SUPERASSOCIATIONS IN DISTANT GALAXIES

The Large Magellanic Cloud contains in addition to a considerable number of ordinary O–associations a certain number of larger objects which, however, are similar in nature to the associations. These objects were named "constellations" by Shapley. But the large complex 30 Doradus surpasses notably all these objects both in diameter and in absolute brightness. The latter is of the order of $-15^m.0$ while the diameter is of the order of 600 pc. If we take the average absolute brightness of associations in our Galaxy as equal to $-10^m.0$ then it turns out that 30 Doradus is 100 times more luminous than the ordinary associations. The photographic images of more distant galaxies reveal that sometimes complexes occur in them of the same order of luminosity and dimensions as 30 Doradus. Therefore it seems to us useful to regard these complexes as a special class of objects and call them *superassociations*.

The frequency of occurrence of superassociations within the galaxies is being investigated at Byurakan. On plates taken by means of the 21–inch Schmidt reflector the superassociations are almost star–like if the distance of the corresponding galaxy is over 15 million pc. When exposure are of shorter duration (a few seconds) the general background of the corresponding galaxy does not hinder photometric evaluations, and the images of superassociations can be compared with the focal images of the surrounding stars or of those located in standard areas. In determining the stellar magnitude in this way the error for closer galaxies may however attain $0^m.5$.

We quote here only the preliminary results of the review based on the study of 55 galaxies, mostly belonging to the Sc type. These galaxies (with the exception of two) have been selected from the Shapley–Ames catalogue at random, if we disregard the fact that Sc galaxies were preferably observed while E type galaxies have not been observed at all.

In Table 1 the NGC number of 14 galaxies are listed, in which superassociations have been found. Concentrations exceeding —$13^m.5$ in absolute magnitude have been considered as superassociations. Naturally we could not have regarded as superassociations the long sections of the bright parts of the spiral arms.

The second column of the table reproduces the galactic types; the third column, the number of superassociations in each galaxy; the fourth column, the mean absolute magnitudes of the superassociations; the fifth, the absolute magnitudes of the galaxies(Sandage's scale of distances assumed); and the sixth, for comparison, the absolute magnitude of the nucleus of the galaxy as determined from the same plates. The data of this table make it clear that the superassociations are found particularly often in supergiant galaxies with an absolute magnitude of $-20^m.5$ and above. Of the observed 35 galaxies of the Sc type eight, containing superassociations, have an average absolute magnitude of $-20^m.6$ whereas the absolute magnitude of Sc galaxies without superassociations is equal to $-18^m.8$. As for the Sb galaxies, the number of the observed objects is small. It is therefore hard to speak of any existing difference. However, there is no doubt that Sb galaxies containing superassociations, are at the same time systems of high luminosity.

NGC	$Type$	N_{sa}	$\overline{M}_{sa}$	M_g	M_n
1087	Sc	8	$-14 \cdot 9$	$-20 \cdot 6$	$-15 \cdot 9$
1961	Sb	3	$-15 \cdot 8$	$-21 \cdot 5$	$-17 \cdot 1$
2276	Sc	4	$-15 \cdot 2$	$-20 \cdot 7$	$-15 \cdot 9$
3991	$Haro$	2	$-17 \cdot 2$	–	no
3995	Sc	4	$-14 \cdot 8$	$-20 \cdot 3$	$-17 \cdot 0$
4303	Sc	4	$-14 \cdot 6$	$-21 \cdot 6$	$-17 \cdot 6$
4496	SBc	1	$-14 \cdot 9$	$-19 \cdot 8$	no
4559	$Sc0$	2	$-13 \cdot 6$	$-19 \cdot 6$	$-14 \cdot 1$
5676	Sc	2	$-15 \cdot 5$	$-20 \cdot 8$	$-16 \cdot 0$
5678	Sc	4	$-17 \cdot 5$	$-20 \cdot 5$	$-15 \cdot 8$
6217	Sc	4	$-14 \cdot 5$	$-19 \cdot 8$	$-16 \cdot 6$
6412	Sc	1	$-15 \cdot 5$	$-19 \cdot 4$	$-15 \cdot 8$
6643	Sb	3	$-14 \cdot 8$	$-20 \cdot 0$	$-15 \cdot 4$
7448	Sc	3	$-15 \cdot 0$	$-20 \cdot 8$	$-16 \cdot 2$

Table 1. The Galaxies with Superassociations.

In Table 2 the number (N) of all the observed galaxies of the Sc type are quoted for three different intervals of absolute magnitude, together with N_{sa}, the number of galaxies containing superassociations for the same intervals.

The last column contains the average numbers of superassociations per galaxy of the given class of luminosity.This Table shows more convincingly that the superassociations are encountered almost exclusively in supergiant galaxies.

Apparently the picture is somewhat different in irregular galaxies. We have not as yet treated the problem in detail, but the NGC 275 Haro–type galaxy, involving at least five superassociations and of an absolute magnitude $-19^m.0$, testifies to the fact that in irregular galaxies the situation is different. This is also attested by the example of the Large Magellanic Cloud.

Interval of M	N	N_{sa}	ν^*
$M > -20 \cdot 0$	21	3	$0 \cdot 3$
$-20 \cdot 5 < M < -20 \cdot 0$	6	1	$0 \cdot 7$
$M < -20 \cdot 5$	8	6	$3 \cdot 1$

Table 2. Frequency of Superassociations in Sc Galaxies.

As became evident from the work of Shapley and Paraskevopoulos [3], most of the luminosity of the 30 Doradus complex is contained in the nebula. But 30 Doradus contains also hundreds of blue supergiant stars with the richest cluster of supergiants located in the centre of this complex. At the same time, the lifetime of the superassociations as a whole must considerably exceed the mean lifetime of the of ordinary associations. This follows from the fact that the lower limit of the duration of life of any such complex must be the value D/v, where D is the diameter of the complex while v indicates the mean relative velocity traced in it. Making $D = 600$ pc and $v = 10$ km/sec we obtain for the lifetime a lower limit of 6×10^7 years. This is nearly one order of magnitude more than the age of ordinary O–associations and that of hot supergiants. It must therefore be assumed that the blue supergiants observed in the superassociations represent only one of the numerous generations of these objects. Many thousands of supergiants appear, presumably, during the lifetime of the superassociations, which thereupon turn into other stars. If we take into account the fact that also the T–Tauri type stars usually originate in similar complexes and in far greater numbers, then we must believe that hundreds of thousands of stars come into being there.

In 1939 in the book "Theoretical Astrophysics" [1] we made the initial estimation of the mass of the nebula 30 Doradus at $2 \times 10^6\,M_\odot$, while in the Observatory of Mount Stromlo Johnson [2] re–estimated, four years ago, the gaseous mass of this nebula. It turned out to be $5 \times 10^6\,M_\odot$. Consequently, hundreds of stars are likely to be genetically bound with this nebula.

In conclusion, I take the liberity of making one more remark of a cosmogonic nature.

If one realizes that superassociations are formed out of gaseous masses distributed within the given galaxy, one must believe that in galaxies of a great total mass the tidal forces should hinder the formation of such large complexes. On the contrary, in galaxies of a small mass no such hindrance will exist. For this reason we could not expect to meet superassociations in supergiant galaxies. In fact, we note the reverse picture. This apparently contradicts the assumption as to the possibility of the formation of superassociations from initial matter diffused all over the galaxy.

This paper is a preliminary report on the work being continued at Byurakan together with R. Shahbazian, S. Iskudazian and K. Sahakian.

R E F E R E N C E S

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