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GAS KINEMATICS IN THE CENTRAL REGIONS OF SEYFERT GALAXIES. I. MRK 573

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ABSTRACT. *We formulate an observational problem concerning gas kinematics in the central parts of Seyfert galaxies with the extended NLR for being setting at the 6-m telescope. As the first results we present our investigation on Mrk 573. The velocity field of ionized gas reveals a presence of a strongly inclined disk having the line-of-nodes position angle* $P.A._0=106^\circ$ *and strong non-circular motions in the centre probably resulting from a non-axisymmetrical potential. The morphology investigation in the narrow spectral bands (≃40 A) has shown a prominent difference between continuum image of the nuclear region and that in the [OIII] emission line: the bar (length ≃1 kpc or 4″) is seen in the continuum near the position angle ≃62°, and there are three [OIII] condensations - one is in the centre of the bar, and the two others - near the edges of the bar at a distance of 1.6″ from the centre. The position angle of the [OIII] structure is equal to 105°. In the centre of the galaxy we also see the regions of strong radial gas inflows (velocity ≃200 km/s) giving the low intensity wings to emission lines [OIII] and* H_β*; they are shifted relative to the [OIII] condensations and are coincident with the radio lobes at the* $\lambda=6$ *cm being aligned in the position angle 126°. The picture obtained in our paper is in accordance with the theoretical models of gas response in the non-axisymmetrical gravitational field of bar and contradicts the hypothesis of relativistic jet phenomenon in the centre of Mrk 573.*

На 6-метровом телескопе поставлена задача исследования кинематики газа в околоядерных областях сейфертовских галактик с протяженными областями запрещенных линий. В рамках этой программы детально изучена галактика Mrk 573. По исследованию кинематики газа обнаружен газовый диск с углом наклона 66° и линией узлов 106°. Характер движения газа в центральной части такого диска указывает на наличие некруговых движений, вероятно, связанных с неосесимметричным потенциалом. Исследование морфологии в центральной области галактики в узких (≃40A) спектральных полосах показало сильное расхождение между структурой изображения в континууме и эмиссионной линии [OIII]λ5007 на

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расстояниях <4″ от центра. В континууме виден бар длиной около 1 кпк (4″), имеющий позиционный угол 62°, а в линии [OIII] видны три конденсации - одна в центре бара и две вблизи его границы на расстоянии ±1.6″ от центра. Общее направление наблюдаемой структуры в [OIII] имеет позиционный угол 105°. Вблизи центра галактики наблюдаются области сильных радиальных потоков газа, обнаруживаемые в виде компонент в крыльях линии [OIII] и H_β. Указанные области не совпадают с центрами яркости в изображении, полученном в [OIII], и расположены в позиционном угле 126°, который соответствует вытянутости структуры, обнаруженной в радиоконтинууме на λ=6 см по наблюдениям на VLA. Эти области находятся на тех же расстояниях от центра (1.4″), что и наблюдаемые radio-lobes. Наблюдаемая картина соответствует представлениям о движении газа в области неосесимметричного потенциала (бара) и противоречит гипотезе о наличии релятивистского джета в центре Mrk 573.

SETTING OF THE PROBLEM

With this paper we begin the cycle of papers on kinematics of ionized gas in the central parts of Seyfert galaxies which have linear radio structures of 1 kpc near the nucleus. Up to now these linear structures, separating sometimes into 2-3 brightness centres located quasisymmetrically around the active nucleus, are considered to be collimated nuclear jets. A comparison of the structure of the central region in continuum and that in the forbidden emission lines [OIII] has led to a conclusion on their identity (see e. g. Whittle et al., 1988; Haniff et al., 1988). A question under discussion now is the relation between relativistic jet electrons, displaying as synchrotron radiation in the radio, and warm ionized gas emitting in lines in optics. Different mechanisms of relation are suggested - from the shock gas ionization by the jet up to simple compression of the emitting gas cloud, increasing its surface brightness. But the jet existence is not called in question.

However alternative explanation of the extended (jet-like) structures observed in the central parts of Seyfert galaxies is possible. If in the galaxy disk there is a non-axisymmetrical (bar-like) perturbation of potential, then the observed gas distribution and kinematics will be determined by motion peculiarities of gaseous clouds in the bar region. Really, since the gaseous disk around the bar is thinner than the latter, it has smaller chaotic velocities and rotates more rapidly than the bar (Freedman, 1977), and near the centre the difference in linear velocities of the rigid-body rotating non-axisymmetrical perturbation of density and gaseous disk can exceed the sound velocity in the galaxy disk. The formed shock wave will be seen as linear structures in forbidden lines and radio continuum which will be aligned along the bar (Afanasiev et al., 1987). An analysis of observational data for close Seyfert galaxies does not qualitatively contradict this assumption (Afanasiev, 1989).

Numerical experiments carried out to study the motion of gaseous clouds in the bar region of the rotating stellar disk, show together with the radial gas motions along the bar, the presence of shock wave regions near the bar edges (see e. g. Sanders and Tubbs, 1980; van Albada and Sanders, 1982;

Matsuda et al., 1987; Athanassoula, 1988; Roberts et al., 1979; Afanasiev et al., 1989). These calculations have shown that for shock wave generation it is sufficiently enough to have 5-10 % contrast of the bar potential over the general axisymmetrical potential. Location of shock wave regions is under discussion. So in calculations allowing for the gas viscosity in the bar region (Afanasiev et al., 1989), the shock front is located on the back (relative to rotation) side of the bar. Matsuda et al. (1987) and Athanassoula (1988) supposed the shock wave front to be on the front side of the bar. Which variant should be chosen is determined by the accepted model of gaseous cloud motion. It should be noted that explanation of the observed in the central region of the galaxy peculiarities of gas motion in the frame of the bar model is interesting from the view point of search for mechanisms of providing the galaxy nucleus with gas that finally causes its activity (Shlosman et al., 1989).

To choose between the considered alternatives we need more detailed investigation of gas kinematics in the central regions of the galaxy with a high angular resolution. The existence of bar in the galaxy centre should be revealed both by surface brightness distribution and gas rotation character. The considerations mentioned above became the main reason for this observational programme to be set on the 6-m telescope.

Table 1. **The sample of galaxies with linear radio structures**

Object	scale pc/″	$(\text{P.A.})_r$ radio	Δ(″)	P.A. gal.	P.A. [OIII]	P.A. cont.	N
Mrk 3	270	86°	0.3″E, 1.1″W	20°	82°	70°	13
Mrk 6	360	177	0.4″N, 0.6″S	127	8	–	5
Mrk 34	920	158	0.9″NW, 1.5″SE	27	148	130	6
Mrk 78	685	90	1.4″E, 1.9″W	85	84	75	6
Mrk 79	420	2(9)	1.9″N, 1.0″S	140:	9	(*)	8
Mrk 270	210	48	0.7″SW, 1.5″NE	(*)	58	–	3
Mrk 573	330	125	1.4″SE, 1.4″NW	(*)	116	101	15
Mrk 1126	210	100	0.3″SE, 0.6″NW	(*)	–	–	7
MCG 8-11-11	390	0(124)	1.0″N, 0.36″SE, 0.29″NW	90	–	–	5
NGC 5929	170	62	0.7″NE, 0.6″SW	35:	67	(*)	4

(*) – face-on

A SAMPLE OF GALAXIES

A sample of Seyfert galaxies included into our observational programme coincides practically (90 %) with the one of Whittle et al. (1988), since the objects were selected according to the same observational data and criteria: that is Seyfert galaxies visible in the northern sky which according to Ulvestad and Wilson's (1984a, 1984b) data have linear double or triple radio structure with the component separation $\geqslant 1''$. However in contrast to Whittle and his colleagues who favoured for investigation of kinematics only two spectral cross-sections, along the radio structure and perpendicular to it, we wanted to obtain velocity field as full as possible for each galaxy.

Table 1 presents the complete list of the sample galaxies. There are given also the characteristics which will be used at discussions. The linear scale was determined from the systemic galaxy velocity for Hubble constant H_0= =75 km·s^{-1}·Mpc^{-1}. Position angles of nuclear radio structure (P.A.)$_r$ and line of nodes of the galaxy disk (P.A.)$_0$, and also distances from the optical nucleus up to the radio components Δ are taken from the Table given by Whittle et al. (1988), except Mrk 1126: the data on radio structure for this galaxy are taken from the radio survey made by Ulvestad and Wilson (1984b) and the optical structure – from Morphological catalogue of galaxies (MCG). Isophote position angles in [OIII] emission line (P.A.)$_{[OIII]}$ and in the nearby continuum band (P.A.)$_c$ are taken from Haniff et al. (1988); here we mean the most central ($r \ll 5''$) regions of the galaxy. Number of spectra N, obtained for each object appeared to be noticeably different for various galaxies. Observations of Mrk 573 were found to be the most successful, up to date we have the most complete set of observational data just for this galaxy. We think this galaxy to be the best example of an object which reveals rather noticeably the gas motion properties in the central bar region.

Table 2. **The journal of observations for Mrk 573**

Spectrum	Date	Exposure	P.A.	Spectral range (Å)
MO3805	10/11.X.86	20^m	104°	6300 - 7000
MO6301	14/15.X.87	15	105	4700 - 5400
MO6302	14/15.X.87	15	81	4700 - 5400
MO6303	14/15.X.87	15	49	4700 - 5400
MO6409	16/17.X.87	10	110	4700 - 5400
MO6410	16/17.X.87	8	98	4700 - 5400
MO6411	16/17.X.87	8	128	4700 - 5400
MO6412	16/17.X.87	8	143	4700 - 5400
MO6413	16/17.X.87	8	159	4700 - 5400
MO6414	16/17.X.87	8	175	4700 - 5400
MO6415	16/17.X.87	8	10	4700 - 5400
MO6416	16/17.X.87	8	26	4700 - 5400
MO6417	16/17.X.87	8	42	4700 - 5400
MO6418	16/17.X.87	8	59	4700 - 5400
MO6419	16/17.X.87	8	89	4700 - 5400

OBSERVATIONS OF MRK 573

Gas kinematics in the central region of the galaxy was studied with the long-slit spectrograph installed in the prime focus of the 6-m telescope. Two-dimensional TV photon-counting system was used for spectrum registration (for the description of the equipment see Afanasiev et al., 1986).

In 1986-1987 15 spectra of Mrk 573 were obtained at different position angles; one spectrum in October, 1986 in H_α band and 14 spectra in October, 1987 in the green spectral band including emission lines H_β and [OIII] λλ4959, 5007 (a journal of observations is presented in Table 2). 11 spectra obtained on October 16, 1987 at a seeing of ~ 1″ involve almost the full range of the slit orientation, (P.A.)$_{slit}$ from 10° to 175° in every 15°. The slit size, dispersion and scale along the slit were 100″×2″, 1.5 Å/pix, and 0.37 ″/pix respectively. A real spectral resolution was 3-3.5 Å. We have used only short exposure times since we were interested in the central galaxy region only, but nevertheless at one of the spectra - (P.A.) = 110° - the [OIII] emission was extended over 30″ (±5 kpc from the centre) that allowed to judge on gas kinematics of regions rather distant from the nucleus.

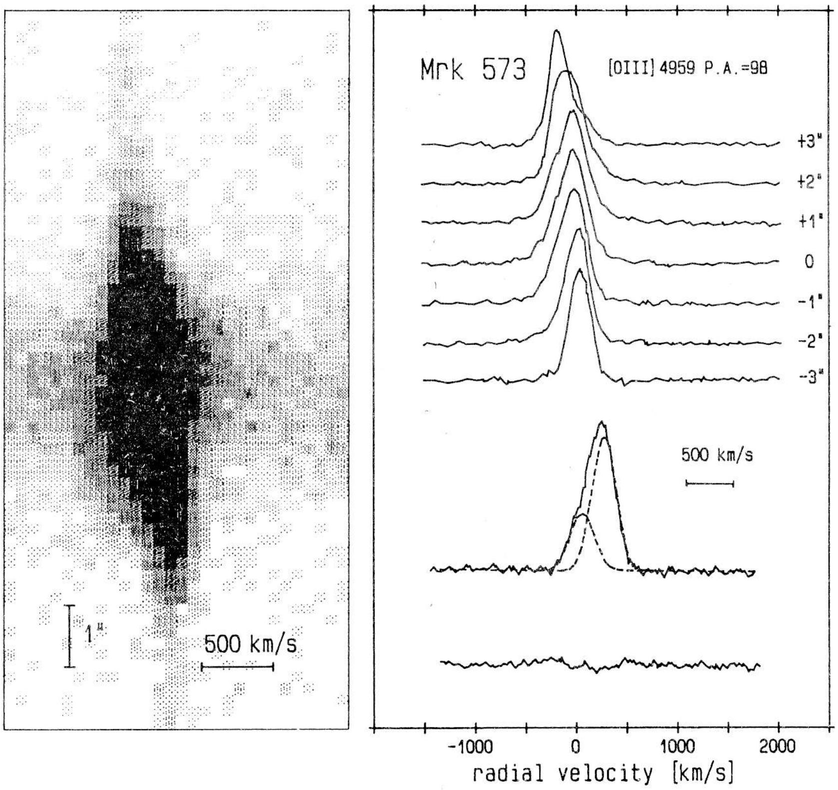

Fig. 1. The emission line [OIII] λ5007 registered in the central region of Mrk 573 with the digital two-dimensional photon-counting system. The profile variation along the slit and an example of its Gaussian component analysis are shown.

To obtain the line-of-sight velocities of ionized gas the spectrum reduction was made in two ways. First, using the standard reduction procedure (Alyavdin et al., 1988), the data being corrected for geometrical and photometrical distortions of television registration system, line-of-sight velocities were determined from emission line maxima for distances from the nucleus larger than 3″. In the central region of Mrk 573 emission lines have a complicated asymmetric profiles varying along the spectrograph slit (Fig.1), therefore for distances smaller than 4″ we used Gaussian component analysis of the line profiles extracting in each slit point 2-3 components of the line profile differing in line-of-sight velocities. An example of emission line division into components is shown in Fig. 1. Fig. 2 presents all 11 line-of-sight velocity curves obtained from spectra of October 16, 1987, taking into account velocity component division in the central region of the galaxy.

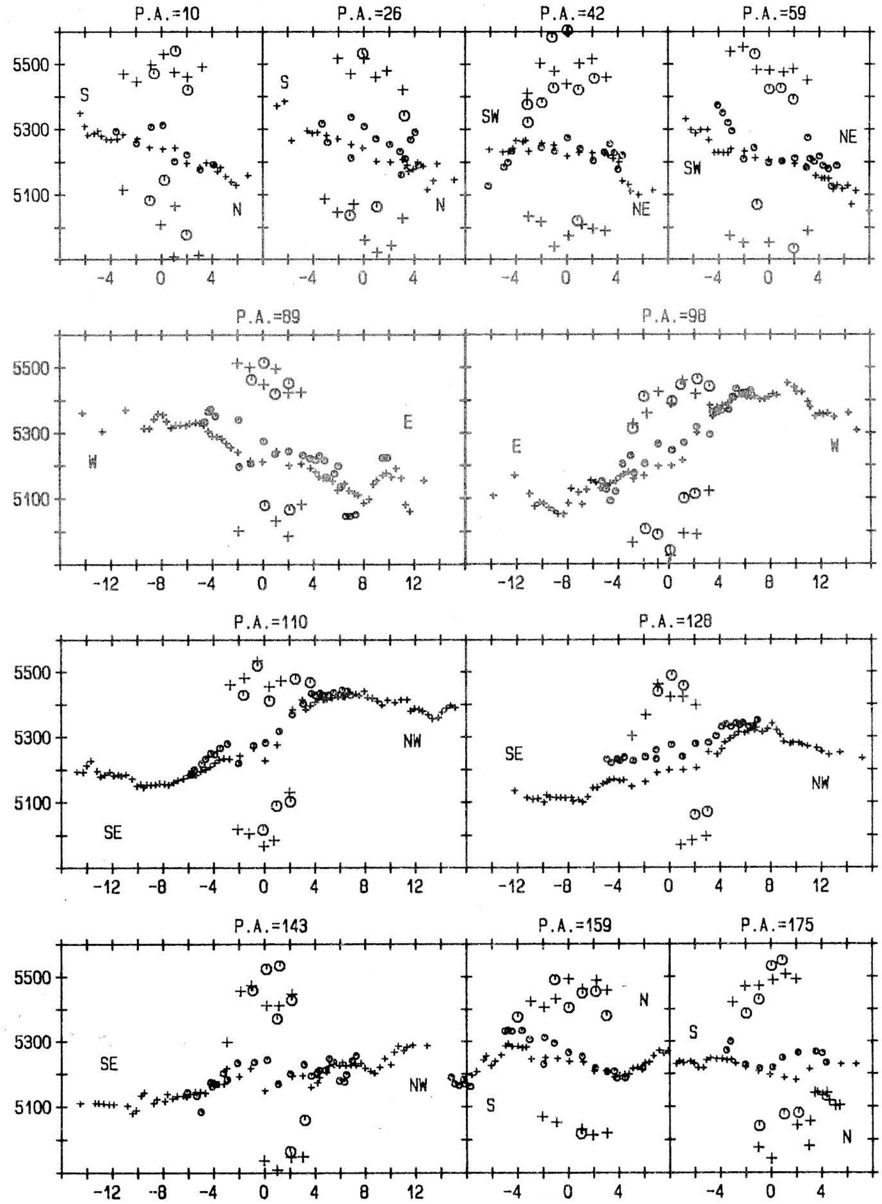

Fig.2. The radial distributions of gas line-of-sight velocity in Mrk 573 for various position angles. Crosses - [OIII] $\lambda\lambda$4959, 5007, circles - H_β. The larger signs indicate high- and low-velocity components.

It should be noted that using the long-slit spectra we distinguish three gas subsystems: central - which velocity is close to systemic V_{sys}, - high-velocity and low-velocity ones. The central component everywhere is the brightest one. In Fig. 2 low-velocity and high-velocity components are shown using the signs of larger size than the central component. An accuracy of line-of-sight velocity measurements for the central component is 20-25 $km \cdot s^{-1}$, and for high- and low-velocity ones it is about 40 $km \cdot s^{-1}$, which is caused by a lower brightness as compared with the central component. The widths of all the components coincide within the measurement accuracy and its typical value corrected for instrumental profile is of the order of 200-250 $km \cdot s^{-1}$.

From the spectra obtained at different position angles we can make a rather detailed picture on gas kinematics in the central region of Mrk 573, but these data do not allow to consider the galaxy morphology near the centre in different spectral ranges. The data available in literature are not of high angular resolution. A more detailed spectral investigation of Mrk 573 central part was carried out with the new spectrograph installed in the prime focus of the 6-m telescope - multipupil fiber spectrophotometer MPFS. Observation and reduction procedures with MPFS and its operation are described in detail by Afanasiev et al. (1990). In general this spectrograph allows to obtain simultaneous spectra from several dozens of adjacent quadratic elements locating as rectangular matrix on the galaxy disk. It is realized with rectangular set of microlenses (raster) amounted in the focal plane of the telescope. The mentioned raster builds matrix of micropupils (images of the main telescope mirror illuminated by separate elements) whose images are got into the input of the multiobject fiber spectrograph. The format of the used TV photon-counting system (512×512 elements) makes it possible to register up to 80 spectra from elements of the galaxy image with a spectral resolution of 2-3 Å. After the spectrum reduction it is possible to obtain the galaxy image on the matrix of spatial elements at any registered spectrum part and to construct the detailed velocity field. An angular resolution of such images will be determined by the size of the raster element and seeing quality. In contrast to observations with the long slit such method allows to locate details on the galaxy image which have some peculiarities in the spectrum, with a high accuracy.

On August 28, 1989 central regions of Mrk 573 were observed with the spectrograph MPFS installed in the prime focus of the 6-m telescope. An exposure was 30 m, seeing - better than 1.5″. The spectra were obtained with a dispersion of 1.3 Å/pix from the matrix 8×10 spatial elements the size of each being 1.25″×1.25″. When the spectra were reduced for the distortions of registration system and different transmittance of microlenses and fibers of the spectrograph were taken into account we built the maps of the brightness distribution in the central region of Mrk 573 in continuum (central wavelength - 5110 Å, spectral window - 40 Å) (Fig.3a), and in the [OIII]λ5007 Å emission line peak (Fig.3b). The vertical position angle in both images is 148°.

GAS ROTATION IN MRK 573

Mrk 573 is SO-galaxy with a Seyfert 2 nucleus. On Palomar prints it is absolutely round that is confirmed by MCG and UGC catalogues (dimensions given along the "major" and "minor" axes are equal) and also by Whittle et al. (1988) who classified the galaxy as "face-on". Only Keel (1980) for some reason reported b/a value equal to 0.75 referring to Palomar prints also. In general the galaxy with such orientation should not reveal any line-of-sight velocity variations. However the line-of-sight velocity curves along P.A. 90°-130° show undoubtedly gas rotation.

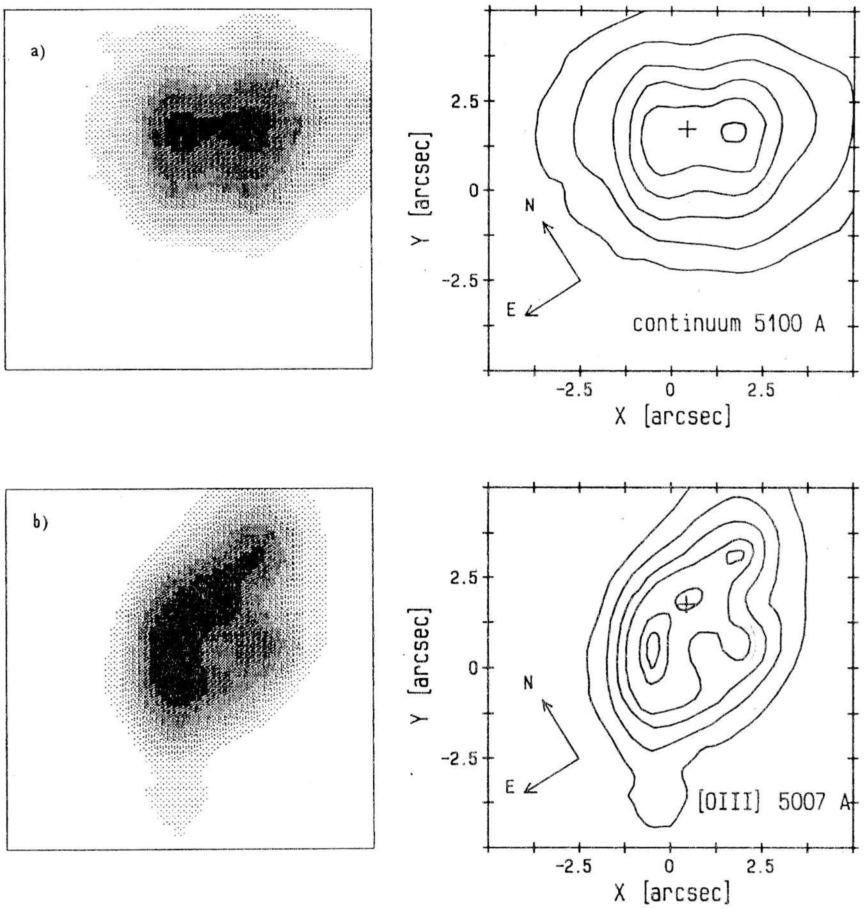

Fig.3. The maps of the central region of Mrk 573 (10″×10″) in the continuum band λ5110 A (a) and in the emission line [OIII] λ5007 (b) obtained with MPFS.

Using the formula of circular rotation

$$V_{\rm rot} = (V_{\rm r} - V_{\rm sys}) \frac{\sqrt{\mathrm{tg}^2\alpha + \cos^2 i}}{\sin i \cos i} ,$$

$$R = R_{\rm observ} \frac{\sqrt{\sin^2\alpha + \cos^2\alpha \cos^2 i}}{\cos i} , \qquad (1)$$

where α is the angle between the line of nodes and the spectrograph slit: α =

=(P.A.)-(P.A.)$_0$ in the sky plane, i is the angle of the disk inclination to the sky plane. We compared location and values of line-of-sight velocity maxima according to M06301 (P.A. 105°) and M06302 (P.A. 81°) spectra. Solving the set of two equations (1) we found the disk inclination angle i = 66° and P.A. of the line of nodes 106°. Fig.4 shows the rotation curve for Mrk 573 obtained from M06409 spectrum with these parameters of disk orientation in the assumption of gas circular rotation. The influence of the bar which exists in the centre of Mrk 573 (it will be shown below) in this case may be neglected not only because its sizes are small as compared to the curve extension but also due to the fact that the slit orientation of M06409 cross-section is close to the disk line of nodes; with such orientation the observed line-of-sight velocity is close to $V_{rot} \cdot \sin i$ (Duval and Monnet, 1985). Maximum velocity of the gaseous disk rotation, 155 km/s, is achieved at a distance of 2.7 kpc from the centre and further up to 4.5 kpc the rotation velocity falls practically according to Kepler law. This galaxy region mass is estimated to be $1.4 \cdot 10^{10} M_\odot$. The fact that gas at distances larger than 3 kpc has Kepler velocities indicates undoubtedly the presence of compact massive condensation in the centre of the galaxy.

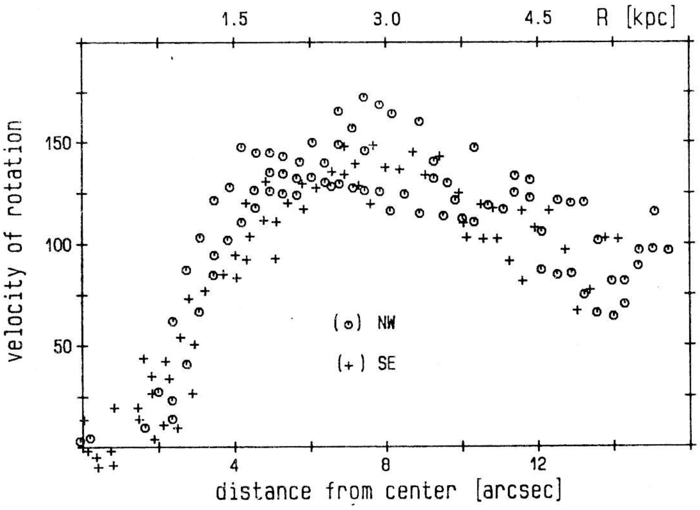

Fig.4. The rotation curve of Mrk 573 gaseous disk.

It is interesting to note that the surface brightness distribution in the continuum obtained by Haniff et al. (1988) with a spatial resolution of 1.6″, has a direction of isophote elongation (P.A. 102°±5°) that agrees with the P.A. of the line of nodes obtained by us. (According to Wagner and Anton (1989) data, [OIII] image isophotes at R = 18″ also turn from P.A. 120° to the smaller position angles). However isophote flattening in the continuum is not high: it is not in agreement with the inclination angle of gaseous disk i = 66°. So if the stellar component is also distributed in the disk whose orientation follows the gaseous disk, the stellar disk thickness must be rather essential. We shall be able to speak more confidently on the stellar component distribution only when we measure the stellar velocity field from absorption lines and evaluate the velocity dispersion. It is necessary to do this in order to answer the question on origin of rotating gas moment: either it is the galaxy proper gas - then it is not clear, why in the centre of the galaxy seen face-on there appeared a strongly inclined disk, or this gas is accepted - then, since Mrk 573 is an isolated galaxy, we can speak only on the satellite merging. In such a case it is necessary to search for other features of that catastrophic event (outer envelopes, etc.).

To study the gas rotation in the very central region of Mrk 573 let us consider azimuthal variations of V_r at fixed distances from the centre R (Fig. 5). If the gas rotates rigidly, that is true for Mrk 573 up to the distances ≃ ≃2.5 kpc from the centre, then from (1) we obtain a cosine law for the azimuthal variations of V_r:

$$V_r = \omega R \sin i \cos \alpha + V_{sys}, \tag{2}$$

where ω is the angular rotation velocity, R is the fixed distance in the sky plane from the centre up to the point where V_r is measured, and V_{sys} is the line-of-sight velocity of dynamical centre of the galaxy (systemic velocity).

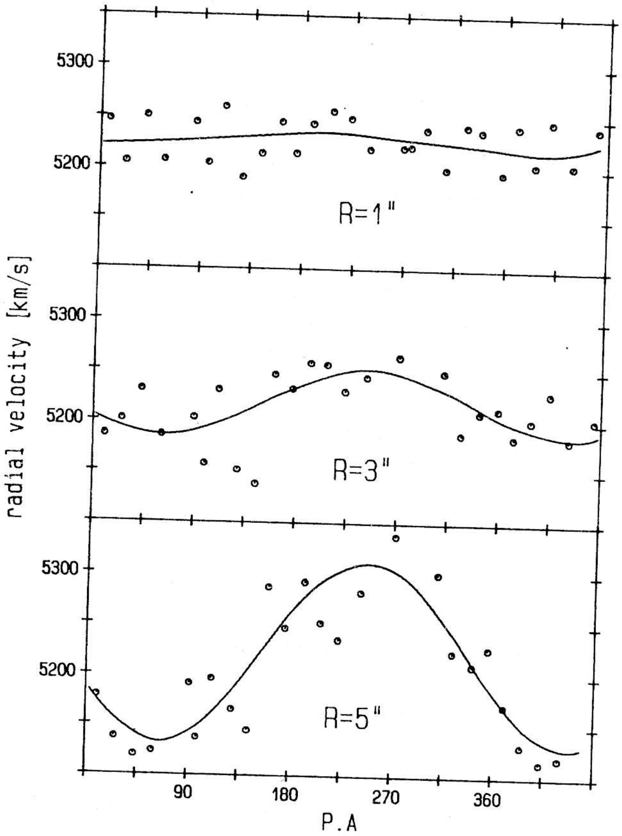

Fig.5. The azimuthal variations of gas line-of-sight velocity at three fixed distances from the centre for the central component of emission line [OIII]λ5007 in Mrk 573.

In the case of purely circular rotation cosine maximum falls on the location of the line of nodes, i.e. on $(P.A.)_0$. If in the galaxy centre there is a bar whose orientation relative to the line of nodes is at an angle not equal to 0°

or 90°, then orbits of gaseous clouds are elongated along the bar and cosine maximum is shifted (Chevalier and Furenlid, 1978). Using the least square method, for relations of Fig. 5 we have found cosine laws with three free parameters, namely: amplitude, phase and V_{sys}. The following results were obtained (for the central emission components):

$$R=1'' \qquad V_r = (6\ \text{km/s}) \cdot \cos(\text{P.A.} - 212^\circ) + 5227\ \text{km/s},$$

$$R=3'' \qquad V_r = (32\ \text{km/s}) \cdot \cos(\text{P.A.} - 242^\circ) + 5220\ \text{km/s},$$

$$R=5'' \qquad V_r = (88\ \text{km/s}) \cdot \cos(\text{P.A.} - 246^\circ) + 5222\ \text{km/s}$$

(discordant points at P.A. 220° and 250°-290° were excluded).
From here we can draw a conclusion that, first, the galaxy systemic velocity V_{sys}=5223±2 km/s; second, with R diminishing cosine maximum is shifted from P.A. 286° (line of nodes) to the smaller position angle: in some cross-sections, for instance M06419 (P.A. 89°) or M06413 (P.A. 159°), it imitates appearance of the nucleus counter-rotation; and finally third, within the radius 1.5 kpc (5″) the angular rotation velocity grows while moving from the centre, that is unusual for normal circular rotation (in case of rigid-body rotation, which is to be observed in the galaxy centre, ω=const). The second and the third conclusions bring us to an idea on the existence of a bar in the centre of Mrk 573: the "flattening" of rotation curves in the bar region is known from observations of the gas velocity field in galaxies with large, visible on the large-scale images bars (Duval and Monnet, 1985).

It is necessary to note that the presented above analysis of gas rotation in the central region of Mrk 573 deals with the brightest [OIII] central component. A slope of the velocity distributions along the slit on the spectra obtained at P.A.s close to the line of nodes also indicates a rotation of the gas emitting in low-velocity and high-velocity line components whose velocity distributions are shifted relative to the central component by ±200 km/s. It is worth noting that direction and angular velocity of this rotation coincide with those for gas emitting in the central component. However we cannot study in detail this rotation within the full range of position angles due to compactness of the gas regions emitting high- and low-velocity emission components.

MORPHOLOGY OF THE CENTRAL REGION OF MRK 573

The maps of brightness distribution in the galaxy central region constructed according to MPFS data show a notable difference in images of the central region in continuum at λ5100 Å (Fig. 3a) and in [OIII] line (Fig. 3b). With this it should be noted that the image shown in Fig. 3b refers to the central line peak.

[OIII] line exhibits a structure elongated at the P.A. 105° and consisting of three condensations. The central condensation coincides practically with the galaxy mass centre which is marked in Fig. 3b with a cross. A comparison with the data on velocity distribution at various position angles (Fig. 2) shows that south-east condensation has a line-of-sight velocity about -60 km/s relative to V_{sys}, and the north-west one - +70 km/s. Both condensations are located at equal distances from the centre (about 1.6″), but the south-east is noticeably brighter than the central one, and the north-west is weaker. A comparison with the radio maps of the central region of Mrk 573 (Ulvestad and Wilson, 1984a) shows that the condensations visible in [OIII] are turned in position angle relative to the radio structure with P.A. 125° and are located somewhat farther from the centre.

Surprising is the fact that the image of the central region in continuum differs from that in [OIII] and has a shape of oval elongated at P.A. 62°. On the image we can see two condensations with a distance between them about 3″ (≈ 1kpc), located approximately symmetrically relative to the centre. Since the image in continuum reflects the matter distribution of stellar component of the galaxy we can conclude that in the centre of Mrk 573 we see mini-bar of 1 kpc that agrees with the conclusion of analysis of rotation in the central region made in the previous Section. The observed axes ratio of such a bar (about 1.7) corresponds to the contrast of nonaxisymmetrical potential in the centre of order of 25 - 30 % (Chevalier and Furenlid, 1978). A comparison of brightness in different components indicates that closer to us is the south side of the central galaxy disk. In such a case a visible structure in [OIII] and in radio continuum is on the front edge of the detected bar relative to the rotation direction.

RADIAL GAS FLOWS

Since the bar is known to be present in the centre of Mrk 573 we have a reason to expect radial gas flows to the centre with velocities of order of rotation velocity (Roberts et al., 1979). With such flows we identified high- and low-velocity components of emission lines whose line-of-sight velocities are plotted in Fig. 2. Really on the cross-sections P.A. 89°, 98° or 159° it is seen that, for example, the high-velocity component traces the gaseous disk rotation, but is systematically redshifted (radial velocity?) by 200 km/s. The low-velocity component is less notable as to rotation, apparently due to its strong compactness in the space; however its systematical blueshift is also of order of 200 km/s. Whittle et al. (1988) have identified components of [OIII] emission line, falling out of general rotation by their line-of-sight velocity, with the brightness centres in radio continuum (λ = 6 cm) located at 1.4″ from the nucleus symmetrically to the south-east and north-west at P.A. 125°, the north-west component according to their identification being in our terminology the low-velocity. To check up their conclusion we constructed intensity distributions along the slit for high- and low-velocity component of [OIII]λ5007 emission line at all 11 position angles (Fig. 6). The spectra were normalized so that the central component intensity was 300 units, i.e. Fig. 6 gives intensities of the line wings relative to its peak. At P.A. 100° - 160° the low-velocity component has a prominent maximum at 1″ - 2″ to the north-east from the nucleus (absolute maximum, 70 % of the central component, is reached at P.A. 143°). Thus, it is really not far from the north-west radio lobe. High-velocity component has more flat intensity distribution, as a rule it is more extended along the slit than the low-velocity and has intensity maximum in the nucleus. Only at position angles 98° and 110° an asymmetry is seen in its intensity distribution that refers it to the south-east half of the galaxy and thus, though with uncertainty, allows to relate with the south-east radio lobe.

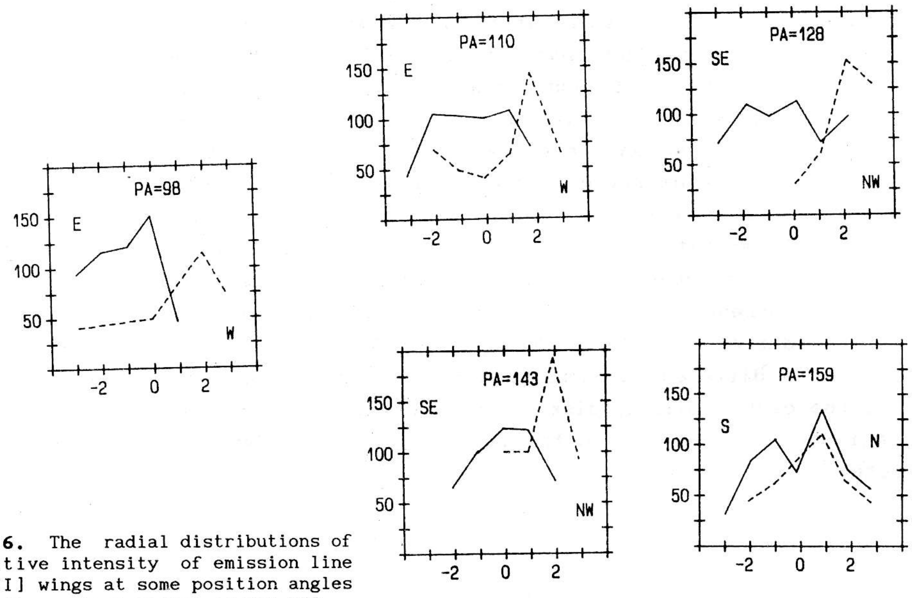

Fig.6. The radial distributions of relative intensity of emission line [OIII] wings at some position angles for the central region of Mrk 573.

To compare more correctly the location of high- and low-velocity components with the [OIII] brightness distribution maps (Fig. 3b) and radio image at 6 cm, we constructed the brightness distribution in [OIII] line wings, which isophotes are shown in Fig. 7. The high-velocity component is shown in the Figure with solid lines, and low-velocity - with dashed ones. It is seen that the images in the wings show two condensations, located symmetrically relative to the centre. The position angle of the line passing through the condensations is 125° that coincides with the direction of radio structure, and these condensations are turned in the position angle relative to the image in the central peak of [OIII].

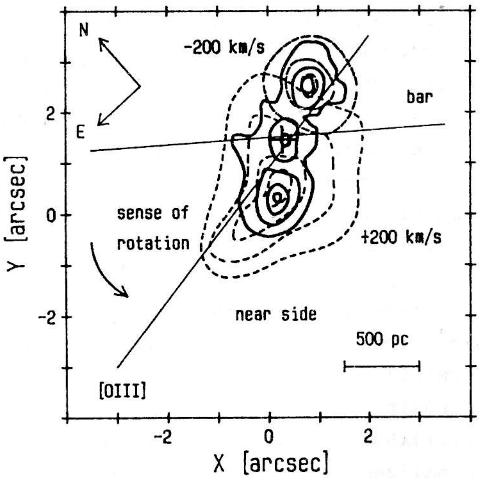

Fig.7. The maps of radial gas flow locations in the centre of Mrk 573 (dashed isophotes) with superimposed solid radio-isophotes at λ=6 cm.

The condensations seen in [OIII] wings are with this at the same distances from the centre as the lobes visible on the radio map and thus the radio structure and the structure in the wings of [OIII] emission line are fully coincident.

So the analysis presented above brings us to an inference that maxima of emission line wings brightnesses (seen in [OIII] and H_β) designate the regions of radial gas flows with velocities of order of 200 km/s, coinciding with radio lobes at 6 cm. The noted regions, according to all mentioned above in the previous Section, are located in front of the bar on the nearest side of the galaxy disk, and thus in the line wings we observe radial gas inflows to the nucleus. It should be noted that this inference is in agreement with theoretical conceptions on the radial gas motions in the bar region, which is indicated by the surface brightness distribution in the continuum and phase shift of line-of-sight velocity dependence upon the position angle at fixed distance from the centre, determined for the central emission-line component.

DISCUSSION

The obtained results allow to conclude that gas kinematics in the central region of Mrk 573 is determined by peculiarities of gas motion in the bar region. The existence of massive bar with a potential contrast about 30 % is of no doubt. This is confirmed by morphology in the central part of the galaxy in continuum and gas kinematics analysis in the circumnuclear region. Such a bar can be caused either by nonaxisymmetrical perturbation of the central massive disk which shows Kepler velocities at distances larger than 3 kpc, or by the triaxial potential of the central massive bulge. The shock-wave regions observed in Mrk 573 and marked with a high brightness both of [OIII] emission and synchrotron radio emission, are visible on the bar side, the front one as to the rotation direction. Identification of these regions with a jet is apparently unacceptable due to two reasons. First, location of lobes visible in radio does not fit the condensations seen in the image obtained from the central [OIII] line component. It fits only the weak images corresponding to the high- and low-velocity emission components. The central line component with regular rotation gives the main contribution in the observed image morphology in [OIII]. In the case of a jet the observed structure in [OIII] must fit the radio structure, but it is not observed. Second, the gas flow direction in condensations, visible in line wings and fitting in location the radio lobes, is to the galaxy centre. An assumption on motions from the centre does not agree in this case with the character of the central disk rotation and conception on the far and near sides of the galaxy inferred from comparison of brightnesses of south-east and north-west condensations.

The shock wave regions observed in the circumnuclear part of Mrk 573 can be caused by the gas motion near the bar edges. Rather large angle between the direction to the shock wave regions and bar may indicate the very slow bar rotation (Sanders and Tubbs, 1980; Van Albada and Sanders, 1982). In this case high-velocity condensations and radio lobes are associated with the shock front where the gas looses effectively the moment and falls to the centre;

they are situated near the bar edges in the rotation direction. Such consideration agrees well with many results of theoretical simulations of gas "response" on the bar-like potential perturbation.

The very high velocity of radial gas inflow gives rise to doubts in the suggested interpretation. This difficulty can be avoided if imagine that we deal with mini-bar counter-rotating relative to the galaxy rotation direction. In such a case on the bar edges of 1 kpc in size there can appear vortex regions - anticyclones. Then the condensations observed in the central component of the line and its wings will represent the rotating borders of anticyclone regions, which centres are located on the bar edges. The regions located nearer to the centre will show high velocities directed contrary to the galaxy rotation and there a shock wave will be observed, and the regions located further from the centre will reveal the velocities aligned with the galaxy rotation direction. It is evident that the anticyclone regions will be located in front of the bar as to the galaxy rotation. For Mrk 573 the estimates indicate that in such a case the bar should rotate with an angular velocity of order of 150 km/s·kpc, and the linear rotation velocity of the vortex will be of order of 80 km/s, the vortex being of 0.5 kpc in size. It should be noted that such an opinion allows to understand "switching over" of radial velocity on scales of $1''$ observed in the regions of radio lobes. To verify this we need observations of two-dimensional velocity field of stars in the centre of Mrk 573.

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