Study of the Structure and Kinematics of the NGC 7465/64/63 Triplet Galaxies

O. A. Merkulova1*, G. M. Karataeva1, V. A. Yakovleva1, and A. N. Burenkov2

1Astronomical Institute, St. Petersburg State University, Universitetskii pr. 28, Petrodvorets, 198504 Russia
2Special Astrophysical Observatory, Russian Academy of Sciences, Nizhnij Arkhyz, Karachai-Cherkessian Republic, 69167 Russia

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Abstract—We analyze new observational data obtained at the 6-m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences with the multimode SCORPIO instrument and the Multi-Pupil Fiber Spectrograph for the group of galaxies NGC 7465/64/63. For one of the group members (NGC 7465), the presence of a polar ring has been suspected. We have constructed the large-scale brightness distributions, the ionized-gas velocity and velocity dispersion fields for all three galaxies as well as the line-of-sight velocity curves based on emission and absorption lines and the stellar velocity field in the central region for NGC 7465. As a result of our analysis of the data obtained, we have discovered an inner stellar disk (r ≈ 0.5 kpc) and a warped gaseous disk in NGC 7465, in addition to the main stellar disk. Based on a joint study of our photometric and spectroscopic data, we have established that NGC 7464 is an irregular IrrI-type galaxy whose structural and kinematic peculiarities most likely resulted from its gravitational interaction with NGC 7465. The velocity field of the ionized gas in NGC 7463 turns out to be typical of barred spiral galaxies, and the warp of the outer parts of its disk could arise from a close encounter with one of the galaxies of the environment.

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INTRODUCTION

The NGC 7465/64/63 triplet belongs to the NGC 7448 group that includes nine galaxies with line-of-sight velocities from 1800 to 2350 km s\(^{-1}\) and a velocity dispersion of \(\sim 150\) km s\(^{-1}\) (Li and Seaquist 1994). Basic information about the NGC 7465/64/63 galaxies collected from published data and obtained through our study is given in Table 1. Many papers are devoted to studying both individual galaxies and the group as a whole. An extensive investigation of six members of the NGC 7448 group in the optical, far-infrared and radio bands (van Driel et al. 1992) showed that most of these galaxies are peculiar. Peculiarities in the HI distribution and kinematics were found for NGC 7448, NGC 7463, UGC 12313, and UGC 12321. Distortions of the outer spiral arms are clearly seen in the optical images of NGC 7448 and NGC 7463, while NGC 7464 and NGC 7465 are probably the result of a merger, as suggested by their large ultraviolet (UV) excesses, the presence of regions with intense star formation, etc. In the optical band, all objects exhibit emission lines; most of the galaxies have HII-type spectra indicative of active star formation; some galaxies are more similar to LINERs. Nuclear activity is observed only in NGC 7465. The latter together with NGC 7464 and NGC 7463 form a close subgroup.

NGC 7464 and NGC 7465 (Mrk 313) are early-type galaxies with a projected distance between them of 1.9, while NGC 7463 is a peculiar barred spiral galaxy seen almost edge-on. It is \(\sim 0.7\) away from NGC 7464 and \(2.5\) away from NGC 7465. These three galaxies are classified as UV-excess galaxies (Takase 1980). NGC 7465 was included in the catalog of Whitmore et al. (1990) in the D category (D-42), systems possibly related to polar-ring galaxies (PRGs), due to the presence of a faint outer ring in the optical band at a position angle of \(\approx 45^\circ\).

Li and Seaquist (1994) obtained 21-cm observations of this compact triplet and two more faint galaxies (UGC 12313 and UGC 12321) from the NGC 7448 group (occasionally, these five galaxies are combined into the small NGC 7465 group) with a higher resolution than those in van Driel et al. (1992). They showed that tidal perturbations in the
Table 1. Main characteristics of the NGC 7465/64/63 galaxies

| Characteristics       | NGC 7465 | References | NGC 7464 | References | NGC 7463 | References |
|-----------------------|----------|------------|----------|------------|----------|------------|
| Morphological type    | (R′)SB0° | RC3        | E1 pec   | RC3        | SABb: pec | RC3        |
|                       | Sab?     | 1          | IrrI     | 1          |          | 1          |
| \( V_{ke} \), km s\(^{-1}\) | 1963 ± 3 | 1          | 1765 ± 2 | 1          | 2366 ± 3 | 1          |
| \( B_{1.0} \), mag    | 13.05    | 1          | 14.23    | 1          | 12.35    | RC3        |
| \( (B−V)_0 \), mag    | 0.85     | 1          | 0.40     | 1          | 0.28     | RC3        |
| \( (V−R)_0 \), mag    | 0.47     | 1          | 0.32     | 1          |          |            |
| \( M_B \), mag        | −19.30   | 1          | −18.12   | 1          | −19.90   | LEDA       |
| \( F_{H\alpha} \), erg s\(^{-1}\) cm\(^{-2}\) | 1.1 × 10\(^{-12}\) | 1 |          |            |          |            |
| \( SFR_{H\alpha}, M_\odot \) yr\(^{-1}\) | 0.9      | 1          |          |            |          |            |
| \( V_{max} \), km s\(^{-1}\) | 105      | 1          | 40       | 1          | 115      | 1          |
| \( V_{hel} \) (HI data), km s\(^{-1}\) | 1962 ± 6 | LEDA       | 1870 ± 9 | LEDA       | 2445 ± 8 | LEDA       |
| \( F_{\lambda 21 cm} \), mag | 14.53 ± 0.16 | LEDA       | 14.66 ± 0.15 | LEDA | 15.33 ± 0.16 | LEDA |
| \( \log M_{HI}/M_\odot \) | 9.70 ± 0.01 | 2          | 9.3      | 3          | 9.2      | 3          |
| \( W_{50} \), km s\(^{-1}\) | 81       | 3          | 292      | 4          | 218      | 4          |

Note. 1—this paper, 2—Fernandez et al. (2010), 3—van Driel et al. (1992), 4—Springob et al. (2005).
* \( F_{H\alpha} \) is the total flux within the 9.3 × 10\(^{-19}\) erg s\(^{-1}\) cm\(^{-2}\) arcsec\(^{-2}\) isophote, \( SFR_{H\alpha} \) is the corresponding star formation rate.

H I distribution and kinematics are observed in four of the five members of the NGC 7465 group. It was established that an H I “bridge” connects, in projection, UGC 12313 with NGC 7463 or with the triplet as a whole, with the sides of both galaxies connected by the bridge showing evidence of a recent interaction. A change in the position angle of the H I disk is observed near the center of NGC 7463, and the velocity field reverses its sign in the same region. These peculiarities are explained by the existence of a high-velocity gas, the bulk of which is above the eastern side of the galaxy’s optical disk. The H I of NGC 7463 is separated from that of NGC 7465/64 in the velocity space. An arc-like structure is observed south and southeast of NGC 7465 at a distance of \( \sim 80'' \) (11.4 kpc). Together with the weak emission to the north of NGC 7465, it forms a ring. Taking into account the orientation of NGC 7465 and the H I ring, the authors of the above paper hypothesize that it is a polar ring around NGC 7465 and could be the material pulled out from NGC 7464 during a close encounter with NGC 7465. The southern part of the ring that contains the bulk of the H I flux coincides with the string of knots seen in optical images at a level of \( \sim 24 \) mag arcsec\(^{-2}\) in the V band (Casini and Heidmann 1978; van Driel et al. 1992). However, in contrast to the H I ring, the optical string apparently extends further to the southwest rather than turns toward NGC 7464. Therefore, it is unclear whether the optical string and the H I ring are related.

Since panoramic (2D) spectroscopy makes it possible to construct a more complete kinematic picture of an object, especially if several components are present, the peculiar galaxies NGC 7465/64/63 were included in the program of our investigation. This paper is a continuation of the study of candidates for PRGs by 2D spectroscopy that was begun by Shalyapina et al. (2007). In addition to spectroscopic
Table 2. Photometric observations

| Object         | Band | Exposure time (frames × s) | z, deg |
|----------------|------|----------------------------|--------|
| NGC 7465/64/63 | $B$  | $600 + 2 \times 300 + 2 \times 30$ | $40–44$ |
|                | $V$  | $9 \times 60$              | $37–40$ |
|                | $R_c$ | $4 \times 30 + 2 \times 20 + 3 \times 120$ | $35–37$ |

Table 3. Spectroscopic observations

| Object         | Instrument, date | Exposure time, s | Field   | Seeing, arcsec | Spectral region, Å | P.A.  |
|----------------|------------------|------------------|---------|----------------|-------------------|-------|
| NGC 7465       | LS Aug. 16, 2006 | $4 \times 1200$  | $1'' \times 6'$ | 1.8            | 4800–5570         | 160°  |
| NGC 7465/64/63 | IFP Aug. 16, 2006| $32 \times 180$  | $6'' \times 6'$ | 1.8            | $H\alpha$         |       |
| NGC 7465       | LS July 26, 2008 | $2 \times 900$   | $1'' \times 6'$ | 1.6            | 5700–7400         | 161°  |
| NGC 7465       | LS July 27, 2008 | $2 \times 1200$  | $1'' \times 6'$ | 2.9            | 5700–7400         | 45°   |
| NGC 7465       | MPFS Aug. 5, 2008| $3 \times 900$   | $16'' \times 16''$ | 2.0          | 4196–5712         | Central region |
| NGC 7465       | MPFS Aug. 8, 2008| $4 \times 900$   | $16'' \times 16''$ | 3.0          | 5630–7166         | Central region |

observations, we tried to obtain deep optical images for a more detailed study of the morphology and structure of these objects. In the next section, we give brief information about the instruments used for our observations and about the data reduction technique. Subsequently, we present the results of our study of the structure and kinematics of each galaxy. In conclusion, we discuss all the available data.

As the distances to NGC 7465/64/63, we take the distance to the NGC 7448 group, 29.5 Mpc ($H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$) (van Driel et al. 1992); the scale is then $1'' = 0.14 \text{ kpc}$.

**OBSERVATIONS AND REDUCTION**

The observations of NGC 7465/64/63 were performed at the 6-m BTA telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences (SAO RAS). The detector was an EEV 42-40 2048 × 2048-pixel CCD-array (the pixel size is 13.5 × 13.5 μm).

The photometric observations of the galaxies in the Johnson $B$ and $V$ bands and the Cousins $R$ band were performed with the SCORPIO focal reducer (Afanasiev and Moiseev 2005) on the night of August 16/17, 2004. For calibration, we observed standard stars from the list by Landolt (1983) during the night. Information about the photometric observations is given in Table 2. The observations were reduced using the ESO-MIDAS software package. The mean transparency coefficients for the SAO RAS (Neizvestnyi 1983) were used to correct the magnitudes for the atmosphere. The accuracy of the total magnitude estimates for the galaxies is ±0.1.

The spectroscopic observations of the galaxies were also carried out at the prime focus of the 6-m telescope using the SCORPIO focal reducer in the modes of a Fabry–Perot interferometer (IFP) or long-slit spectroscopy (LS) and using the Multi-Pupil Field Spectrograph (MPFS) (see the SAO RAS site.¹ Afanasiev et al. 2001). A log of observations of the galaxies is given in Table 3.

Parameters of the focal reducer in interferometric observations are given in Moiseev (2002). Prenomochromatization was performed using the narrow-band filter IFP 661 with a central wavelength $\lambda_c$ of 6604 Å and a full width at half maximum

¹http://www.sao.ru/hq/lsfvo/devices/mpfs/mpfs_main.html
FWHM = 21 Å. The spacing between adjacent orders of interference was 28 Å (1270 km s⁻¹). The IFP spectral resolution was 2.5 Å (≈110 km s⁻¹).

The detector (EEV 42-40 CCD-array) readout was performed in a 4 × 4-pixel binning mode, so that 512 × 512-pixel images at a scale of 0.714'' per pixel were obtained in each spectral channel.

The interferometric observations were reduced with software developed at CAO RAS (Moiseev 2002). After the primary procedures (the subtraction of night-sky lines and the reduction to the wavelength scale), the observational data were “data cubes” in which each point in a 512 × 512-pixel field contained a 32-channel spectrum. Optimal data filtering, a Gaussian smoothing in spatial coordinates with FWHM = 1.5 channels and a 2D Gaussian smoothing in spectral coordinate with FWHM equal to 10 km s⁻¹ per pixel were about 10 km s⁻¹. We also constructed images in the continuum (near Hα).

To analyze the velocity field, we used the “titled-ring” method (Begeman 1989; Moiseev and Mustsevoi 2000); it allows us to determine the positions of the dynamical center and the dynamical axis, to refine the galaxy’s inclination to the plane of the sky, and to construct the rotation curve. Analysis of the dependence of the position angle of the dynamical axis and the inclination on radius gives information about the peculiarities of the gas motion in the galaxy.

The long-slit observations for NGC 7465 were performed in two spectral ranges: “green” and “red.” In the green range containing the Hβ, [O III]λλ4959,5007 Å emission lines and the Mg I 5175Å, Fe I + Ca 5270 Å, and other absorption lines of the old stellar population, we used the VPHG2300G grism with the spectral resolution δλ = 2.2 Å in the range Δλ = 4800–5570 Å. The VPHG 1200R grism was used for the red range Δλ = 5700–7400 Å (near Hα), with the spectral resolution being 5 Å. The data obtained were reduced using standard procedures of the ESO-MIDAS package. After the primary reduction, we performed a smoothing along the slit with a rectangular window 3 pixel in height to increase the signal-to-noise ratio. The line-of-sight velocities of the gaseous component were measured from the positions of the centers of the Gaussians fitted to the emission lines. The accuracy of these measurements was estimated from the night-sky Hg I λ5461 Å and [O I]λ6300 Å lines to be 10–15 km s⁻¹. The cross-correlation method (Tonry and Davis 1979) was used to determine the line-of-sight velocities and velocity dispersions from absorption lines.

The MPFS simultaneously takes the spectra from 256 spatial elements (in the form of square lenses) that constitute a 16 × 16-element array in the plane of the sky. During our observations, the angular size of one element was 1'''. The spectral resolution was 3 Å. The comparison spectrum of a He–Ne–Ar lamp was used to calibrate the wavelength scale; the linearization accuracy was ~0.3 Å. The spectroscopic MPFS data were reduced using a software package developed by V.L. Afanasiev and A.V. Moiseev (SAO RAS).

MULTICOLOR PHOTOMETRY

During our photometric observations, the objective was to reveal faint tidal structures between the triplet galaxies and to study the suspected polar ring. Therefore, the frame was centered on NGC 7463 and the most distant galaxy NGC 7463 was not entirely in the frame. The B-band image of NGC 7465/64/63 with the superimposed isophotes in the Hα line and the isophotes in the B, V, R_c bands are presented in Fig. 1. We obtained deeper images than those in previous works (van Driel et al. 1992; Schmitt and Kinney 2000) in which the features of the outer regions of the galaxies are seen more clearly.

Despite its clumpy structure, three spiral arms rather than a faint ring, the presence of which was pointed out previously by several authors (see, e.g., van Driel et al. (1992) etc.), are prominent in NGC 7465. The northeastern and southeastern arms are superimposed on the arc-like structure observed in H I that was called the polar ring by Li and Seaquist (1994). The southwestern arm bends and extends to the northwest toward NGC 7464, whose isophotes are asymmetric and extend toward this arm. The presence of three spirals also manifests itself in the color distribution (Fig. 1). However, because of the clumpy structure and the low surface brightness at the ends of the spirals, only their brightest parts close to the main body of the galaxy are seen.

As has been noted above, NGC 7463 is not entirely in the frame, but the central bar-like structure and the eastern spiral arm branching off from it, whose end turns to the north, are clearly distinguished in its images.

The total apparent magnitudes and colors of NGC 7465 and NGC 7464 were found using multiperture photometry, whose accuracy, as was pointed out above, was ±0.1. However, emission lines fall within the passbands of all three filters, which can
cause the errors to increase, especially in the regions where the contribution of the radiation in emission lines is significant. The total magnitudes corrected for Galactic extinction (Schlegel et al. 1998) are given in Table 1. The color indices for NGC 7464 and NGC 7465 are close to those typical of IrrI and Sa–Sab galaxies, respectively.

The $B-V$ and $V-R_c$ color distributions are presented in Fig. 1. As follows from these maps, the bluest colors are observed in the circumnuclear region of NGC 7464 ($B-V \approx 0.2$) and in the region of the spiral arms of NGC 7465 ($\approx 0.36$) and NGC 7464 ($\approx 0.3$). In the circumnuclear region of NGC 7465, the colors are distorted due to the presence of emis-
MORPHOLOGY AND STRUCTURE OF THE TRIPLET GALAXIES

To analyze the photometric structure of the galaxies, we used the technique proposed by Jedrzejewsky (1987). It is based on the Fourier expansion of the deviation of isophotes from an elliptical shape. For this purpose, the IRAF system was used for the data reduction. Let us consider our results for each galaxy.

NGC 7465. In the central region ($r < 5''$), the $R_{f}$-band isophotes have an approximately elliptical shape with ellipticity $\epsilon \approx 0.2$ and a position angle of the major axis $PA \approx 120^\circ$. We also analyzed the shape of the isophotes in this region in the “red” and “green” continua based on IFP and MPFS data (Fig. 2) to eliminate the influence of emission lines. The values of both $\epsilon$ and $PA$ turned out to coincide with those of the broadband photometry.

The images of the galaxy’s circumnuclear region in continua (the F547M and F791W filters) were obtained with the Wide-Field Camera (WFPC2) of the Hubble Space Telescope (HST) (Ferruit et al. 2000). Owing to its high spatial resolution ($\sim 0.1''$), a number of interesting features are revealed in these images. Figure 2 presents the HST frame in the F547M filter. The brightest (in continuum) regions are located within a circle with $r = 4''$ and show an inverted $S$ shape with a position angle of the major axis $PA \approx 120^\circ$; further out, the major axis gradually turns and $PA \approx 160^\circ$ at a distance of $10''$. The morphology of the central regions southeast of the nucleus is strongly distorted by dust lanes perpendicular to the galaxy’s major axis. The deep compact minimum in log (F547M/F791W) is achieved with the following parameters: the exponent $n = 1 \pm 0.2$ (typical of disks), the effective radius $R_{e,b} = 4''.6$, and the central surface brightness $\mu_{0} = 16''''3$.

Let us analyze the brightness distribution in emission lines. Comparison of the brightness distributions in continuum and Hα (Figs. 2 and 1) showed that they differ noticeably. The isophotes in Hα are elongated along the NE–SW direction (PA $\sim 50^\circ$), and their shape is far from being elliptical (a rough estimate is $\epsilon \sim 0.3$ ($i \sim 46^\circ$)). The emission peak corresponds to the galactic nucleus, and a slightly less bright region is south of the nucleus at $r \approx 5''$; other less bright knots are also observed. A bent outgrowth with a brightening at its end, which apparently belongs to the SE spiral arm, is clearly seen on the SE side. A string of regions shining in Hα is distinguished on the southeastern side at a distance of $55''$ from the galactic center. This string has the shape of a “ragged” semiring. One more extended region bright in Hα is seen to the NE at a distance of $80''$ from the center. Note that all these regions fall on the spiral arms of the galaxy. The total flux in Hα and the lower limit for the star formation rate (without any correction for extinction) estimated using the relation from Kennicutt (1998) are given in Table 1.

Comparison of the brightness distributions in permitted (Hα, Hβ) and forbidden ([N II], [S II], [O III]) lines. At a distance from $10''$ to $30''$ from the nucleus, $B-V$ changes little ($0''''7-0''''8$); further out, it gradually turns blue and reaches $0''''36$ in the region of the spiral arms. The color distribution in the main body of NGC 7463 is highly nonuniform, which is apparently related to the presence of a bar, numerous H II regions, and a dust lane, where $B-V$ is $\approx 0''''8$. We also analyzed the photometric structure of NGC 7465 in the $K_s$ band based on 2MASS (Two Micron All Sky Survey) data. The radius of the galactic disk in the image in this band is $\approx 23''$. In the central region $PA \approx 120^\circ$, $PA$ increases with distance from the center to $160^\circ$ (at $r = 15''$) and remains approximately constant further out. The ellipticity changes from 0.2 to $\approx 0.4$, which coincides with the behavior of these parameters in the optical band.
Fig. 2. NGC 7465. Top: the IFP image in the continuum near Hα. Middle: left: the image in the continuum in the F547 filter (Fig. 24 (top, right) from Ferruit et al. (2000)); right: the MPFS image in the [O III] λ5007 Å line. Bottom from left to right: the MPFS images in the continuum near Hα, in the [N II] λ6584 Å line, and in Hα.

Fig. 3. NGC 7464. The results from IFP data: (a) the brightness distribution in a narrow continuum near Hα; (b) the brightness distribution in Hα; (c) the line-of-sight velocity field in Hα; (d) the line-of-sight velocity dispersion field in Hα. The results of the tilted-ring method: (e) the gas rotation curve.
emission lines (Fig. 2) for the central region of the galaxy shows that the images in all emission lines are similar and there are no significant differences in the emission extent.

**NGC 7464.** The brightness distribution both in broadband filters and in continuum (Figs. 1, 3) is amorphous, and the shape of the isophotes is approximately elliptical. In the central region ($r \leq 7''$), PA $\sim 50^\circ$ and the ellipticity changes from $0.3 (r \approx 2'')$ to $0.1 (r \approx 8'')$. At a distance of $\approx 9'' - 11''$, the isophotes are circular; further out, $\epsilon$ increases to $0.2 (r \approx 15'')$; PA in the outer parts is $\sim 120^\circ$. The photometric profile along the major axis (PA = $120^\circ$) is asymmetric; the SE wing is flatter. The elongation toward the SW spiral arm of NGC 7465 increases with distance from the center, as we have already mentioned in the section “Multicolor Photometry.” The turn of PA from $\approx 120^\circ$ at the center to $\approx 50^\circ$ in the outer parts is observed.

Since the brightness distributions in the H$\alpha$ and [N II] $\lambda 6584$ Å lines are similar, we give only the H$\alpha$ image in Fig. 3. Two bright regions located approximately along the direction of $65^\circ$ on both sides of the nucleus and embedded in the diffuse emission in these lines are distinguished in the central part. Van Driel et al. (1992) pointed out that a bar is possibly present at the center of this galaxy; however, our study of its kinematics (see the next section) does not confirm the presence of a bar. PA of the outer isophotes ($r \geq 8''$) is $\approx 68^\circ$. It should be noted that the isophotes in emission lines are turned with respect to those in continuum.

**NGC 7463.** Figures 1 and 4a present the brightness distributions in broadband filters and continuum, respectively. The main parameters of the bar are: PA$_{\text{bar}} \approx 57^\circ$, the bar ellipticity is $\epsilon_{\text{bar}} \approx 0.7$, and the semimajor axis of the bar $a_{\text{bar}}$ is $\approx 11''$. The galactic disk has the following characteristics: PA$_{\text{disk}} \approx 90^\circ$ and $\epsilon_{\text{disk}}$ gradually changes from 0.45 at a distance of 12'' to 0.6 at $r = 30''$ (the disk inclination changes from $57^\circ$ to $66^\circ$). The outer parts of the disk are asymmetric relative to the minor axis; the western side appears more perturbed, and the turn/bend of this part of the disk to the south is observed.

In the H$\alpha$ image of the galaxy (Fig. 4b), no bar-like structure is distinguished, but only two brightenings at its ends are seen, with the eastern one being brighter. In addition, several bright knots located along the spiral arms are observed in this image and are probably H II regions. All of this is embedded in the diffuse emission in H$\alpha$ that extends approximately to the same distances as the continuum emission.

**KINEMATICS OF THE GAS AND STARS**

Our spectroscopic observations of the triplet galaxies included IFP observations. Based on them, we constructed the line-of-sight velocity fields and velocity dispersion maps in H$\alpha$ for each of the galaxies (Figs. 5, 3c, 3d, 4c, 4d) and in the [N II] $\lambda 6584$ Å line for NGC 7464. For NGC 7465, we performed a more detailed spectroscopic study (see Table 3). The observations with the MPFS and the long-slit spectrograph were carried out in two spectral ranges (“red” and “green”), which allowed us to study the kinematics of not only the gaseous component but also the stellar one.

**NGC 7465.** Let us consider the results of our observations for the gaseous component of this galaxy. Figure 5c presents a large-scale line-of-sight velocity field in H$\alpha$. It can be seen from the figure that the gas disk rotates, with the eastern side recedes from us, while the western side approaches us. In the central region of the galaxy ($r < 4'' - 5''$), a kink in the isovels is noticeable. We will dwell on this feature below when discussing the MPFS data. At greater distances (up to $r \approx 20'' - 25''$), the shape of the isovels corresponds to the disk rotation.

Our analysis of the large-scale line-of-sight velocity field by the tilted-ring method showed that the photometric and dynamical centers coincide and the heliocentric velocity of the system is $1963$ km s$^{-1}$. Figure 6a shows the rotation curve of the ionized gas; the maximum rotation velocity is reached at a distance of $8''$ and is $70$ km s$^{-1}$; further out, it decreases and, in the region from $13''$ to $25''$, changes little and is approximately $40$ km s$^{-1}$. The change in the position angle of the dynamical axis with distance from the center is presented in Fig. 6b. It can be seen from this figure that the dynamical axis gradually turns with increasing distance from the center, with the disk inclination to the plane of the sky also changing. The parameters of the model of circular rotation of the ionized gas turn out to be the following: at $r = 2'' - 3''$, PA$_{\text{dyn}} \approx 50^\circ$ and the inclination to the plane of the sky is $i_{\text{dyn}} \approx 50^\circ$, while in the region from $15''$ to $20''$, PA$_{\text{dyn}}$ changes from $120^\circ$ to $130^\circ$ and $i_{\text{dyn}} \approx 60^\circ$.

For the central region of NGC 7465, the velocity fields in all emission lines were constructed from the MPFS data. They turned out to be similar; therefore, the fields in the H$\alpha$, [N II] and [O III] lines are presented in Figs. 5a, 5b, and 5d. A kink in the isovels like that revealed by the IFP data is observed in the circumnuclear region ($r \leq 3''$). On the whole, the eastern part of the gas disk recedes from us, while the western part approaches us; the dynamical axis gradually turns with increasing distance from the center.
Fig. 4. NGC 7463. The results from IFP data: (a) the brightness distribution in a narrow continuum near Hα; (b) the brightness distribution in Hα; (c) the line-of-sight velocity field in Hα; (d) the line-of-sight velocity dispersion field in Hα. The results of the tilted-ring method: (e) the gas rotation curve; (f) PA$_{\text{dyn}}(R)$. 

STUDY OF THE STRUCTURE AND KINEMATICS
Fig. 5. NGC 7465. The line-of-sight velocity fields of the ionized gas in the following lines: (a) Hα (MPFS); (b) [N II] λ6584 Å (MPFS); (c) Hα (IFP); (d) [O III] λ5007 Å (MPFS); (e) The line-of-sight velocity field of the stellar component (MPFS).
from \( \text{PA}_\text{dyn} \approx 70^\circ (r = 2''') \) to \( \text{PA}_\text{dyn} \approx 110^\circ (r = 8'') \), which closely agrees, within the error limits, with the IFP data.

As regards the bright knots in H\( \alpha \) that form the arc/semiring (see Fig. 5c), as we have already pointed out when analyzing the structure of this galaxy, most of them belong to different spiral arms (the NE, SE, SW arms). Their velocities most likely characterize the line-of-sight velocities of the gas in the corresponding parts of the spirals.

The line-of-sight velocity curves in emission lines (long-slit spectra) along the major axes of the main body (\( \text{PA} = 160^\circ \)) and the suspected polar ring (\( \text{PA} = 45^\circ \)) are similar and agree well with the MPFS and IFP data. The coincidence of the line-of-sight velocities measured using three different spectral instruments, within the accuracy limits, suggests that our data are reliable.

Let us now consider the kinematics of the stellar component. Figure 5e presents the stellar velocity field from the MPFS observations in the green range. In the central region (\( r \leq 4'' - 5'' \)), the shape of the isovels is regular and typical of a rotating disk. Our analysis of this field by the tilted-ring method showed that \( \text{PA}_\text{dyn, st} \approx 300^\circ \) and \( i_{\text{dyn, st}} \approx 60^\circ \) and they are close to the corresponding photometric parameters that we obtained above.

Let us consider the motion of the stellar component of this galaxy based on our long-slit spectroscopy. Figure 6c presents the line-of-sight velocity curve of the stars along the major axis of the galaxy (\( \text{PA} = 160^\circ \)). The absorption lines are traceable in this direction up to about 30'' from the center. The line-of-sight velocities of the stars from our long-slit and MPFS observations coincide, within the error limits. In the line-of-sight velocity curve of the stars at \( r \geq 6'' \) (outside the MPFS field of view), the direction of the gradient is reversed (Fig. 6c). This is probably related to the rotation of the galaxy’s main stellar disk around its minor axis, with the NW side of the disk approaching us, while the SE side receding from us.

Comparison of the line-of-sight velocity curve of the stars at \( \text{PA} = 160^\circ \) with the profile of the line-of-sight velocity field in H\( \alpha \) along the same direction (Fig. 6c) shows that the line-of-sight velocities of the stars and the ionized gas differ significantly starting from a distance of \( \approx 3'' - 4'' \) from the center. This means that these components in the region under consideration rotate around different axes.

If we assume that the dynamical axis of the stellar disk in the galaxy’s outer regions coincides with the photometric axis, then \( \text{PA}_\text{dyn, st} \approx 160^\circ \) and the inclination of the stellar disk to the plane of the sky is \( i_{\text{dyn, st}} \approx 50^\circ \). Under these assumptions, we can construct the rotation curve of the galaxy’s stellar disk (Fig. 6d). The maximum rotation velocity is reached at a distance \( r_{\text{max}} \approx 13'' \) from the nucleus and is \( \approx 105 \text{ km s}^{-1} \).

Based on our study of the stellar kinematics, we established that a stellar disk-like structure whose rotation axis is at a considerable angle (~140°) to the rotation axis of the main stellar disk is distinguished in the central region of NGC 7465.

Let us say a few words about the line-of-sight velocity dispersions of the stellar and gaseous components. According to our data, the velocity dispersion of both stars and ionized gas is low and does not exceed considerably the determination errors. A slight increase in the dispersion by 10–20 km s\(^{-1}\) is observed in the circumnuclear region (\( r \leq 2'' \)) for both components.

**NGC 7464.** For this galaxy, we constructed the line-of-sight velocity fields in the H\( \alpha \) and [N II] \( \lambda 6584 \) Å lines; they turned out to be similar and, therefore, the field in H\( \alpha \) is shown in Fig. 3c. Although the shape of the isovels is not very smooth, the rotation of the galaxy with a low velocity is noticeable (the S side recedes from us, while the S side approaches us). The nucleus is clearly distinguished in the galaxy’s continuum image. The line-of-sight velocity at this point is \( \approx 1765 \text{ km s}^{-1} \) and is taken as the system’s velocity. It coincides with the results of van Driel et al. (1992) but differs approximately by 100 km s\(^{-1}\) from the H\( \alpha \) data (Paturel et al. 2003; see Table 1). An asymmetry is observed between the N and S parts of the velocity field: the S part is more extended and is elongated toward the spiral arm of NGC 7465. In addition, \( \text{PA}_\text{dyn} = 240^\circ \) at \( r \leq 5'' \) and \( \text{PA}_\text{dyn} = 185^\circ \) further out. Under the assumption of circular rotation, we constructed the rotation curve (Fig. 3e) at the following parameters: \( \text{PA}_\text{dyn} = 185^\circ \), \( i_{\text{dyn}} = 40^\circ \), and \( V_{\text{sys}} = 1765 \text{ km s}^{-1} \). The maximum rotation velocity is reached at a distance of 9'' and is 40 km s\(^{-1}\). Despite the errors in these quantities, we can assert that NGC 7464 has a regular rotation.

An increase in the velocity dispersion from the N edge of the galaxy to the S edge approximately by 50 km s\(^{-1}\) is noticeable in the velocity dispersion map (Fig. 3d), which may be related to the interaction with NGC 7465. Further observations are needed to refine the behavior of the velocity dispersion.

**NGC 7463.** The line-of-sight velocity field of this galaxy is rather complex (Fig. 4c). It is well known that noncircular motions should be observed in the bar region. Therefore we attempted to analyze the part of the line-of-sight velocity field of NGC 7463 outside the bar (12'' \( \leq r \leq 34'' \)) by the tilted-ring method. The model of circular rotation of a disk with
the following parameters gave the best agreement with the observed field: the positions of the photometric and dynamical centers coincide, the heliocentric velocity of the system is \(2366\, \text{km s}^{-1}\), \(\text{PA}_{\text{dyn}} \sim 75^\circ\), and \(i_{\text{dyn}} = 62^\circ\) under the assumption of a thin disk. Figure 4e presents the corresponding rotation curve.

In the region of \(12'' \leq r \leq 34''\), the rotation velocity changes little and is \(\approx 115\, \text{km s}^{-1}\).

**DISCUSSION AND CONCLUSIONS**
Our photometric and spectroscopic data for the NGC 7465/64/63 triplet galaxies revealed an inter-
est ing, complex structure and kinematics in each of them. We will note at once that we did not detect the outer classical polar ring in NGC 7465 that was suspected by Whitmore et al. (1990). According to our data, the observed SE arc (see the Hα images in Fig. 1, the right column at the top) consists of separate knots belonging to different spiral arms. At the same time, as it turned out, the distribution and pattern of motion of the ionized gas differ from the corresponding data for neutral hydrogen (Li and Seaquist 1994); the ionized gas of this galaxy most likely forms its own separate system.

Moreover, such facts as the perturbed structure of NGC 7464, the elongation of its outer isophotes in continuum and emission lines toward NGC 7465, and the spiral arm extending from NGC 7465 to NGC 7464 led us to conclude that there is a close connection between these galaxies. On the whole, the detected photometric and spectroscopic properties of NGC 7464 (such as the blue colors and the presence of regular motions typical of disks) allowed us to classify it as an IrrI-type galaxy.

In turn, the set of our data for NGC 7463 shows that it is a barred spiral SBb-c galaxy. However, the warp of its outer parts indicates that a close encounter of NGC 7463 with a galaxy passing by probably took place in the past; it may have been one of the galaxies from the triplet or the NGC 7448 group.

Let us discuss the results of our analysis of the data for NGC 7465 in more detail. In addition to the main stellar disk with a position angle of the major axis of 160° and with an inclination to the plane of the sky of ~50°, a distinct inner (circumnuclear) stellar structure ~4′′ (0.56 kpc) in radius with PA_phot = 120° was detected in this galaxy. The photometric properties (the shape of the isophotes in images in various spectral ranges, the approximation of the photometric profile along its major axis by the Sersic law with the exponent n = 1 ± 0.2) and the stellar kinematics in this region (the appearance of the stellar velocity field corresponds to the rotation of a disk with PA_{dyn, st} = 300° and i_{dyn, st} ~ 60°) led us to conclude that there is an inner stellar disk almost “counter-rotating” relative to the main stellar disk.

Based on the large-scale brightness distribution in Hα and the complex behavior of the ionized-gas isovels in the region with a radius of 25″ (PA_{dyn, gas} changes from ~70° at r = 2″ to PA_{dyn, gas} ~ 120° at r = 20″; i_{dyn, gas} ~ 50°), we suggest the existence of a warped gas disk; in the circumnuclear region (r ≤ 5″), this gas disk is polar relative to the main stellar disk, and the angle between the planes of the main stellar disk and the gas disk at its outer boundary is estimated to be 45° and 83°. The observed circumnuclear dust lanes perpendicular to the galaxy’s major axis also argue for the polarity of the gas disk (see, e.g., Sil’chenko and Afanasiev 2004).

The observed structure of NGC 7465, which combines at least three systems distinguished by their properties (the inner and main stellar disks + the warped gas disk), owes its origin to the gravitational interaction with other galaxies. It seems unlikely to us that such a complex structure was formed as a result of one interaction. The circumnuclear stellar disk most likely could be formed as a result of the capture and swallowing of a dwarf companion. In turn, the warped gas disk could arise from the accretion of matter from a gas-rich galaxy onto NGC 7465 (Bournaud and Combes 2003). Judging by our results, NGC 7464 could serve as such a companion galaxy.

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