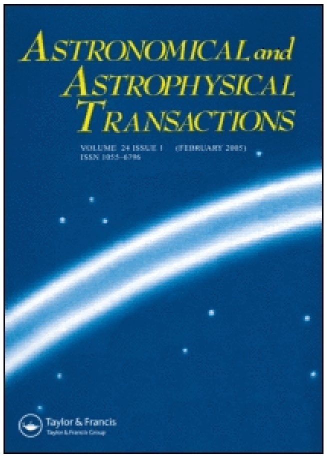

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FINE OPTICAL STRUCTURE OF THE RADIO SOURCE MG 1131+0456

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Preliminary results of optical observations of Einstein Ring are presented in this paper. Possible interpretation is also given.

The object MG 1131+0456 was discovered during VLA survey by Hewitt *et al.* (1988). The object looks like an elliptical ring on the 6-cm radiomap which shows two compact opposite sources. The object has similar structure on the 2-cm radiomap, but there is difference. Ring structure is transformed into two bright radioarcs which have two above mentioned compact sources. According to the opinion of Hewitt *et al.*, this object represents a highly symmetrical case of gravitational lensing. They call it "Einstein ring". Other explanations of this radio morphology analyzed by them were excluded by combined observational data.

Hewitt *et al.* (1988) discovered also faint ($m_R \approx 22$) red object near the radio source. They were not able to obtain the spectrum of the object. Therefore, we have no firm belief that MG 1131+0456 is a gravitational lense. For proving the fact it is necessary to resolve the object at least into two optical components and to obtain the spectrum of each component. The first part of the problem was solved by our group. We have resolved the optical image into two components.

The observations of Einstein ring were done in March–April, 1989 with the 1-m "Karl Zeiss" telescope of the Institute of Physics of Lithuanian Academy of Sciences at Mt. Maidanak (Uzbekistan). As light receiver, we used the TV system "KVANT". The best images were obtained by I. Rakitin, D. Smirnov, and M. Shirokova on 5/6 April, 1989. The TV system with an Electronic image converter was used in the Cassegrain focus (focal length is equal to 13170 mm) of telescope. The observations were made without any filters to reduce light losses (sensitivity range is 400–700 nm). During 3 hours of observations, 10 images were obtained with exposure of 5–30 minutes.

To reveal optical image from sky noise and system noise we combined four best frames using five stars as reference system. It allowed to reduce main geometrical distortions of the frames. The summary frame was smoothed by four-point averaging to achieve the highest contrast of the image.

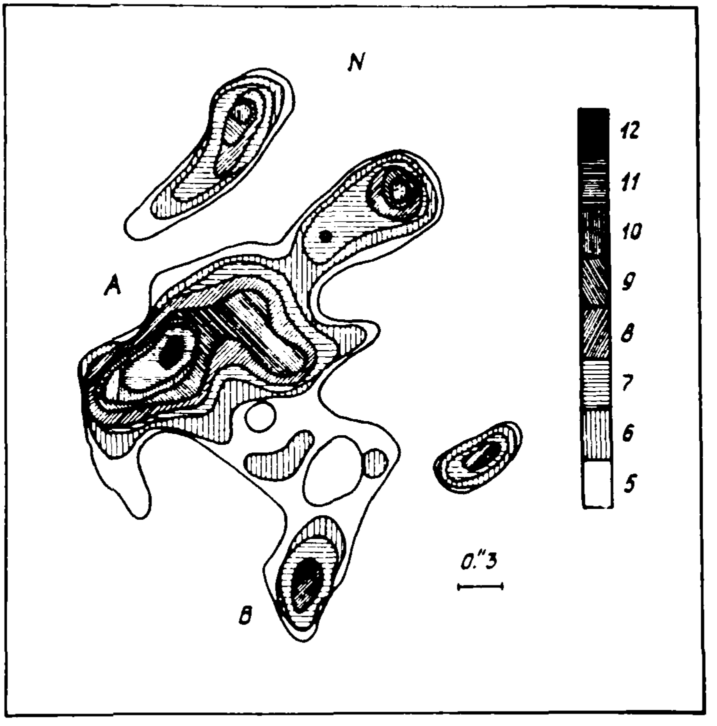

Figure 1

We located the Einstein ring using the photographic chart (Hewitt *et al.*, 1988). The object found in the position marked by them was analyzed.

This place (having size 5″ x 5″) is presented in Figure 1. The objects which may belong to the Einstein ring are designated A and B. The distances between them and their orientation are in complete agreement with radio data, relative positions of the object and field stars are identical with optical data (Hewitt *et al.*, 1988). Thanks to the fact it is possible to confirm the reality of objects A and B.

Figure 1 shows that the optical structure of the object resembles its radio structure on the 2-cm map. The optical image is a binary objects, but there is some difference between them. Component A is elongated along the arc of the main circle, but its angular size (for the observer who is at the supposed place of the gravitational lense) is less than that of the radio component A. The optical size A is equal approximately to 60° and its radio size ($\lambda = 2$ cm) is equal approximately to 180°.

The average seeing was $\sim 0.6''$. Therefore, one can consider that only component A has been resolved. Its angular sizes are $\sim 2.5'' \times 0.9''$. Component B has angular diameter 0.7" and as a result we are not able to consider its structure.

Contours with equal signal-to-noise ratio (S/N) are plotted in the figure. The necessity to analyze the S/N ratio is connected with the fact that the object is ex-

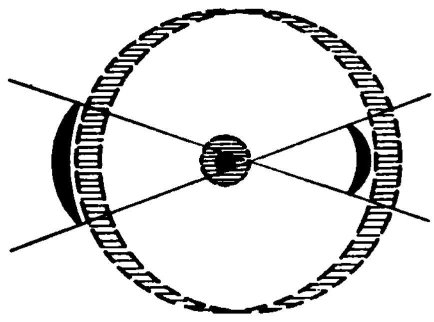

Figure 2

tremely faint for the 1-m telescope. In the brightness peak of A the ratio is equal to 9 (12 events). The external contour corresponds to $S/N \approx 4$ (5 events). Significant S/N ratio allows us to consider the optical structure of the MG 1131+0456 image in spite of the small number of events for a TV channel (events, not photons!).

We would like to add some words on a possible interpretation of the result in terms of axisymmetric case (Liebes, 1963; Sazhin, Sidorov, 1989) having in mind that a gravitational lense is a dimensionless point. Here we do not consider some other interpretations (Kovner, 1987) and a more rigorous but complex interpretation (Kochenek, Blandford, 1989). The simplification makes the results clearer and does not change the main properties. At the same time, we shall consider the source of optical light of MG 1131+0456 as a disk which has some brightness distribution over it.

Figure 2 presents the image of the disk when its rays passed through a spherically symmetric gravitational lense. Schematically, the source is drawn as two coaxial rings. Both optical and radio data show that optical radiation emerges from the small circle and radio waves emerge from the big one. It is clear from comparison of radio data at 6 and 2 cm with optical data that the radius of the luminous region is proportional to the wavelength. Radiation which has smaller λ emerges from a smaller region of the source.

We define the optical radius ϕ_0 and the distance between the lense center and the source center ρ. The size of the cone of invertion is θ. Therefore, we obtain an equation for ρ:

$$\rho \approx \theta \frac{\Omega_1 - \Omega_2}{\Omega_1 + \Omega_2}.$$

Here Ω_1 and Ω_2 are solid angles which form images. Also we obtain an equation for source radius:

$$\rho \approx \pi \left(\frac{\Phi_A}{360^\circ} \right) \theta \frac{\Omega_1 - \Omega_2}{\Omega_1 + \Omega_2},$$

where Φ_A is the size of A along the arc ($\Phi_A = 60^\circ$), Ω_1 and Ω_2 are proportional to the intensities of the images. Therefore, we obtain the angular sizes of the source in optical and radio wave bands, respectively: $\phi_0 \approx 0.7''$ and $\phi_r \approx 0.85''$ ($\lambda = 2$ cm).

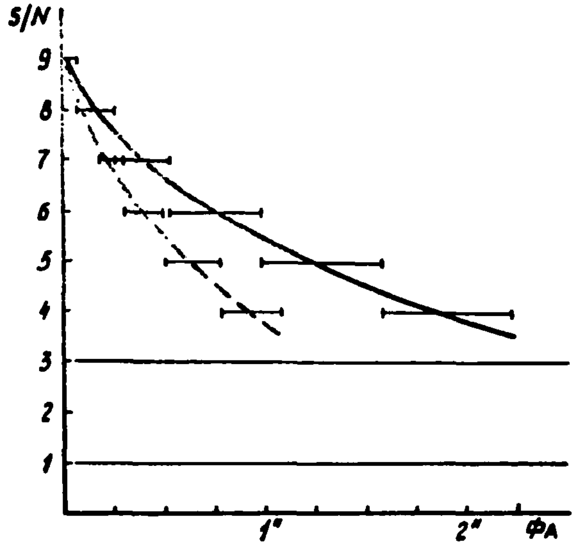

Figure 3

As far as the optical object A is resolved along one coordinate, it is possible to construct the function of brightness distribution over A image. It is plotted in Figure 3. The brightness distribution of A along the arc of cone of invertion is plotted by solid curve, the dashed line represents the brightness distribution along the line which connects the centers of A and B. The latter curve has the size (FWHM)$\approx 0.7''$ which is approximately equal to size of B and other field stars, and as a result, A image is unresolved along this curve. So, the dashed curve represents the FWHM of our system.

The size of the optical region (down to the $s/n = 3$ level) is 4 kpc ($z = 0.5$ and $H = 50$ km/Mpc s). Both the size of the optical region and brightness distribution over the disk support the hypothesis that the object is the nucleus of an active galaxy (Blandford, 1989).

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