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PRESENTACIÓN MURAL

New old star clusters in the Small Magellanic Cloud

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Abstract. Using Ca triplet spectroscopy and PSF photometry performed on data taken with the "Very Large Telescope" (Chile), we derived reliable ages and metallicities of 15 Small Magellanic Cloud (SMC) star clusters. Three of them were found to be very old clusters so that the determination of their fundamental properties allows us to improve our current knowledge on the SMC chemical evolution during the earliest epochs. Based on our new data, we further discuss the age-metallicity relation. The procedures and results included in this article will be presented in a more extensive and detailed way in Parisi et al. (2011 - in preparation).

Resumen. Usando espectroscopía del Triplete del Calcio Ionizado y fotometría PSF realizada sobre datos tomados con el "Very Large Telescope" (Chile), derivamos edades y metalicidades confiables de 15 cúmulos estelares de la Nube Menor de Magallanes (NmM). Encontramos que 3 de ellos son cúmulos muy viejos, por lo que la determinación de sus propiedades fundamentales permite mejorar nuestro actual conocimiento sobre la evolución química de la NmM durante su etapa más temprana. Basados en nuestros nuevos datos, rediscutimos la relación edad-metalicidad en esta galaxia. Los procedimientos y resultados incluidos en este artículo, serán presentados de manera más extensa y detallada en Parisi et al. (2011 - en preparación).

1. Introduction

Using spectra taken with the FORS2 instrument on the VLT, we measured the equivalent width of the three Calcium Triplet (CaT) lines (8498Å, 8542Å and 8662Å) as well as the radial velocities (RVs) of more than 350 red giant stars belonging to 15 SMC clusters and their surrounding fields. Using these parameters and following the so-called "CaT technique" (Cole et al. 2004, Grocholski et al. 2006), we calculated the cluster mean metallicities and radial velocities with average errors of 0.05 dex and 2.7 km/s, respectively (see Parisi et al. 2009 for more details). In addition, using the Color-Magnitude Diagrams (CMDs) built from PSF V and I photometry on the cluster pre-images, also obtained with the VLT, we measured the parameter δV, which is defined as the difference between the V magnitude of the Main Sequence Turnoff (MSTO) and that of the Red Clump (RC). This morphological index is well correlated with cluster ages (Janes & Phelps 1994). To estimate them, we used the calibration of Salaris et al. (2004), together with the cluster metallicities and δV values derived in the present work. According to this calibration, we discovered that three of our observed clusters (L4, L6 and L110) were very old clusters

In order to corroborate the obtained values, we decided to derive an "SMC δV calibration", using the work of Glatt et al. (2008) as reference. These authors observed a sample of SMC clusters with the "Hubble Space Telescope" and reported the magnitude m555 of the MSTO and of the RC as well as their ages, using three different isochrone models. Fig.1 illustrates the relation found by using the Glatt et al. values. We then applied the "SMC δV calibration" to our three old clusters. This calibration is only valid for clusters older than $\sim$ 6 Gyr, having similar metallicities ([FeH] $\sim$ -1). For the subsequent analysis, we decided to use the ages derived from the "SMC δV calibration" for the old clusters and those from Salaris et al. (2004) for all the other clusters in our sample. We noted that the Salaris et al. calibration tends to overestimate cluster ages for old clusters.

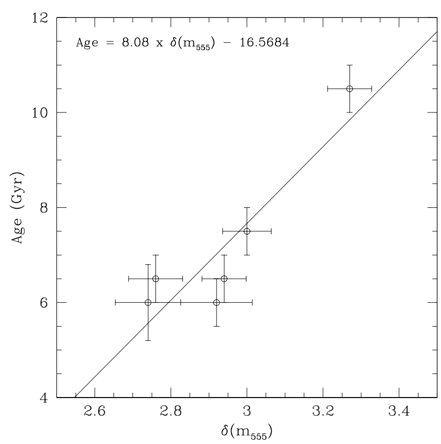

Figure 1. Ages vs. δ(m555). Points represent clusters taken from Glatt et al. (2008) and the solid line shows a linear fit to the data.

2. The ages of the three newly recognized old clusters

According to the "SMC δV calibration", the ages of L110, L4 and L6 are between 6.0 and 8.5 Gyr. If we consider these values, L4 and L6 are the second and fourth oldest clusters known in the galaxy, respectively. Figure 2 shows the CMDs of

L4 (left) and L6 (right), together with the corresponding fiducial curves (built following the procedure described by Glatt et al. 2008) and a preliminary fit of four Dartmouth isochrones: 6, 7, 8 and 9 Gyr (Dotter et al. 2007). The fitted isochrones appear to confirm that these clusters are in fact old. It is interesting to notice that L4 and L6 are two of the oldest SMC clusters and lie right next to each other, way out in the outer regions of the galaxy. Although the ages of these clusters have been previously derived by other photometric studies (Piatti et al. 2005, Piatti et al. 2007), our photometry is at the moment the only deep enough to show their MSTO without doubt.

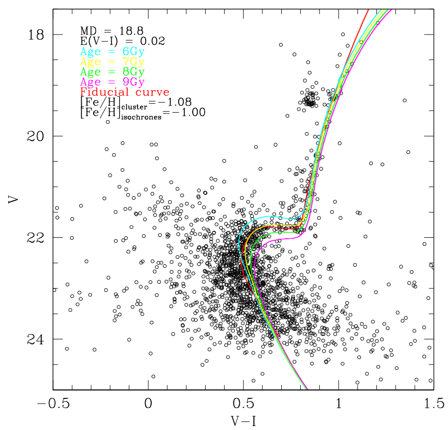

Figure 2. CMDs for the SMC clusters L4 (Left) and L6 (Right). Fiducial curves are represented by red solid curves while the other curves indicate Dartmouth isochrones (color vertion of this figure can be seen in the online journal)

3. Age-Metallicity Relation

We present the SMC Age-Metallcity relation (AMR) in Figure 3. Since some authors have derived SMC cluster metallicities on a similar scale with relatively small errors, we added such objects to our cluster sample. Then, we compared this extended sample with different models (see the caption of Figure 3 for details regarding the additional cluster sample and models). The AMR does not show a clear agreement with the bursting model of Pagel & Tautvaisiene (1998, PT98), except for clusters younger than 3Gyr. Although the observations are compatible with a small chemical enrichment predicted by the PT98 model for the intermediate period, the metallicities of most observed clusters in that period are significantly higher than those predicted by the model. On the other hand, the youngest cluster, NGC330, is much more metal-poor than the prediction of the PT98 model. Nevertheless, Carrera et al. (2005) model fits reasonably well most data between 3 and 10 Gyr. It is also clear that the "close box" model does not satisfy the observations. Glatt et al. (2008) mentioned the possible existence of a small age gap between ∼7.5 and ∼10.5 Gyr. As one or two of the old clusters newly recognized in this work fall within the mentioned gap, it would seem reasonable to assume that this gap is not real.

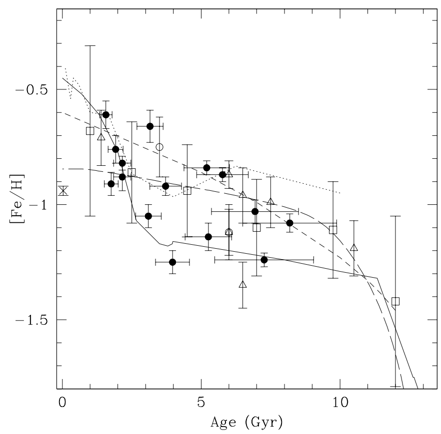

Figure 3. Age-Metallicity relation. Open circles and triangles represent clusters from Da Costa & Hatzidimitriou (1998) and Glatt et al. (2008), respectively. Clusters of our sample are represented by filled circles. NGC330 (Gonzalez & Wallerstein 1999) is shown by a cross. Mean metallicities in six age bins calculated by Carrera et al. (2008) are also shown (squares). The short dashed line represents the model of closed box continuous star formation computed by Da Costa & Hatzidimitriou (1998). The solid line corresponds to the bursting model of Pagel & Tautvaivsiene (1998) while the long dashed line shows the best-fit model derived by Carrera et al (2005). The dotted line shows the AMR obtained by Harris & Zaritsky (2004).

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