A STUDY OF THE COMPACT GROUP OF GALAXIES SHAHBAZIAN 4

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ABSTRACT. For the members of the compact group of galaxies Shahbazian 4 the radial velocities are defined. The velocity dispersion is 440 km s^{-1}. Moreover the appparent and absolute magnitudes of galaxies in the V band as well as the mass-to-luminosity ratio are obtained. The latter is approximately 220 $M_\odot/L_\odot$. The "crossing time" for the group Shahbazian 4 is equal to 4.7×10^7 years. It is one of the densest group of galaxies with $n \sim 10^4$ galaxies Mpc^{-3}.

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Considerable attention has been given recently to the so-called Shahbazian's compact groups of the compact galaxies (Shahbazian 1973; Ambartsumian et al., 1975). This is one of the interesting classes of groups of galaxies. At present a large number of these groups are known and moreover some of them have been studied morphologically (Shahbazian and Amirkhanian, 1978) and photometrically (Shahbazian, 1978; Amirkhanian and Egikian, 1987; Amirkhanian, 1988; Amirkhanian et al., 1990). Because of the considerable distance of the majority of the compact groups and the faintness of their members spectral studies of these objects are not numerous. We should like to note pioneering work by Robinson and Wampler (1973) concerned with the spectral study of the group Shahbazian 1.

At this time interest in compact groups of galaxies has been stimulated for two principal reasons:

1. These are the most compact objects among the known groups of galaxies; the space density of galaxies in these groups is very high.

2. The first determination of the mass-to-luminosity (M/L) ratio for the group Shahbazian 1 (Robinson and Wampler, 1973; see also Shahbazian, 1978) has given a value one order of magnitude less than M/L for double galaxies and close to that of globular clusters.

However, later, a small value of the M/L ratio for the group Shahbazian 1 has not been confirmed (Kirshner and Malumuth, 1980). For other groups the mass-to-luminosity ratio has been

found greater as well, from 30 to 260 $M_\odot/L_\odot$ (see Amirkhanian and Egikian, 1987; Amirkhanian, 1989; Amirkhanian, et al., 1990). A detailed study of the compact groups of galaxies in the lists of Shahbazian et al. is of great interest from the point of view of the evolution of galaxy groups, too.

In this work results of spectral and photometric study of one of the most remarkable groups in Shahbazian's lists (No. 4) are presented. The late publication of the spectral observations is due both to objective and subjective reasons.

In June 1973 spectral observations of five galaxies from the compact group Shahbazian 4 were carried out with the 84-inch telescope at Kitt Peak National Observatory (USA) in order to obtain their radial velocities. The spectra were acquired with the grating spectrograph at the Cassegrain focus of the telescope. The six-camera secondary electron image intensifier of type P829D supplied with a "Lynds mask" (with the photoemulsion extension in the direction perpendicular to the dispersion during the exposure) was used as the photodetector. The image intensification was great enough to detect individual photoelectrons in the spectrum image.

The wavelength range 3500 - 7500 Å with a dispersion of 240 A/mm and a spectral resolution of about 10 A was covered during one exposure. In Shahbazian 4 the radial velocities of five galaxies (out of seven) are defined by a correlation analysis method. The root-mean-square error in determination of radial velocities is about 100 km s^{-1}. The radial velocities of group member galaxies V_o are given in Table 1. These velocities were corrected for solar motion by the formula:

$$\Delta V_o \ (km\ s^{-1}) = 300 \sin \ell^{II} \cdot \cos \beta^{II}$$

TABLE 1

Galaxy	Corrected Radial Velocity V_o (km s^{-1})
C. G. 4(1)	29 520
(2)	29 110
(3)	30 220
(4)	30 100
(5)	29 220

From the data in Table 1 the mean velocity $\langle V_o \rangle$ = 29 630 km s^{-1}, that corresponds to a group distance of 395 Mpc (here and throughout H_o = 75 km s^{-1} Mpc^{-1}). The mean harmonic distance between the galaxies is $\langle R^{-1} \rangle^{-1}$ = 37 kpc. The radial velocity dispersion $\langle \Delta V^2 \rangle^{1/2}$ corrected for observational errors is 440 km s^{-1}.

Taking for the virial mass definition an expression according to Karachentsev and Karachentseva (1975) we have:

$$M = 3\pi G^{-1} \frac{n}{n-1} \langle \Delta V^2 \rangle \langle R^{-1} \rangle^{-1} = 1.8 \cdot 10^{13} M_\odot ,$$

where n - the number of galaxies in group.

A picture of this group obtained by one of the authors (E. Ye. Khachikian) on hypersensitized emulsion Kodak IIIaJ emulsion (GG385 filter with 45 minutes exposure at the prime focus of the 4 meter telescope at Kitt Peak Observatory) is given in Figure 1. The plate limiting magnitude is about $23^{m}.5$.

The apparent magnitudes of the galaxies in V have been determined by detailed surface photometry of plates obtained at the prime focus of the 2.6 meter telescope of the Byurakan Astrophysical Observatory using extrafocal images of stars for calibration. The plate scale is about 21 "/mm. The plates have been measured with the Shnell microphotometer. The size of the scanning aperture corresponds to 100 μm x 100 μm. The total apparent and corresponding absolute magnitudes (corrected for absorption in our Galaxy and for redshift according to Peterson (1970) and Whitford (1971)) are given in Table 2.

TABLE 2

Galaxy	Apparent Magnitude m_V	Absolute Magnitude M_V
C.G. 4(1)	17.04	- 21.34
(2)	17.72	- 20.66
(3)	18.19	- 20.19
(4)	17.87	- 20.51
(5)	18.46	- 19.92
(6)	19.5	- 18.88
(7)	19.73	- 18.65

The total luminosity of the seven galaxies 8.1×10^{10} $L_\odot$ and the mass-to-luminosity ratio is about 220 $M_\odot/L_\odot$.

The estimate of the "crossing time" for this group is of interest as well. According to Gott, Wrixon and Wanner (1973) we get an expression for the crossing time

$$\Delta t = (3/5)^{3/2} \langle R \rangle \langle \Delta V \rangle^{-1/2} = 4.7 \times 10^7 \quad \text{years}$$

(the quantity $\langle R \rangle$ is equal to 0.045 Mpc for the compact group Shahbazian 4).

Such a small crossing time corresponding to approximately 1/300 of the age of the Universe age may be interpreted in two ways:

a. The group has a very small age (of order 10^8 years) and, possibly, it is not stable;

b. If the group has an age of order $H^{-1} = 13 \times 10^9$ years it is undoubtedly gravitationally connected.

In the second case one can suppose that the observable group was a considerably richer cluster in the past which lost most of its "lighter" (i.e., fainter) members in the process of dynamical evolution. In the favor of this view the fact speaks that five galaxies from seven ones have the higher luminosities from -20^m up to $-21^m.3$.

It is important to call attention to a high space density of galaxies in the group of order 10^4 galaxies Mpc^{-3} which is considerably higher than that of the central regions of the regular clusters of galaxies. According to Bahcall (1975) the space density of the galaxies amounts from 60 to 300 galaxies Mpc^{-3} for 15 clusters with the richness classes 0, 1, and 2 from the Abell's list (1958). The group consists exclusively of E and SO/a galaxies. According to Postman and Geller (1984) the overwhelming majority of the galaxies in the densest regions of the groups and clusters ($n \gtrsim 600$ galaxies Mpc^{-3}) belong to E and SO types. This fact is interpreted by them as a result of effects in the outer regions of galaxies of stripping mechanisms effective at such high space densities. Quite possibly the same mechanism acts in the case of compact group Shahbazian 4.

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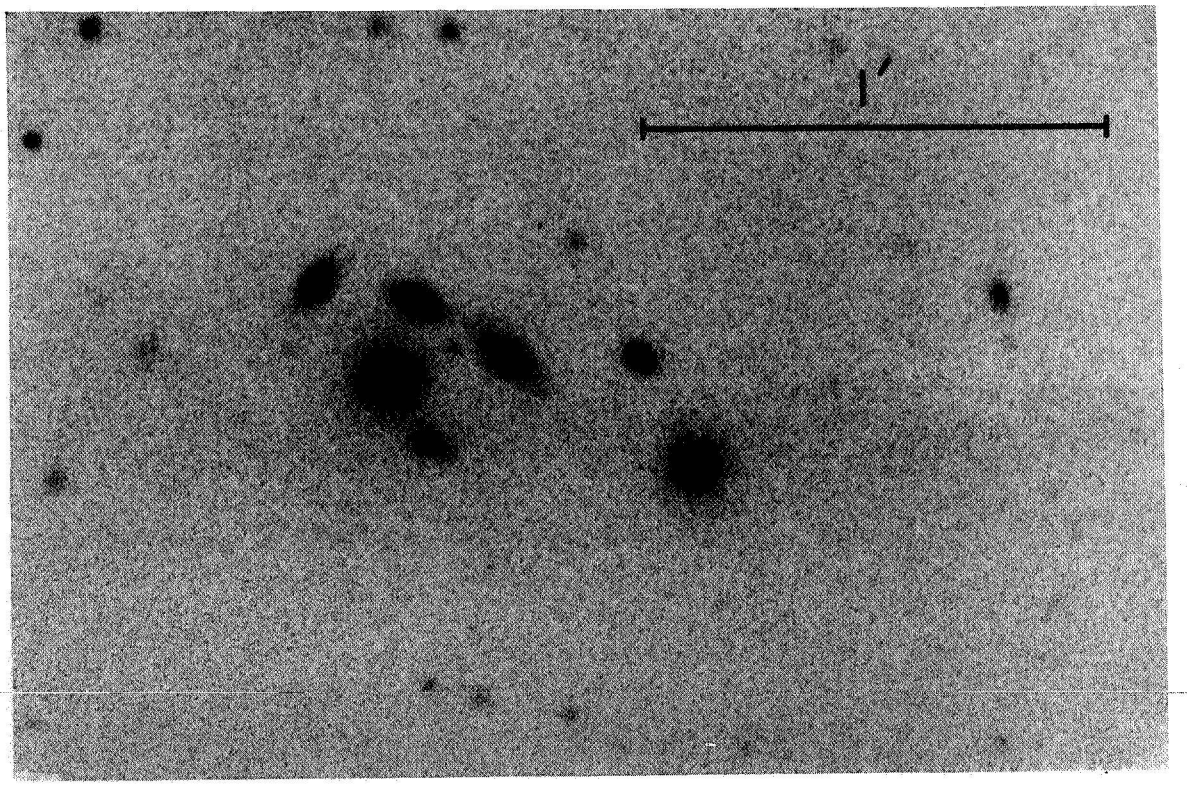
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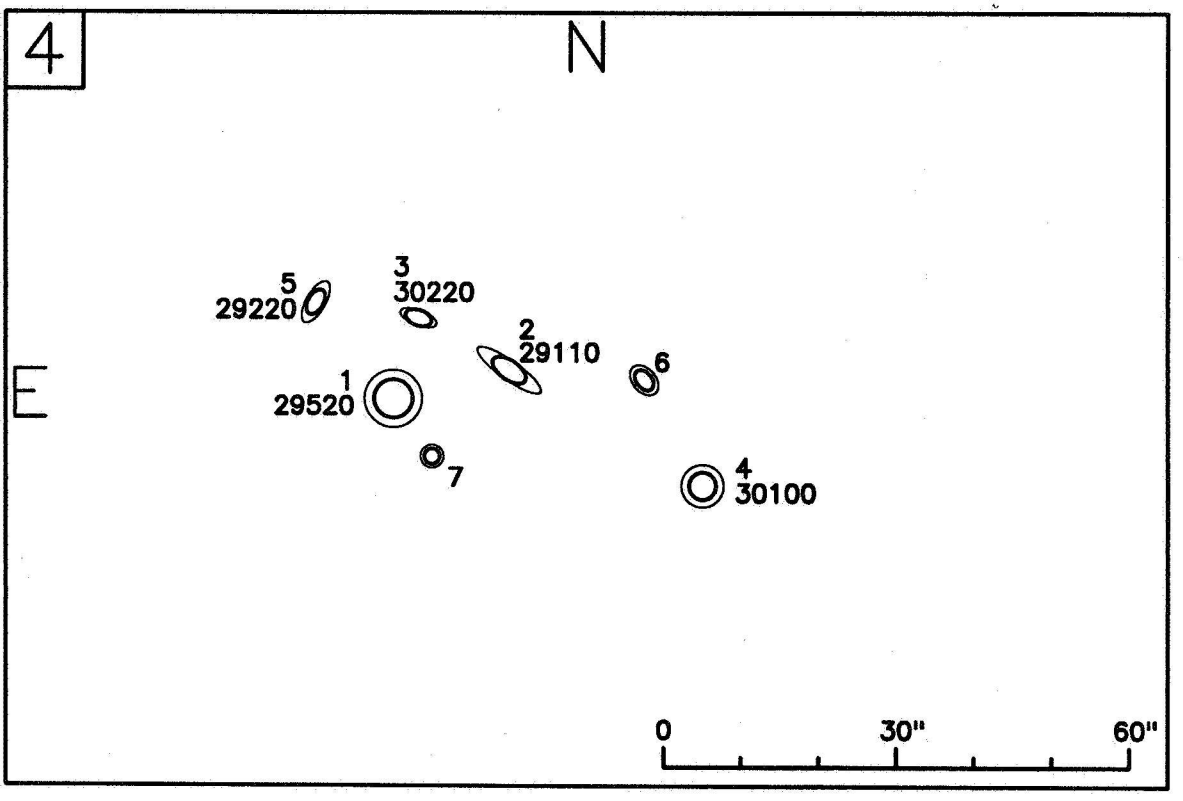
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