

Impact of active galactic nuclei and nuclear star formation on the ISM turbulence of galaxies: Insights from JWST/MIRI spectroscopy

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ABSTRACT

Active galactic nuclei (AGNs), star formation (SF), and galaxy interactions can drive turbulence in the gas of the interstellar medium (ISM), which, in turn, plays a role in SF taking place within galaxies. The impact on molecular gas is of particular importance, as it serves as the primary fuel for SF. Our goal is to investigate the origin of turbulence and the emission of molecular gas, as well as low-and-intermediate-ionisation gas, in the inner few kpc of both AGN hosts and star-forming galaxies (SFGs). We used archival JWST MIRI/MRS observations of a sample consisting of 54 galaxies at $z < 0.1$. We present flux measurements for the H_2 S(5) λ 6.9091 μm , [Ar II] λ 6.9853 μm , [Fe II] λ 5.3403 μm , and [Ar III] λ 8.9914 μm emission lines along with velocity dispersion estimated by the W_{80} parameter. For galaxies with coronal line emission, we included measurements of the [Mg V] λ 5.6098 μm line. We compared the line ratios to photoionisation and shock models to explore the origin of the gas emission. AGNs exhibit broader emission lines than SFGs, with the largest velocity dispersions observed in radio-strong (RS) AGNs. The H_2 gas is less turbulent compared to ionised gas, while coronal gas presents higher velocity dispersions. The W_{80} values for the ionised gas show a decrease when going from the nucleus out to radii of approximately 0.5–1 kpc, followed by an outward increase up to 2–3 kpc. In contrast, the H_2 line widths generally display increasing profiles with distance from the center. Correlations between the W_{80} parameter and line ratios such as H_2 S(5)/[Ar II] and [Fe II]/[Ar II] indicate that the most turbulent gas is associated with shocks, enhancing H_2 and [Fe II] emissions. Based on the observed line ratios and velocity dispersions, the [Fe II] emission is consistent with predictions of fast shock models, while the H_2 emission is likely associated with molecules formed in the post-shock region. We speculate that these shocked gas regions are produced by AGN outflows and jet-cloud interactions in AGN-dominated sources; whereas in SFGs, they might be created through stellar winds and mergers. This shock-induced gas heating may be an important mechanism of AGN (or stellar) feedback, preventing the gas from cooling and forming new stars.

Key words. galaxies: active – galaxies: evolution – galaxies: ISM – galaxies: kinematics and dynamics

1. Introduction

The interplay between active galactic nuclei (AGNs) or stellar-driven galactic winds and star formation (SF) in galaxies is a crucial aspect of galaxy evolution. Both AGNs and stellar winds can significantly suppress or regulate SF by injecting large amounts of energy into the interstellar medium (ISM; e.g. Silk & Rees 1998; Di Matteo et al. 2005; Hopkins et al. 2012; Dalla Vecchia & Schaye 2012; Heckman & Best 2014; Fierlinger et al. 2016; Harrison 2017; Harrison & Ramos Almeida 2024; Veilleux et al. 2020; Silk et al. 2024). The strong radiation field from AGNs or nuclear starburst, nuclear winds, and jets can all generate turbulence in the gas and induce shocks; in turn, this can disrupt the dense gas necessary for SF. These dynamic processes hinder or even prevent SF (i.e. negative feedback), as they inhibit the gas from condensing and cooling effectively. However, these mechanisms can also promote SF (i.e. positive feedback). For instance, fast outflows may enhance SF by compressing

molecular clouds under pressure or by fostering SF within the outflowing material itself (Silk 2013; Zubovas & King 2014; Cresci et al. 2015; Maiolino et al. 2017; Gallagher et al. 2019; García-Bernete et al. 2021; Bessiere & Ramos Almeida 2022; Hermosa Muñoz et al. 2024). Consequently, the balance between these outflows and the gas available for SF can have a profound impact on the star-forming potential of galaxies. A central problem in this context is to understand the origin of the gas turbulence observed in the central regions of galaxies and to establish the role of shocks in driving it. Determining whether turbulence is primarily induced by AGN outflows, radio jets, or stellar feedback, as well as how it regulates the physical state of the ISM, is essential to assess its impact on galaxy evolution. Addressing this issue is crucial for disentangling the mechanisms of feedback that suppress or promote star formation in different environments.

Shock-induced turbulence, triggered by AGN activity or stellar winds, can excite a variety of transitions in molecular and ionised gas, enhancing its emission across multiple wavelengths (e.g. Dopita & Sutherland 1995; Contini & Viegas 2001; Allen et al. 2008; Dors et al. 2021;

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Riffel et al. 2021b; Venturi et al. 2021; Appleton et al. 2017, 2023; Audibert et al. 2023, 2025; Schönell et al. 2025; Rodríguez-Ardila & Cerqueira-Campos 2025). Understanding gas emission mechanisms and the resulting turbulence in the central regions of galaxies is crucial for advancing our knowledge of how feedback processes, driven by both stellar activity and AGNs, contribute to the evolution of galaxies.

Observations of the ionised gas kinematics using integral field spectroscopy (IFS) show that AGNs exhibit higher [O III] λ 5007 emission line widths compared to star-forming galaxies (SFGs), extending up to distances greater than one effective radius (R_e) from the nucleus. In addition, high-luminosity AGNs, with $L_{[\text{O III}]}$ $> 2 \times 10^{40}$ erg s $^{-1}$, display a sharp increase in line widths within $0.4 R_e$, which is associated with AGN-driven outflows (Wylezalek et al. 2020; Deconto-Machado et al. 2022; Gatto et al. 2024). Evidence of increased turbulence is detected in luminous and ultra-luminous infrared galaxies (ULIRGs) using optical emission lines (e.g. Bellocchi et al. 2013; Arribas et al. 2014; Perna et al. 2022). Albán et al. (2024) found that radio-selected AGNs exhibit broader [O III] λ 5007 lines compared to those selected by other techniques, such as optical or infrared (IR) diagnostics. The authors conclude that this difference arises because radio-selected AGNs represent a population in which AGN-driven kinematic perturbations have been active for longer durations, consistent with the radio emission being driven by shocks from outflows. Studies of the ionised gas in the inner kpc of AGN hosts show that broadened or complex emission line profiles are generally associated with outflows or turbulence induced by the interaction of radio jets or outflows with the ISM (e.g. Mullaney et al. 2013; Fischer et al. 2018; Freitas et al. 2018; Förster Schreiber et al. 2019; Avery et al. 2021; Kakkad et al. 2022; Zhang et al. 2024; Davies et al. 2024; Speranza et al. 2024; Esposito et al. 2024; García-Berneté et al. 2024b; Hermosa Muñoz et al. 2024). In some cases, this interaction results in additional emission from gas excited by shocks (e.g. Riffel et al. 2021b; Venturi et al. 2021).

Vibrational and ro-vibrational H $_2$ emission in the central few kpc of nearby AGN hosts and ULIRGs can be strongly enhanced by shocks from outflows or jet-cloud interactions (e.g. Ogle et al. 2010, 2025; Hill & Zakamska 2014; Colina et al. 2015; Kristensen et al. 2023; Riffel et al. 2021a,c, 2025; Costa-Souza et al. 2024; Villar Martín et al. 2023; Leftley et al. 2024; Bohn et al. 2024; Dasyra et al. 2024). These shocks can heat the gas, promoting the excitation of H $_2$ molecules and leading to the emission of these diagnostic lines. A comparison of the emission lines from hot molecular gas and ionised gas, using near-IR lines, shows that the former are typically narrower than the latter, but both are observed in kinematically disturbed regions (KDRs) around AGNs and in ULIRGs (e.g. Emonts et al. 2017; Ramos Almeida et al. 2017, 2019, 2025; Bianchin et al. 2022; Riffel et al. 2023; Zanchettin et al. 2025).

With the use of the James Webb Space Telescope (JWST; Gardner et al. 2023) Mid-Infrared Instrument medium-resolution spectrometer (MIRI/MRS; Wright et al. 2015, 2023), it is possible to map the kinematics of multiple gas phases in the central regions of galaxies, including areas that are heavily obscured at optical wavelengths, as the extinction in the mid-IR is up to ~ 40 times lower than in the optical (Gordon et al. 2023). This allows unprecedented access to the deeply embedded gas emission structures and processes in dusty galactic nuclei, such as AGN-driven winds, turbulence in the ISM produced by outflows and jets, as well as circum-

nuclear SF. Here, we use archival JWST MIRI/MRS observations of a large sample of AGN hosts and ULIRGs at redshifts $z < 0.1$ to compare the kinematics across warm molecular gas and low-to-moderate-ionisation phases. We investigate the origin of the gas emission and turbulence in these galaxies. We focus on the H $_2$ 0 – 0 S(5) λ 6.9091 μm transition and a set of low-to-medium-ionisation fine-structure lines, including [Ar II] λ 6.99 μm , [Fe II] λ 5.34 μm , and [Ar III] λ 8.99 μm . These lines are among the brightest in the mid-IR spectra and they often trace spatially extended emission in nearby AGNs and SFGs. Their excitation can arise from different mechanisms, such as photoionisation by massive stars or AGNs, as well as shocks produced by stellar and AGN-driven outflows and jets. The analysis of both the line intensities and their kinematics therefore provides powerful diagnostics of the physical conditions and dominant excitation processes in the nuclear regions of galaxies.

This paper is organised as follows. Section 2 describes the sample and Section 3 presents the data and measurements. Our main results are presented in Section 4, followed by a discussion on the origin of the gas emission and turbulence in Section 5. Finally, Section 6 summarises our key conclusions.

2. The sample

Our goal is to investigate the origin of the emission and the dynamics of warm molecular gas as well as low-and-medium-ionisation ionised gas. In local galaxies ($z \lesssim 0.1$), the aforementioned emission lines are observed in Channels 1 and 2 of the MIRI/MRS, which provide angular resolutions of approximately 0.35–0.40 arcsec (FWHM; Law et al. 2023). Additionally, we used the [Mg V] λ 5.6098 μm emission line to identify objects with high-ionisation gas and H $_2$ S(3) λ 9.6649 μm to investigate the origin of the molecular gas emission. The ionisation potentials are 7.9 eV for Fe II (Nave & Johansson 2013), 15.8 eV for Ar II (Sansonetti & Martin 2005), 27.6 eV for Ar III (Kaufman & Whaling 1996), and 109 eV for Mg V (Biémont et al. 1999), as listed in the National Institute of Standards and Technology (NIST) Atomic Spectra Database Ionisation Energies Data (Kramida et al. 2014).

The sample was defined as follows: we queried the Mikulski Archive for Space Telescopes (MAST) portal for JWST observations of galaxies with $z < 0.1$ obtained using the MIRI instrument in the MRS observing mode. The redshift threshold was selected to allow the study of gas emission and kinematics on scales of hundreds of parsecs, enabling meaningful comparisons across objects with similar spatial resolutions. Our search was limited to projects with publicly available data that provide complete spectral coverage with MIRI/MRS, including all three subbands (short, medium, and long) and extended emission in the relevant emission lines, resulting in a sample of 54 galaxies. Table 1 summarises the properties of the sample, including the distance (D), hard X-ray (14–195 keV) luminosity (L_{BAT}), radio powers at 1.4 GHz and 4.8 GHz ($P_{1.4\text{GHz}}$ and $P_{4.8\text{GHz}}$), H-band luminosity (L_{H}), and infrared luminosity (L_{IR}) of each galaxy.

In our sample, 25 objects (46%) are detected in the Swift BAT survey, while 51 objects (94%) have 1.4 GHz data, and 30 objects (56%) have measurements at 4.8 GHz (see notes in Table 1 for references). Table A.1 presents the list of galaxies and the corresponding details of the observational proposals. Strong correlations are found between radio power and X-ray luminosity for the objects detected in both bands. Specifically, the 1.4 GHz and 4.8 GHz radio powers show Pearson correlation coefficients of 0.79 and 0.85, respectively, with the X-ray luminosity. Additionally, for the objects detected at both radio

Table 1. Properties of the sample.

| (1) Object | (2) D [Mpc] | (3) $\log L_{\text{BAT}}$ [erg/s] | (4) $\log P_{1.4\text{GHz}}$ [W/Hz] | (5) $\log P_{4.8\text{GHz}}$ [W/Hz] | (6) $\log L_{\text{H}}$ [erg/s] | (7) $\log L_{\text{IR}}$ [erg/s] | (8) Sub-samples |
|-------------------|---------------------|---|---|---|---------------------------------------|--|---------------------|
| Arp220 | 78.8 | – | 23.36 | 23.20 | 43.19 | 45.68 | SF |
| Centaurus A | 3.1 ^d | 42.19 | 21.71 ^c | 21.83 ^c | 41.19 | 43.25 | BAT; [Mg V] |
| Cygnus A | 240.9 | 44.98 | 26.74 ^d | 27.15 ^d | 43.58 | 45.79 | BAT; RS; [Mg V]; IR |
| ESO137-G034 | 31.0 ^b | 42.43 | – | – | 42.54 | 44.05 | BAT; [Mg V] |
| ESO420-G13 | 51.0 | – | 22.30 | – | 43.06 | 44.95 | [Mg V]; IR |
| IC5063 | 48.6 | 43.28 | 23.73 ^e | 23.17 ^e | 43.06 | 45.13 | BAT; RS; [Mg V]; IR |
| IIZw96 | 154.7 | – | 23.08 | 22.26 ^f | 42.72 | 45.82 | IR |
| IRAS05189–2524 | 188.8 | 43.60 | 23.07 | – | 44.13 | 46.13 | BAT; IR |
| IRAS07251–0248 | 375.2 | – | 23.27 | – | 43.73 | 45.91 | IR |
| IRAS09022–3615 | 255.6 | – | 23.80 | – | 43.77 | 45.92 | RS; IR |
| IRAS09111–1007 | 232.0 | – | 22.26 | – | 43.81 | 45.38 | SF |
| IRAS10565+2448 | 184.7 | – | 23.35 | – | 43.91 | 45.68 | SF |
| IRAS13120–5453 | 131.8 | – | 23.49 | 23.12 | 43.96 | 45.91 | SF |
| IRAS14348–1447 | 352.8 | – | 23.69 | – | 43.74 | 45.00 | SF |
| IRAS15250+3609 | 236.6 | – | 22.96 | – | 43.56 | 45.89 | IR |
| IRAS19297–0406 | 367.4 | – | 23.64 | – | 43.89 | 45.85 | SF |
| IRAS19542+1110 | 278.4 | – | 23.25 | – | 43.97 | 45.72 | SF |
| IRAS20551–4250 | 184.3 | – | 23.08 | – | 43.58 | 45.85 | IR |
| IRAS22491–1808 | 333.2 | – | 22.86 | – | 43.61 | 45.78 | SF |
| IRAS23128–5919 | 191.1 | – | – | – | 43.31 | 45.85 | IR |
| IRASF01364–1042 | 206.7 | – | 22.87 | 22.76 | 43.26 | 45.20 | IR |
| IRASF08572+3915NW | 249.4 | – | 22.48 | – | 43.09 | 46.07 | IR |
| IRASF14378–3651 | 289.9 | – | 23.50 | – | 43.71 | 45.68 | IR |
| IRASF23365+3604 | 276.3 | – | 23.37 | – | 43.78 | 45.81 | IR |
| M81 | 3.3 | 40.42 | 20.05 | 20.11 | 41.80 | 42.32 | BAT |
| M87 | 15.8 ^e | – | 24.64 | 24.24 | 42.23 | 42.79 | RS |
| M94 | 4.2 | – | 19.41 | 20.35 | 42.09 | 42.84 | SF |
| M104 | 8.0 ^f | – | 20.86 | 21.08 ^g | 42.43 | 42.37 | SF |
| MCG-05-23-016 | 36.6 | 43.52 | 21.36 | – | 42.97 | 44.70 | BAT; [Mg V]; IR |
| Mrk231 | 180.7 | – | 24.06 | 24.19 | 44.81 | 46.46 | RS; IR |
| Mrk273 | 160.0 | 43.18 | 23.63 | 23.33 | 43.73 | 45.81 | BAT; [Mg V]; IR |
| NGC 0253 | 3.5 ^h | – | 21.59 | 21.55 ⁱ | 41.38 | 44.37 | SF |
| NGC 0424 | 50.4 | 42.81 | 21.84 | – | 43.23 | 44.86 | BAT; IR |
| NGC 1052 | 19.2 ^j | 42.14 | 22.60 | 23.14 ^k | 42.75 | 43.63 | BAT |
| NGC 1068 | 10.1 ^l | 41.66 | 22.77 | 22.29 ^l | 42.90 | 45.23 | BAT; [Mg V]; IR |
| NGC 1365 | 18.3 ^m | 42.40 | 22.18 | 22.08 ^m | 42.00 | 44.90 | BAT; [Mg V] |
| NGC 1566 | 6.6 ⁿ | 41.01 | 20.93 | 20.72 | 41.62 | 42.71 | BAT; [Mg V] |
| NGC 1808 | 9.5 ^o | – | 21.76 | 21.41 ^o | 42.21 | 44.47 | SF |
| NGC 3081 | 23.8 ^p | 42.74 | 20.56 | – | 42.30 | 44.10 | BAT; [Mg V] |
| NGC 3256N | 40.1 | – | – | – | 43.06 | 45.60 | SF |
| NGC 3256S | 40.1 | – | 23.07 ^q | 22.78 | 43.17 | – | IR |
| NGC 4258 | 6.8 | 41.11 | 21.44 | 21.23 ^r | 41.80 | 42.76 | BAT |
| NGC 4395 | 4.4 | 40.81 | 19.75 | 18.07 ^s | 39.78 | 41.61 | BAT; [Mg V] |
| NGC 5506 | 23.8 ^t | 43.21 | 22.36 | 22.09 ^t | 42.92 | 44.57 | BAT; [Mg V]; IR |
| NGC 5728 | 39.0 | 43.18 | 22.10 | – | 42.86 | 44.36 | BAT; [Mg V] |
| NGC 6240 | 104.2 | 43.94 | 23.73 | 23.32 | 43.89 | 45.66 | BAT; RS; [Mg V] |
| NGC 6552 | 113.7 | 43.50 | 22.68 | 22.70 ^u | 43.48 | 45.25 | BAT; [Mg V]; IR |
| NGC 7172 | 37.4 | 43.42 | 21.79 | – | 42.88 | 44.20 | BAT; [Mg V]; IR |
| NGC 7319 | 96.5 | 43.60 | 22.76 | – | 43.11 | 44.59 | BAT; [Mg V]; IR |
| NGC 7469 | 69.7 | 43.61 | 23.01 | 22.60 | 43.75 | 45.56 | BAT; [Mg V] |
| NGC 7582 | 23.2 | 42.72 | 22.22 | 21.68 ^v | 43.02 | 44.77 | BAT; [Mg V]; IR |
| UGC05101 | 168.7 | 43.37 | 23.75 | 23.40 | 43.88 | 45.54 | BAT; RS; IR |
| VV114 | 86.0 | – | 23.33 | 22.92 ^w | 43.20 | 45.58 | IR |
| VV340a | 144.3 | – | 23.34 | 22.81 | 43.87 | 45.05 | [Mg V] |

Notes. (1) Galaxy name; (2) Distances were taken from the literature when available; otherwise, they were estimated from the redshift, assuming a cosmology with $h = 0.7$, $\Omega_m = 0.3$, and $\Omega_\Lambda = 0.7$. Superscript letters indicate the corresponding references: a: Majaess et al. (2008), b: Willick et al. (1997), c: Gerke et al. (2011), d: Oldham & Auger (2016), e: Radburn-Smith et al. (2011), f: Spitler et al. (2006), g: Tully et al. (2013), h: Nasonova et al. (2011), i: Riess et al. (2016), j: Tully et al. (2016), k: Bottinelli et al. (1984), l: Hoffmann & Macri (2015), m: Sabbi et al. (2018), n: Karachentsev et al. (2014), o: Rest et al. (2014); (3) Hard X-ray (14–195 keV) luminosity from Oh et al. (2018); (4) 1.4 GHz power taken from the NRAO VLA Sky Survey (NVSS; Condon et al. 1998), and supplemented with additional data from the literature (indicated by superscripts): a: Tingay et al. (2003), b: Steenbrugge et al. (2010), c: Allison et al. (2014), d: Brown et al. (2017), e: Condon et al. (1996); (5) 4.8 GHz radio power taken from the Green Bank 4.85 GHz survey (Gregory et al. 1996), with additional data from the literature (indicated by superscripts): a: Tingay et al. (2003), b: Becker et al. (1991), c: Wright et al. (1994), d: Gregory & Condon (1991), e: Baan & Klöckner (2006), f: Griffith et al. (1994), g: Sajina et al. (2011), h: Stil et al. (2009), i: Wright et al. (1994), j: Nagar et al. (2005), k: Orienti & Prieto (2010). (6) H -band luminosity from The Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006); (7) IR luminosity obtained from the WISE W4 luminosity (Wright et al. 2010) using the relation from Cluver et al. (2017). The northern nucleus of NGC 3256 is an order of magnitude brighter in IR than the southern nucleus (Bohn et al. 2024); thus, we quote L_{IR} only for the northern nucleus. High-resolution IR data reveal an AGN in the southern nucleus (Ohshima et al. 2015), which is included in our IR AGN sample. For IRAS 13120-5453, L_{IR} was estimated from the 25 μm IRAS flux, as WISE magnitudes are unavailable; (8) The sub-samples to which each object belongs.

Table 2. Mean properties for each sub-sample. Uncertainties are the standard deviation of each parameter.

| Sub-sample | BAT AGN | RS AGN | [Mg v] AGN | IR AGN | SF |
|--|------------------|------------------|------------------|------------------|------------------|
| # of galaxies | 25 | 7 | 21 | 27 | 13 |
| $\langle \log D/\text{Mpc} \rangle$ | 1.50 ± 0.56 | 2.03 ± 0.44 | 1.55 ± 0.51 | 2.02 ± 0.41 | 1.80 ± 0.78 |
| $\langle \log L_{\text{H}}/\text{erg s}^{-1} \rangle$ | 42.79 ± 0.98 | 43.60 ± 0.80 | 42.81 ± 0.97 | 43.39 ± 0.47 | 43.17 ± 0.87 |
| $\langle \log L_{\text{IR}}/\text{erg s}^{-1} \rangle$ | 44.46 ± 1.18 | 45.33 ± 1.19 | 44.58 ± 1.04 | 45.45 ± 0.57 | 44.97 ± 1.17 |
| $\langle \log P_{1.4}/\text{W Hz}^{-1} \rangle$ | 22.23 ± 1.65 | 24.35 ± 1.11 | 22.42 ± 1.60 | 23.07 ± 1.00 | 22.51 ± 1.29 |

frequencies, the 4.8 GHz and 1.4 GHz radio powers are tightly correlated, closely following a 1:1 relation, with a Pearson correlation coefficient of 0.96.

In this work, we are not focussed on discussing individual objects, many of which exhibit a rich abundance of physical properties. Instead, our goal is to investigate the general properties of the sample, specifically the physical characteristics of warm molecular gas and low-to-moderate-ionisation gas. Consequently, we do not present individual maps for all galaxies. We present our results by dividing the sample into five subsamples, where a single galaxy may belong to more than one group, defined as follows.

- BAT AGN sub-sample: This sub-sample of X-ray selected AGNs is composed of 25 galaxies. It was obtained by cross-matching the sample with the 105-month catalog of hard X-ray sources (14–195 keV) from the Swift Burst Alert Telescope (BAT) survey (Oh et al. 2018), including all X-ray detected sources. The hard X-ray emission offers a direct measurement of AGN activity, as it predominantly captures the intrinsic emission from the AGN rather than scattered or reprocessed emissions. Additionally, it is significantly less affected by line-of-sight obscuration compared to optical wavelengths or softer X-ray bands.
- RS AGN sub-sample: This sub-sample of radio-strong (RS) AGNs is composed of seven galaxies. SFGs typically exhibit 1.4 GHz radio luminosities below $P_{1.4\text{GHz}} = 10^{23} \text{ W Hz}^{-1}$, although some can reach up to $\sim 10^{24} \text{ W Hz}^{-1}$ (Condon et al. 2002; Jose et al. 2024). On average, AGNs exhibit radio luminosities higher than those expected purely from SFGs (e.g. Condon et al. 2002), due to additional emission from jets (Padovani 2017) and/or shocks generated by outflows (Zakamska et al. 2016). The standard definition of radio-loud AGNs identifies them as those with a ratio of 5 GHz radio luminosity to *B*-band luminosity of $L_{5\text{GHz}}/L_{\text{B}} \gtrsim 10$ (e.g. Kellermann et al. 1989). However, several studies have used the 1.4 GHz radio power to distinguish between radio-loud and radio-quiet AGNs, often defining thresholds at $P_{1.4\text{GHz}} = 10^{23} \text{ W Hz}^{-1}$ (e.g. Best et al. 2005) or $P_{1.4\text{GHz}} = 10^{24} \text{ W Hz}^{-1}$ (e.g. Tadhunter 2016). Since most galaxies in our sample were detected at 1.4 GHz, we used their observed radio powers to define a sub-sample of RS AGNs. Only three objects in our sample have $\log P_{1.4\text{GHz}}/[\text{W Hz}^{-1}] > 24$. On the other hand, our sample includes ULIRGs, for which the commonly used threshold of $\log P_{1.4\text{GHz}}/[\text{W Hz}^{-1}] > 23$ might be insufficient to ensure the presence of an AGN. Therefore, we adopted an intermediate value of $\log P_{1.4\text{GHz}}/[\text{W Hz}^{-1}] > 23.7$, which lies between the thresholds commonly used in the literature. This sample includes four ULIRGs (i.e. IRAS 09022–3615, Mrk 231, NGC 6240, and UGC 05101) all of which are classified as AGNs using the other methods adopted in this work. In these objects, a significant fraction of the radio

emission may still be attributed to SF. Among all the RS AGNs, the only galaxy not included in any other AGN sample is the radio galaxy M 87. In addition, we note that only two galaxies in this sample exhibit a clear radio excess: Cygnus A and M 87. This is evidenced by $q_{23} < 0$, where $q_{23} = \log(S_{23\mu\text{m}}/S_{1.4\text{GHz}})$, with $S_{23\mu\text{m}}$ and $S_{1.4\text{GHz}}$ representing the flux densities at 23 μm and 1.4 GHz, respectively (Radcliffe et al. 2021). Therefore, interpretations regarding the role of AGNs in this sub-sample should be approached with caution.

- [Mg v] AGN sub-sample: This sub-sample is composed of 21 galaxies with coronal line emission. In brief, coronal lines are emitted by highly ionised gas with ionisation potentials of $\text{IP} \gtrsim 100 \text{ eV}$. They serve as reliable indicators of AGN activity, generated either by photoionisation from the AGN’s intense radiation field or by shocks associated with jets and outflows (e.g. Rodríguez-Ardila & Cerqueira-Campos 2025; Ramos Almeida et al. 2025). We used the [Mg v] $\lambda 5.6098 \mu\text{m}$ emission line to select galaxies for this sub-sample, using the MIRI MRS datacubes. We show the [Mg v] flux maps and line profiles for each galaxy in Fig. A.2.
- IR AGN sub-sample: This sub-sample is composed of 27 IR-selected galaxies, based on the fact that AGNs exhibit an excess of IR emission, which arises from the dusty torus heated by the radiation from the central engine (Antonucci 1993; Netzer 2015). We selected the IR AGN sample based on magnitudes from the Wide-field Infrared Survey Explorer (WISE; Wright et al. 2010). We adopted the definition of Stern et al. (2012), considering AGNs as objects with a colour criterion of $W1 - W2 \geq 0.8$. This criterion allows us to efficiently identify AGNs even in galaxies with significant host galaxy contamination and it is particularly sensitive to dust-obscured AGN populations (Assef et al. 2010; Stern et al. 2012).
- SF sub-sample: The sub-sample comprises 13 SFGs that are not classified as AGNs by any of the methods described above and it is predominantly composed of U/LIRGs (i.e. seven ULIRGs and two LIRGs). Although some of these galaxies show evidence of buried or obscured AGNs, their gas excitation is predominantly driven by SF (Cicone et al. 2014; Su et al. 2023; García-Bernete et al. 2025).

Table 2 presents the mean properties of each sub-sample. The H-band luminosity can be used as a reliable proxy for stellar mass (Davies et al. 2015), allowing us to compare the stellar mass distributions across different subsamples. The sample includes objects with L_{H} in the range 10^6 – $10^{11} L_{\odot}$. The mean H-band luminosities for all subsamples are similar, with the BAT AGN and [Mr v] AGN sub-samples presenting slightly smaller values than the other samples. In addition, we performed two-sample Kolmogorov–Smirnov (KS) tests to assess whether the H-band luminosity distributions of the AGN and SF samples differ

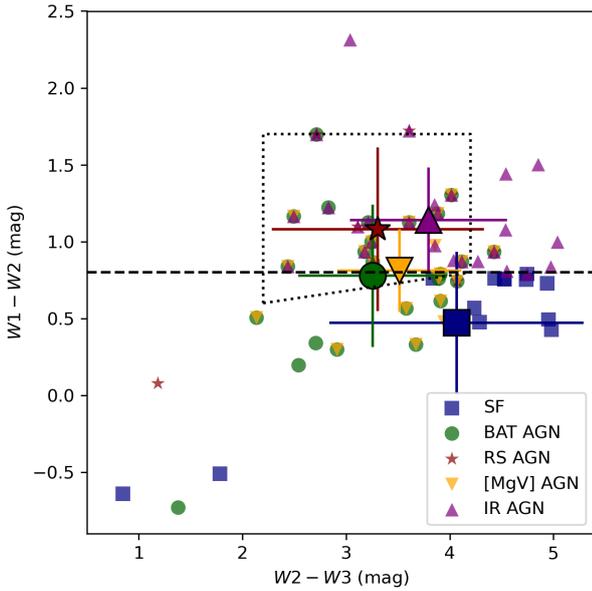


Fig. 1. WISE colour–colour diagram showing the five subsamples, as indicated by the symbols. The uncertainties are comparable to the symbol sizes. The large symbols with error bars correspond to the mean values for each sub-sample, with the error bars representing the standard deviation. The dashed line represents the threshold $W1 - W2 = 0.8$, while the dotted polygon marks the region typically occupied by Seyfert galaxies (Jarrett et al. 2011).

significantly. The p-values indicate that the AGN and SF samples are drawn from the same parent population.

The four AGN sub-samples were defined using tracers of different physical processes. The BAT sub-sample directly probes the emission of the hot corona located above the AGN accretion disk, while the RS sub-sample is associated with the mechanical energy released in the form of jets. The [Mg v] sub-sample is related to the local gas physics, as it primarily traces the ionisation parameter rather than directly probing the AGN emission, similar to optical diagnostic diagrams (Baldwin et al. 1981; Negus et al. 2023). Coronal line emission, however, can also be associated with shocked gas regions in the inner ~ 1 kpc of AGN hosts (Rodríguez-Ardila & Cerqueira-Campos 2025; Rodríguez-Ardila et al. 2025). Finally, the IR sub-sample traces the physics of the hot dust heated by AGN radiation. Since these physical processes are interconnected and can occur simultaneously in an AGN, many of our objects appear in more than one sub-sample. In Fig. A.1, we show the Venn diagram illustrating the overlap among the different AGN sub-samples.

In Fig. 1, we present the WISE colour–colour diagram for our subsamples. The mean $W1 - W2$ and $W2 - W3$ values for all AGN sub-samples fall within the region typically occupied by Seyfert galaxies, as indicated by the dotted polygon. The IR AGN sub-sample includes representatives of dustier objects, exhibiting larger colours along both axes of the diagram; some BAT and [Mg v] AGNs exhibit lower $W1 - W2$ values than typical Seyfert galaxies, consistent with low-luminosity AGNs; and objects in the SF sample are located in a region consistent with Starburst galaxies; finally, all three associations are consistent with the locations of these classes among WISE objects (Wright et al. 2010).

3. Data reduction and measurements

We used archival mid-IR JWST spectroscopic data obtained with the MIRI/MRS instrument (Wells et al. 2015; Labiano et al. 2021; Argyriou et al. 2023) of a sample of nearby galaxies. The observations were carried out using different observational strategies, according to the scientific objectives of the approved proposals. We downloaded the processed data from MAST archive, using a set of filters (`obs_collection='JWST'`, `intentType='science'`, `dataRights='PUBLIC'`, `instrument_name='MIRI/IFU'`, `calib_level=3`, `proposal_id=pidm` `obs_id='jw*{pid}-c*''), where pid refers to the proposal IDs listed in the table, identified from the list of approved projects up to cycle 3. These data were processed using version 1.16.1 of the JWST Science Calibration Pipeline (Bushouse et al. 2024), employing the reference file jwst_1303.pmap.`

The MIRI/MRS field of view (FoV) for channel 1 is 3.2×3.7 arcsec², while channel 2 has a FoV of 4.0×4.8 arcsec². Before performing the emission line flux and kinematic measurements, we rebinned the channel 1 data cubes to a spaxel size of 0.17 arcsec and convolved them with a Gaussian function with FWHM = 0.40 arcsec to match the angular sampling and spatial resolution of the channel 2 cubes. Subsequently, each spaxel in the cube was replaced with the average of its nearest neighbors within a 3×3 spaxel box. This process minimises the residual instrumental effects, particularly the continuum wiggles caused by the under-sampling of the point spread function (PSF; Law et al. 2023).

We performed the flux measurements and calculated the velocity dispersion, parametrised by the W_{80} parameter, which is defined as the width encompassing 80 per cent of the total line flux. These measurements were carried out for the following emission lines: H_2 S(5) $\lambda 6.9091 \mu\text{m}$, H_2 S(3) $\lambda 9.6649 \mu\text{m}$, [Ar II] $\lambda 6.9853 \mu\text{m}$, and [Ar III] $\lambda 8.9914 \mu\text{m}$, [Fe II] $\lambda 5.3403 \mu\text{m}$, and [Mg v] $\lambda 5.6098 \mu\text{m}$. For each emission line, we subtracted the continuum contribution by fitting a linear function to regions adjacent to the line. The line profile was then integrated within a 3000 km s^{-1} window centered on the emission line. We only considered spaxels where the emission line was detected with $s/n > 5$, determined as the ratio between the line profile amplitude and the standard deviation of the adjacent continuum within a 1000 km s^{-1} window. Figure 2 presents several examples of the flux and W_{80} measurements for the emission lines H_2 S(5) $\lambda 6.9091 \mu\text{m}$, [Ar II] $\lambda 6.9853 \mu\text{m}$, [Fe II] $\lambda 5.3403 \mu\text{m}$, and [Ar III] $\lambda 8.9914 \mu\text{m}$ in the galaxy Arp 220. The gray regions indicate areas where the corresponding emission line is either not detected with $s/n > 5$ or lies outside the FoV of the MIRI instrument. The measured W_{80} values were corrected for instrumental broadening using the resolving power described by $R = 4603 - 128 \times \lambda[\mu\text{m}]$ (Jones et al. 2023), along with the relation $W_{80} = 1.09 \times \text{FWHM}$ for a Gaussian profile.

4. Results

We used the W_{80} parameter to trace the velocity dispersion of the gas, which can be associated with turbulence and kinematic disturbances in the nuclear regions. In Fig. 3, we present the nuclear W_{80} distributions for the H_2 S(5) $\lambda 6.9091 \mu\text{m}$, [Fe II] $\lambda 5.3403 \mu\text{m}$, [Ar II] $\lambda 6.9853 \mu\text{m}$, and [Ar III] $\lambda 8.9914 \mu\text{m}$ emission lines (from top to bottom) for the BAT AGN, RS AGN, [Mg v] AGN, IR AGN, and SF sub-samples (from left to right). These values are computed as the flux-weighted mean W_{80} values measured for spaxels within a 0.5 arcsec radius aperture. We observed that for

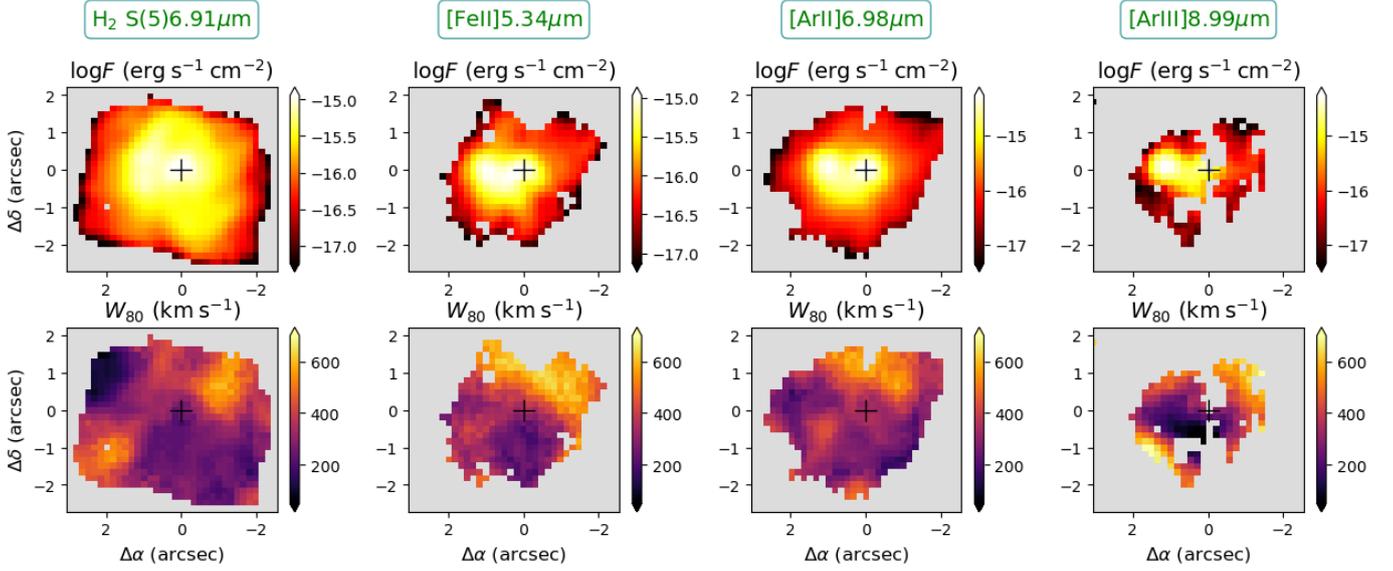


Fig. 2. Examples of flux (top panels) and W_{80} (bottom panels) maps for Arp 220. From left to right, the H_2 S(5) λ 6.9091 μm , [Ar II] λ 6.9853 μm , [Fe II] λ 5.3403 μm , and [Ar III] λ 8.9914 μm . The central crosses identify the location of the peak of the continuum, corresponding to the western nucleus, used as reference to calculate radial distances from the galaxy nucleus. The gray regions correspond to locations where the corresponding emission line is not detected with a signal-to-noise ratio of $s/n > 5$ and regions not covered by the MRS FoV.

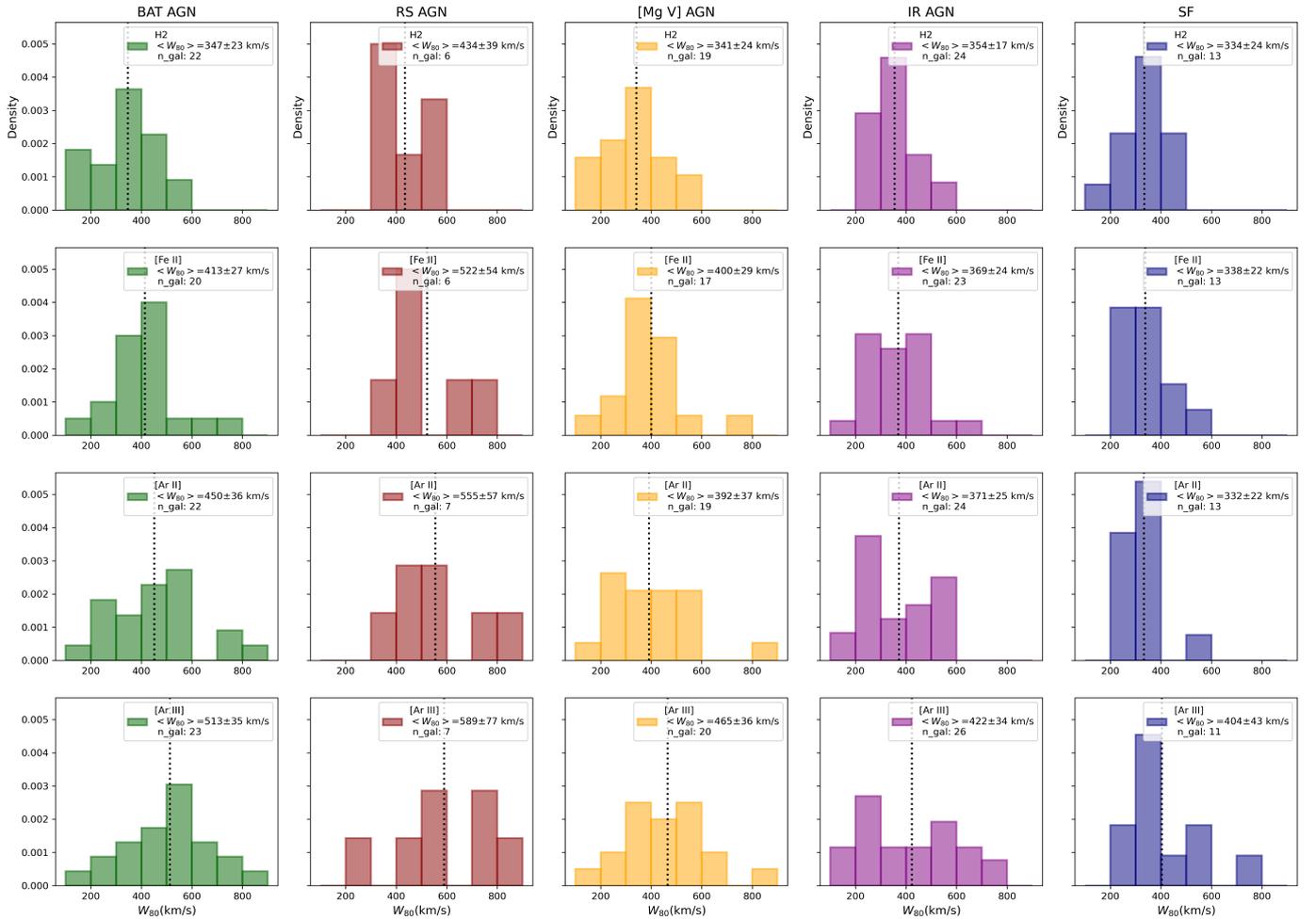


Fig. 3. Nuclear W_{80} values for the H_2 S(5), [Fe II], [Ar II], and [Ar III] emission lines are ordered by increasing ionisation potential from top to bottom, shown for the five subsamples, displayed in separate columns. The W_{80} values are estimated as the flux weighted mean W_{80} values of spaxels within a radius of 0.5 arcsec centered at the peak or the continuum emission. The mean values (vertical dotted lines), standard error, and the number of galaxies are displayed in each panel.

all AGN samples, the H₂ emission lines consistently present the lowest mean values of W_{80} . Furthermore, the W_{80} values of the ionised gas emission lines increase from [Fe II] through [Ar II], reaching the highest values for [Ar III], following the order of increasing ionisation potential. These higher W_{80} values indicate enhanced gas turbulence in the more highly ionised regions. For example, the mean difference of W_{80} between [Fe II] and H₂, considering all AGN sub-samples, is $56 \pm 28 \text{ km s}^{-1}$, while the mean difference between [Ar III] and [Fe II] is $115 \pm 35 \text{ km s}^{-1}$. On the other hand, the SF sub-sample shows similar mean W_{80} values for H₂, [Fe II], and [Ar II], while [Ar III] exhibits higher values. Finally, we note that the AGN samples include objects with $W_{80} > 500 \text{ km s}^{-1}$, which exceed the values expected for motions solely governed by the gravitational potential of galaxies and are commonly used as a criterion to identify outflows in AGN hosts in the Local Universe (e.g. Wylezalek et al. 2020). Even smaller values, around $\geq 300 \text{ km s}^{-1}$, have also been linked to ionised gas outflows in low-luminosity AGNs (Riffel et al. 2023; Gatto et al. 2024). Such high W_{80} also reflects strong turbulence associated with AGN-driven outflows. In addition, three galaxies in the SF sample (M 104, IRAS 19542+1110, and IRAS 13120–5453) exhibit nuclear W_{80} values exceeding 500 km s^{-1} . In M 104, this is observed across all ionised-gas emission lines, while in the other two it is present only in [Ar III].

In Fig. 4 we show W_{80} radial profiles for the H₂ (top left), [Fe II] (top right), [Ar II] (bottom left) and [Ar III] (bottom right) for the five sub-samples. These radial profiles were constructed by computing the median W_{80} and median radii values within 250 pc radial bins, considering all spaxels in all galaxies in each sample. The radial distances are calculated relative to the position of the peak of the continuum emission at $6.75 \mu\text{m}$. The bin size was chosen as a compromise between the angular resolution for more distant objects and the field-of-view size for nearer ones. The bin width is smaller than the PSF radius only for the four most distant objects ($D \geq 300 \text{ Mpc}$). The number of galaxies used in each bin is indicated next to each data point. Fig. C.1 presents the same W_{80} radial profiles, but grouping the four emission lines for each sub-sample.

The lowest values of W_{80} at most radii are found for the SF sample across all emission lines within distances up to 1.5–2 kpc, beyond which the number of objects with spatial coverage for larger distances becomes small. An exception is seen in [Ar III], where the W_{80} values for SFGs at distances greater than 1 kpc exceed those in AGNs; however, only two SFGs show emission in this line beyond 1 kpc. For the ionised gas lines, there is a trend of decreasing W_{80} values from the nucleus up to ~ 0.5 –1 kpc, followed by an increase with radius in more distant regions. These variations likely reflect changes in the turbulent motions of the gas across different spatial scales. This behaviour is less evident in [Fe II], where the radial profiles show more monotonically increasing values with the distance from the nucleus, except for the RS AGNs. At distances larger than $\sim 2 \text{ kpc}$, the W_{80} values start to decrease, but the number of objects with measurements at these scales is very reduced. For H₂, the radial profiles show values increasing with distance from the nucleus for all subsamples, except in the RS AGNs, where a similar behaviour (to that described above for the ionised gas) was observed. Furthermore, the gas velocity dispersion values in our SF sample are significantly higher than those observed in low- z SFGs, which typically exhibit $\sigma \approx 10$ – 40 km s^{-1} or $W_{80} \approx 25$ – 100 km s^{-1} (e.g. Epinat et al. 2010). Instead, our measurements are comparable to those observed in local U/LIRGs, which

are often attributed to gas outflows (e.g. Piqueras López et al. 2012; Bellocchi et al. 2013; Arribas et al. 2014).

Emission-line flux ratios can be used to investigate the origin of gas emission, while the line widths provide insights into the origin of gas turbulence and the behaviours observed in the radial profiles of W_{80} . In Fig. 5, we present the W_{80} density maps for [Fe II] $\lambda 5.3403 \mu\text{m}$ versus the flux ratios H₂ S(5) $\lambda 6.9091 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ (top panels), [Fe II] $\lambda 5.3403 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ (central panels), and [Ar III] $\lambda 8.9914 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ (bottom panels) for the different subsamples. These maps were constructed using spaxel-based measurements.

As observed in Fig. 5, the SF sample exhibits the highest densities at $W_{80} \lesssim 300 \text{ km s}^{-1}$, while the AGN samples display higher values, typically ranging between 300 and 600 km s^{-1} ; there is a secondary clustering in the distribution of points at values similar to those of SFGs, except for the RS AGNs. The clustering of points with lower values of W_{80} and line ratio (the secondary clustering) is associated with spaxels located closer to the nucleus, compared to the clustering of points with higher values of these parameters. For regions with $W_{80} < 300 \text{ km s}^{-1}$ (and low line ratios, as seen in Fig. 5), the median distance of spaxels from the nucleus is 234, 282, and 340 pc for the BAT, [Mg V], and IR AGN samples, respectively. For regions with $W_{80} > 300 \text{ km s}^{-1}$, these distances increase to 267, 321, and 534 pc for the same samples. The secondary clustering detected in the AGN samples is probably linked to SF within the MIRI FoV, as observed in several of these galaxies (e.g. Ricci et al. 2018; Zanchettin et al. 2024; Cassanta et al. 2025). The highest W_{80} values for the AGN samples reach 800 km s^{-1} , whereas for the SF sample, the maximum values reach up to 600 km s^{-1} . The BAT and [Mg V] AGN subsamples show remarkably similar distributions in these plots. This is not surprising, since both are direct tracers of AGN emission, either through the X-rays produced by the central engine or through the high-energy photons required to ionise the coronal gas. For all subsamples, a trend of increasing H₂ S(5) $\lambda 6.9091 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ and [Fe II] $\lambda 5.3403 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ with the line width of [Fe II] is observed. However, the SF sample exhibit lower values of flux ratios compared to the AGN samples. A similar trend is observed with the [Ar III]/[Ar II] flux ratio (bottom panels), a diagnostic of the ionisation degree of the gas since it involves lines of the same element with different ionisation states. However, this trend is only evident for the BAT, [Mg V], and IR AGN samples. For the SF sample, most points are concentrated at low flux ratios and W_{80} values, with some contours extending to higher values. In contrast, the RS AGN sample exhibits two structures: one with $W_{80} < 600 \text{ km s}^{-1}$ spanning a wide range of [Ar III]/[Ar II] ratios and another with $W_{80} > 600 \text{ km s}^{-1}$ and lower flux ratios.

5. Discussion

As presented in the previous section, we found that: (i) AGNs exhibit higher gas turbulence, as indicated by the emission line widths, compared to SFGs; (ii) there is a trend of increasing gas turbulence with distance from the nucleus, which is more evident for H₂ and [Fe II] (Fig. 4). Overall, RS AGNs present more turbulent gas compared to other samples; (iii) there is a correlation between the width of the [Fe II] emission line and the line ratios H₂ S(5) $\lambda 6.9091 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ and [Fe II] $\lambda 5.3403 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ for all sub-samples (Fig. 5). However, only AGN samples show a trend of increasing [Ar III] $\lambda 8.9914 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ with gas turbulence. In this section, we investigate the origin of the observed behaviour in

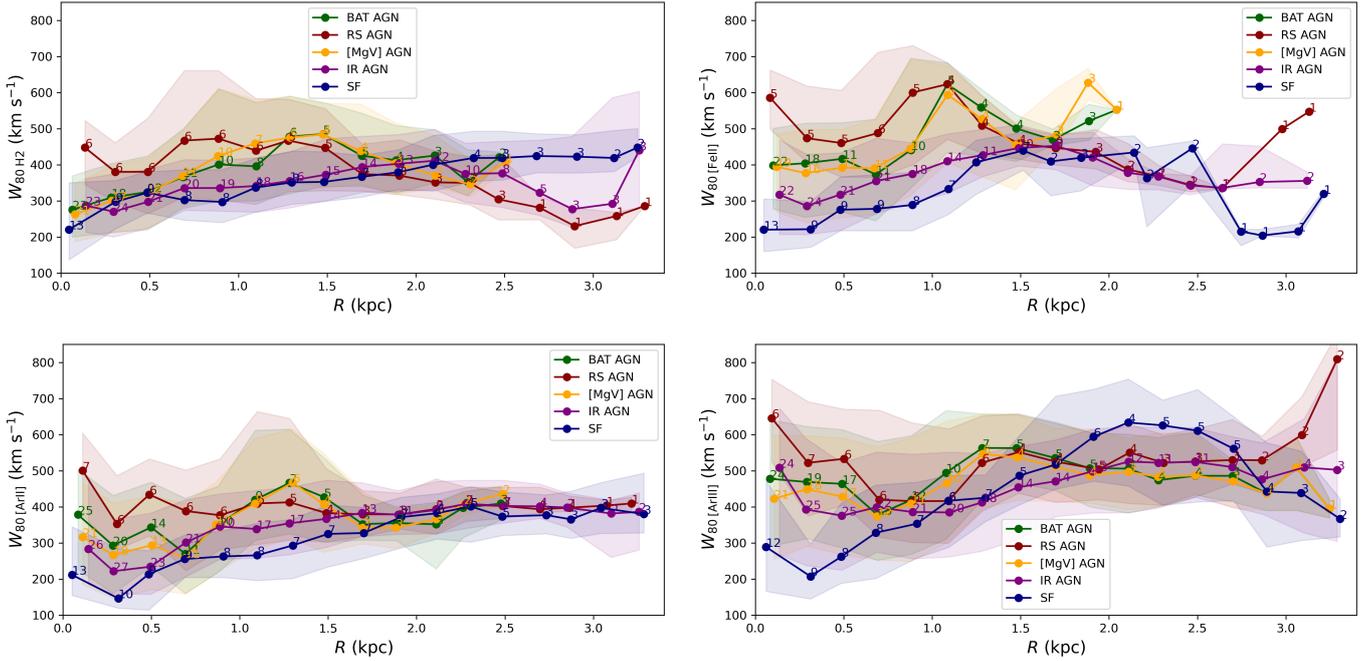


Fig. 4. Radial W_{80} profiles for H₂ (top-left), [Fe II] (top-right), [Ar II] (bottom-left), and [Ar III] (bottom-right) for the five subsamples, as indicated by the different colours. These profiles are computed as median values of W_{80} and distance of the spaxel from the position of the continuum peak, within circular rings of 250 pc width. The numbers next to each point indicate the number of galaxies used to compute it, and the shaded regions represent the range between the 25th and 75th percentiles of the W_{80} values within each radial bin, illustrating the spread of values observed in each emission line.

the W_{80} radial profiles and the physical mechanisms responsible for the line emission in our sample.

5.1. W_{80} radial profiles

When gas motions are governed by the gravitational potential, a decrease in the velocity dispersion with increasing distance from the nucleus is expected; therefore, the observed W_{80} radial profiles in our sample cannot be solely explained by virial motions. Such profiles could be interpreted as being generated by outflows or associated with shocks that enhance the turbulence of the gas (e.g. Wylezalek et al. 2020; Ruschel-Dutra et al. 2021; Audibert et al. 2023; Bessiere et al. 2024). Similar increases in velocity dispersion with distance from the nucleus are observed in the inner few hundred parsecs of nearby AGN hosts, in both hot molecular gas (traced by the H₂ 2.1218 μm line) and ionised gas (traced by the Br γ line), based on near-IR integral field spectroscopy observations of a sample of 31 AGNs. In those observations, KDRs were detected in 94% of the cases for the ionised gas and in 76% for the hot molecular gas (Riffel et al. 2023). A similar result is found using a larger sample of 88 AGNs, in which flat or increasing velocity dispersion profiles are observed within the inner 200 pc for obscured, unobscured, and LINER sources, including in the coronal gas traced by the [Si VI] 1.9641 μm emission line (Delaney et al. 2025). The origin of the enhanced line widths in these sources is associated with outflows and the shocks they produce (e.g. Riffel et al. 2021c). On galaxy-wide scales, AGN hosts exhibit enhanced velocity dispersion relative to normal galaxies, extending out to distances of up to 2 effective radii, as revealed by observations from the Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey using the [O III] λ 5007 emission line (Wylezalek et al. 2020; Albán et al. 2024). Radio-selected AGNs exhibit the largest differences at all radii, indicating that

AGN-driven kinematic perturbations in this population have been active for longer durations than in purely photoionised AGNs, consistent with radio emission originating from shocks associated with outflows (Albán et al. 2024). On the other hand, Kukreti et al. (2025), using MaNGA data, find that radio AGNs exhibit higher [O III] λ 5007 velocity dispersions than optical AGNs within the inner 0.5 effective radii, but show lower values at larger radii. These authors suggest that the discrepancy with the results of Albán et al. (2024) could be explained by the presence of low-luminosity AGNs in their optical AGN sample, which are not included in the Albán et al. (2024) sample due to different selection methods. Despite the discrepancies at large distances from the nucleus, the results for the central regions of the galaxies, which are the focus of the present work, indicate that radio AGNs exhibit higher gas turbulence.

Recently, Marconcini et al. (2025a) modelled the ionised gas kinematics of a sample of ten galaxies observed with the Multi Unit Spectroscopic Explorer (MUSE), using the MOKA^{3D} tool (Marconcini et al. 2023). They found that ionised outflows exhibit constant or slightly decreasing velocities within the inner 1 kpc from the nucleus, followed by a rapid increase, very similar to the behaviour observed in our sample. Marconcini et al. (2025a) argued that the increase in outflow velocity, relative to the galaxy escape velocity, was observed in the transition region, where a momentum-driven phase shifts to an energy-conserving phase beyond 1 kpc, with the outflow expanding as an isothermal, consistent with theoretical predictions of AGN outflows (e.g. King & Pounds 2015). Thus, the observed behaviour of the W_{80} radial profiles in our sample, when compared with previous results, suggests that they are associated with energy-conserving winds driven by AGNs or SF that are capable of escaping the bulge of the galaxy, in both low-ionisation and warm molecular gas phases. These findings indicate that the enhanced gas turbulence observed in our sample may play a significant role in

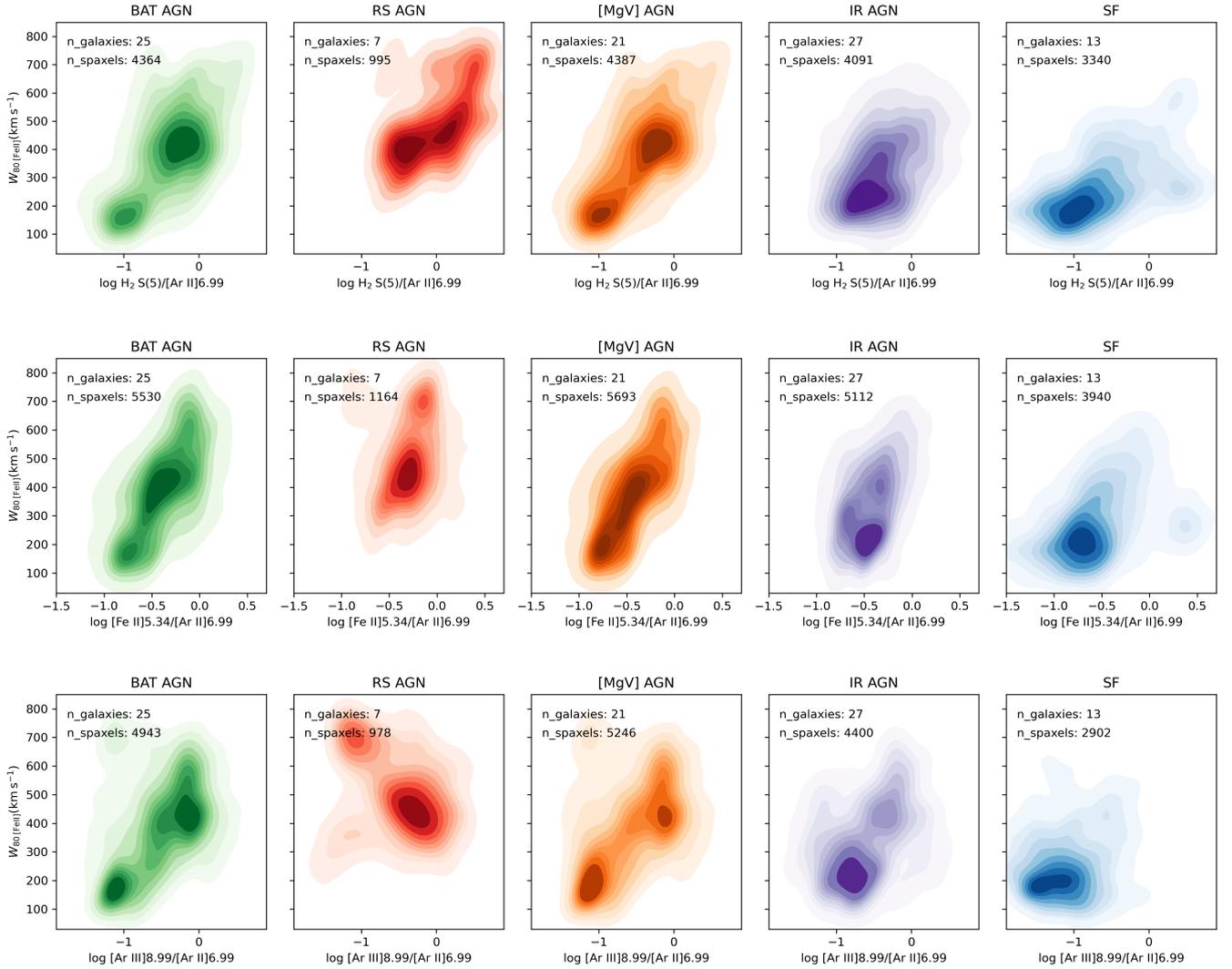


Fig. 5. Density maps of W_{80} for [Fe II] λ 5.3403 μm emission line as a function of the flux ratios: H_2 S(5) λ 6.9091 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm (top panels), [Fe II] λ 5.3403 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm (middle panels), and [Ar III] λ 8.9914 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm (bottom panels). The contours are spaced at intervals of 10% in data density. Results are shown for the different subsamples, as identified in the title of each panel.

the evolution of the host galaxies. However, a comprehensive analysis of the gas kinematics, including detailed modeling of individual sources, is required to fully characterise the outflow properties and assess their potential impact on SF.

5.2. Origin of the emission

The emission of [Fe II] is highly sensitive to shocks, increasing significantly when shocks release iron from dust grains (Oliva et al. 2001; Hashimoto et al. 2011; Aliste Castillo et al. 2025). The emission of H_2 lines can also be enhanced in regions of shocked gas (Hollenbach & McKee 1989; Guillard et al. 2009; Kristensen et al. 2023; Appleton et al. 2023; Godard et al. 2024; Zanchettin et al. 2025). The [Ar III] λ 8.9914 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm flux ratio can be used to map the ionisation degree and the intensity of the incident radiation field in photoionised gas regions, as their parent ions have significantly different ionisation potentials; namely, 15.8 eV and 27.6 eV for Ar II and for Ar III, respectively. The observed trend of increasing W_{80} with increasing values of the H_2 S(5)/[Ar II] λ 6.9853 μm and [Fe II] λ 5.3403 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm (first two rows of Fig. 5)

could be interpreted as an additional contribution from shocks to the excitation of H_2 and [Fe II] emission lines. On the other hand, an increase in the [Ar III] λ 8.9914 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm ratio for the larger W_{80} , seen for the AGN samples, might suggest that although part of the gas is in the outflow, it remains predominantly photoionised by the central AGN.

To further investigate the origin of gas turbulence and the trends observed in emission-line flux ratios, we present in Fig. 6 density plots for the [Fe II] λ 5.3403 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm versus H_2 S(5)/[Ar II] λ 6.9853 μm (top panels) and [Fe II] λ 5.3403 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm versus [Ar III] λ 8.9914 $\mu\text{m}/[\text{Ar II}]$ λ 6.9853 μm (bottom panels), for all subsamples. A strong correlation is observed for the first pair of intensity ratios in all samples, with Pearson correlation coefficients ranging from 0.53 to 0.76. As [Ar II] is predominantly produced by photoionisation, while [Fe II] and H_2 are more sensitive to shocks, the observed correlation suggests that these latter lines trace shock-excited gas, particularly at larger distances from the nucleus. Moreover, the increase in line ratios with line widths (Fig. 5) provides strong evidence that the enhanced gas turbulence in these regions is driven by shocks. A much weaker

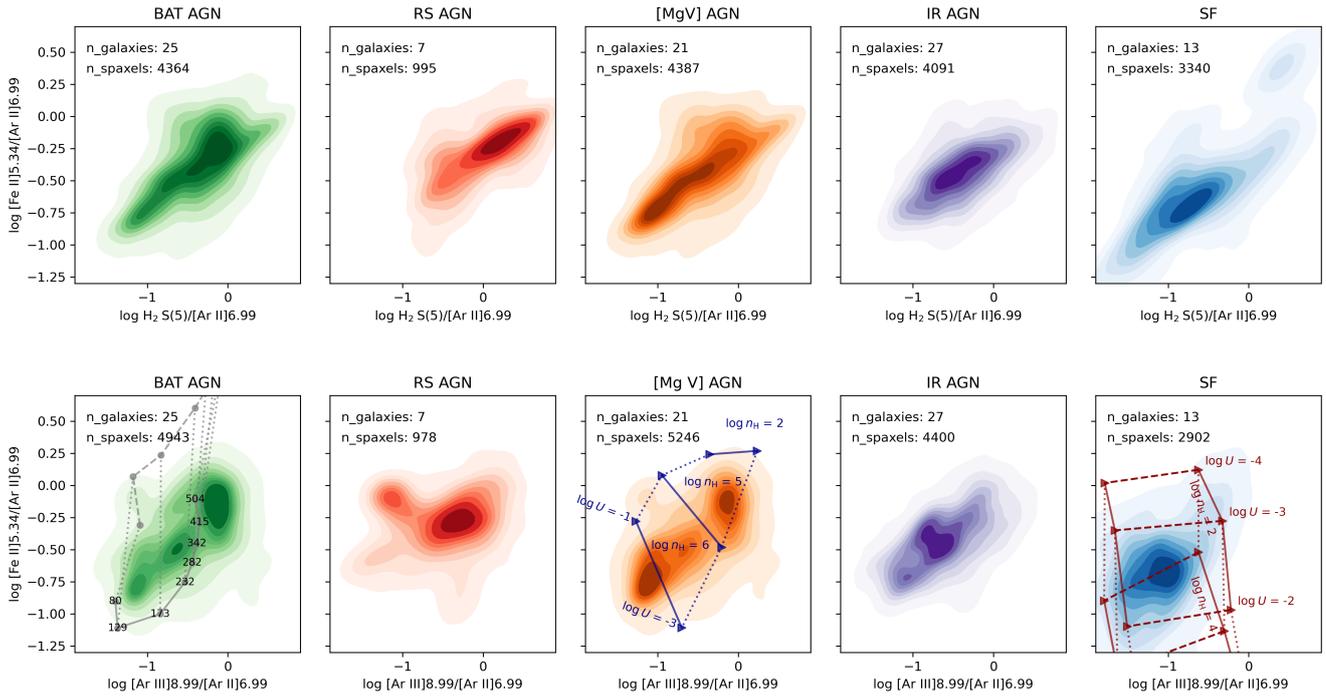


Fig. 6. Density plots for the $[\text{Fe II}]\lambda 15.3403 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ versus $\text{H}_2 \text{S}(5)/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ (top panels) and $[\text{Fe II}]\lambda 15.3403 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ versus $[\text{Ar III}]\lambda 8.9914 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ (bottom panels). The dark red lines (bottom-right panel) show predictions from photoionisation models of star-forming regions, assuming stellar clusters aged 6 and 7 Myr. Solid lines indicate different gas densities, dotted lines correspond to varying ionisation parameters (as labelled in the figure), and the predictions for both cluster ages are connected by dashed lines. Similarly, results from AGN photoionisation models are shown as dark blue lines (bottom-central panel). The gray lines and filled circles (bottom-left panel) are predictions of fast shock models from [Pereira-Santaella et al. \(2024\)](#) using the MAPPINGS V code ([Sutherland & Dopita 2017](#)) for $\log R_p = 6$ (dashed) and $\log R_p = 8$ (continuous). The numbers indicate the shock velocities in km s^{-1} .

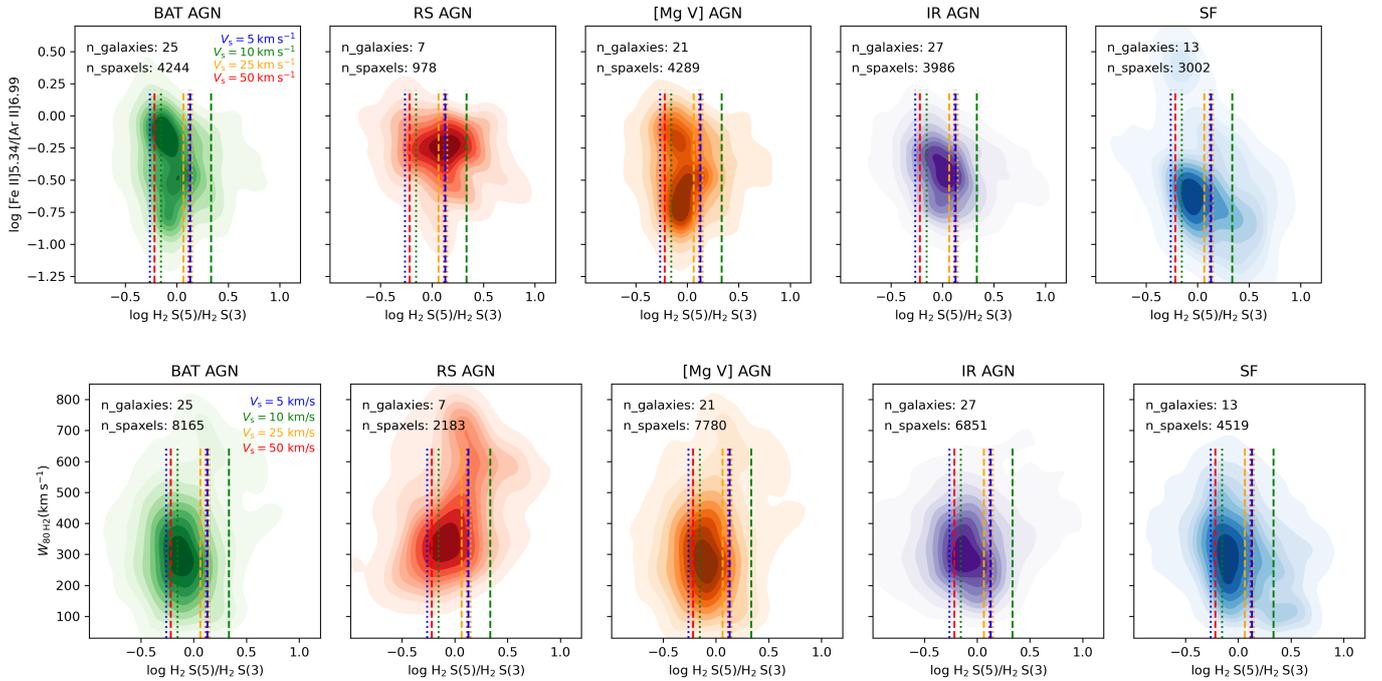


Fig. 7. Density plots for $[\text{Fe II}]\lambda 15.3403 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ vs $\text{H}_2 \text{S}(5)/\text{H}_2 \text{S}(3)$ (top) and W_{80} for the $\text{H}_2 \text{S}(5)$ line vs $\text{H}_2 \text{S}(5)/\text{H}_2 \text{S}(3)$ (bottom) for all sub-samples. The vertical lines represent the mean $\text{H}_2 \text{S}(5)/\text{H}_2 \text{S}(3)$ predictions of the shock models from [Kristensen et al. \(2023\)](#) for velocities of 5, 10, 25, and 50 km s^{-1} (different colours) and densities of $n_H = 10^3$ (dotted lines) and $n_H = 10^6 \text{ cm}^{-3}$ (dashed lines).

trend is observed between $[\text{Fe II}]\lambda 5.3403 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ and $[\text{Ar III}]\lambda 8.9914 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$, and only for the AGN samples (excluding the RS AGN). No clear relationship is observed between these line ratios for the SF sub-sample, where argon emission is attributed to SF. Since the $[\text{Fe II}]$ and H_2 fluxes increase relative to $[\text{Ar II}]$ emission and also increase with line width, this suggests that both $[\text{Fe II}]$ and H_2 exhibit enhanced emission due to shocks, which could be associated with stellar winds and mergers. This is consistent with the fact that the SF sub-sample is predominantly composed of U/LIRGs, which are known for intense SF activity and their presence in merger systems. Similarly, no clear relationship is observed between these line ratios for the RS AGN sample. In this case, the possible origin of the shocked $[\text{Fe II}]$ and H_2 gas may be associated with radio emission, stellar winds, or interactions in the U/LIRGs of this sub-sample.

We can compare the observed emission-line ratios with predictions from shock and photoionisation models. The results from fast shock models by [Pereira-Santaella et al. \(2024\)](#), using the MAPPINGS V code ([Dopita & Sutherland 1996](#); [Sutherland & Dopita 2017](#)), are shown overlaid as gray lines in the bottom-left panel of Fig. 6. A short description of these models are presented in Appendix D. Although these authors produced an extensive grid of models (see their work for more details), we only show a subset in the figure to avoid overcrowding. The displayed models assume solar metallicity, shock velocities (v_s) ranging from 80 to 500 km s^{-1} , and ram pressure parameters defined as $R_p = \frac{n_H}{\text{cm}^{-3}} \times \left(\frac{v_s}{\text{km/s}}\right)^2$, with values of 10^6 and 10^8 , where n_H is the gas volume density. We also constructed extensive photoionisation model grids for AGNs and SF using the CLOUDY code ([Ferland et al. 2017](#)), as detailed in Appendix D. The SF models are shown as dark red lines in the bottom-right panel of Fig. 6. We present the predictions for gas densities, namely, $\log(n_H/\text{cm}^{-3}) = 2$ and 4, along with ionisation parameters of $\log U = -4, -3$, and -2 , based on spectral energy distributions (SEDs) generated with the STARBURST99 code ([Leitherer et al. 1999](#)) for stellar clusters aged 6 Myr (yielding higher $[\text{Ar III}]/[\text{Ar II}]$ ratios) and 7 Myr (lower ratios). These models are able to reproduce the lower line ratios, supporting a interpretation that they originate from gas photoionised by young stellar populations. The predictions from AGN photoionisation models are shown as blue lines in the bottom-central panel of Fig. 6, for densities of $\log(n_H/\text{cm}^{-3}) = 2, 5$, and 6, and ionisation parameters of $\log U = -1$ and -3 . These models are able to reproduce the highest line ratios, including the extreme $[\text{Ar III}]/[\text{Ar II}]$ values observed, which are not well matched by the shock models.

As shown, the observed $[\text{Fe II}]\lambda 5.3403 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ flux ratios align well with the values predicted by shock models. In contrast, the $[\text{Ar III}]\lambda 8.9914 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ ratios exhibit values higher than those predicted by shock models, but they can be aptly reproduced by AGN photoionisation models. In addition, the lowest values of both ratios are consistent with predictions from SF photoionisation models.

In Fig. 7, we display the density plots of $[\text{Fe II}]\lambda 5.3403 \mu\text{m}/[\text{Ar II}]\lambda 6.9853 \mu\text{m}$ and W_{80} of the H_2 S(5) line against the H_2 S(5)/ H_2 S(3) line ratio, which is a tracer of the H_2 temperature and is enhanced in shock dominated-regions (e.g. [Zakamska 2010](#); [Pereira-Santaella et al. 2014](#); [Togi & Smith 2016](#); [Dan et al. 2025](#); [Riffel et al. 2025](#)). The observed values for this ratio are consistent with those predicted by low velocity shock models ($2\text{--}90 \text{ km s}^{-1}$), as indicated by the vertical lines representing predictions by the models

from [Kristensen et al. \(2023\)](#). However, no evident correlation was observed. This indicates that if the H_2 emission is produced by shocks, these are not the same shocks responsible for the $[\text{Fe II}]$ emission ([Hollenbach & McKee 1989](#); [Mouri et al. 2000](#); [Allen et al. 2008](#)). This is expected, as the shock waves produced by fast shocks with velocities of $200\text{--}300 \text{ km s}^{-1}$ necessary to generate ionised gas emission would lead to the dissociation of H_2 molecules. On the other hand, the tight correlation observed between the $[\text{Fe II}]$ and H_2 emission (top row of Fig. 6) indicates that they share the same physical origin. A possible interpretation for this correlation is that the H_2 emission originates in the post-shock gas, where the molecules reform after being dissociated by the fast shock ([Guillard et al. 2009](#); [Richings & Faucher-Giguère 2018a,b](#)). Another explanation is the excitation of H_2 in the molecular shock precursor, as observed in NGC 7319. In this case, the ionised gas is significantly more turbulent than the molecular gas, with $\sigma \approx 300 \text{ km s}^{-1}$ for the ionised gas and $\sigma \approx 150 \text{ km s}^{-1}$ for the H_2 , in regions co-spatial with a radio hotspot ([Pereira-Santaella et al. 2022](#)). Although the W_{80} values for H_2 are typically lower than those for the ionised gas (Fig. 3), the radial profiles of W_{80} for H_2 and $[\text{Fe II}]$ show similar trends, with values increasing from the nucleus outward, suggesting that the first interpretation is more likely.

The analysis of emission line ratios, gas kinematics, and comparisons with shock and photoionisation models indicates that shocks driven by outflows and jets are a key factor in producing the $[\text{Fe II}]$ and H_2 emission within the inner few kpc of AGN host galaxies. The $[\text{Fe II}]$ emission arises from partially ionised zones situated beyond the main hydrogen ionisation front in narrow-line region clouds, forming a transition between fully ionised and neutral gas ([Forbes & Ward 1993](#); [Simpson et al. 1996](#)), while the mid-IR, H_2 lines trace warm molecular gas at temperatures of a few hundred Kelvin ([Pereira-Santaella et al. 2014](#); [Togi & Smith 2016](#)). Our results suggest that turbulence produced in the ISM by outflows and/or radio jets may constitute an important mechanism of maintenance-mode AGN feedback, as it prevents the gas from efficiently cooling and forming stars, thereby regulating star formation.

6. Conclusions

We used archival JWST MIRI/MRS observations of a sample consisting of 54 galaxies at $z < 0.1$ to investigate the origin of the warm molecular and low-ionisation gas emission. The sample includes SFGs and AGN hosts, with AGNs selected on the basis of their X-ray, radio, and coronal line emissions. We investigate the origin of the emission and turbulence of the gas from flux measurements and velocity dispersion, parameterised by the W_{80} parameter, for H_2 S(5) $\lambda 6.9091 \mu\text{m}$, $[\text{Ar II}]\lambda 6.9853 \mu\text{m}$, $[\text{Fe II}]\lambda 5.3403 \mu\text{m}$, $[\text{Ar III}]\lambda 8.9914 \mu\text{m}$, and $[\text{Mg V}]\lambda 5.6098 \mu\text{m}$ emission lines. Our main conclusions are the following:

- AGNs exhibit broader emission lines than SFGs, with the largest velocity dispersions observed for radio-strong AGNs. The H_2 gas is less turbulent compared to the ionised gas for all the sub-samples studied, followed by $[\text{Ar II}]$, $[\text{Ar III}]$, and $[\text{Fe II}]$. Among the galaxies with coronal emission, the coronal gas shows higher velocity dispersion values compared to lower ionisation lines, suggesting stratified emission clouds.
- The velocity dispersion of molecular and low-ionisation gas increases with distance from the nucleus, particularly for the emission lines of H_2 and $[\text{Fe II}]$, which is contrary to what is expected from gravitationally dominated motions. Additionally, the high values of W_{80} indicate the presence

of outflows in AGN hosts. Meanwhile in SF, the W_{80} values are lower than those for AGNs, yet they still require an additional component, such as shock-heated gas emission from stellar winds or galaxy interactions.

- There is a strong correlation between the W_{80} parameter and the line ratios $H_2 S(5)/\lambda 6.9091 \mu\text{m}$ [Ar II] $\lambda 6.9853 \mu\text{m}$ and [Fe II] $\lambda 5.3403 \mu\text{m}$ and [Ar II] $\lambda 6.9853 \mu\text{m}$, as well as between these two ratios themselves. This indicates that the [Fe II] and H_2 emissions originate from linked physical processes. Since H_2 and [Fe II] emissions are enhanced in shocked gas, these correlations offer additional evidence that shocks play an important role in the observed emission in our sample.
- The lowest W_{80} values ($<300 \text{ km s}^{-1}$) across all samples are associated with SF, presenting line ratios consistent with predictions from SF photoionisation models for gas densities in the range 10^2 – 10^4 cm^{-3} . As gas turbulence increases, the contribution from shocks becomes significant, with [Fe II] $\lambda 5.3403 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ intensity ratios consistent with predictions from fast shock models, assuming shock velocities in the range of ~ 100 to $\sim 300 \text{ km s}^{-1}$ and gas densities between 10^3 and 10^4 cm^{-3} . Some contribution from AGN photoionisation could be important, particularly for the highest [Ar III] $\lambda 8.9914 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$ ratios, which are consistent with AGN photoionisation models for gas densities of 10^2 and 10^5 cm^{-3} .
- Although the observed $H_2 S(5)/H_2 S(3)$ flux line ratios are consistent with predictions from slow shock models, there is no trend between this line ratio and the H_2 velocity dispersion and [Fe II] $\lambda 5.3403 \mu\text{m}$ /[Ar II] $\lambda 6.9853 \mu\text{m}$. These results, along with the similar trends observed in the gas turbulence for [Fe II] and H_2 , increasing from the nucleus outwards, leads to the interpretation that the H_2 emission could be produced by molecules re-forming in the post-shock region.
- We find similarities in line widths and line ratios between the BAT and [Mg V] AGN sub-samples, consistent with the fact that both are direct tracers of AGN emission, either through the X-rays generated by the central engine or the high-energy photons necessary to ionise the coronal gas. Similarly, among the AGN subsamples, the IR AGN subsample shows line widths and ratios that more closely resemble those of the SFGs. This is consistent with many IR AGNs being U/LIRGs that exhibit intense star formation.

Our analysis reveals that high turbulence is a pervasive feature present in all the sub-samples studied. This turbulence, driven by AGN outflows, radio jets or stellar winds, plays a crucial role in influencing the kinematics and physical state of the ISM in these galaxies. The widespread presence of such energetic feedback mechanisms underscores their importance in galaxy evolution, affecting gas dynamics and potentially regulating SF across diverse environments.

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Appendix A: Observational proposals

Our sample consists of 54 galaxies, listed in Table A.1, along with details of the observational proposals. Our sample includes representatives from the The Great Observatories All-Sky LIRG Survey (GOALS; e.g. Armus et al. 2009; U et al. 2022; Evans et al. 2022; Buiten et al. 2024), The Galaxy Activity, Torus, and Outflow Survey (GATOS; e.g. García-Burillo et al. 2021; Alonso-Herrero et al. 2021; Davies et al. 2024; García-Bernete et al. 2024a), Mid-IR Characterisation Of Nearby Iconic galaxy Centers (MICONIC; e.g. Alonso Herrero et al. 2024; Alonso-Herrero et al. 2025; Hermosa Muñoz et al. 2025), Mid-InfraRed Activity of Circumnuclear Line Emission (MIRACLE; e.g. Marconcini et al. 2025a; Ceci et al. 2025) projects, among others.

As described in Sec. 2, we have defined four AGN and SFG subsamples, which may overlap. Fig A.1 presents a Venn diagram illustrating the intersections among the different AGN subsamples.

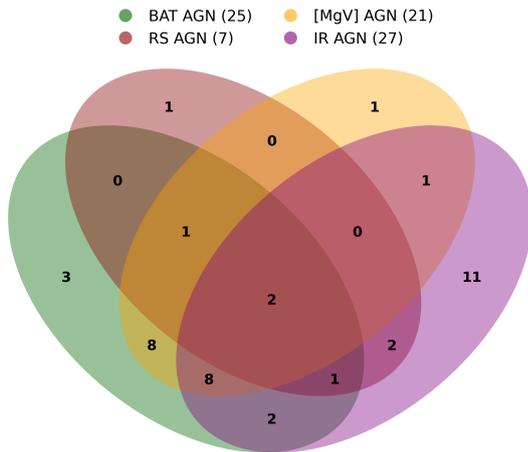


Fig. A.1. Venn diagram illustrating the overlap among the different AGN subsamples.

Appendix B: [Mg V] flux distributions

In Fig. A.2, we present the flux maps for all galaxies with [Mg V] λ 5.6098 μ m emission detected in individual spaxels at a confidence level greater than 5 sigma, along with integrated line profiles considering all spaxels with detected emission. The sample galaxies exhibit diverse flux distributions, ranging from highly collimated structures to more rounded shapes. The discussion on the origin of coronal lines in this sample is beyond the scope of this paper, as we use them solely as a selection criterion. Detailed results on some individual objects, including the analysis of coronal line emission, have already been published on the basis of MIRI MRS data (e.g. Armus et al. 2023; Hermosa Muñoz et al. 2024, 2025; Zhang et al. 2024, among others).

Appendix C: W_{80} radial profiles per sub-sample

Figure C.1 presents the W_{80} radial profiles grouping the four emission lines for each sub-sample, providing a clearer comparison of the differences observed among the distinct emission lines. For the [Mg V] AGN sample (bottom panel) we include also the [Mg V] λ 5.6098 μ m W_{80} values. For the SF sample, the nuclear W_{80} values are typically below 300 km s $^{-1}$, reaching maximum values of \sim 450 km s $^{-1}$ farther from the nucleus. The [Ar III] emission line is detected at radii larger than 1 kpc only for two objects in the SF sample (IRAS 10565+2448 and IRAS 23128-5919), which have higher W_{80} values resulting in the increased values at these distances. For the AGN samples, the lowest W_{80} values are typically observed for H $_2$ and [Ar II], which show similar values, while the highest values are found for [Fe II] and [Ar III]. Among AGNs with coronal emission, within the inner \sim 1 kpc, the highest W_{80} values are observed for [Mg V]. At larger distances, however, the coronal gas shows velocity dispersion similar to that of the other ionised gas lines.

Appendix D: Shock and photoionisation models

D.1. Shock models

In this work, we use the fast shock models from Pereira-Santaella et al. (2024). These models were computed with the MAPPINGS V code (Dopita & Sutherland 1996; Sutherland & Dopita 2017) and are designed to investigate the origin of ionised gas emission lines in nearby galaxies observed with MIRI/MRS. They follow the prescription of Sutherland & Dopita (2017), varying several parameters: the gas metallicity (Z_{gas}), the shock velocity (v_s), and defining a ram pressure variable as $R_p = \frac{n_H}{\text{cm}^{-3}} \times \left(\frac{v_s}{\text{km/s}}\right)^2$, where n_H is the gas volume density, and the magnetic-to-ram pressure ratio $\eta_M = \frac{B^2}{4\pi\rho v_s^2}$, where B is the magnetic field and ρ the gas density. In this work we adopt models with solar metallicity, shock velocities in the range 80–500 km s $^{-1}$, and ram pressure parameters $R_p = 10^6$ and 10^8 . Further details on the shock models are given in Pereira-Santaella et al. (2024).

D.2. AGN and SF photoionisation models

We used CLOUDY code version c23.01 (Ferland et al. 2017; Chatzikos et al. 2023) to construct grids of photoionisation models for AGN and SF, following procedures similar to those described by Pereira-Santaella et al. (2024) and Dors et al. (2012).

For the AGN models, we adopt the ionising Spectral Energy Distribution (SED) from Jin et al. (2012), based on the OPTX-AGNF model (Done et al. 2012). This model describes accretion disk emission with three components powered by a single mass accretion flow: a multi-colour blackbody disk producing optical/UV emission, a warm corona generating soft X-rays via Comptonisation, and a hot corona responsible for hard X-rays. It is particularly suited for AGN with low Eddington ratios and is included in the CLOUDY SED library.

For the SF models, we generated the SEDs using the STARBURST99 code (Leitherer et al. 1999), adopting an instantaneous SF mode. We assume a Kroupa initial mass function (IMF) (Kroupa 2002), with a slope of $\alpha = 1.3$ for masses between 0.1 and 0.5 M_{\odot} , and $\alpha = 2.3$ for masses from 0.5 to 100 M_{\odot} . We use the Padova evolutionary tracks with solar metallicity (Bressan et al. 1993). The geometry is assumed to

Table A.1. Sample.

| Galaxy | RA (HH:MM:SS) | Dec (DD:MM:SS) | Redshift | PID | PI |
|-------------------|------------------|-------------------|----------|------|------------------------|
| Arp220 | 15:34:57.3 | 23:30:11.4 | 0.0184 | 1267 | Dicken, D |
| Centaurus A | 13:25:27.6 | -43:01:08.8 | 0.0018 | 1269 | Luetzgendorf, N |
| Cygnus A | 19:59:28.4 | 40:44:02.1 | 0.0562 | 4065 | Ogle, P |
| ESO137-G034 | 16:35:14.0 | -58:04:47.9 | 0.0095 | 1670 | Shimizu, T |
| ESO420-G13 | 04:13:49.7 | -32:00:25.2 | 0.0119 | 1875 | Fernandez Ontiveros, J |
| IC5063 | 20:52:02.3 | -57:04:07.6 | 0.0113 | 2004 | Dasyra, K |
| IIZw96 | 20:57:24.4 | 17:07:39.7 | 0.0361 | 1328 | Armus, L |
| IRAS05189-2524 | 05:21:01.4 | -25:21:45.4 | 0.0441 | 3368 | Armus, L |
| IRAS07251-0248 | 07:27:37.6 | -02:54:54.2 | 0.0876 | 3368 | Armus, L |
| IRAS09022-3615 | 09:04:12.7 | -36:27:01.7 | 0.0596 | 3368 | Armus, L |
| IRAS09111-1007 | 09:13:36.5 | -10:19:30.1 | 0.0541 | 3368 | Armus, L |
| IRAS10565+2448 | 10:59:18.1 | 24:32:34.3 | 0.0431 | 3368 | Armus, L |
| IRAS-5453 | 13:15:06.3 | -55:09:22.7 | 0.0308 | 3368 | Armus, L |
| IRAS14348-1447 | 14:37:38.4 | -15:00:21.3 | 0.0823 | 3368 | Armus, L |
| IRAS15250+3608 | 15:26:59.4 | 35:58:37.5 | 0.0552 | 3368 | Armus, L |
| IRAS19297-0406 | 19:32:22.3 | -04:00:01.0 | 0.0857 | 3368 | Armus, L |
| IRAS19542+1110 | 19:56:35.8 | 11:19:04.4 | 0.0650 | 3368 | Armus, L |
| IRAS20551-4250 | 20:58:26.8 | -42:39:00.3 | 0.0430 | 3368 | Armus, L |
| IRAS22491-1808 | 22:51:49.3 | -17:52:24.0 | 0.0777 | 3368 | Armus, L |
| IRAS23128-5919 | 23:15:46.7 | -59:03:11.1 | 0.0446 | 3368 | Armus, L |
| IRASF01364-1042 | 01:38:52.8 | -10:27:11.8 | 0.0482 | 1717 | U, V |
| IRASF08572+3915NW | 09:00:25.4 | 39:03:54.2 | 0.0582 | 3869 | Veilleux, S |
| IRASF14378-3651 | 14:40:59.0 | -37:04:31.9 | 0.0676 | 3869 | Veilleux, S |
| IRASF23365+3604 | 23:39:01.3 | 36:21:08.3 | 0.0645 | 3869 | Veilleux, S |
| M81 | 09:55:33.2 | 69:03:55.1 | -0.0001 | 2016 | Seth, A |
| M87 | 12:30:49.4 | 12:23:28.0 | 0.0043 | 2016 | Seth, A |
| M94 | 12:50:53.1 | 41:07:13.0 | 0.0010 | 2016 | Seth, A |
| M104 | 12:39:59.4 | -11:37:23.0 | 0.0036 | 2016 | Seth, A |
| MCG-05-23-016 | 09:47:40.1 | -30:56:56.0 | 0.0085 | 1670 | Shimizu, T |
| Mrk231 | 12:56:14.2 | 56:52:25.3 | 0.0422 | 1268 | Maiolino, R |
| Mrk273 | 13:44:42.1 | 55:53:13.5 | 0.0373 | 1717 | U, V |
| NGC0253 | 00:47:33.1 | -25:17:18.4 | 0.0008 | 1701 | Bolato, A |
| NGC0424 | 01:11:27.5 | -38:05:01.8 | 0.0118 | 6138 | Marconcini, C |
| NGC1052 | 02:41:04.8 | -08:15:20.8 | 0.0052 | 2016 | Seth, A |
| NGC1068 | 02:42:40.8 | -00:00:45.9 | 0.0038 | 6138 | Marconcini, C |
| NGC1365 | 03:33:36.5 | -36:08:26.7 | 0.0055 | 6138 | Marconcini, C |
| NGC1566 | 04:20:00.2 | -54:56:17.2 | 0.0050 | 6138 | Marconcini, C |
| NGC1808 | 05:07:42.4 | -37:30:47.0 | 0.0033 | 6138 | Marconcini, C |
| NGC3081 | 09:59:29.5 | -22:49:34.8 | 0.0081 | 1670 | Shimizu, T |
| NGC3256N | 10:27:51.2 | -43:54:14.0 | 0.0094 | 1328 | Armus, L |
| NGC3256S | 10:27:51.2 | -43:54:19.2 | 0.0094 | 1328 | Armus, L |
| NGC4258 | 12:18:57.5 | 47:18:14.3 | 0.0015 | 2016 | Seth, A |
| NGC4395 | 12:25:48.9 | 33:32:48.7 | 0.0011 | 2016 | Seth, A |
| NGC5506 | 14:13:14.9 | -03:12:27.8 | 0.0061 | 1670 | Shimizu, T |
| NGC5728 | 14:42:23.9 | -17:15:11.1 | 0.0092 | 1670 | Shimizu, T |
| NGC6240 | 16:52:58.9 | 02:24:03.7 | 0.0243 | 1265 | Alonso-Herrero, A |
| NGC6552 | 18:00:07.3 | 66:36:54.3 | 0.0265 | 1039 | Dicken, D |
| NGC7172 | 22:02:01.9 | -31:52:10.5 | 0.0087 | 1670 | Shimizu, T |
| NGC7319 | 22:36:03.6 | 33:58:33.2 | 0.0225 | 2732 | Pontoppidan, K |
| NGC7469 | 23:03:15.6 | 08:52:26.0 | 0.0163 | 1328 | Armus, L |
| NGC7582 | 23:18:23.6 | -42:22:14.1 | 0.0054 | 3535 | Garcia-Bernet, I |
| UGC05101 | 09:35:51.7 | 61:21:12.3 | 0.0394 | 1717 | U, V |
| VV114 | 01:07:47.5 | -17:30:25.2 | 0.0201 | 1328 | Armus, L |
| VV340a | 14:57:00.7 | 24:37:02.8 | 0.0337 | 1717 | U, V |

Notes. The galaxy name, coordinates (RA and Dec), redshift, proposal ID (PID), and principal investigator (PI) of the MIRI/MRS proposal are provided, from left to right.

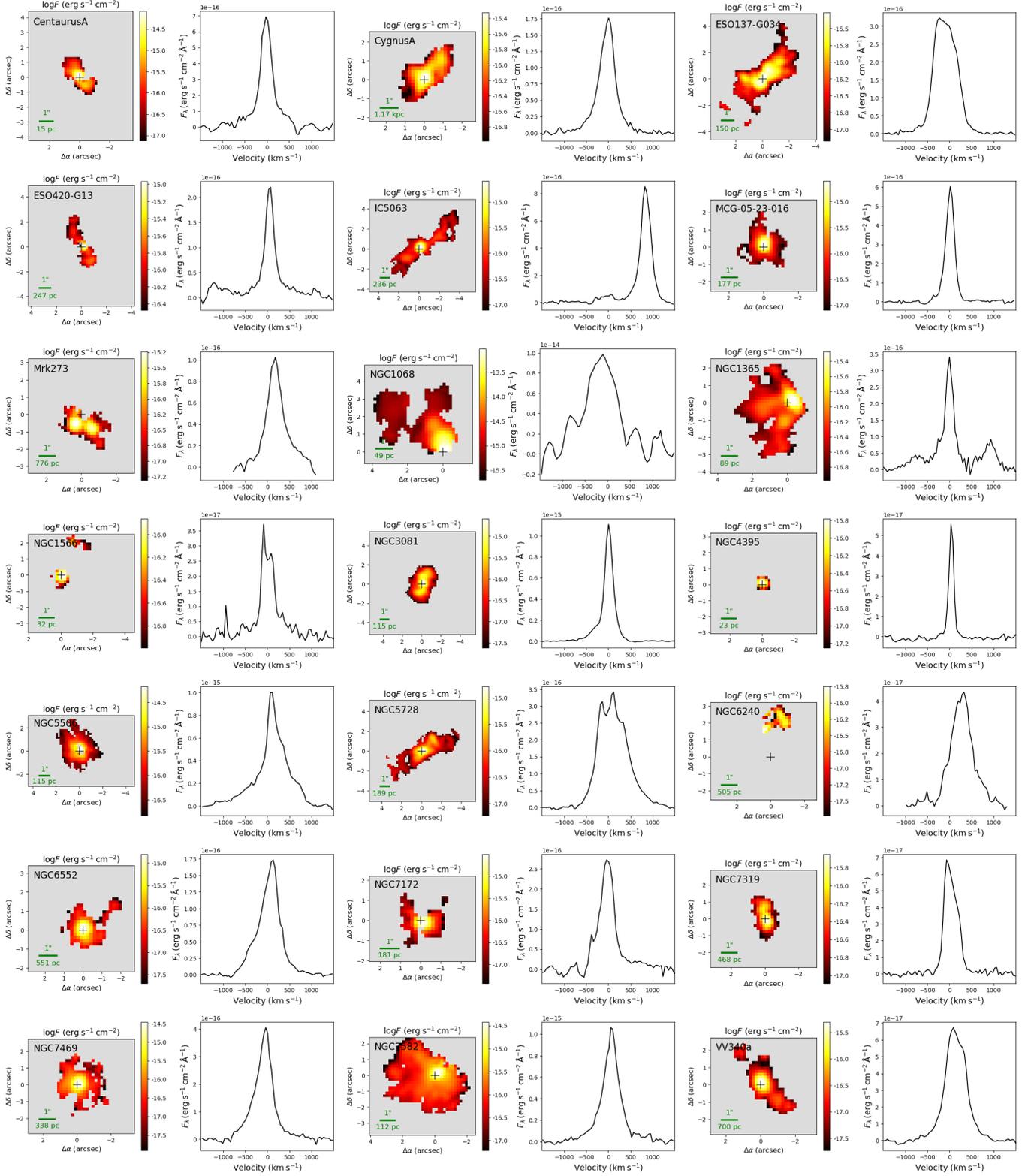


Fig. A.2. [Mg v] λ 5.6098 μ m flux distributions for galaxies with coronal line emission in our sample. The maps illustrate the flux distributions, with gray regions indicating areas where the corresponding emission line is not detected at $s/n > 5$. The plots display the [Mg v] λ 5.6098 μ m integrated profiles, obtained by summing the observed profiles across all detected spaxels and subtracting the continuum. The name of each galaxy is shown in the top-left corner of each plot, the spatial scale is shown in the bottom-left corner, and the central cross marks the position of the galaxy's nucleus.

be plane-parallel, and the ionisation parameter (U) is used to scale the source intensity. We used the SEDs output by the STARBURST99 code for ages ranging from 1 to 10 Myr, in 1

Myr increments, to construct the photoionisation models with CLOUDY.

For both AGN and SF models, we adopted solar abundances for all elements based on [Grevesse et al. \(2010\)](#), with an oxygen abundance of $12 + \log(\text{O}/\text{H}) = 8.69$. The only exception is iron, which is known to exhibit significant scatter at a fixed O/H value ([Izotov et al. 2006](#)). Therefore, we estimate the iron abundance using the relation between iron and oxygen abundances presented by [Izotov et al. \(2006\)](#), resulting in $\log(\text{Fe}/\text{H}) \approx -5.60$ for solar oxygen abundance, which is adopted in our models. We adopted grain abundances based on the Orion Nebula, but scaled the PAH abundance to match the range observed in local galaxies, as reported by [Draine et al. \(2007\)](#).

We computed a sequence of models with densities spanning $2 \leq \log n_{\text{H}}/\text{cm}^{-3} \leq 6$ and ionisation parameters covering $-4.0 \leq \log U \leq -1.0$, both sampled in increments of 1 dex. The models were stopped once the gas temperature fell below 4000 K, the default stopping criterion in CLOUDY. This implies that our models do not predict the H₂ emission lines, which are produced at lower temperatures. The stopping criterion is necessary to obtain robust predictions for the ionised gas emission lines, avoiding the complex physics of the transition regions to neutral and molecular gas. Moreover, CLOUDY assumes a simplified one-dimensional structure for AGNs, with a central point-like ionising source and gas in static layers, which is sufficient for modeling the ionised gas emission; however, this does not capture the detailed three-dimensional geometry or the physical conditions in the colder molecular gas regions.

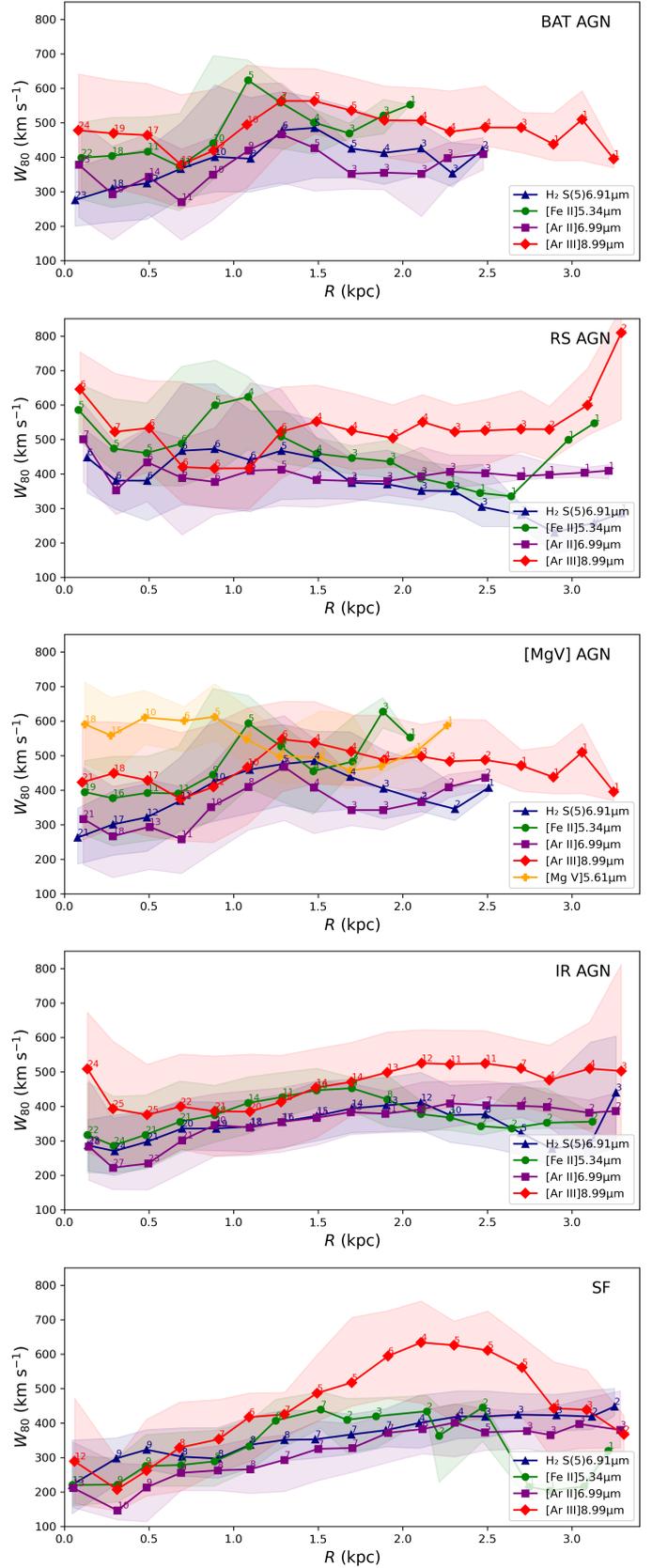


Fig. C.1. W_{80} radial profiles for the four emission lines given for the BAT AGN, RS AGN, [Mg v] AGN, IR AGN, and SF sub-samples, from top to bottom. These profiles were computed following the same methodology as those shown in Fig. 4.