IFU study of the morphologically distorted galaxy Kaz364

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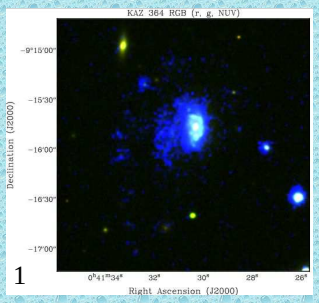
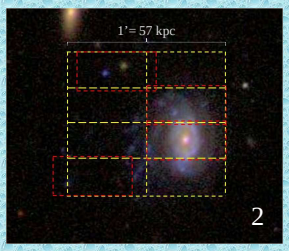
We present the results of a study of the morphologically distorted galaxy **Kaz364**, a probable member of a substructure of the galaxy cluster Abell 85 (A85). The aim of this study is to disentangle hydrodynamical from gravitational effects as possible origins for this distortion.
Kaz364 was catalogued as a galaxy with UV excess in Kazarian and Kazarian (1982). It presents a very long and fragmented spiral arm bending to the E, while its central part presents a ring with intense UV emission, which resembles the letter D. Also, the eastern part of the central region seems to be subject to intense star formation (Figure 1).



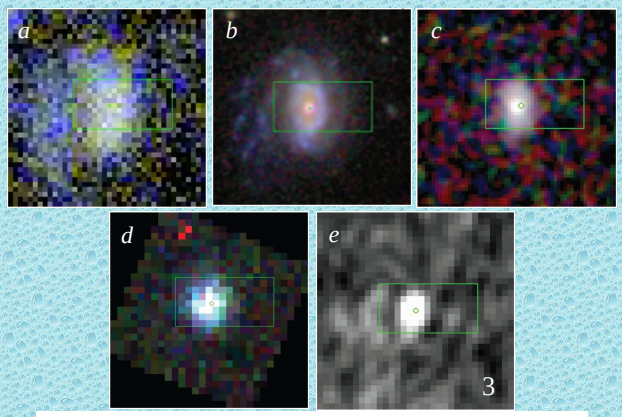


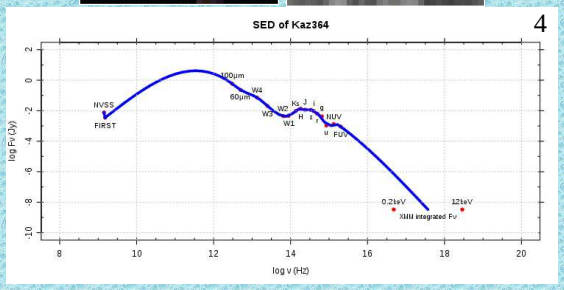
METHODOLOGY

We used IFU data obtained with the *Eucalyptus* spectrograph (prototype of SIFS, at SOAR Telescope) at the 1.6m telescope of Pico dos Dias Observatory. Four 30"×15" **fields** (512 spaxels of 0.93 □") were observed (red rectangles in Figure 2) – here we present the results only for the field covering the central region of the galaxy. A 600 l/mm grating was used, covering the 6480-7120Å wavelength range (centered around H_α for Kaz364). Besides H_α (6563Å), [OI] (6300), [NII] (6548 and 6583Å) and [SII] (6716 and 6730Å) lines were found in this range.

SPECTRAL ENERGY DISTRIBUTION (SED)

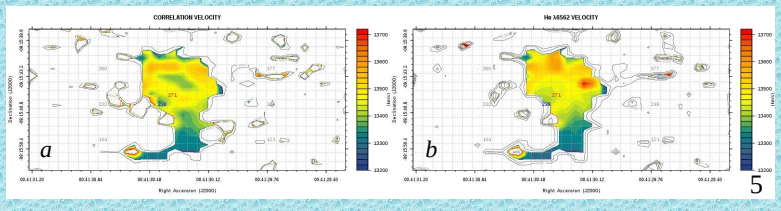
We used **photometric data** from all the available large surveys that included Kaz364 (Figure 3, panels *a* to *e*), namely FUV and NUV from the Galaxy Evolution Explorer (GALEX, e.g. Morrissey *et al.* 2007); u, g, r, i and z from the Sloan Digital Sky Survey (SDSS, e.g. Abazajian *et al.* 2009); J, H, Ks from the 2 Micron All Sky Survey (2MASS, e.g. Skrutskie *et al.* 2006), W1, W2, W3 and W4 from Wide Field Infrared Survey Explorer (WISE, e.g. Wright *et al.* 2010); and the Faint Images of the Radio Sky at Twenty Centimeters (FIRST, e.g. White *et al.* 1997), among others. With these data we constructed an approximated **SED** for Kaz364 in the range from UV to Radio (Figure 4).

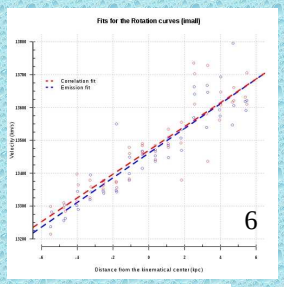


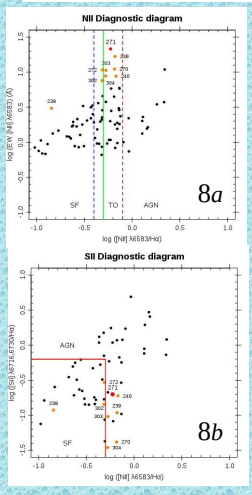


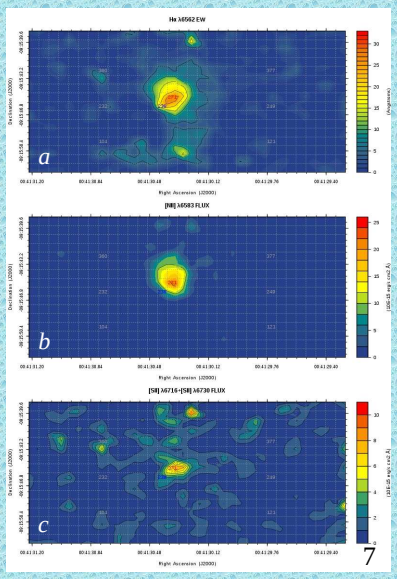
KINEMATICAL MAPS AND ROTATION CURVE

We obtained **kinematical maps** of absorption (cross-correlation) and emission (for the observed emission lines) velocities. Figure 5 shows these maps for correlation velocities (panel *a*) and H_α emission velocities (panel *b*). In these maps one can see that the northern portion of the galaxy central part presents a complex velocity structure. This peculiarity can also be seen in the **rotation curve** presented on Figure 6: the dispersion of points is larger in right side of the curve. Since the sampled region covers only a few kpc around the center of Kaz364, the rotation pattern is dominated by the rigid body profile. The rotation velocity in this range reaches about 200 km s^{-1} (probably very close to the galaxy's maximum velocity. The kinematical major axis of Kaz364 has a PA around 5°.









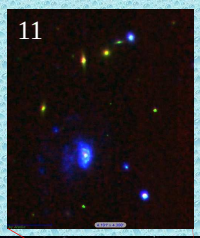
EQUIVALENT WIDTHS, FLUXES AND THE AGN

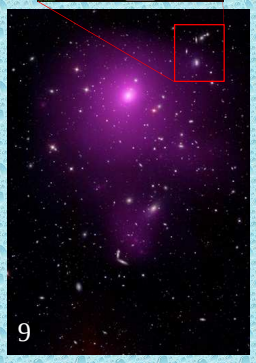
The H_α **equivalent width** (EW) **map**, [NII] (6583Å) and [SII] (6716Å + 6730Å) **flux maps** are shown in Figure 7 (respectively in panels *a*, *b* and *c*). They reveal a centrally concentrated emission (with some spots mainly in the direction of the kinematical major axis). This emission is probably dominated by the AGN emission of Kaz364, although some circum-nuclear star formation (SF) is also expected (the L_{UV} from GALEX suggests a SF rate of about 20 $M_\odot$ yr^{-1}).

Kaz 364 has been poorly classified (no previous spectrum or measurement published) as a **Seyfert** galaxy (e.g. Pislar *et al.* 1997). This classification was improved by distinct analyses we performed:

- The SED shows a little "blue-bump" characteristic of AGNs. Also, the IR emission is much stronger than the optical and UV, revealing a large amount of dust, expected more in a Sy2 than a Sy1.
- The equivalent width of H_α in the central spaxel (271, the AGN, marked on Figures 5 and 7) is of about 1500 km s^{-1} (not large enough for a Sy1).
- The diagnostic diagrams (shown in Figure 8: panel *a* for [NII] diagram and panel *b* for [SII] diagram, Coziol *et al.* 1998) show that spaxel 271 and its eight adjacent neighbours reside close to the Sy2 region but on the TO (transition objects) band. This means that, although the [NII] and [SII] emissions are dominated by the Sy2 AGN, there is also some SF occurring in the central region. In fact there is a neighbouring spaxel (238, also marked on Figures 5 and 7) that is clearly dominated by SF.

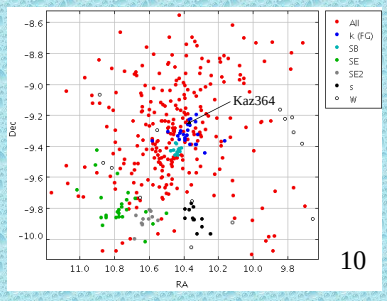
It is also worth to mention that some X-ray emission from Kaz364 was also reported (e.g. Sivakoff *et al.* 2008).





KAZ ENVIRIONMENT AND A85 CLUSTER

Abell 85 is a relatively massive and dynamically very active cluster at z ~ 0.056 (Figure 9: X-ray emission detected with Chandra X-ray Observatory over optical image from SDSS). It is one of the best studied nearby clusters (farther than Coma) and a frequent reference concerning the presence of substructures (e.g. Bravo-Alfaro *et al.* 2010). In Figure 10 we show the distribution of galaxies in the distinct substructures of this cluster (Caretta *et al.* 2014), where the position of Kaz364 is marked (as a member of the "**Foreground Group**", FG). The immediate vicinity of Kaz364 is also zoomed in Figure 11 (a combination of NUV, g and Ks bands). The closest neighbours in projection to Kaz364 (the early-type galaxies toward NE and N) are, in fact, members of the A85 main body, about 2300 km s^{-1} behind the FG. The nearest relatively massive real neighbours are the early and the late-type galaxies toward NW.



CONCLUSIONS AND PERSPECTIVES

- We have confirmed the AGN nature of Kaz364, have classified it as a Sy2 and found evidence of circum-nuclear SF.
- The northern portion of the central region presents a complex kinematical structure.
- The hydrodynamical effects from the ICM of A85 are probably minimum since the foreground group is sufficiently far from the main structure.
- We have refined the membership of Kaz364 and now we can estimate (after we have calculated its mass) the gravitational attraction between it and its closest neighbours and between it and the main structure of A85.
- We will finish the analyses of the remaining fields, complete the rotation curve and estimate the mass of Kaz364.

REFERENCES

K.N. Abazajian, J.K. Adelman-McCarthy, M.A. Agüeros, Marcel *et al.* 2009, ApJS 182, 543.
H. Bravo-Alfaro, C.A. Caretta, C. Lobo *et al.* 2009, A&A 495, 379.
C.A. Caretta, H. Andernach, R. Coziol *et al.* 2014, in preparation.
R. Coziol, A.L.B. Ribeiro, R. de Carvalho *et al.* 1998, ApJ 493, 563.
M.A. Kazarian and E.S. Kazarian 1982, Afa 18, 512.
P. Morrissey, T. Conrow, T.A. Barlow *et al.* 2007, ApJS 173, 682.
V. Pislar, F. Durret, D. Gerbal *et al.* 1997, A&A 322, 53.
G.R. Sivakoff, P. Martini, A.I. Zabludoff *et al.* 2008, ApJ 682, 803.
M.F. Skrutskie, R.M. Cutri, R. Stiening *et al.* 2006, AJ 131, 1163.
R.L. White, R.H. Becker, D.J. Helfand *et al.* 1997, ApJ 475, 479.
E. Wright, P. Eisenhardt, A. Mainzer *et al.* 2010, AJ 140, 1868.