VIMOS-VLT two-dimensional kinematics of local luminous infrared galaxies

Julia Alfonso-Garzón, Ana Monreal-Ibero, Santiago Arribas, Luis Colina

Abstract In this work, preliminary results of a kinematic study based on optical integral field spectroscopy with the VIMOS (Visible Multi-object Spectrograph) instrument on the VLT (Very Large Telescope) of some representative (U)LIRGs ((Ultra) Luminous Infrared Galaxies) is presented. Velocity fields and velocity dispersion distributions of the ionized gas are obtained from Hα 6563 Å emission line. Two representative examples, an isolated galaxy (NGC 3110) and a merger (IRAS F01159-4443), are shown. The isolated galaxy presents a velocity field typical of a rotating spiral galaxy with a peak to peak velocity difference of $\sim$ 440 km s^{-1}. The merger shows a more perturbed kinematics although indepent rotation for each individal galaxy has been found with a peak to peak velocity of $\sim$ 260 km s^{-1} in the northern galaxy and of $\sim$ 250 km s^{-1} in the southern one and a relative velocity between the two galaxies of $\sim$ 130 km s^{-1}.

1 Introduction

LIRGs are those galaxies with infrared luminosity $10^{11}L_{\odot} < L_{IR} < 10^{12}L_{\odot}$ and ULIRGs are those with $10^{12}L_{\odot} < L_{IR} < 10^{13}L_{\odot}$ [6]. Among other reasons, the study of this kind of galaxies is relevant because they are thought to be the coun-

Julia Alfonso-Garzón
CAB/LAEFF (CSIC-INTA), POB 78 28691 Villanueva de la Cañada, Madrid, Spain, e-mail: julia@laeff.inta.es

Ana Monreal-Ibero
ESO, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei München, Germany, e-mail: amonreal@eso.org

Santiago Arribas
DAMIR-IEM-CSIC, Serrano 121 28006 Madrid, Spain, e-mail: arribas@damir.iem.csic.es

Luis Colina
DAMIR-IEM-CSIC, Serrano 121 28006 Madrid, Spain, e-mail: colina@damir.iem.csic.es

terparts of cosmologically important galaxy populations at z>1 [4]. The dominant energy source in (U)LIRGs is the star formation although sometimes the presence of an AGN can be relevant. In several cases, these systems are mergers although there are isolated (U)LIRGs as well. These galaxies are very rich in gas and dust and they present some emission lines, like Hα 6563 Å, from the ionized gas. The study of these lines allows us to characterize the ionized state and the kinematics of the galaxy. Because of the complexity of these objects, integral field spectroscopy (IFS), a technique able to obtain spectra over a more or less continuum field of view, is ideal to carry out their study. For that reason, observations of a representative sample of LIRGs and ULIRGs using IFS have been done with VIMOS. These observations are part of a larger project focused in the study of (U)LIRGs ([2] and references therein).

2 Observations

The observations were obtained in service mode using the integral field unit of VIMOS [3] on the VLT. The high resolution mode 'HR Orange' was selected so the wavelength coverage was approximately 5250-7400 Å with a spectral resolution of R$\sim$3400. With this configuration of the instrument, the field of view is of 27"$\times$27" using 40$\times$40 fibers. To correct the effects of bad fibers and bad columns, four pointings with exposure times of 720-750s were taken with a square dither pattern of 2.7" for each object, giving an effective field of view of 29.5"$\times$29.5" [2].

3 Data reduction

First of all, the pipeline provided by ESO (version 2.0.15 [1]) was used to perform the basic reduction steps to the individual quadrants (VIMOS field of view is divided in four quadrants for this mode): bias correction, spectra tracing and extraction, correction of fiber and pixel transmission and relative flux calibration.
Then, several IRAF and IDL scripts have been developed to complete the reduction, creating the datacubes from the individual quadrants data, masking fibers with low transmission or uncorrectly traced, combinig the four pointings for each observing block (OB) and substracting the sky signal.
Finally, some tests to evaluate the quality of the spectral and flux calibrations have been done. The [O I] 6300.3 Å sky line has been used to measure the instrumental width, obtaining an average value of 0.8$\pm$0.1 Å and to estimate the flux calibration errors (typically $\sim$25%) and wavelength calibration errors ($\sim$0.1Å).

[1] http://www.eso.org/sci/data-processing/software/pipelines/index.html

4 Line fitting

In order to extract the ionized gas emission line information from the triplet H$\alpha\lambda$6563+[N II]$\lambda\lambda$6548,6584, the line profiles were fit with a gaussian model. An IDL script, using the MPFIT least squares curve fitting package (Markwardt IDL library[2]), has been developed to find the best set of model parameters which match the data. This script allows us to impose some constraints in the parameters of the fitting, such as the wavelenth differences between the three lines, the line intensity ratios between the two [N II] lines and the same line width for the three lines. In most of the cases (in particular in those presented below), a single component per emission line was appropiate, but in some cases, multi-component fits had to be performed in some regions of the field of view [1].

5 Results

Velocity fields and velocity dispersion distributions of the ionized gas have been obtained from Hα 6563 Å emission line for a representative sample of (U)LIRGs. In fig.1, maps of stellar continuum, Hα flux, velocity and velocity dispersion for two representative systems are shown. By comparing them, some important differences in the kinematics can be found.

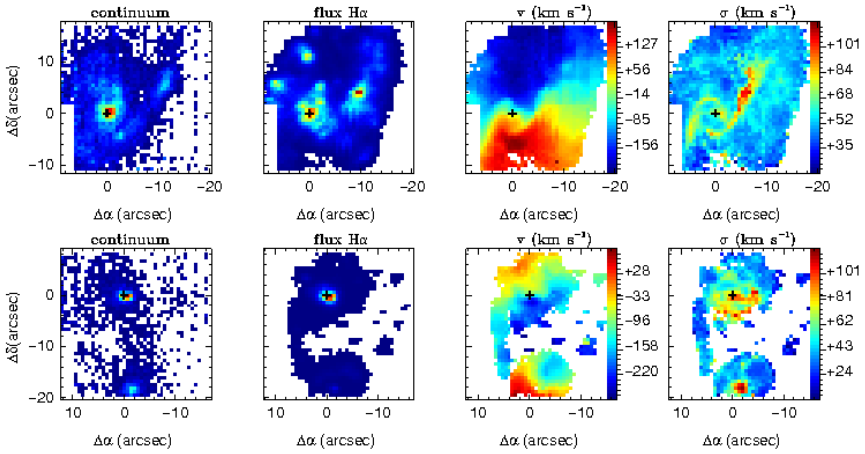

Fig. 1 Maps from Hα emission line showing from left to right: stellar continuum (rest-frame 6390-6490 Å), Hα flux, velocity relative to the nucleus (km s^{-1}), and velocity dispersion (km s^{-1}). **Top**: NGC 3110. **Bottom**: IRAS F01159-4443.

[2] http://cow.physics.wisc.edu/∼craigm/idl/idl.html

NGC 3110 is a LIRG classified as an isolated galaxy and presents a velocity field typical of a rotating disk with a peak to peak velocity difference of $\sim$ 440 km s^{-1} slightly perturbated in the centre.
On the other hand, IRAS F01159-4443 is a merger in a pre-coalescense phase and it shows a more perturbated kinematics with a well developed bridge between the two galaxies. In addition, some Hα clumps are detected. These clumps usually are star-forming regions, or tidal dwarf galaxy candidates, formed as a consequence of a collision. However, both galaxies present indepently a velocity field consistent with a rotating disk. In this case, the peak to peak velocity difference is of $\sim$ 260 km s^{-1} in the northern galaxy and of $\sim$ 250 km s^{-1} in the southern one and the velocity difference between the two nucleis is of $\sim$ 130 km s^{-1}. For these galaxy, previous kinematical studies with Fabry-Pérot have been done obtaining similar maps [5].

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