Dissecting Ionized-Gas Outflows in Nearby Galaxies Using MEGARA/GTC

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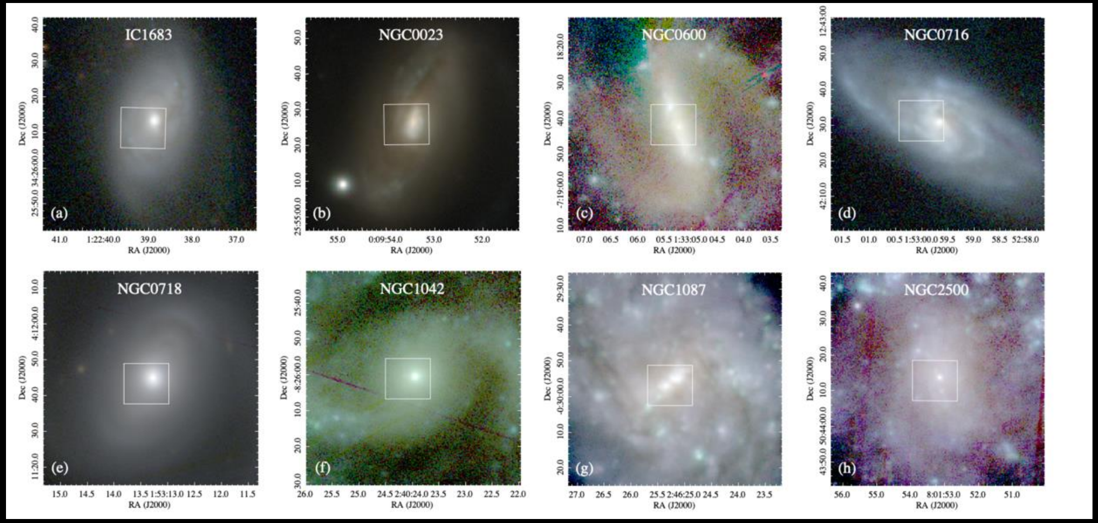
Sample and Methodology

MEGADES: MEGARA galaxy disc evolution survey
(Chamorro-Cazorla et al. 2023)

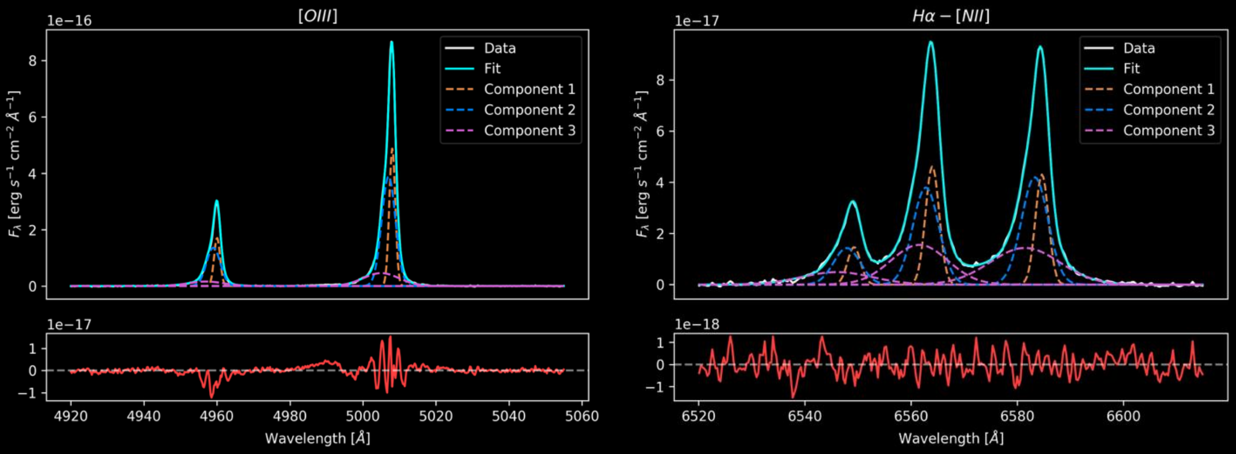


38 local late-type galaxies:

- Redshift range: 0.031 – 0.564.
- Mainly late-type galaxies, with two lenticular galaxies and one elliptical galaxy.
- 29% HII; 13% LINER; 18.5% AGN; 39.5% Unclassified galaxies.

1) Stellar continuum subtraction with pPXF

2) Multicomponent emission line fitting with ALUCINE



2) Outflow candidate selection (Rodríguez del Pino et al. 2019 method):

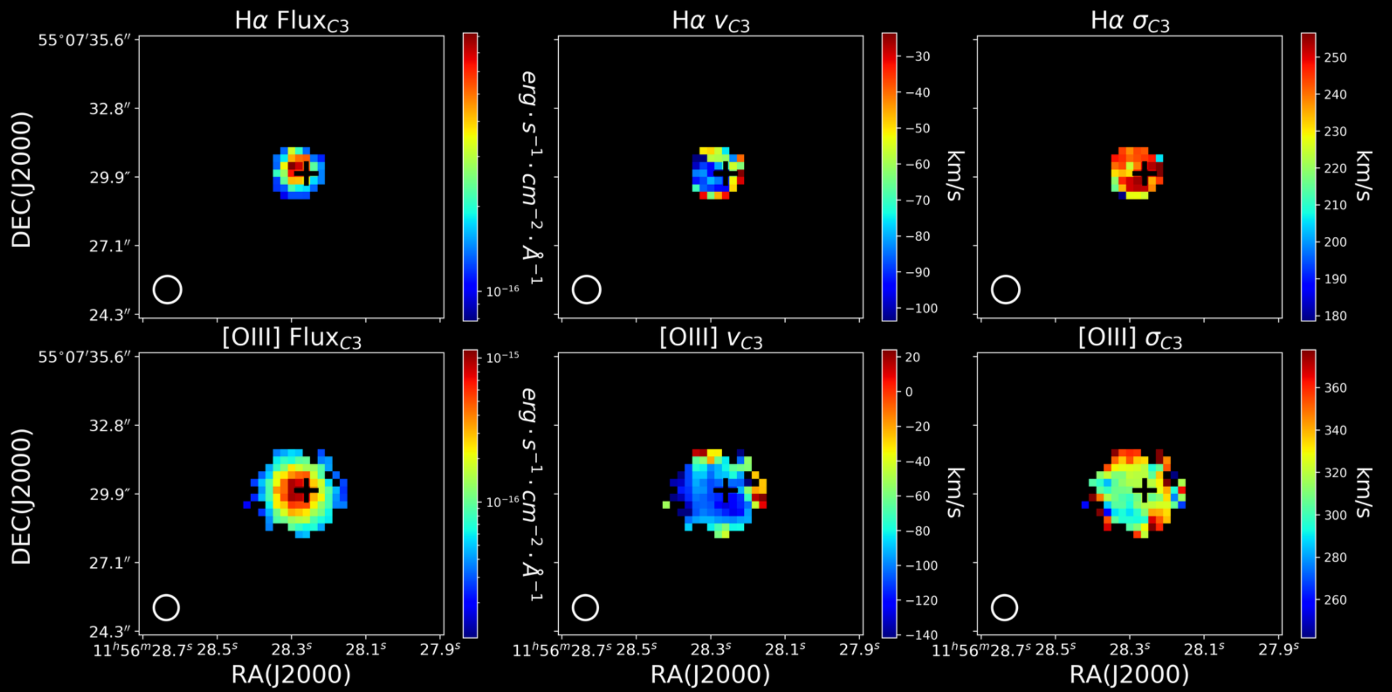
1. Detection of two components in the emission: Kinematic components detected with S/N>3; flux contribution of the weakest component to the total flux is > 5%.
2. Presence of radial outflowing gas: σ_broad > 1.4 × σ_narrow, and σ_broad > 1.2 × σ_1comp.
3. Extra: Eliminate cases that present a rotational pattern in the outflow component and cases with low velocity dispersions (σ < 100 km/s).

Detected outflows in the sample

Galaxy	Outflow component	
	Hα	[O III]
NGC 1042	2c	2c
NGC 3982	3c	3c
NGC 3998	–	2c
NGC 4037	2c	2c
NGC 4593	3c	2c
NGC 4750	2c	2c
NGC 5953	2c	–
NGC 6217	2c	2c
NGC 7479	3c	2c
NGC 7591	3c	–
NGC 7738	3c	–

Outflows in 11/38 galaxies:

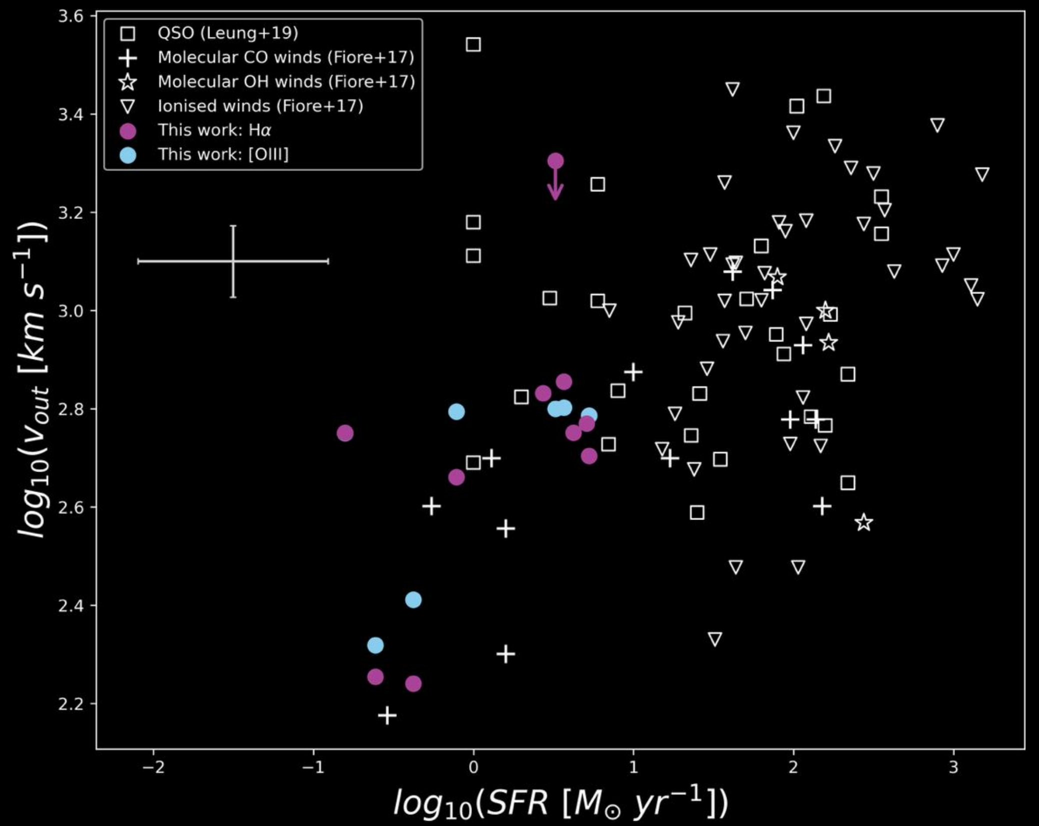
- 7 in AGN galaxies.
- 1 in a LINER Galaxy.
- 1 in an HII Galaxy.
- Remaining 2 in unclassified galaxies.



NGC 3982 Outflow kinematic maps from the Hα and [OIII]λ5007 lines.

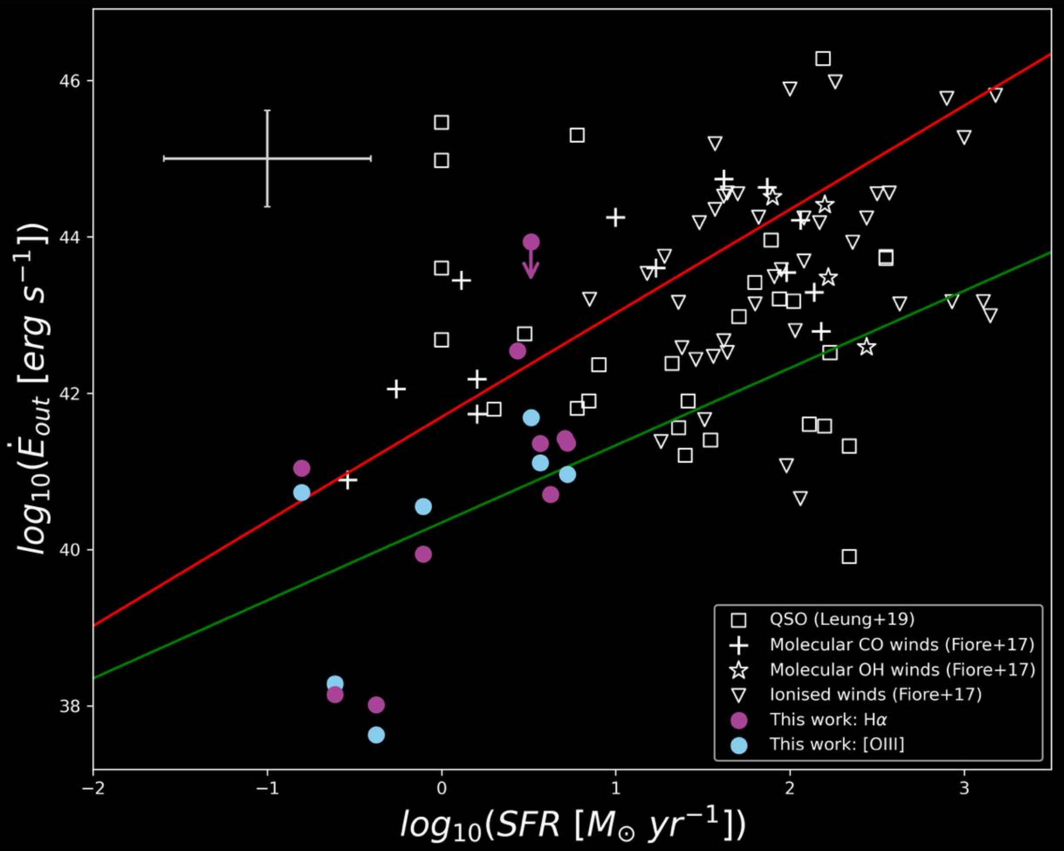
Properties of the outflows

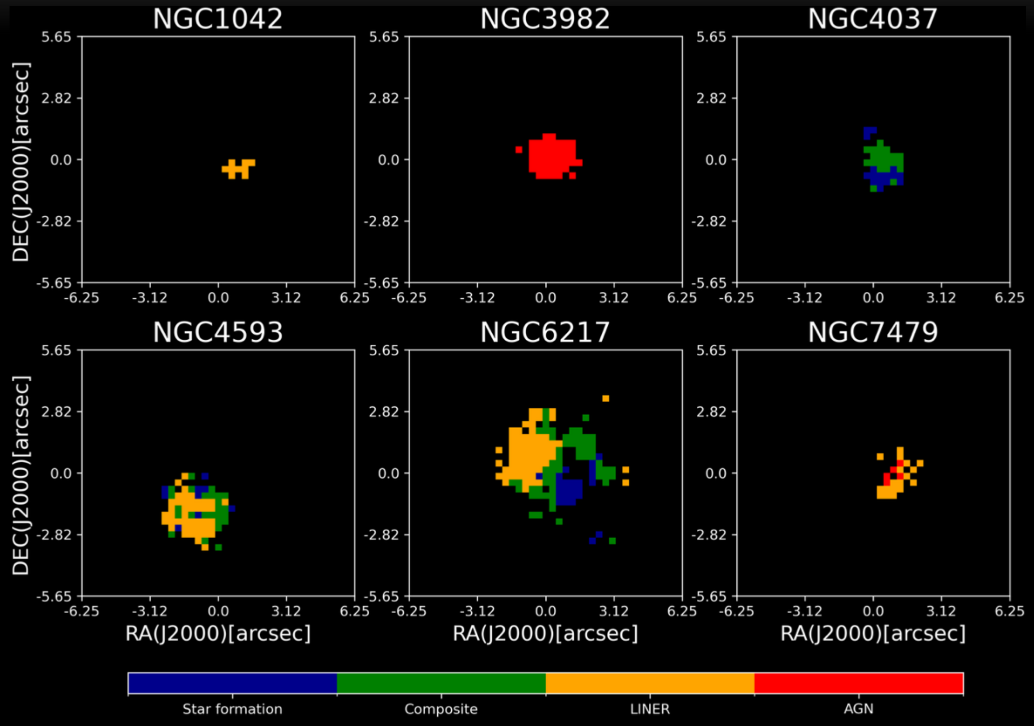
Outflow Parameter	Mean (and median) values	
	Hα	[O III]
$L_{out} \times 10^{38}$ [$erg\ s^{-1}$]	376±151(151)	188±100(101)
R_{out} [kpc]	0.27±0.07(0.24)	0.13±0.02(0.11)
$\|\Delta v_{max}\|$ [$km\ s^{-1}$]	314±76(263)	248±39(228)
v_{out} [$km\ s^{-1}$]	645±155(564)	520±59(617)
σ_{out} [$km\ s^{-1}$]	281±72(243)	231±33(228)
$M_{out} \times 10^5$ [$M_\odot$]	5.11±2.37(1.31)	0.74±0.44(0.28)
$\dot{M}_{out}$ [$M_\odot\ yr^{-1}$]	6.61±4.03(0.81)	0.71±0.32(0.46)
η	2.47±1.27(0.27)	0.48±0.24(0.18)
$E_{out} \times 10^{52}$ [erg]	157.12±133.86(7.7)	3.8±1.77(1.49)
$\dot{E}_{out} \times 10^{40}$ [$erg\ s^{-1}$]	904.14±812.24(16.85)	12.91±5.44(7.26)
n_e [cm^{-3}]	537±132(311)	613±153(423)
SFR [$M_\odot\ yr^{-1}$]	3.26±0.88(1.46)	



Outflow Parameter	Mean (median) values			
	Hα	[O III]	Leung+19	Fiore+17
v_{out} [km s^{-1}]	645 ± 155 (564)	520 ± 59 (617)	955 ± 140 (933)	1047 ± 95 (1202)
SFR [$M_\odot\ yr^{-1}$]	3.26±0.88(1.46)		82.50 ± 19.12 (30.5)	257.38 ± 63.09 (85.20)

Driving mechanisms of the outflows





Outflow Parameter	Mean (median) values			
	Hα	[O III]	Leung+19	Fiore+17
$\dot{E}_{out} \times 10^{40}\ [erg\ s^{-1}]$	904.14±812.24(16.85)	12.91±5.44(7.26)	$89.93 \pm 56.04\ (0.41) \times 10^3$	$90.75 \pm 35.49\ (4.35) \times 10^3$

Rodríguez del Pino et al. 2019:

$$V_{out}\,(SF - driven) < 500\ km\ s^{-1}$$

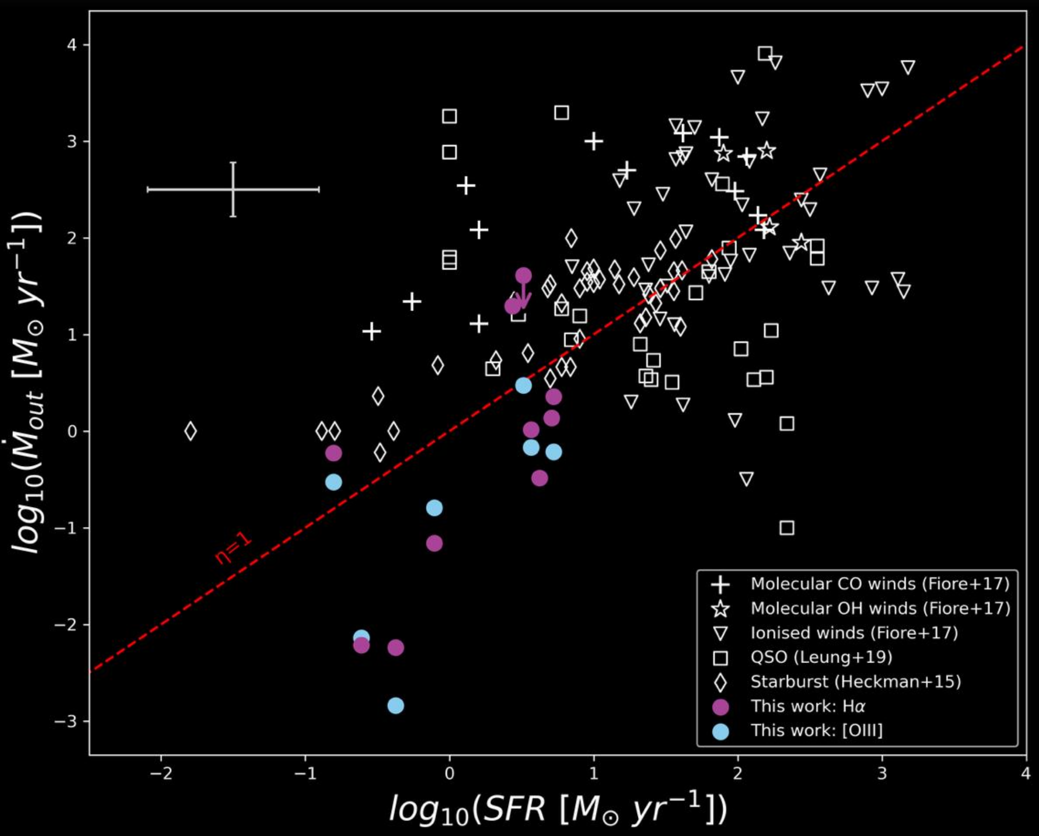
↓

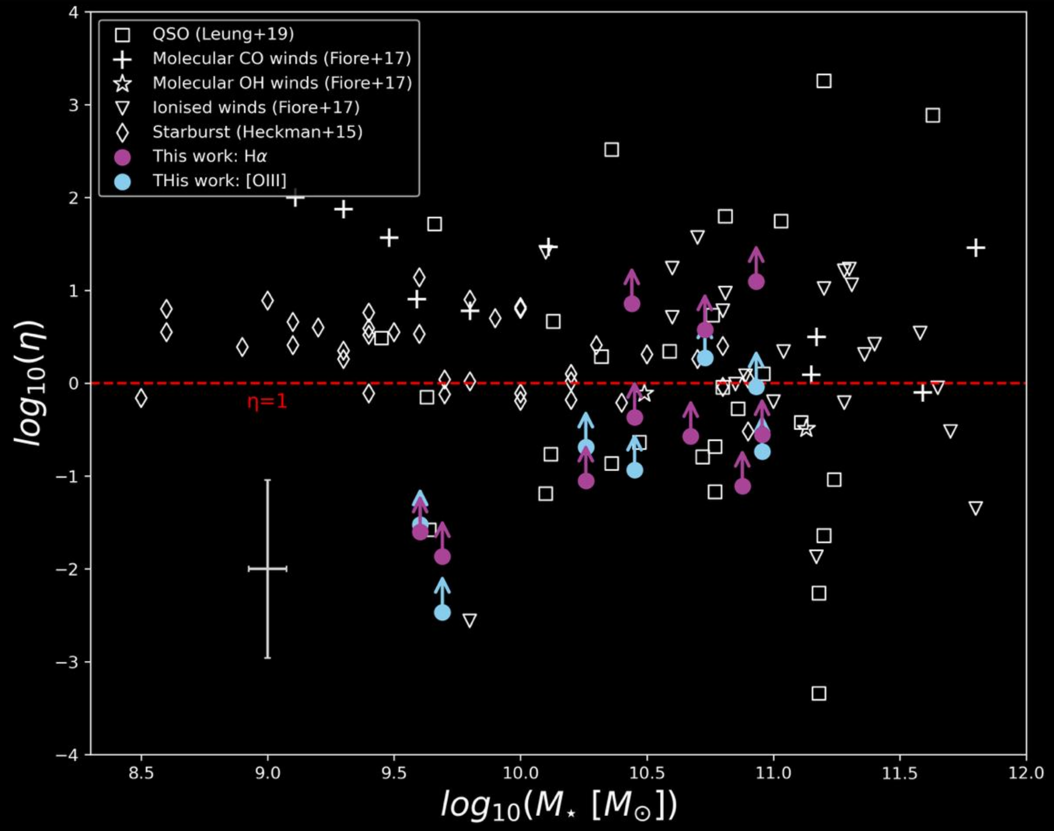
2 SF-driven outflows

8 AGN- or LINER-driven outflows

1 SF+LINER-driven outflow

Ionized gas outflows as tracers of energetic feedback





Outflow Parameter	Mean (median) values				
	Hα	[O III]	Heckman+15	Leung+19	Fiore+17
$\dot{M}_{out}\ [M_\odot\ yr^{-1}]$	6.61±4.03(0.81)	0.71±0.32(0.46)	27.31 ± 3.94 (26.00)	481.55 ± 290.62 (15.85)	846.21 ± 249.41 (154.89)
η	2.47±1.27(0.27)	0.48±0.24(0.18)	4.76 ± 1.57 (2.51)	110.57 ± 68.01 (0.61)	7.42 ± 1.96 (2.63)
$SFR\ [M_\odot\ yr^{-1}]$	3.26±0.88(1.46)		82.50 ± 19.12 (30.50)	257.38 ± 63.09 (85.20)	14.69 ± 3.94 (9.00)
$log_{10}M_\star\ [M_\odot]$	10.37±0.08(10.46)		9.63 ± 0.13 (9.70)	11.05 ± 0.10 (11.17)	9.63 ± 0.13 (9.70)

Conclusions

1. Outflows detected in 11/38 galaxies (~25%), suggesting that galactic winds are a common but not widespread phenomenon in local late-type galaxies.
2. Lower outflow parameters values compared to previous studies indicate less violent outflows than those observed in more extreme systems, such as AGN (Fiore et al. 2017), high redshift QSOs (z = 1.4-3.8; Leung et al. 2019) and Starbursts (Heckman et al. 2015).
3. Galactic outflows are mainly detected in AGN-hosting galaxies, with their properties (velocity, energetics and ionization mechanisms) indicating nuclear activity as the predominant driving mechanism.
4. Low values of mass loading factor imply a low impact on the host galaxy; however, ionized-gas mainly traces the energetic component of the feedback rather than the total mass involved.