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OBSERVATIONS OF AGNs WITH THE 2m TELESCOPE OF ROZHEN OBSERVATORY: AIMS AND PRELIMINARY RESULTS

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Abstract. Here we present an observational program for four Active Galactic Nuclei (AGNs) with the 2-meter telescope of Rozhen observatory (Bulgaria). The aims of the observations are given. Some of the preliminary results for Mrk 1040 are presented.

1. INTRODUCTION

Active Galactic Nuclei (AGNs) are one of the most interesting objects in astrophysics today (Osterbrock, 1989). First, by investigation of the processes in central part of these objects we can learn about the innermost part of other, 'normal', galaxies, i.e. the nucleus can be directly observed in multi- wavelength region, that can bring us information about the most central part of galaxies. Second, AGNs are located at different cosmological time-scales, consequently their investigations are cosmologically important. One of the characteristics of AGNs are emission lines. The lines can have very complex shapes (see e.g. Sulentic et al., 2000, and references therein), it depends where is their forming region. Using radiation in lines and continuum we are able to conclude about structure and kinematics of the emission region in AGNs as well as about the physics of the innermost part of these objects. One of interesting question is; what can generate the activity in these objects? To answer on the question, the investigation of connection between the nucleus and an extensive structure of AGNs are needed.

Here we will present our program for observations of four AGNs with 2 meter telescope of Rozhen observatory in order to investigate an extensive structure of AGNs.

Table 1: The selected objects

Object	Typ	red-shift	mag.
Akn 120	Sy1 with doub.-peaked lines	0.03230	14.1
Arp 102B	Sy1 with doub.-peaked lines	0.02417	15.12
Mrk 1040	Sy1 with comp.	0.01665	14.46
Mrk 817	Sy 1 with asymm. [OIII]	0.03145	14.50

2. ASTROPHYSICAL CONTEXT – AIMS

We intend to observe four objects in different narrow filter bands as well as in U and I filters. The idea is, for different astrophysical reasons (see below), using the images in different filters to explore an extensive structure of these AGNs. The selected objects are presented in Table 1.

2.1. Mrk 1040 AND COMPANION

LEDA 212995 is a small galaxy with emission lines that indicates star-forming region (H II lines, see Popović et al., 2004a). The dimension of galaxy is $0.20' \times 0.10'$ and magnitude >19. The galaxy is visually located near the Sy 1 galaxy Mrk 1040 (z=0.01665, Huchra et al., 1999).

Afanasiev and Fridman (1993) pointed out that an analysis of the (B-R) color distribution in the galactic disk and the presence of a distinct dust lane in the disk show that 'the northeast side of the galaxy is farther away, and the companion, which is bluer than the disk of Mrk1040, is closer to the observer'. The spectroscopical observations of Mrk1040 and LEDA 212995 were given in Amram et al. (1992), where the asymmetry in velocity field of companion is found and assumed that this asymmetry is due to interaction of these two galaxies. According to the red-shift of companion 0.0169 ± 0.00015 estimated by Popović et al. (2004b), it seems that objects are close each other and with the observations we would like to see any evidence for interaction between these galaxies.

2.2. AGNs WITH DOUBLE-PEAKED LINES

The double-peaked line shapes indicate that in these AGNs the emission of an accretion disk is present (Eraclous and Halpern, 1994; 2003). These galaxies not only have the similar (double-peaked) line profiles, but they show some similarity as (Eraclous and Halpern, 1994; 2003): i) an unusually large contribution of starlight to the optical continuum around Hα, ii) unusually large equivalent widths of low-ionization lines, iii) unusually large ratio of [OI]/[OIII]. With observations in different narrow filter bands of two AGNs (see Table 1) we would like to investigate an extensive structure of these objects, in order to see differences and similarities in AGNs with double-peaked lines.

2.3. Mrk 817 - AGN WITH ASYMMETRIC [OIII] LINES

Mrk 817 was observed spectroscopically several times. The narrow [OIII] lines show very extensive blue part (Popović et al., 2004b). This indicates an outflow in narrow

Table 2: Narrow-Band Filters

λ_c nm	τ_m %	$FWHM$ nm	Emission
468.1	0.607	18.8	HeII, 4686
500.9	0.726	22.3	[OIII], 4959,5007
575.5	0.644	23.5	Continuum
653.0	0.685	20.8	Hα, 6563
673.2	0.672	21.0	[SII], 6717, 6734

line region. In principle, narrow line region is enough large that can be resolved in near AGNs. We would like to explore an extensive structure in [OIII] lines, continuum, He II and Balmer lines in order to see sign of the outflow in the extensive region of the AGN.

3. OBSERVATIONS AND DATA REDUCTION

The observations have been made at Rozhen National Astronomical Observatory (longitude: 01h38m58s (E), latitude: $+41°41'35''$, altitude 1759 m) with the 2 m Ritchey-Chretien-Coude telescope. In Ritchey-Chretien focus the equivalent focal length is 16 m, the field is one square degree with a scale of 12.89 arcsec/mm. The telescope is equipped with a Photometrics AT200 CCD camera with 1024×1024 pixels array, with 1 pixel=0.32 arcsec and field $5.45'\times5.45'$.

The realization of the UBVRI broad-band system on the telescope is as follows – U: 2mm UG1 + 1mm BG39; B: 1mm BG14 + 1mm GG11 + 1mm BG23; V: 2mm GG495 + 1mm BG39; R: 2mm OG570 + 1mm KG3; I: 3mm RG9.

The set of narrow-band filters in Rozhen Observatory (diameter 45 mm) is given in Table 2.

All AGNs fro the Table 1, should be observed with filters noted in Table 2.

Additional observations of Mrk 1040 in the period 25-29 November 2003e, were performed with the two-channel focal reducer of the Max-Plank-Institute for Aeronomy (MPAe, Jockers et al., 2000). The blue channel was equipped with the Rozhen Photometrics AT200 CCD camera. A mask was used to remove the scattered light. This reduces the useful field to 512×512 pixels, where 1 pixel=$0.88''$ and field $7.5'\times7.5'$.

For the red channel the MPAe CCD camera was used. The field is also $7.5'\times7.5'$ with 1 pixel=$0.88''$. A color divider reflecting for λ <520 nm and transmitting for $\lambda > 580$ nm has been used. The filters used with the two-channel focal reducer during the observations in the period 25-29 November 2003 are given in Tables 4 and 5.

Standard reduction procedures including bias subtraction, trimming and flat-fielding have been performed with the help of the IRAF software package.

4. PRELIMINARY RESULTS

Till now, we have a complete set of observations only for Mrk 1040. The galaxy was observed in November 2003, and in January 2004. We observed narrow and broad-band images of the object Mkn1040 (described in previous section). Here we

Table 3: The MPAe Narrow-Band Filters

Filter	λ_c nm	τ_m %	$FWHM$ nm	Emission	Notes
IF 443	443	0.797	4.4	[OIII] 4363	No blocking filter is necessary
IF 501	500.2	0.701	4.1	[OIII] 4959	
IF 510	509.4	0.734	4.4	[OIII] 5007	
IF 667	666.2	0.910	5.5	Hα, 6563	

Table 4: The MPAe Broad-Band Filters

Filter	λ_c nm	τ_m %	$FWHM$ nm	Notes
DUG 11	338	0.832	75	Stronger cut-off than the cut-off of the filter because of absorption in the camera lens and the collimator
I	797	0.964	153	Up to 900 nm only

processed only the observations in the U- and I-band (broad band filters) and in the [HeII]4686 and [OIII]4959,5007 narrow filter bands. Also, we compare the narrow bands with continuum filter $\lambda = 5755$ Å.

Mrk 1040 is a Sy1 galaxy with different star-forming regions in stellar disk. LEDA 212995, a close companion, is also under star-formation (see Fig. 1). It is not clear if the companion is under interaction or not, and if the star-formation (in companion) and nuclei activity (in Mrk 1040) are caused by the interaction of these two galaxies.

In order to find any evidences about interaction we have processed the images applying the following techniques:

(1) A surface brightness analysis over the narrow-band images has been applied, assuming an elliptical isophotal model, and based on the technique given by Jedrzejewski (1987). We used own code (Sanchez) for the analysis, which provides us with a model (for Mrk 1040) of the smooth component in the images. This model has been subtracted from the images (in different narrow bands). After subtraction we obtained an image where can be seen the substructures in the objects as well as structure(s) that may indicate interaction between the objects (see Figs. 2 and 3, panel top-left).

(2) We have modeled Mrk 1040 galaxy using GALFIT (Peng et al., 2002). The galaxy model has been done including three components: The nuclear point-like source, a bulge and disk. This model has been subtracted to the images in order to detect the substructures (Figs. 2 and 3, panel down-left).

(3) We have scaled the continuum image to the narrow-band images, and subtracted from them. It provides us with images of the pure HeII and [OIII] emission lines (Fig. 4, bottom-right).[1]

[1]We should note that the continuum image is not as deep as the non-subtracted narrow-band images. It is due to the noise of the continuum image.

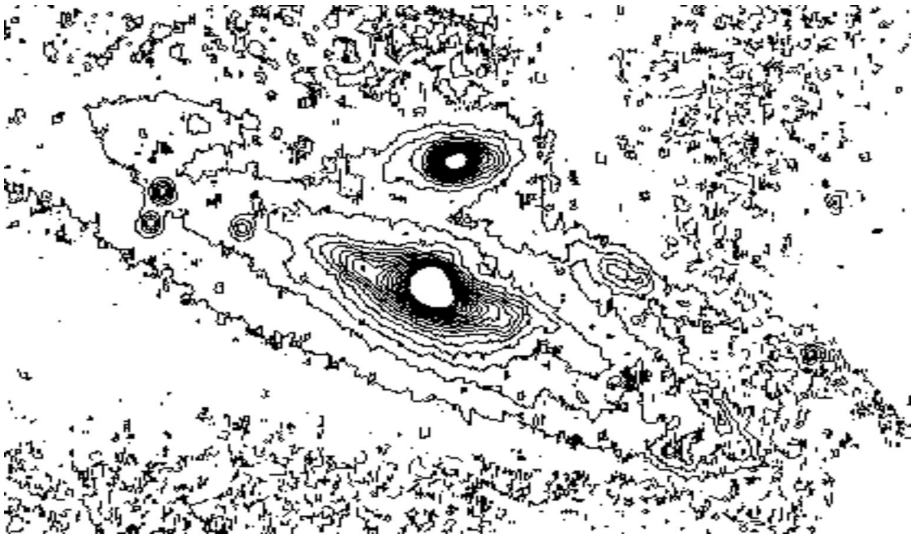

Figure 1: The brightness of Mrk 1040 and companion in the [OIII]4959,5007 lines.

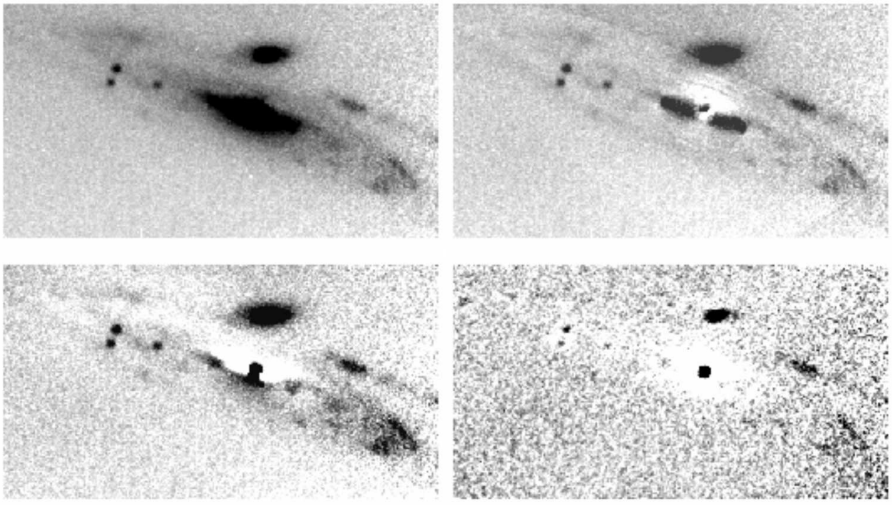

Figure 2: The image in [OIII] narrow band: Original Narrow-band image (top-left) Residual Image once subtracted the model obtained by the Surface Brightness analysis (top-right); Residual Image once subtracted the model obtained using GALFIT (bottom-left); Residual Image once subtracted the continuum scaled image (bottom-right).

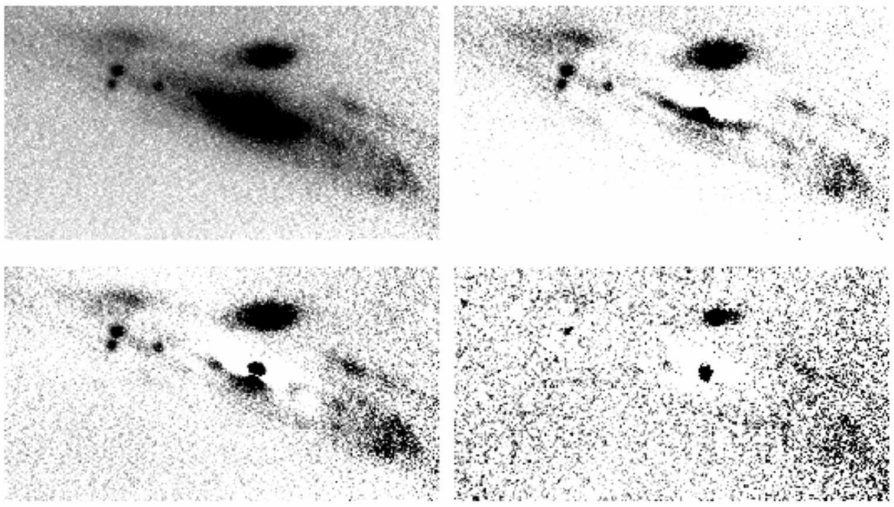

Figure 3: The same as in Fig. 1, but for the He II line.

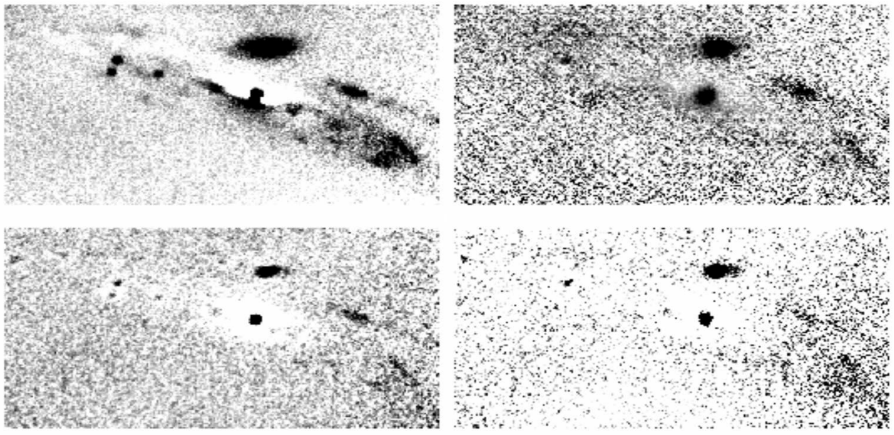

Figure 4: The original continuum narrow-band image (top-left); U-I color image (top-right); The [OIII] line regions after subtracting continuum (bottom-left); The HeII4686 line region after subtracting the continuum (bottom-right).

(4) We have divided the U-band image by the I-band image, in order to get a U- I color image (Fig. 4, top-right)

As one can see from Figs. 2-4, the substructures seen in all images are remarkably similar, indicating that: (i) There is very strong point-like innermost center of Mrk 1040, that is from AGN. The companion has un-regular structure that is expectable in the case of star-forming region; (ii) Different star-forming regions in the disk of Mrk 1040 galaxy, seen in west part of the arm; (iii) From our preliminary analysis we can conclude that there is no tidal tail of young stars in between Mrk 1040 and LEDA 212995.

In future work, we are going to apply the above described methods to the all observed narrow band filters of Mrk 1040 and companion, but first look in the data is in favour that there is no evidence for an interacting system.

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