Near-infrared diagnostic diagrams of the gas ionization sources in nearby galaxies: a JWST NIRSpec view

Costa-Souza et al. 2026, arXiv: 2605.04925

Introduction

Central regions of galaxies: AGN, SF, Shock
→ Emission line ratio
Optical emission lines → Dust attenuation
→ Near-IR emission line diagnostics

- Fe: Shock, X-ray heating
- H_2: UV, Low-energy X-ray, Shock
- PAH: Strong in SF, Weak in AGN

→ Further investigate the gas excitation mechanism and explore different tracers with JWST NIRSpec-IFU and Cloudy

Data

Archival NIRSpec IFU
→ Emission line fitting → Flux, width, and uncertainties

Table 1. Sample of galaxies.

Object	Redshift	Distance (Mpc)	RA (deg)	Dec. (deg)	PID	log(L_{IR}) ($L_\odot$)	BPT –	Scale pc/arcsec
VV114	0.020067	84 ± 5	16.9466	-17.5070	1328	11.71[a]	HII galaxy[c]	409
IRASF14378-3651	0.067637	302 ± 21	220.2459	-37.0755	1204	12.23[a]	Seyfert 2[e]	1465
IRASF17208-0014	0.042810	189 ± 13	260.8415	-0.2835	1204	12.46[b]	HII galaxy[c]	916
IRASF23365+3604	0.064480	280.37± 19	354.7554	36.3523	1204	12.20[b]	Composite[c]	1359
NGC3256 North	0.009354	45 ± 3	156.9635	-43.9039	1328	11.64[a]	HII galaxy[d]	221
NGC3256 South	0.009354	45 ± 3	156.9635	-43.9054	1328	–	–	–
Arp220	0.018398	83 ± 5	233.7384	23.5037	1267	12.28[a]	LINER[c]	403
NGC6240	0.024307	107 ± 7	253.2453	2.4009	1265	11.93[a]	LINER[c]	523
NGC7469	0.016268	66 ± 4	345.8151	8.8739	1328	11.65[a]	Syfert 1[c]	322

Aperture = 0.20'' radius > FWHM=0.15''
→ Accurate fit of emission lines

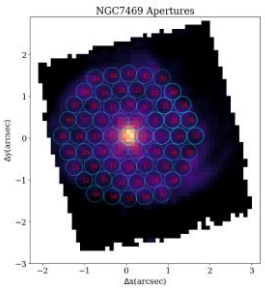
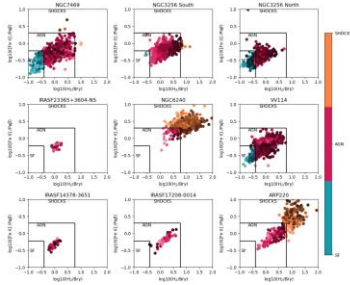


Photo-ionization models

- Cloudy c23.01
- SF = STARBURST99, instantaneous burst
- AGN = Mean AGN SED model for low L_{bol}/L_{edd} from Jin+2012
- Stop Criteria = Proton fraction
  → To produce low ionization species
- Gas-phase abundance (C, Fe, PAH, H_2)
  = Based on previous studies

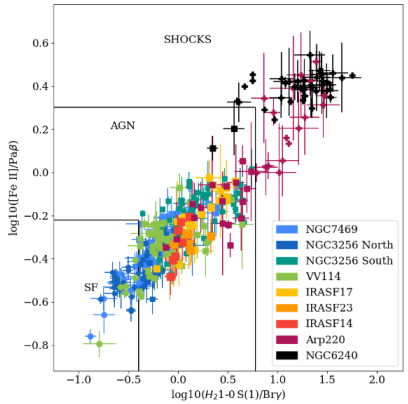


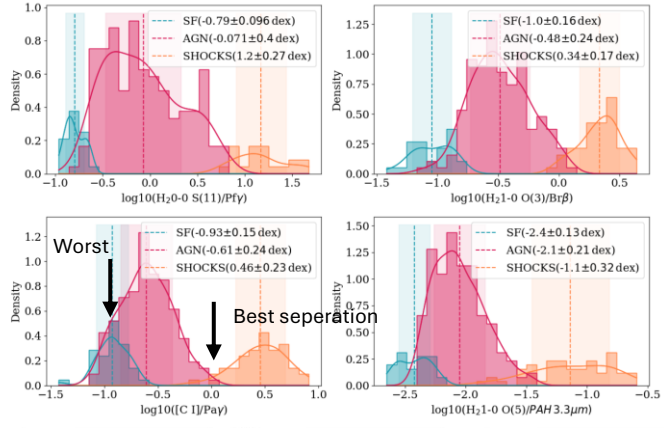
Spatially resolved Diagrams

- Dominated by AGN
- Specific regions (SF ring, nuclear starburst) can be attributed to SF

Line ratios in high-S/N spectra (0.2'' aperture)

- Vast majority in AGN region
- SF = NGC7469, NGC3256-North, VV114
- Shock = Arp 220, NGC6240
- Other common emission lines
  - AGN and shock are well separated
  - SF mixed with AGN, although small SF data points

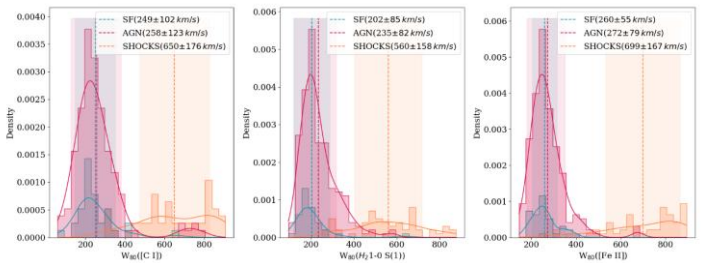




Line Width (W80)

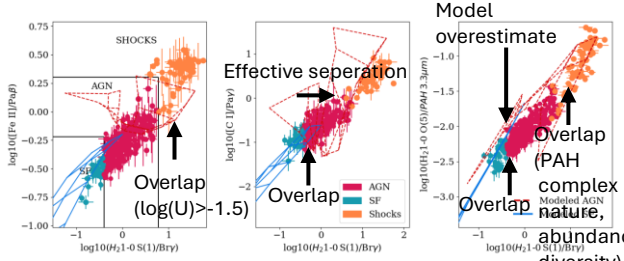
- Large W80 for shocked regions
- Similar for AGN and SF (Slightly higher mean value of AGN regions)

→ W80 can be used for separating shocked regions



Alternative diagnostics

- [CI]/Paγ, H2/PAH
  = Indicator of the extent of the ionization region
  - [CI], PAH: At interface between ionized and molecular zone



H2 excitation

- Thermal ← High density
  - AGN, SF: Radiation, density, temperature
  - Shock: J- or C- shock, velocity, density

→ Complex