Detailed stellar and gaseous kinematics of M31

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We observed the nearby spiral galaxy M31 with the VIRUS-W integral field unit spectrograph on the 2.7m telescope at the McDonald Observatory in Texas. We covered the whole bulge and sampled the disk along six different directions. We fit the line-of-sight velocity distribution (LOSVD) of the stars and the gas, using the Hβ, [OIII] and [NI] emission lines for the latter. From our data we produce kinematical maps of unprecedented detail. We find that the gas emission lines in a large fraction of our covered region show double peaks, pointing to two kinematically distinct gas components. The difference in velocity exceeds 200 km/s in some regions.

Introduction

Due to its proximity M31 is an ideal target to investigate the kinematics and dynamics of a spiral galaxy in high detail. However, its large angular extent complicates the collection of spectroscopic data for the whole galaxy. One of the notable examples uses stitching of multiple longslit observations [1]. With the arrival of the integral field spectrograph VIRUS-W [2], it has become possible to obtain high-quality two-dimensionally distributed spectra over a large field of view.

Observations and data reduction

The spectral resolution of VIRUS-W is R=9000, corresponding to σ_{inst} = 15 km/s. Its fiberhead consists of 267 fibers and at the 2.7m telescope at the McDonald observatory it has a field of view of 105" x 55". With 199 pointings observed during 14 nights, our data cover the whole bulge and sample the disk of M31 along six different directions. We reach approximately one scalelength along the major axis [3]. The locations of the individual pointings are shown in Fig. 1. The data result in 53400 individual spectra. We rebin the data to 7625 spectra for the extraction of stellar kinematics and 2393 spectra for the gas kinematics using a Voronoi binning scheme [4]. The stellar and gas kinematics are fitted with pPXF [5] and GANDALF [6]. For the stars, the Mg b absorption triplet at 5180Å is the most prominent feature. Gas emission lines include Hβ at 4861Å, the [OIII] doublet at 4959Å and 5007Å and the [NI] doublet at 5198Å and 5200Å.

First results

The maps for stellar velocity and velocity dispersion are shown in Figs. 2 and 4.

Figs. 5 and 6 show the kinematics obtained for the [OIII] emission line at 5007Å. In many spectra the emission lines exhibit two distinct peaks (see Fig. 3). The velocity amplitude of the first component reaches 300 km/s, the one of the second component is significantly smaller with a maximum of about 140 km/s.

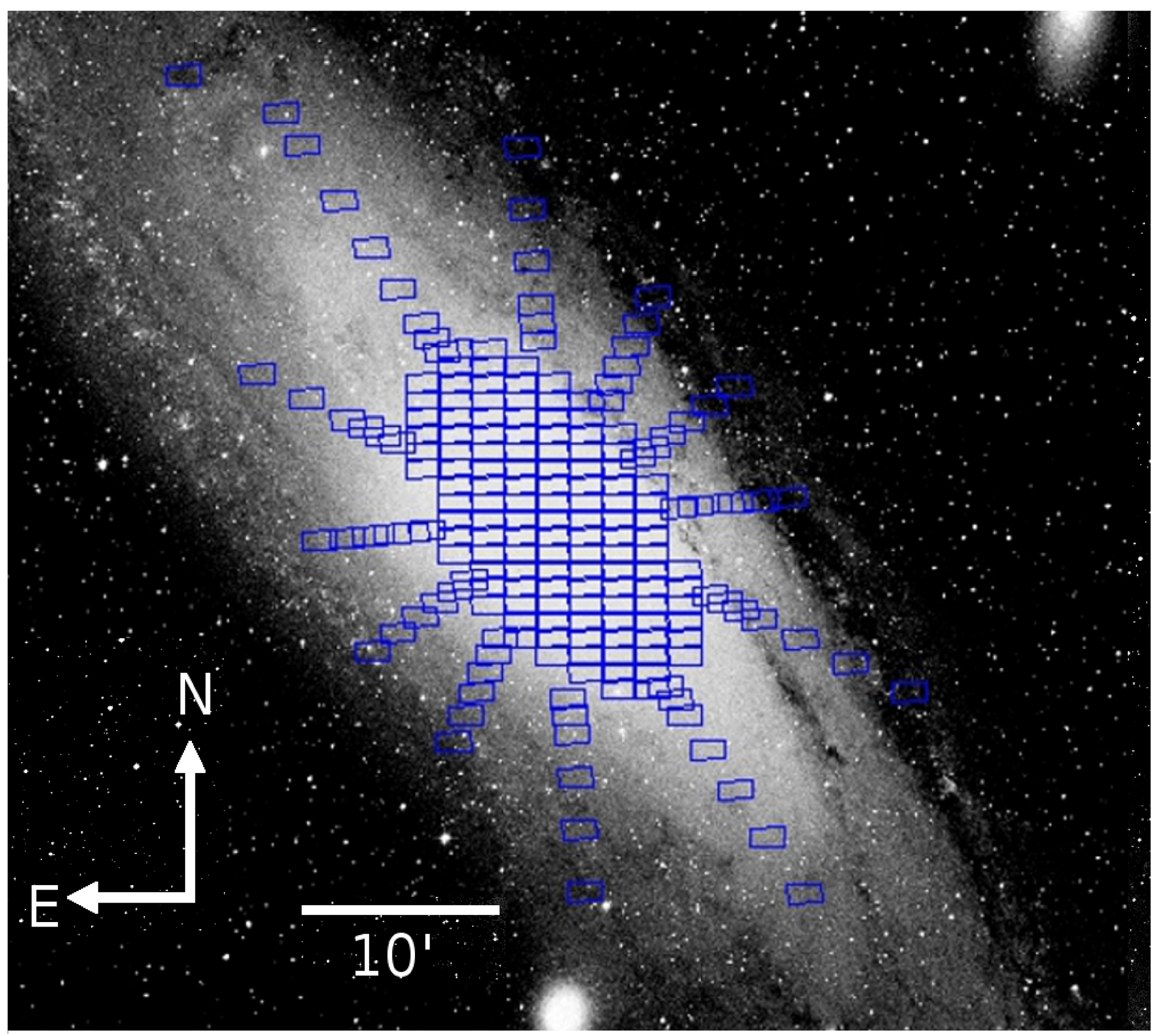

Fig.1: Observed VIRUS-W pointings superposed on a SDSS g-band image.

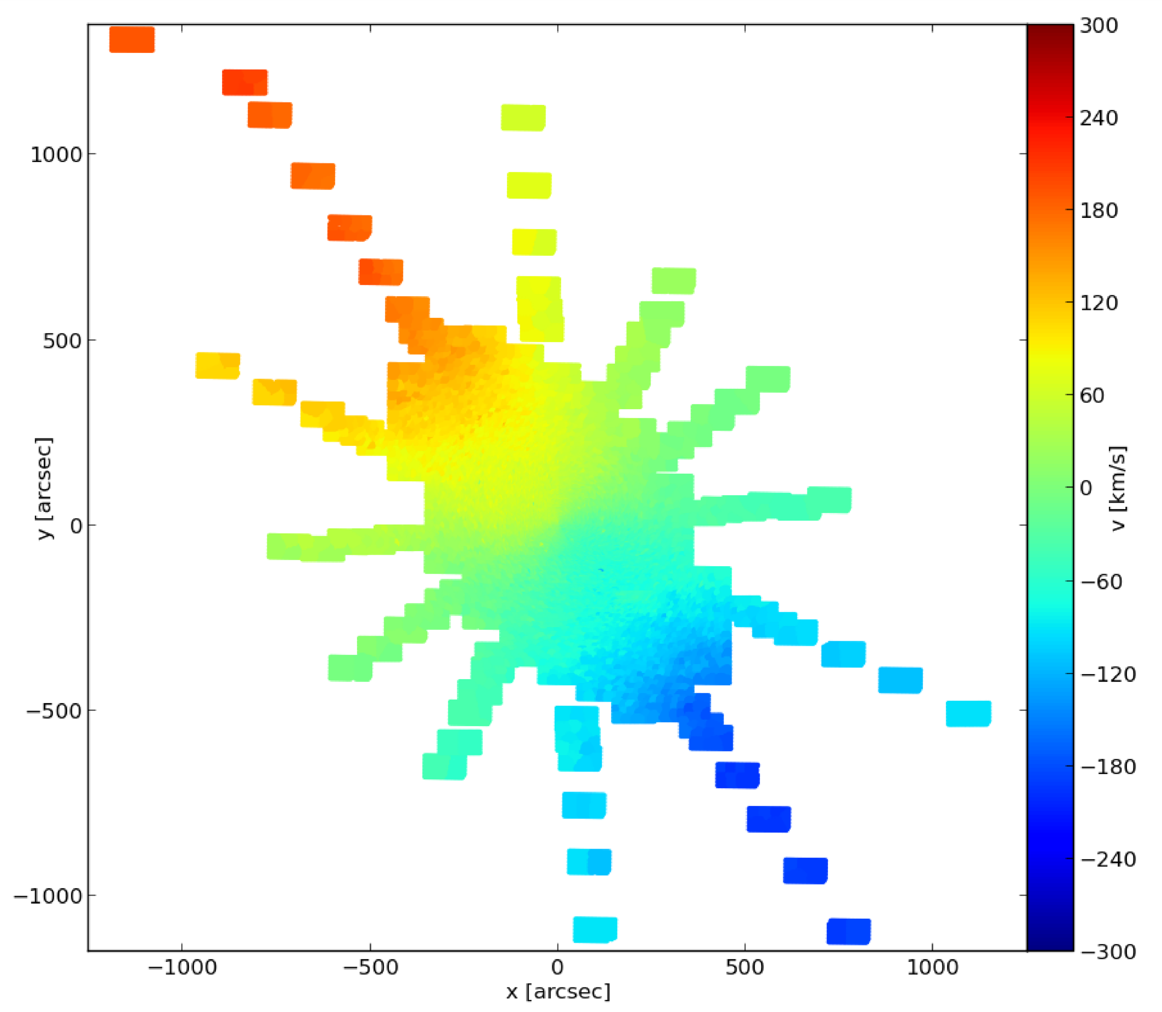

Fig. 2: pPXF derived stellar velocity field from our 7625 binned spectra.

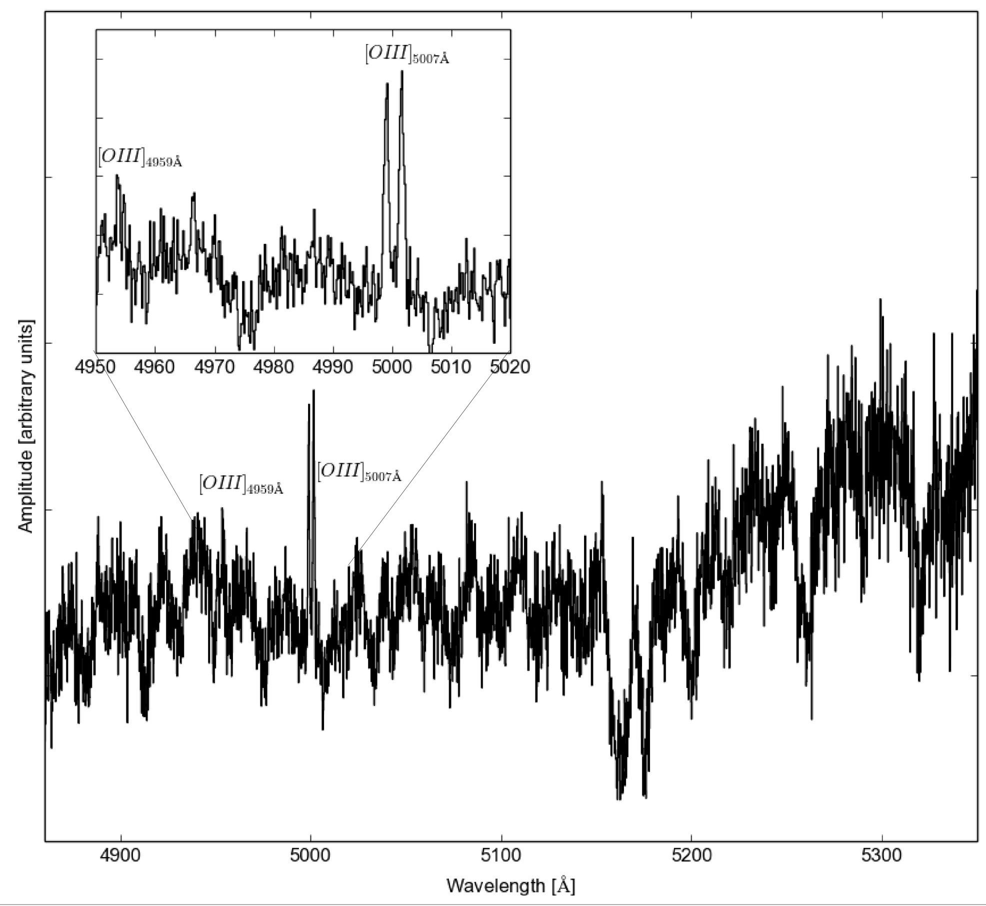

Fig.3: Spectrum extracted from one of the outer bulge pointings. The inset shows a zoom-in on the [OIII] emission doublet. It is readily seen that the brighter of the two lines is split into two components with a velocity offset of 180 km/s.

Outlook

The detailed modelling of the two gaseous components allows us to derive accurate stellar velocities and velocity dispersions, which will form the basis of a three-dimensional dynamical mass model for M31. This model will study the nature of the bar of M31 and help us to interpret the micro-lensing events which we are collecting within the Pandromeda project [7].

Further, we will measure the line strengths of the absorption and emission lines in order to study age, metallicity, [α/Fe] overabundance and ionization mechanisms of the stellar populations and the gas, respectively.

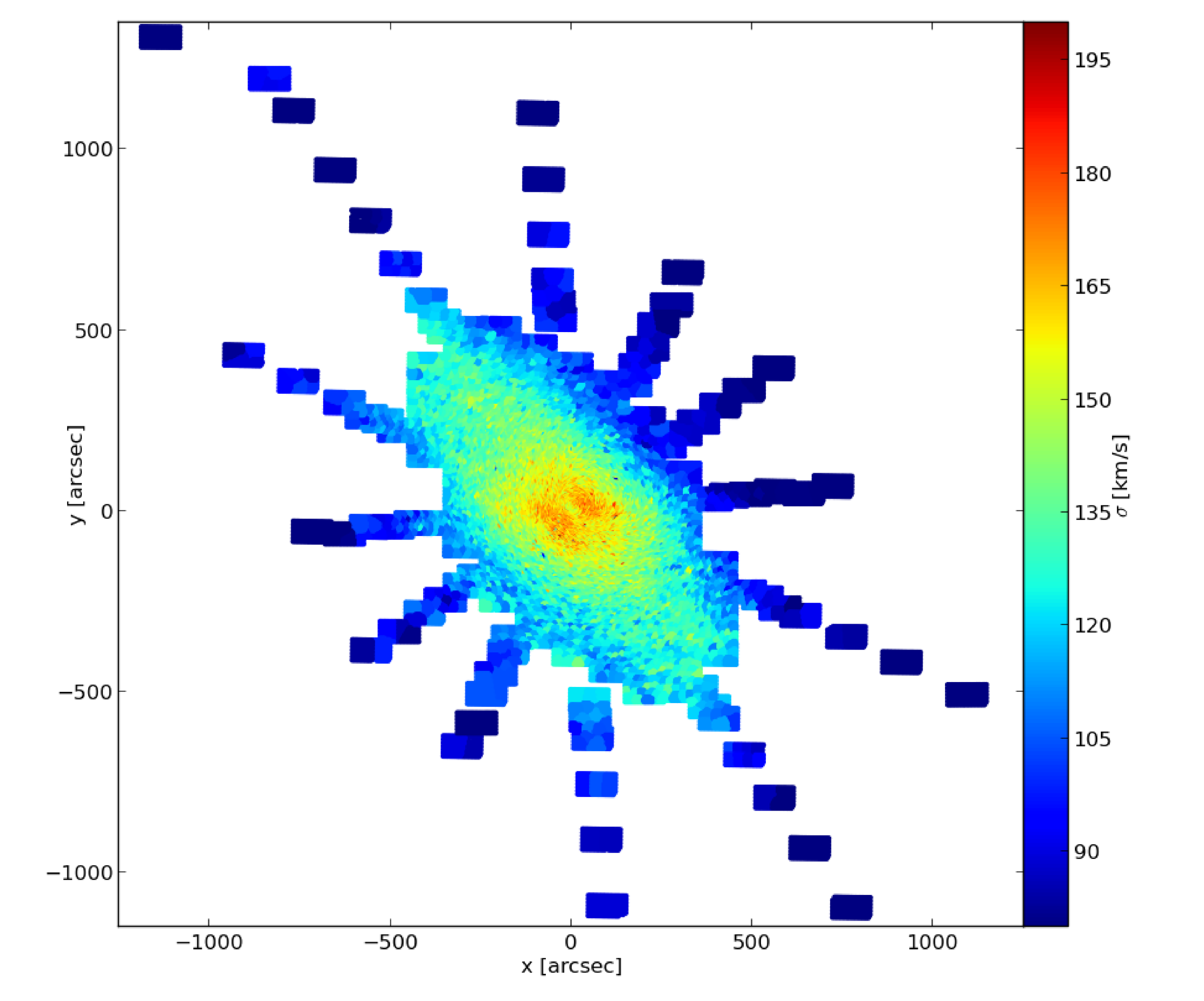

Fig. 4 Stellar velocity dispersion. The dispersion is lower in the northwestern (upper right) region of the bulge than on the opposite side. This may be due to dust obscuring the view in the northwest.

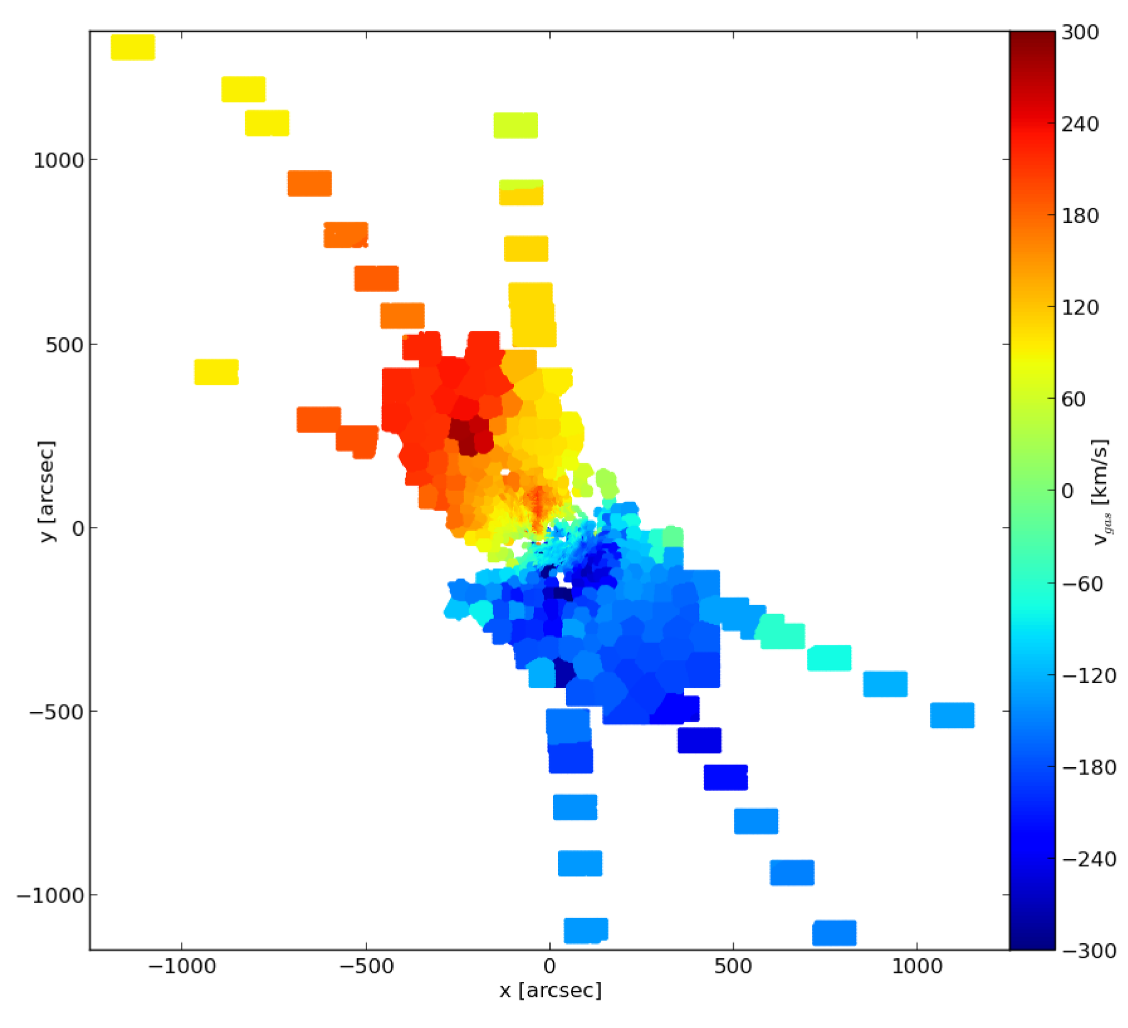

Fig. 5: Velocity field of the higher velocity component of the [OIII] line at 5007Å. The gas rotates faster than the stars. The velocity dispersion is in general low, at roughly 20 - 30 km/s.

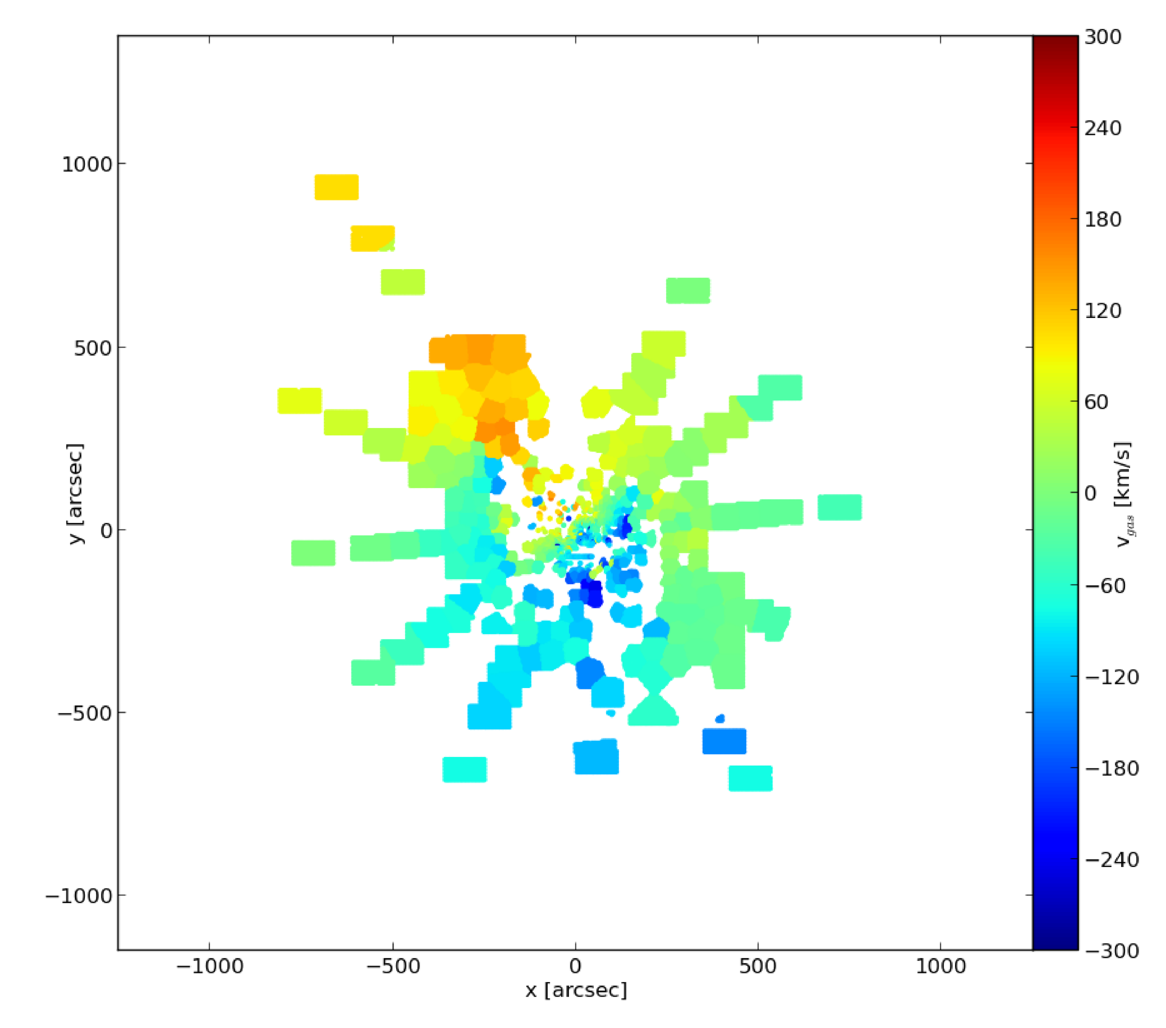

Fig. 6: Velocity field of the lower velocity component of the [OIII] line. The difference between the two gas components exceeds 200 km/s in some regions.

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