Gaseous Streaming Motions Around the Nucleus of M81

Allan Schnorr Müller[1], Thaisa Storchi-Bergmann[1], Rogemar André Riffel[1]; Fabricio Ferrari[2]

[1] Instituto de Física. Universidade Federal do Rio Grande do Sul; [2] Universidade Federal do Pampa

Introduction

Goals: look for feeding mechanisms to the AGN nucleus of M81 via inward gaseous streaming motions and understand how they are related to nuclear spiral arms observed in the structure map (Simões Lopes et al. 2007).

Data: Integral field spectroscopy was obtained with the Integral Field Unit of the Gemini Multi-Object Spectrograph (GMOS-IFU) at the Gemini North telescope. The observations consisted of three adjacent IFU fields (covering 7×5 arcsec² each) resulting in a total angular coverage of 7×15 arcsec² around the nucleus. 1arcsec correspond to 17 pc on the galaxy. The spacial resolution is 0,6 arcsec or 10 pc.

The Galaxy: M81 is a SAab galaxy at a distance of 3,5 Mpc (Paturel et al. 2002). Its AGN is classified as LINER-Seyfert1 and the central black hole mass (M_{BH}) is of 7×10^7 Solar Masses (Devereux et al. 2003).

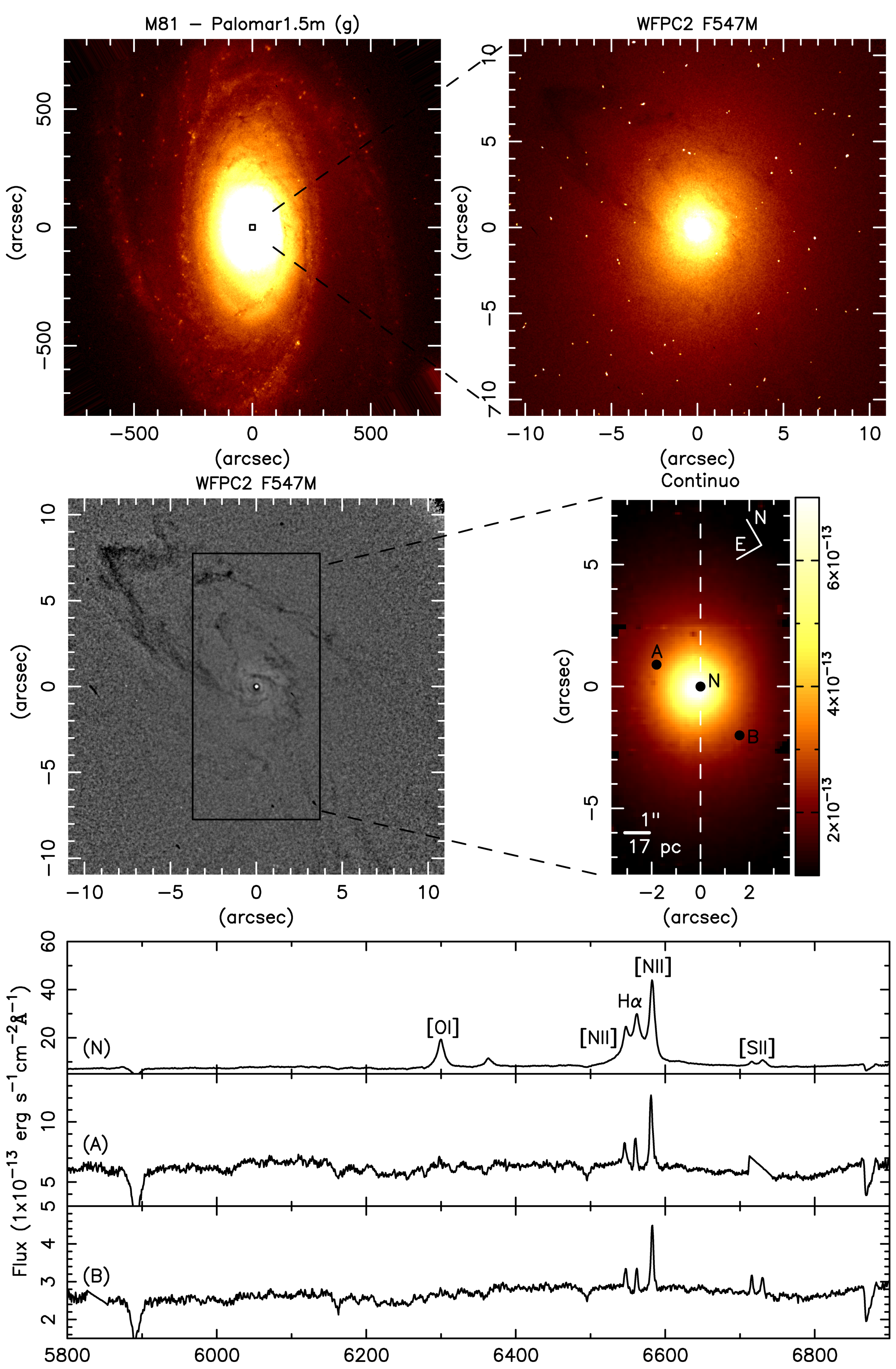

Fig. 1: Top left: large scale image of M81 in the R band (Cheng et al. 1997). The central square shows the field of the WFPC2 observations. **Top right**: image of the central region of the galaxy obtained with the HST WFPC2. **Center left**: structure map obtained from the HST image. The rectangle shows the field of the IFU observation. **Center right**: image obtained from the IFU spectra in the continuum. The dotted white line indicates the position of the line of nodes. **Bottom**: spectra corresponding to the regions marked as N, A and B in the IFU image.

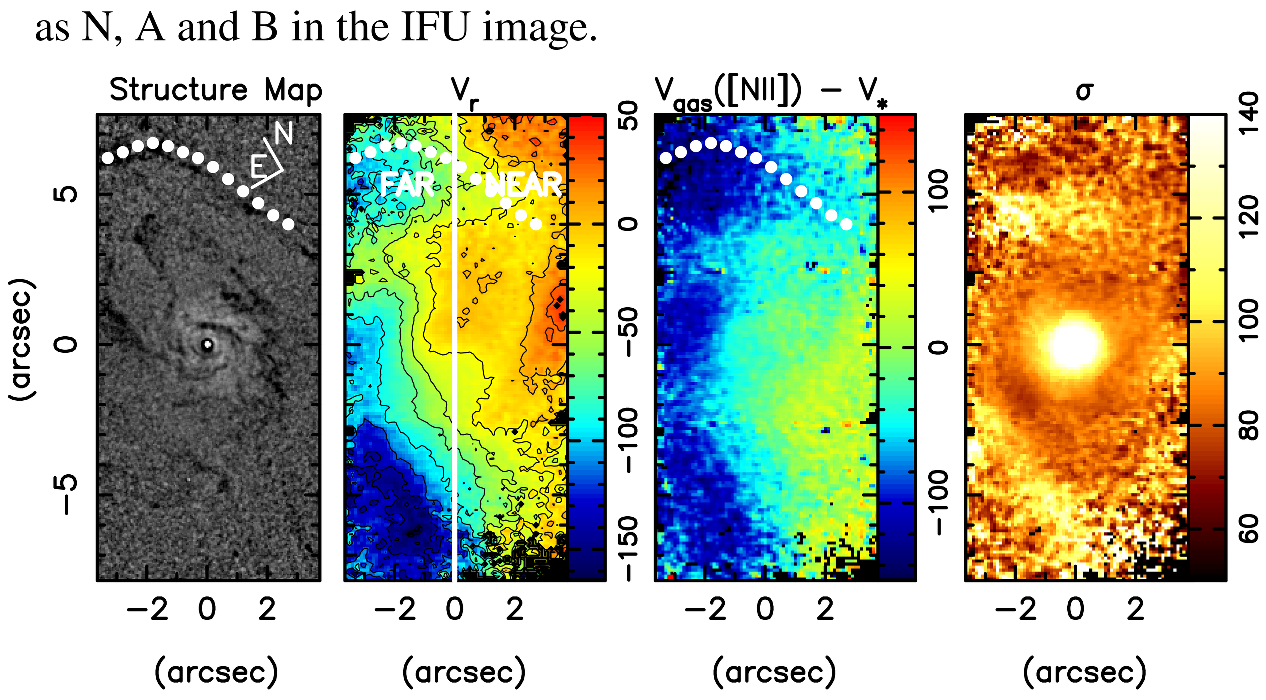

Fig. 2: Gaseous kinematics: The velocity field and velocity dispersion for the gas were obtained fitting gaussians to the [NII]λ6584Å emission line. Above are shown from left to right: structure map, velocity field, residual between gaseous and stellar velocity field and velocity dispersion. The straight white line indicates the position of the line of node and the white dots mark a dust structure related to residuals and features in the velocity field.

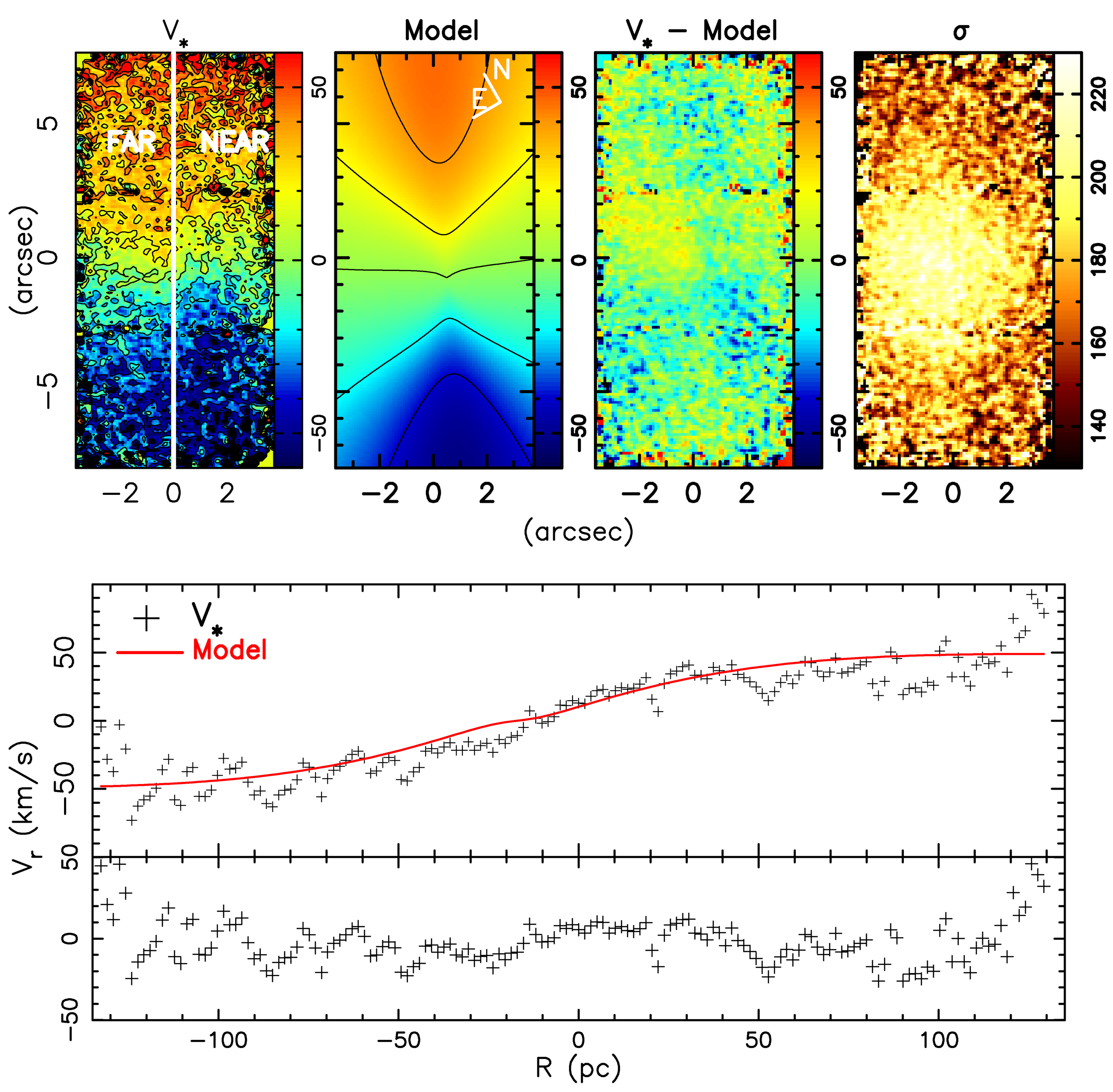

Fig. 3: Stellar Kinematics: The stellar velocity field and velocity dispersion were obtained using the pPFX (penalized pixel fitting) technique (Cappellari & Emsellem 2004). The stellar velocity field was modeled by circular orbits in a Plummer potential. Above we show at the top, from left to right: stellar velocity field, model velocity field, residuals between stellar and model velocity field and stellar velocity dispersion. The straight white line indicates the position of the line of nodes. At the bottom we show the stellar and model velocity curve along the major axis (top) and the residuals along the major axis (bottom).

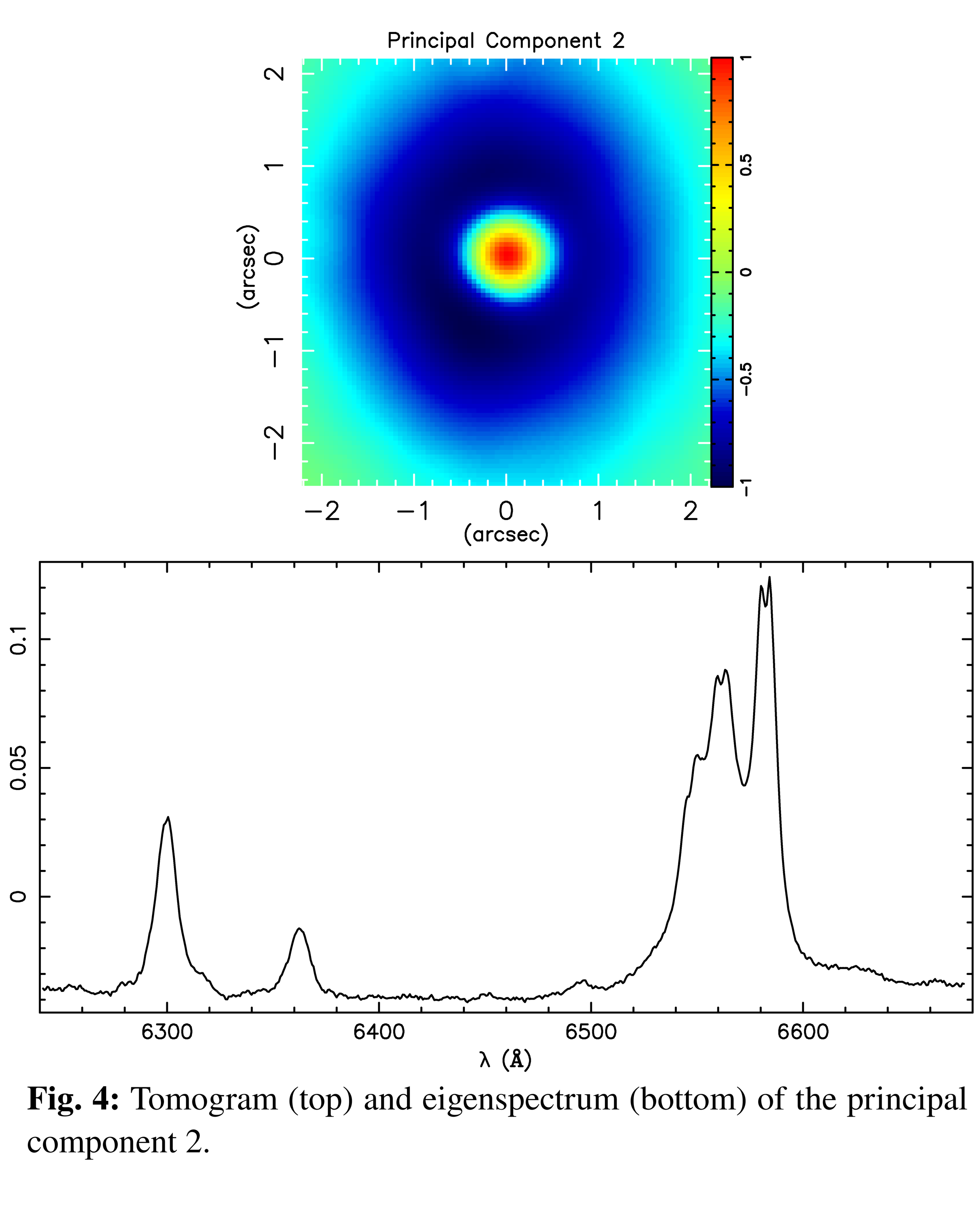

Fig. 4: Tomogram (top) and eigenspectrum (bottom) of the principal component 2.

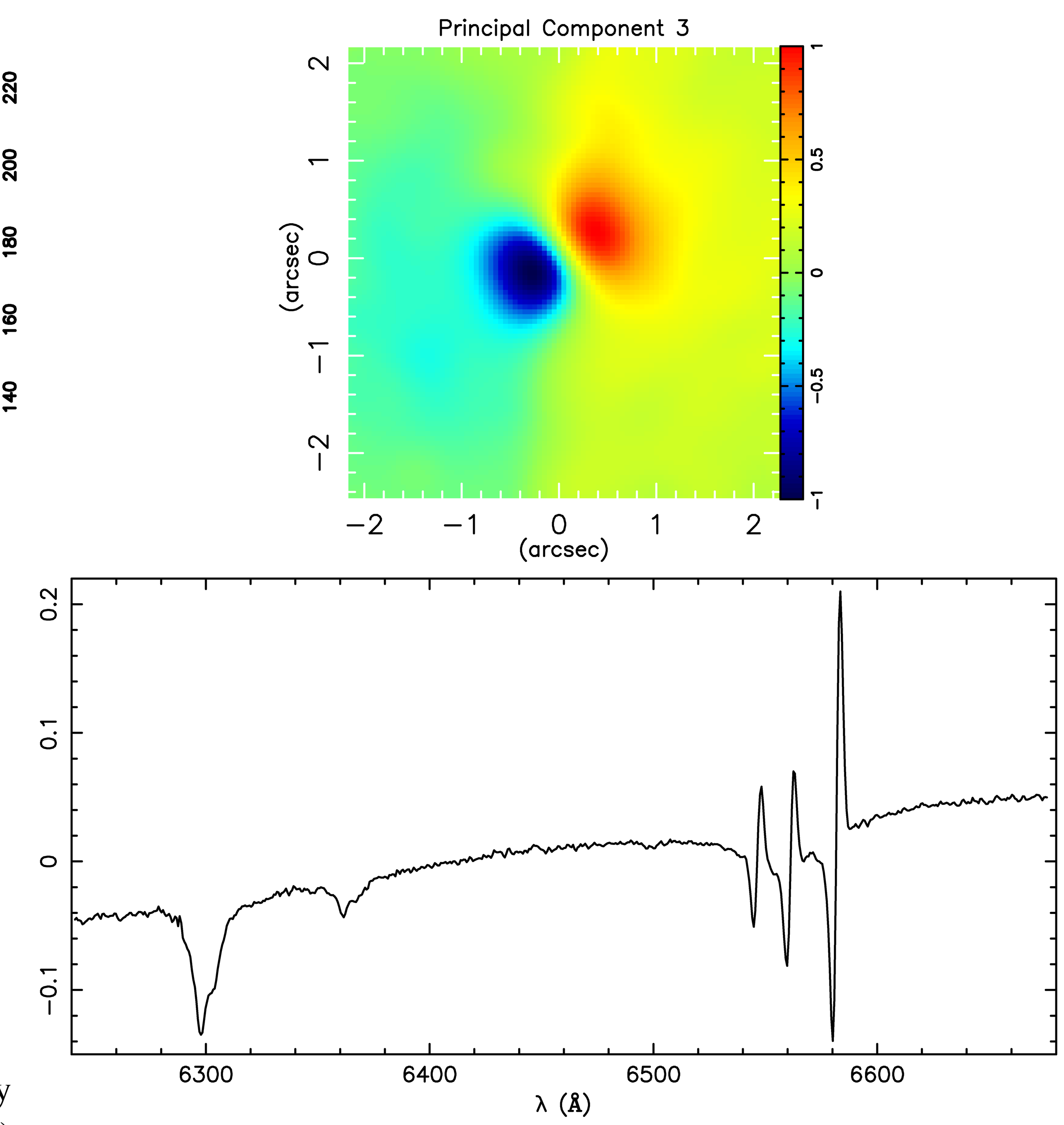

Fig. 5: Tomogram (top) and eigenspectrum (bottom) of the principal component 3.

Principal component analysis: A method of Principal Component Analysis (Steiner et al 2009) was applied to the data cube.

Principal component 1 contributes 97,15 per cent of the variance and its respective eigenspectrum basically represents the stellar population and dominant AGN contribution thus it is not shown.

Principal component 2 contributes 2,48 per cent of the variance and it displays a double peak in the Hα and [NII]λ6584Å emission lines, indicating two kinematic components with positive correlation (Fig. 4).

Principal component 3 contributes 0,23 per cent of the variance and shows two anti-correlated components suggesting the presence of rotation in the emission line gas in the inner 30 parsecs of the galaxy (Fig. 5).

References

Cappellari, M.; Emsellem, E. 2004, PASP, 116, 138.

Cheng, K. P.; Collins, N.; Angione, R.; Talbert, F.; Hintzen, P.; Smith, E. P.; Stecher, T. 1997, UITVi Vol. U.

Devereux, N.; Ford, H.; Tsvetanov, Z.; Jacoby, G. Stis 2003, AJ, 125, 1226.

Paturel, G.; Teerikorpi, P.; Theureau, G.; Fouqué, P.; Musella, I.; Terry, J. N. 2002 A&A, 389, 19.

Simões Lopes, R. D.; Storchi-Bergmann, T.; de Fátima Saraiva, M.; Martini, P. 2007, AJ, 655, 718.

Steiner, J. E.; Menezes, R. B.; Ricci, T. V.; Oliveira, A. S. 2009, MNRAS, 395, 64.

Conclusions

•Measurements of the gaseous and stellar kinematics and a principal component analysis were performed to look for feeding mechanisms to the AGN nucleus of M81 via inward gaseous streaming motions and understand how they are related to nuclear spiral arms observed in the structure map. The residuals between gaseous ([NII]λ6584Å) and stellar velocity field show blueshifted residuals in the far side of the galaxy and redshifted residuals in the near side. This indicates motion of the gas towards the central region of the galaxy.

•The stellar velocity field displays a rotation pattern which agrees with the pattern observed at larger scales by previous authors. The mean velocity dispersion is 180 km\s. Using the M-σ relation the resultant M_{BH} is 9×10^7 solar masses which is in agreement with previous results.

•A principal component analysis shows that principal component 2 displays a double peak in the Hα and [NII]λ6584Å emission lines, suggesting either an unresolved outflow or rotation. Principal component 3 reveals what appears to be a rotating disc in the inner 30 parsecs of the galaxy.