Fabry Pérot interferometry of two nearby irregular dwarf galaxies

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Abstract

Fabry-Pérot interferometry centered on the Hα line was performed to analyse the kinematics of the most prominent ionised gas structures in two nearby irregular dwarf galaxies, NGC 2366 and NGC 4861. The complete spatial coverage of the galaxy in one exposure enables us to follow already known expanding gas structures further out than before. Additionally, we use these 3d images to determine the velocities of structures which could not be kinematically analysed, yet. Altogether, we get a complete view of the kinematics of the ionised gas in these two dwarf galaxies.

I. Ionised gas in irregular dwarf galaxies

Irregular dwarf galaxies can be the sites of giant star formation regions. Photoionisation and shocks that are produced by stellar winds and supernova explosions lead to numerous ionised structures in and around the galactic plane of those galaxies. Many of them have already been detected by e.g., [1], [4] and [5]. However, ionised gas also exists at kpc distances away from any place of current star formation ([3]). In this case, the excitation mechanisms are not obvious. Additionally, it is not clear whether these gaseous features stay gravitationally bound to their host galaxy or whether they can leave the gravitational potential into the intergalactic medium.

We here present a detailed kinematical analysis of two nearby irregular dwarf galaxies, NGC 2366 and NGC 4861. Both galaxies are very similar in shape and their appearance in Hα is dominated by a Giant Extragalactic HII Region (GEHR) in the southern part of the disk (see Fig. 1).

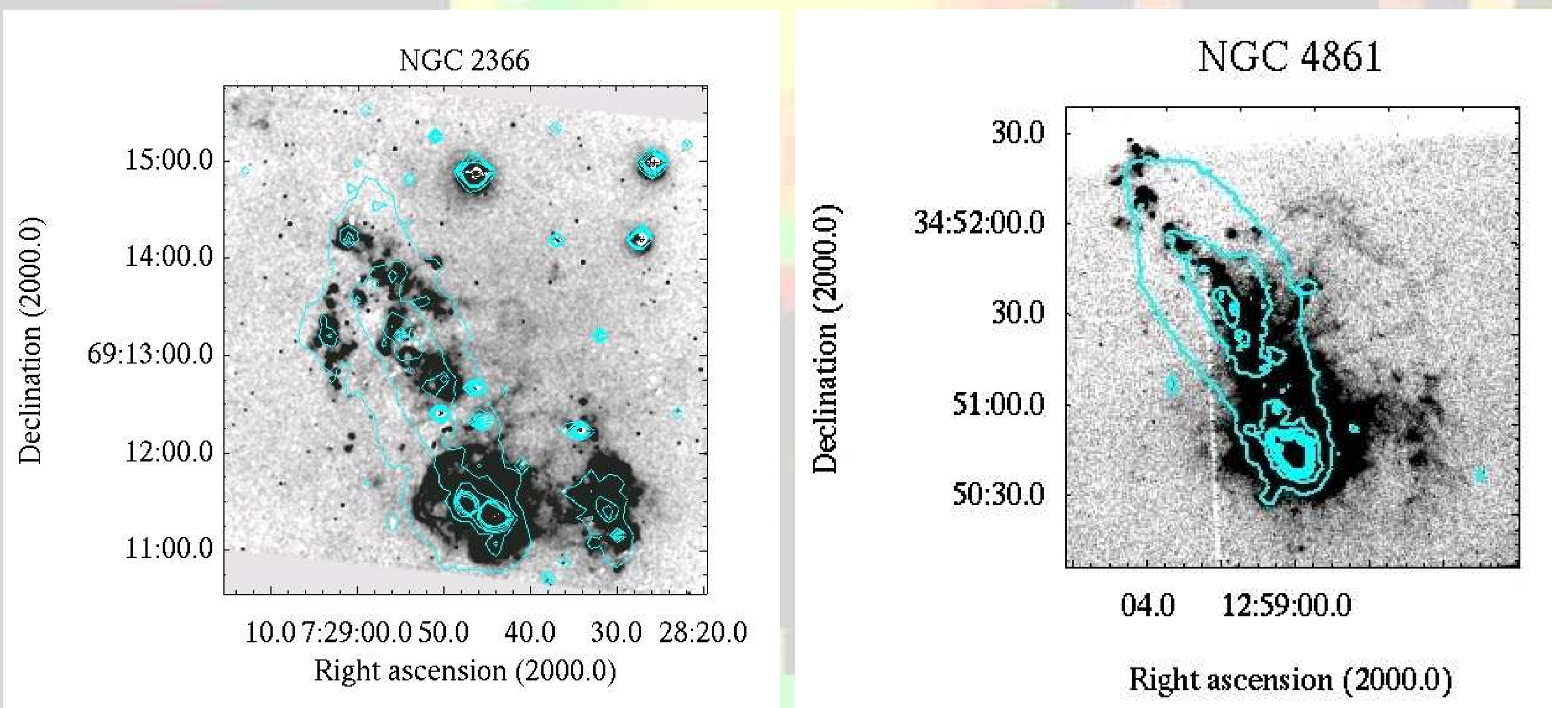

Figure 1: Continuum-subtracted Hα images of both galaxies with the continuum contours overlaid in blue. As searching for the weakest structures, we used adaptive filters based on the H-transform algorithm ([6]).

II. Observations and data reduction

Fabry Pérot (FP) interferometry of the irregular dwarf galaxies NGC 2366 and NGC 4861 was performed at the 1.93m telescope at the Observatoire Haute Provence, France. We used the Marseille's scanning FP and a photon counting camera with a field of view of 5.5′ x 5.5′. The Hα line was observed through an interference filter centered at the rest wavelength of 6564.53 Å (NGC 2366) and 6581 Å (NGC 4861) with a FWHM of 10 Å. The free spectral range of the interferometer (376 km/s) is scanned through 24 channels with a sampling step of 15 km/s. The spatial resolution is about 0.68″.

Object	α J2000	δ J2000	Type (1)	v_{sys} [km/s], (1)	D [Mpc]	
NGC 2366	07:28:54.6	69:12:57	IB(s)m	80	3.44	(2)
NGC 4861	12:59:02.3	34:51:34	SB(s)m	833	7.5	(3)

(1) Data from NED = Nasa Extragalactic Database, (2) Tolstoy et al. (1995), (3) de Vaucouleurs (1991)

In total, NGC 2366 was observed for about 4 hours and NGC 4861 for about 3 hours. We used a neon lamp for the wavelength calibration. The data reduction was done using the software ADHOCw by Jacques Boulesteix (CNRS, Marseille).

III. Analysis and first results

Both galaxies have already been observed by the authors performing high-resolution long-slit echelle spectroscopy ([2]). The spectral resolution of both echelle spectroscopy and FP interferometry is about the same, whereas by using FP interferometry, we are not longer limited by the size of the slit. The echelle data were used during the analysis of the FP data to verify the velocities.

For the analysis, a mix of IRAF and Miriad tools was used. All velocities were measured manually, using a Gaussian fitting routine, with a smoothing of 3 x 3 Pixels to improve the signal to noise. Only detections above a 3 σ limit were considered.

At several places, the Hα emission is split into two to three components. The following velocity maps only contain the velocities of the strongest component.

NGC 2366

- Velocity gradient from the south-west to the north-east indicates the rotation of the galaxy.
- Blue-shifted 'hole' north of the GEHR NGC 2363 gives a hint for an underlying expanding gas component.
- Several small HII regions are detected which are far away from the galactic disk (kpc-distance), especially the one south of the GEHR.
- The huge outflow to the north-west of the GEHR is two times larger than thought before ([2]) and even four times larger than measured by [7], having now a total length of 1.4 kpc. The gas expands with velocities of about 35 km/s, which fits to the detections of [7] and [2].

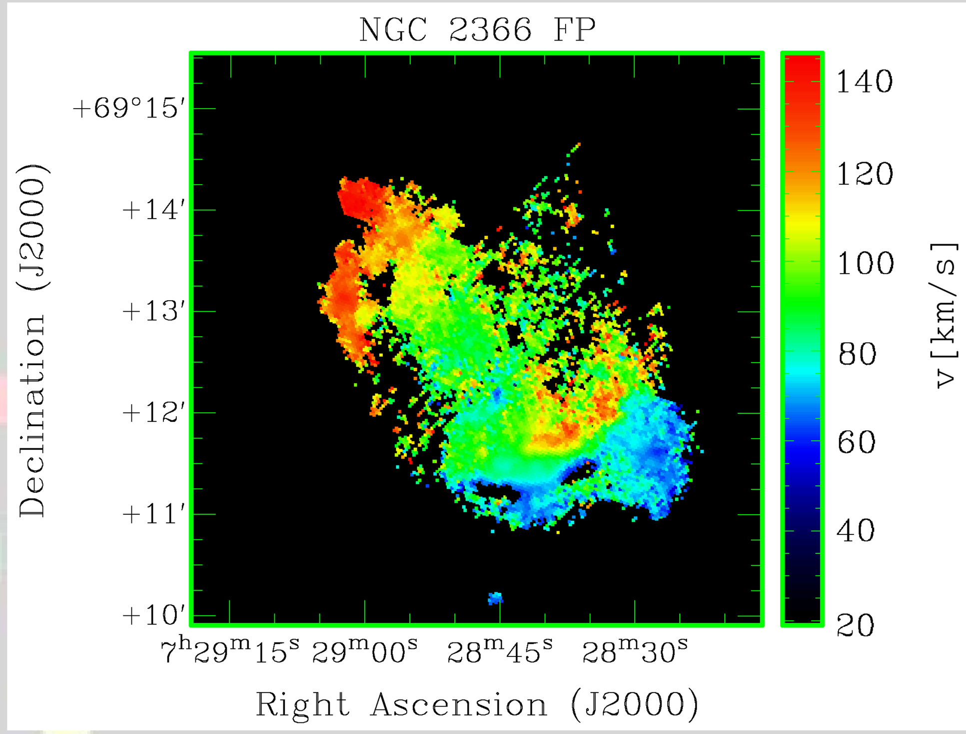

Figure 2: FP velocity map of NGC 2366.

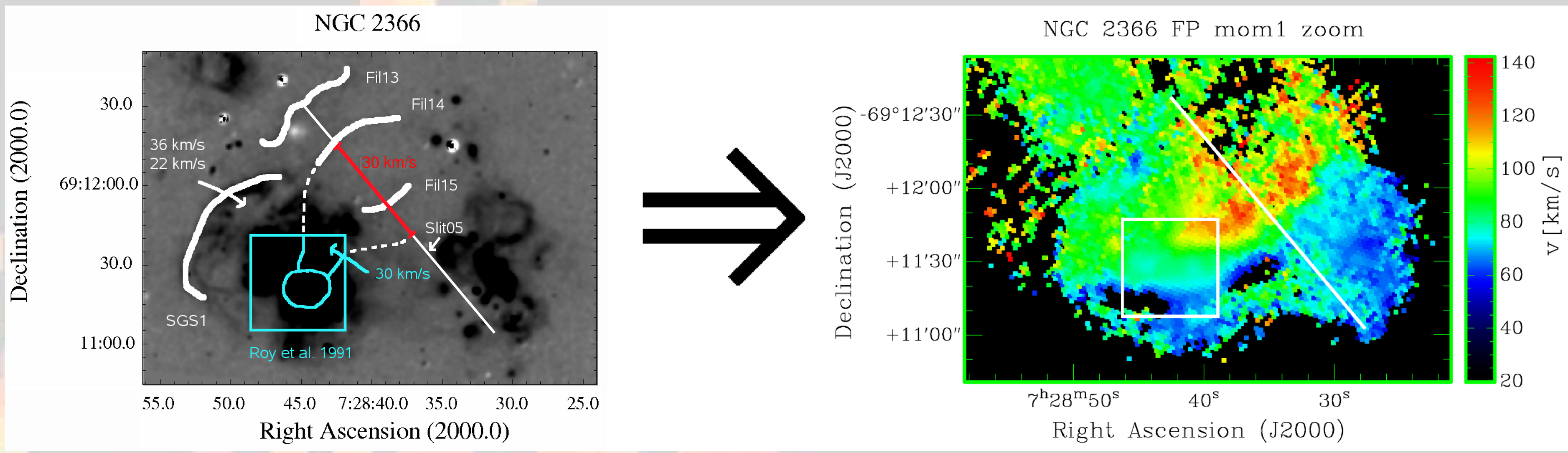

Figure 3: Left-hand side: Scheme of the north-western outflow of NGC 2366. The results of [7] are shown in blue, our results from the echelle spectroscopy ([2]) are shown in red. Right-hand side: Enlarged view of the FP velocity map. The field of view of the observations by [7] is marked in white as well as the position of our echelle spectrum. The outflow can be traced much further out, giving it a size of 1.4 kpc.

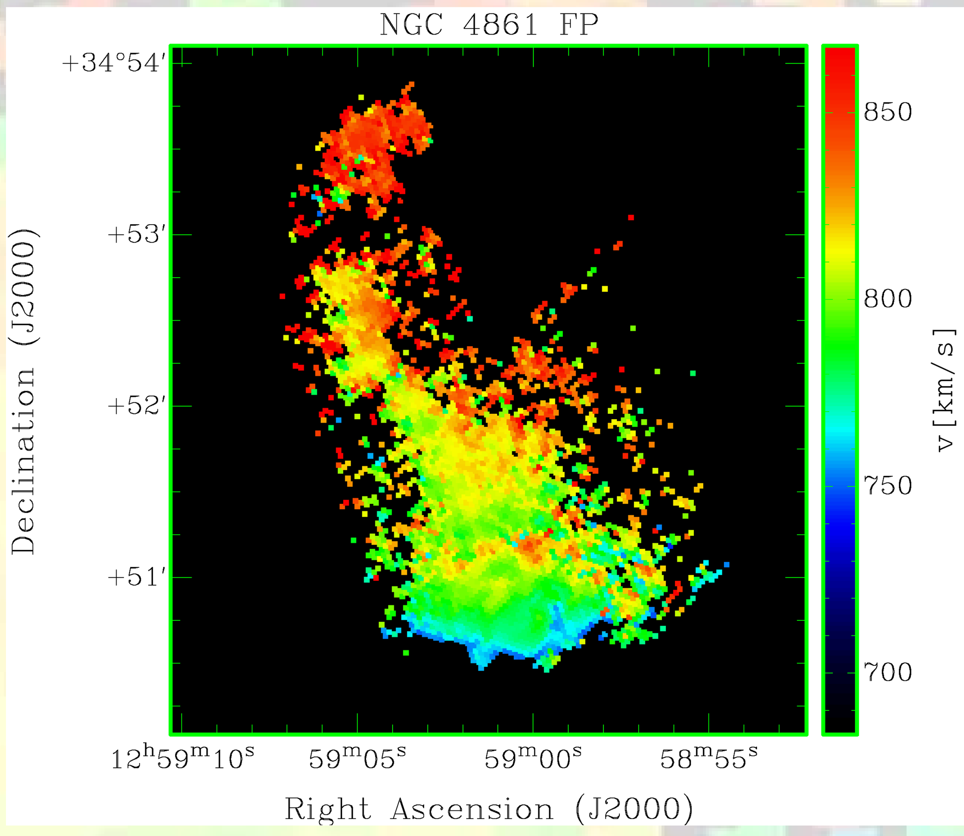

Figure 4: FP velocity map of NGC 4861.

NGC 4861

- Velocity gradient from the south-west to the north-east shows the rotation of the galaxy.
- A red-shifted band north of the GEHR shows an expanding structure. The northern tail of the galaxy shows gas which is redder than expected from the rotational gradient and which seems to flow out from the disk to the supergiant shells.
- Blue-shifted finger-like structure south of the GEHR I Zw 49 indicates an underlying expanding gas structure (also detected on the echelle data).
- The supergiant shells west of the main body have different velocities, which means that they are clearly separated and do not belong to one single giant shell as thought before ([2]).

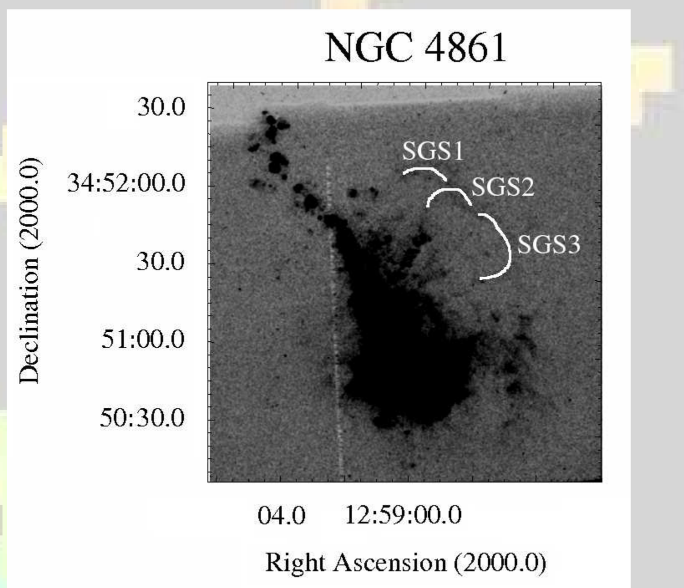

Figure 5: Continuum-subtracted Hα image of NGC 4861. The three supergiant shells are marked in white.

IV. Conclusions

- Both galaxies show prominent large ionised gas features which are expanding in comparison to the main body rotation.
- In NGC 2366, we proved the already detected outflow to the north-west of the GEHR to be twice as large as measured before, which makes it one of the largest outflows measured in dwarf galaxies.
- The three supergiant shells in NGC 4861 show different expansion velocities, which means that they probably belong to two different ionisation mechanisms. The distance of these shells to the disk is of kpc-order so that photoionisation cannot be the driver. Instead, there seems to be a connection between slowly expanding gas in the disk and those shells (chimney-like features).

References

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