Stellar Populations - Planning for the Next Decade
Proceedings IAU Symposium No. 262, 2009
Gustavo Bruzual & Stéphane Charlot, eds.

doi:10.1017/S174392131000308X

Age and metallicity of star clusters in the Small Magellanic Cloud from integrated spectroscopy

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Abstract. Analysis of integrated spectra of star clusters in the Magellanic Clouds can bring important information for studies on the chemical evolution of the Clouds. The aim of the present work is to derive ages and metallicities from integrated spectra of 15 star clusters in the Small Magellanic Cloud (SMC), some of them not studied so far. Making use of a full spectrum fitting technique, we compared the integrated spectra of the sample clusters to three different sets of single stellar population models available in the literature. We derived ages and metallicities for the sample clusters employing the codes STARLIGHT and ULySS. Out of the 15 clusters in our sample, 9 are old/intermediate age clusters and 6 are young clusters. We point out the results for the newly identified as old/intermediate age clusters HW1, NGC 152, Lindsay 3 and 11. We also confirm old ages for NGC 361, NGC 419 and Kron 3, and the oldest well-known SMC cluster NGC 121.

Keywords. (galaxies:) Magellanic Clouds, galaxies: star clusters

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1. Introduction

The star clusters in the Small Magellanic Clouds (SMC) form a rich system (> 3700 objects) (Bica *et al.* 2008) that have been used to probe the dynamical and chemical evolution of these neighboring and interacting dwarf irregular galaxies. Harris & Zaritsky (2004) recovered the star formation history in the SMC, based on $\sim$6 billion SMC stars, and they suggest the following main properties: i) a significant epoch of star formation older than 8.4 Gyr; ii) a long quiescent epoch between 3 and 8.4 Gyr; iii) a continuous star formation extending from 3 Gyr until the present; iv) in period iii, three main peaks of star formation should have occurred at 2-3 Gyr, 400 Myr and 60 Myr. In this work we intend to verify if the age distribution of SMC star clusters share the same characteristics as the field stars, as described above. In particular we aim at clusters in the range ii, classied as intermediate-age clusters.

Star clusters are also important templates to test and calibrate Single Stellar Population (SSP) models, and the clusters in SMC are particularly interesting as they show combinations of age and metallicity not found in the Milky Way. (Santos Jr. & Piatti 2004).

We obtained ages and metallicities for the clusters in our sample by comparing them to 3 sets of SSP (Bruzual & Charlot (2003) = BC03; Charlot & Bruzual (in prep.) = CB08;

Le Borgne *et al.* (2004), PEGASE-HR team; Vazdekis *et al.* (in prep.)), employing the spectrum fitting codes STARLIGHT (Cid-Fernandes *et al.* 2005, 2009) and ULySS (Koleva *et al.* 2009). We also compare our findings to previous results available in literature.

2. Results and conclusions

Table 1. Ages and metallicities [Z/Z$_\odot$] derived for the oldest clusters in our sample. Parameters are given for the 3 SSP bases and 2 codes used in the analysis.

	Literature		BC03/CB08		PEGASE-HR		Vazdekis *et al.*	
Cluster	Age (yr)	[Z/Z$_\odot$]	Age (yr)	[Z/Z$_\odot$]	Age (yr)	[Z/Z$_\odot$]	Age (yr)	[Z/Z$_\odot$]
				STARLIGHT results				
HW1	5 ± 1.0	−0.7 ± —	—	—	—	—	—	—
L3	1.5 ± 0.5	−0.7 ± —	0.71 ± 0.17	−0.33 ± 0.00	—	—	—	—
K3	6.5 ± 0.5	−1.2 ± 0.2	—	—	4.75 ± 1.70	−1.63 ± 0.00	3.80 ± 0.93	−1.63 ± 0.0
N121	11 ± 0.5	−1.46 ± 0.10	12.5 ± 0.0	−1.43 ± 0.92	13.0 ± 0.0	−1.46 ± 0.71	12.6 ± 0.0	−1.43 ± 0.28
L11	3.5 ± 0.5	−0.8 ± 0.14	1.4 ± 1.8	0.47 ± 0.07	2.1 ± 1.8	0.467 ± 0.03	1.7 ± 0.8	0.25 ± 0.00
N152	1.4 ± —	−1.25 ± 0.25	0.3 ± 0.2	−2.17 ± 1.13	0.02 ± 0.01	−0.25 ± 1.48	0.1 ± 0.0	−1.63 ± 0.0
N361	6.8 ± 0.5	-1.45 ± 0.11	5.8 ± 1.3	−0.32 ± 0.76	7.1 ± 2.4	−0.12 ± 1.10	—	—
N419	1.4 ± 0.2	−0.3 ± —	—	—	1.8 ± 0.6	1.63 ± 0.01	1.3 ± 0.7	-1.13 ± 1.31
				ULySS results				
HW1	5 ± 1.0	−0.7 ± —	7.4 ± 2.2	−1.6 ± 0.1	6.8 ± 1.9	−1.6 ± 0.1	7.6 ± 2.1	−1.6 ± 0.1
L3	1.5 ± 0.5	−0.7 ± —	2.7 ± 2.3	−1.2 ± 0.4	3.3 ± 2.6	−1.3 ± 0.3	3.1 ± 2.5	−1.3 ± 0.3
K3	6.5 ± 0.5	−1.2 ± 0.2	3.2 ± 1.4	−1.5 ± 0.2	2.8 ± 0.6	−1.5 ± 0.2	3.2 ± 1.2	−1.5 ± 0.2
N121	11 ± 0.5	−1.46 ± 0.10	8.6 ± 1.0	−1.4 ± 0.1	8.2 ± 0.8	−1.2 ± 0.1	8.1 ± 1.0	−1.3 ± 0.1
L11	3.5 ± 0.5	−0.8 ± 0.14	7.6 ± 4.2	−0.3 ± 0.3	5.2 ± 3.0	−0.3 ± 0.1	8.5 ± 4.5	−0.4 ± 0.2
N152	1.4 ± —	−1.25 ± 0.25	1.1 ± 0.2	−1.6 ± 0.1	0.6 ± 0.1	−0.8 ± 0.1	1.0 ± 0.2	−1.4 ± 0.1
N361	6.8 ± 0.5	−1.45 ± 0.11	0.18 ± 0.11	−0.7 ± 0.6	3.0 ± 0.8	−0.8 ± 0.1	0.19 ± 0.13	−0.8 ± 0.7
N419	1.4 ± 0.2	−0.3 ± —	8.8 ± 1.0	−1.4 ± 0.1	1.13 ± 0.03	−0.8 ± 0.1	8.4 ± 1.0	−1.3 ± 0.1

Among the less well-studied clusters, we highlight the importance of further studying the intermediate age clusters HW1, L3, L11, NGC 152, NGC 361 and NGC 419. We also confirm the intermediate age for Kron 3 and old age for NGC 121. Results obtained with STARLIGHT and ULySS codes and the 3 sets of SSP models are in good agreement with previous studies available in literature for the older clusters in our sample, as shown in the Table 1.

We have found four clusters into the epoch ii (between 3 and 8.4 Gyr) from the Harris & Zaritsky (2004) classification: HW 1, Kron 3, Lindsay 11 and NGC 361. They are good candidates for exploring in more detail the star formation history in the SMC.

It is interesting to note that a number of clusters show metallicities lower than [Fe/H]<-1.0, whereas planetary nebulae of ages older than 1 Gyr show [Fe/H]=-1.0±0.2 with very few exceptions (Idiart *et al.* 2007). Therefore it seems that metal-poor clusters have no counterpart on the planetary nebulae population.

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