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The Shape of the Mrk533 [OIII] Lines: Indication of an Outflow in NLR

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Abstract. We present an analysis of the 3D spectra of Mrk 533, a Sy 2 nucleus, observed with integral-field spectrograph MPFS of the SAO RAS 6-m telescope. The narrow emission lines have a blue asymmetry that indicates an outflow from the nucleus. We found that the narrow line region (NLR) is composed from two kinematically separated regions, where in one of them an outflow is present. The velocity of the outflow vary from -300 km/s to -600 km/s. The maximal outflow velocity is coming from the nucleus and corresponds to the position of the observed radio structure assumed to be created in an out-coming jet.

1 Introduction

Mrk 533 (also denoted as NGC 7674, Arp 182, UGC 12608, H96a) is the brightest member of the Hickson 96 compact group of galaxies [2]. This is only spiral (Sbc pec) galaxy among four tidal interacting galaxies in the group [9]. The [OIII]4959,5007 image from HST [7] clearly shows extended structure of this Sy 2 galaxy. [8] found that radio maps reveal the presence of a triple radio source with a total angular extent of about 0.7 arcsec. This provide evidence that the radio emission is powered by collimated ejection. Recently, VLBI continuum and H I absorption observations of the central part with 100 mas resolution, showed six continuum structures extending over 1.4" (742 pc), with a total flux density of 138 mJy [4]. They also suggested that the overall S-shaped radio pattern could be the result of the interstellar medium diverting the out-coming jets from the central AGN, but also it cannot be ruled out a possibility of a black hole merger that could result in a similar structural pattern.

The aim of this paper is to investigate the emission line structure in the central part of Mrk 533 in order to map gaseous outflows indicated in the previous radio and UV observations.

2 Observations and Data Reductions

Mrk 533 was observed in 2005 September with the MultiPupil Fiber Spectrograph (MPFS), the integral-field unit mounted at the primary focus of the 6-m telescope [1]. The MPFS takes simultaneous spectra from 256 spatial elements (constructed in the shape of square lenses) that form on the sky an array of 16×16 arcsec elements with a scale 0.75"/element. The detector was EEV CCD42-40 (2048×2048 pixel). The data were reduced using the software developed at the SAO RAS by V.L. Afanasiev and A. V. Moiseev and running in the IDL environment.

3 Line Profile Analysis

The shapes of the narrow spectral lines have a blue asymmetry only in the nuclear part of the galaxy (see Figure 1). To analyze the shape of the [OIII] lines,

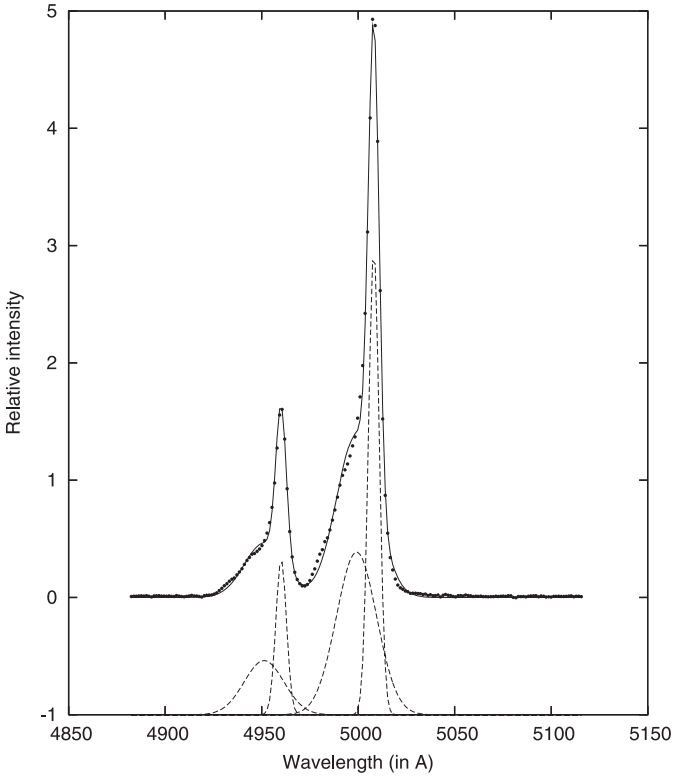

Figure 1. Decomposition of [OIII] lines. With dots the observations and with full line the best fit are presented. The components of decomposition are shown below.

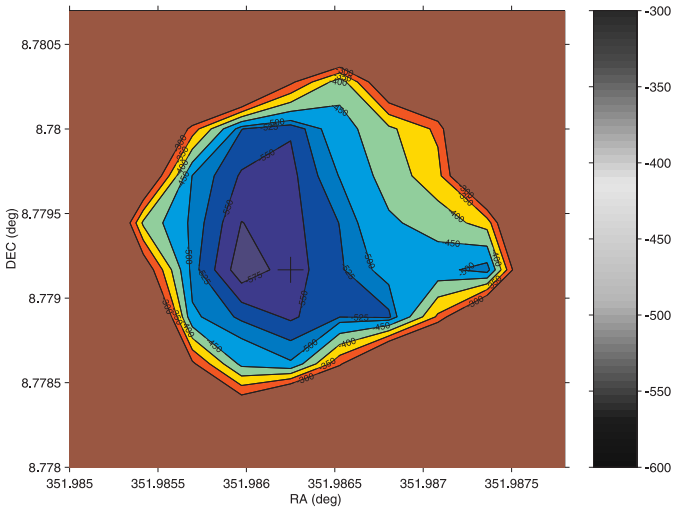

Figure 2. Velocity distribution obtained from relative shift of the NLR1 line component.

we first fitted each line with the sum of Gaussian components. We applied a χ^2 minimalization routine to obtain the best fit parameters. We also assumed that the narrow emission lines can be represented by one or more Gaussian components. In the fitting procedure, we looked for the minimal number of Gaussian components needed to fit the lines. To limit the number of free parameters in the fit we set some a priori constraints [5]:

(i) The two Gaussian representing the [OIII]4959,5007 lines are fixed at the same red-shift (z=0.0289) and the Gaussian widths are set proportional to their wavelengths.

(ii) We imposed the intensity ratio of the two [OIII]4959,5007 lines as 1:3.03. As it was mentioned above (see in Figure 2) the [OIII] lines show a blue asymmetry, and can be properly fitted with two Gaussian components.

4 Results and Discussion

It is evident that the line shapes of [OIII]4959,5007 lines can be fitted if one assumes the emission of two kinematically separated regions (see Figure 1); one where outflow is present (NLR1) and another that corresponds to the originally narrow line region (NLR2). Also we found that NLR1 has higher random velocities ($\sim$800 km/s–900 km/s). As can be seen in Figure 2, the maximum of the outflow velocity ($\sim$600 km/s) corresponds to the optical center of the nucleus (presented as a cross in Figure 2). The outflow velocities are changing from the

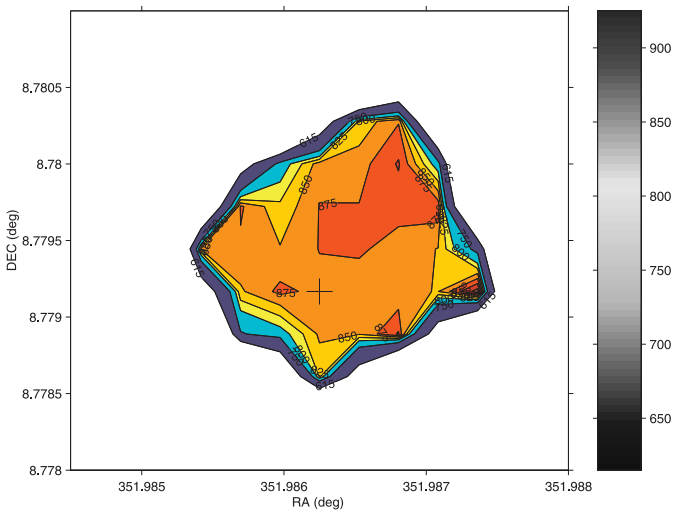

Figure 3. Random velocity distribution obtained from the width of the NLR1 component.

center (-600 km/s) to the outer parts (-300 km/s). This shows a collimation of an outflow around the central part, that is in support the idea about existence an out-coming jet from the central active galactic nucleus [4]. We should mention here that the velocity field of the outflow has a south-north elongated structure (Figure 2), but it is probably due to projection of the jet. On the other hand, the random velocity field has relatively small difference in NLR1 ($\sim$800 km/s–900 km/s), see Figure 3. The similar case is for the NLR2 random velocity region, where random velocities are from 210 km/s to 260 km/s (Figure 4). The shift of lines from NLR2 indicates that there no systemic gas motion with significant velocities.

5 Conclusion

In this paper we analyzed the spectra of Mrk 533 observed with 6-m telescope of the SAO RAS with 3D spectroscopy. We found:

(i) That the emission line shapes in the region of the nucleus have a blue asymmetry that indicates an outflow from the center.

(ii) That the [OIII]4959,5007 lines are originated from two kinematically separated regions: NLR1 contributes to the blue part of spectral lines, where exist a gaseous outflow with velocities from -300 km/s (farther from the center) to -600 km/s around the nucleus (the random velocities are around 800 km/s–900 km/s); NLR2 has smaller random velocities ($\sim$ 200 km/s) and there is no systemic motion.

With this investigation we found a stratification in the NLR of Mrk 533, where in one part of the NLR is registered an out-coming jet. This is in the agreement with previous results obtained from the UV and radio observations.

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