2-D neutral gas kinematics and galactic winds for a sample of local LIRGs

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Outline

Luminous and UltraLuminous InfraRed Galaxies and Galactic Winds

(U)LIRGs and Galactic Winds

LIRGs: L_{Ir}=$L_{8-100\mu m}$ = 10^{11}-10^{12} $L_{\odot}$ & (U)LIRGs $L_{Ir} \geq 10^{12}$ $L_{\odot}$

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- Dynamical process, the interaction triggers starburst and AGN activity with the starburst usually dominating, *e.g. Lonsdale et al.2006*;
- Low-z and high-z galaxies.

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- Outflows energized by stellar winds and SNe ejecta;
- Impact (feedback prescriptions):
  - regulates and quench both SF and the BH activity, *Veilleux 2005*;
  - intergalactic metals enrichment, *Heckman et al.2000*.
- Star-forming galaxies at any redshift, *Martin et al.2012*.

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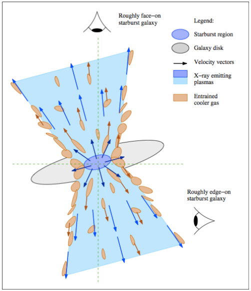
GWs “Strategy”

Basic Physics of GWs (*Veilleux 1995*)

The gas surroundings the starburst evolves with an adiabatic expansion. Later, the bubble assumes an “onion” shape (multilayer $\gg$ multiphase).

Revealing GWs

Phase	Tracers
Warm - Ionized	H_α,λ6563, $[S_{II}]\lambda\lambda$6716,6731/H_α
Cold - Neutral	NaD $\lambda\lambda$5890,5896, $Fe_{II}\lambda$2374
Cold - Molecular	CO 4.6 μm



Strickland et al.2009

GWs cold component: Optical Abs.Line detections via **NaD**

2-D Kinematics and description of GWs;

- Signature of blue/redshifted material in front of the continuum source;
- Tracer of GWs extension and the mass of outflowing material;

!!! Faint and complex feature (physical origin: Star & Gas, IP = 5.14 eV).

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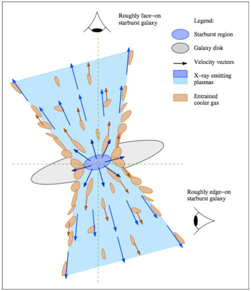

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Observations, Data & Sample

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10 2-D spatially resolved spectra, IFS data: the high S/N LIRGs sample.

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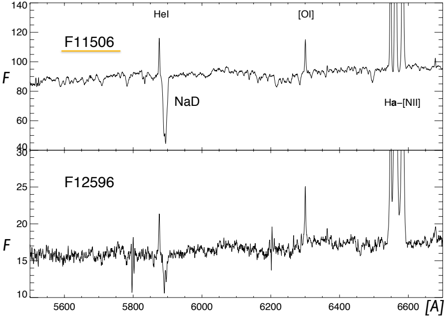
Properties of the high S/N LIRGs sample

ID (*IRAS*) (1)	Other Name (2)	α (J2000) (3)	δ (J2000) (4)	z (5)	L_{Ir} (6)	Nuc. Spectral Classification (7)	Morphology Class (8)
F01341-3734 (N)	ESO-297-G011	01:18:08.1	-44:27:40	0.01725	10.65	H	INTERACTING
F01341-3734 (S)	ESO-297-G012	01:36:24.0	-37:19:14	0.01743	11.06	H	INTERACTING
F04315-0840	NGC 1614	04:34:00.0	-08:34:46	0.01573	11.69	H	P.C. MERGER
F06076-2139		06:09:45.1	-21:40:22	0.03724	11.67	-	INTERACTING
F10409-4556	ESO 264-G036	10:43:07.0	-46:12:43	0.02071	11.26	H/L	ISOLATED
F11506-3851	ESO 320-G030	11:53:12.0	-39:07:54	0.01047	11.30	H	ISOLATED
F12115-4656	ESO 267-G030	12:14:12.6	-47:13:37	0.01792	11.11	H	ISOLATED
F13229-2934	NGC 5135	13:25:43.0	-29:49:54	0.01348	11.29	S	ISOLATED
F18093-5744 (N)	IC 4687/4686	18:13:38.6	-57:43:36	0.01722	11.57	H	INTERACTING
F22132-3705	IC 5179	22:16:10.0	-36:50:36	0.01100	11.22	H	ISOLATED



F11506
-Selected-

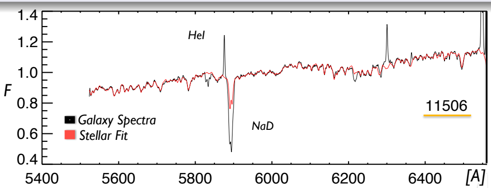
F12595
-Rejected-

1-D Spatially Integrated Spectra

1-D Analysis

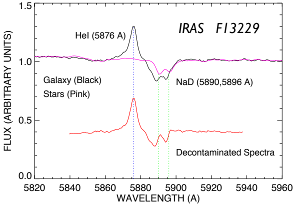
- Properties of Stellar and Interstellar NaD: cross-correlating our dataset and the *Indo-U.S.* stellar library (*Valdes et al. 2004*) with a penalized pixel fitting technique, (pPXF, *Cappellari et al.2004*)

Goal: Stellar and neutral gas kinematics for the whole sample (38 (U)LIRGs);



- Development of tools for decontaminating spectra from the stellar component;

Goal: "Pure neutral gas" kinematics for the high S/N LIRGs sample (10 objects).



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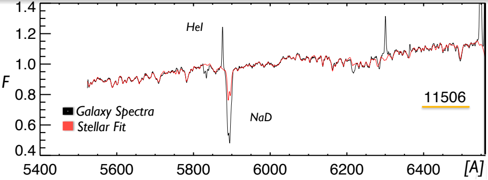

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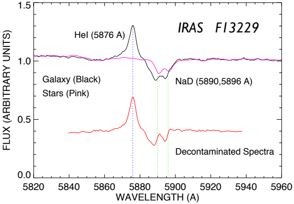
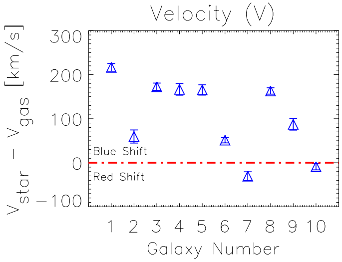
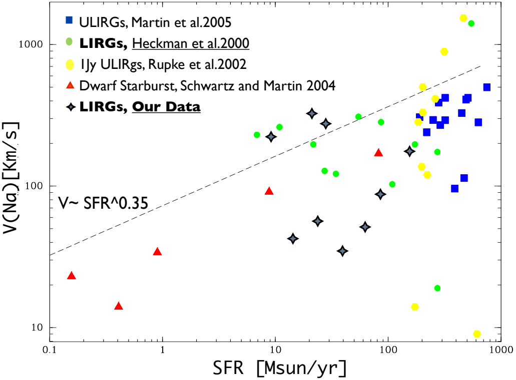


First results for the selected sample of LIRGs and comparison with literature





2-D Spatially Resolved data

2-D Analysis

Using Optical-IFS spectroscopy:

- Obtain the neutral gas structure and kinematics;
- Disentangle different contributors to NaD in each spaxels;
- Reveal (and characterize) GWs.

Disentangling Stellar and Interstellar NaD in 2-D

- The S/N in each spaxels it is not enough to do a stellar fit for each spectra (as done in the 1-D analysis) spaxels by spaxels;
- Alternatively, using the $EW_{NaD,\star}$ obtained analyzing the 1-D Integrated Spectra, we applied another criteria based on:

$$EW_{NaD,\star} \sim 1/3\ EW_{MgIb},\ \textit{Schwartz \& Martin 2004}$$

$$\rightsquigarrow EW_{NaD,\star} \leq \mathbf{1.2}\ \AA$$

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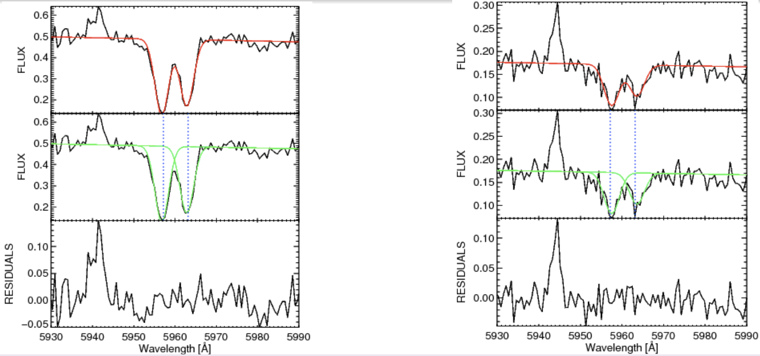
Line fitting technique:

IDL L.M. least-squares fitting routine, *Press 1992*;

- Single component ▷ couple of Gaussian;
- Fixed wavelength separation, $2 \geq EW_{5890}/EW_{5896} \geq 1$, flux unconstrained.



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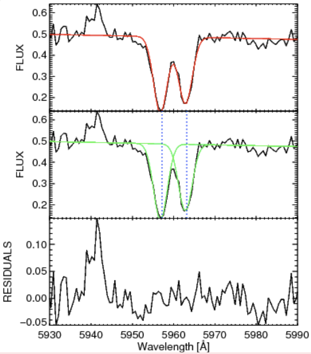

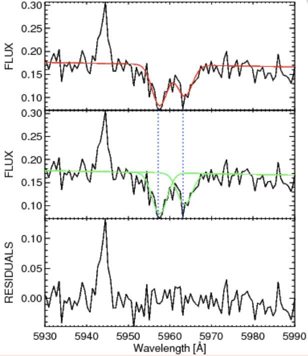

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Mapping the neutral gas 2-D properties...

Kinematics

- Velocity and Velocity Dispersion patterns (e.g., Rotating disk);
- Amplitude, velocity gradients and asymmetries.

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- Flux $\longmapsto$ Morphology and spatial extension;
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- EW= Flux/Cont. $\longmapsto$ Where the absorption is actually interstellar or not;
- R=EW_{5890}/EW_{5896} $\longmapsto$ Optical depth (R=1(2) $\rightsquigarrow$ opt. thick(thin));

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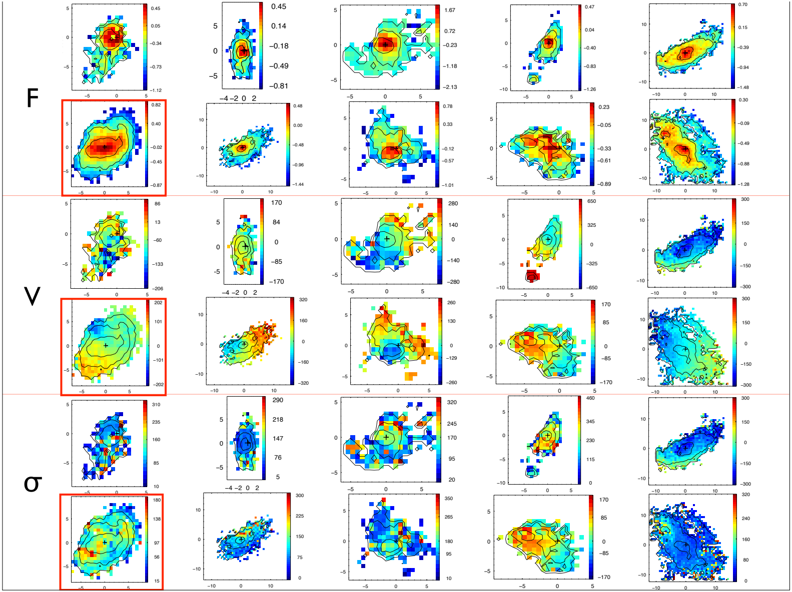
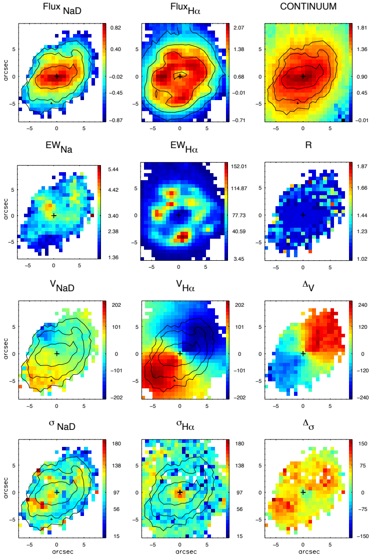

F
V
σ

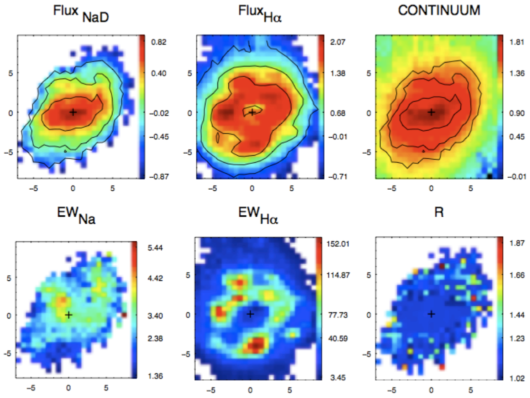
IRAS F11506-3851



IRAS F11506-3851 (ESO 320-G030)

IRAS F11506-3851 (I)

General Properties: isolated SB, z= 0.018, $\log(L_{ir}/L_{\odot})$=11.30, H-II-type.

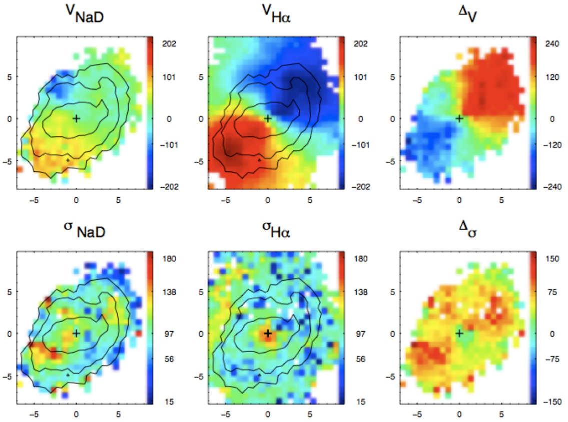


Results:

- Extension ∼ 20 kpc;
- The morphology of the absorption follows that of the continuum;
- Differencies with respect that of H_{α};
- Absorption dominated by neutral gas: $EW_{5890} \geq 1.2$ $\AA$:
- Optically thick gas: R $\leq$ 1.4.

IRAS F11506-3851 (II) - Kinematics -

Neutral gas seems to trace both a rotating disk and a GW

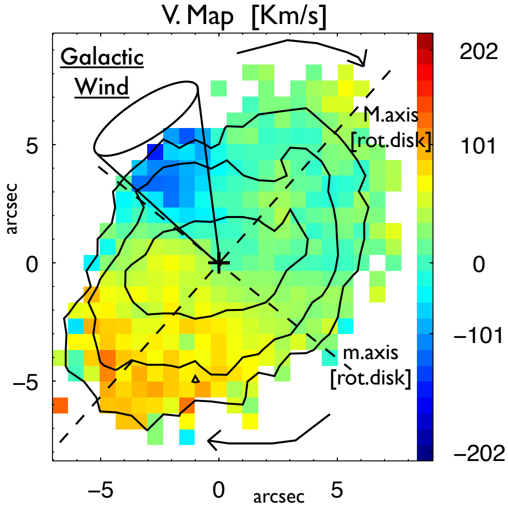


Rotating Disk:

- $V_{NaD} \ll V_{H_\alpha}$, $\Delta V = 105\ kms^{-1}$;
- $\langle \sigma_{NaD} \rangle \geq \langle\ \sigma_{H_\alpha} \rangle$ (90 vs 40) kms^{-1} ;
- The neutral gas is in a thicker disk than that of ionized gas.

Galactic Wind (?)

IRAS F11506-385 scenario: Rotating Disk + GW



Rotating Disk

Galactic Wind (!):

- Projected radius: ∼ 2 kpc;
- Orientation: minor axis
- Extremely optically thick gas: R ≤1.3;
- Velocities: up to -140 kms^{-1};
- High value of σ ∼ 90-130 km/s.

Conclusions
and
Work in Progress

This 2yr-work represent a study of neutral phase GWs's signatures with the spatially resolved spectra of 10 LIRGs.

- 2-D kinematics: Neutral gas slower then ionized gas, tipically ΔV=V_{NaD}-V_{H_α} $\sim$ (100-200)kms^{-1};
- Gas/$\star$ Neutral gas dominates the absorption over $\sim$ 90% of the sources, (except 3 objects);
- τ_{gas} Neutral gas is mainly in the optically thick regime (R$\sim$1.1-1.5);
- GWs Outflows detection rate: 5/10 (+2?)
  - V,σ Typical values are V: (130-260)kms^{-1}, σ: (80-160)kms^{-1};
  - τ_{GW} N_H = (1.8-4.5) $\times$ 10^{21} cm^{-2}

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-Cazzoli et al. [in prep]-

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THE END

THANKS FOR YOUR ATTENTION