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SHAKHBAZIAN COMPACT GROUPS OF GALAXIES

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I. INTRODUCTION

The Shakhbazian compact groups (SCG) of galaxies form a large and well-defined sample of groups of (presumably) interacting galaxies. The list of 377 SCGs (F. Baier & H. Tiersch (1979), Astrofizika 15, 33 and references therein) is the largest sample of such objects

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The Shakhbazian groups belong to the densest concentrations of galaxies. Due to the small galaxy population the analysis of tidal features within them is much simpler than in clusters of galaxies. Therefore, they are ideal laboratories for studying the effects of strong interactions, and it is expected to find SCGs in all stages of a merging process. In an extensive study about 40 Shakhbazian groups have been investigated till now. Some obtained results are reported here.

II. THE SHAPE OF THE SHAKHBAZIAN GROUPS

The Shakhbazian groups are the most highly flattened entities yet discovered. The mean value of axial ratio $< b/a >$ of about 360 SCGs is equal to 0.5. Such distribution can be best represented by prolate spheroids (cigars), randomly orientated in space, with true axial ratios of 0.3 ± 0.15 (Oleak et al. (1959) AJ 109, 1485). Oblate spheroids can be excluded. This result also confirms the reality of most the groups since groups projected by chance in the line-of-sight would provide a much higher axial ratio.

III. THE MORPHOLOGY AND COLOURS OF THE SHAKHBAZIAN MEMBER GALAXIES

An important effect, produced by the high-density environment, is the ejection of interstellar gas and dust from the galaxies by ram pressure and tidal forces resulting in a higher percentage of E and S0 galaxies in compact groups compared to field galaxies. The SCGs are an outstanding example for this effect. The visual inspection of CCD images has shown that the SCGs have a large fraction, 77% (out of a sample of 243 galaxies), of early-type galaxies. This morphological concordance is much higher than, e.g., in the Hickson groups (HCG) with ~ 51%. The investigation of the colours B-V and V-R of the SCG member galaxies has given a surprising result. They are, due to the lack of young blue stars (the gas have been expelled out of the galaxies) significantly redder than field galaxies of the same morphological type. The difference in B-V and V-R is about 0.2 mag compared to galaxies from the RC3 catalogue.

Thus, two selection effects determine the redness of most of the SCG member galaxies: a higher percentage of E's and S0's with intrinsically red colours (compared to spirals and irregulars) in groups, and an additional reddening of these objects due to tidal interactions within groups.

IV. DYNAMICAL PROPERTIES OF SHAKHBAZIAN GROUPS

Normally, the redshifts of at least 4 galaxies of each SCG have been determined. They were used to derive distances and other physical properties of the groups (using a Hubble constant of 55 km/s/Mpc). The analysis has shown that about 90% of the groups are real entities, i.e. three or more galaxies have a $\Delta v < 1000$km/s from the mass-weighted mean velocity of the group. The redshift, z, of the SCGs range from 0.0224 to 0.1433 with a median $z = 0.0825$. Thus the SCGs are about three times more distant than the HCGs. The distribution of the velocity dispersion of the SCGs covers a wide range (from 52 to 840 km/s) with a median of 300 km/s. This is much less than typical velocity dispersion for rich clusters (~ 750 km/s). The crossing time, t_{cr}, ranges for the investigated SCGs from 50 to 600 millions of years with a median of about $140 \cdot 10^6$yr (in comparison to $t_{cr} \sim 270 \cdot 10^6$yr of the HCGs (Hickson et al. (1992) ApJ 399, 353)). As N-body simulations have shown the evolution of compact groups is influenced sensitively by the mass. The SCGs have a median virial mass of $8 \cdot 10^{12} \mathcal{M}_\odot$ compared to $1.3 \cdot 10^{12} \mathcal{M}_\odot$ of the HCGs. The mass-to-light ratio of the SCGs covers a range from 3 to 230 $\mathcal{M}_\odot/\mathcal{L}_\odot$, the median $\mathcal{M}/\mathcal{L} \sim 45$. This value is higher than the one of the HCGs (~ 30).

On the base of the morphological types and the colours of the constituent galaxies, the velocity dispersion, the crossing-time, and the virial mass the SCGs

can be classified into a longer-lasting and thus more evolved type of systems than loose galaxy groups and also the HCGs.

V. X-RAY EMISSION FROM SHAKHBAZIAN GROUPS

The presence of hot X-ray emitting gas in a subset of the 12 SCGs (out of 28 investigated groups) is interpreted as the result of the interaction between the galaxies. Considering the evolution scenario of compact groups as well as the cooling time for the hot gas the X-ray emission of compact groups cannot be a stable phenomenon. It is expected that the different stages of the evolution of the hot intra-cluster gas (ICG) can be traced. Thus relatively loose Shakhbazian groups at the beginning of a strong interaction should have no X-ray emission. In the first phase of the violent interaction the ICG is ejected from the cluster perpendicular to the collision direction in form of lens-shaped shock fronts (see the N-body calculations of Schindler & Müller (1993) A&A 272, 137). After the virulent shock stage the ICG is reaching a quasi-equilibrium stage resulting in an almost symmetric huge X-ray emitting region concentrated in the gravitational well of the galaxy groups. It is worth mentioning that the SCGs provide X-ray images which may be satisfactorily interpreted by the above mentioned evolutionary scenario.

VI. FAR INFRARED EMISSION (FIR) FROM SHAKHBAZIAN GROUPS

The investigation of the IRAS catalogue has shown that about 30 SCGs are FIR emitters. This is a low rate of FIR sources compared to other galaxy groups, but it is not astounding because E's and S0's are the dominant population in SCGs and are known to be weak emitters. Moreover, the sensitivity limit of the IRAS satellite as well as the large distances of the SCGs imply that only FIR sources with luminosities above $\sim 10^{11} L_{\odot}$ are detectable. Thus it is expected that active galaxies in the SCGs are probably responsible for the infrared emission. Indeed, the spectroscopy has shown that a Seyfert or a starburst galaxy in 30% of the groups occur. These active galaxies should be gas-rich newcomers, falling from the outskirts into the inner region of the SCGs. Then the collisions or tidal interaction between the galaxies may trigger bursts of enhanced star formation or non-thermal core activities. From these FIR objects only the more powerful sources (because of the distances or the SCGs) can be detected, thus explaining the small number of the FIR active SCGs found.