MRK 1040 AND ITS COMPANION LEDA 212995

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Abstract

The Sy 1 galaxy Mrk 1040 and its close companion LEDA 212995 have been observed in several narrow spectral bands, as well as in the U and I bands, in order to look for possible interaction between them. The analysis of the observations shows a very strong point-like innermost center of Mrk 1040 that is from AGN, an irregular structure of the companion expected in the case of a star-forming region, and different star-forming regions in the stellar disk of Mrk 1040. No tidal tail of young stars between Mrk 1040 and LEDA 212995 has been identified.

1. Motivation

The influence of interactions on the fueling of the nuclei of AGNs, as well as of HII galaxies, has been the topic of several studies (see [1] and references therein). There are two interesting questions: (1) the origin of the gas that fuels the nuclear black hole, and (2) the mechanisms responsible for making the gas lose angular momentum and move from galactic scales down to the innermost central region of the AGN. Several mechanisms have been suggested to explain how it is possible to transport gas from the disk of a spiral galaxy to its nucleus. One of them is interaction between two galaxies.

One of visually galaxy pairs is Mrk 1040 and LEDA 212995. The companion LEDA 212995 is a small galaxy with emission lines indicating a star-forming region (HII lines, see [2]). Its dimensions are 0.20' x 0.10' and its magnitude is >19. The galaxy is visually located near the Sy 1 galaxy Mrk 1040 (z = 0.01665, [3]).

Afanas'ev & Fridman [4] 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 Mrk 1040, is closer to the observer'. The spectroscopic observations of Mrk 1040 and LEDA 212995 are given in [5], where the asymmetry in the velocity field of the companion is found and it is assumed that this asymmetry is due to interaction of the two galaxies. According to the redshift of the companion 0.0169±0.00015 estimated by Popović et al. [2], it seems that the two objects are close to each other.

Mrk 1040 is a Sy 1 galaxy with different star-forming regions in stellar ring. The close companion LEDA 212995 is also under star-formation. It is not clear if the companion is under interaction or not, and if the star-formation in it and the nuclei activity in Mrk 1040 are caused by the interaction of the two galaxies. To ascertain
this, we observed the pair in several narrow and broad spectral bands.

2. Observations

The observations have been made at the National Astronomical Observatory Rozhen with the 2 m Ritchey-Chretien-Coude telescope. We observed Mrk 1040 and LEDA 212995 in November 2003 and in January 2004. The dates of observations and the used spectral filters are given in Table 1.

Table 1. Observations of Mrk 1040 and LEDA 212995

RA DEC	Redshift	Date of observation	Spectral line	Number of images	Exposure time [s]
2h 28m 14.3s +31° 18′ 40.4″	0.016652	16-Jan-04	HeII	3	600, 900, 1200
		16-Jan-04	[OIII]	2	600
		16-Jan-04	U band	2	900
		17-Jan-04	I band	5	120, 300, 420
		17-Jan-04	Continuum	2	300, 600
		17-Jan-04	[SII]	1	600

Standard reduction procedures including bias subtraction, trimming and flat-fielding have been performed with the help of the IRAF software package. Here we present results only from the processing of the

observations in the *U* and *I* broad bands and in the HeII 4686 and [OIII] 4959, 5007 narrow bands, as well as the comparison of the narrow bands with the continuum (λ = 5757 Å).

3. Results

In order to find any evidence of interaction we have processed the images as follows:

(1) A surface brightness analysis over the narrow-band images has been applied assuming an elliptical isophotic model, based on the technique given by Jedrzejewski [6]. 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 the substructures in the objects can be seen, 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 using GALFIT [7]. The galaxy model has been done including three components: the nuclear point-like source, a bulge and a disk. This model has been subtracted from 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 it from them. It provides us with images of the pure HeII and [OIII] emission lines (Fig. 4, 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).

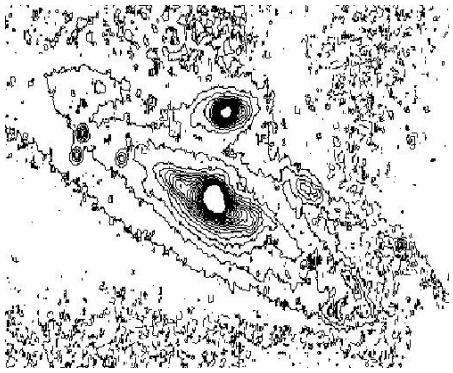

Fig. 1

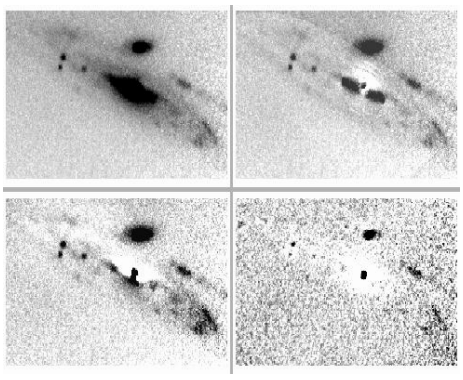

Fig. 2

Fig. 1. The brightness of Mrk 1040 and companion in the [OIII] 4959, 5007 lines.
Fig. 2. Original narrow-band image in [OIII] (top-left); residual image once subtract- ed 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).

Fig. 3

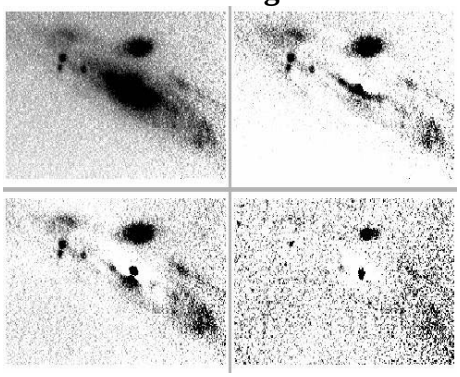

Fig. 4

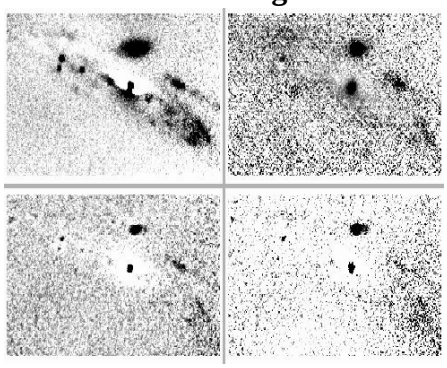

Fig. 3. Same as in Fig. 2, but for the HeII line.
Fig. 4. The original continuum narrow-band image (top-left); *U-I* color image (top-right); the [OIII] line regions after subtracting the continuum (bottom-left); the HeII 4686 line region after subtracting the continuum (bottom-right).

As one can see from Figs. 2-4, the substructures seen in all images are remarkably similar, indicating that: (i) There is a very strong point-like innermost center of Mrk 1040 that is from AGN. The companion has irregular structure that is expected in the case of star-forming region. (ii) Different star-forming regions in the disk of Mrk 1040 galaxy are seen in the western 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.

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