Stellar Populations as Building Blocks of Galaxies
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Integrated spectral properties of blue concentrated star clusters of the Large Magellanic Cloud

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Integrated spectra of 17 blue Large Magellanic Cloud (LMC) clusters were obtained in the (3600-6800 Å) range using the CASLEO (Argentina) 2.15 m telescope. The typical resolution and dispersion were 12 Å and 3.5 Å/pixel, respectively. Cluster ages were derived by means of two methods: the template matching, in which the observed spectra are compared and matched to template spectra with well-known determined properties, and the equivalent width (EW) method, in which diagnostic diagrams involving the sum of EWs of selected spectral lines were employed together with their calibrations with age and metallicity given by Santos & Piatti (2004), hereafter SP. The spectra were normalized to $F_\lambda = 1$ at ~ 5870 Å. The EWs of H Balmer, KCaII, G band and MgI were measured within the spectral windows defined by Bica & Alloin (1986). We then obtained the sum of EWs of the 3 metallic lines (S_m) and of the 3 Balmer lines Hβ, Hγ and Hδ (S_h). As a first approach to get cluster ages, we used the diagnostic diagrams defined by SP. The clusters were then age-ranked according to the SP's calibrations. We used S_m to get a first age estimate using: log t(Gyr) $= a_0 + a_1 S_m + a_2 S_m^2$, where $a_0 = -2.18 \pm 0.38$, $a_1 = 0.188 \pm 0.080$ and $a_2 = -0.0030 \pm 0.0032$. We then used S_h to get a second age estimate guided by the previous S_m estimate, since from S_h two solutions are possible: log t(Gyr) $= \{-b \pm [b^2 - 4a(c - S_h)]^{1/2}\}/2a$, where a = -6.35 ± 0.18, b = -8.56 ± 0.35 and c = 23.32 ± 0.20. The average of these two estimates is listed in column 7 of Table 1.

All 17 clusters are well represented by blue stellar populations, according to their spectral properties. Since the continuum distribution is affected by reddening, we firstly adopted a colour excess E(B-V) for each cluster, taking into account the Burstein & Heiles (1982) extinction maps. Secondly, we corrected the observed spectra accordingly and then we applied the template matching method. The resulting ages, together with estimates from the literature (whenever available), were used to get final averaged ages (Table 1). Piatti, Bica, Geisler *et al.* (2003a) observed in the Washington system 6 LMC clusters, which increased up to 37 the total sample of clusters with uniform estimates of age and metallicity. The general tendency is for the older clusters to lie in the outer disk regions of the galaxy while the younger ones tend to be located not far from or in the bar. This tendency is compatible with the findings of Smecker-Hane, Cole, Gallagher *et al.* (2002), who derived the LMC star formation history from HST observations of field stars.

Table 1. Cluster parameters

Cluster	$E(B-V)$	$t_{\text{literature}}$ (Gyr)	Ref.	$t_{\text{Sh,Sm}}$ (Gyr)	t_{template} (Gyr)	t_{adopted} (Gyr)
NGC 1804	0.08	0.08 ± 0.01	1	0.035 ± 0.004	0.05 ± 0.01	0.06 ± 0.02
NGC 1839	0.06	0.10 ± 0.01	1	0.09 ± 0.02	0.06	0.09 ± 0.03
		0.033 ± 0.008	2			
		0.125 ± 0.025	4			
SL 237	0.07	0.038 ± 0.004	1	0.03 ± 0.02	0.05 ± 0.01	0.04 ± 0.02
		0.027 ± 0.009	2			
NGC 1870	0.08	0.09 ± 0.01	1	0.033 ± 0.004	0.05 ± 0.01	0.06 ± 0.03
		0.07 ± 0.03	2			
NGC 1894	0.09	0.071 ± 0.008	1	0.10 ± 0.08	0.13 ± 0.03	0.10 ± 0.03
NGC 1902	0.04	–		0.07 ± 0.03	0.06	0.07 ± 0.03
NGC 1913	0.09	0.024 ± 0.002	1	0.03 ± 0.02	0.06	0.04 ± 0.02
NGC 1932	0.05	–		0.2 ± 0.1	0.4 ± 0.2	0.3 ± 0.2
NGC 1943	0.08	0.14 ± 0.02	1	0.08 ± 0.06	0.28 ± 0.08	0.14 ± 0.06
		0.10 ± 0.01	3			
NGC 1940	0.06	–		0.06 ± 0.02	0.06	0.06 ± 0.02
NGC 1971	0.06	0.10 ± 0.01	1	0.05 ± 0.01	0.05 ± 0.01	0.06 ± 0.02
SL 508	0.06	0.10 ± 0.01	1	0.06 ± 0.04	0.06	0.06 ± 0.04
NGC 2038	0.06	0.13 ± 0.02	1	0.039 ± 0.008	0.06	0.08 ± 0.05
SL 709	0.06	–		0.3 ± 0.2	0.13 ± 0.03	0.3 ± 0.2
NGC 2118	0.07	–		0.05 ± 0.02	0.06	0.05 ± 0.02
NGC 2130	0.05	–		0.03 ± 0.02	0.06	0.04 ± 0.02
NGC 2135	0.05	–		0.085 ± 0.008	0.05 ± 0.01	0.07 ± 0.02

References: (1) Pietrzyński & Udalski (2000); (2) Alcaino & Liller (1987); (3) Bono, Marconi, Cassisi *et al.* (2005); (4) Piatti, Bica, Geisler *et al.* (2003b).

We used the integrated UBV colours of 624 LMC clusters and associations obtained by Bica, Clariá, Dottori *et al.* (1996) to check the trend of (U-B) and (B-V) with age according to the present estimates. The colour gap seen in both (U-B) and (B-V) is a real feature first identified by van den Bergh (1981). The gap is probably a natural consequence of cluster evolution with increasing metallicities towards the present, and epochs of reduced cluster formation between ≈ 300 Myr and ≈ 1 Gyr. At least in the LMC bar, such a period of reduced cluster formation is not observed for the field stars (Smecker-Hane, Cole, Gallagher *et al.* 2002).

Keywords. galaxies: star clusters - Magellanic Clouds - techniques: spectroscopy

References

Alcaino, G. & Liller, W. 1987, *AJ* 94, 372
Bica, E. & Alloin, D. 1986, *A&A* 162, 21
Bica, E., Clariá, J.J., Dottori, H., Santos Jr., J.F.C. & Piatti, A.E. 1996, *ApJS* 102, 57
Bono, G., Marconi, M., Cassisi, S., *et al.* 1996, *ApJS* 102, 57
Burstein, D. & Heiles, C. 1982, *AJ* 87, 1165
Piatti, A.E., Bica, E., Geisler, D. & Clariá, J.J. 2003a, *MNRAS* 344, 965
Piatti, A.E., Bica, E., Geisler, D. & Clariá, J.J. 2003b, *MNRAS* 343, 841
Pietrzyński, G. & Udalski, A. 2000 *AcA* 50, 337
Santos Jr., J.F.C. & Piatti, A.E. 2004, *A&A* 428, 79 (SP)
Smecker-Hane, T.A., Cole, A.A., Gallagher, J.S. & Stetson, P.B. 2002 *ApJ* 566, 239
van den Bergh, S. 1981, *A&AS* 46, 79