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OB ASSOCIATIONS IN SEXTANS A DWARF IRREGULAR GALAXY

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Abstract. The galaxies of the Local Group serve as our laboratories for understanding star formation and stellar evolution in differing environments. Irregular galaxies provide unique opportunities for studies of star formations triggered by the combined effect of stellar winds and supernova explosions in rich stellar groupings. Sextans A is a dwarf irregular galaxy located just beyond the Local Group. Using the public data from the new wide-field mosaic camera attached to the 4-m KPNO telescope we are producing a catalogue of UBVRI photometry of roughly 100 thousand stars in area around Sextans A. Using an automatic and objective method (Battinelli's technique) 36 groups of young objects (OB associations) were found. The mean size of these stellar groups is about 50 pc. Some basic properties of the associations are defined.

1. INTRODUCTION

The stellar content investigations of the Local Group galaxies allow us to study in fine details the star formation history of these systems. They also provide important verification information for the stellar evolution theory. The youngest and the brightest stars of one galaxy are the OB stars. These massive stars are rare and short lived but are the most important agents in shaping the interstellar medium. They rapidly inject heavy elements and have a strong energy input into this medium. Thus they are playing a key role in regulating star formation for the next generation stars. The distribution of young and massive stars in space and by mass is very important for understanding the processes of star formation. The most of the youngest and massive stars are found in OB associations and star clusters but there are also runaways. Stellar association is "a single, unbound concentration of early-type luminous stars,

embedded in a very young starforming region" (Kontizas et al., 1999). The properties of the associations and the ionized gas clouds in which they are embedded allow tracing of the regions of most recent star formation in the galaxies.

Sextans A is an irregular galaxy located just beyond the Local Group, which is possible to resolve into stars from the ground. The young stellar content of Sextans A was investigated by van Dyk et al.(1998). They record that the galaxy shows the most recent burst of star formation (< 50 Myr). It is very interesting for us to investigate OB associations in the galaxy and to define their parameters.

2. OBSERVATIONS AND REDUCTIONS

A set of $UBVRIH\alpha$ frames of the area around Sextans A galaxy were obtained with new, wide-field Mosaic cameras attached to the 4-m KPNO telescope. The exposure time of each image is from 60 to 600 sec. The observing area is $36' \times 36'$. The seeing during these observations was good: $1.0 - 1.2''$. The standard transformation equations for this camera were used to calibrate the data and transform the instrumental magnitudes in Johnson $UBVRI$ system. Transformation equations ere given in `http://www.lowell.edu/users/massey/phot.html`.

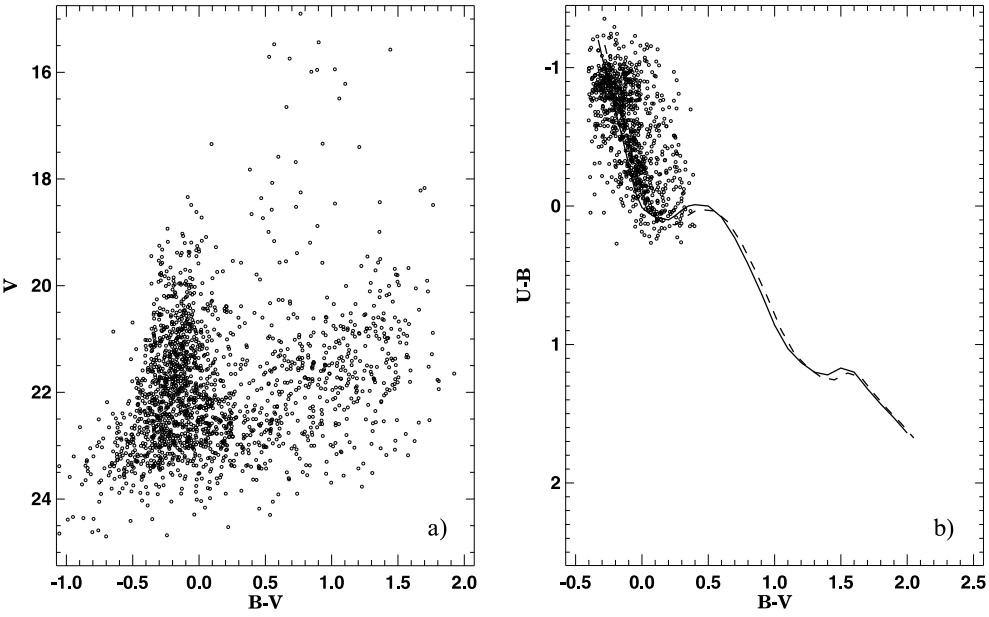

Figure 1: a) $(B-V, V)$ color-magnitude diagram of Sextans A galaxy. Only stars with photometric errors not larger than 0.15 in both filters are plotted. **b)** $(B-V, U-B)$ color-color diagram (CCD) of the bluest stars in the Sex A galaxy. Only stars with photometric errors not larger than 0.15 in all filters are plotted. The fiducial loci of stars (luminosity class V) without reddening (solid line) and reddened with $E(B-V) = 0.05$ (dashed line) are superimposed.

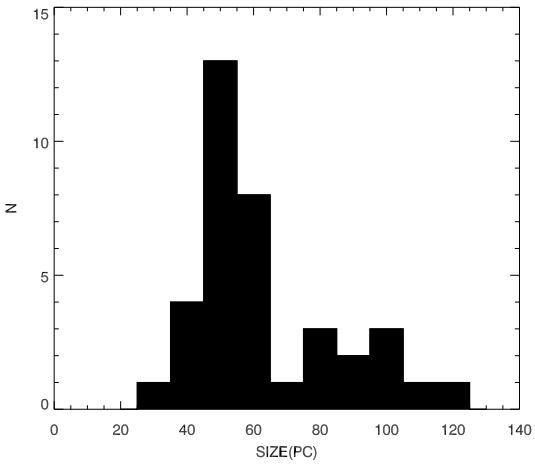

Figure 2: Size distribution of the associations in Sextans A.

The stellar photometry of the frames was performed with the point-spread function fitting routine ALLSTAR available in DAOPHOT (Stetson, 1993). Complete details of the data reduction and analysis may be found in Georgiev et al. (1999). The stars with values of DAOPHOT CHI > 2 and those with formal errors from the PSF fitting greater than 0.15 mag are rejected so the final photometry list contains about 8000 Sextans A stars with photometry in two filters at least.

3. RESULTS

3.1. COLOR-MAGNITUDE AND COLOR-COLOR DIAGRAMS

Fig. 1a represents the $(B-V), V$ color-magnitude diagram (CMD). To construct this CMD only the stars with photometric errors not larger than 0.15 in both filters have been selected. The mean feature is distinctive plume of luminous blue stars in the Sextans A galaxy mixed with the foreground stars of the Milky Way mostly with $B-V > 0.3$

The "unshifted" $(B-V, U-B)$ color-color diagram (CCD) of the 960 bluest (OB) stars from the galaxy is given in Fig. 1b. We used Q-parameter technique to measure the reddening. Our final estimation is $E(B-V) = 0.04$. This is also the most frequent value used from different authors.

3.2. OB ASSOCIATIONS

The automatized search for OB associations was carried out using the method of Battinelli (1991) (so called friend-of-friends algorithm). The bright blue stars from the Main sequence in Sex A were selected by strong photometric criterion by absolute magnitude $M_V < -2.0$ and color $(B-V)_0 < 0$. In the most cases friend-of-friends

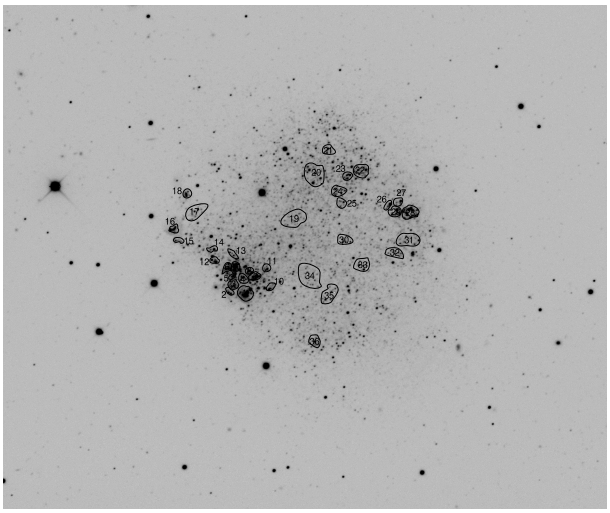

Figure 3: The boundaries of the OB associations superimposed on U image of Sex A.

algorithm selects the minimum number of 4 OB stars in some clump in order to have a "real" association. We put in our case the same minimum number of stars.

The friend-of-friends algorithm selects 36 associations with sizes between 30 and 120 pc (with accepted true distance modulus of $\mu_0 = 25.61$). The mean size is about 50 pc. The distribution of the associations' sizes is given in Fig. 2.

The spatial distribution of the OB associations around the galaxy is given in Fig. 3. The youngest associations occupy NW and SE parts of Sextans A. There is a clear connection between these young, compact and bright associations and ionized medium in the galaxy seen in the Hα image.

The X, Y coordinates in pixels, the mean size of the associations in pc, the V magnitude of the brightest member, the number of OB members, and the mean absolute magnitude ($M_V < 3 >$) of the three brightest members are given in Table 1.

Comparing Sextans A with the Magellanic Clouds, M 33 and NGC 6822 (Bresolin et al., 1998; Ivanov, 1996) we can see that the distribution of the OB associations in size is similar with peak between 40 and 80 pc. Those in M 31 are slightly larger – 90 pc. Bresolin et al. (1998) obtain for LMC – 60 pc, SMC – 70 pc and M33 – 60 pc, confirming in this way the idea that the size of the associations do not depends on the morphological type of the galaxy. The mean size of the OB associations in Sex A, obtained in this work, is very near to the value for SMC associations, obtained in a very recent paper of Oey et al. (2004) – 34 pc. These much smaller values are consistent with a greater completeness in the data, yielding a higher density of OB stars, and therefore smaller clustering distance.

Table 1: Properties of the OB associations in Sextans A

No	X	Y	size(pc)	Vmax	Nmem	Mv< 3 >
1	1890.5	3433.5	83.2	17.345	20	-6.501
2	1832	3405.5	40.6	19.971	4	-4.882
3	1845.5	3427	52.8	20.213	7	-4.614
4	1881.5	3451.5	51.7	20.167	8	-5.236
5	1835	3425	29.7	21.528	4	-3.269
6	1819	3449	51.9	20.125	8	-5.789
7	1858	3464.5	55.2	18.620	15	-6.546
8	1907.5	3481.5	45.3	19.574	8	-5.485
9	1931.5	3486	50.8	20.199	8	-5.966
10	1990	3493	48.9	20.006	8	-5.089
11	1970.5	3519	38.9	20.193	4	-4.963
12	1771.5	3438	40.3	19.969	3	-5.383
13	1845	3484	63.8	20.375	9	-4.681
14	1764	3457.5	48.3	19.193	4	-4.809
15	1637	3410	46.5	21.351	4	-4.652
16	1615	3419.5	51.0	20.530	5	-5.395
17	1701.5	3489.5	85.6	19.854	8	-4.765
18	1667.5	3510	47.4	20.913	7	-4.629
19	2077	3672.5	96.0	20.567	18	-5.203
20	2149.5	3785.5	106.8	19.278	15	-6.521
21	2208	3865.5	54.5	21.900	6	-3.983
22	2330	3886.5	75.9	20.990	16	-4.941
23	2279	3846	50.2	19.387	9	-5.804
24	2248	3807.5	68.1	19.953	10	-5.750
25	2255.5	3785	56.7	19.983	6	-4.899
26	2436.5	3869.5	45.5	18.932	4	-4.982
27	2474	3896.5	40.4	19.596	5	-4.586
28	2518	3902.5	86.2	19.324	19	-6.017
29	2462	3872	60.1	18.339	11	-6.276
30	2275.5	3731	55.9	20.218	5	-4.853
31	2515.5	3854	97.9	20.625	9	-4.893
32	2461	3801.5	77.8	21.603	10	-4.313
33	2336.5	3708	63.6	19.365	7	-5.740
34	2139.5	3574	122.9	21.265	17	-4.465
35	2205.5	3587	103.3	19.964	11	-5.394
36	2159	3473.5	58.0	20.156	5	-5.315

4. A BRIGHT FUTURE

- We are going to refine our analysis about the OB associations.
- We are going to select candidates for red supegiant stars and are going to define their physical parameters. We are going to look for connection between the associations' parameters, distribution of the OB associations and other young objects like LBVs, WRs, HII regions, etc.
- Sextans A is the first of ten Local group galaxies in which we plan to investigate OB associations. We would like to carry out a qualitative and quantitative comparative analysis of the OB associations in the Local Group - the major purpose of the project. This has been made only in part until now.

Acknowledgements

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