Formation and Evolution of Galaxy Bulges
Proceedings IAU Symposium No. 245, 2007
M. Bureau, E. Athanassoula & B. Barbuy, eds.
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doi:10.1017/S1743921308018395

Mass and kinematics of late-type galaxies (1.3 < z < 3.3) from the VVDS

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Abstract. Galaxy kinematics at early epochs give a key insight into the assembly of mass. Redshifts $z \sim 1-3$ appear to be the peak of the star formation rate of the Universe, possibly corresponding to the maximal merger activity. 2D velocity fields of late-type galaxies can be used to put important constraints on its total mass and hence on its dark matter halo. As dark halos are thought to govern the rate of galaxy evolution, securing reliable mass measurements for early systems at high redshift is a fundamental observational goal. In addition, accurate inner shape rotation curves, only drawed by 3D spectroscopic studies, should allow to disentangle cosmological scenarii. In the purpose of probing the evolution in masses and mass-to-light ratios of the galaxies during an epoch of expected strong evolution, and setting constrains on their formation and evolution, we present preliminary results obtained from Integral Field NIR Spectroscopy with SINFONI/VLT of a first sample of ten high-z (1.3 < z < 3.3) late-type galaxies selected in the VIMOS/VLT Deep Survey (VVDS). The SINFONI NIR-IFU mode allow to spatially resolve galaxy dynamics using bright rest-frame optical emission lines, in order to perform statistical studies of dynamical masses at this early epochs.

Keywords. techniques: radial velocities, galaxies: kinematics and dynamics, galaxies: high-redshift, galaxies: starburst

1. Sample selection

The VVDS (Le Fevre *et al.*, 2005, A&A, 439, 845) is an on-going program to map the evolution of galaxies, large scale structures and AGNs from the redshift measurement of more than 100 000 objects down to a magnitude $I_{AB} = 24$, in combination with a multi-wavelength dataset from radio to X-rays. Dedicated effort has been invested to successfuly enter the so-called "redshift desert" $1.0 < z < 3$. Using the VVDS database, we have assembled a sub-sample of carefully-selected star-forming late-type galaxies in the VVDS with $1.4 < z < 3.5$: **1)** we select those showing the strongest [OII]3727Å emission line (EW > 50 Å and flux > 5×10^{-17} $\mathrm{ergs^{-1}cm^{-2}}$, measured on VIMOS spectra) for Hα to be easily detected in the near-IR. For these galaxies, we are able to estimate the [OII]/Hα ratio and put constrains on the SFR at these redshifts. For higher redshift galaxies ($z > 1.5$), [OII]3727Å is not detected anymore in VIMOS optical spectra. For these galaxies, we use the photometric $UBVRIK$ SED to select late-type star-forming galaxies. **2)** The redshift of the galaxy places Hα (or [OIII]5007 for $z > 1.8$ galaxies) emission line between the OH sky lines in the H or K bands. **3)** The galaxies are more extended that 2 arcsec, making the measurement of spatially-resolved kinematics viable given the median seeing on the VLT.

https://doi.org/10.1017/S1743921308018395 Published online by Cambridge University Press

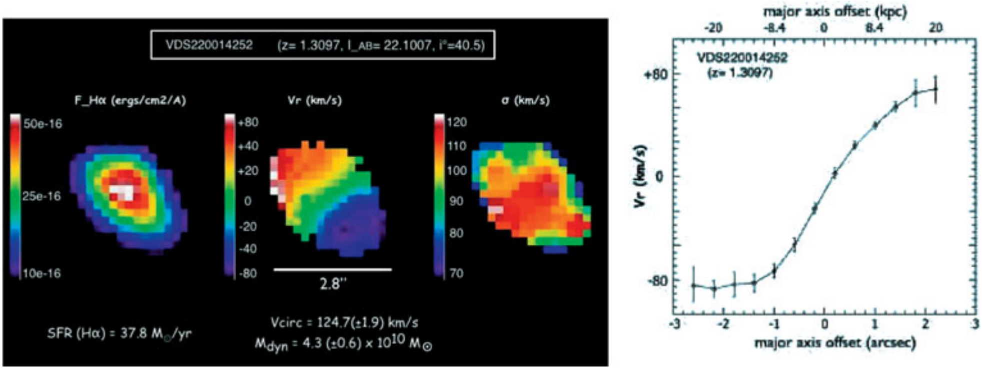

Figure 1. Typical example of SINFONI processed data on the galaxy VVDS220014252 at $z \sim 1.31$ obtained during our pilot run (ESO program 75.A-0318; PI: M. Lemoine-Busserolle). LEFT: a) integrated Hα intensity map - b) Hα velocity field, obtained from Gaussians fits to the data cubes after smoothing spatially with a two-dimensional Gaussian of FWHM = 3 pixels - c) Hα FWHM velocity width obtained from the same fits. Each map is color-coded with a linear scaling such that the values increase from dark to light. These data have been acquired with the 125×250mas sampling configuration of SINFONI, without any AO correction. RIGHT: Rotation curve derived from the Hα emission line. The data points show the rotation velocities (relative to systemic velocity) as a function of position along the kinematic ma jor axis. The error bars correspond to the formal 1σ uncertainties of the velocities. The line is a fit to the data. This galaxy is a clear example of rotating disk with circular velocity (after correction for the inclination of 40.5deg derived from the morphological analysis of CFHT image with a seeing lower than 0.6″) of 125 km s^{-1} leading to a total dynamical mass of $\sim 4.3 \times 10^{10} M_{\odot}$.

2. Results and conclusion

The above criteria for selecting late-type star-forming galaxies seems to be very efficient as our success rate of selection for our pilot run (4 nights in Sept. 2005) is around 85%: 10 galaxies over 12 observed have strong rest-frame optical emission lines. Promising results have already been obtained. We obtained high-quality H or K SINFONI spectra of 10 galaxies (8 galaxies at $z \sim 1.5$, 2 others at z∼ 3.3) selected in the two VVDS fields VVDS0226-04 ($I_{AB} \leqslant 24$) and VVDS2217+00 ($I_{AB} \leqslant 22.5$). These data allowed us to measure with a good S/N ratio the brightest rest-frame optical emission lines: Hα or [OIII]5007 (depending on the redshift). Data reduction has been done and analysis of these data is currently under process. We detected velocity fields for 7 objects and only 3 appear to be rotating disks, thus 30% of our current sample. Fig. 1 shows preliminary results for 1 galaxy of the sample : VVDS 220544252 ($z = 1.3097$).

Starting with this pilot run, we plan to build a 3D data-cube (position, wavelength) for more than 100 galaxies. This data will allow to construct the velocity field using the brightest rest-frame optical emission lines, a prime indicator on the physical processes of mass build up. From the data-cube, several other spatially resolved informations will be obtained, like metallicity estimated with the [NII]6584/Hα ratio. Using these data, the following science topics will be investigated over the redshift range $1.0 \leqslant z \leqslant 4$: (i) The mix of dynamical types: the internal dynamics will be studied, including rotation curves, bulk gas motions, interactions with close neighbors and mergers, spatially-resolved ISM metallicity, etc., thus establishing for each galaxy whether it is a likely precursor of a big spiral or of a massive spheroid; (ii) the evolution of the Tully-Fisher relation; and the (iii) evolution of the mass-metallicity relation.

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