Bulgarian Academy of Sciences. Българска академия на науките

Astrophysical Investigations,6.Астрофизически изследвания,6

Sofia.1991.София

Extragalactic astronomy

CCD-spectra of the galaxy Arakelian 144

G. T. Petrov

Using spectra obtained on the 3,5 m telescope of the Calar Alto Observatory, Spain, by means of a CCD device, we determined the relative intensities of the emission lines. Two (or three) components were established in the nucleus with $\Delta V_r = \pm 240$ km/s at the H_α line. The data obtained were compared to those from previous observations.

Key words: galaxies, spectrophotometry, emission lines, CCD-spectra.

Address: Department of Astronomy with National Astronomical Observatory, Bulgarian Academy of Sciences, 72 Lenin blvd., 1784 Sofia, Bulgaria.

I. Introduction

The galaxy Arakelian 144 (Akn 144) (MCG 10-12-23) is one of the high surface brightness galaxies on Arakelian's list (1975). Its integral magnitude is $m_p = 15{,}2$ (CGCG), corresponding to surface brightness $B = 21{,}5$ m/s^2 in the Arakelian system. In the MCG the listed galaxy's angular dimensions are $18'' \times 15''$. D i b a y et al. (1976) established that for the redshift $Z = 0{,}028$ the linear dimensions of the galaxy are 9800×8100 pc at $H = 75$ km/s.Mpc.

Akn 144 was spectroscopically studied by M i n e v a et al. (1981, 1982), and morphologically — by G o l e v et al. (1985); K o j o y a n et al. (1981) determined its precise optical position.

This galaxy is on the programme of investigation of active galactic nuclei at the Department of Astronomy and National Astronomical Observatory of the Bulgarian Academy of Sciences.

II. Observing Data

The initial observing data on Akn 144 are presented in Table 1.

The results of this study are based on two spectra of Akn 144, obtained on the 3,5 m telescope of the Calar Alto Observatory of the Deutch-Spanish Astronomical Centre, Spain. For the purpose a Bouler & Shivens spectrographer of dispersion about 20 Å/mm was used. For the light signal we used a CCD matrix, a device of Texas Instruments, 356×520 pixels, TI-type, sensitive to red spectral re-

Table 1

Initial observational data for Arakelian 144

α_{1950}: 07h 52m 48s, 3; δ_{1950}: +61° 47′ 44″ (K o j o i a n et al. 1981)
Z=0,028; M_p= —20,5 (D i b a y et al. 1976, H=75 km/s.Mpc; m_p=15,2 (CGCG); a×b=0,30 ×0,25=9800×8100 pc (MCG)

gion, together with liquid nitrogen as cooling agent, keeping the temperature at 120°C. The spectral resolution was 1 pixel=29 km/s, or about 0,7 Å/pixel. We investigated the region around H_α line.

The spectra were processed at the Max Planck Institute of Astronomy, Heidelberg, Germany. The spectrum reduction software used was Dr. J. Solf's, and CCD data were reduced to the appropriate format by means of a "MIDAS" packet of programs and a "VAX-11" minicomputing system so that Dr. Solf's software could be made operative.

III. Discussion

The first to investigate spectrally Akn 144 were D i b a y et al. (1976). They detected strong emission in the H_α line, as well as an emission of medium intensity in the forbidden lines of sulfur and nitrogen, but did not make any estimations.

In 1978 the spectra were examined for weak emission lines and we detected a certain inclination of sulfur and nitrogen lines. For this reason Akn 144 was included in the programme of spectral studies for 1980, to determine the velocity field and physical conditions of the emitting gas. Spectra of the galaxy of dispersion 50 Å/mm were obtained on the 6 m telescope of the Special Astrophysical Observatory of the Soviet Academy of Sciences (see M i n e v a et al., 1981).

The surprising results obtained (the extremely strong forbidden lines of ionized sulfur and the very high electron density in particular) were indicative of a probable activity in the nucleus of Akn 144. This galaxy was photographed in the B-colour at a seeing of approximately 1″ on the 2 m telescope of the Rozhen National Astronomical Observatory. In Figure 1 three nuclei can be discerned for Akn 144.

The plate imaging Akn 144 questions its participation to SO-galaxies (N i l s o n, 1973). On the original plate an initial spiral structure and a non-symmetrical nucleus can be clearly discerned.

Table 2

Spectrophotometric data for Arakelian 144

Spectrophotometric data	Oct. 1985 3,5 m tel.	Oct. 1980 6 m tel.	Jan. 1976 1,25 m tel.
$I_{\lambda 6548}/I_{H_\alpha}$	0,37	0,61	H — strong
$I_{\lambda 6717}/I_{H_\alpha}$	0,11	1,00	S II — mean
$I_{\lambda 6731}/I_{H_\alpha}$	0,08	2,56	N II — mean
$I_{\lambda 6717}/I_{\lambda 6731}$	1,39	0,40	
n_e, cm^{-3}	50	$3{,}6 \cdot 10^4$	
FWHM, km/s			
H_α	140		
λ 6548, 6584	130		
λ 6717, 6731	165		

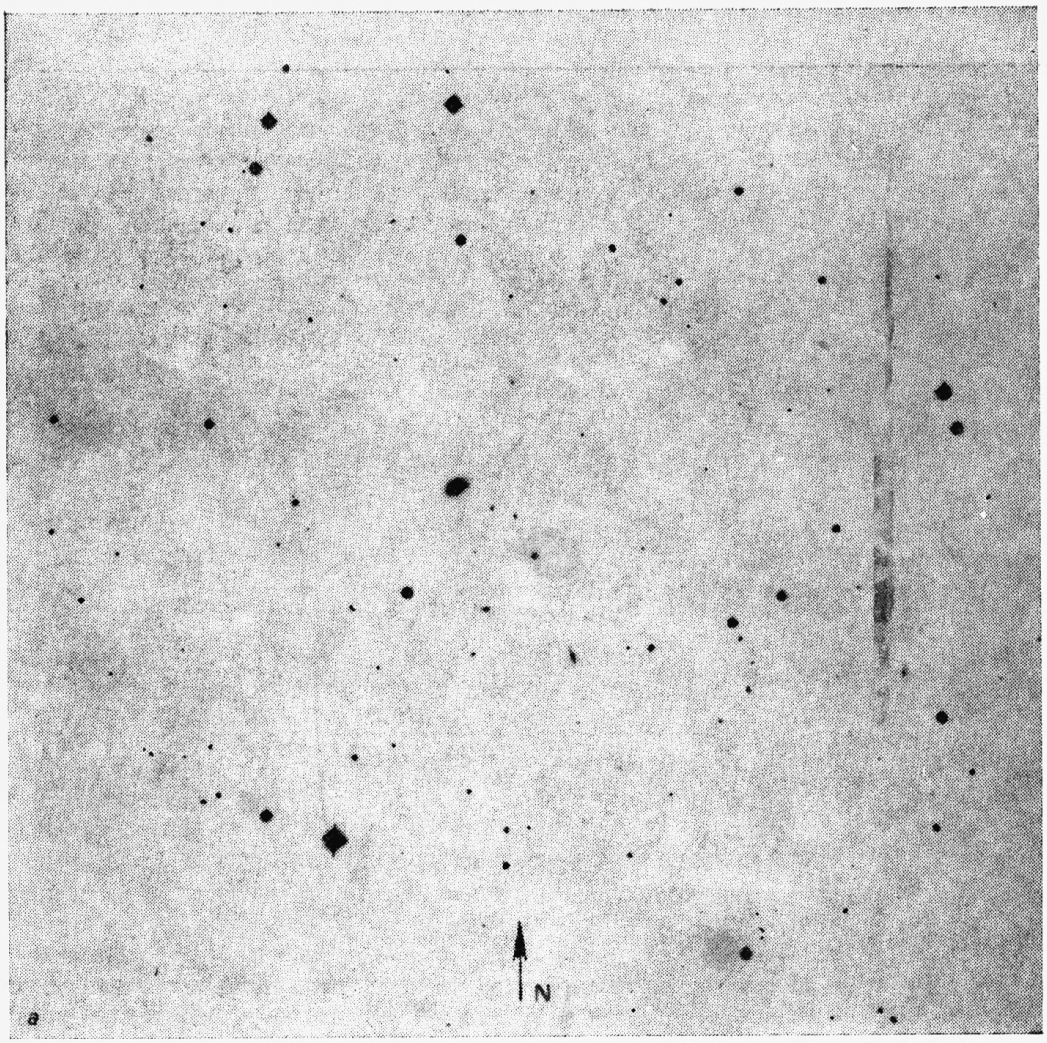

Fig. 1. Arakelian 144 galaxy
a — direct picture in B-colour of Akn 144 (the original scale is 12,9″/mm, 2 m telescope of the "Rozhen" NAO) *b*, *c*, *d* — demonstration of the multystructure nucleus of the galaxy (linear diameters of the nuclei are about 1 pc)

In October 1985 a number of spectra were obtained on the 3,5 m telescope at the Calar Alto Observatory, the width of the slot set in right ascension being 1″.

Table 2 lists the results of the relative spectrophotometrical study and data from the above-mentioned papers for comparison purposes.

We are faced with a completely different picture as to the spectrum of the galaxy. The ratio [SII]/H_α is smaller by a factor of 10 so that now Akn 144 seems to be a typically ordinary galaxy with emission lines in its spectrum (P e t r o v, 1980). Gas electron density has decreased by a factor of 10^3. Table data suggest cyclicity of an about 5-year quasiperiod.

Figure 2 presents a spectrogram of Akn 144, obtained on the 3,5 m telescope at the Calar Alto Observatory, using a CCD matrix. By means of "MIDAS" reduction programs fed into a "VAX-11" computer, the spectra were corrected for the night sky and CCD proper noise.

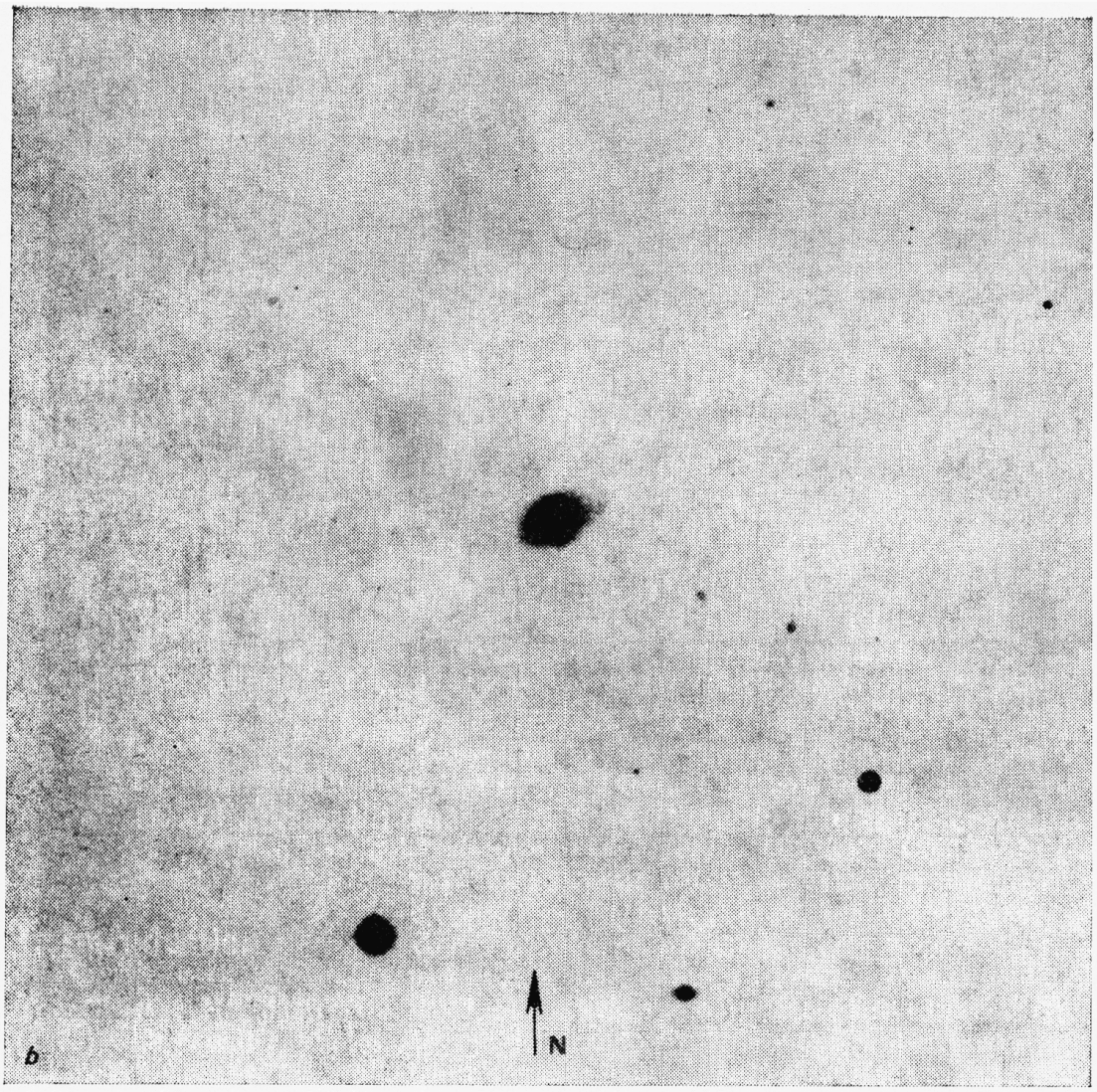

Fig. 1*b*

Figure 3 shows equal intensity lines for H_α and ionized nitrogen forbidden lines, and for ionized sulfur forbidden lines, respectively. This figure supplies information about the spatial structure of the emitting gas. At least two (or even three) components can be discerned, of relative velocity $\Delta V_r = \mp 165$ km/s for sulfur lines, and $\Delta V_r = \mp 240$ km/s for H_α in respect to the central maximum. The dimensions of the emitting region are approximately 5″, i. e. 2700 pc for H=75 km/s. Mpc, and distance to the galaxy 112 Mpc. The third component is best observed at the λ6584 [N II] line and completely absent at H_α.

The width of the lines at half-intensity, as well as the relative intensity of the emission lines are reliable criteria to classify a galaxy as an active object of a certain type (V e r o n, 1981). In the case of Akn 144 the full width at half-intensity (FWHI) is 140 km/s for H_α, 130 km/s for the nitrogen lines, and 165 km/s for the sulfur lines, respectively. Because of the smaller intensity of the latter, the relative measurement error for the lines' width is bigger. The estimation values for the width are quite smaller than 500 km/s, the width indicating the participation

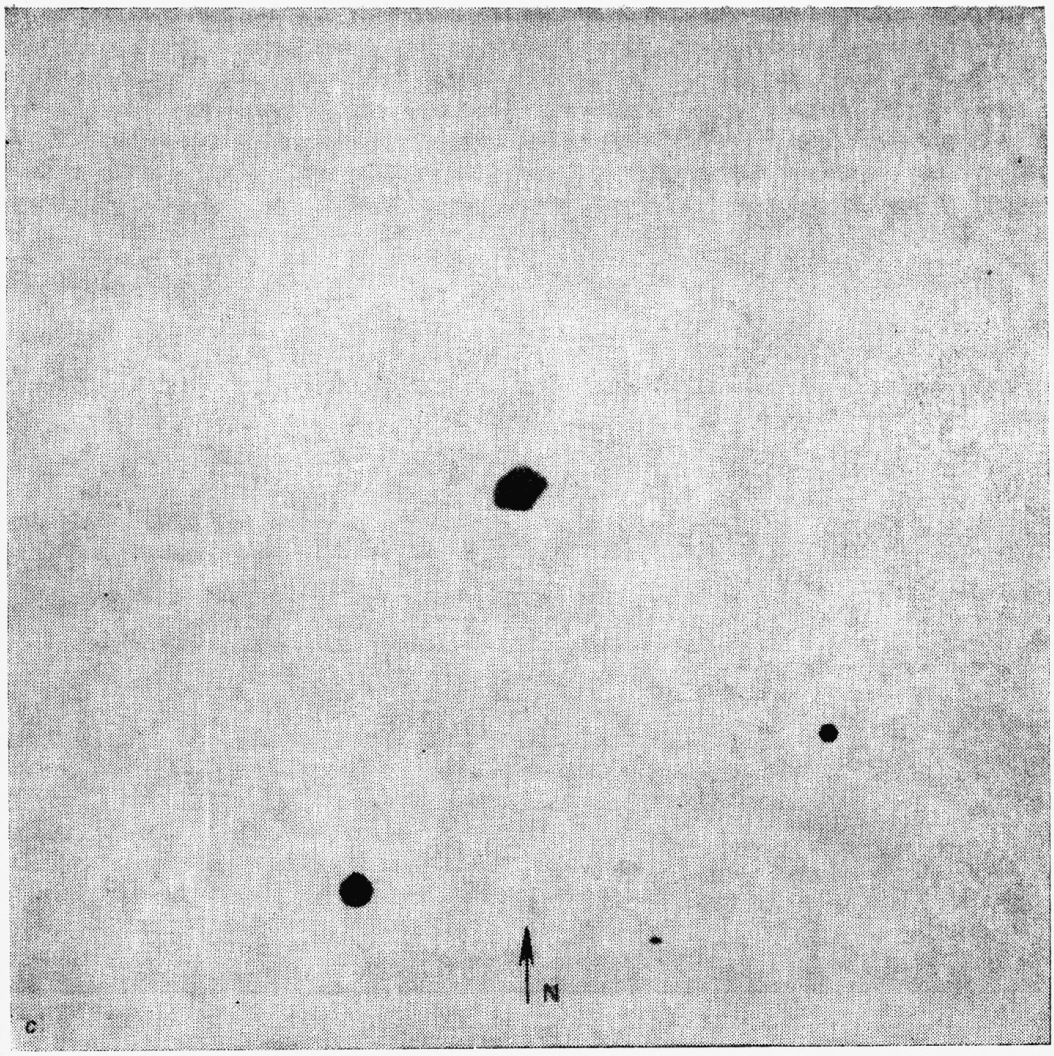

Fig. 1*c*

of a galaxy to the Seyfert type. On the basis of spectrophotometric and photographic data, Akn 144 can be classified as an object with three nuclei and strong spectral emission lines, as well as a cloud structure of the gas, outflowing off the nucleus at a velocity up to ∓ 240 km/s.

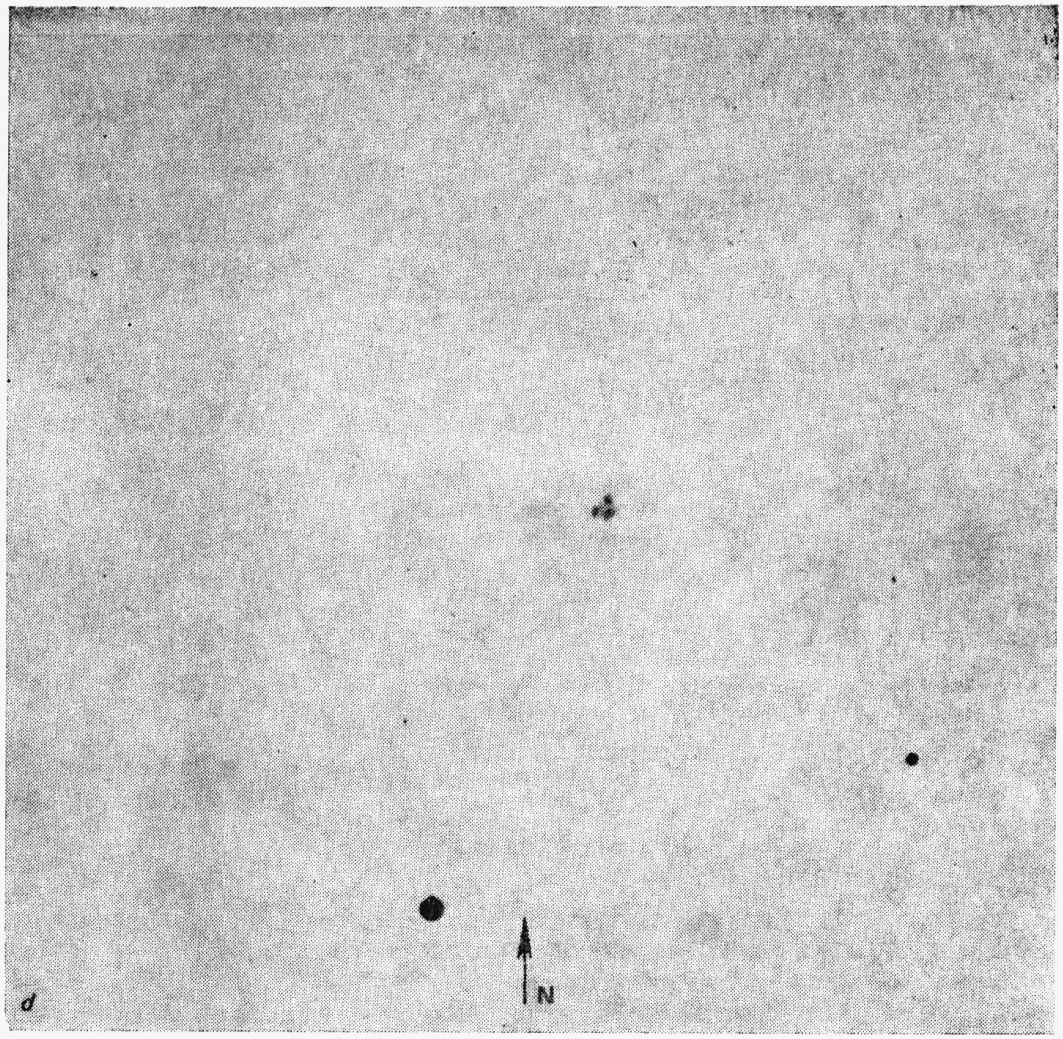

Fig. 1*d*

IV. Conclusions

There are at least three possible explanations of the drastic changes observed in the spectrum of Akn 144, and of the possible activity in its nucleus, on which we shall make the following brief comments:

a) A possible misidentification of the object during the observations on the 6 m telescope (namely in those spectra are observed differences in the relative intensities). Though possible, such a contention is hardly probable, since in a radius of 20′ around Akn 144 no other bright galaxies have been observed. The nearest bright one is fainter by $1{,}5\text{-}2^{m}$.

b) The differences observed really exist and those in the radial velocities reflect the outflow of gas off the nucleus. The linear dimensions of the emitting region are approximately 2700 pc. Thus, for a period of 5 years the gas outflow at

a velocity of 165-240 km/s would eventually cause an increase of dimensions by 1-2 pc, i. e. this insignificant change can hardly explain the change of electron density by a factor of 10^3, which is the case, judging by the relative intensity of the forbidden lines of ionized sulfur.

c) At least one out of the three nuclei is a remnant of a Supernova and its spectrum had influenced the galaxy's integral one obtained in 1980.

Such an eccentric conclusion is not devoid of sense, since the width of the slot in this case was 3″, and the spectral resolution — 2-3 times lower. Besides, this high [S II]/H_α ratio is typical for gas, excited by shock waves, which is the case with Supernovae remnants. In order to corroborate or reject this assumption, more observations would be necessary, with high-quality large-size imaging so that the spectra of each individual nucleus should be obtained.

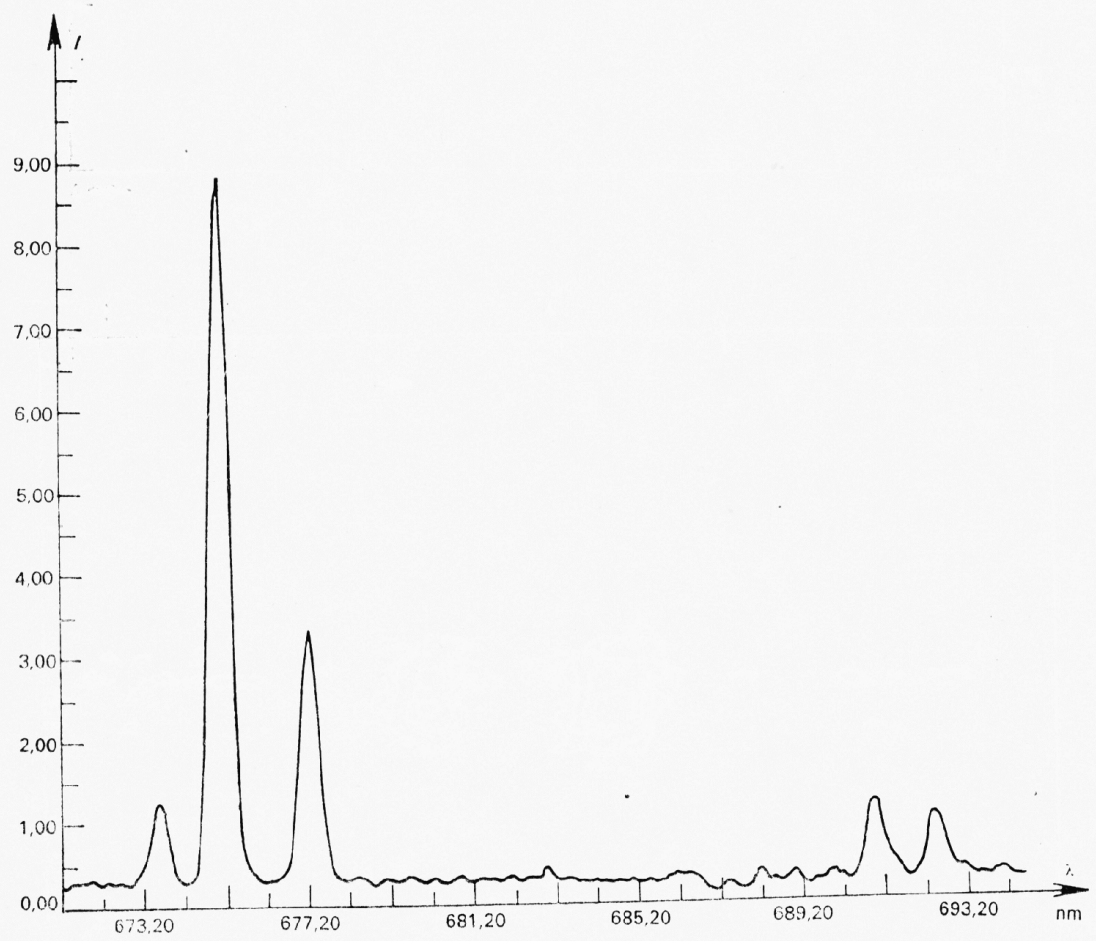

Fig. 2. CCD-spectra of the Akn 144

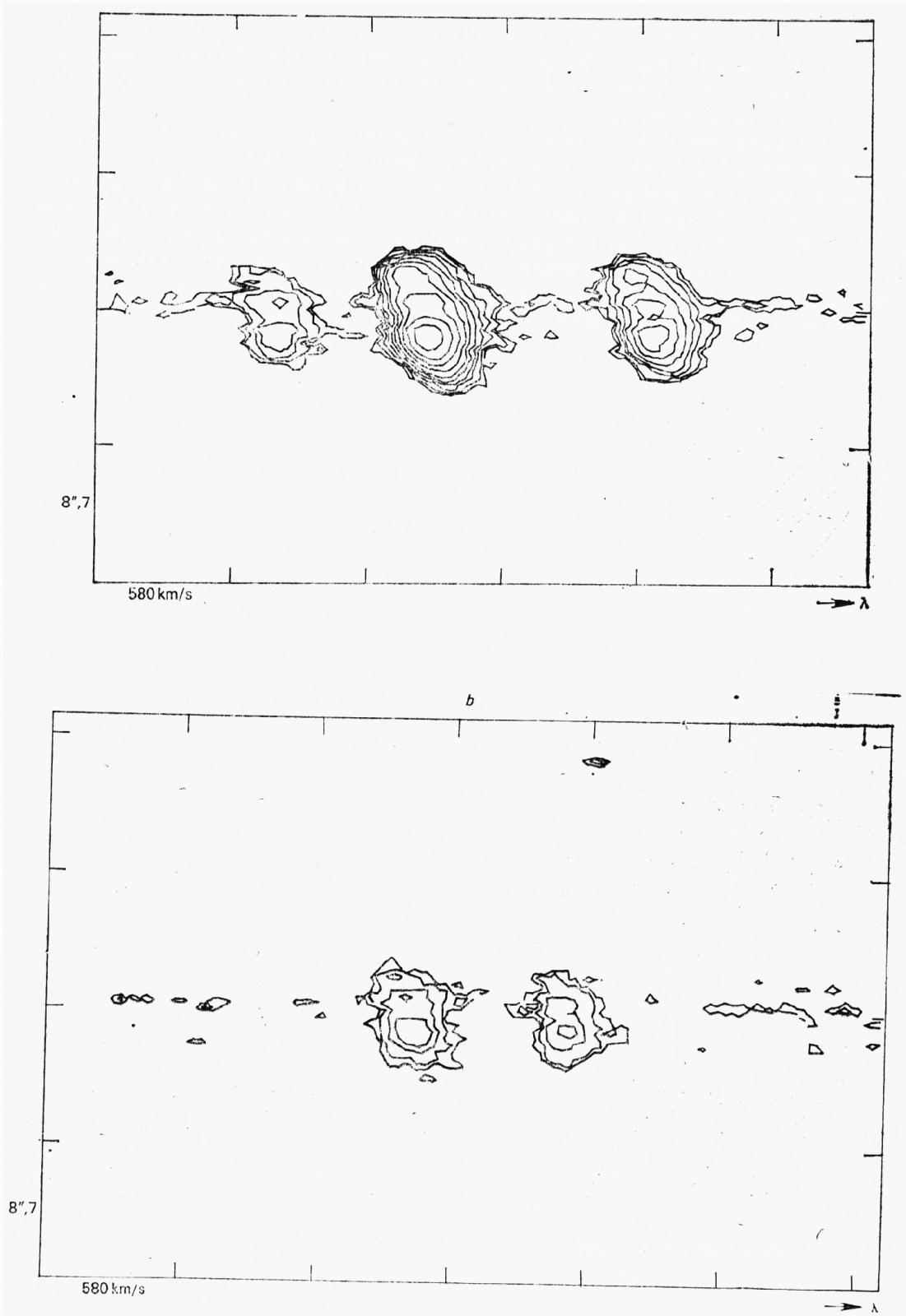

Fig. 3. Spatial structure of the emitting gas in the light of H_α (*a*) and [S II]θ λ 6717, 6731 Å (*b*)

The author of this paper is indebted to the management of the Max Planck Institute o Astronomy, Heidelberg, Germany, for the opportunity to work at the Calar Alto Observatory and in the laboratories of the Institute, and personally to Dr. Solf for the valuable recommendations.

References

Arakelian, M. A. 1975. Soob. Burac. Obs. **47**, 3.
Dibay, E. A., Doroschenko, V. T., Terebi, V. Iu. 1976. Astrofizika, **12**, 689.
Golev, V. K., Tsvetanov, Z. I., Petrov, G. T. 1982. Astrophys. Invest. (Bulg. Acad. Sci.), **4**, 95.
Kojoian, G., Elliot, R., Bicay, M. D., Arakelian, M. A. 1981. Astron. J., **86**, 820.
Mineva, V. A., Petrov, G. T., Kovatchev, B. J. 1981. Compt. rend. Bulg. Acad. Sci., **34**, 1629.
Mineva, V. A., Petrov, G. T., Golev, V. K., Tsvetanov, Z. I. 1982. Letters in A. J., **8**, 210.
Petrov, G. T. 1980. Dissertation, University of Yerevan, USSR.
Veron, M. P. 1981. Astr. and Ap., **100**, 12.

Received 14. 07. 1986.