THE MAGELLANIC INTER-CLOUD PROJECT (MAGIC). I. EVIDENCE FOR INTERMEDIATE-AGE STELLAR POPULATIONS IN BETWEEN THE MAGELLANIC CLOUDS

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Received 2012 September 25; accepted 2013 March 1; published 2013 April 19

ABSTRACT

The origin of the gas in between the Magellanic Clouds (MCs)—known as the “Magellanic Bridge” (MB)—is puzzling. Numerical simulations suggest that the MB formed from tidally stripped gas and stars in a recent interaction between the MCs. However, the apparent lack of stripped intermediate- or old-age stars associated with the MB is at odds with this picture. In this paper, we present the first results from the MAGellanic Inter-Cloud program (MAGIC) aimed at probing the stellar populations in the inter-Cloud region. We present observations of the stellar populations in two large fields located in between the Large and Small Magellanic Clouds (LMC/SMC), secured using the WFI camera on the 2.2 m telescope in La Silla. Using a synthetic color–magnitude diagram technique, we present the first quantitative evidence for the presence of intermediate-age and old stars in the inter-Cloud region. The intermediate-age stars—which make up ∼28% of all stars in the region—are not present in fields at a similar distance from the SMC in a direction pointing away from the LMC. This provides potential evidence that these intermediate-age stars could have been tidally stripped from the SMC. However, spectroscopic studies will be needed to confirm or rule out the tidal origin for the inter-Cloud gas and stars.

Key words: galaxies: evolution – galaxies: stellar content – galaxies: structure – Local Group – Magellanic Clouds – stars: evolution

Online-only material: color figures

1. INTRODUCTION

Encounters between galaxies, common in the early universe, are still frequent today (e.g., Larson & Tinsley 1978; Barnes & Hernquist 1992). Interactions reshape the galaxies, transferring mass, energy, and metals between them, creating new sites of star formation both within the galaxies and in stripped gas between the galaxies. As such, understanding these encounters is key to understanding galaxy formation and evolution.

One of the best places for studying such interactions is the Local Group, where galaxies are close enough that they can be resolved into individual stars. In particular, the Magellanic Clouds (MCs) are ideal for investigating the effects of interactions due to three key factors: their close proximity to our Galaxy (~50–70 kpc away); their mutual association over the past few Gyr (as determined from their proper motions: Kallivayalil et al. 2006, Besla et al. 2007, 2012, Piattek et al. 2008; and numerical simulations: Bekki 2011); and their significant gas reservoirs (e.g., Stanimirovic et al. 2000; Kemper et al. 2010).

The interactions of the MCs with each other and with the Milky Way (MW) are believed to have produced several gaseous features: the Magellanic Bridge (MB), first discovered by Hindman et al. (1963), a common envelope of H1 in which both the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC) are embedded; the Magellanic Stream, a pure-gaseous stream trailing the MCs as they orbit the MW (Mathewson et al. 1974; Nidever et al. 2010); and the Leading Arm, connecting both of the MCs with the MW (Putman 2000). Theoretical works (e.g., Gardiner et al. 1994; Yoshizawa & Noguchi 2003; Diaz & Bekki 2012) suggest that the MB has a tidal origin. In a recent encounter between the MCs, the

LMC stripped large amounts of H1 from the SMC to create the MB (e.g., Muller & Bekki 2007), possibly “puffing-up” the stellar distribution on the northeastern side of the SMC (Nidever et al. 2011). However, only stars younger than 1 Gyr old, consistent with in situ formation, have been found to date in the MB’s main H1 ridgeline (Harris 2007), while only hints of intermediate-age stars are present in the inter-Cloud region (from carbon stars (e.g., Kunkel et al. 2000); giant stars ~6 kpc from the SMC (Nidever et al. 2011); old stars in the MB from the analysis of 2MASS7 and WISE8 near-infrared data (Bagheri et al. 2013); and intermediate-age stars in the south at ~6.5 kpc (Noël & Gallart 2007)). Recently, Olsen et al. (2011) found metallicity differences in 30 red giants located in the outskirts of the LMC, which they interpreted as a strong evidence that this kinematically distinct population originated in the SMC. This may be evidence of tidally stripped SMC stars, presumably removed in a past LMC–SMC interaction. This could mean that the ram pressure stripping—believed to have played an important, or even dominant, role in forming the MB and Stream (Mastropietro et al. 2005)—would not likely be the main driver of the MB.

With the purpose of shedding light on the stellar content of the MCs’ inter-Cloud area, we have initiated the MAGIC (MAGellanic Inter-Cloud) project, aimed at disentangling the population age and distribution in the inter-Cloud region. In this paper, we present the first results from MAGIC. We performed quantitative studies of the star formation history (SFH) and age–metallicity relations (AMRs) of two large fields in the inter-Cloud region. Our fields are deliberately chosen to lie away from

7 http://irsa.ipac.caltech.edu/applications/2MASS/IM/
8 http://wise.ssl.berkeley.edu/
the main H I ridgeline region (around \( \sim 1.5 \) kpc in projection on the northern side). There are several reasons for this. First, a tidally stripped stellar population is expected to inhabit a broad region around the H I ridgeline of at least the width of the SMC (e.g., Read et al. 2006; Binney & Tremaine 2008). Second, if pressure stripping from the MW halo has played a significant role in the evolution of the Magellanic system, then it is possible that the gaseous MB is now systematically displaced from the region where the tidally stripped stars between the MCs lie. Third, no deep photometry has been performed in these fields before (or indeed anywhere around the MB). This is of particular importance for the region where the tidally stripped stars between the MCs lie. There are several reasons for this. First, a tidal stripping process is expected to inhabit a broad region around the H I ridgeline of at least the width of the SMC (e.g., Read et al. 2006; Binney & Tremaine 2008).

This paper is organized as follows. In Section 2, we describe the observations, data reduction and photometry. The analysis and results are discussed in Section 3. Finally, in Section 4 we present our conclusions.

2. OBSERVATIONS, DATA REDUCTION, AND PHOTOMETRY

With the aim of characterizing the stellar content of the inter-Cloud region, we obtained \( B \)- and \( R \)-band images of six fields during the nights of 2010 December 4–7 using the Wide Field Imager (WFI) on the 2.2 m telescope in La Silla. In order to compensate for the small number statistics in the observed inter-Cloud fields, we merged them into two large fields. These fields cover two large areas (\( 0.75 \times 0.75 \) in the Bridge region. They are depicted as large red diamonds in Figure 4 (we will return to this figure later): B1, located at a distance of \( \sim 8.7 \) (\( \sim 9 \) kpc) from the LMC, and B2, at \( \sim 6.7 \) (\( \sim 8 \) kpc) from the SMC. In Table 1, we present the centers of the observed fields, the observing conditions, and the 50% completeness level of the data.

The basic data reduction and astrometric solution was performed by the Cambridge Astronomical Survey Unit pipeline (Irwin & Lewis 2001). For each night, master bias and master flat frames were created from the individual biases and sky flat frames, then master frames from adjacent nights were combined to form a rolling-average frame which was then applied to the data. Each science frame then underwent source extraction and an astrometric solution was determined through crossmatching with the Two Micron All Sky Survey (2MASS) point source catalog. Astrometric accuracy is obtained through a Median Absolute Deviation estimator comparing the offsets between the R.A. and decl. of the source versus the 2MASS catalog. This is then scaled, assuming the errors are Gaussian, forming a robust rms estimate of the overall fit. This resulted in an accuracy of better than \( 0.2 \) in almost all fields and in a few cases better than \( 0.1 \).

The final photometric catalog was undertaken using DOLPHOT\(^9\) (Dolphin 2000). DOLPHOT extracts the sources and determines the magnitudes for the two bands, \( B \) and \( R \), simultaneously. This was run on all of the fields creating a catalog of sources per field in both filters. The output files of DOLPHOT include detailed information for each star, including the position and global solution such as: \( x \), sharpness, roundness, and object type. For our purposes, we selected a value for \( \chi \) of \( \sim 4 \), reasonable for good stars within relatively crowded fields, a value of (sharpness)\(^2 \) \( \lesssim 0.1 \) for a perfectly-fit star, and an object type (which ranges from 1 to 5) of 1 indicating a “good star.” These parameters allow us to remove all spurious objects from the photometry, including background galaxies. Typically this corresponds to \( \sim 2400 \) objects removed per field from our area of interest in color–magnitude diagram (CMD) space which is consistent with predictions of expected background contamination.

During the photometric nights of 2010 December 4 and 6 we took short exposures (60 s) in the center of B1 and B2 (see Figure 4) in both the \( B \) and \( R \) bands. This exposure overlap with all the long exposures and were used to provide the final calibration. Landolt (Landolt 2009) and Stetson’s (Stetson 2000) standard fields SA95 and RU149 were also observed during photometric nights at different air masses ranging from 2.2 to 1.15. We obtained several 30 s exposures per standard field per filter (in the \( B \) and \( R \) bands). Since the standard images are uncrowded fields, no profile-fitting photometry was necessary for them.

To put our observations into the standard system, we used the following transformation equations:

\[
B = b + \alpha_b + \beta_b (B - R) + \gamma_b X_b \\
R = r + \alpha_r + \beta_r (B - R) + \gamma_r X_r
\]

where \((b, \alpha)\) and \((B, \beta, \gamma)\) are the instrumental and standard magnitudes, respectively, and \((X_b, X_r)\) are the airmasses.

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\(^9\) http://purcell.as.arizona.edu/dolphot/

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**Table 1**

Summary of Observations

| Fieldname | R.A. (°) | Decl. (°) | Date Observed | Seeing | Filter | Airmass | 50% Completeness |
|-----------|---------|-----------|---------------|--------|--------|---------|-----------------|
| 0220–7230 | 35.168160 | −72.49942 | 2010-12-05T05:15:760 | 1°53 | \( B^\alpha \) | 1.548 | 24.12 |
| 0220–7230 | 35.167300 | −72.49958 | 2010-12-05T05:59:720 | 1°44 | \( R^\alpha \) | 1.650 | 22.68 |
| 0220–7300 | 35.167970 | −72.99959 | 2010-12-06T06:26:38510 | 1°39 | \( B \) | 1.588 | 23.98 |
| 0220–7300 | 35.168490 | −72.99974 | 2010-12-06T06:11:19:400 | 1°92 | \( R \) | 1.700 | 22.39 |
| 0227–7300 | 36.750970 | −72.99963 | 2010-12-08T06:24:12:400 | 1°88 | \( B \) | 1.586 | 23.98 |
| 0227–7300 | 36.751540 | −72.99948 | 2010-12-08T06:08:30:380 | 1°45 | \( R \) | 1.696 | 23.68 |
| 0338–7300 | 54.500650 | −72.99946 | 2010-12-05T07:51:41:300 | 1°74 | \( B \) | 1.758 | 23.26 |
| 0338–7300 | 54.499860 | −72.99942 | 2010-12-05T06:34:11:750 | 1°59 | \( R \) | 1.560 | 21.96 |
| 0345–7230 | 56.416990 | −72.49967 | 2010-12-06T06:46:01:980 | 1°63 | \( B \) | 1.586 | 24.12 |
| 0345–7230 | 56.417650 | −72.998968 | 2010-12-07T07:03:34:480 | 1°32 | \( R \) | 1.618 | 22.46 |
| 0345–7300 | 56.416720 | −72.99945 | 2010-12-07T05:12:35:840 | 1°39 | \( B \) | 1.438 | 23.83 |
| 0345–7300 | 56.416970 | −72.99972 | 2010-12-06T07:39:23:810 | 1°77 | \( R \) | 1.710 | 21.38 |

Notes. The zero points of the data are 25.25 in \( B \) and 24.68 in \( R \). The atmospheric extinction parameters, \( \epsilon_B = 0.271 \) and \( \epsilon_R = 0.07 \), were taken from Giraud et al. (2006) and Tüg (1977), respectively, as this gave the best \( B-R \) color in comparison with established catalogs.

\(^a\) BB\#B/123_ESO878.

\(^b\) BB\#Rc/162_ESO844.
time dependence terms were added since a preliminary fit showed no trends in the residuals of both $B$ and $R$ with time. The color terms ($\beta_b, \beta_r$) and extinction coefficients ($\gamma_b, \gamma_r$), as well as the zero points ($\alpha_b, \alpha_r$) are unknown, most likely constant, transformation coefficients and should be calculated. Both the color-dependent term and the zero point in the transformation, are expected to be constant properties of the telescope/filter/detector combination. The above equations were applied to the standard star magnitudes, and solved for $\alpha_b, \alpha_r, \beta_b, \beta_r, \gamma_b$ and $\gamma_r$, for each night using a custom program. Then, we followed an iterative procedure to refine our photometric transformation. First, a new set of unique ($\alpha_b, \alpha_r$) and ($\beta_b, \beta_r$) values was obtained by imposing the extinction coefficients ($\gamma_b, \gamma_r$) corresponding to each night. Then, we applied the resultant zero points and color terms to each night and new extinction coefficients were derived for each night. In this way, we have a set of ($\alpha_b, \alpha_r$) and ($\beta_b, \beta_r$) values and ($\gamma_b, \gamma_r$) values for each night.

DOLPHOT was then subsequently used to perform an artificial star experiment allowing the magnitude completeness of the data to be determined (see Noël et al. 2007 for details). The magnitude completeness was then determined by fitting a logistic function to the ratio of retrieved stars versus input stars. Each frame was first processed with DOLPHOT to locate the positions of the real stars and then, to ensure good number statistics, $\sim$48,300 stars were introduced per chip one at a time into specific pixel positions. In this manner, DOLPHOT applies a single artificial star in that location and attempts to recover it. The pixel positions of the artificial stars are chosen such that no two artificial stars probe the same region of the CCD, i.e., there will be no interaction between them, with artificial stars being around 11 pixels apart (roughly PSF radius + Fitting radius + 1) one from another. A grid with artificial stars spaced 11 pixels is displaced randomly for each test to ensure a dense sampling of the observational effects all over the image of the galaxy. In this way, the artificial stars are spread evenly over the chip and each chip receives the same number of artificial stars. In total, a given exposure has $\sim$384,000 artificial stars inserted into the image.

The resulting CMDs of field B1 and B2 are shown in Figure 1. As we can see, even at $\sim$8 kpc from the SMC center (field B2), the main features of a CMD are still present. We will come back to Figure 1 in Section 3.

3. RESULTS

3.1. The Star Formation History in the Inter-Cloud Region

The CMD fitting technique was carried out using the software package MATCH (Dolphin 2002). The observed CMD was converted into a Hess diagram and compared with synthetic CMDs of model populations from Girardi et al. (2004). Theoretical isochrones were convolved with model of the completeness and photometric accuracy in order to create the synthetic CMDs. We also obtained a foreground estimation based on a Galactic structure model given by MATCH that is included in the software as an extra model population. The software uses a maximum-likelihood technique to find the best linear combination of population models, resulting in an estimate of the SFH and the AMR. In order to obtain the SFHs for the inter-Cloud fields analyzed here, we used the color range $-0.18 \leq (B-R) \leq 1.8$ and the magnitude range $R \leq 22.3$, $B \leq 22.7$ for the CMD of B1 and $-0.35 \leq (B-R) \leq 1.6$ with $R \leq 22.3$, $B \leq 22.7$ for the CMD of B2 as marked by the dashed lines in Figure 1. In this way, we avoid the inclusion of red low mass foreground stars in the fitting. To further test the influence of unidentified background galaxies contaminating our sample in the region between $21 \leq R \leq 22.3$, we calculated the ratio of objects in the red clump to the number of objects at the lower edge of the CMD ($21 \leq R \leq 22.3$). For field B2, we find this ratio to be 15%, while in the q0111 SMC wing field from Noël et al. (2007), where the contamination is known to be very low, we obtain a ratio of $\sim$11%. This exercise, together with the constraints given by DOLPHOT (see Section 2), make it clear that any background contamination has been minimized for our data set.

We recovered the SFH and metallicity for both fields B1 and B2 using age bins in the range from 10 Myr to 13 Gyr (9 bins for B1 and 11 bins for B2) and metallicities in the range $-2.4 \leq \left[\text{Fe/H}\right] \leq 0$ in bins of width 0.2 dex. We used a Salpeter initial mass function (IMF) and assumed a 30% binary fraction. The fitting software then finds a linear combination of model CMDs that best fit the observed CMD. The resulting relative star formation rates (SFRs) and the [Fe/H] as a function of time for B1 and B2 are presented in Figure 2.

The upper panels of Figure 2 show the SFHs for both fields. The SFR for each bin is the average of the values given by the fits at the different distances and the error bars represent the complete range of SFR values found. The lower panels of Figure 2 show the AMRs. The metallicities are only plotted for age bins with significant star formation (SFR $\geq 0.2$). The metallicity of each bin is the average of the fits weighted by the SFH. Error bars in the AMR represent the standard deviation. Horizontal bars in both the SFH and the AMR plots represent the width of the age bins used.

In both fields, there is a conspicuous old population (older than $\sim$10 Gyr old). Very little star formation took place after then in the inter-Cloud field B1 with only hints of the presence of older population.

10 We can afford more bins for field B2 since it has more stars.

11 Since fields B1 and B2 contain predominately intermediate- and old-age stars, the choice of IMF is not critical (see, e.g., de Jong et al. 2010). The binary fraction we assume is taken from Noël et al. (2007).
of stars of intermediate-age between \(\sim7\)–10 Gyr. However, at \(6.7\) (\(\sim8\) kpc) from the SMC center, in field B2, there are intermediate-age stars and a young component. In the last 1 Gyr, field B2 had an increment in the SFR with a conspicuous peak at around 200 Myr ago (corresponding to the young MS plume in the CMD).

The AMR of field B1 (Figure 2) is consistent with being constant, with \([\text{Fe}/\text{H}]\sim-1\). The AMR of field B2 is almost constant with \([\text{Fe}/\text{H}]\sim-1\) until the last few Myr when it goes up to \([\text{Fe}/\text{H}]\sim-0.8\). These values are in good agreement with the calcium triplet metallicities obtained for the outskirts of the SMC (Carrera et al. 2008) and—within the quoted uncertainties—the LMC (Carrera et al. 2011). Note that these AMRs obtained from CMD fitting should only be taken as indicative of the metallicity range; accurate metallicities are only possible with spectroscopy.

Further quantitative information on the stellar distribution is given by the cumulative SFH that provides the fraction of stellar mass formed prior to a given time. This is shown for field B2 in Figure 3. The upper-y-axis shows the redshift as a function of time.\(^{12}\) The dashed line indicates that 50\% of the stars were formed prior to \(z\sim1.8\) (\(\sim10\) Gyr ago). A significant amount (\(\sim28\%)\) of stars were formed between then and 1 Gyr ago. The remaining stars formed in the last Gyr with a conspicuous increment (20\% of the stars) in the past few Myr. This recent burst appears to correlate with the most recent pericentric passage between the Clouds (\(\sim0.2\) Gyr ago; Kallivayalil et al. 2006). The arrows in Figure 3 show this last pericentric passage, together with (tentative) previous close encounters up to \(\sim8\) Gyr ago derived from numerical modeling (Kallivayalil et al. 2006). The size of the arrows represent the proximity of the pericentric passage, with longer arrows representing closer and therefore more extreme interactions. Except for the last encounter \(\sim200\) Myr ago, when the MCs were \(<5\) kpc from each other, there seems to be no correlation between enhancements in the SFR and the pericentric passages.

\(^{12}\) The redshifts were obtained using the following cosmology: \(H_0 = 71\), \(\Omega_M = 0.270\), \(\Omega_\Lambda = 0.730\) (http://map.gsfc.nasa.gov/).

in agreement with the previous results from the 12 SMC fields of Noël et al. (2009). We discuss this further in Section 4.

### 3.2. Are These Intermediate-age Stars Tidally Stripped?

We now turn to the issue of whether there are tidally stripped stars in the inter-Cloud region. To determine this, we compare our results for the SFH and AMR of fields B1 and B2 with other...
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Figure 4. Spatial location of the two fields presented in this paper (large red diamonds denoted as B1 and B2) together with the SMC fields from Noël et al. (2007, 2009; small magenta circles); Noël & Gallart (2007; large yellow circles); and the LMC fields from Carrera et al. (2011; brown squares). The fields are superimposed over the H\textsubscript{i} map from Putman et al. (1998). Metallicities of the SMC fields are taken from Carrera et al. (2008), except for the yellow circle fields where the metallicity comes from isochrone fitting of Noël & Gallart (2007). Metallicities for the LMC are taken from Carrera et al. (2011). The inset figures show the cumulative SFHs (where available; black lines), the age distributions (magenta lines; see text for details) and the stellar content determined from isochrone fitting (blue lines; see text for details). In order to see how the SFHs and the age distributions compare, we plot both in two of the SMC fields at 1.1 kpc and 3.3 kpc, where both have been measured. [Fe/H] and distance from the center of the SMC/LMC are also marked on each panel. In the case of B1 and B2, distances to both the LMC (d\textsubscript{L}; brown text) and the SMC (d\textsubscript{S}; magenta text) are marked. Except for fields B1 and B2, the axis labels for the inset panels (identical to fields B1 and B2) are omitted for clarity. The center of both the LMC and the SMC are marked with a black filled star.

(A color version of this figure is available in the online journal.)

fields around the SMC and LMC taken from the literature, as compiled in Figure 4. The cumulative SFHs (i.e., the average SFR at a given age times the width of the age bins) for the new fields B1 and B2 (large red diamonds) are plotted together with the cumulative SFHs for the SMC (magenta and yellow circles) and for the LMC (brown squares) taken from Noël & Gallart (2007), Noël et al. (2007, 2009) and Carrera et al. (2011). All the fields are superimposed on the H\textsubscript{i} map of the MCs from Putman et al. (1998). For the LMC fields we obtained the SFHs from the “age distributions” from Carrera et al. (2011; red lines with errors as magenta lines). These age distributions were obtained by comparing the CMD position and spectroscopic (Ca ii triplet) metallicity with synthetic CMD models. Since spectra are only available for the brightest stars, this is less accurate than a SFH obtained from a full deep CMD (black lines with errors marked as gray lines). For two fields (see the rightmost inset panels in Figure 4), we show both the quantitative SFHs from CMD fittings and the age distributions; they agree well within the quoted 1\sigma uncertainties. For the two outermost SMC fields in the south (marked as large yellow circles), we obtained the SFH from isochrone fitting. This is a more qualitative approach; however, the depth of the CMDs, reaching the oldest MS turnoffs (see Noël & Gallart 2007) and the little crowding in these outskirt fields allow us to have a very accurate estimation of the SFH.

The metallicities for all the LMC fields are taken from the calcium triplet study of Carrera et al. (2011) and the metallicities for the SMC fields for which quantitative SFHs are available (black lines, from the small magenta circles) are from the calcium triplet of Carrera et al. (2008). The metallicities of the fields presented here (red large diamonds) were obtained through the CMD fitting technique while the ones for the two southernmost SMC fields (large yellow circles) were obtained overlapping isochrones.

Fields within ~7 kpc from the LMC center at all position angles have near-continuous star formation with a star formation “burst” at \( \lesssim 3 \) Gyr for the fields closer to the LMC center; more distant fields in the direction away from the SMC show a slowly declining SFH. By contrast, in the SMC there are few stars formed over the past few Gyr at distances \( \gtrsim 2.5 \) kpc from the SMC center. Interestingly, fields B1 and B2 resemble SMC fields much more closely than LMC fields. Field B2, located at 8 kpc from the SMC center, presents both active star formation and intermediate-age stars, with an enhancement in the star formation at \( \sim 4 \) Gyr, resembling the SMC fields that lie closer than \( \sim 2.5 \) kpc. Similarly, field B1—which shows only...
stars older than \( \sim 7 \) Gyr—most closely resembles the distant southern SMC field at 6.5 kpc, despite lying significantly closer to the LMC than the SMC. The similarity between fields B1 and B2 and other SMC fields that lie much closer in projection to the LMC could be evidence that fields B1 and B2 contain tidally stripped SMC stars. The metallicities of fields B1 and B2 also support this interpretation, though the errors are large. Since the stellar distributions presented in Figure 4 are not homogeneous, this only allows a qualitative, instead of a more quantitative, interpretation of the tidal scenario.

As a sanity check of the hypothesis that fields B1 and B2 contain tidally stripped SMC stars, we crudely estimate the projected tidal radius of the SMC by matching field B2 to the SMC fields to the south and west of the SMC. This gives \( R_t \sim 1.5-2.5 \) kpc. Kallivayalil et al. (2000) estimate that the Clouds passed within \( r_p \sim 5 \) kpc of one another \( \sim 200 \) Myr ago. The dynamical tidal radius at this pericentric passage is approximately given by (e.g., Read et al. 2006):

\[
R_t = \left( \frac{M_{\text{SMC}}}{M_{\text{LMC}}} \right)^{1/3} (r_p - R_c)
\]

where the masses of the Clouds, \( M_{\text{SMC, LMC}} \), corresponds to that enclosed within \( R_t \). Current estimates from the literature suggest that \( M_{\text{SMC}}/M_{\text{LMC}} (R < 5 \) kpc) \( \sim 1 \) (see, e.g., van der Marel et al. 2002; Hatzidimitriou et al. 1997), from which we derive \( R_t \sim r_p/2 \sim 2.5 \) kpc, consistent with our value derived above. This is by no means a proof that B2 contains tidally stripped stars; spectroscopy will be required to really confirm or rule out this hypothesis, but it is encouraging.

4. DISCUSSION AND CONCLUSIONS

We have presented the stellar populations of two fields located in the area between the MCs—the “inter-Cloud” region. The fields—located at a distance of \( \sim 8.7 \) kpc from the LMC (9 kpc field B1), and at \( \sim 6.7 \) kpc from the SMC (8 kpc field B2)—were chosen deliberately to avoid the MB formed by the main ridgeline of H1 gas. We found that the stellar populations and mean metallicities of the fields are similar to fields to the south and west of the SMC but at smaller radii from the SMC center (\( \sim 6 \) kpc in the case of field B1 and \( \sim 2.5 \) kpc in the case of field B2). The similarity between fields B1 and B2 and other SMC fields that lie much closer in projection to the SMC could be an indication that fields B1 and B2 contain tidally stripped SMC stars.

Our key result is that intermediate-age stars are present in the inter-Cloud region. We found, through a quantitative CMD fitting analysis, that some \( \sim 28\% \) of the stars in field B2 have intermediate ages. These findings are consistent with several independent results in the literature. Carbon stars (unequivocal indicators of intermediate-age population) were already discovered in the inter-Cloud area over a decade ago (e.g., Kunkel et al. 2000); the kinematically peculiar stars found in the LMC by Olsen et al. (2011) could be evidence of SMC stars being captured by the LMC; Nidever et al. (2011) found a break in the radial density profile from \( \sim 7.5 \) up to \( 10.6 \) which could be a population of extra-tidal stars or a bound stellar halo; finally, \( N \)-body models from Diaz & Bekki (2012) predict that diffuse tidal features are stripped away from the MCs during the interaction between the Clouds that forms the MB. Our findings are at odds, however, with Harris (2007), who found only old stars east of \( \alpha \sim 03^{h} 18^{m} \) and \( \delta \sim -74^{d} \) and only young stars in their inter-Cloud fields along the MB’s main ridgeline, with no evidence of an intermediate-age component. Some of these differences are likely due to the fact that we have deeper CMDs that reach the oldest MS turnoffs, of key importance for finding intermediate-age stars (see, e.g., Noël 2008).

In addition to the intermediate-age stars, field B2 shows a significant young population that correlates with the last close pericentric passage between the Clouds \( \sim 200 \) Myr ago, as determined from their proper motions and radial velocities (Kallivayalil et al. 2006). This is the only clear starburst associated with a pericentric passage, which could reflect the much closer proximity of the last fly-by (Kallivayalil et al. 2006), the difficulty of determining orbits backward in time (Lux et al. 2010), and/or the poorer temporal resolution of the SFH backward in time (Dolphin 2012).

We thank the anonymous referee for useful suggestions that helped improve the manuscript. We also thank Nicolas Martin and Matteo Monelli for their helpful insights during the initial stages of the project. N.E.D.N. and B.C.C. thank the Max-Planck Institute for Astronomy. N.E.D.N. and J.I.R. thank the ETH Zürich. B.C.C. also thanks the Alexander von Humboldt Foundation Fellowship under which funding for this project was completed. R.C. acknowledges funds from the Spanish Ministry of Science and Innovation under the Juan de la Cierva fellowship. J.I.R. acknowledges support from SNF grant PP00P2_128540/1.

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