

16. SPIRAL STRUCTURE AND DISTRIBUTION OF STELLAR ASSOCIATIONS IN NGC 6946

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Abstract. The associations of NGC 6946 outline its spiral arms. There is no relation between the colour or magnitude of the associations and their distance from the centre. Their mean absolute magnitude is $-11^m.1$ and their mean colour index near zero.

1. Introduction

Some photometric results concerning a number of stellar associations in the spiral galaxy NGC 6946 are discussed.

The observational material was obtained with the 2-m Schmidt camera of Tautenburg Observatory (DDR) by one of us (Khachikian). The results of a detailed two-colour surface photometry investigation of this galaxy have been published earlier (Börngen *et al.*, 1966). The method of observations is described there as well.

NGC 6946 is a Sc type galaxy. There are a great number of stellar associations in it. The galaxy has a small nucleus and two strong spiral arms with many branches. The remarkable feature of NGC 6946 is the abundance of supernova explosions during the last 60 years. The last explosion took place in 1968 (Wild, 1968). This fact allows to consider NGC 6946 as a giant galaxy (Kukarkin, 1965; Ambartsumian, 1965).

We have adopted the following data for this galaxy: distance modulus $(m - M)_0 = 28.3$, absorption $A_{pg} = 2^m.3$, absolute magnitude $M = -20^m.6$. (A more detailed discussion of these data is presented by Khachikian and Sahakian (1970).)

2. Distribution of Associations

The chart of distribution for all the 148 measured associations is given in Figure 1. The associations are shown projected on the spiral structure. It seems that in general associations are located in spiral arms. Two spiral arms are coming out directly from the nucleus. These arms split into three branches at a distance of $1'$ from the centre of the galaxy. The two innermost branches are the richest in associations, containing 35 of them each. Outside the arms the number of associations decreases abruptly.

3. Magnitudes of Associations

The absolute magnitude of associations varies between $-9^m.6$ and $-12^m.8$, the mean being $-11^m.1$. These data are in good agreement with Markarian's (1959) and Bok and Bok's (1962) observations. According to them the mean absolute magnitudes of the associations of M 101, M 51 and LMC are $-11^m.1$, $-11^m.2$ and $-10^m.6$ respectively.

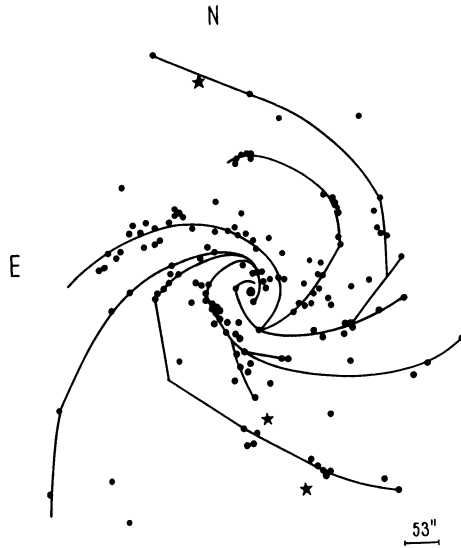


Fig. 1. The distribution of the associations in NGC 6946 together with the galaxy's spiral structure.

Let us examine the distribution of associations according to their magnitude. For this purpose the associations have been divided into four groups in the following way:

- | | |
|-----------|------------------------|
| I group | $B > 20^m0$ |
| II group | $19^m5 < B \leq 20^m0$ |
| III group | $19^m0 < B \leq 19^m5$ |
| IV group | $B \leq 19^m0$. |

In Figure 2 the distribution of each of these groups is given. Among the groups there is no clear-cut distribution depending on the distance from the centre. It is necessary to note that the brighter the associations, the more they form concentrations. The associations with $B > 19^m5$ do not show such a feature, while about half of the associations with $B < 19^m5$ form concentrations of 2, 3 and 4. Some of these are located in those parts of spiral arms where branches are formed. It is interesting to note that the majority of associations with $19^m0 < B < 19^m5$ are located in the two inner spiral arms. Among the faint associations with $B > 20^m0$, four are forming a chain which is located near the nucleus between the two spiral arms.

4. Colour Indices of Associations

The observed colour indices of associations vary from -0^m1 to $+1^m3$. With the adopted value of colour excess 0^m6 , the real indices fall in the interval -0^m7 , $+0^m6$. The mean colour index for all associations is $(B-V)_0 \simeq 0^m0$. The majority of associations have colour indices between $+0^m3$ and $+0^m8$. In Figure 3 the distribution of associations all over the galaxy according to their colour is given. As it is seen from Figure 3

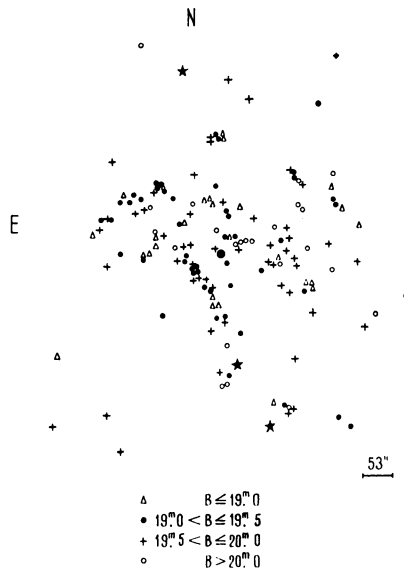


Fig. 2. The distribution of the different groups of associations along the galaxy: ○) $B > 20^m.0$; +) $19^m.5 < B \leq 20^m.0$; ●) $19^m.0 < B \leq 19^m.5$; △) $B \leq 19.0$.

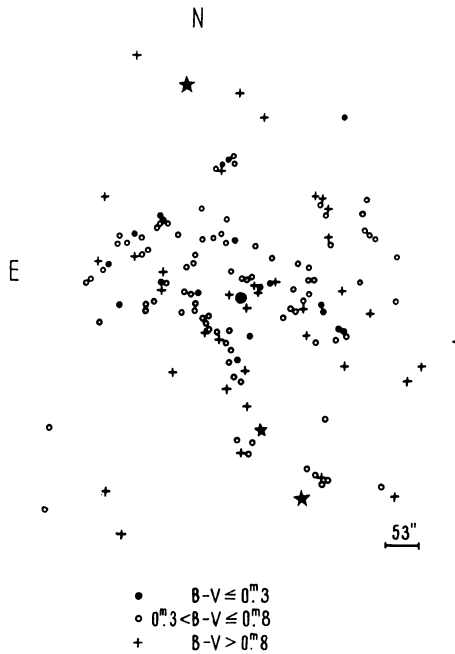


Fig. 3. The distribution of the associations depending on their colour: ●) $B-V \leq +0^m.3$; ○) $+0^m.3 < B-V \leq +0^m.8$; +) $B-V > +0^m.8$.

there is no correlation between the colour of associations and their distance from the nucleus. Associations with different colours are found in all spiral arms and at any distance.

5. HII Regions in NGC 6946

It is known that stellar associations often contain emission nebulae. As the O-associations include stars of earlier spectral classes, they are responsible for regions of ionized hydrogen around them. When the quantity of hydrogen is high enough, these regions can be observed as emission nebulae. Therefore most of the associations can be observed as HII regions and vice-versa. According to Hodge (1967) NGC 6946 contains 40 HII regions. We can expect that most of them coincide with associations investigated by us. In fact 26 HII regions have been identified with our associations. Among them there are objects with colours varying from $-0^m.45$ to $+0^m.35$. However most of them have negative colour indices. The mean value of $(B-V)_0$ for the HII regions identified as associations is $-0^m.07$.

6. Conclusions

(1) The galaxy NGC 6946 is rich in stellar associations, that outline its whole spiral structure. The brighter associations have a tendency to form concentrations. This is observed especially near the points where spiral arms split into branches. The majority of associations are found in the two inner spiral arms of the galaxy.

(2) The associations do not show any relation between their colour or magnitude and their distance from the centre of the galaxy. The same phenomenon has been also noticed by Markarian (1959) in the associations of M 51 and M 101. The associations apparently have similar characteristics, not depending on their position in the galaxy. Therefore the process of stellar formation occurs simultaneously all along the spiral arms. Hence, the sources that lead to the formation of associations are distributed more or less uniformly along the arms.

(3) The mean absolute magnitude of associations is $-11^m.1$ and their mean colour index near zero. NGC 6946 is probably a giant galaxy with absolute magnitude about $-20^m.6$.

References

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