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Using the Age and Metallicity of 8 Star Clusters to confirm the Chemical Enrichment History of the LMC

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Abstract. In this paper, we find the ages and metallicities of 8 Large Magellanic Cloud (LMC) star clusters obtained from integrated light spectra and use them to obtain the Chemical Enrichment History of the host galaxy. Our results are in good agreement with those obtained from resolved studies. This confirms that this method can be used for far away galaxies for which their star clusters are not resolved.

Introduction

The star formation history (SFH) of galaxies can be obtained through analysing individual stars in clusters (Dirsch et al. 2000; Carrera et al. 2008; Maschberger & Kroupa 2011; Livanou et al. 2013; Piatti et al. 2017). However, the disadvantage of this method is that it only applies to galaxies that have a proximity of ~ 1 Mpc. Recently, Chilingarian & Asa'd (2018) confirmed that the integrated light spectra of massive star clusters can be used to determine the Chemical Enrichment History (CEH) of their host galaxy.

In this work, we follow the method of Chilingarian & Asa'd (2018) to obtain the ages and metallicities of 8 star-clusters in the Large Magellanic Cloud (LMC) galaxy and use the results to confirm the Chemical Enrichment History obtained from resolved data.

Getting the Metallicities and Ages of the Clusters

In previous studies, we use that integrated spectra of star clusters to obtain their age and reddening (Asa'd et al 2013; Asa'd 2014; Asa'd et al 2016; Asa'd et al 2018), In this work we use the integrated spectra to obtain the age and metallicity of our sample.

1.1. Merging the Spectra

The data used in this work was obtained from the WiFeS Atlas of Galactic Globular cluster Spectra (WAGGS) website (<http://www.astro.ljmu.ac.uk/%7Eastcushe/waggs/>). The data was observed using different filters (U, B and R). Hence, each cluster had three spectra, each covering a different range of wavelengths (Usher et al. 2017). We merged the three spectra of each cluster. To do that, we unified their step-size using IRAF by interpolating them to a step-size of 0.5.



1.2. Running the Merged Spectra on NBursts

We ran the merged spectra in NBursts (Chilingarian et al. 2007a, 2007b) to obtain the best-fit for age and metallicity of each cluster. The results are listed in Table 1.

CEH from Resolved Data

Spitoni et al. (2017) proposed a model for the Chemical Enrichment History.

$$Z(T) = Z(0) + y_Z (1 - R) \int_0^T \frac{\psi(t)}{M_{\text{gas}}(T)} dt \quad (1)$$

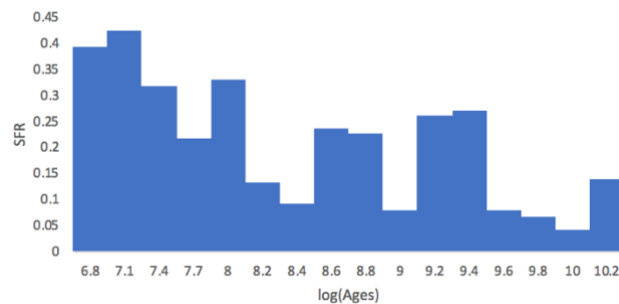
$$= Z(0) + \frac{y_Z (1 - R)}{1 - R + \lambda} \ln \frac{M_{\text{gas}}(0)}{M_{\text{gas}}(0) - (1 - R + \lambda) \int_0^T \psi(t) dt} \quad (2)$$

Where y_Z is the mass fraction of heavy elements formed in stars and returned into the ISM, R is the returned mass fraction of gas that goes back to ISM after stars evolve and can be recycled for star formation. λ is the outflow coefficient, M_{gas} is the initial mass of the gas and $\psi(t)$ is the star formation rate. For Chabrier IMF (Chabrier et al. 2003), $R = 0.441$, $y_Z = 0.0631$.

We used the resolved SFH survey from Harris and Zaritsky (2009) available on Vizier website (<http://vizier.cfa.harvard.edu/viz-bin/VizieR?-source=J/AJ/138/1243>), we followed the procedure of Chilingarian and Asa'd (2018), of summing up the SFR estimates in each of the available bins corresponding to every unique age. This was used to approximate the area by taking the size of age bin as the width and the corresponding SFR as the height as shown in Figure 1.

The area obtained was used as an approximation for the integration $\int_0^t \psi(t) dt$, in equation (2) in order to solve for the free parameters.

Figure 1. The area used to approximate the integration $\int_0^t \psi(t) dt$ by summing up the SFR estimates in each of the available bins corresponding to every unique age from Harris and Zaritsky (2009).



Results

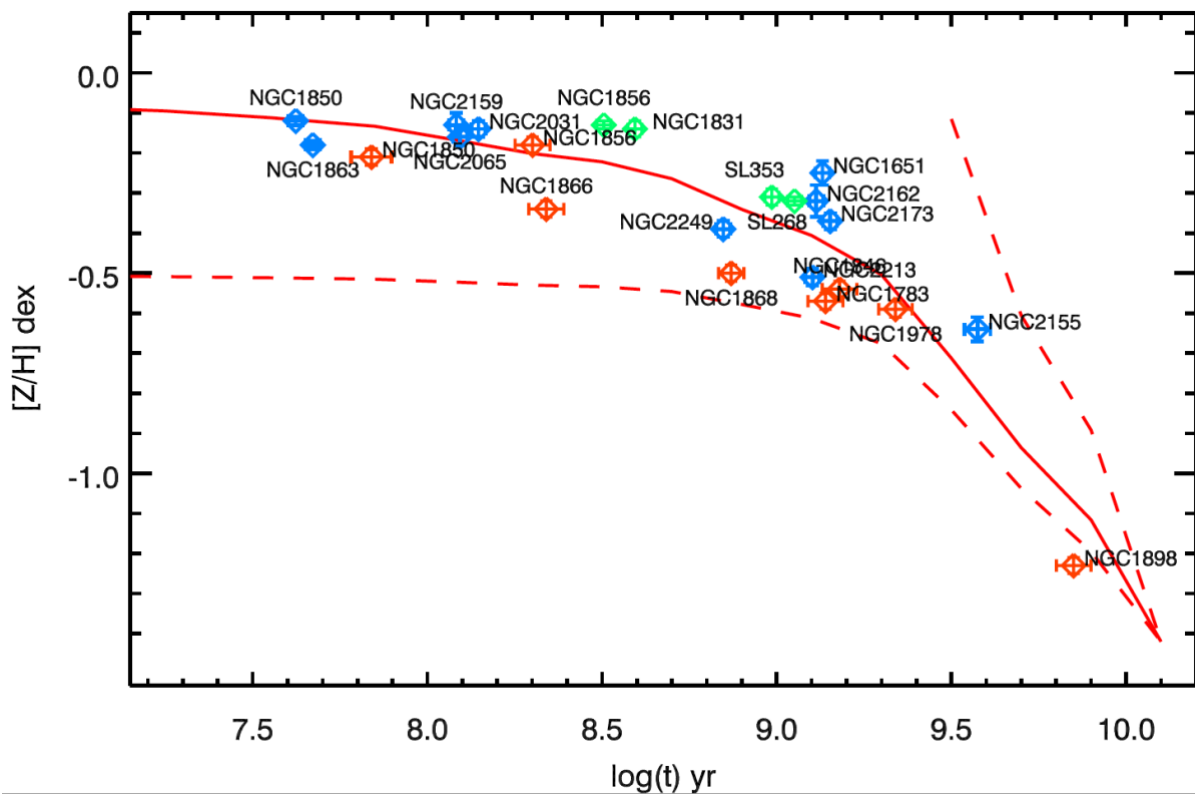
Table 1 shows that the age and metallicity of our sample. Figure 2 shows the age-metallicity relation for the 8 LMC clusters (the red points) combined with the results obtained in Chilingarian & Asa'd (2018) (the blue and green points), compared to the predictions of the IRA chemical evolution model based on the LMC global star formation rate from Harris & Zaritsky (2009). The red line represents the

best approximation of the SFR and the red dotted lines represent the error range. Our data agrees with the model.

Table 1. Ages and Metallicities of the Clusters of our sample using NBursts

Clusters	t, log (Myrs)	[Z/H], dex
NGC1783	9.14	-0.57
NGC1846	9.18	-0.54
NGC1850	7.84	-0.21
NGC1856	8.30	-0.18
NGC1866	8.34	-0.34
NGC1868	8.87	-0.50
NGC1898	9.85	-1.23
NGC1978	9.34	-0.59

Figure 2. Age-metallicity diagram for LMC clusters compared to Harris and Zaritsky (2009) IRA model.



Conclusion

We obtained the age and metallicity of 8 LMC star clusters from integrated light spectra in order to determine the CEH of their host galaxy. Our results are in good agreement with the resolved data results. This indicates that this method can be used for far away galaxies (~10 Mpc) for which the star clusters are not resolved.

Acknowledgments

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