Barred Galaxies
ASP Conference Series, Vol. 91, 1996
R. Buta, D. A. Crocker, and B. G. Elmegreen, eds.

Gas and Stellar Kinematics in the Disk and Bar of Mrk 573

V. L. Afanasiev, A. N. Burenkov, A. I. Shapovalova, and V. V. Vlasyuk

Special Astrophysical Observatory, Nizhnij Arkhyz, Karachai-Cherkessia, Russia, 357147

Abstract. Results of 3D-spectroscopy for the nearby Seyfert galaxy Mrk 573 obtained at the 6-m telescope with the scanning Fabry-Perot interferometer and the Multi-Pupil Field Spectrograph (MPFS) are presented. Emission lines images of the galaxy center demonstrate a complex structure of ENLR, coinciding with the radio data. An analysis of the velocity field shows that some gas structures do not lie in the plane of the galaxy. An explanation of the observed velocity field and gas distribution by radiation of a helical structure located inside an ionization cone is proposed.

1. Observations and Data Reduction

3-D spectroscopy data were obtained at the 6-m telescope: - with the scanning Fabry-Perot interferometer (in the Hα line, spectral resolution ~40 km s^{-1}, angular resolution ~1$''$.2); and using MPFS (Afanasiev et al. 1990) in the region of Hα and [OIII] λ5007 lines (spectral resolution ~120-150 km s^{-1}, spatial data sampling 1$''$.3 per lens).

A deep CCD image in the V-band (Figure 1a, b) was obtained with the Cassegrain focus of the 1-m SAO telescope with angular resolution ~1$''$.3. Monochromatic maps and the velocity field in the selected components were constructed by gauss-fitting of the Hα, [NII] λ6584/48 and [OIII] λ5007 line profiles. The stellar velocity field was derived from the MgIb λ5167/84 absorption triplet.

2. Morphology and Disk Kinematics

A large spheroidal component is seen in the deep CCD frame, which we identify with the small-contrast bar of a non-axisymmetrical potential. This large bar is elongated in the NS direction and has a size of ~40$''$ or 13 kpc for $H_\circ$=75 km s^{-1} Mpc^{-1}. A weak external ring ≈45$''$ in diameter with ellipticity 0.85-0.9 is present around it and elongated in P.A.=101±5° The inclination of the galaxy plane, derived under assumption of circular intrinsic form of the ring, is 30°±3°. An internal spiral arm, which is slightly twisted and has two condensations at the edge in P.A.≈65°, has been found at a distance from the center of r=10$''$ in the continuum-subtracted Hα image (Figure 1d).

https://doi.org/10.1017/S0252921100049769 Published online by Cambridge University Press

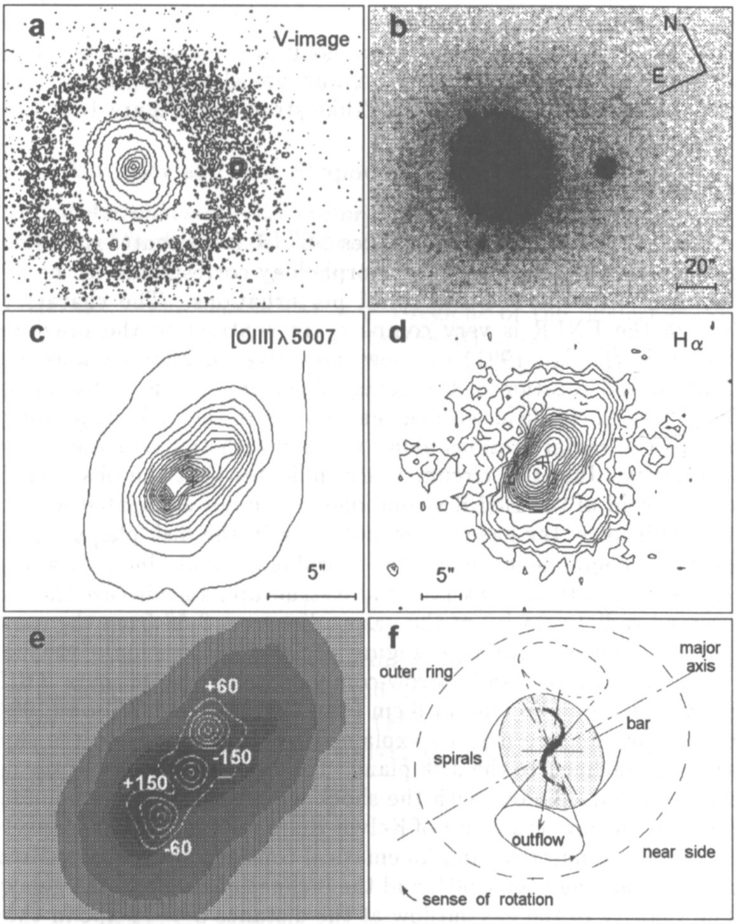

Figure 1. Morphology and kinematics of Mrk 573

The gas motion at distances of $>6''$ from the center, derived from the Fabry-Perot interferometer data, is well described by circular motions with the P.A. of the line of nodes of $103\pm1°$ and a maximum rotation velocity of 250 ± 20 km s^{-1}. Gauss-fitting of the components in the Hα line from the interferometric data reveals in the region of $<6''$ the presence of at least three gaseous components: a regularly rotating one and two others showing noncircular motions of $\sim$100 km s^{-1}. The last two components define the morphology of the circumnuclear region in Hα.

An analysis of MPFS data within $15''$ of the galaxy center shows in Hα, [NII] λ6584 and [OIII] λ5007 lines the broad component (FWHM>300 km s^{-1}) shifted in radial velocity with respect to the narrow one (FWHM $\approx$150km s^{-1}) by about $\pm$200 km s^{-1} with comparable intensity. These components conform well to the two last ones from the interferometric data. Narrow and broad components

https://doi.org/10.1017/S0252921100049769 Published online by Cambridge University Press

have different signs of velocity deviation from solid-body rotation. The regions of localization of the largest deviation of the broad component velocities from circular ones and this component morphology are nearly coincident with the image structure obtained with the VLA and are elongated along P.A.=110°. The narrow component image shows a Z-like structure (Figure 1c).

3. Discussion

The gas kinematics of Mrk 573 at distances $>6''$ from the center is well described by the gas rotation and the observed morphology corresponds to the dynamics of the flat disk with the two-arm spiral perturbations. The character of the gas motion in the ENLR is very complex. In contrast to the previous paper (Afanasiev & Sil'chenko, 1991) the new data give an unambiguous notion on the orientation and rotation of the galaxy disk. In this case, if one associates distortion of the velocity field with the gas motion in the disk plane, they should correspond to the radial motions along the bar with the velocities larger than parabolic velocity. Just this circumstance indicates that the observed features in the velocity field of the ENLR's components are not associated with the bar, but are determined by the gas outflow not lying in the disk plane.

Thus, these components reflect the morphology and kinematics of gaseous outflow, coinciding with the observed radio structure. In this case the switching of the observed radial velocity of the gas at distances 3-5$''$ from the center near the SE and NW knots is surprising. Figure 1e shows localization of the maximum residual velocities of broad and narrow components on the image in [OIII] while isophotes present the radio map at 6 cm from Ulvestad and Wilson (1984). The observed Z-shaped feature may be explained by projection onto the sky of the helical structure inclined to the disk plane. The helical structure of the emitting gas is related, in our opinion, with the shock wave arising at the boundary of a rotating conical outflow as a result of Kelvin-Helmholtz instability, as sketched in Figure 1f. Simple geometrical and kinematical considerations give an estimation of the cone opening angle as $\sim 66°$, and the inclination angle to the galaxy plane $< 15°$. The velocity of the gas outflow at the distance 3-4$''$ (2 kpc in the galaxy plane) is of the order of 70 km s^{-1}, and the linear velocity of the cone rotation is $\sim$100 km s^{-1}.

This research has been supported by a grant from the Russian Foundation of Fundamental Research 93-02-1703.

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