



CAUGHT IN THE ACT BY HERSCHEL: GALACTIC STORMS SWEEP AWAY THE GAS

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Herschel press release 2011.05.09
Sturm, E., et al. 2011, ApJL, 733, L16
Massive molecular outflows and negative
feedback in ULIRGs observed by Herschel-PACS

NEWS

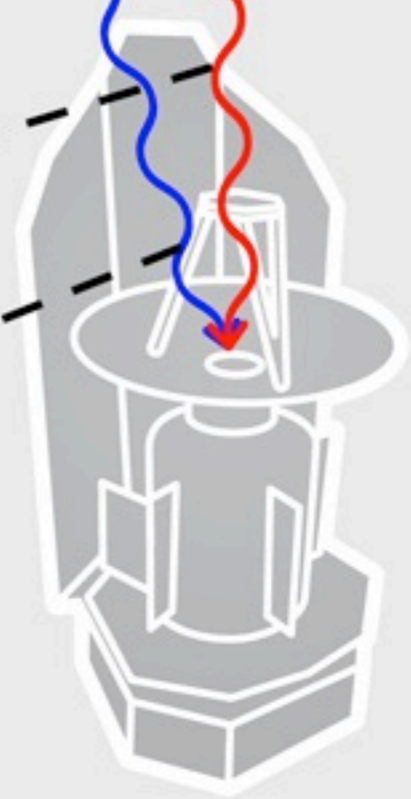
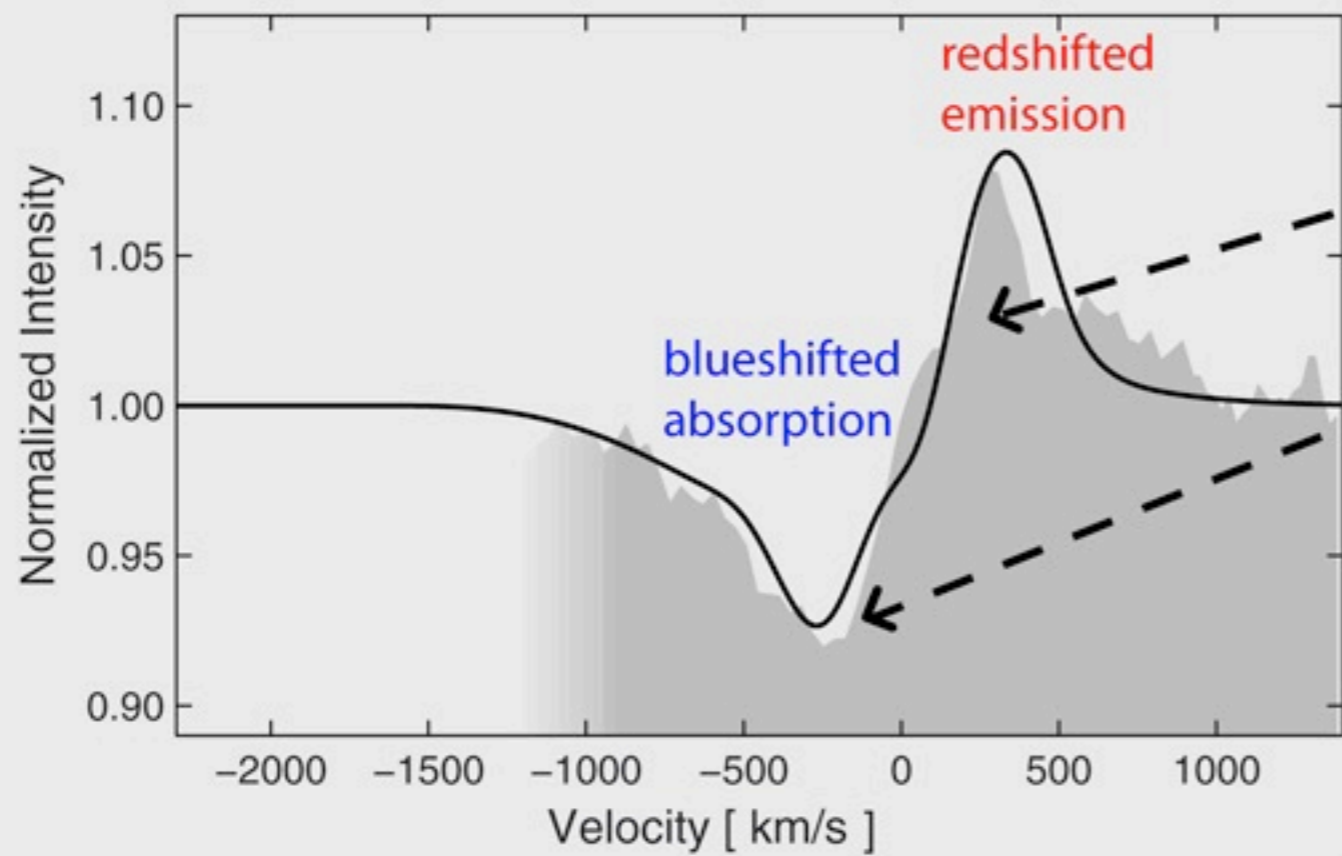
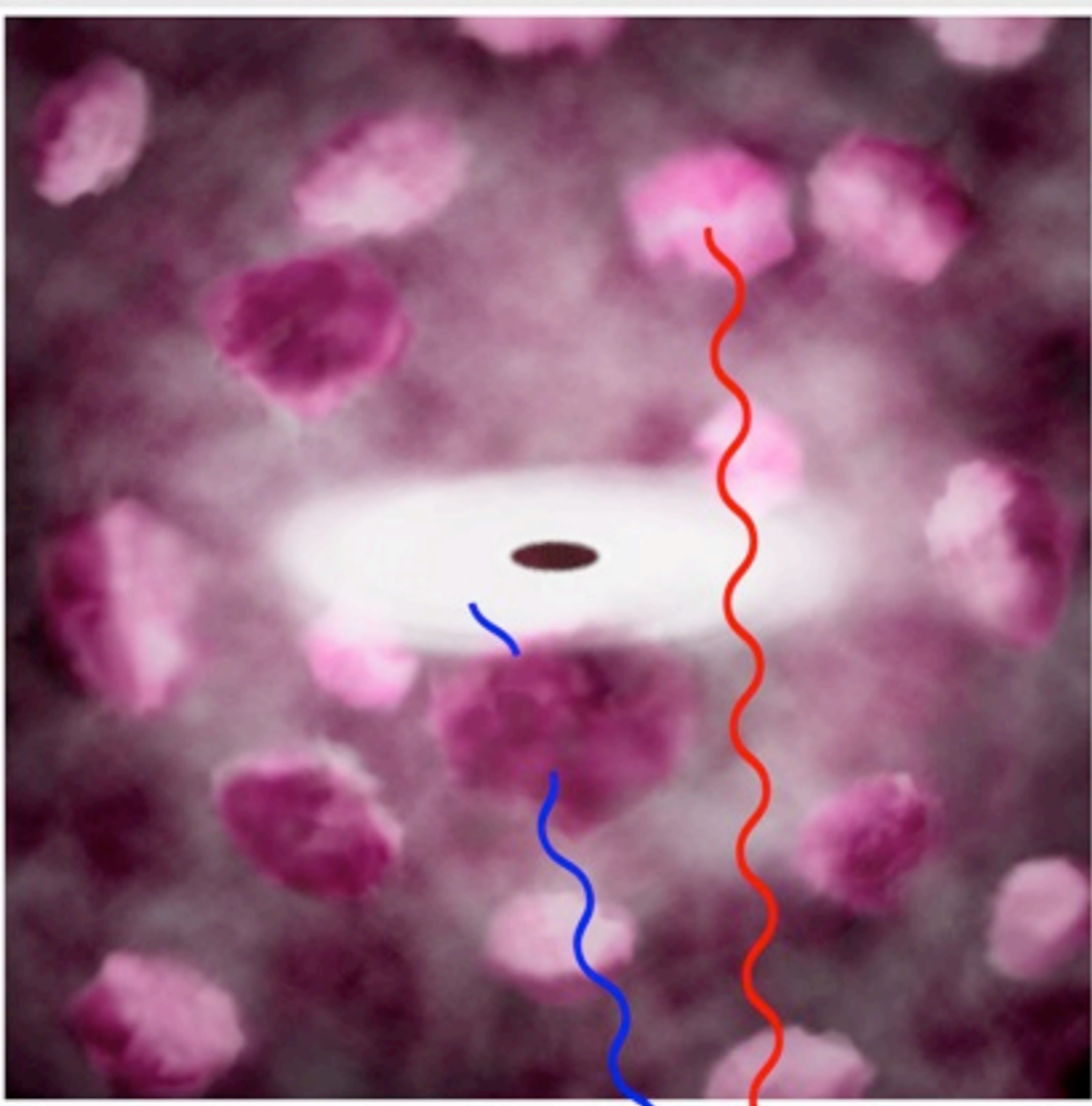
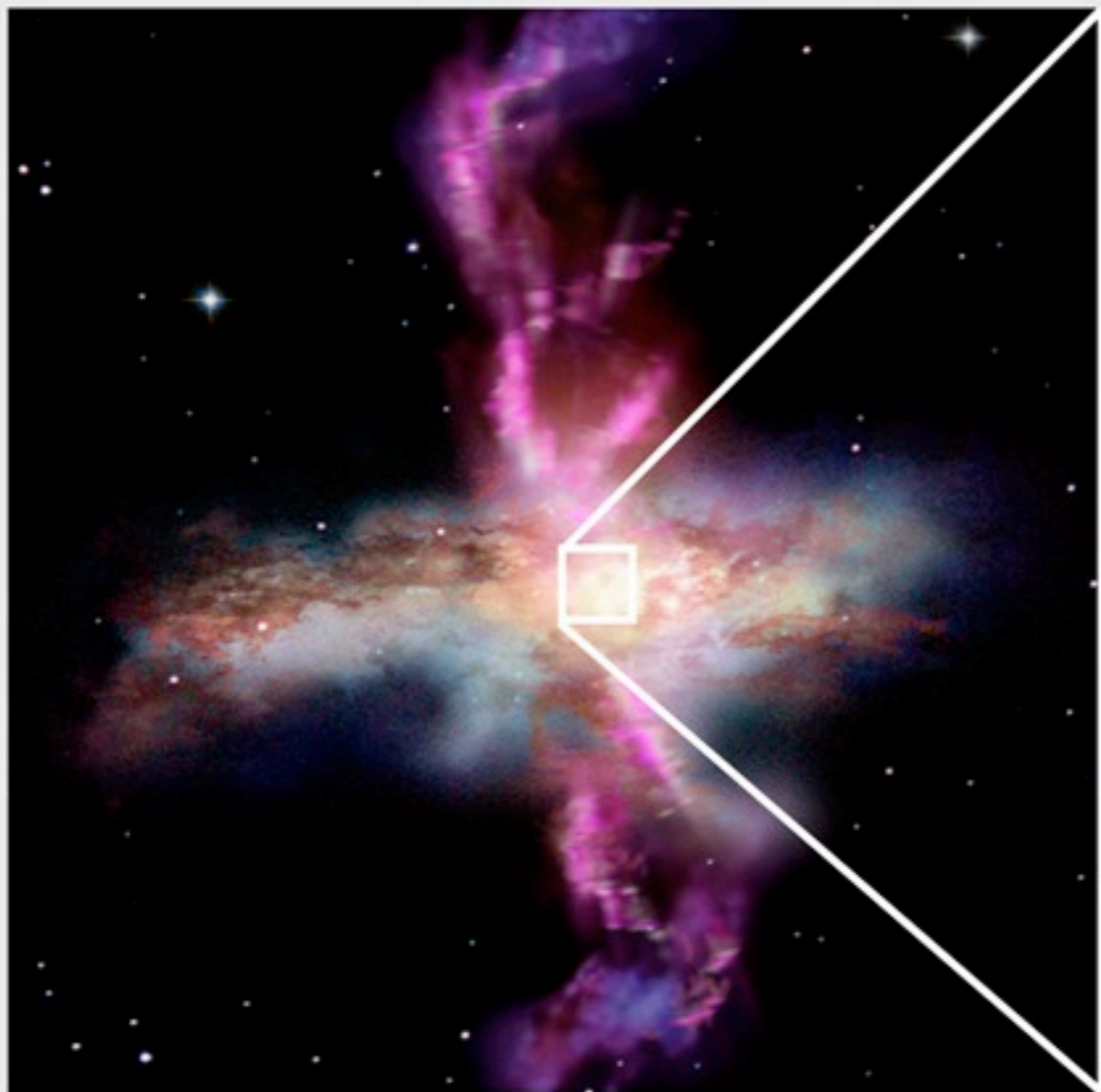
- Evidences showing that Ultra-Luminous InfraRed Galaxies (ULIRGs) exhibit massive outflows of molecular gas.
- In support of the **merger-driven scenario** for the formation of elliptical galaxies.

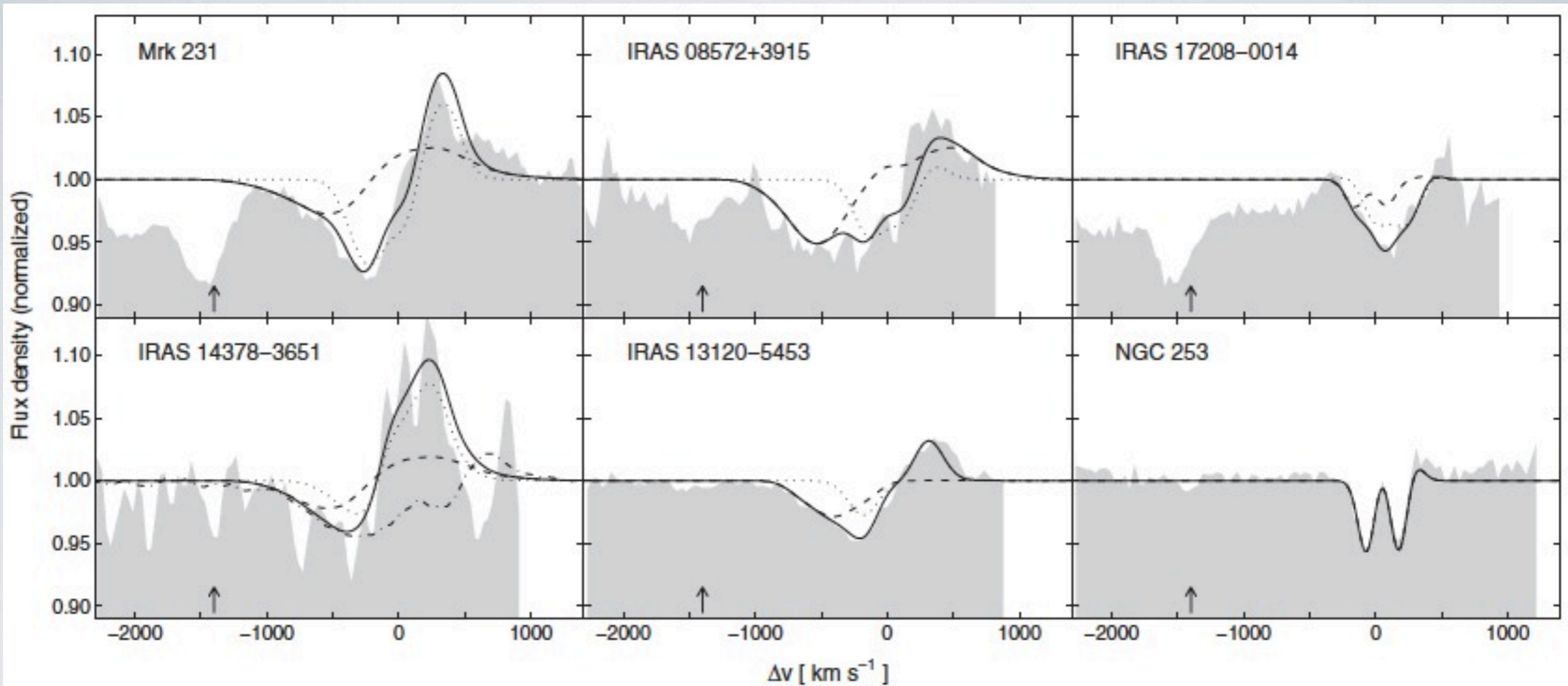
GALAXY EVOLUTION

- Gas-rich spiral galaxies with a central black hole merge → Ultra-Luminous InfraRed Galaxy (ULIRG) → AGN, gas-poor elliptical galaxies
- **Negative feedback process** suppresses the star formation and black hole mass growth/accretion.

HERSCHEL OBSERVATIONS

- **Cold molecular gas** component instead of atomic gas components; the molecular gas is responsible for the star formation materials.
- Herschel-PACS far infrared spectrometer observations of OH $79\mu\text{m}$ lines with a resolution of $\sim 140 \text{ km s}^{-1}$.
- Targets: 6 samples.
 - a starburst template (NGC 253),
 - a cold, starburst-dominated ULIRG (IRAS 17208–0014),
 - warm ULIRGs ($S_{25}/S_{60} > 0.1$) and/or ULIRGs with strong AGN contributions (Mrk 231, IRAS 13120–5453, IRAS 14378–3651),
 - a heavily obscured ULIRG (IRAS 08572+3915), which hosts a powerful AGN.



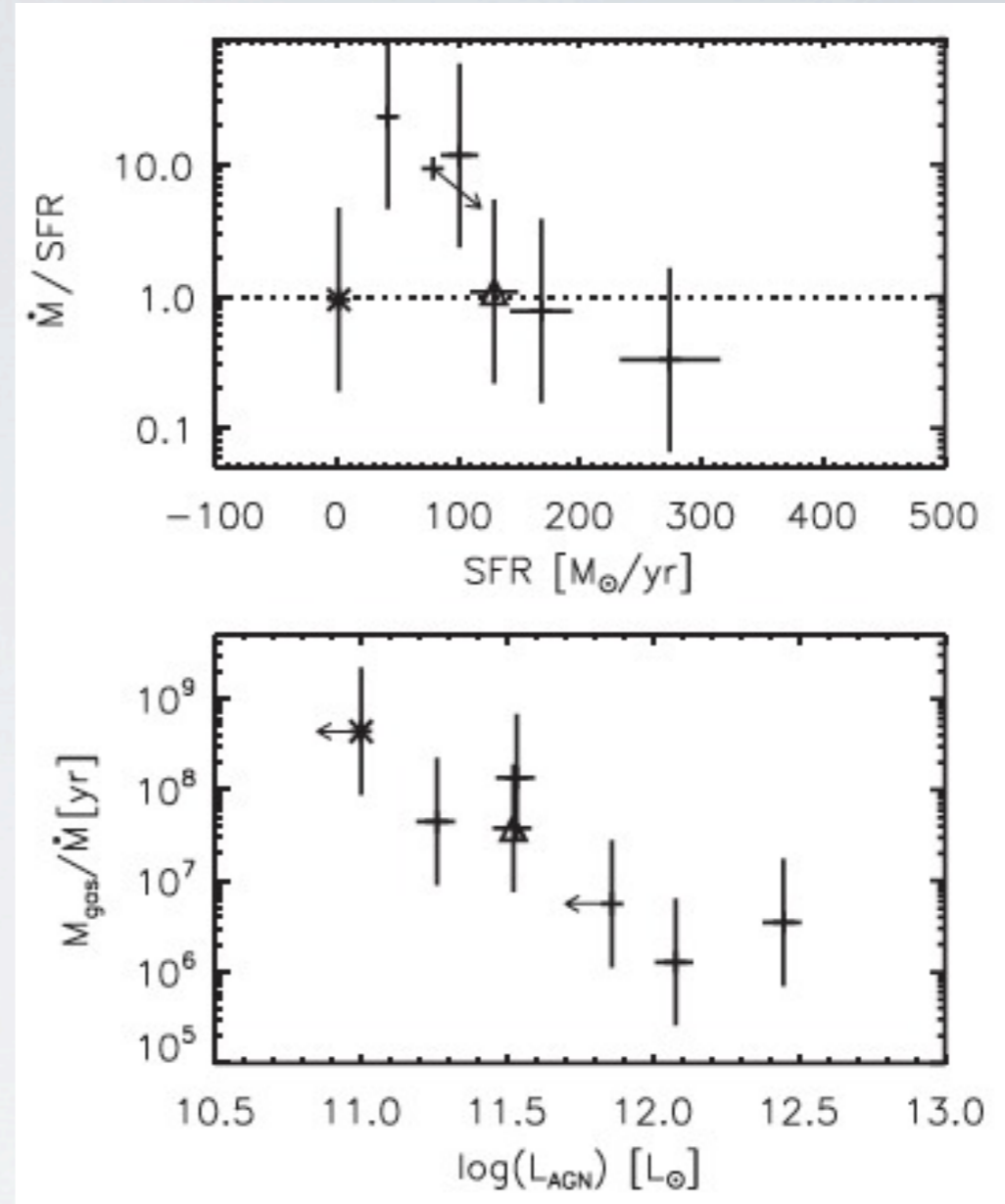
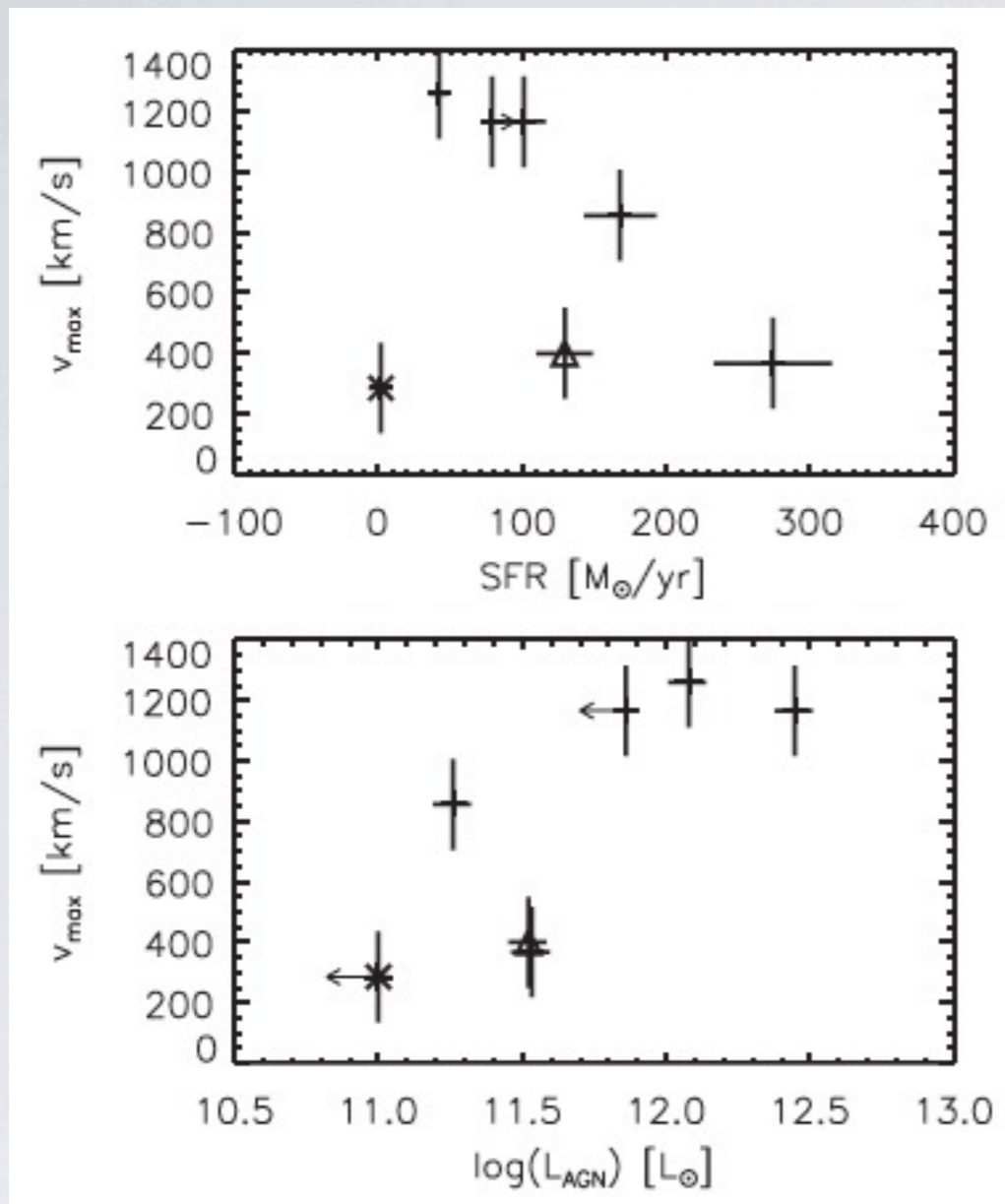


- Observed PACS spectra (continuum-normalized) of the OH transition at 79 μm (gray). Overplotted are the low-velocity (dotted) and high-velocity (dashed) fit components and the total fit (solid). The arrow indicates the rest position of H₂O 4₂₃-3₁₂. The dash-dotted line for IRAS 14378 shows the observed spectrum of the OH transition at 119 μm for this object.

Table 1
Target Properties, Outflow Rates, and Outflow Velocities (1σ Uncertainties in Parentheses)

Source	SFR ($M_{\odot} \text{ yr}^{-1}$)	α^a (%)	L_{AGN} ($10^{11} L_{\odot}$)	M_{gas}^b ($10^9 M_{\odot}$)	\dot{M}^c ($M_{\odot} \text{ yr}^{-1}$)	v_{peak}^d (km s^{-1})	$v_{85\%}^e$ (km s^{-1})	v_{max}^f (km s^{-1})
Mrk 231	101 (15)	71 (11)	28 (4)	4.2 (1.3)	1190^{+4700}_{-890}	-600	-660	-1170
IRAS 08572+3915	42 (6)	72 (11)	12 (2)	1.3 (0.4)	970^{+2900}_{-730}	-700	-740	-1260
IRAS 13120-5453	168 (25)	9 (1.4)	1.8 (0.3)	5.8 (1.7)	130^{+390}_{-95}	-520	-600	-860
IRAS 14378-3651	>79	<45	<7.2	4.2 (1.3)	740^{+2200}_{-550}	-800	-860	-1170
IRAS 17208-0014	274 (41)	11 (1.7)	3.4 (0.5)	12.2 (3.7)	90^{+270}_{-65}	-100	-170	-370
NGC 253	1.7 (0.3)	0	0	0.7 (0.2)	$1.6^{+4.8}_{-1.2}$	-75	-130	-280

- Estimated uncertainty for all velocities: $\pm 150 \text{ km s}^{-1}$.
- a: Fraction of the AGN contribution to L_{bol} , where $L_{\text{bol}} = 1.15 \times L_{\text{IR}}$.
- b: Gas mass.
- c: Mass outflow rate.
- d: Peak velocity of the blueshifted high velocity component (relative to systemic velocities).
- e: Velocity for which 85% of the outflowing gas has lower (absolute) velocities.
- f: Terminal velocity.



- The strong outflows are driven by the AGN rather than by the star formation in these objects.
- The outflow carry sufficient molecular gas to remove the star formation fuel and actually quench the star formation.
- The asterisk denotes NGC 253 and the triangle denotes Arp 220.

THANK YOU!