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Clustering of Young Stellar Groups in M 33 Galaxy

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Abstract.

We perform dereddening and obtain age estimates of 26 306 stars in M33, using precise UBVRI photometry of the recently published Local Group Survey. The clustering of the massive stellar population is studied through simple technique, assuming range of typical densities for stellar associations and clusters. The classical OB associations seem to be spatial superpositions of clusters of several young generations with different ages.

1 Introduction

M 33 is a spiral galaxy in constellation Triangulum and third largest member of the Local Group after M 31 and our Galaxy. Its position and orientation in space provide excellent opportunities to study in details young stellar populations. (In this paper we adopted $PA = 23°$ and an inclination value of $35.6°$). The OB associations and the young stellar population in Triangulum galaxy were subject of intensive study in the last two decades. By analysis of UBV images, taken with a 2 m RCC telescope, were detected 289 associations [1]. Over 65 000 young massive stars were detected from plates taken with 3.6 m CFHT telescope [2]. The most extensive up to date catalog of bright stars in M 33 is the Local Group Survey [3], based on high-quality CCD images.

2 Data Sources

We used reliable UBVRI photometry from the Local Group Survey of 146 622 stars in the field of M 33. The mosaic CCD images cover $0.8\ deg^2$ and were taken with Kitt Peak National Observatory 4 m telescope. The photometry is deep enough to achieve a precision of 1–2% at 21^m (corresponding to stellar masses above 20 Solar masses) and $< 10\%$ at 23^m. The typical seeing is about $1''$. We adopt numbering of the associations according to [4].

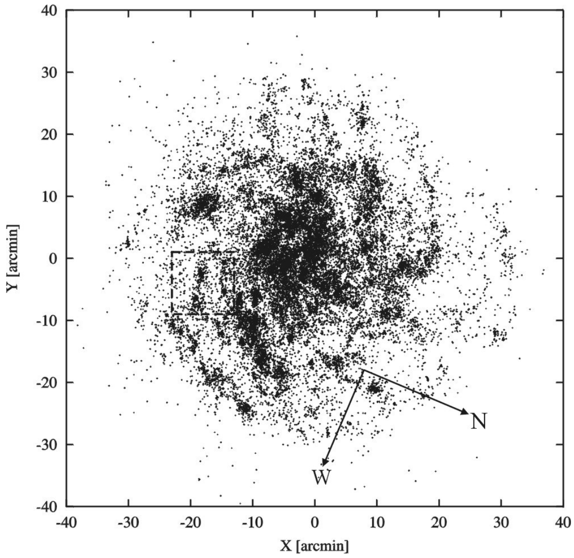

Figure 1. 26 306 dereddened blue stars on the rectiffied plane of M33 galaxy ($PA = 23°$ and inclination angle of $35.6°$ have been adopted). The $10' \times 10'$square area drawn with a dashed line is shown in details in Figure 2.

Our final sample consists of 26 306 early type stars (see Figure 1). They were successfully dereddened on the (U-B) vs. (B-V) diagram by means of the classical Q-method. We adopted constant slope of the reddening vector, equal to 0.72, and zero-reddening main sequence from [5]. About 10 000 stars on the color-color diagram lie above the line, corresponding to bluest possible color $(U - V)_0 = -1.6^m$, and are not taken into account in this work. Most of their unauthentic colours are possibly due to blending effect. The 'reddest' MS stars in our sample have $(U - V)_0 = -1.1^m$, corresponding to stellar mass of 10 Solar masses. Some stars below the zero-age main sequence on the diagram M_V vs. $(U - V)_0$ are ommited as well. Geneva isohrones for $Z = 0.008$ [6] were used to divide the sample into subsamples of different age ranges (see Figure 2). In order to improve 'the age resolution' we imposed some additional conditions related to luminousity of the stars. Basic information about the samples with the selection criteria are given in Table 1.

3 Cluster Search Algorithm and Results

The galaxy field, covered by the photometry, was mapped by a rectangular grid. Local stellar density was calculated in each grid point within search radius, equal to the grid box size. Neighboring grid points that satisfy some fixed density criterion (some lower density limit) build up a group. Coordinates of the group

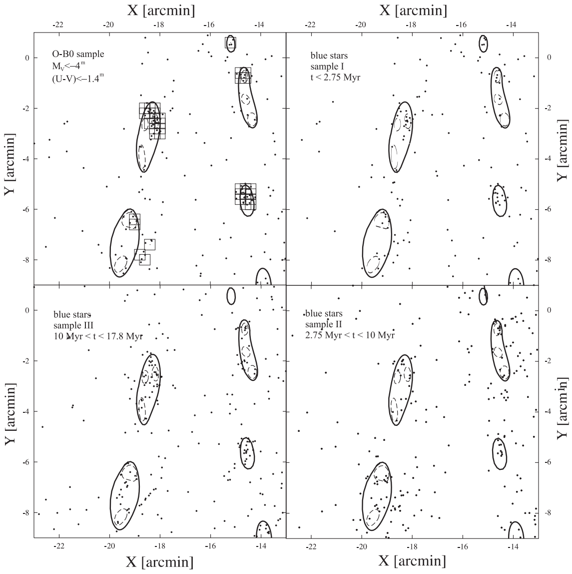

Figure 2. Locations of 4 stellar samples of different age range in the selected $10' \times 10'$ area in Figure 1. Stellar complexes and associations according to [7] are delineated.

center are determined as weighted means of the coordinates of the group members, where the weights are the point density values.

Algorithm is applied many times to different samples of stars, varying the search radius (grid box size d) and minimum number of the group members n as free parameters. Figure 3 illustrates the results when the described procedure was applied to the sample of O-B0 stars.

It clear that the number of indentified groups depends on the nominal stellar density assumed: the smaller is the minimum number of the group members at a fixed grid box size the larger is the number of the identified groups. Another interesting trend is the shift of the distribution maximum with the n. For example when the minimum number of the group members is $n = 3$ about $N_{\max} = 600$

Table 1. Data samples.

samples	age [Myr]	Number of objects	Criteria
age1	< 2.75	4 968	$M_V < -3.5$
age2	2.75-10	8 198	$M_V < -3.5$
age3	10-17.8	13 140	$M_V < -2.5$
total	< 17.8	26 306	
O-B0		6 654	$M_V < -4$; $(U-V)_0 < -1.4$

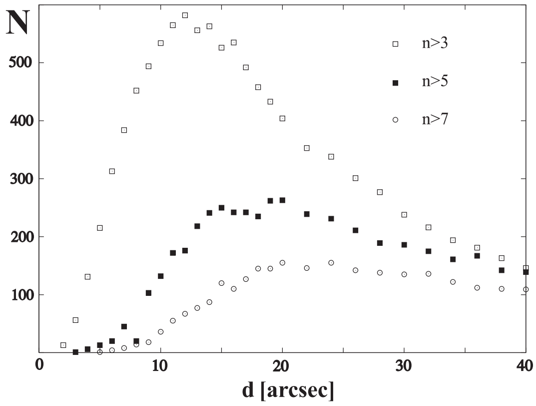

Figure 3. Number of clusters as a function of grid box size d and minimum number n of member stars.

groups are identified while when the same number is $n = 7$ only $N_{\max} = 130$ groups are found. If a steplike behaviour is presented for some of the constructed functions it can be intepreted as evidence for a heiranchy among the studied stellar groups. Such effect can be traced in Figure 3 for the minimum number of the group members n, equal to 5. It is observed for the first time at grid box size of $d = 12''$, corresponding to about 50 pc. However, the most intriguing finding is that at $d = (15 \div 20)''$, (70 pc) a plateau is observed in all distributuins for an arbitrary stellar density.

4 Conclusions

We identify 180 stellar groups in M 33 with typical size that is 50 pc smaller than the mean size 80 pc of the classical OB associations [7].

The number of newly defined groups $N = 240$ with a mean size of 80 pc (second hierarchical group) is close to the number of groups identified in previous photographic studies ($N = 210$).

The classical OB associations seem to be spatial superpositions of group of several young generations with different ages.

Acknowledgments

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