



Morphology and Star Formation Rates of the Circumnuclear Regions of 5 LIRGs at $z < 0.0263$



Authors: K. Jones, M. Wold, T. Greve, M. Lacy, A. Evans, D. Farrah, H. Kaufl, J. Mazzarella, R. Siebenmorgen, J. Surace

Scientific Justification:

We present the initial results of a VLT/VISIR observation of 5 Luminous Infrared Galaxies (LIRGs). LIRGs are identified by their exceptionally bright infrared luminosities, with $L_{IR} > 10^{11} L_{solar}$, which is driven by both obscured starburst (SBs) and AGN activity. SBs appear to be the consequence of mergers (e.g. Barnes & Hernquist, 1992), are a common element among high- z sub-mm sources (e.g. Scott+ 2002), and may contribute to the FIR background. Some evidence suggests that high mass ($> 4 M_{solar}$) star formation is particularly important in SBs both locally and at high redshift: Baugh+2005, for example, suggests that a low-mass-truncated IMF plays a role in adapting semi-analytic models to better fit high- z sub-mm distribution density, and locally Leitherer+1999 suggests high-mass SF is necessary to explain local SB properties. The study of obscured star formation, especially obscured *high mass* star formation, is thus a vital step in understanding galactic evolution across redshifts.

With this in mind, we have made a study of the circumnuclear region of a small sample of local LIRGs, using the [NeII] 12.8-micron emission line as a tracer of high-mass star formation in dusty regions (see, e.g., Woosley+Weaver, 1995, Ho+Keto, 2007 [hereafter HK07]). HK07 points out that ionized neon is an ideal measure of star formation rate. It has a nearly one-to-one correlation with infrared luminosity; it is less sensitive to dust extinction; and it is the direct product of high-mass star nuclear synthesis. We have put upper limits on these objects' SFR using eq 13 from HK07 and assuming the ionization fraction goes to 1 in these regions.

Object	Emission Type	On-line Flux (Jy)	Off-line Flux (Jy)	Redshift	Aperture Rad. (pixels)	Luminosity (erg/s)	SFR (Msol/yr)
F12243-0036	point	1.748	1.471	0.007268	10.5	6.80E+41	29.50
IRAS07160-6215	extended	0.737	0.677	0.010807	27.5	6.33E+41	27.49
F04118-3207	spiral	0.801	0.658	0.011908	22.5	8.36E+41	36.29
F13229-2934	extended	0.0596	0.0423	0.013693	22.5	8.23E+40	3.57
F13197-1627	point	1.116	n/a	0.016541	10.5	2.25E+42	97.55

Methodology:

A sample representative of local LIRGs with available Spitzer data was chosen for this study based on redshift, IRAS 12-micron flux and RA and DEC.

Narrow-band images were obtained with the VISIR instrument of the VLT in January 2006.

Using the intermediate field of the detector with pixel scale of $0.127''$ gave a FOV of $32.5'' \times 32.5''$, reduced to $\sim 10'' \times 10''$ by the chop-nod technique. The VISIR images therefore cover only the very center of each galaxy.

We obtained two images of each nucleus, one in the 12.81-micron filter and one in the 13.01-micron filter. Due to redshift, the rest-frame 12.8-micron [NeII] line we are interested in falls in the 13.01-micron filter, so this is considered the "on-line" image and the other, the "off-line" or continuum. Object F13197-1627 has no continuum measurement.

The VLT has a diffraction limit of $.38''$ at 12.8-microns, but we did not reach this limit due to atmospheric variability. See the table. The raw data were processed through the ESO pipeline, which builds the average of all chopped frames for each telescope nodding position. The different nodding frames are thereafter combined to produce a final image with two negative and one positive beam.

We performed a pseudo-flat-field on these images by subtracting the median of each row.

A Hubble constant of $H_0 = 75 \text{ km/s/Mpc}$ and a cosmology with $\Omega_M = 0.3$ and $\Omega_\Lambda = 0.7$ is used throughout.

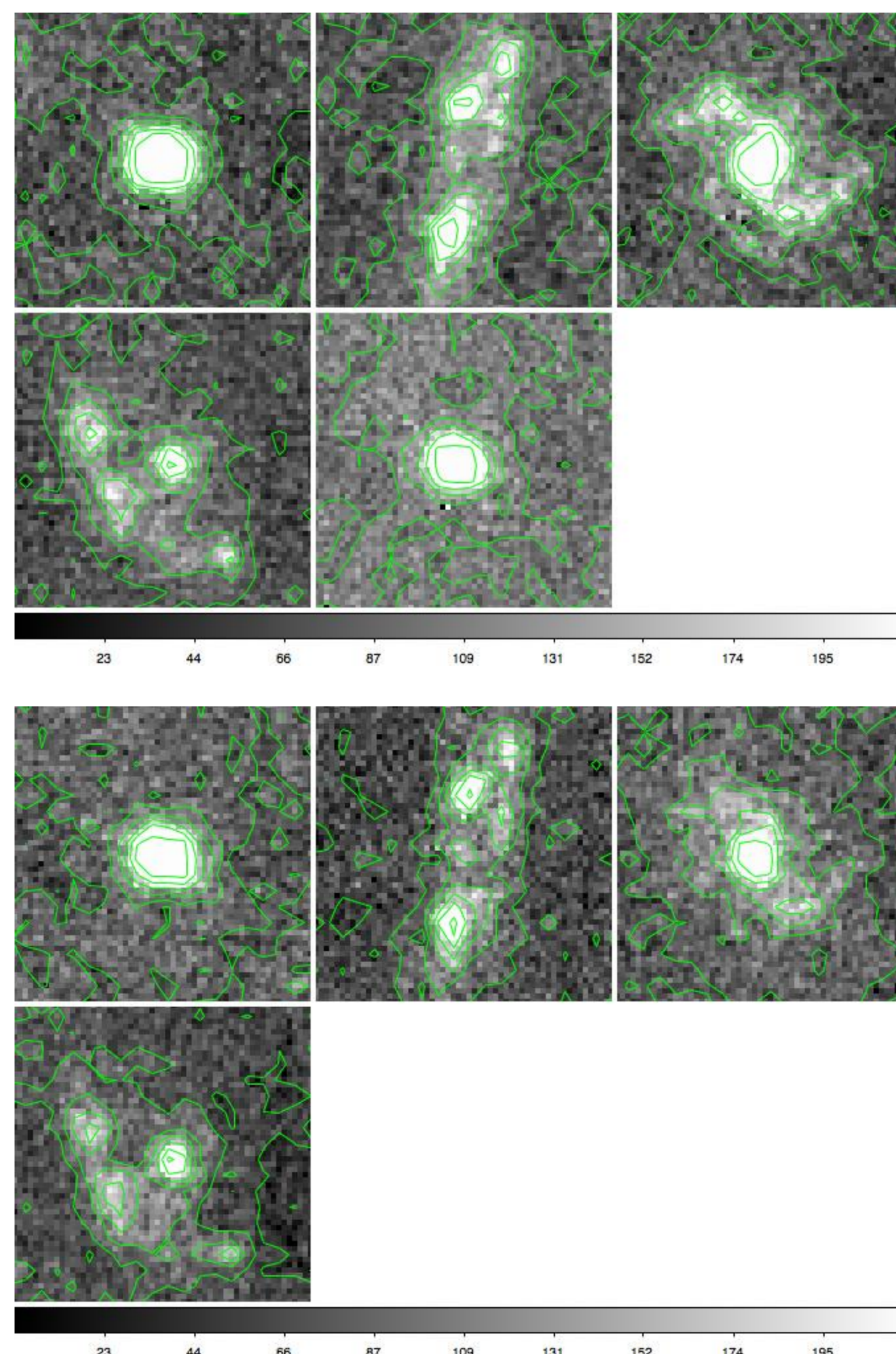


Figure 1: On-line and continuum images with level 10 DS9 contours of Objects 1-5, respectively. No off-line image was taken for F13197-1627.

Results and Discussion:

We have calculated the above SFR as an upper limit from the line+continuum flux, using HK07's eq 13:

$$\text{SFR} = 4.34 \cdot 10^{-41} (L_{\text{Ne}} / a)$$

where a is a scale factor dependent on the fraction of ionization which we have taken to be one for this upper-limit scenario, representing complete ionization of the emitting gas.

Our sample, though small, is varied. F12243 is part of a pair, shows signs of Sy2 activity, and is an S0/a type. IRAS07160 is a group member, shows no signs of activity, and is a SB type. F04118 does not appear to be interacting, shows signs of Sy2 activity, and is an E type. F13229 is a possible group member, shows signs of Sy2 activity, and is a SB type. Finally, F13197 does not appear to be interacting, shows signs of Sy1 activity, and is a S0/a type. The different nuclear structures observed for these different types of galaxies are of particular interest.

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-0809128 and by the Research Council of Norway through Grant No. 177304. We are grateful for the support.

References:

Sanders & Mirabel 1996	Scott+2002	Genzel+1997
Farrah+2003	Baugh+2005	Ho & Keto 2007
Surace+1998	Farrah+2005	Farrah+2007
Barnes & Hernquist 1992	Barger+1998	Soifur & Neugebauer 1990
Dunlop+1996	Veilleux+1999	Leitherer+1999
	Woosley & Weaver 1995	