda, Y., Herrera-Endoqui, M., et al. 2023, *ApJS*, 265, 37, doi: [10.3847/1538-4365/acb349](https://doi.org/10.3847/1538-4365/acb349)
- Yamada, S., Ueda, Y., Kawamuro, T., et al. 2024, *ApJ*, 965, 153, doi: [10.3847/1538-4357/ad2936](https://doi.org/10.3847/1538-4357/ad2936)
- Yaqoob, T., George, I. M., Kallman, T. R., et al. 2003a, *ApJ*, 596, 85, doi: [10.1086/377687](https://doi.org/10.1086/377687)
- Yaqoob, T., McKernan, B., Kraemer, S. B., et al. 2003b, *ApJ*, 582, 105, doi: [10.1086/344541](https://doi.org/10.1086/344541)
- Yoshida, M., Kawabata, K. S., & Ohyama, Y. 2011, *PASJ*, 63, 493, doi: [10.1093/pasj/63.sp2.S493](https://doi.org/10.1093/pasj/63.sp2.S493)

- Young, A. J., Lee, J. C., Fabian, A. C., et al. 2005, *ApJ*, 631, 733, doi: [10.1086/432607](https://doi.org/10.1086/432607)
- Zdziarski, A. A., Johnson, W. N., Done, C., Smith, D., & McNaron-Brown, K. 1995, *ApJL*, 438, L63, doi: [10.1086/187716](https://doi.org/10.1086/187716)
- Zhang, S. N., Ji, L., Marshall, H. L., et al. 2011, *MNRAS*, 410, 2274, doi: [10.1111/j.1365-2966.2010.17595.x](https://doi.org/10.1111/j.1365-2966.2010.17595.x)
- Zheng, Z. Y., & Wang, J. X. 2008, *ApJ*, 688, 116, doi: [10.1086/592141](https://doi.org/10.1086/592141)
- Zoghbi, A., Fabian, A. C., Uttley, P., et al. 2010, *MNRAS*, 401, 2419, doi: [10.1111/j.1365-2966.2009.15816.x](https://doi.org/10.1111/j.1365-2966.2009.15816.x)
- Zoghbi, A., Miller, J. M., & Cackett, E. 2019, *ApJ*, 884, 26, doi: [10.3847/1538-4357/ab3e31](https://doi.org/10.3847/1538-4357/ab3e31)
- Zoghbi, A., Reynolds, C., Cackett, E. M., et al. 2013, *ApJ*, 767, 121, doi: [10.1088/0004-637X/767/2/121](https://doi.org/10.1088/0004-637X/767/2/121)
- Zubovas, K., & King, A. 2012, *ApJL*, 745, L34, doi: [10.1088/2041-8205/745/2/L34](https://doi.org/10.1088/2041-8205/745/2/L34)